Testing complexity theory in service research

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Abstract

Purpose – This study aims to draw on the complexity theory and uses a non-an asymmetrical method – fuzzy-set qualitative comparative analysis (fsQCA) to test the core tenets of complexity theory, namely, asymmetry, equifinality and causal complexity and valence reversals or conjunction with a focus on testing the relationships between service quality, customer satisfaction and loyalty. Case outcome forecasting accuracy rather than relationships are tested in asymmetric testing.

Design/methodology/approach – Both symmetrical (structural equation modelling or SEM) and non-symmetrical (fsQCA) methods were used to test the proposed relationships (symmetrical testing) and case outcome forecasting accuracy (asymmetric testing). The former was used as a comparison. The study setting was in Australian airports. The data were collected from departure passengers.

Findings – The results from SEM and fsQCA differ substantially. The former provides very simplistic findings of variable directional relationships; whereas the latter presents asymmetrical, equifinal and conjunctural relationships regarding service quality, customer satisfaction and behavioural intentions. These findings support the core tenets of the complexity theory.

Research limitations/implications – The study findings conform to the complexity theory that indicates relationships between variables can be nonlinear and the same causes can produce different effects. The findings suggest the outcomes of interest often result from combined antecedent conditions rather than a single causal factor. The study confirms that asymmetrical thinking relies on Boolean algebra and set theory principles.

Originality/value – This study uses both symmetrical and asymmetrical methods to reveal the nuanced information about the relationship that has been tested primarily using symmetrical methods.

Keywords Services marketing, Customer service, Service quality, Behavioural intentions, Airline industry, Service delivery, Complexity theory, FsQCA

Paper type Research paper

Introduction

Recently a few scholars (Hubbard, 2015; Woodside, 2013, 2016a, 2016b, 2018a, 2018b) have been advocating for banning null hypothesis significance testing (NHST) and reassessing reliability of symmetric testing methods such as multiple regression analysis (MRA) and structural equation modelling (SEM) (hereafter using symmetrical testing), which are the current dominant logic in social science research. Among those, Woodside (2013, 2016a, 2016b, 2017, 2018a, 2018b) has been a strenuous protagonist in this journey by publishing articles, conference papers and editorials with uncompromising comments and critics against NHST and symmetric testing. Hubbard (2015) refers to this testing as “corrupt research”. Others (Trafimow and Marks, 2015; Ziliak and McCloskey, 2008) indicate that such research is invalid for useful crafting theory and testing of empirical findings or for building a cumulative body of knowledge. This observation also applies to “meta-analyses” using symmetric tests of effect sizes as measures of cumulative knowledge (Woodside, 2018a, 2018b).

The journal of Basic and Applied Social Psychology (BASP) 2014 Editorial clearly states that the null hypothesis

significance testing procedure (NHSTP) is invalid (Trafimow, 2014). Refuting the null hypotheses in NHST does not inform the reader about the usefulness/accuracy of a model in predicting a specific outcome of interest. Most scholarly behavioural and management research using the dominant logic of symmetric tests currently mismatches theory (case-focussed) and analysis (variable-focussed) (Fiss, 2007). The rationale for reassessing symmetric tests is that such testing is too simplistic of an approach to the rich tapestry inside most data files (Woodside, 2016a, 2016b). While parsimony is a worthy objective in data analysis, nearly all symmetric tests appearing in articles of social science journals are overly simplistic. “Science seeks parsimony, not simplicity: searching for a pattern in phenomena,” stated in Simon (2001, p. 51). The issues and problems with symmetric tests and NHST are documented in a series of studies (De Villiers and Woodside, 2018; Hsiao *et al.*, 2015; Woodside, 2016a, 2016b, 2018a, 2018b) and summarised as follows.

Symmetrical testing (MRA/SEM) focusses on estimating the variance-in-common between scores for a linear independent empirical model with the values for a dependent variable. The variance-in-common is generally low because of the occurrences of false positive and/or negative cases among the cases for the

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independent model and the dependent variable. False positives are cases in the data set whereby the model predicts to have all low scores for but in which some cases have high values. False negatives are the reverse of false positives. The frequent practice for researchers using symmetrical testing and NHST is to ignore false positive and false negative cases.

The focus of most studies using dominant symmetric testing logic is on the relative sizes (“importance”) of standardized partial regression coefficients in multiple regression and structural equation models by holding constant for the impact of each variable in the models (Armstrong, 2012). The variances among some of the independent variables overlap considerably in most models and the removal and addition of a variable often dramatically affects the sizes of betas in the models. Also, the focus on the size of betas and whether the non-standardized partial regression coefficients differ significantly from zero (NHST findings) can be misleading to the actual relationships between variables.

With sufficiently large sample sizes, all differences are statistically significant from zero (Ziliak and McCloskey, 2008). Having sufficiently large samples and using stepwise regression analysis with several independent variables guarantees statistical significance of some of these variables with the dependent variable or high multicollinearity among the independent variables – along with a significant adjusted R^2 no matter how inconsequential the associations and inaccurate the predictive validity of the model. High multicollinearity among independent variables can result in nonsignificant beta coefficients for the independent variables and a highly significant adjusted R^2 for the dependent variable. Armstrong (1970, 2012) used random numbers from Rand’s book starting with 31 observations and 30 potential variables, and stepwise-regressed variables where t was higher than 2.0. The final regression had eight variables and an R^2 (adjusted for degrees of freedom) of 0.85. This testing had no theoretical foundation and explanation yet the R^2 value is substantial.

Theoretical background

The issues arisen from symmetrical testing prompts the call for asymmetrical method. This method is a case-based approach (a case means the study subject) and draws upon complexity theory that explains variety (rather than symmetrical) of relationships between study variables. Weick (2007, p. 16) provides a useful introduction on the need to achieve “requisite variety” that is relevant for recognizing the need to embrace complexity theory and case-based modelling, “The importance of a head full of theories is that this increases requisite variety. Asymmetric models such as theory-based algorithm screens [i.e. “computing with words” (CWW) (Zadeh, 1996, 2010)] are examples of a useful paradigm for replacing symmetric theory and tests.

