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Spoilt by choice? Understanding the effects of customization and variety increases on service performance: the role of service modularity

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***Abstract* -** We empirically examine the effects of customization and variety increases on service and business performance and explore the role of service modularity. A survey was conducted using a sample of 692 service firms providing varying levels of customization. Using structural equation modelling (SEM), the results suggest that service modularity plays as critical a moderating role in supporting the mass customization - cost efficiency relationship in services as product modularity plays in manufacturing. Consequently, satisfactory cost and customer service performance are achieved by a mass customization approach in services. Also, expansion beyond a core service may not guarantee financial improvement, and firms should consider operational challenges and their capabilities to effectively implement a modular approach. In addition, customer service performance was found to be more dependent on the level of customization offered rather than the variety offered. We provide guidance and insights for researchers and industry managers on how to improve service-related business performance through understanding the roles of service customization, variety and modularity.

***Index Terms* –** customization, service variety, service modularity, service performance, business performance

Managerial Relevance Statement – The findings guide engineering managers and decision-makers on how to enhance service performance by better understanding the role and relationships amongst service customization, variety, and modularity. In particular, the findings suggest that managers should endeavour to configure service modules as a means to achieve service customization as service customization has a significant influence on improving customer service performance and does so significantly more than the total service variety that the organisation offers. Also, similar to manufacturing environments, service modularity in a mass customization environment improves cost performance by mitigating the cost burden of providing customized services. This paper also contributes to SDG 9.

I. INTRODUCTION

Most research studies concerning variety changes and their impact on firm performance focus on manufactured products. The limited research into the implications of service variety changes has highlighted the complex relationships that exist between service variety increases and firm performance [21], [43], for example, a curvilinear relationship between product variety and firm performance [72]. In particular, an increase in variety leads to a positive impact on a firm's brand image, increased customer satisfaction and customer service [116], [93]. However, there exists a competing mechanism that the excessive expansion of a product or service portfolio is likely to harm both the internal and external processes of a firm. This is attributable to increasing complexity and costs as a consequence of variety expansions, in turn, increased costs may outweigh the differentiation benefits realised from increased variety [34].

Service variety concerns a firm's level of customization and diversification into different service markets [56]. Research into the impact of service variety increases on performance has revealed less of a consensus on whether there is a positive or negative relationship [36]. Some researchers argue in favour of wide service variety and have demonstrated that increased service offerings can be linked to positive implications for a service firm [50], [51], [22]. Other researchers have argued that increased service variety has negative implications (e.g., variety-induced cost) on firm performance [91], [33]. Others have tried to convey that increased service variety has no guaranteed impact on firm performance, either in reducing risk or increasing profit [82]. To understand the reasons for divergent results on the impact of service variety, which mainly stems from customization, on firm performance, Carman and Langeard [21] explain that strategic paths that may be suitable for product firms may not be as suitable or as easy to implement for service firms because of some of the innate characteristics services possess. The first characteristic is the intangibility of service offerings, meaning that, unlike products, typical services cannot be touched or stored. The second characteristic is the simultaneous process of the production and consumption of services [21]. Unlike a manufacturing environment, typical service firms cannot separate production from consumption, and consequently, services cannot be stored. Not all service firms exhibit the same level of service characteristics, and types of services which have distinct decoupling points face different levels of intangibility and simultaneity in production and consumption. Consequently, Nayyar [70] argues that different types of customization have differing foci and impacts on a variety-related strategy.

Manufacturers recognize that a trade-off exists between product variety and operations performance [101], mainly due to a cost burden through an increase in the complexity of the production process when variety is increased [34]. However, few studies have empirically addressed how service customization and variety impact service operations and business performance [92]. The majority of service customization related studies are conceptual [114], [66] or focused on particular areas and activities such as service satisfaction [114], customer focus [30], employee adaptiveness [48], service risk [71], marketing [94], [45], [106], customer behaviour [61] and loyalty [11] rather than providing comprehensive implications of service customization and variety on diverse service and business performance. Therefore, we developed the following research questions: 1) how does service customization and/or different decoupling points impact variety, cost and customer service performance? 2) how is the trade-off relationship between customization and cost efficiency mitigated using service modularity? Notably, a significant theoretical and pragmatic gap remains in previous research regarding the potential of service modularity as a strategic tool (e.g., cost reduction) in a mass customization environment [36]. Additionally, practical dilemmas of decision-making regarding the appropriate levels of customization provision and when to invest, considering the cost burden of modularity versus its benefits, still exist. In light of these gaps, the purposes of this study are to:

- employ existing literature to establish the relationships between service customization, variety, modularity and organizational performance;
- determine how different levels of service customization have an impact on variety increases, cost efficiency and customer service performance;
- establish the role of service modularity in mitigating cost burdens against service variety and customization-induced inefficiencies;
- explore the appropriate strategic focus of pure standardization, mass customization and pure customization for better organizational performance

II. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Scholars have interchangeably used the terms 'service customization' and 'service discretion' with 'variety' (see [95]). Variety and customization are related but both conceptually and practically distinct concepts [97]. Duray et al. [32] articulated the difference between variety and customization: "Variety provides choice for customers but not the ability to specify the product". A high variety offering may act as a proxy for customization, but true customization requires customer involvement [63]. As a high level of customization typically leads to high product variety [1], service customization increases discretion at the decoupling point [104]. The service can be differentiated according to the stage in the value chain where customization occurs at the point where customer input is inserted [105]. Thus, we defined service variety as the breadth and depth of different services and diversification offered by a focal firm at any single point in time, while service customization is defined as the degree of customer involvement (i.e., decoupling point) throughout the design to delivery processes. Trade-off relationships between service variety and volume still exist [94], whereas how customization and service variety impact service performance metrics such as cost, quality, time, flexibility and satisfaction is unclear.

Service standardization is known to reduce costs and defects, and improve reliability and productivity [114]. For example, to control, predict and minimize the risks associated with human errors, standardized operating procedures and regulated individual behaviours help provide uniform service conformance [99], [114], [30]. In addition, although significant investment costs related to design, employee training and capital equipment (e.g., technology) are involved in the provision of service standardization, a decrease in failure rate reduces costs and improves reliability and customer waiting time. Service customization is a significant source of differentiation [84], improving customer satisfaction and service flexibility, although higher prices and longer waiting times are expected due to higher customer involvement.

