Is Mass Customisation Suitable for Every Industry?

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Abstract
The aim of this research is to examine the development of mass customisation across different industry sectors. Using a contingency lens, this study develops and tests an integrated model of mass customisation, industry sector and country competitiveness. The hypotheses are empirically tested using data collected from 5th round of Global Manufacturing Research Group and secondary data obtained from the World Economic Forum. Our results indicate that mass customisation is suitable for every industry. In addition, we found that mass customisation development is country-contingent. However, the relationship between mass customisation development and a country's global competitiveness is counter-intuitive.

Keywords: Mass Customisation, Industry Sector, Global Competitiveness

Introduction

Beginning from the introduction of Mass Customisation (MC) (Pine, 1993) to more recent studies (Sandrin et al., 2018), there is little or no empirical research on the specific relationship between MC and industry sectors. The literature includes studies that have examined MC in a single sector context (Brabazon and MacCarthy, 2017) and across a variety of sectors (Wiengarten et al., 2017b, Zhang et al., 2017, Sandrin et al., 2018). Fang et al. (2016) make the point that MC is not suitable for all industries while Huang et al. (2010) and Duray et al. (2000) highlight that not all industries employ MC. Gilmore (1997) suggests that some industries partially adopt MC while Tu et al. (2004) assert the adoption of MC in "almost every industry". Thus, there is little consensus on the relationship, if any, between MC and industry sector. According to the strategic management literature, industry sectors can be characterised based on their structural variables (Robinson and McDougall, 1998, Spanos et al., 2004).

In addition, the literature suggests that research should examine the moderating role of the contingency factors that affect MC development (Huang et al., 2008, Liu et al., 2012, Sandrin et al., 2014). In this regard, Yin et al. (2017) note that high capital and labour costs, coupled with high rates of technological and competitive change, present challenges for manufacturers particularly in developed countries. Many of these contingency factors are country or industry dependent. In terms of country-dependency these factors are often suggested to be competitiveness related (Kauppi et al., 2016). As such, we will analyse the impact of a country's competitiveness on MC and industry sector. We will use the Global Competitiveness Index (GCI) published by the World Economic Forum which is measured based on a comprehensive set of twelve pillars.

Accordingly, we strive to answer the following research questions:

RQ1: Is MC development industry-contingent?

RQ2: Is MC development country-contingent?

Literature review and research hypotheses

Definitions

Pine (1993, p48) defines MC as the "mass production of individually customized goods and services". Zipkin (2001) notes that MC represents a company's capability to offer individually tailored products or services on a large scale. In line with extant literature (Huang et al., 2008, Zhang et al., 2015), we adopt the Tu et al. (2001) definition of MC capability as the capability to provide high product variety and customisation with an operational performance level that is comparable to those of a mass producer, without any consequent trade-offs in cost, quality and delivery. In addition, our understanding and operationalisation of MC development are aligned with this definition.

A firm's operational capability identifies what activities a manufacturing firm can do better than its competitors (Hayes and Pisano, 1996, Brown and Blackmon, 2005). Koufteros et al. (2002) note that higher levels of capability positively impact on performance. Alternatively, Peng et al. (2008, p730) defines capabilities as "a business unit's intended or realized competitive performance or operational strengths".

In this regard, Tu et al. (2001) conceptualise MC capability as competitive performance (i.e. as an outcome) (see, Peng et al., 2008). We do not follow their conceptualisation of MC capability. In contrast, we concur with Zipkin (2001), who conceptualises MC capability as a combination of routines and related inputs that enable performance (i.e. as the means to an outcome) (Trentin et al., 2015).

We prefer Zipkin (2001)'s conceptualisation, because we also view MC development as the means to an outcome, an emergent operational capability that enables operational performance (Liu et al., 2006, Huang et al., 2008). Building on this view, like other operational capabilities elsewhere in the literature (Wu et al., 2010), MC is considered not a capability that a firm can buy and it is difficult to imitate.