Urry (2005) provides a far-ranging literature review of complexity theory in the natural and social sciences and offers many useful insights. “Relationships between variables can be non-linear with abrupt switches occurring, so the same cause can, in specific circumstances, produce different effects” (Urry, 2005, p. 4). In other words, if a system passes a particular threshold with minor changes in the controlling variables, switches occur such that, for example, a liquid turns into a gas,

a large number of apathetic people suddenly tip into a powerful movement for change (Gladwell, 2002). Such tipping points give rise to “unexpected structures and events” (Urry, 2005, p. 5). Similarly, Greckhamer *et al.* (2008) and Ordanini *et al.* (2014) suggest that outcomes of interest rarely result from a single causal factor. Causal factors rarely operate in isolation; and the same causal element may have different – even opposing – effects depending on the context. The complexity theory is manifested in the core tenets described as follows.

First, *asymmetry*: In symmetrical testing, a statistically significant, sizeable main effect of a simple independent variable on a dependent variable may cause a researcher to fail to notice the occurrence of several contrarian cases to this main effect. The complexity theory indicates that for different cases, both high and low scores for the same simple antecedent condition (e.g. individualism) can appear in two different recipes whereby both indicate a high score in an outcome condition. Explaining these contrarian cases with additional algorithms (i.e. recipes or configurations) serves to increase the information of a study. On the other hand, high scores for a simple antecedent condition may be a necessary condition, but high scores for a simple condition is rarely sufficient for a high score to occur consistently for an outcome condition. Second, the *equifinality*: this tenet indicates that an outcome can be reached by multiple paths or configurations (path, configuration, recipe are used interchangeably in this study) of proposed antecedent conditions. Few-to-several configurations of antecedent conditions can lead to high outcomes. Thus, a high score for a given recipe may be sufficient for indicating a high outcome for a given case but this recipe is not necessary for a high outcome score to occur. Third, *causal complexity or conjunction*: The same simple antecedent condition can appear in both positive and negative models for the same outcome condition, whereby the recipes indicating the negation of an outcome condition are not the mirror opposites of the recipes showing a positive response for the same outcome condition.

This asymmetrical thinking of complexity theory can be manifested in a data analytical method named fuzzy-set qualitative comparative analysis (fsQCA hereafter) originated by Ragin (2000). FsQCA offers parallel insights and data analysis methods in sociological research and beyond (Ordanini *et al.*, 2014). This method is a configurational or set theory testing, and relies on Boolean algebra and set theory principles, rather than the now dominant research paradigm of using matrix algebra with additive-based statistical methods (Ragin, 2000, 2006, 2008). FsQCA generates the results that are reflective of the core tenets of complexity theory. First, fsQCA shows that variables found to be causally related in one configuration may be unrelated or even inversely related in another configuration, implying the asymmetrical relationships (Ragin, 2008). Second, fsQCA illustrates the existence of multiple equally effective pathways (or recipes for) to the same outcome, indicating equifinality. Third, fsQCA shows that the influence of antecedents on a specific outcome depends on how the antecedents are combined, rather than on the levels of the individual antecedents *per se*, which is indicative of complexity or conjunction.

On the basis of the foregoing discussion, the current study aims to examine the core tenets of complexity theory by testing the link of service quality, customer satisfaction and behavioural

intentions. This link has been widely and extensively tested in various contexts (Bogicevic *et al.*, 2013; Ching, 2014; Cronin *et al.*, 2000; Lee *et al.*, 2000; Moon *et al.*, 2016; Prentice, 2013; Saleem *et al.*, 2017; Shi *et al.*, 2014; Subha and Archana, 2013). No study has tested this link using the asymmetrical method. The findings from previous symmetrical-based research are rather inconsistent although in general a high level of overall service quality and customer satisfaction are predictive of customers' favourable behavioural intentions or loyalty. The inconsistency is manifested in the role of customer satisfaction and the options of service quality dimensions. Some researchers (Prentice, 2013, 2014; Zeithaml *et al.*, 1996) argue that service quality has a direct effect on customers' behavioural intentions, and customer satisfaction is not a necessary condition of these intentions; whilst others (Edvardsson *et al.*, 2000; Lam *et al.*, 2004; Hallowell, 1996; Mägi, 2003; Olsen, 2002; Shi *et al.*, 2014) emphasised the role of customer satisfaction in the favourable outcomes for the firm. On the other hand, most research in symmetrical testing used overall service quality without attending to the specific dimensions to examine its impact on customer-related outcomes. Furthermore, the symmetrical tests in the literature fail to reveal the nuances between different study contexts and population in this relationship link. Those tests offer limited value as it is important for businesses or firms to understand what specific aspects of services affect customer satisfaction and loyalty, and how different aspects affect different customers, so that improvement can be made on these aspects to optimise use of organizational resources. These limitations can be answered by using fsQCA with asymmetrical testing. Consequently, the study examines the asymmetry, equifinality and causal complexity of service quality dimensions in customer satisfaction and behavioural intentions. The following section offers a brief literature review on these constructs and their relationships. Methodology is outlined subsequently, followed by presenting the asymmetrical results from fsQCA. This paper also presents symmetrical findings using SEM to demonstrate the nuances of the two tests.

Literature review

Service quality, customer satisfaction, behavioural intentions

Service quality often reflects customers' perceptions and value-judgment of a product or service, and is widely acknowledged as a driver of organisations' profitability and a form of achieving a competitive advantage (Alexandris *et al.*, 2002; Parasuraman *et al.*, 1995; Prentice, 2013, 2014; Shi *et al.*, 2014). Customer satisfaction is defined as an overall feeling of pleasure or disappointment that emerges from comparing perceived service performance with pre-service expectations (Oliver, 1980). Satisfaction is generally regarded a post-consumption response (Athanasopoulos *et al.*, 2001). Behavioural intentions reflect customers propensity and intention to engage with a product or service, and are manifested in, inter alia, customers' repurchase, revisit, recommend and word of mouth (Cronin *et al.*, 2000; Rezaei *et al.*, 2017; Žabkar *et al.*, 2010).