A. *Service customization and variety*

The fundamental, theoretical grounding of this work concerns the resource-based view (RBV) of the firm, which suggests that firms gain and sustain competitive advantage by deploying valuable resources and capabilities [81], such as modularity capabilities and deployment in mass customization offerings. This is also linked to Porter's framework [77] on how firms compete and create value through cost advantages or differentiation. By enlarging its service portfolio, a firm can more efficiently use its underutilized resources and capabilities and thereby benefit from economies of scope [70] to achieve competitive advantages. Also, extending customization with customer involvement and satisfying consumer choice can provide a source of competitive advantage.

Researchers have proposed several standardization-customization classification frameworks across manufacturing sectors [45], [55], [2], [97], [85], [78], [62], [105]. However, the nature of the service customization process is different to the manufacturing process since perishable services are difficult to standardize, and service provision and consumption emerge simultaneously [119], [6]. The most prominent service customization classification was proposed by Silvestro et al. [94], offering three archetypes derived from a volume-variety analysis. These are professional services (i.e. pure customization), mass services (i.e. pure standardization), and service shops (i.e. mass customization). Professional services provide a process of co-creation with customers, while mass production of services results in a standardized service. Professional services are highly or purely customized and process-oriented, with typically long contact times, with most value-added in the front office, where considerable judgment is applied in satisfying customer needs. Mass services have numerous customer transactions, involving limited contact time and little customization applied by the front office staff. Service shops fall between professional and mass services, for example, hotels and banking services. Similarly, Pekkarinen and Ulkuniemi [76] conceptualized different levels of service customization through an empirical modular service platform resulting in standard, mass-customized and tailored categories. McCarthy et al. [66] considered both the time pressure to customize and the level of customization in their service classification and suggested four types of service customization including embellished, prompt, predetermined and intuitive customization.

Modular service architectures, where a service offering contains distinct, self-contained service modules, are rare, but modular approaches have proven suitable for financial, insurance and information technology applications [73]. Few studies have explored service modularity from theoretical perspectives, and most of those employ product modularity adapted for the service sector (see [6], [42]). For example, a service shop operating a mass customization process can consider modular-based services that encourage customers to decide their combination of final service [30] while minimizing the cost increase. Bask et al. [7] also developed a framework relating the degrees of service customization with modularity. They used the decoupling point as a primary differentiating criterion combining service customization and modularity, and suggested four types: 1) non-modular regular that is standard and monolithic (i.e. pure standardization); 2) modular customized providing a large number of options with both standard and customized modules which can be mixed and matched together (i.e. make to order); 3) modular regular in which a customer chooses pre-determined bundles of service or a combination of standardized modules (i.e. make to assemble); 4) non-modular customized in which service is fully customized based on customer needs (i.e. pure customization). Bettiol et al. [9] employed four service types according to a level of service customization, identified as fully customized service, limited customization, modular service and fully standardized service. Also, Ding and Keh [30] simply defined the levels of service customization as standardization, mass customization and customization.

Supplementary Appendix I cross-compares the degree of service customization based on categories from Silvestro [95].

We propose a conceptual framework representing different levels of service customization, variety and their relationships to organizational and business performance (Figure 1). First, service variety acts as a key intermediate variable that theoretically mediates the links between service customization and different organizational service performance. Second, we explore the moderating role of service modularity to enhance service cost performance. Third, we investigate the relationships between service performance and business performance. The relationships and connections between the structural elements depicted in the framework are discussed in detail, followed by the corresponding hypotheses.

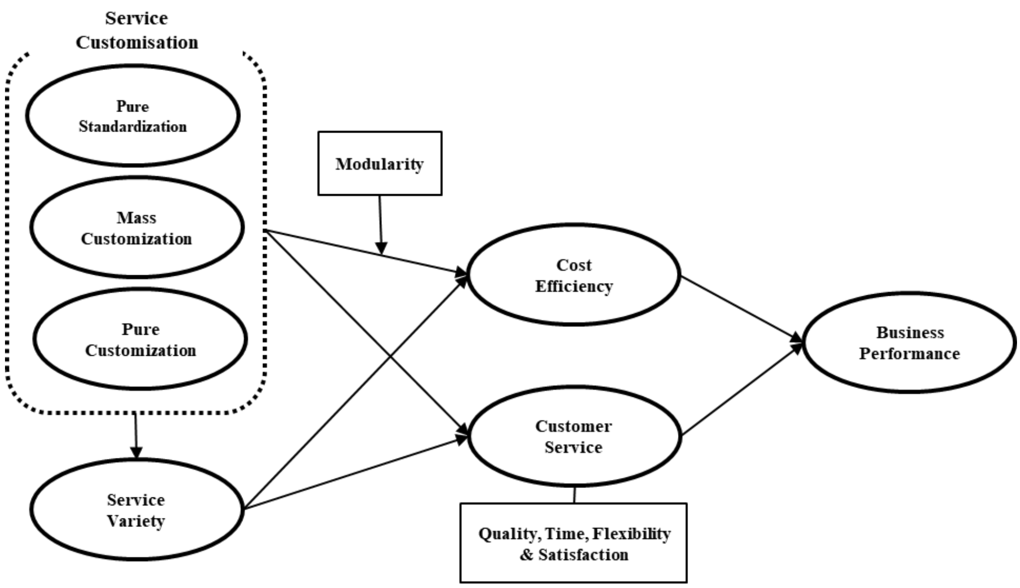

Fig. 1. A research framework

The concept and scope of service variety are different to that of customization. In the manufacturing sector, for example, since variety can be defined as several different offers of a particular class of the same general kind, an increase in product variety can be calculated as the number of stock-keeping units (SKUs) [34], [113]. However, the measurement of service output is less straightforward. Silvestro [95] defined service variety via several characteristics such as contact time, options, discretion, and people or equipment focus. However, although such characteristics can be used to ascertain a variety increase, such approaches are conceptual and insufficient to measure the service variety. MacDuffie et al. [66] defined variety to refer to company choices about the breadth and depth of different product lines using three dimensions: first, fundamental (i.e., different core services); second, intermediate (i.e., different options dependent on core service); and third, peripheral (i.e., particular options and accessories independent of core service). Such an explanation is a reference to an 'internal variety' that is generally regarded as the variance involved in creating the outputs within a firm, which conceptually fits with the nature of service operations.

