Using co-creating mass-customisation and innovation climate for enhanced value

Empirical investigation in international modular jewellery market

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Abstract

Purpose – This paper aims to study the impact of innovation climate (IC) on co-creating modular mass-customisation (CMMC) in terms of cost effectiveness, volume effectiveness, responsiveness, product modularity and collaborative assembly. Additionally, this research paper investigates the effect of IC and CMMC on the value to customer (VC) in a modular jewellery emerging market that includes international companies.

Design/methodology/approach – After conducting a comprehensive literature review, the authors suggested a conceptual framework and examined it using mixed methods approach. In addition to qualitative focus groups, questionnaires were filled – across five-point Likert scale format – through 63 depth interviews carried out with subject-matter-experts working at 14 international organisations in the Egyptian modular jewellery market. SmartPLS software was used for structural equation modelling analysis.

Findings – Results showed that CMMC positively and significantly affects VC. Furthermore, IC positively and significantly affects both CMMC and VC.

Practical implications – Recent industrial developments that can be observed in such international modular jewellery sector can be enhanced by the empirical evidence of this research regarding the importance of developing IC for more creative manufacturing approach of modular mass-customisation and better VC.

Originality/value – To the best of our knowledge, it is the first empirical study that investigates the relationship between CMMC, IC and VC in a unique jewellery market, which recently generated high customer involvement in the assembly/reassembly processes. Conceptually and empirically, it consolidates and adds to the literature of production and operations management (mass-customisation), organisational studies and innovation science (organisational climate for innovation) and applied social sciences.

Keywords Customer value, Innovation climate, Product modularity, Co-creating mass-customization, Collaborative assembly, Jewellery market, Creative product designs

Paper type Research paper

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1. Introduction

As customers' needs change, competitive intensity increases requiring companies to evolve its manufacturing strategies in order to cope with that continuous change (Huang *et al.*, 2010; Jitpaiboon *et al.*, 2013). One of these evolved functional strategies is mass-customisation, which can integrate the best of two manufacturing approaches; namely customisation and mass production (Ulrich *et al.*, 2003; Comstock *et al.*, 2004; Kamrani *et al.*, 2012). In other words, it provides product variety on a large scale along with succeeding to maintain cost efficiency (Huang *et al.*, 2010; Murat Kristal *et al.*, 2010; Jitpaiboon *et al.*, 2013). However, mass-customisation without innovation in the process and products will not be able to sustain customer delight (Huang *et al.*, 2010). Thus, organisations need to create an innovation climate (IC), which is an internal environment that motivates its human resources to exchange innovative ideas about creative products/services/processes in order to promote its performance and maintain a sustainable competitive advantage (Shanker *et al.*, 2017). After conducting a comprehensive review to the literature of production and operations management, organisational studies and innovation science, many studies (Karlsson, 2002; Blecker and Abdelkafi, 2006; Huang *et al.*, 2010; Fogliatto *et al.*, 2012; Jitpaiboon *et al.*, 2013; Wang *et al.*, 2016; Liu *et al.*, 2018) were found to be investigating the *mass-customisation* approach in different industries other than the jewellery market (e.g. computers, electronics, automobile, furniture, food and beverage and textile). Some other researchers studied the important role of developing an internal *organisational climate for* supporting *innovation* (Worren *et al.*, 2002; Panuwatwanich *et al.*, 2008; Chan and Liu, 2012; Oke *et al.*, 2013; Popa *et al.*, 2017; Shanker *et al.*, 2017). Besides, very limited number of studies examined the mass-customisation (MC) – only in terms of cost efficiency, volume effectiveness, and responsiveness – and *innovation* as constructs in the same research model. For example, Liu *et al.* (2018) studied these two constructs but as separate mediators between the absorptive capacity-business performance relationship. From a generic manufacturing perspective, Gunday *et al.* (2011) studied the effect of different types of innovation (organisational, marketing, process and product) on the production performance (in terms of volume, speed and cost) generally not related to MC strategy. In terms of modularity dimension, Worren *et al.* (2002) and Salvador and Villena (2013) explored the relationship between product modularity and innovation. However, there is a lack of studies that investigated the relationship between the IC, co-creating modular mass-customisation (CMMC) – in terms of cost effectiveness, volume effectiveness, responsiveness, product modularity, and collaborative assembly – and value to customer (VC) in a creative jewellery market, which recently generated higher customer involvement in the assembly/reassembly and remix processes of its product modules/charms. According to Tu *et al.* (2001) and Abdallah and Matsui (2008), value to the customer (VC) is the degree to which products offered by an organisation can benefit and satisfy its customers. Therefore, the authors of this research were encouraged to study this relationship in such unique evolving market.