Service quality has been extensively discussed as an antecedent of customer satisfaction in the relevant literature (Chan *et al.*, 2015; Eusébio and Vieira, 2013; Kim *et al.*, 2016; Zeithaml *et al.*, 1996), whereas customer satisfaction is directly

related to behavioural intentions (James, 2004; Kim and Kim, 2015; Lee *et al.*, 2004; Liu and Lee, 2016; Rezaei *et al.*, 2017; Shoemaker and Lewis, 1999; Wu and Cheng, 2013). Satisfaction leads to the phenomena of post-consumption responses and is a core prerequisite of behavioural intentions such as repurchase, positive word of mouth and loyalty (Chen and Chen, 2010; Cronin *et al.*, 2000; Shi *et al.*, 2014). Notwithstanding, other empirical studies could not confirm this direct relationship (Bitner and Hubbert, 1992; Kivela *et al.*, 2000; Rust *et al.*, 1995). Neal (1999) argued that satisfaction on its own cannot predict customers purchase behaviour or loyalty, but possibly improves behavioural intentions to patronage. For example, an extremely dissatisfied passenger might continue to display "loyal" behaviours by using the same service provider if there are no other alternative options available.

On the other hand, numerous studies have also shown that service quality has a direct influence on customers' behavioural intentions (Alexandris *et al.*, 2002; Baker and Crompton, 2000; Ladhari, 2009; Prentice, 2013, 2014; Wakefield and Blodgett, 1996; Zeithaml *et al.*, 1996). Positive perceptions of service quality create favourable behavioural intentions to repurchase/reuse, engage in positive word of mouth, endorse the products/services, price sensitivity, and ultimately, become loyalty towards the firm. Conversely, unfavourable behavioural intentions are related to negative actions such as switching (Bigovic and Prašnikar, 2015). Burton *et al.* (2003) reported a positive experience will encourage customers' future return to the service. Zeithaml *et al.* (1996) assert the higher the quality of the service, the more likely customers will revisit, reuse or purchase with the firm. This rapport has been widely supported (Baker and Crompton, 2000; Caruana, 2002; Cronin *et al.*, 2000; De Nisco *et al.*, 2017; Prentice, 2013).

In sum, service quality affects customer satisfaction, which leads to customers' behavioural intentions; equally, service quality can be directly related to these behavioural indicators. Such inconsistency is indicative of the complexity of the relationships among service quality, customer satisfaction and behavioural intentions. The complexity may result from the following observations.

Dimensionality of service quality

Service quality is a multidimensional construct (Cronin and Taylor, 1992; Parasuraman *et al.*, 1993, 1994; Santos, 2003). The dimensions differ in different study contexts (e.g. online vs offline) and different schools of thoughts (e.g. the US vs Nordic school). The literature shows that different service quality dimensions have been used in various studies (Kang and James, 2004; Prentice and Kadan, 2019; Santos, 2003). Although overall service quality generally predicts customer satisfaction and behavioural intentions, some dimensions have non-significant effects on these outcomes (Prentice, 2014; Prentice and Kadan, 2019). These findings lead to positing that service quality dimensions should be included in the testing to understand their respective influences on the proposed outcomes, rather than the overall perception of service quality. It is imperative for researchers and practitioners to look into those that do impact.

Case-based asymmetry and complexity

Different service quality dimensions result in different effects on customer satisfaction and behavioural outcomes. Equally the same dimension has different effects on the same proposed outcomes in different study samples and research contexts (Prentice, 2013, 2014; Prentice and Kadan, 2019; Shi *et al.*, 2014). Service quality is often assessed on the basis of customers' perceptions and experiences (Cronin and Taylor, 1992). Customers' perceptions are formed on experiences over personal and/or impersonal service encounter/s with the service provider (Bitner *et al.*, 1990; Prentice, 2013). Different customers would have different experiences, which result in different perceptions. The same customer may have different experiences over different service encounters. Some may be positive; others negative, which results in contrasting perceptions and assessments towards the same service provider. The negative experiences and perceptions may overshadow some customers and influence their subsequent attitudes and behaviours. Other customers may focus on positive experiences, which lead to their satisfaction with the service provider. Indeed, research (Gountas and Gountas, 2007; Matzler *et al.*, 2005) shows that customers' personalities influence their perception of service quality, satisfaction and behavioural intentions. Personalities vary across individuals. The foregoing discussion indicates that the relationships between service quality, customer satisfaction and behavioural intentions are case-based (case here indicates an individual customer) and vary on cases/customers. High and low perceptions of some service quality dimensions may lead to the same outcomes (customer satisfaction and favourable behavioural intentions). This observation is indicative of asymmetrical relationships among these variables and informs the following hypothesis:

- H1.* Service quality dimensions are asymmetrically related to customer satisfaction and behaviour intentions

Research also shows that different service quality dimension/s lead/s to the same outcomes for different cases. Prentice (2014) finds that responsiveness, assurance and empathy of SERVQUAL dimensions have significant effects on customer retention in the case of high-volume customers, only empathy on retention for medium-volume customers, and food service for low-volume customers. Although other service quality dimensions in her study demonstrated non-significant effects, they did contribute to the overall service quality perception and customer retention, which is manifested in the significant R^2 values across different customer groups. The foregoing discussion informs the following hypotheses:

- H2.* There are multiple configurations of service quality dimensions that lead to the customer satisfaction and behavioural intentions.
- H3.* Each service quality dimension is combined with others rather than independently to explain customer satisfaction and behavioural intentions.

Methodology

Sample

The study was undertaken in the airport context. In the airport industry, service quality is delivered through complex

collaborations between numerous stakeholders (Bogicevic *et al.*, 2016; George *et al.*, 2013; Jeon and Kim, 2012) and ensuring high service quality has implications for airport profitability that can be reflected in passengers' favourable behaviours (Prentice and Kadan, 2019), for instance, spending in the airport retail outlets (referred to airport spending in this study) and choosing the airport as the first choice (referred to as airport preference). Consequently, airport spending and preference have opted as customers' behavioural intentions in this study.