Thus, this study employed the variety concept proposed by MacDuffie et al. [66] and previous empirical research (e.g., see [104]), from the perspective of manufacturers to service providers to cover both service breadth and depth. 'Core service variety' is the number of core service provisions (i.e., fundamental variety). For example, solicitors (i.e., legal services) provide core services relating to property, divorce, employment, accident claims, tenancy agreements and commerce. Rail transport systems provide passengers with a wide variety of routes between many locations as a core service. 'Core optional service variety' in service is the number of different options dependent on the core service (i.e., intermediate variety). For instance, property or solicitor services can include options such as renting, mortgage provision, investment, shared ownership and auction. A rail transportation system provides different speeds, times, prices and seat types for its destinations. Lastly, 'optional service variety' is several special options and requests independent of the core service (i.e., peripheral). For example, a solicitor can provide no-win no-fee, fixed price, court protection or tax planning services. A rail transport system enables a customer to use extra luggage, meals, and insurance services. If the decoupling point is close to a pure customization level, the customers are often actively involved in the process of defining the service specification, detailing individual requirements with the negotiation of the service specification required as part of the service process [69], leading to an increase in service variety. Thus, we propose the following hypothesis:

Hypothesis 1: The different levels of customization: a) Pure standardization b) Mass customization and c) Pure customization increase the level of service variety differently.

B. Service and business performance

Fitzgerald et al. [38] and Brignall and Ballantine [17] proposed six dimensions of service performance: financial, competitiveness, resource utilization, quality of service, innovation and flexibility. Parasuraman et al. [74] suggested five dimensions for service quality: tangibility, empathy, competence, responsiveness and reliability. These performance metrics focus on individual perceived quality from customers and are widely employed in marketing. Breu et al. [15] highlighted workforce agility variables in service to stress the importance of speed and responsiveness as a flexibility capability. Gaiardelli et al. [41] defined operational level service performance as customer satisfaction, flexibility and productivity. Reliability and responsiveness are suggested as measures of front office activities, while internal lead time, waste, costs and utilization are regarded as being appropriate for back-office activities. Cho et al. [27] extended service performance measurement to service supply chains based on the SCOR model and three metrics: 1) service supply chain operation (i.e., responsiveness, flexibility and reliability); 2) customer service (i.e., tangibles, assurance and empathy); 3) corporate management (i.e., cost, asset and resource utilization). As a simple classification, Jayaram and Xu [53] suggested quality and efficiency as key performance metrics for service operations.

Based on the literature review, we structure service performance from an operations perspective into five dimensions: 1) quality: customer perception of quality, consistency of service, conformance of service standards [53]; 2) time: reliable service time, short response time and service lead time [27]; 3) cost: service cost, productivity [53] and resource utilization [38]; 4) flexibility: response to customer requirements (i.e., specification flexibility), changing needs (i.e., market flexibility), coordination across functional boundaries (i.e. organizational flexibility) [15], [59], service skill (i.e., delivery flexibility) and responsiveness to varying levels of demand (i.e. volume flexibility) [38]; 5) satisfaction: customer loyalty [27], meeting customer expectations and forging close relationships [38].

Professional service organizations typically build long-term and close relationships with individual clients, which enhances the importance of human resource issues such as knowledge-oriented challenges [33] and incur high staff costs [38]. Also, a highly customized process with long contact time incurs a low number of customers processed by a typical unit, which leads to more of a cost burden than mass service (i.e., standardization). Sasser et al. [94] argued that the complex and specialized nature of tasks in customized services, coupled with the limited opportunity for repetitive learning, makes it difficult for such services to set a standard of quality for individual tasks and to control the quality of tasks. However, unlike manufacturing firms employing make-to-order (MTO) or design-to-order (DTO) methods, pure customization has higher marginal costs with comparatively low fixed costs.

In mass service, specifications are determined before the customers participate in the service process [95] and are essentially non-varying with pre-determined service variety similar to make-to-stock (MTS) in the manufacturing environment, which enables relatively short throughput times. Therefore, highly standardized services with limited scope need to manage customer expectations and invest in customer training [68]. Although mass service can be labour-intensive [90], for example, a call centre, it is often equipment-based and offers opportunities for the substitution of service by technology such as an automatic teller machine (ATM), paying at the pump, automotive hotel checkout and internet banking services [30].

Providing consistent process quality is important, and flexibility is less important than in a pure customization environment [95]. Typically, part-time and casual staff can be employed, and level capacity strategies are appropriate with predictable demand, which can lead to a lack of trusting relationships and satisfaction.

A service shop can be regarded as a modular-based service in which a customer decides the combination of service modules required for the final service. Different degrees of service customization exist among service types and even within the same service sector. Mass customization based on modularization and postponement achieves the cost advantages of standardization with the ability to meet diverse demands and quality [37], [35], [118].

Therefore, pure standardization, mass customization and pure customization can impact service performance in terms of cost efficiency, quality, time, flexibility and customer satisfaction differently. Based on RBV, more customized service offerings are associated with higher costs since they require dedicated resources, customer-specific knowledge, longer lead times, process flexibility and the need to adjust the offering continuously to changing needs and situations [71]. To explore the relative impact of customization on service performance based on the previous concepts and studies, we propose the following hypotheses:

Hypothesis 2: Pure standardization focuses more on cost efficiency performance than customer service.

Hypothesis 3: Mass customization focuses on both cost efficiency and customer service performance.

Hypothesis 4: Pure customization focuses more on customer service than cost efficiency performance.

Some business services that are highly customized have different standards when compared to services that are offered with identically similar standards [52]. Similarly, some organizations provide more service offerings and options than others to benefit from economies of scope [70] and reduce market risk [3]. On the other hand, low service variety benefits from economies of scale [22]. As a result of these high levels of service variety and customer involvement found in pure customization environments, it is difficult for clients to ascertain the quality of services prior to purchase and sometimes even after purchase and consumption [95], [29], [110]. Some researchers have argued that an increased variety of service offerings creates an opportunity to enjoy certain benefits that allow for business growth [47], [22]. However, a high provision of service variety brings certain knowledge intensity challenges when expanding a service portfolio [33], and there is a limited opportunity for resources to repeat learning and to transfer and use tacit knowledge gained over time into new tasks [120]. This is mainly derived from the differing, complex demands of clients and the limited opportunities for repetitive learning leading to consistent control of a standard of quality for individual needs [88], [111], [54], particularly in high customization environments. Increasing the number of services offered can intensify the complexity of controlling the quality of service provision [53]. In many cases, flexibility-enhancing initiatives have been adopted to support organizations implementing customer-centric strategies to satisfy their high-variety ambitions [104]. Further, the impact of variety (i.e., number of service offerings) on service performance is distinct from the effect of customization level (i.e., degree of customer involvement) on service performance. For example, some hotel mass services can provide more standardized service variety than others that provide service variety using the same or a different level of customization. Thus, considering high variety stemming from customization [1], [69] and variety impact on organizational performance [33], [93], we regarded variety as a core explanatory construct to link customization and service performance. Since variety has a positive relationship with customer service [116], [93] and a negative impact on cost [91], [33], service variety can improve customer service performance, such as quality, flexibility, time and satisfaction, while the service variety relationships with cost are not expected to be positive in a similar manner as would be expected to occur in a manufacturing environment. To explore these exploratory relationships in service environments, considering the potential tradeoff relationship between cost efficiency and customer service, we propose the following hypotheses:

Hypothesis 5: A service variety increase impacts an organization's service performance differently: a) a service variety increase impacts negatively on cost efficiency performance; b) a service variety increase impacts positively on customer service performance.