Contingency perspective

Sousa and Voss (2008) argue that scholars need to consider the effect of contingency factors such as national culture, firm size and strategic context when conducting research. More specifically Sousa and Voss (2008, p.705) argue that *"a particular challenge for contingency research is to develop measures that are both valid and comparable across different contexts"*. In addition, Sousa and Voss

(2008) note that contingency perspective includes performance as well as organisational and environmental factors. More recently, Chavez et al. (2015) found support for the impact of technological turbulence, as an external environmental characteristic, on the capability-performance link.

In searching for suitable moderating factors of the business context, first, we need to identify the main components of MC. Then, we need to search for the potential contingency factors that could impact on the components of MC development. In this regard, Zhang et al. (2017) highlight four components of MC development, namely: customisation cost efficiency, high volume customisation, customisation responsiveness and customisation quality.

As for potential contingency factors, the MC literature offers a limited number of studies. For example, Kortmann et al. (2014) note that MC is contingent on factors such as advanced manufacturing technologies, advanced information technologies, effective process implementation and operational efficiency. Liu et al. (2012) and Zhang et al. (2017) suggest future studies to examine the moderating role of environmental uncertainty on the effects of MC. With regard to our research questions, a contingency perspective examines the match of industry sector and in turn the business context with MC development.

In more recent literature, we found a consistent and recurring theme in relation to the potential role of both cost and country effects (Ketokivi, 2017, Ketokivi et al., 2017). In particular, Yin et al. (2017) note that high costs linked with high rates of change in competitiveness and technologies offer challenges for manufacturers in developed countries, often spurring them to offshore production to low cost sources. Accordingly, we base our contribution to the literature on our analysis of country level factors that could reflect these two dimensions of cost and responsiveness.

Using publicly available and reliable indices on country level factors, we chose GCI as the relevant corresponding measure for our study. Specifically, the GCI has twelve pillars, namely: institutions, infrastructure, macroeconomic environment, health and primary education, higher education and training, good market efficiency, labour market efficiency, financial market development, market size, business sophistication and innovation.

Hypotheses

Industry sector. Industry sectors can be characterised based on structural variables such as industry concentration, product differentiation, entry barriers and industry growth rate (Robinson and McDougall, 1998, Spanos et al., 2004). For example, the Herfindahl-Hirschman Index (Rhoades, 1993) indicates that the food manufacturing industry is highly competitive and not concentrated; whereas the motor vehicle manufacturing is highly concentrated. Enumerating the differences between industry sectors is out of the scope of our study. As such, we build on the extant literature and accept that there are differences between industries because of the differences in their characteristics. Accordingly, we hypothesise:

> *H1:* There are statistically significant differences between MC development levels in different industry sectors.

Country. Porter (1991) highlights the role of environmental changes (such as competition and technology) in building/enhancing competitive value. Varying levels of investment in infrastructure and institutions lead to differences in the business environment for firms across countries (The Global Competitiveness

Report, 2011) (Wiengarten et al., 2014). The global spread of supply chains and the increase of international trade has amplified the importance of macro-level factors (Kinra and Kotzab, 2008). Furthermore, Kinra and Kotzab (2008) argue that in the age of international trade and global supply chains, infrastructural dissimilarities among countries have important effects and that these dissimilarities remain under-studied.

Building on this, we argue that plants that are located in countries with high levels of GCI (in particular, high levels of: infrastructure, higher education and training, good market efficiency, labour market efficiency, financial market development, market size, business sophistication and innovation) are more likely to have developed high levels of MC. For example, plants with access to cost-efficient high quality logistical capabilities can often benefit from customisation cost efficiency and customisation responsiveness. Besides, in countries with good roads, transport should be better and delivery times will be both shorter and more certain. Shorter and more certain delivery times positively influence high volume customisation as well as cost efficiency, responsiveness and quality (Pine, 1993, Kotha, 1995). Accordingly, we hypothesise:

H2: The higher the level of GCI, the higher the level of MC development.

