Optimisation of the determinants of e-service operations

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Abstract *E-service operations that attract and influence customers to buy products and/or services from specific sites is a complex process involving service design, marketing, and delivery, and encompass a number of essential determinants. Determinants that integrate all the three service processes form the basic framework on which a survey was conducted involving e-service companies, and their views were ascertained on those determinants affecting e-service operations. The aim of this paper is to provide a specific solution that isolates the critical determinants for e-service operations. This paper demonstrated the usability of optimisation technique in isolating critical determinants based on companies' responses. It was found that optimisation technique works well and is able to isolate optimum number of key determinants that are critical to e-service operations. Pareto analysis and statistical significance test were also used to explore the relative importance of the determinants; however, it was found that they failed to identify specific and optimum number of critical determinants. The rationale and limitations of each technique and their applicability were also critically assessed.*

Introduction

The number of companies and customers embracing web-based services is growing at a faster rate than ever before and as estimated by Forrester Research (cited in Chaffey, 2002), the growth of e-business would increase three times between 2002 and 2004. E-business is a broad term used to express the conduct of business (buying and selling, servicing customers, and collaborating with partners) through the internet (whatis.com, cited in Chen, 2001), in which e-commerce and e-service can be established as its two underlying dimensions (Surjadjaja *et al.*, 2003). E-commerce mainly focuses on the buying and selling of physical goods/products that results in monetary exchange whereas e-service refers to delivery of services through the internet either paid or free (Voss, 1999). E-service operations encompass all customer centric activities starting from pre-transaction, transaction and post transaction interactions through the internet in delivering products/services within a service level agreement (Surjadjaja *et al.*, 2003). By definition, it is implied that e-business, e-commerce and e-service do overlap each other's boundaries as illustrated through the Venn diagram (Figure 1). To clarify any ambiguity that may have been caused by the overlapping boundaries, each segment was numbered and assessed by a range of criteria developed in Table I to ascertain the uniqueness of each segment and to distinguish one from another.

As the customers' expectation of e-service quality is continuously increasing (Curtis, 2000; Zeithaml *et al.*, 2002), more and more quality features need to be incorporated to satisfy their e-service requirements. As a consequence, a number of

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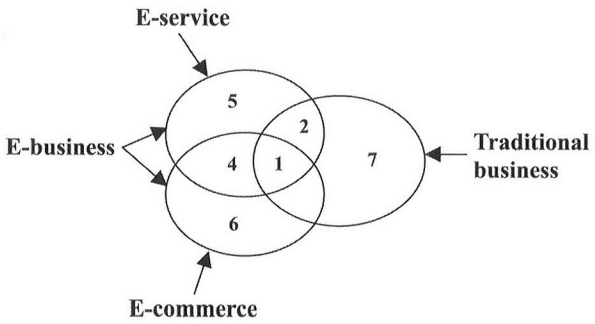


Source: Surjadjaja *et al.* (2003, p.41)

Figure 1.
E-business versus traditional business

	Segment						
Criteria	1	2	3	4	5	6	7
Monetary exchange	Y/N	Y/N	Y	Y/N	N	Y	Y
Involve physical product	Y	N	Y	Y	N	Y	Y
Virtual/digital product	Y	Y	Y	Y	Y	Y	Y
Physical agent/stores exist	Y	Y	Y	N	N	N	Y
Virtual agent (web site) exists	Y	Y	Y	Y	Y	Y	N
Physical business processes	Y	Y	Y	Y	N	Y	Y
Virtual business processes	Y	Y	Y	Y	Y	Y	N

Note: Y = Yes; N = No; Y/N indicates a combination of free and paid services
Source: Surjadjaja *et al.* (2003, p. 42)

Table I.
A set of determinants illustrating differences and uniqueness between e-business and traditional business

determinants need to be incorporated in e-service operations to create a delightful online experience for potential and existing customers. A total of 20 essential determinants of e-service operations were identified and critically examined through the literature (Surjadjaja *et al.*, 2003). The determinants were selected based on their relevance and potential contribution to the overall e-service experience. The 20 determinants and their definitions are provided in Table II.

The main objective of this paper is to explore the suitability and effectiveness of various techniques such as optimisation, Pareto, and significance test to isolate critical determinants from the list of the 20 identified determinants through a survey of e-service providers. In particular, this study is focussed on developing an appropriate mathematical model and subsequently applying optimisation technique as an attempt to provide a definitive solution in isolating an optimum number of critical determinants. Prior to the application of the methods, the identified determinants were grouped into three main service processes and were subsequently used to develop a conceptual framework of e-service operations.