Hypothesis 6: The relationship between different levels of customization and customer service is mediated by service variety.

Service performance can be treated as an intermediate performance outcome to improve customer loyalty, while financial performance is viewed as the business performance outcome [109] to be competitive in the market. Improved service performance, such as in terms of quality, short lead time, customer satisfaction, flexibility and efficiency, is positively related to better business performance [117], [99]. Customer loyalty and re-purchase intention as a result of better customer service performance enable the company to charge a premium price [77], which can also boost business performance. Return on sales (ROS), return on assets (ROA), market share growth and sales growth (see [109], [83], [87], [105]) are four dimensions of business performance that capture a variety of financial and market outcomes [13].

Castaldi and Giarratana [22] argued that when service providers increase their service offerings, they are able to cater to a wider range of clients, which leads to better financial performance. However, Eckardt and Skaggs [33] concluded that service variety negatively impacts a firm's revenue growth, although several pieces of research support the positive impact of service diversification and innovation on firm performance (see [25]). Some researchers have even tried to convey that increased service variety has no guaranteed impact on firm performance, either in reducing the risk or increasing profit (see [82]). To examine the impact of variety and customization on business performance through service performance, the following hypothesis is proposed:

Hypothesis 7: Increased service a) cost efficiency and b) customer service performance lead to better business performance.

C. Service modularity

Voss and Hsuan [112] defined modularity as "a system built of components, where the structure of the system, the functions of the components (i.e. modules), and relations (i.e. interface) of the components can be described so that the system is replicable, the components are replaceable, and the system is manageable". Another definition of a service module is "a system of components that offers a well-defined functionality via a precisely described interface and with which a modular service is composed, tailored, customized and personalized" [102]. Similarly, a service modularity process can be defined as the design of a new service that combines different service modules and components through an interface [76]. An interface can be described in modular service as a set of rules and guidelines governing the flexible arrangement, interconnections and interdependence of service components [10]. A combination of modules that may have several small components can be a final service. For example, a flight company offers purchasing tickets as a core service as well as insurance options, car rental reservations, and hotel booking at the point customers book the flight. Each module can be customized as the smallest components within each module, such as different classes of seats, luggage options or options for insurance coverage (i.e., components). Cheng and Shiu [26] provided details of examples in different service sectors, including information, financial, tourism, technical and retailing services. For example, mobile phone services from different providers can be regarded as a service module, while different contracts and internet-based shopping from different stores can be provided through a mobile app as service components. In this case, the mobile phone operating system can be an interface. Thus, the service module can be seen as one or more service components [19]. Logistics and supply chain services can be composed of service modules such as transportation and warehousing, while different transportation modes, insurance, and delivery speed options can be regarded as examples of service components (see [80]).

To conceptualise modularity, Pekkarinen and Ulkuniemi [76] suggested service, process and organization as three elements of modularity. Based on this classification, Rahikka et al. [79] employed three service elements, including modularity in service, modularity in processes, and modularity in an organization to explain service modularity. Modularity in service can be defined as the usage and development of services that can be combined [6], and modularity enables the breakdown of the offerings into standard sub-offerings and customized sub-offerings [103], which are components (i.e., service areas exposed to the customer). For example, in business-to-customer (B2C) delivery services, warehousing could be regarded as one type of service module, and the required storage conditions and space in the warehouse could be regarded as the service components. Process modularity is defined as the indivisible service process steps that are essential to make a service module or offer available to the customer (i.e., intra-organizational processes). Thus, process modules are standardized as indivisible process steps, for instance, sending and receiving orders through standardized IT, transport and quality assurance processes [6]. These concepts of modularity have been closely related to mass customization strategies and employed in service shops [7], [8], [15] rather than professional or mass services.

The benefits of modular service are cost reduction, enabling customization, facilitating innovation, allowing faster development and implementation, increasing quality performance, and structuring of innovation [31] as well as an increase in service quality, flexibility, redesign and reusability, standardization of service and simplification of complex service systems [76], [58], [7], [13], [59], [10], [20]. Also, modularity can achieve flexibility and agility in the process, which results in improvements in efficiency and customer service [89], [8], [104]. In this study, service modularity is regarded as a valuable, rare and inimitable resource (i.e., RBV) to minimize operations costs [79] for customization to achieve an efficiency-related competitive advantage, as well as an organizational capability that integrates several underlying resources, including modular service architectures, configurations and standardized interfaces [10]. Due to a decrease in service complexity through a postponement approach, modularity achieves better responsiveness to service variety [76], which can support a cost-efficient process. Modularity, in particular, is suitable for mass customized services rather than purely standardized or customized services. Silvestro and Lustrato [96] stressed that the key enabler of mass customization is modularity, and used the term ‘mid-office’ to explain the role of mass customization as an enabler of service modularity. It has been stressed that modularity can be used to increase responsiveness and functional flexibility [6], [102], which ultimately reduces the cost burden from service variety and customization. Modular design as a mass customization management strategy mitigates the cost burden, such as the unit cost of the service, engineering design or change cost, manufacturing process cost, set-up cost, direct labour cost, material cost, overhead cost, process technology investment cost, purchasing cost, inventory cost, material handling cost and transportation cost incurred by variety [63]. In this study, the role of modularization in a mass customization environment is regarded as a mitigating tool to make service production more efficient when a firm increases service customization. Thus, the following hypothesis is proposed:

Hypothesis 8: Service modularity enhances the impact of mass customization on service cost efficiency performance.

III. METHODOLOGY

A. Samples and data collection

The study employed a survey to collect data from service providers in the UK and the United Arab Emirates (UAE). A pilot test, conducted with staff from three service firms, ensured that the questions were clear and unambiguous. Using a UAE database and expert panels in the UK, the final questionnaire was distributed via an online survey platform in the UK and through email and face-to-face meetings in the UAE. After excluding 31 incomplete or inappropriate responses, 692 completed questionnaires were obtained (207 from the UK and 485 from the UAE), representing a 48% response rate. This sample provides sufficient statistical power to investigate even minor relationships among constructs [40] and moderating effects at 0.9 power with $\alpha = 0.01$ [100], [107]. Respondents included CEOs (10.4%), directors (20.4%), managers (49.6%), staff (4.1%), and others (15.5%), while 64.9% of the firms were SMEs and 35.1% were large enterprises ($n > 250$ employees). Supplementary Appendix II categorizes the respondent firms by service sector, using fourteen industries based on the UK Standard Industrial Classification (SIC) code, excluding sectors offering physical products as part of their core service.