The study is focussed on Australian major airports. Due to security and geographic restrictions that prevent from accessing participants in airport terminals, online social networking platforms were used to reach potential respondents. The online survey is cost-effective and easy to complete a wide range of question styles (Fowler, 2009). The study was conducted with passengers who recently departed in one of major airports. To better understand the proposed relationships, the sample's target population consisted of non-local passengers (over 18) who had departed from the selected airports in the past 12 months. Local passengers were excluded from this study to minimise the effects exerted by the situation factors (e.g. convenience). For instance, a selected respondent who recently departed from Melbourne airport must not reside in Melbourne and the adjacent areas. To reduce the non-completion rate, the survey was designed to prevent previewing and skipping questions (Baltar and Brunet, 2012). Snowball sampling was adopted as this method is able to access hidden populations and overcome the selection bias in traditional snowball techniques (Baltar and Brunet, 2012). Departure passengers were the focus of this study as they experience all processing and discretionary activities in the airport terminal because of the long waiting time required before their flight. Also, examining departures allowed the inclusion of domestic and international travellers collectively. Screening questions were developed to ensure only responses from the required population were included (Fowler, 2009).

Measures

All measures for this study were adapted from existing studies. All items were measured on a seven-point Likert scale from, 1 (Strongly disagree) to 7 (Strongly agree). The use of a seven-point Likert scale enabled flexibility to use a range of statistical techniques, which can be applied to ordinal scaled data (Shi *et al.*, 2014).

Airport service quality was measured by adopting Bezerra and Gomes's (2016) and Correia *et al.* (2008). The scale was focussed on layout, check-in process, security, ambience, facilities, staff and self-service technology, which embrace the major components of airport services. The items that measure layout capture the servicescape of the airport, namely, the tangible settings that facilitate passengers' departure. Check-in includes the efficiency and helpfulness of check-in staff. Security measures the security check at the airport including waiting for time and passengers' feeling of being safe and secure at the security screening. Ambience measures the atmosphere of the airport. Facilities include availability and comfort of various facilities. The items measuring self-service technology are indicative of passengers' technological control over their preferred level of service and interaction. The scale

reliability and validity are reported in the next section. Passenger satisfaction was measured using four items adapted from Bogicevic *et al.* (2017) and Cronin *et al.* (2000). The items addressed overall satisfaction with the airport, happiness with the airport choice, wise decision and satisfaction with the experience.

Behavioural intentions have been mostly treated as one construct in the literature. However, researchers (Cong, 2016; Söderlund, 2006) questioned whether these items reflect the same underlying meaning. Tam and Lam (2004) found nomological validity to treat them as discrete constructs. Cong (2016) supports this notion; each behavioural intention item behaves differently with the predecessors. Therefore, for the purpose of this study, passenger behavioural intentions are tested separately. This ties in with Moon *et al.* (2016), who treated willingness to spend and revisitation separately. The measurement of behavioural intentions (airport spending and preference) was adopted from Moon *et al.* (2016), Tosun *et al.* (2015) and Omar and Kent (2001).

Procedure

The online survey was disseminated through social media networks (e.g. Facebook, LinkedIn). The invitation email contained a brief description of the project and a hyperlink that directed participants to the survey host and the social media platforms. Participants were informed the completion of the questionnaire was taken as implied consent. Participants remained anonymous and the data was kept de-identifiable. A few raffle tickets were offered as an incentive to participate and safeguarded by directing them to an independent web-page to provide their contact details so that their identities could remain anonymous. A pilot test was conducted to ensure clarity of questionnaire items and reasonable length of the survey completion time (less than 15 min as suggested in Neuman (2013)). Minor changes were made to improve the wording and sentence structure of the items. The survey time fell in between 11-14 min. The respondents' demographic profiles are shown in Table I.

Data analysis

This study tests asymmetrical relationships among service quality, customer satisfaction and behavioural intentions by using fsQCA. To reinforce the merits of this testing, the results for the symmetrical testing using structural equation modelling are presented first. The respondents' demographic and situational factors were added as control variables in the symmetrical testing to limit confounding effects and gain insights into the influence of airport service quality on the proposed outcome variables.

Results

Symmetrical testing

Airport service quality (ASQ) is a multidimensional construct. The study presents both the influence of overall service quality, as well as each dimension on the proposed outcomes. To understand its overall effect on passengers' satisfaction and behavioural intentions, a second-order factor structure was tested first, followed by presenting the effects of each

Table I Demographic information for the respondents

Variables	Categories	(%)
Gender	Male	29
	Female	70.5
Income	\$0-24,999	38.1
	\$25,000-49,999	15.8
	\$50,000-74,999	19
	\$75,000-99,999	10.7
	\$100,000-124,999	18
Education	Secondary school	24.1
	Diploma or trade certificate	14.2
	Bachelor	30.8
	Postgraduate	30.9
Age	18-25	42.4
	26-35	28.7
	36-45	11
	46-55	10.7
	56-65	6.2
	65+	1.1
Travel purpose	Leisure (Holiday)	47.5
	Business	9.7
	Education	9.7
	Visiting family/friends	33.2

Note: $N = 373$

dimension used in this study to understand the complexity theory in fsQCA testing.

First, we assessed the validity of ASQ following the procedures described in Prentice *et al.* (2018). The second-order CFA model fits for this construct were acceptable: $\chi^2 = 907.87$, $df = 246$; CFI = 0.91; TLI = 0.90; RMSEA = 0.06. The path coefficients between the indicators and their respective first-order factors were significant at the 0.05 level. The model fits for the second-order factor structure by conducting a one-factor CFA on the average scores of the six first-order constructs (Jayachandran *et al.*, 2005) were $\chi^2 = 95.52$, $df = 14$; CFI = 0.98; TLI = 0.96; RMSEA = 0.06. All the path coefficients were significant at the 0.05 level. The study, thus, used the aggregated scale consisting of the average scores of the dimensions of airport service quality as their indicators for further analyses (Prentice *et al.*, 2019).