Concerning the modular jewellery sector, different reasons inspired the authors to select it for the empirical part of the current research. First, there are contemporary industrial developments that can be observed in the international modular jewellery sector related to the creative manufacturing approach of modular mass-customisation. For example, according to the interviews conducted with subject-matter-experts (SMEs) working at Swarovski, Pandora and other international companies in Egypt, the jewellery products are now designed/produced in the form of modules/charms to enhance customer involvement in the assembly/reassembly processes. Through this creative mass-customised approach of the jewellery remix collection, each customer can choose a standard base unit of a necklace/bracelet and can enjoy a personalised jewellery experience by assembling charms and mixing them together in various changing combinations (e.g. different jewellery types, sizes,

stone colours and shapes) to match each customer's taste. Second, regarding the Egyptian jewellery market, the ancient Egyptians have been known since 5000 B.C. by their unique and creative gold products and other precious metals (Industrial Modernisation Center, 2007). Currently, the Egyptian modular jewellery market includes reputable international companies producing and selling in Egypt and having skilled human assets with low labour cost, and their exports are increasing to different countries (e.g. the UK, Turkey and Saudi Arabia) (The Egyptian-British Chamber of Commerce, 2016; General Organisation for Export and Import Control, 2018). For example, the value of exports of Egyptian jewellery as well as precious stones have been raised by 37 per cent from $248m in 2017 to $339m in 2018 (General Organisation for Export and Import Control, 2018).

The next sections of this research paper are arranged as follows. Section 2 provides a comprehensive review of the relevant literature on CMMC, IC and VC. As for the research methodology, Section 3 proposes the conceptual framework and discusses the mixed methods approach with the data collection methods used in this study. Regarding the nature of the selected manufacturing sector, Section 4 presents a holistic picture of the modular jewellery market of a creative emerging Egyptian economy. Then, Section 5 discusses the findings of the quantitative data analysis using PLS-SEM. Consequently, Section 6 encapsulates the main conclusions, limitations and practical implications of this research.

2. Literature review

From a multidisciplinary perspective, the authors in this paper consolidated the relevant literature on production and operations management, organisational studies and innovation science to discuss the relationships between the research variables: CMMC, IC and VC. This paper critically discusses the previous studies that investigated these constructs in addition to generating a new streamline of research that explores the relationship between IC, VC and CMMC with higher level of customer involvement in the assembly and reassembly processes.

2.1 Co-creating modular mass-customisation and customer value

Based on a comprehensive review of the literature of production and operations management, the authors found that many studies (Karlsson, 2002; Piller *et al.*, 2004; Blecker and Abdelkafi, 2006; Dellaert and Dabholkar, 2009; Huang *et al.*, 2010; Fogliatto *et al.*, 2012; Jitpaiboon *et al.*, 2013; Wang *et al.*, 2016; Liu *et al.*, 2018) have investigated the mass-customisation approach in different industries (e.g. computers, electronics, automotive, furniture, food, beverage, textile and apparel and footwear). However, the CMMC, as a construct, was considered in the literature as three separate factors: mass-customisation capability, modular design or product modularity, and co-creating/collaborative customer assembly. But for this unique industry, after carrying out the qualitative interviews in the modular jewellery market, CMMC approach was found to be regarded empirically as one construct instead of dealing with it as three independent factors. These three factors can be traced in the literature as follows. First, mass-customisation strategy was defined as the ability of offering product variety on a large scale along with succeeding to maintain cost efficiency (Huang *et al.*, 2010; Murat Kristal *et al.*, 2010; Jitpaiboon *et al.*, 2013; Zhang *et al.*, 2015). It merges the best of two manufacturing approaches; namely customisation and standardization/mass production (Ulrich *et al.*, 2003; Comstock *et al.*, 2004; Kamrani *et al.*, 2012). The mass-customisation capability was operationalised by some scholars in terms of cost efficiency, volume effectiveness, and responsiveness. For example, Tu *et al.* (2001) pointed out that these three dimensions are crucial for the implementation of mass-customisation in any company. Moreover, Tu *et al.* (2001) concluded its direct positive effect on the VC, which they defined as the degree to which the products offered by organisations

can benefit and satisfy its customers. With different empirical findings, Squire *et al.* (2004) tested the same relationship between mass-customisation and VC but argued that mass-customisation can increase VC for only specific markets/customers. Therefore, the authors of this research paper detected mixed reported findings in the previous literature, that represent a gap for the current study as well as future researches as suggested by Squire *et al.* (2004). Second, product modularity, the modular design is one technique for the mass-customisation approach, in which products are designed in the form of modules/components that are flexibly assembled/exchanged (Karlsson, 2002; Tu *et al.*, 2004; Abdallah and Matsui, 2008; Heizer *et al.*, 2017; Viana *et al.*, 2017; Stevenson, 2018). This product modularity or modular design tactic satisfies both organisational functions, production and operations management in addition to marketing, because it saves manufacturing costs better than the customisation approach and augments customer delight more than the standardisation strategy (Duray, 2002; Heizer *et al.*, 2017; Stevenson, 2018). Yet, Ahmad *et al.* (2010) addressed the importance of effective synchronisation between these two organisational functions in addition to the R&D to ensure that the product modules satisfy customers' needs. By this means, product modularity can facilitate the assembly/reassembly processes conducted by customers according to their unique preferences/tastes. Thus, modular product design can lead to unlimited number of varied and individualised products (Bask *et al.*, 2011). Heizer *et al.* (2017) gave examples on the successful implementation of that technique in different sectors such as the automotive and fast food industries. Yet, Abdallah *et al.* (2009) asserted that such approach cannot be suitable for all kinds of products and markets.