T-tests following Armstrong and Overton [4] showed no significant differences between early and late respondents ($p > 0.05$), indicating minimal response bias. Common method variance was not a major concern, as Harman's one-factor test identified eleven factors (eigenvalues > 1) explaining 43.4% of variance, with the largest factor accounting for 9.87%, and the marker variable approach following Lindell and Whitney [60] found all correlations < 0.6 (vs. $r > 0.9$ threshold).

Multi-group CFA across countries [24], using ordinal SEM [12], supported measurement invariance with similar fit indices for baseline (RMSEA = 0.033, SRMR = 0.058, CFI = 0.901) and constrained models (RMSEA = 0.033, SRMR = 0.059, CFI = 0.900) [67]. Invariance was also confirmed across roles, with baseline (RMSEA = 0.032, SRMR = 0.073, CFI = 0.901) and constrained models (RMSEA = 0.032, SRMR = 0.073, CFI = 0.899), indicating model stability.

B. Measurement development

All measurement items were adapted from peer-reviewed studies. Customization was classified into pure standardization (PS), mass customization (MC), and pure customization (PC) [95], [8], [30] and measured on five-point Likert scales (1 = strongly disagree, 5 = strongly agree). Variety was assessed along fundamental, intermediate, and peripheral dimensions [64], with practical examples provided to support respondents' understanding based on industy average (1 = lowest and 5 = highest). Service modularity included nine items covering modular service offerings and process modularity [76], [26], [79] including decomposition of final service, decomposition of modules, changeability in components, reusability of components, number of components, and service process modularity, including decomposition of the final service processes, decomposition of process modules, modular process options, and standardized process. Customer service was modeled as a second order construct with four first order factors such as quality, time, flexibility, and service satisfaction [18], [49], showing strong factor loadings (0.798 - 0.951) and good fit indices (SRMR = 0.030, RMSEA = 0.039, GFI = 0.963, CFI = 0.978). Service and business performance were measured using five-point Likert scales. All items were adapted from prior literature: PS [90], [69], [95], [7]; MC [7]; PC [69], [95], [76], [7]; service quality [53]; time [25]; cost [53]; flexibility [16], [57]; satisfaction [38], [27]; business performance [109], [83].

C. Measurement validation

To determine composite reliability (CR) and convergent and discriminant validity, we conducted confirmatory factor analysis (CFA) rather than exploratory factor analysis (EFA), based on theoretical links between items and constructs, enabling SEM to test both the model and hypotheses [115]. SEM in AMOS 25 examined overall model fit, while moderation was analyzed via PROCESS [49] to explore conditional effects (i.e., low, medium and high), and mediation was tested using bootstrapping approach for the accuracy of the sample estimate in AMOS 25.

All 53 items with loadings above 0.6 were retained, including a pure standardization item with the lowest loading (>0.618). The measurement model showed acceptable fit ($\chi^2/df = 2.10$, GFI = 0.877, SRMR = 0.038, RMSEA = 0.040, CFI = 0.921). Composite reliability (CR) indicated good internal consistency (>0.759), and convergent validity was supported with high factor loadings (>0.6) and acceptable AVEs (>0.4), including mass customization (AVE = 0.482, CR = 0.865) [see 39]. Content and criterion validity were ensured using items from prior studies [8], [9], and discriminant validity was confirmed following Fornell and Larcker [39] since there was no case where the square of the correlation between a pair of constructs was greater than the AVE of the constructs (see Supplementary Appendix III). Table I presents the factor loadings, composite reliability (CR), and average variance extracted (AVE), with the fit indices.

TABLE I. CONFIRMATORY FACTOR ANALYSIS

Structure	Code	Abbreviated item statement	FL	CR	AVE
Pure Standardization	PS1	We provide standard services that have pre-determined designs in order to reach many customers	.720	.880	.513
	PS2	We provide service specifications that are determined prior to the customer's participation in the service process	.736		
	PS3	Specifications are built into the service design rather than being individually negotiated with each customer during the service process	.746		
	PS4	We have a low level of interaction between staff and the customer during the service provision	.711		
	PS5	The service process does not vary and is often provided by equipment or technology	.711		
	PS6	We have casual and/or part-time staff rather than full-time experts in order to provide the standardized service	.691		

	PS7	We use the 'Buy from Store' concept: i.e., the customer can only choose from a few integrated service options.	.757		
	PS8	Customer involvement is often limited in the service provision	.681		
Mass Customization	MC1	Customers can choose a suitable mixture of different service alternatives	.732	.865	.482
	MC2	Customers decide their combination of service alternatives in the final service	.668		
	MC3	We can provide flexible service options in which customers can choose a suitable combination of different alternatives.	.626		
	MC4	We provide various pre-defined standardized bundles of services for the customer to choose from	.651		
	MC5	We can provide both pre-determined alternatives and customized services that can be mixed and matched together to meet individual customer needs	.628		
	MC6	The customization can start from the early stages of the service production process	.679		
	MC7	The final assembly can be postponed close to the customer interface and involvement point.	.631		
	MC8	We use 'Buy to Order' and/or 'Buy to Configure' concepts: i.e., customers can be involved in the early stages of the service production plan with both standard and customized options.	.641		
Pure Customization	PC1	Services are fully specified according to customer needs	.757	.888	.502
	PC2	We provide a unique service design in which customer input is at the start of the service design process	.763		
	PC3	Customers often actively participate in the process of defining the service specification	.665		
	PC4	Customers often actively participate in the process of detailing individual requirements	.646		
	PC5	We are keen to build long-term relationships with individual customers for the provision of purely customized services	.618		
	PC6	We have professional and highly skilled staff to provide a tailored service for individual customers	.655		
	PC7	We use the' Buy from Tailor' concept: i.e., customer involvement extends to the design stages of the service process.	.642		
	PC8	Customer involvement is unlimited	.660		
Cost Efficiency	CE1	Ability to minimise service delivery cost	.739	.825	.542
	CE2	Ability to improve productivity	.781		
	CE3	Ability to improve resource utilization	.716		
	CE4	Ability to minimise final service cost	.687		
Customer Service (Quality)	SQ1	Ability to improve customer perception of quality	.717	.846	.507
	SQ2	Ability to provide consistency of service	.751		
	SQ3	Ability to provide conformance of service	.747		
	SQ4	Ability to provide better service relative to customer expectations	.731		
Customer Service (Time)	ST1	Ability to provide reliable service time	.717	.838	.566
	ST2	Ability to provide short response time	.727		
	ST3	Ability to provide short service lead time	.799		
	ST4	Ability to provide short service development time	.711		
Customer Service (Flexibility)	SF1	Ability to provide service customization	.694	.864	.515
	SF2	Responsiveness to the changing needs of customers	.724		
	SF3	Effectiveness of coordination across functional boundaries	.660		
	SF4	Speed of acquiring the skills necessary for customers	.693		
	SF5	Speed of applying new management and service skills	.744		
	SF6	Responsiveness in an organization to varying levels of demand	.708		
Customer Service (Service Satisfaction)	SS1	Customer fulfilment and loyalty	.751	.833	.556
	SS2	Meeting customer expectations overall	.697		
	SS3	Trustful relationship between customer and organization	.745		
	SS4	Customer complaints reduction	.707		
Business Performance (BP)	BP1	Return on sales (ROS)	.678	.806	.511
	BP2	Return on assets (ROA)	.722		
	BP3	Market share growth	.635		
	BP4	Sales growth	.734		
Service Variety (SV)	SV1	Number of different core service provisions by your company	.731	.759	.512
	SV2	Number of different options that are dependent on the core service provisions by your company	.744		
	SV3	Number of special options and requests (i.e. independent of the core service) from customers	.651		