Next, CFA was performed and shows that the model had acceptable fit indices: $\chi^2 = 468.46$, $df = 125$; CFI = 0.94; TLI = 0.92; RMSEA = 0.06. All items have significant loadings on their corresponding constructs (Table I). The composite reliabilities for all factors were acceptable, and the average variance extracted (AVE) for each factor was over 0.50, indicative of adequate convergence (Fornell and Larcker, 1981). The results of standardized residuals and modification indices show no conspicuously significant changes to the model. Table II shows the correlations among variables. The square root of average variance extracted for each construct exceeds the correlation between constructs, indicating discriminant validity.

Symmetrical testing results

The results in Table III show that overall service quality has a positive effect on passenger satisfaction ($\beta = 0.75$, $p < 0.001$).

Table II Correlations among study variables

Variables	1	2	3	4	5	6	7	8	9	10
1.Layout	0.75									
2.Check-in	0.59**	0.75								
3.Security	0.53**	0.49**	0.81							
4.Ambience	0.60**	0.53**	0.52**	0.86						
5.Facilities	0.49**	0.33**	0.31**	0.46**	0.73					
6.Staff	0.40**	0.40**	0.42**	0.36**	0.32**	0.79				
7.SST	0.47**	0.66**	0.40**	0.42**	0.30**	0.45**	0.92			
8.Satisfaction	0.66**	0.57**	0.54**	0.61**	0.47**	0.45**	0.54**	0.85		
9.Spending	0.12*	0.09	0.06	0.09	0.12*	0.24**	0.15**	0.13*	0.88	
10.Preference	0.47**	0.40**	0.35**	0.44**	0.34**	0.30**	0.37**	0.63**	0.06	0.91

Notes: Preference = Airport preference. * $p < 0.05$; ** $p < 0.001$; *** $p < 0.0005$

Table III Symmetrical results for the relationships between service quality, satisfaction and behavioural intentions

Service quality	Outcome variables		
	Sat	Spend	Reuse
Layout accessibility	0.28***	0.04	0.19**
Check-in	0.06	-0.06	0.06
Security	0.13**	-0.09	0.05
Ambience	0.17***	-0.01	0.15*
Facilities	0.12**	0.07	0.08
Personnel	0.08	0.23***	0.06
SST	0.17**	0.08	0.11
Education	-0.07	-0.02	0.02
Income	-0.02	0.02	-0.01
Occupation	0.03	-0.01	-0.07
Domestic/overseas	0.01	-0.03	0.02
First point of contact	-0.02	-0.00	0.03
Purpose	-0.04	0.12	-0.04
R^2	0.60***	0.15*	0.32***

Notes: * $p < 0.05$; ** $p < 0.001$; *** $p < 0.0005$

Further, passenger satisfaction has a positive effect on airport spending ($\beta = 0.13$, $p < 0.05$), airport preference ($\beta = 0.63$, $p < 0.001$). Further analysis was performed to understand the influence of each service quality dimension on the outcome variables. Results are presented in Table III. The results show that the respondents' demographic and situational factors had no significant effects on the variables in question and that the service quality dimensions exert different effects on the outcome variables for respondents. The factor that drives respondents to spend was staff service, to opt the airport as the first choice was ambience.

Asymmetrical testing results - the fuzzy-set qualitative comparative analysis method

FsQCA is grounded in set theory, a branch of mathematics (Smithson and Verkuilen, 2006) that builds on the idea that relationships between constructs are "often best understood in terms of set membership" (Fiss, 2007). Set membership indicates differences in kind. Accordingly, the analysis is rooted in Boolean algebra (as opposed to linear algebra) and aims to identify necessary and sufficient subset relations. The

independent variables in symmetrical testing are referred to as antecedent or causal conditions. The dependent variables are referred to as outcomes.

FsQCA involves calibrating raw data by converting scores of the study variables into set membership scores to enable Boolean analysis. Calibration is driven by theoretical and substantive knowledge and allows for flexibility in determining set membership, from crisp set operationalisations (0 versus 1) to fully continuous fuzzy sets and everything in between, such as multi-value sets (e.g. three- or four-value). The detail discussion on performing fsQCA can be found in Olya and Mehran (2017), Olya and Al-ansi (2018) and Woodside *et al.* (2015). The calibrated data are presented in Table IV.

FsQCA testing is reflected in the "consistency" and "coverage" of the resulting configurations. *Consistency* is equivalent to statistical significance in regression analysis, indicates "how closely a perfect subset relation is approximated" (Ragin, 2008, p. 44), with 1 indicating perfect consistency. *Coverage* is equivalent to R^2 in multiple regression analysis, "indicates the empirical relevance" (Ragin, 2008, p. 45) of a configuration to the cases under consideration, with 1 representing perfect coverage (e.g. a single configuration common to all respondents).

Predictive validity testing

Prior to performing fsQCA for this study, predictive validity was tested for the proposed configurational model by analysing the relationship between service quality and customer satisfaction. Two methods were used to test the predictive validity of the model (Olya and Mehran, 2017; Olya and Al-ansi, 2018; Prentice and Woodside, 2013). First, the data was divided into two sub-samples. The casual model from subsample 1 was tested with subsample 2. The fuzzy XY plot in Figure 1(a) shows that Model 1 demonstrated a high level of coverage (0.70) and consistency (0.82) (Ragin, 2008). Subsequently, the causal model from Subsample 2 was tested using Subsample 1. As depicted in the XY plot in Figure 1(b), a similar pattern with a reasonable coverage (0.58), consistency (0.87) is present. Second, the correlations of the predicted versus actual scores for two sub-samples were analysed and shown in Table V. The predicted scores were significantly related to the predictor variables as well as actual scores (highlighted in bold) at the 0.01 level. These results are indicative of the predictive validity of the proposed model.