As for the jewellery sector, the continuous involvement of customer in the reassembly/remixing processes even after the purchase of the product creates an innovative environment for greater VC with diverse individualised experiences. This brings us to the *third factor*, which is *customer involvement* in the assembly process (i.e. collaborative assembly). Prior authors (Duray *et al.*, 2000; Choy and Loker, 2004; Tu *et al.*, 2004; Abdallah and Matsui, 2008) contended that the level of customer involvement in the different phases of production process (e.g. assembly) is considered as a required dimension in the effectiveness of mass-customisation and the personalised value received by each customer. The customer engagement in the phases of the production process was also pinpointed in the literature by the term *co-creating mass-customisation* (Loef *et al.*, 2017). With different levels of customer involvement, Gilmore and Pine (1997) shaped four types for mass-customisation (*collaborative*, *adaptive*, cosmetic and transparent) that were pointed out later by other studies (Da Silveira *et al.*, 2001; Comstock *et al.*, 2004; Bask *et al.*, 2011) that described the manufacturing approach used in specific industries. In the modular jewellery industry, the mass-customisation strategy is used as a blend of the collaborative and adaptive approaches. Through collaborative mass-customisation, each customer specifies her needs from diverse modular jewellery types, charms' shapes and colours and then collaborative assembly of the chosen bracelets/necklaces modules are done at the store. Afterwards, adaptive mass-customisation can be conducted later by each customer in terms of the remix and reassembly of extra jewellery modules/charms resulting in infinite shapes of assembled jewellery products. Regarding the relationship between the research factors, Abdallah and Matsui (2008) within one research model assessed the impact of *product modularisation* and *customer involvement* in the production process as one factor on *mass-customisation* and VC. They asserted that product modularity together with customer involvement are two important factors for maintaining a comprehensive approach towards mass-customisation that enhances the distinctive experience of each customer. However, there is a lack of empirical research assessing the relationship between IC, VC and CMMC especially in a unique modular jewellery industry with high level of *customer involvement* in

the assembly and reassembly processes. Thus, the findings of this paper can contribute conceptually and empirically to this research area.

2.2 Innovation climate and customer value

Innovation is a crucial pillar that enables organisations to survive, change and improve their performance in a competitive market especially during challenging times (Liao *et al.*, 2007; Tejeiro Koller *et al.*, 2017; Younis, 2019). It helps firms in delivering the required value to their customers by flexibly adapting to new market changes via introducing new products or improving the current ones (Wang *et al.*, 2016). Wang *et al.* (2016) view innovation as the new employment of knowledge and approaches, which can produce developed processes or products for the purpose of achieving stakeholders' delight. Scholars (Dambiski Gomes de Carvalho *et al.*, 2017; Younis, 2019) advocated that innovation should be investigated in terms of its fruitful outcomes, as well as its inputs (i.e. factors that support innovation such as the organisational climate). In this paper, IC is regarded as the internal organisational environment that motivates human resources to exchange innovative ideas about creative products or processes to promote its performance and maintain a sustainable competitive advantage (Worren *et al.*, 2002; Shanker *et al.*, 2017). As a construct, IC was studied in the literature from different perspectives. Some studies (Van der Vegt *et al.*, 2005) regarded IC as the common interpretation of employees regarding the rewarded activities by their organisations, which can lead to new ideas for improvement. Similarly, Chan and Liu (2012) contended that IC can be considered in terms of human resources' perceptions of the extent to which their institutions are supporting innovation. For example, organisations should provide their HR with the needed financial and nonfinacial resources in order to incentivise them to be creative (Chan and Liu, 2012; Silva, 2014). With the aid of giving specific examples, Parry *et al.* (2009) regarded IC as the internal organisational environment that allows its human capital to work freely while providing them with the time needed to generate creative ideas. Sarros *et al.* (2008) added that the type of leadership together with the organisational culture will promote the IC.

At both individual and organisational levels, Rui and Kun (2016) conceptualised this term by the working environment that affect the individual as well as the institutional innovative performance. Following the same streamline of research, Jha (2017) and Shanker *et al.* (2017) elaborated on the important role of IC in elevating the innovative behaviour and psychological empowerment (i.e. at an individual level). In addition, it boosts the company's innovative performance and degree of innovativeness (i.e. at an organisational level) (Chan and Liu, 2012; Kmieciak *et al.*, 2012; Wang *et al.*, 2016; Cai *et al.*, 2017; Popa *et al.*, 2017; Shanker *et al.*, 2017). Besides, Chen *et al.* (2010) and Cai *et al.* (2017) addressed the IC capability in fostering and exchanging new ideas/strategies for both product and process innovation. Regarding its relationship with the VC, Panayides (2006) and Kim *et al.* (2012) pinpointed the role of innovation capability in boosting the firm's responsiveness towards meeting unique demands via new product/market development; thus, enhancing value delivered to customers. Also, Gunday *et al.* (2011) reported the positive impact of innovation not only on production and financial organisational performance but also on the competitive market performance. Building on these studies, this paper investigated the IC according to the perceptions of subject-matter-experts (SMEs) in the modular jewellery companies about the IC practices held by their institutions, which can lead to innovative process/product and enhanced VC.