Composite Reliability (CR) = $(\sum \text{standardized loading})^2 / \{(\sum \text{standardized loading})^2 + \sum \varepsilon_i\}$
Average variance extracted (AVE) = $\sum(\text{standardized loading})^2 / (\sum(\text{standardized loading})^2 + \sum \varepsilon_i)$
Note: Fit indices: χ^2/df (chi square) = 2661/1266 = 2.10, GFI (goodness of fit index) = 0.877, SRMR (standardized root mean square residual) = 0.038, RMSEA (root mean squared error of approximation) = 0.040, CFI (comparative fit index) = 0.921

IV. RESULTS

A. SEM analysis

First, the study conducted path analysis using SEM with bootstrapping to examine relationships among ten constructs and mediation effects. First, a separate SEM analysis assessed the impact of service customization and variety on service and business performance. Most model paths were significant ($t \geq 4.126$, $p < 0.05$), except PS-SV, PC-CS, PC-CE, and SV-CE. Model fit indices indicated acceptable fit (GFI = 0.861, CFI = 0.913, RMSEA = 0.042, SRMR = 0.064). As shown in Table II, the results support H1 (except H1a), H2, H3, H4, H5 (except H5a), and H7.

Second, mediation analysis shows that H6 is supported, with stronger direct effects of customization on customer service performance than indirect effects via service variety. PS–CS, MC–CS, and PC–CS relationships exhibit significant indirect effects ($p < 0.05$). For instance, the direct effect of MC on CS (0.305) exceeds the indirect effect through service variety (0.088 = 0.306 × 0.288). Overall, direct effects dominate on customer service performance, and service variety does not significantly mediate cost performance across customization levels.

TABLE II STRUCTURAL EQUATION MODEL (SEM)

Construct (Model)	Path Coefficient	t-value	Significance	Indirect Effect	Total Effect	H Acceptance
PS-SV	-.075	-1.469	.142	-	-0.75	H1a (R)
MC-SV	.306***	5.035	.000	-	.306	H1b (A)
PC-SV	.323***	6.076	.000	-	.323	H1c (A)
PS-CE	.405***	8.262	.000	.003	.408	H2 (A)
PS-CS	.033	0.714	.475	-.022**	.011	
MC-CE	.207***	4.126	.000	-.013	.194	H3 (A)
MC-CS	.305***	5.064	.000	.088***	.393	

PC-CE	-.022	-0.526	.599	.-.014	-.036	H4 (A)
PC-CS	.292***	5.496	.000	.093***	.385	
SV-CE	-.043	-0.992	.321	-	-.043	H5a (R)
SV-CS	.288***	5.236	.000	-	.288	H5b (A)
CE-BP	.212***	5.391	.000	-	.212	H7a (A)
CS-BP	.770***	10.435	.000	-	.770	H7b (A)

Ch-sq/df = 2808/1277 = 2.20, SRMR = 0.064, RMSEA = 0.042, GFI = 0.861, CFI=0.913
Total effect PS-BP (0.095^{+}), MC-BP (0.344**), PC-BP (0.289**)
$^{+}$ represents significant at the 0.1 level, * 0.05 level, ** 0.01 level, and *** 0.001 level
Note. Bootstrapping 1,000 times in SEM

B. Moderation effect of modularity

The study took account of moderation effects using ‘Model 1’ in PROCESS, proposed by Hayes [49], to explore whether the relationship between mass customization and cost performance is contingent on service modularity (i.e., H8). Following Baron and Kenny [5], moderation is supported when the interaction term is significant. Thus, we used a bootstrap analysis on 10,000 resamples, from which a bias-corrected 95 percentile confidence interval (CI) was estimated. Relationships are significant if CIs exclude the 0 between the upper limit confidence interval (ULCI) and the lower limit confidence interval (LLCI) [49], [23]. Also, modularity as a moderating variable indicates the acceptable factor loadings (> 0.671) that ensure structural reliability.

Results indicate that service modularity significantly moderates the relationship between mass customization and cost efficiency (interaction $\beta = 0.170$, $p = 0.020$). Conditional effects are also significant depending on the level of usage of modularity ($p < 001$). In particular, the coefficients of low (0.319), medium (0.418) and high clusters (0.516) indicate that the strength of the moderation effect increases when a firm adopts service modularity more intensively. Therefore, the result from the conditional effect analysis responses to ‘when’ questions, that is, cost efficiency, is improved when the company employs a more modular approach in a mass customization environment. Also, the moderation effect answers the ‘how’ questions regarding the strength of the impact of mass customization on cost performance. Therefore, H8 is supported. Table III summarizes the results of the moderation model together with their path coefficients, significance levels and conditional effects.