Table IV Calibrations of all conditions

Variable/antecedent	Descriptive statistics	Calibrations (0.95, 0.50, 0.05)
<i>Airline service quality</i>		
Layout accessibility	$\mu = 5.06, \sigma = 1.22, \min = 1.67, \max = 7.00$	(6.00, 5.33, 4.00)
Check-in	$\mu = 5.27, \sigma = 1.17, \min = 1.43, \max = 7.00$	(6.29, 5.43, 4.29)
Security	$\mu = 5.38, \sigma = 1.21, \min = 1.60, \max = 7.00$	(6.40, 5.60, 4.40)
Ambience	$\mu = 5.54, \sigma = 1.12, \min = 1.33, \max = 7.00$	(6.33, 6.00, 4.67)
Facilities	$\mu = 5.02, \sigma = 1.39, \min = 1.00, \max = 7.00$	(6.00, 5.50, 4.00)
Service Personnel	$\mu = 4.65, \sigma = 1.18, \min = 1.00, \max = 7.00$	(6.00, 4.50, 4.00)
Self-Service Technologies	$\mu = 4.90, \sigma = 1.49, \min = 1.00, \max = 7.00$	(6.00, 5.00, 4.00)
Passenger Satisfaction	$\mu = 5.54, \sigma = 1.19, \min = 1.00, \max = 7.00$	(6.50, 6.00, 5.00)
Spend at airport retail	$\mu = 3.68, \sigma = 1.61, \min = 1.00, \max = 7.00$	(5.00, 3.50, 2.00)
Intention to reuse the airport	$\mu = 5.87, \sigma = 1.38, \min = 1.00, \max = 7.00$	(7.00, 6.00, 5.00)

Notes: μ = Average value; σ = Standard deviation; min = Minimum value, max = Maximum value

Figure 1 Results for predictive validity

Results for configurational models

In the case of the relationship between service quality and customer satisfaction, the analyses in Table VI show that there are seven configurations of airport service quality to explain passenger satisfaction with the airports. The results show that not all high scores (aka high membership) of service quality factors appear in the same configuration. Some factors with both high and low scores are present in different configurations to explain customer satisfaction. For instance, security in Model 1 has a low membership but high in Model 2. Further analysis was performed to understand the configurations for low customer satisfaction. As shown in Table VI, the results indicate that negation of outcome does not mirror the negation of antecedents of high customer satisfaction.

For behavioural outcomes (spending and airport preference), passenger satisfaction was included in the antecedent configuration, as the symmetrical testing shows that passenger satisfaction significantly influences the behavioural indicators. There were 5 and 17 configurations explaining the outcomes, respectively. In the case of spending in the airport, passengers'

overall satisfaction and airport ambience appear in every antecedent configuration; whereas other factors with either high or low scores are present in different configurations. For airport preference, all antecedent conditions with high or low scores appear in these 17 configurations. These findings support the asymmetrical relationships among service quality, customer satisfaction and behavioural intentions proposed in *H1*. While the ambience is the only factor that affects airport preference in symmetrical testing, the results from fsQCA confirm the importance of this factor as it is present in all configurations.

Given that each proposed outcome is explained by multiple paths as shown in Tables VI and VII, equifinality proposed in *H2* is confirmed. As for the conjunctive combinations of service quality factors proposed in *H3*, evidently, the results in the tables show that these antecedent conditions are combined as different recipes to explain the outcomes. Hence, *H3* is supported (Table VIII).

In the symmetrical testing, the respondents' demographic and situational factors show no effects on the outcome in question. The solution coverages in fsQCA in both cases of

Table V Samples 1 and 2 results for correlations between variables

Variables	Layout	Check-in	Security	Ambience	Facility	Staff	SST	Sat
Sample 1								
Layout	—							
Check-in	0.65**							
Security	0.65**	0.59**						
Ambience	0.73**	0.63**	0.59**					
Facility	0.68**	0.49**	0.52**	0.62**				
Staff	0.46**	0.39**	0.44**	0.37**	0.52**			
SST	0.52**	0.62**	0.47**	0.43**	0.55**	0.55**		
Satisfaction	0.67**	0.55**	0.62**	0.58**	0.69**	0.49**	0.57**	
Pre_sat	0.86**	0.71**	0.79**	0.74**	0.88**	0.63**	0.74**	0.78**
Sample 2								
Layout	—							
Check-in	0.52**							
Security	0.48**	0.39**						
Ambience	0.59**	0.45**	0.50**					
Facility	0.64**	0.45**	0.46**	0.62**				
Staff	0.37**	0.34**	0.39**	0.30**	0.44**			
SST	0.43**	0.60**	0.32**	0.37**	0.48**	0.38**		
Satisfaction	0.70**	0.50**	0.46**	0.60**	0.60**	0.43**	0.50**	
Pre_sat	0.91**	0.65**	0.59**	0.78**	0.78**	0.56**	0.64**	0.77**

Notes: Sample 1: SQCS = $1.43 + 0.18 \times \text{Layout} + 0.22 \times \text{Security} + 0.32 \times \text{Facility} + 0.15 \times \text{SST}$ ($R^2 = 0.62$, $df = 7/157$, $p < 0.0005$). Sample 2: SQCS = $0.16 + 0.40 \times \text{Layout} + 0.20 \times \text{Ambience} + 0.12 \times \text{Staff} + 0.14 \times \text{SST}$ ($R^2 = 0.60$, $df = 7/197$, $p < 0.0005$)