2.3 Innovation climate and co-creating modular mass-customisation

As for this research paper, we suggest that IC promotes the CMMC approach in terms of cost effectiveness, volume effectiveness, responsiveness, product modularity, and collaborative

assembly. To the best of our knowledge, there is a lack of studies that investigated in one research model the relationship between IC, CMMC (in terms of CE, VE, MCR, PM and CA) and VC especially in a creative jewellery market, which recently generated high customer involvement in the assembly/reassembly processes of its product modules. Yet, the relationships between IC and one or more dimensions of CMMC (cost effectiveness, volume effectiveness, responsiveness, product modularity, and collaborative assembly) were measured independently in a number of different studies. *First*, very limited studies examined the relationship between mass-customisation – only in terms of cost efficiency, volume effectiveness, and responsiveness – and innovation as constructs in the same research model. For example, Gunday *et al.* (2011) studied the effect of different types of innovation on the production performance (in terms of *volume, speed* and *cost*) generally not related to MC strategy. Second, in terms of *modularity* dimension, Worren *et al.* (2002) and Salvador and Villena (2013) explored the relationship between product modularity and innovation. Worren *et al.* (2002) suggested that IC augments both the creativity of modular design process and the innovativeness and variety in products. These product modules can be shared and assembled together easily, quickly and efficiently to form different products with unique features delighting various customers' needs (Wang *et al.*, 2014). Also, Chen *et al.* (2010) and Cai *et al.* (2017) addressed the IC capability in fostering and exchanging new ideas/strategies among the employees for enhancing both product and process innovation. Third, regarding IC relationship with responsiveness, Panayides (2006) and Kim *et al.* (2012) pinpointed the role of innovation capability in boosting the firm's responsiveness towards meeting unique demands via new product/market development; thus, enhancing value delivered to customers. Building on the above-mentioned studies, the authors of this paper proposed the three main hypotheses (as shown in Table I) that describe the relationships between the research variables (IC, CMMC and VC) in a creative international modular jewellery market.

3. Research methodology

As for the research variables and its measurement items, the authors relied on the scales used in the previous literature. First, the independent variable (i.e. IC) was assessed through a scale developed by Oke *et al.* (2013) and used later by Popa *et al.* (2017). Second, the dependent variable (i.e. VC) was operationalised using the measurement-items adopted from Tu *et al.* (2001). Third, the mediating variable (i.e. CMMC) was measured in terms of five dimensions: cost effectiveness (adapted from Tu *et al.*, 2001, 2004; Huang *et al.*, 2008), volume effectiveness (adopted from Tu *et al.*, 2001, 2004), responsiveness (adapted from Tu *et al.*, 2001), product modularity (adopted from Tu *et al.*, 2004), and collaborative assembly (adapted from Duray *et al.*, 2000; Tu *et al.*, 2004). Concerning the suggested conceptual framework, Figure 1 illustrates the relationship between CMMC, IC and VC. Table I summarises the research main variables, its conceptualisation, and related hypotheses.

The purpose of this research is to study the impact of IC on CMMC in terms of cost effectiveness, volume effectiveness, responsiveness, product modularity, and collaborative assembly. In addition, it investigates the effect of IC and CMMC on the VC within the international companies operating in the Egyptian modular jewellery market. The target population encompasses 16 international modular jewellery companies operating in Egypt. All these sixteen companies were contacted, first through emails then direct visits, and fourteen of them agreed to participate (i.e. 87.5 per cent response rate) via 63 SMEs from their product management and production and operations management departments. Due to the lack of a formal list to our target population, the authors used snowball sampling or

Hypothesis	Variable	Conceptualisation	Operationalisation
H1. The IC positively affects the VC	*The independent variable*: IC *The dependent variable*: VC	*IC* refers to an internal organisational environment that motivates human resources to exchange innovative ideas about creative products or processes in order to promote its performance and maintain a sustainable competitive advantage (Worren *et al.*, 2002; Shanker *et al.*, 2017)	IC was assessed through a scale developed by Oke *et al.* (2013) and used by Popa *et al.* (2017)
H2. The IC positively affects CMMC	*The independent variable*: IC *The mediating variable*: CMMC	*Mass-customisation* can be defined as a strategy that can integrate the best of two manufacturing approaches; namely customisation and mass production. It provides product variety on a large scale along with succeeding to maintain cost efficiency (Huang *et al.*, 2010; Murat Kristal *et al.*, 2010; Jitpaiboon *et al.*, 2013). *Product modular design* is one technique for the mass-customisation approach, in which products are designed in the form of modules/components that are flexibly assembled/exchanged (Abdallah and Matsui, 2008; Heizer *et al.*, 2017; Stevenson, 2018). *Collaborative assembly* refers to customer involvement in the assembly process (Duray *et al.*, 2000)	CMMC was measured in terms of five dimensions: cost effectiveness (Tu *et al.*, 2001, 2004; Huang *et al.*, 2008), volume effectiveness (Tu *et al.*, 2001, 2004), responsiveness (Tu *et al.*, 2001), product modularity (Tu *et al.*, 2004), and collaborative assembly (Duray, 2004; Duray *et al.*, 2000; Tu *et al.*, 2004)
H3. CMMC positively affects the VC	*The mediating variable*: CMMC *The dependent variable*: VC	*VC* is the degree to which products offered by organisations benefit and satisfy its customers (Tu *et al.*, 2001; Abdallah and Matsui, 2008)	VC was operationalised using the measurement-items adopted from Tu *et al.* (2001)