TABLE III MODERATION EFFECT OF MODULARITY

SM Moderation / Conditional Effect	Path coefficient	*t*-value	Significance	LLCI	ULCI
MC * SM – CE	0.170**	3.102	0.020	.063	.278
3.132 (Low SM)	0.319***	6.042	0.000	.215	.423
3.710 (Middle SM)	0.418***	9.656	0.000	.333	.502
4.289 (High SM)	0.516***	9.434	0.000	.409	.623

Note: Bootstrap resample = 10,000.
Low (mean minus one standard deviation) / Middle (mean) / High (mean plus one standard deviation) at 95% CI
* represents significant at the 0.05 level, ** 0.01 level, and *** 0.001 level

V. DISCUSSION AND IMPLICATIONS

A. Major findings

The survey reveals how service customization and variety affect service and business performance and exposes the role of service modularity in efficient service provision. First, differing levels of customization and service variety impact service performance differently. Comparing the effects, pure standardization shows the strongest influence on cost efficiency, followed by mass customization, while mass customization (i.e., β = 305) improves customer service the most, followed by pure customization (i.e., β = 292). Regarding the relationships between pure standardization and service performance, the findings reveal that a pure standardized service improves cost efficiency (β = 0.405) rather than customer service. An increase in standardization enhances cost reduction and service lead time while reducing service flexibility. This is a parallel outcome to standardization in manufacturing environments. In mass customization environments employing a hybrid strategy, the impacts are all positive and significant as noted by Feitzinger and Lee [37] and Ezzat et al. [35], and particularly higher concerning customer service (β = 0.305), followed by cost efficiency (β = 0.207), which reveals that a hybrid strategy is more effective for customer service than cost efficiency in the service environment. Mass customization still facilitates a low service unit cost, leading to short throughput time and cost efficiency [95]. A pure customization environment demonstrated a focus on customer service ($\beta = 0.292$) rather than cost efficiency, similar to the findings made by Sasser et al. [88] and Fitzgerald et al. [38]. These results are similar to outcomes proposed in both manufacturing (see [98]) and service environments (see [95]). Comparing impact, notably, the tradeoff relationships between cost efficiency and customer service were observed since cost efficiency decreases with an increase in customer service when customization increases.

Regarding service variety, we found the impact on customer service ($\beta = 0.288$) is significant, while service variety itself does not influence cost efficiency significantly. The result implies that a higher level of customer involvement can incur a cost burden. Similar to manufacturing environments (see [34]), the results of variety impacts on customer service, including quality, flexibility and satisfaction, are consistent with the findings of earlier research (i.e., [70], [95], [71], [114]). Regarding the SEM structural directions, potential reverse causality (e.g., firms with high customer service performance adopting more variety) is excluded based on the established theory and prior empirical findings (see [70], [22], [47], [116], [93], [104]). In addition, RBV and Porter's framework highlight that the deployment of valuable resources and capabilities (i.e., customization and variety offering) leads to a competitive advantage (i.e., cost efficiency and customer service).

Second, cost performance (i.e., cost reduction) in a mass customization environment is dependent on the level of service modularity (i.e., moderating effect). The role of service modularity was demonstrated to be positive in strengthening the relationship between mass customization and cost efficiency [95], [7], [96] as a mitigating tool, similar to the benefits of product modularity. When the usage of service modularity is greater (i.e., low to high), the modular approach more significantly moderates the effect of mass customization on cost performance. High deployment of service modularity (β = 0.516) more strongly enhances the relationship between mass customization and cost efficiency than the low service modularity condition (β = 0.319). Thus, a trade-off relationship between customization and cost performance can be mitigated when the use of modularity increases. Since the benefit of modularity is higher in mass customization environments, as suggested by Bask et al. [8] and Silvestro and Lustrato [96], we conclude that when the usage of service modularity is intensive in the service shop, the cost benefits of service modularity increase significantly as seen in manufacturing environments (i.e., RBV).

Third, the results demonstrated the impact of different customization levels on service variety as well as the mediation effects of variety between service customization and customer service performance. Service variety derived from customization mainly depends on the level of customer involvement, as supported by Murdick et al. [69]. Pure standardization does not significantly guarantee an increase in service provision. Consistent results in service types [95] as in manufacturing environments [98] reveal that the higher the service customization, the more service product variety exists. Also, the findings reveal that variety is a core mediating mechanism to explain the link between customization and customer service performance, considering the impact of variety on customer service (β = .288), although customer service performance is more dependent on levels of customization (β = .305 and .292) rather than variety offerings. Thus, the findings reveal that the significance of the customer involvement level (e.g., MTS, MTO and DTO) and related service processes influences customer service performance through variety.

Last, regarding the relationships between service performance and business performance, better customer service (β = 0.770) effectively improves business performance. Thus, the expansion of a service portfolio, especially in a high customization environment, can be a financial benefit by enhancing and meeting customer service. Business performance in the service sector is still highly dependent on cost efficiency, particularly in pure standardization environments with low customer interaction and a cost efficiency focus [95], [108]. However, expansion of an existing variety beyond a core service may not guarantee financial improvement (see [42]), and firms should consider operational challenges and their capabilities to effectively implement a modular approach. Also, through contextualizing knowledge, tailored providers in higher customization environments gain a competitive advantage from service expansion [47]; hence, the focus should be on better customer service.

B. Theoretical research implications

There are several implications which help address an important gap in the literature as well as provide an extension to the traditional perspective on the resource-based view. First, we enrich the theoretical understanding of service customization and variety by defining them as distinct concepts and developing structures with key conceptual items [76]. This is one of a few studies to explain the effects and implications of increasing service customization, variety and modularity. We identified specific boundary conditions under which mass customization achieves a superior balance and better customer service than pure customization, as well as revealing that the customization versus cost trade-off applies equally in a service environment. In particular, the finding refines existing theory by explaining how mass customization outperforms a pure customization strategy through the use of service modularity. The results also confirm the role of service modularity in handling emerging service customization practices [87]. Notably, the concept of service modularity is extended through the use of nine variables concerning a modular service offering [76], and through the use of service process modularity [79] as a mitigating strategy for better cost-efficiency. Second, this study contributes to the understanding of the structural relations amongst service customization, variety, modularity and performance. The mediation effect of service variety and the moderating effect of service modularity suggest clear theoretical paths to achieve better service and business performance [89], [104]. Third, from an engineering perspective, the study clarifies the key role of service modularity in evaluating its connections to mass customization and cost efficiency. Service modularity is proven as an appropriate mitigating tool when an organization increases service customization without incurring a significant cost burden in a mass customization environment [7]. The service decoupling point rather than variety is found to be a key factor that impacts customer service, while the drawbacks of mass customization, such as the cost of customer involvement, can be managed by a service modularity approach. Since service has simultaneous production and consumption processes [21], customer heterogeneity [119] with knowledge intensity challenges [33], service modularity or an enhanced value co-creation structure, and knowledge are required to mitigate the risk of cost burdens. Thus, the findings bridge the existing gaps in the literature and offer an improved understanding of the service-specific logic of modularity.