Conceptual framework of e-service operations

During an e-service experience, a customer is likely to encounter any of the determinants. We argue that all of the determinants are important to any e-service

Determinants (supporting references)	Definition
Trusted service (Barua *et al.*, 2001a, b; Ridley, 2002)	Exact delivery of promised services
Responsiveness (Voss, 1999; Clark, 2001; Meuter *et al.*, 2000)	Lead time, accuracy, and consistency of response
Site effectiveness and functionality (Saenz, 2001; Voss, 1999; Teeter and Schointuch, 2000)	Effectiveness of web functions such as: help desk, search engine, FAQ (Frequently Asked Questions) section
Customer service representative (CSR) (Clark, 2001; Dicksteen, 2001)	Availability and helpfulness of a CSR
Fulfilment (Curtis, 2000; Saenz, 2001; Ridley, 2002)	Delivery of products/services on time and as specified
External communication (Dourado, 2002; Barua *et al.*, 2001b)	Building a positive image of a service provider towards the existing and potential customers
Interactivity (Smith and Wallace, 2002; Sterne, 2002)	Web-enabled interaction between customers, between customer and a service provider, and customers' direct interaction with products/services
Up to date information (Barua *et al.*, 2001a; Zemke and Connellan, 2002)	Keeping customers updated with latest information on products/services
Systems integration (Mottl, 2000; Barua *et al.*, 2001b)	Integration of operational systems within a company
Personalisation (Dourado, 2002; Cook, 2002)	One-to-one interaction, personalised services to individual customer
Navigability (Meuter *et al.*, 2000; Barua *et al.*, 2001b; Voss, 1999)	Ease of finding products/services
Availability (Barua *et al.*, 2001a; Sterne, 2002) Convenience (Fellenstein and Wood, 1999; Kalakota and Robinson, 1999)	24/7 access to web site and services Elimination of physical restrictions such as place and trading hours
Security (Fellenstein and Wood, 1999; Barua *et al.*, 2001a, b; Ridley, 2002)	Safety provided by technology against fraud/hackers during online transaction
Return process (Baird, 2001; Strauss and Hill, 2001)	Return policies and procedures
Supply chain integration (Diese *et al.*, 2000; Barua *et al.*, 2001b)	Close relationships with business partners
Internal communication (Mitchell, 2001; Barua *et al.*, 2001b)	Dissemination of information within a company
Customisation (Peppers and Rogers, 1999; Wind and Rangaswamy, 2001)	Providing facility for customers to modify/adjust the system according to their specific requirements
Service recovery (Bates, 2001; Cook, 2002; Zemke and Connellan, 2002)	Providing an alternative service to the satisfaction of the customer and/or redressing loss to customers in the event of a failure in the service process
Price (Burton, 2001; Kalakota and Robinson, 1999)	Competitive pricing of products/services

Table II. Definitions of the determinants

Source: Adapted from Surjadjaja *et al.* (2003)

experience, in which "return process" is particularly critical only when a physical product is being purchased. Subsequently, these determinants can be grouped into three main service processes:

(1) service marketing;

(2) service design; and

(3) service delivery.

Service marketing involves matching market needs and firm's resources ability (Meredith, 1992). It mainly focuses on determining the marketing mix of product/service features such as price, brand image, and accessibility of services (Palmer, 2001). In other words, marketing deals with the expected quality of products/services. While service marketing evolves on the front-end operation, service design focus on the back-end support of service operations. Service design here refers to the design of facilities, servers, equipment, and other resources needed to produce services. It includes blueprint of service system, specifications, procedures and policies (Meredith, 1992). At the front-end operations, the main function of service delivery is to deliver the core products/services to the customers (Slack *et al.*, 2001).

Having defined the three elements of service processes, each determinant was assigned to these service processes based on the definition of each. Since a determinant may fall within any of the boundaries of the processes, determinants that are exclusive to each process were identified first and then followed by determinants that are common to two or all of the service processes as shown in Figure 2.

In Figure 2, "A", "B", and "C" respectively represents "service marketing", "service design, and "service delivery". By using a Venn diagram and applying set theory, each segment and its representing determinants are established as follows:

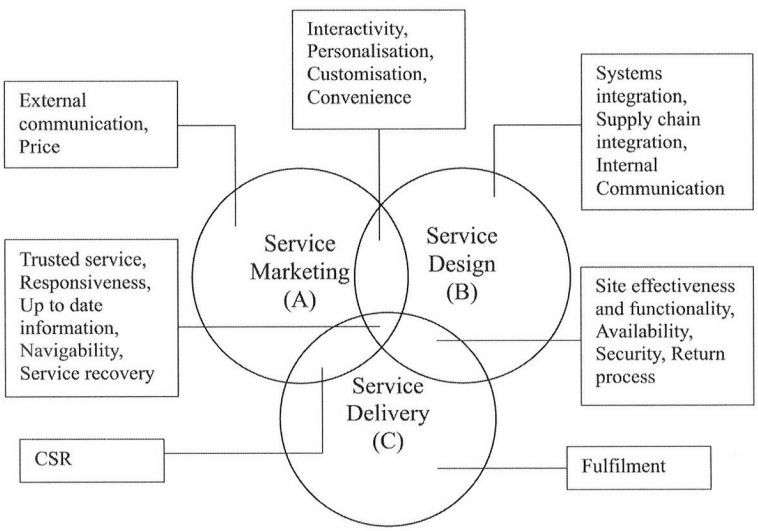


Figure 2.
Determinants of service marketing, design, and delivery

A = {External communication, price, interactivity, personalisation, customisation, convenience, service recovery, real time assistance by CSR, trusted service, responsiveness, up to date information, navigability, service recovery}