Table I.
The research main variables, its conceptualisation and related hypotheses

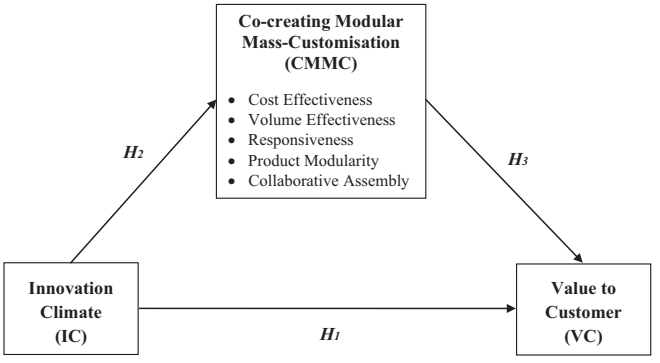

Figure 1.
Conceptual framework showing the relationship between CMMC, IC and VC

chain-referral technique – as recommended by Illenberger and Flötteröd (2012) – to identify these companies through depending on the referrals/competitors suggested/recognised by the initial group of respondents, who are pioneering this new industrial approach (e.g. Swarovski and Pandora SMEs).

Following Mangan *et al.* (2004); Collis and Hussey (2014) and Creswell (2014), the authors of the current study used the methodological triangulation mixed methods approach. The following qualitative and quantitative data collection methods were applied to overcome the limitations resulted from depending on only one technique and enhance the gains of investigating thoroughly the research topic from different angles (Mangan *et al.*, 2004; Collis and Hussey, 2014; Sekaran and Bougie, 2016):

- For testing the research hypotheses, 63 questionnaires (quantitative primary data collection method) were filled – across a five-point Likert scale format – by SMEs working at the product management and production and operations management departments within 14 international organisations in the Egyptian modular jewellery market. Appendix presents the questionnaire's measurement items used in this study and filled through face-to-face interviews. Before data collection, as advocated by Hair *et al.* (2014a), depth interviews were carried out with 10 SMEs at these companies to verify the *face or content validity* of the measurement scale.
- 63 personal face-to-face interviews (qualitative primary data collection technique) were conducted with those aforementioned SMEs at these 14 companies in order to deepen the authors' comprehension about the relationship between research variables. Based on these in-depth interviews, the authors developed Figure 2 that depicts the co-creating mass-customisation and IC practices of the international modular jewellery market in Egypt, which can be considered as one of the contributions of this research.
- Two qualitative focus groups with the Head of Inclusive and Creative Economies Programme in the British Council and seven industry and academic experts in the field of handicrafts, product design, and production and operations management. Throughout these focus groups, fruitful discussions took place that helped the authors to develop comprehensive understanding about the nature and the future of the creative industries (including the modular jewellery sector) inside the emerging inclusive economies like Egypt.

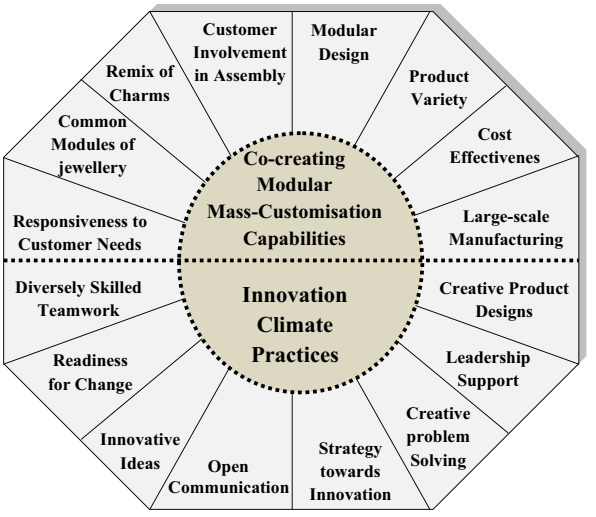

Figure 2.
The co-creating mass-customisation and IC practices of modular jewellery market in Egypt

- The qualitative group discussions and individual presentations that took place at the British Council Conference of "Developing Inclusive and Creative Economies" helped the authors to critically reflect on the reviewed literature and in shaping the conceptual framework. This conference involved representatives from the British Council, Egyptian Ministry of Trade and Industry, Federation of Egyptian Industries, Egyptian Industrial Modernisation Centre, and Goethe Institute for the Middle East and North Africa in addition to industry experts in the field of handicrafts especially jewellery manufacturing.
- Secondary data available about these international companies operating in the modular jewellery market in Egypt (Pandora, 2017; Swarovski, 2018) facilitated the identification of their practices concerning co-creating mass-customisation and IC.

As pointed out by Wong (2013) and Hair *et al.* (2014b) for the multivariate data analysis related to business research of small sample sizes, the authors of this study carried out the partial least squares (PLS) approach to structural equation modelling (SEM) technique using SmartPLS software to examine the relationships between the research variables.