Research Methodology

Data

Our study is based on the data collected by the Global Manufacturing Research Group (GMRG). GMRG is a global consortium of operations management researchers dedicated to the worldwide study and improvement of operations and supply chain practices (Wacker and Sheu, 2006, Whybark et al., 2009). The survey has been designed based on specific literature and to explore manufacturing practices and performance taking place at the plant level. A standardised survey instrument has been developed and evolved throughout the several iterations of the GMRG survey. The questionnaire was translated back and forth into the required language of country and English to ensure equivalence, validity and reliability of the survey items (Pagell et al., 2013).

Data (representing the 5th iteration of the survey effort) was collected in 2013 in multiple countries with a few companies added at the beginning of 2014 (Jan.-Feb.). More than 900 responses have been collected, representing 14 countries in most regions of the world. In collecting data, researchers had the freedom to select specific modules of the survey (Wiengarten et al., 2017a). Individual members of the GMRG were asked to gather data and apply the most appropriate population frame depending on country specific circumstances (Schoenherr and Narasimhan, 2012). For example, Sardana et al. (2016) collected data in India where 43% of their sample is represented by textile, apparels and electronics manufacturers.

The unit of analysis for this survey is the manufacturing site or plant and all the data were collected from plant/operations managers as key informants within that site. These managers were targeted as they were deemed to have a comprehensive knowledge of the plant operations. However, they were advised to seek input from other functions if required. This ensured that the data collected were reliable and reflected the current state of the particular site. Due to complexity and length of the questionnaire, flexibility was required in terms of collection. Most of the questionnaires have been collected during on-site visits, though web and mailed surveys were also employed.

Following a rigorous approach, we only considered records for which no data were missing and we only included industries with minimum of ten representatives. This led to a dataset of 419 records. Table 1 provides an overview of the dataset.

Table 1 – Sample overview (n = 419)

Country	n	%	Industry	n	%	No. of employees	n	%
Australia	20	4.8	Food & Kindred	58	13.8	≤ 50	122	29.1
Croatia	88	21.0	Textile Mill Products	15	3.6	51 - 100	92	21.9
Hungary	32	7.6	Apparel & Textile	28	6.7	101 - 500	150	35.8
India	51	12.2	Lumber & Wood	26	6.2	501 - 1000	30	7.2
Ireland	28	6.7	Paper & Allied	18	4.3	> 1000	25	6.0
Poland	63	15.0	Printing Publishing & Allied	10	2.4	**Total**	**419**	**100**
USA	68	16.2	Chemicals & Allied	25	6.0			
Vietnam	69	16.5	Rubber and Plastic	41	9.8			
Total	**419**	**100**	Primary Metal	21	5.0			
			Fabricated Metal	52	12.4			
			Machinery & Computer	22	5.3			
			Electronic and Electrical	41	9.8			
			Instruments & Watches	10	2.4			
			Motor Vehicles	18	4.3			
			Furniture and fixtures	16	3.8			
			Stone, Clay, Glass & Concrete	18	4.3			

According to Table 1, the respondents are from eight countries and four different continents. The table shows that respondents are from both developed and developing countries. Given the population of these countries, we acknowledge that the number of respondents per country is not evenly distributed. In particular, 21.0% of the total respondents are from Croatia; whereas, 12.2% are from India. We believe that this might be one of the limitations of our study. However, looking at the big picture of our respondents per country, 80.9% of our respondents are from five countries, four of which have relatively large population, namely: USA, Vietnam, Poland and India. The remaining 19.1% are from three relatively small populated countries of Hungary, Ireland and Australia.