We stretched the RBV perspective by explaining how a service modularity approach in customization facilitates a postponement strategy by delaying the commitment of resources, which, in parallel, mitigates the cost burden. Also, by conceptualizing service modularity as a key resource as well as an organizational capability, the study extends RBV by specifying how service-specific architectures generate sustained competitive advantage [77]. Service modularity is valuable because it allows firms to balance efficiency and customer service, rare because it requires firm-specific design of service architectures and interfaces for decomposition, and difficult to imitate due to its intangibility, and the knowledge embedded in the necessary human interaction.

C. Managerial research implications

The results have managerial implications for service operations and marketing practitioners in tackling service customization and the challenges posed by variety. First, the findings offer guidance on how to improve service performance by understanding the applied role of service customization, variety and modularity. In particular, the selected levels and approaches to customization and variety offerings are critical decision processes in improving service performance that can have a tradeoff relationship, while the mass customization approach allows for better improvement of both cost and customer service performance. Our framework identified how to improve service and business performance in different customization environments and service variety offerings. Second, based on the empirical research results, we demonstrate how and when service modularity enhances cost efficiency under mass customization conditions. The more intensive use of modularity strengthens the opportunity for cost reductions in mass customization environments by mitigating costs against customization-induced inefficiencies, although high levels of human involvement and knowledge intensity may erode the efficiency gains associated with modularity.

Third, the mediating effect of service variety highlights the pivotal role of the decoupling point rather than the total number of diversifications offered or chosen by the company to enhance customer service performance. Also, an increase in service variety does not show a negative relationship with cost efficiency, instead, the higher the level of customization, the lower the cost efficiency benefits. Thus, customer involvement in practice is a critical impact factor on both cost efficiency and customer service performance in the service industry. Also, understanding the relationships among variables offers guidance for engineering managers planning to change their customization or service variety levels based on their strategic focus.

In particular, service modularity is demonstrated to be a potential solution to balance the goals of both customization and standardization by mminimizing the cost burden in this study, which encourages managers to consider the service modularity approach. However, service modularity under a mass customization environment faces operational challenges due to the distinctive nature of the service environment. For example, services are usually more heterogeneous than products and involve varying degrees of human involvement [119], which can be physical or heavily IT-based (e.g., online shopping and information services). Alongside infrastructural investment and knowledge intensity, the capability of human resources to identify service components (i.e., service architecture), configure (i.e., combine components), and provide interfaces (i.e., develop standardized functions) is required for modular service offerings [28]. Also, a modular service platform and standardized processes should be supported to take advantage of service modularity [10], [13]. Thus, engineering managers should not only address the challenge of adopting service modularity strategies but also devote attention to the appropriate process modularity to support the potential value of service modularity.

From a supply chain perspective, a modular service makes integration and disintegration of new potential business components possible by outsourcing modular sub-systems to external suppliers, so that new suppliers, business associates, technology partners or software modules can be removed or plugged in easily through various sourcing options [52]. Thus, although modularity demonstrated sufficient benefits to mitigate the trade-off between cost efficiency and variety expansion, the managerial challenges, such as the decomposition of a module and the changeability of components in the supply chain, should be carefully addressed before diffusing the modular approach.

D. Limitations and future research

The study has several limitations. First, although a large sample was used to enhance generalisability and statistical power, the sample distribution across the two countries may not be equivalent despite bias tests. In addition, the use of cross-sectional data limits causal inference, and reverse causality cannot be ruled out. Thus, future research should adopt longitudinal or experimental designs.

Second, data were consolidated across service sectors for generalisation and simplicity, but results may vary by sector or specific levels of service customization. Third, service modularity was examined within a mass customization context. However, its role in pure standardization and pure customization environments warrants further investigation, potentially through qualitative studies. Finally, measuring service variety in a survey using conceptual criteria across diverse sectors presents limitations, suggesting the need for case-based studies with more practical measurement approaches.

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SUPPLEMENTARY APPENDIX I. DEGREE OF SERVICE CUSTOMIZATION

Silvestro [95]	Pekkarinen and Ulkuniemi [76]	McCarthy et al. [66]	Bask et al. [7]	Bettiol et al. [9]	Ding and Keh [30]
Mass service	Standard	Embellished customization	Non-modular regular	Fully standardized	Standardization
Service shop	Mass customized	Prompt customization Predetermined customization	Modular regular Modular customized	Limited customization Modular service	Mass customization
Professional service	Tailored	Intuitive customization	Non-modular customized	Fully customized	Customization

SUPPLEMENTARY APPENDIX II. SURVEY RESPONDENTS

Manufacturing industry type	Total	Valid %
Hotel, Rooming or Accommodation	92	13.3
Personal service (e.g. cleaning, beauty, funeral)	40	5.8
Business service (e.g. advertising, computing, engineering)	85	12.3
Repair service	37	5.3
Health service	61	8.8
Legal service	39	5.6
Education service	60	8.7
Social/Public service (e.g. job training, childcare)	21	3.0
Publishing, Communication and Art	27	3.9
Energy/Water/Estate agent service (e.g. electricity)	29	4.2
Postal/Courier service	12	1.7
Transportation / Warehouse service	45	6.5
Insurance/Financial service	37	5.3
Administrative/Supporting service (e.g. employment)	35	5.1
Other	72	10.4
Total	692	100 %

SUPPLEMENTARY APPENDIX III. INTER-CONSTRUCT CORRELATION AND DISCRIMINANT VALIDITY

	PS	MC	PC	SQ	ST	SC	SF	SS	BP	SV
PS	.513 +									
MC	.443**	.482 +								
PC	.156**	.354**	.502 +							
SQ	.358**	.443**	.266**	.507 +						
ST	416**	.394**	.175**	.690**	.566 +					
CE	.519**	.428**	080*	.589**	.709**	.542 +				
SF	.112**	.355**	.440**	.474**	.409**	.327**	.515 +			
SS	.104**	.324**	.388**	.456**	.361**	.262**	.706**	.556 +		
BP	.311**	.375**	.338**	.515**	.452**	.406**	.620**	.599**	.511 +	
SV	.119**	.311**	.347**	.289**	.184**	.075*	.321**	.418**	.318**	.512 +
Mean	3.35	3.52	3.76	3.68	3.56	3.51	3.67	3.73	3.61	3.48

+ =Average variance extracted, * represents significant at the 0.05 level and ** 0.01 level.