4. International modular jewellery entrepreneurs in a creative emerging economy

The current growing interest of various international organisations to operate in the Egyptian emerging market can be observed in many different sectors (e.g. higher education) (Adel *et al.*, 2018) not only in the jewellery industry. Regarding the Egyptian jewellery market, the ancient Egyptians have been known since 5000 B.C. by their unique and creative gold products and other precious metals (Industrial Modernisation Center, 2007). Currently, the Egyptian modular jewellery market includes reputable international companies producing and selling in Egypt and having skilled human assets with low labour cost, and their exports are increasing to different countries (e.g. UK, Turkey and Saudi Arabia) (The Egyptian-British Chamber of Commerce, 2016; General Organisation for Export and Import Control, 2018). For example, the value of exports of Egyptian jewellery as well as precious stones have been raised by 37 per cent from $248 million in 2017 to $339 million in 2018 (General Organisation for Export and Import Control, 2018). Worldwide, there are contemporary industrial developments that can be observed in the international modular jewellery sector related to the creative manufacturing approach of modular mass-customisation. For example, according to the interviews conducted with SMEs working at Swarovski, Pandora and other international companies in Egypt, one of the interviewees reported that:

> The jewellery products are currently designed and produced in the form of modules/charms to enhance customer involvement in the assembly/reassembly process. Through this creative mass-customised approach of the jewelry remix collection, each customer can choose a standard base unit of a necklace/bracelet and can enjoy a personalised jewellery experience by assembling charms and mixing them together in various changing combinations (e.g., different jewellery types, colours and shapes) to match each customer's taste. Also, companies in this sector added charms of the symbols of astrological signs and alphabet to enhance its customisation ability. Furthermore, each customer can control the size of the jewellery product connecting the modules together forming bracelets or necklaces or belts according to their changing needs.

Figure 2 gives a picture of the main co-creating mass-customisation and IC practices employed at the international modular jewellery market in Egypt, which can be regarded as one of the contributions of this research. These practices were identified based on:

- the secondary data gathered from previous relevant studies (Duray *et al.*, 2000; Worren *et al.*, 2002; Tu *et al.*, 2001, 2004; Chan and Liu, 2012; Oke *et al.*, 2013; Dambiski Gomes de Carvalho *et al.*, 2017; Popa *et al.*, 2017)
- the qualitative analysis of primary data collected from the personal interviews and focus groups.

These IC practices if being sustained and continuously improved by the innovative jewellery companies will support the third pillar for knowledge and innovation of Egypt's strategy of sustainable development under the country's holistic vision for year 2030 (Egypt Vision, 2030, 2016). Thus, these innovative companies can generate new accelerated developments without depriving others in the society from their future needs in natural resources (Adel and Mahrous, 2018).

5. Data analysis, findings and discussion

As advocated by Wong (2013) and Hair *et al.* (2014b, 2017b) for the multivariate data analysis related to business research of small sample sizes, the authors of this paper carried out the partial least squares (PLS) approach to SEM technique using SmartPLS software (V.3.2.8) to examine the relationships between the research variables. This approach is preferred by researchers to analyse small sample sizes ($n < 100$), complex models and non-normal data (Hair *et al.*, 2014b, 2017b). For this research, the model fit was tested and its values (SRMR: 0.045; NFI: 0.805; Chi-square: 498.3777; d_ULS: 0.770; d_G1: 2.248; d_G2: 1.785) are found to be within the accepted range suggested by Hair *et al.* (2017a).

Following Hair *et al.* (2014a), depth interviews were carried out before data collection with 10 experts at the international jewellery companies to verify the face or content validity of the measurement scale. Afterwards, the convergent, discriminant and nomological validity were assessed and verified for this research. First, the convergent validity was measured and confirmed after

- Checking the weights of the standardised loadings;
- Measuring the average variance extracted (AVE) for each construct, and
- Computing the reliability estimates (Hair *et al.*, 2014a).

As presented in Figure 3, the standardised loading for each measured item was found to be significant and greater than 0.7. Besides, the value of the AVE for each construct exceeds 0.5 (as shown in Table II). Further, two reliability measures were calculated and both of them (composite reliability [CR] and Cronbach's alpha) yielded values >0.7. Based on these results, the existence of sufficient convergence was confirmed (Malhotra, 2010; Hair *et al.*, 2014a) and the outer model validation was supported (Hair *et al.*, 2017b). *Second, the discriminant* validity was assessed through comparing the square root of each construct's AVE with every correlation between two constructs (Hair *et al.*, 2014a). Table II verifies that the square root of each AVE is greater than the correlation among any two constructs. Hence, the discriminant validity was also verified for the research variables.