Measures

Drawing on Da Silveira et al. (2001), we operationalise MC development as a firm's capability to undertake large-scale product customisation, easily adding significant product variety without increasing cost, customising products while maintaining high volume, adding product variety without sacrificing quality, being highly capable of responding quickly to customer requirements and producing high volume and high variety of products. might be one of the limitations of our study. The literature reveals a high level of consensus regarding the elements of MC (Zhang et al., 2017). Using a multi-item measure as suggested by Malhotra and Grover (1998), MC is measured as the degree of agreement with the statements assessing the plant's MC. Respondents were asked to indicate their agreement with the statements assessing their plant's MC development (1 = strongly disagree, 7 = strongly agree).

Reliability and factor analysis

Reliability of the measurements was assessed by conducting Exploratory Factor Analysis (EFA) using IBM SPSS Statistics 20. We employed EFA to test the unidimensionality of the scales, followed by Cronbach's alpha for assessing construct reliability. EFA with Principal Components Maximum Likelihood method and Varimax rotation with Kaiser Normalisation was used. The reliability (internal consistency) was tested and MC development construct had 0.897 indicating a reliable measure. The results are presented in Table 2 in terms of Cronbach alpha, factor loadings, t-values and standard errors.

Table 2 – Measurement characteristics

Construct/Variable	*Loading*	*t-value*	*S.E.*	R^2
Mass Customisation Capability (α = 0.897)				
Capable of large-scale product customisation	.79	66.02	.075	.624
Easily adding significant product variety without increasing cost	.81	61.96	.072	.640
Customising products while maintaining high volume	.86	68.40	.070	.719
Adding product variety without sacrificing quality	.81	73.80	.068	.639
Capability for responding quickly to customisation requirements	.85	72.95	.068	.703
Producing a high volume of products	.63	73.24	.070	.426
Producing a high variety of products	.76	66.73	.075	.599

Results

H1. We investigated the differences in MC development levels between 16 industries using ANOVA. Our result indicates that the differences in MC development levels between these 16 industries are not statistically significant. This means that H1 is not supported. Given the counter-intuitive nature of the result, we further used ANOVA to examine the differences in relation to the components of MC. We found that there are statistically significant differences between industries in the development of two MC components (see Table 3). Similarly, we investigated the differences in MC development levels between 8 countries. Our result indicates that the differences in MC development levels between these 8 countries are statistically significant.

Table 3 – Industry and Country Comparison

Group	DF	F	Sig	Hypothesis test
Industry	36	1.157	.251	H1 Not Supported
Adding product variety without cost	15	1.658	.057	Supported (p<.1)
Producing high volume of products	15	1.517	.096	Supported (p<.1)
Country	36	2.299	0^{***}	Supported

*** p<.001

H2. We used Linear Regression to predict MC development level based on GCI. A significant regression equation was found (F (1,417) =14.202, p<.000), with R^2 of .033 and standardised coefficient of -.181. This means that H2 is not supported. However, the result is significant and GCI predicts MC development level in opposite way of what we initially hypothesised. We further used regression analysis to test for the impact of the relevant pillars of GCI on MC development (See Table 4).

Table 4 – Global Competitiveness (IV) and MC Development (DV)

Predictor	F	Sig	R^2	Standardised coefficient
Global competitiveness	14.202	.000***	.033	-.181
Infrastructure	13.991	.000***	.032	-.180
Higher education & training	16.708	.000***	.039	-.196
Goods market efficiency	20.575	.000***	.047	-.217
Labour market efficiency	13.029	.000***	.030	-.174
Financial market development	7.281	.007**	.017	-.131
Technological readiness	18.384	.000***	.042	-.205
Market size	.029	.864	.000	-.008
Business sophistication	6.775	.010*	.016	-.126
Innovation	8.798	.003**	.021	-.144

* p<.05; ** p<.01; *** p<.001

Furthermore, using Linear Regression we investigated whether or not combination of country and industry predicts MC development. We found significant results (p<.1) for 3 of 16 manufacturing industries, namely: Paper and Allied, Chemicals and Allied and Motor Vehicles.