Table VI Antecedent conditions for high versus low customer satisfaction

Antecedent conditions	Raw	Coverage Uni	Cons.
Model: High_Customer_Satisfaction = f (layout, security, ambience, facility, staff, SST)			
MH1: sst*staff*facility*ambient~security~layout	0.12	0.03	0.91
MH2: sst*facility*ambient*security~check~layout	0.14	0.02	0.89
MH3: ~sst*staff*facility*ambient*security~layout	0.11	0.02	0.89
MH4: sst*staff~ambient*security*check~layout	0.11	0.02	0.89
MH5: sst~staff*ambient*security*check~layout	0.16	0.05	0.92
MH6: ~sst~staff*facility*ambient*security*check*layout	0.11	0.04	0.90
MH7: sst*staff*facility*ambient*security*check*layout	0.21	0.11	0.91
Solution coverage: 0.47; solution consistency: 0.88			
Model: Low_Customer_Satisfaction = f (layout, security, ambience, facility, staff, SST)			
ML1: ~sst~facility~ambient~check	0.42	0.08	0.94
ML2: ~facility~ambient~security~check~layout	0.29	0.02	0.97
ML3: ~staff~facility~security~check~layout	0.28	0.02	0.95
ML4: ~sst~ambient~security~check~layout	0.27	0.02	0.95
ML5: ~sst~facility~ambient~security*layout	0.25	0.03	0.95
ML6: ~sst~staff~security~check*layout	0.26	0.03	0.94
Solution coverage: 0.57; solution consistency: 0.92			

Notes: Cons. = Consistency. Sample 1 SST*staff*facility*ambient*security*layout 0.23 0.01 0.91 SST*staff*facility*security*check*layout 0.24 0.01 0.88 Coverage: 0.70, Consistency: 0.82 Sample 2 SST*staff*facility*ambient*security*check 0.24 0.09 0.90 SST*staff*ambient*security*check*layout 0.17 0.03 0.91 Coverage: 0.58, Consistency: 0.87

airport spending and preference are rather insignificant (0.19 and 0.17, respectively). However, the results show that both high and low income and educated, non-professional domestic passengers, tend to spend in the airport (Table IX). This configuration can be meaningful for airport management.

Discussion

The study deploys a non-symmetrical method (fsQCA) to test the core tenets of complexity theory, namely, asymmetry, equifinality and causal complexity or conjunction with a focus

Table VII Antecedent conditions for airport spending

Model	Sat	Layout	Checkin	Antecedent conditions		Facilities	Staff	SST	Coverage		Consistency
				Security	Ambience				Raw	Unique	
1	•		•	•	•	•	0	•	0.09	0.04	0.88
2	•	•	•	•	•		0	0	0.08	0.04	0.85
3	•	•	0		•	•	•	•	0.09	0.03	0.88
4	•	•	0	0	•	•	0	0	0.06	0.02	0.90
5	•	•	•	0	•	0	•	0	0.06	0.03	0.89

Note: Solution coverage: 0.23; solution consistency: 0.86; • indicates high membership; 0 indicates low membership. The rest indicates "I don't care"

Table VIII Antecedent conditions for airport preference

Model	Sat	Layout	Checkin	Antecedent conditions		Facilities	Staff	SST	Coverage		Consistency
				Security	Ambience				Raw	Unique	
1	•	•		•	•	0		•	0.14	0.01	0.89
2		•	•	•	•		•	•	0.26	0.01	0.88
3		•	•	•	•	•		•	0.25	0.02	0.88
4	•	0	•		0	0	•	•	0.06	0.01	0.93
5	•	•	•	0		•	0	•	0.09	0.01	0.94
6	•	•	•	•		0	0	•	0.10	0.01	0.92
7	•		•	0	•	•	•	•	0.10	0.00	0.91
8	•	•		0	•	•	•	•	0.10	0.01	0.93
9	•	•	•	•		•	•	•	0.22	0.02	0.90
10	•	0	0	•	0	•	0	0	0.07	0.01	0.90
11	•	0	0	0	0	•	•	•	0.05	0.003	0.86
12	0	•	0	•	•	0	•	0	0.05	0.01	0.87
13	•	•	0	•	•	•	0	0	0.08	0.01	0.87
14	•	•	•	•	0	•		0	0.07	0.01	0.89
15	•	0	0	•	•	•	•	•	0.06	0.004	0.89
16	•	0	•	•		0	•	•	0.08	0.00	0.93
17	•		•	•	•	0	•	•	0.12	0.002	0.90

Note: Solution coverage: 0.49; solution consistency: 0.86; • indicates high membership; 0 indicates low membership; The rest indicates "I don't care"

Table IX Demographic conditions for airport spending and preference

Demographic characteristics configurations	Coverage		
	Raw	Uni	Cons.
<i>Model: Spending = f (education, income, occupation, domestic, contact, reason, purpose)</i>			
purpose*~reason*~contact*~domestic*~occupation*~income*~education	0.12	0.03	0.87
purpose*~reason*contact*~domestic*~occupation*~income*~education	0.14	0.06	0.86
~purpose*~reason*~contact*domestic*occupation*income*education	0.09	0.01	0.87
purpose*reason*~contact*domestic*occupation*income*education	0.09	0.01	0.91
Coverage: 0.19, Consistency: 0.84			
<i>Model: Preference = f (education, income, occupation, domestic, contact, reason, purpose)</i>			
purpose*~reason*contact*domestic*~occupation*~income*~education	0.11	0.03	0.86
purpose*~reason*contact*domestic*occupation*income*education	0.14	0.06	0.85
Coverage: 0.17, Consistency: 0.85			
Notes: Reason = Travel reason; purpose = Travel purpose; Cons. = Consistency			

on testing the relationships among service quality, customer satisfaction and behavioural intentions. The symmetrical testing by using SEM is also presented as a comparison. Although using both methods provide greater insights into the service quality – consumer behaviour relationships, the focus of

this study is to propose the fsQCA as an alternative case-based rather than a variable-based method to reveal asymmetrical, equifinal and conjunctural relationships among the study variables. The symmetrical results from SEM analysis are used for reference and comparison. The results confirm the merits of

the core tenets of complexity theory and provide greater insights into the proposed relationships. The detailed discussion is as follows.

Asymmetry

The results from fsQCA testing confirm the asymmetrical relationships among the study variables. FsQCA reveals set relations. Sets are groups of any subjects that are of interest. Set relations are asymmetrical indicating that both high and low scores for the same simple antecedent condition likely appear in two different recipes for the same outcome. In this study, symmetrical testing shows that check-in and staff service have no significant effects on passenger satisfaction. However, the results from fsQCA indicate both appear in seven configurations, additionally the low score of both also lead to the same outcome (passenger satisfaction). However, one with low level of facility service still reaches the same outcome with Raw Coverage of 0.06, Consistency of 0.86. These results in the case of passenger satisfaction confirm the asymmetrical relationships between airport service quality and passenger satisfaction.