Third, the nomological validity was assessed and verified through testing the research hypotheses to make sure that there are logical correlations between the constructs of the proposed model (Hair *et al.*, 2014a). For testing the research hypotheses, the bootstrapping method with 5000 samples was carried out via using SmartPLS software as it is a suitable method for small sample sizes (Preacher and Hayes, 2004). The authors tested the direct effects in the model before and after adding the mediation path to the research model. Table III demonstrates the path coefficients between the main constructs in addition to the

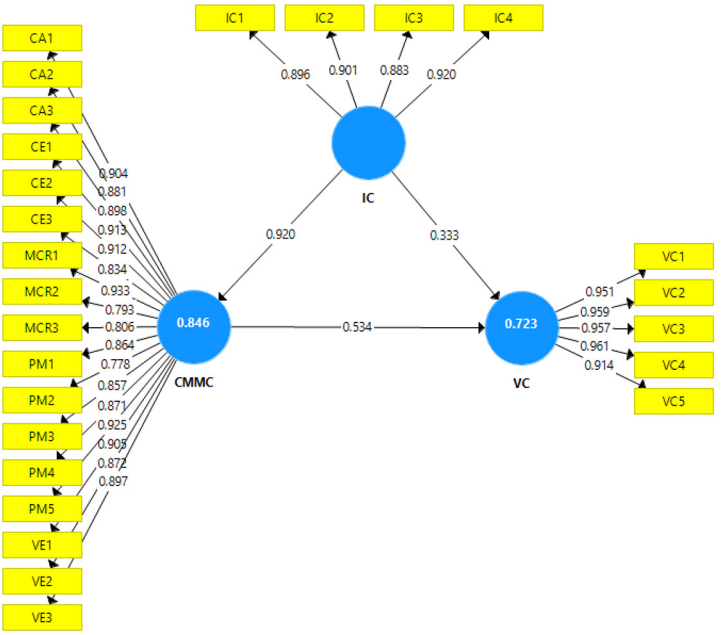

Figure 3.
SEM-PLS Model using SmartPLS software

Constructs	IC	CMMC	VC
IC	*0.9*		
CMMC	0.92	*0.874*	
VC	0.824	0.84	*0.949*
AVE	0.81	0.764	0.9
CR	0.945	0.982	0.978
Cronbach's Alpha	0.922	0.981	0.972

Notes: The square roots of AVE are presented in italic; also, significance is at the level of $p < 0.001$

Table II.
Summary of the measurement results

significance of each relationship. In regard to testing the first hypothesis, the relationship between IC and VC was found to be positive and significant ($\beta = 0.347$, 95 per cent confidence level, p-value < 0.05). Thus, the first hypothesis was supported (i.e. IC creates an internal organisational environment that supports innovation, which promotes VC). Concerning examining the second hypothesis, the relationship between IC and CMMC was found to be positive and significant ($\beta = 0.915$, 99.9 per cent confidence level, p value $<$ 0.001). Consequently, the second hypothesis was supported. In other words, it is important to develop IC for more creative manufacturing approach of modular mass-customisation. IC generates new ideas for producing various creative products modules efficiently that enhance customer involvement in the remix process. Finally, this creative CMMC approach will maximise each customer's personalised experience and perceived value. This finding was supported by accepting the third hypothesis (i.e. CMMC-VC relationship is found to be positive and significant, $\beta = 0.510$, 95 per cent confidence level, p-value < 0.05). In addition, the mediation effect was also tested using the bootstrapping method as was suggested by

Path	Beta value	*p*-value
Direct effects without adding the mediation path in the model		
IC → VC	0.815	0.00
CMMC → VC	0.525	0.01
IC → CMMC	0.915	0.00
Direct effects after adding the mediation path in the model		
IC → VC	0.347	0.047
CMMC → VC	0.510	0.01
IC → CMMC	0.915	0.00
Indirect effect after adding the mediation path in the model		
IC → CMMC →VC	0.467	0.001
Total effect after adding the mediation path in the model		
IC →VC	0.813	0.00
VAF value (ratio of indirect-total effect)	0.578	

Table III.
The direct, indirect and total effects in the model

prior researches (Preacher and Hayes, 2004; Zhao *et al.*, 2010; Nitzl *et al.*, 2016). Results presented in Table III reveal that CMMC mediates the IC-VC relationship (i.e. the indirect effect after adding the mediation path was found to be significant, $\beta = 0.467$). Specifically, the mediation type in this research model can be characterised by being complementary partial mediation (i.e. as indirect effect IC-CMMC-VC is significant, direct effect IC-VC is also significant, and the total effect is positive) (Zhao *et al.*, 2010; Nitzl *et al.*, 2016; Hair *et al.*, 2017a). Furthermore, the VAF value was computed to ensure our mediation type. It determines the degree to which the VC's variance is being explained by the mediation (Nitzl *et al.*, 2016). Our VAF value is 0.578 lies between 0.20 and 0.80 (i.e. a typical partial mediation) (Nitzl *et al.*, 2016). In summary, the international modular jewellery companies when incentivise their employees to exchange and communicate new ideas about creative products/processes/modules will enhance the value delivered to their customers through boosting the capabilities of their CMMC approach.