Discussion

Industry

Our findings address the research gaps in the literature. The results indicate that MC development is not industry-contingent. This means that MC can be developed in "*every*" industry. Our results do not support the findings of Fang et al. (2016), Huang et al. (2010), Duray et al. (2000) and Gilmore (1997). In contrast, our results support the findings of Tu et al. (2004) that suggest the development of MC in "*almost every industry*". There are a variety of possible explanations for this. One is the emergence and implementation of advanced manufacturing technologies across industries. Another explanation is that, regardless of the industry sector, once plants have effectively invested in manufacturing practices that empower product variety, product volume flexibility and product delivery, as a consequence, they will reach acceptable levels of MC development. Needless to say, globalisation, outsourcing and integration help plants to develop MC with costs comparable to mass production.

Our results suggest (1) adding product variety without increasing cost and (2) producing high volume of product are two components of MC development that are significantly different between industries. We believe that industries with high degrees of product differentiation and high concentration are associated with these two components of MC development. We will investigate this speculation in future research.

Country

Our results indicate that MC development is country-contingent. This means that there are statistically significant differences in MC development levels between countries. However, the relationship between countries GCI and MC development (standardised coefficient of -.181) is in the opposite way of what we initially hypothesised. We further analysed the relationships between relevant pillars of the

GCI and MC development. The complementary analysis confirmed the initial finding: a largely negative impact. These findings led to one main question: why does a country's competitiveness negatively impact its MC development?

A possible explanation for our finding in relation to GCI is that countries that score high on this scale, score high on infrastructure, goods and labour market efficiency, technological readiness and business sophistication. As such, firms in such countries could rely on other firms to achieve cost benefits (such as using fast, reliable and cost-effective logistics services). Similarly, doing business in these countries is easier and firms, in these countries, might rely on other firms to gain cost benefits. For example, a firm can benefit from cost savings by outsourcing some of its operations to another firm. As such, there is greater scope for benefiting from outsourcing in such countries. In particular, relying on the services of other firms located in these countries could provide customisation cost efficiency, high volume customisation and customisation responsiveness. In contrast, in countries that score low on GCI, firms cannot rely on other firms to gain cost benefits (for example fast, reliable and cheap logistics services are not available). As a result, plants develop their own MC capabilities.

The findings of our study should be of interest to policy makers and practitioners making decisions about MC. For example, to increase the level of MC policymakers need to focus on country level advisory bodies (such as Enterprise Ireland in Ireland) rather than industry associations across the country. Our findings suggest that focus needs to be on country as a whole and MC can be developed across all the industries and ultimately have cross-industry benefits.

Likewise, our study has important implications for MC implementation. Our empirical findings reinforce that MC is suitable for every industry. Our study makes a managerial contribution by encouraging managers to consider global competitiveness in the design of global supply network and in making strategic choices. Ketokivi et al. (2017) note that location decisions have the potential to inform firm-level strategies. In this regard, we examined the effect of country level factors (components of GCI) on the development of MC. Our findings indicate that there is a negative relationship between GCI and MC development. This suggests that in countries with high level of competitiveness, manufacturing firms can benefit from (and rely on) the services of other firms. This is an important finding, as it explains how managers can reap the benefits of MC and offers an understanding of the mechanism that can be used to achieve better results.

Conclusion

To the best of our knowledge, the present study is the first to examine the relationship between MC development, industry sector and country. It develops and empirically tests a conceptual model, which is grounded in contingency theory. By identifying the circumstances or variables that have an intervening effect on the capability –industry relationship, we contribute to both the academic and practitioner community with potentially compelling answers to the question of why developing capabilities, in MC, are or are not always successful. Our study is limited by the use of cross-sectional and non-random sample to test the hypotheses. This study provides managerial insights by illustrating an effective context-industry-capability perspective.

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