With regard to passengers' behavioural intentions, only airport staff service in the symmetrical testing significantly accounts for spending, ambience for airport preference. In fsQCA, however, three configurations with low scores of staff service and two with high scores lead to spending in the airport. In total, nine recipes with high scores of ambience and four with low scores lead to airport preference for passengers. These results confirm asymmetrical relationships between the identified antecedent condition and behavioural indicators.

Equifinality

Equifinality indicates the same outcome can be reached by multiple paths and solutions. Symmetrical testing shows several service quality factors are related to passenger satisfaction. FsQCA results show seven paths with various combination of service quality indicators lead to passenger satisfaction. In particular, both check-in and staff service appear in four paths explain the outcome, whereas in symmetrical testing these have non-significant effects for the passengers.

Similarly, there are five paths with different configurations of airport service quality factors explain passenger spending in the airport. Interestingly three configurations with low scores of staff service also lead to spending for passengers. In relation to airport preference, while acknowledging the importance of ambience, there are multiple paths with various configurations of service quality factors in explaining these outcomes for passengers. Especially, when every service quality factors explain reusing the airport in symmetrical testing, 17 paths in fsQCA lead to this outcome with a reasonable high solution coverage and acceptable consistency. Equifinality is supported.

Causal complexity

Causal complexity indicates that fsQCA generates combined effects rather than independent effects as a result of symmetrical testing, by configuring the optimal combinations of causal conditions that explain the outcome. The results from fsQCA testing show that each proposed outcome is accounted for by multiple combinations of service quality factors. Each factor either with a high or low score appears in different

configurations and is combined with other factors to explain the outcomes. The complexity also lies in some supposedly antecedent conditions appear in some paths but not others, indicating that the respondents simply are indifferent to these factors. For instance, symmetrical testing shows that layout, ambience, facilities, self-service technologies have significant unique effects on passenger satisfaction. However, a significant portion of passenger satisfaction is not explained by layout (raw coverage of 0.14), ambience (0.34), facilities (0.34) and self-service technologies (0.31). Similar findings appear in other outcomes.

Implications

The study is set in the airport context to test the core tenets of complexity theories by examining the relationships among airport service quality, passenger satisfaction and behavioural intentions. While some novel findings are revealed from both symmetrical and asymmetrical testings, the focus of this study is to apply the complexity theory into commonly recognised symmetrical relationships between service quality, customer satisfaction and behavioural intentions, to provide insights into these relationships through fsQCA testing, and to highlight the merits of the case-based approach. Consequently, the study offers both theoretical and practical implications.

The study findings conform to [Urry's \(2005\)](#) complexity theory that indicates relationships between variables can be nonlinear and the same causes can produce different effects. The findings are also consistent with those in [Greckhamer et al. \(2008\)](#) and [Ordanini et al. \(2014\)](#) suggesting the outcomes of interest often result from combined antecedent conditions rather than a single causal factor. The study confirms that [McClelland's \(1998\)](#) asymmetrical thinking relies on Boolean algebra and set theory principles.

The limitations from symmetrical testing and merits of fsQCA suggest that accurate reporting of what explains in an outcome condition is what most researchers and practitioners would want to learn. The workable and correct solution is to recognize, construct and test models asymmetrically that show opposite directions to expected positive or negative main effects for independent variables with a dependent variable. Complexity theory includes the proposition that the configurations of causes for high versus low outcome scores differ substantially – symmetric tests do not recognize this proposition. Asymmetric modelling/testing solves the theory-analysis mismatching problem first identified by [Fiss \(2007\)](#).

The study also contributes to customer satisfaction and loyalty research. The symmetrical testing shows that customer satisfaction is significantly related to favourable behavioural intentions. Asymmetrical testing shows that high, low scores or absence of passenger satisfaction can lead to favourable behavioural intentions. Customer satisfaction has been almost a ubiquitous solution to customer loyalty and retention in the relevant marketing literature ([James, 2004](#); [Kim and Kim, 2015](#); [Lee et al., 2004](#); [Rezaei et al., 2017](#); [Shoemaker and Lewis, 1999](#); [Wu and Cheng, 2013](#)). The finding in this study provides a fresh perspective into the customer satisfaction research: customer satisfaction is important in some cases but also not a necessary condition of customers' behaviours. Dissatisfied customers (low score of customer satisfaction) or

those with indifferent attitude (absence of customer satisfaction in some configurations) can demonstrate favourable behaviours. The service profit chain model proposed by Heskett *et al.* (1994) that places customer satisfaction as a key component in the chain relationship should be discussed with caution.

The study also informs managerial and practical implications. The research findings indicate that airport authorities and retail management should liaise to co-create collaborative strategies to enhance the commercial benefits of the airport. Airport preference also has implications for tourism revenue for the host city. Symmetrical testing shows that staff service is significantly related to airport spending and that airport ambience to airport preference. Training for airport staff may help improve the retail revenues and attune to passenger's needs, consistent with the suggestion in Chiu *et al.* (2016). The improvement with regard to the airport design can be focussed on the ambient factors such as scent, lighting, cleanliness, and noise, etc. Asymmetrical testing shows multiple paths can lead to these behavioural intentions. These findings provide options for the airport management to improve their services for favourable outcomes, and help airport authorities better recognise needed improvements and strategize accordingly.

Limitations and future research

Like any other research, this study has several limitations. The sample chosen for the study is limited to departure passengers in Australian airports only. This may affect the generalisability of the findings. Future research should use systematic random sampling to capture a more realistic scope of the population. Because data collection was conducted online, passengers had to reminisce memories of their travel journey. The evaluations of either being positive or negative can seem somewhat inaccurate, as emotional responses fade over time. Future research should attend to these aspects.

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