6. Conclusions, limitations and implications

The purpose of this research paper was to study the impact of IC on CMMC in terms of cost effectiveness, volume effectiveness, responsiveness, product modularity, and collaborative assembly. Furthermore, it investigated the effect of IC and CMMC on the VC in a modular jewellery emerging market that includes international companies. After conducting a comprehensive literature review, the authors suggested a conceptual framework and examined it using mixed methods approach. In addition to qualitative focus groups, questionnaires were filled –across five-point Likert scale format– through 63 depth interviews carried out with SMEs working at 14 international organisations in the Egyptian modular jewellery market. Since, the focus of this research was on the co-creating mass-customisation and IC practices carried out by the international organisations operating in the Egyptian modular jewellery market. Hence, the authors chose only those companies who are producing modular jewellery products in Egypt. The population size of that sector was found to be small, which can be considered as a limitation to this research. However, as advocated by Wong (2013) and Hair *et al.* (2014b) for business research of small sample sizes, the authors used the partial least squares (PLS) approach to SEM technique to overcome this limitation. Hair *et al.* (2014b), after scanning the prior business research literature that used PLS-SEM technique, found out that

large number of studies especially in the field of management that used this approach for data analysis due to their small sample sizes reported high degree of statistical power. Accordingly, SmartPLS software was used for SEM analysis in this research. Results showed that CMMC positively and significantly affects VC. Moreover, IC positively and significantly affects both the CMMC and VC. To the best of our knowledge, it is the first empirical study that investigated these relationships in a unique jewellery market, which recently generated high customer involvement in the assembly/reassembly processes. Recent industrial developments that can be observed in such international modular jewellery sector can be enhanced by the empirical evidence of this research regarding the importance of developing IC for more creative manufacturing approach of modular mass-customisation and better VC. Conceptually and empirically, our paper consolidates and adds to the literature of production and operations management (mass-customisation), organisational studies and innovation science (organisational climate for innovation) and applied social sciences. In addition, this article can be beneficial to the modular jewellery manufacturers operating globally because our research hypotheses were being tested in the international companies at that sector. In summary, the findings of this research article have various practical managerial implications to communicate to the leaders and operations managers in that evolving sector. First, employees should be provided with enough time and financial/non-financial resources to increase their abilities in generating and exchanging creative ideas for developing innovative products and processes. Second, employees should be encouraged to work in diversely talented groups to facilitate creative and constructive communication among them. Third, always make sure that human resources are assigned with challenging tasks that trigger an environment of creativity and incentivise their problem solving skills. Fourth, human assets should be appreciated and compensated for their creative practical ideas to sustain a continuous process of improvement. Fifth, continue generating new ideas for producing creative products modules to enhance customer involvement in the remix process and maximise each one's personalised experience. Sixth, the continuous improvement of IC and MC practices while being cost effective will support the innovation pillar of the country's strategy of sustainable development. Worldwide, academics and researchers are recommended to direct their future empirical studies towards investigating the creative IC and CMMC practices implemented at other evolving sectors and contemporary innovative industries.

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Appendix

Table AI.
The questionnaire's measurement items

Construct/item	Description
Factor (1). IC (adopted from Oke et al., 2013)	
IC_1	Our organisation provides time and resources for employees to generate, share, and experiment with innovative ideas/solutions for new products/process
IC_2	Our employees are working in diversely skilled work groups where there is free and open communication among the group members
IC_3	Our employees frequently encounter non-routine and challenging work that stimulates creativity
IC_4	Our employees are recognised and rewarded for their creativity and innovative ideas
Factor (2). Cost effectiveness (CE) (adapted from Tu et al., 2001, 2004; Huang et al., 2008)	
$CMMC_1/CE_1$	Our capability of offering product variety without increasing cost is high
$CMMC_2/CE_2$	Our capability of setting up for a different product at low cost is high
$CMMC_3/CE_3$	Our capability of customising products based on customer needs at low cost is high
Factor (3). Volume Effectiveness (VE) (adopted from Tu et al., 2001, 2004)	
$CMMC_4/VE_1$	Our capability of customising products on a large scale is high
$CMMC_5/VE_2$	Our capability of customising products while maintaining a large volume is high
$CMMC_6/VE_3$	Our capability of offering product variety without sacrificing overall production volume is high
Factor (4). Mass-customisation responsiveness (MCR) (adapted from Tu et al., 2001)	
$CMMC_7/MCR_1$	Our capability of responding to customization requirements quickly is high
$CMMC_8/MCR_2$	Our capability of translating customer requirements into technical designs quickly is high
$CMMC_9/MCR_3$	Our capability of changeover to a different product quickly is high
Factor (5). Product modularity (PM) (adopted from Tu et al., 2004)	
$CMMC_{10}/PM_1$	Our products use modularised design
$CMMC_{11}/PM_2$	Our products share common modules
$CMMC_{12}/PM_3$	Our product features are designed around a standard base unit
$CMMC_{13}/PM_4$	Product modules can be reassembled into different forms
$CMMC_{14}/PM_5$	Product feature modules can be added to a standard base unit
Factor (6). Collaborative assembly (CA) (adapted from Duray et al., 2000; Tu et al., 2004)	
$CMMC_{15}/CA_1$	Customers can select features from listings
$CMMC_{16}/CA_2$	Customers can assemble a product from components in stock
$CMMC_{17}/CA_3$	Customers are involved in rearranging product modules to suit their needs
Factor (7). VC (adopted from Tu et al., 2001)	
VC_1	Our customers are satisfied with the quality of our products
VC_2	Our customers are satisfied with the features that our products provide
VC_3	Our customers are loyal to our products
VC_4	Our customers refer new customers to purchase our products
VC_5	Our customers feel that we offer products with high value

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