B = {Systems integration, supply chain integration, internal communication, interactivity, personalisation, customisation, convenience, site effectiveness and functionality, availability, security, return process, trusted service, responsiveness, up to date information, navigability, service recovery}

C = {Fulfilment, site effectiveness and functionality, availability, security, return process, trusted service, responsiveness, up to date information, navigability, service recovery, real time assistance by CSR}

$(A \cap B)$ = {interactivity, personalisation, customisation, convenience, trusted service, responsiveness, up-to-date information, navigability, service recovery}

$(B \cap C)$ = {site effectiveness and functionality, availability, security, return process, trusted service, responsiveness, up to date information, navigability, service recovery}

$(A \cap C)$ = {Real time assistance by CSR, trusted service, responsiveness, up to date information, navigability, service recovery}

$(A \cap (B \cup C)')$ = {External communication, price}

$(B \cap (A \cup C)')$ = {Systems integration, supply chain integration, internal communication}

$(C \cap (A \cup B)')$ = {Fulfilment}

$(A \cap B \cap C')$ = {Interactivity, personalisation, customisation, convenience}

$(B \cap C \cap A')$ = {Site effectiveness and functionality, availability, security, return process}

$(A \cap C \cap B')$ = {Real time assistance by CSR}

$(A \cap B \cap C)$ = {Trusted service, responsiveness, up-to-date information, navigability, service recovery}

Having applied set theory, "Trusted service", "Responsiveness", "Up to date information", "Navigability", and "Service recovery" were identified as the core determinants of e-service operations.

Since all these service processes may considerably contribute to a customer's perception of service quality, a conceptual framework of e-service operations that integrates the three service processes, service consumption, and perceived service quality is proposed and presented in Figure 3.

The proposed framework can be explained as follow: service quality is argued as a gap between a customer's expectation and perception (Parasuraman *et al.*, 1988).

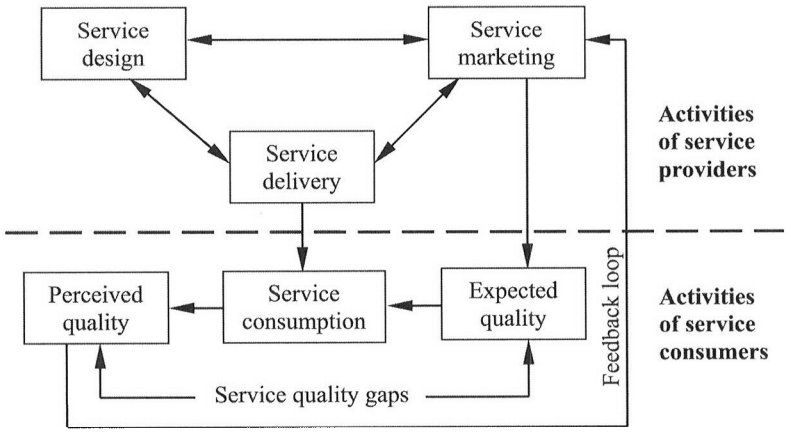


Figure 3.
Conceptual framework of e-service operations

Service marketing feeds a customer's requirements to service design and in return service design communicates the completed service design to marketing. Customer's expectation developed through service marketing needs to be fulfilled and service delivery is an important aspect of it. Service design plans schedule of delivery of services to the customers and in return service design and service marketing need feedback from service delivery whether service has actually been delivered so that service records are accurately kept and personalised services can be designed. Service marketing and service delivery provides valuable inputs, which helps service design to plan resources allocation and design alteration (if any). In return, marketing and delivery needs to retrieve and deliver the designed services to the customers. Therefore, to facilitate effective information flow in delivering quality service, the three processes must have two-way communication, which is represented by two-way arrows as shown in Figure 3.

Delivery process lies in the closing stage of service encounter directly preceding the consumption of services and in some cases may last through the entire service consumption process. Subsequently, the customer's perception of service quality will be based on the service consumption experience.

The 20 determinants are crucial to service consumption process, and service providers are likely to strive for delivering an effective and efficient service by incorporating these determinants in their service processes. However, it is likely that service providers, specifically small and medium enterprises, would be constrained by their available resources in integrating 20 determinants into service processes. Therefore, service providers may need to focus on a limited number of critical determinants as the foundation block on which a successful service operation strategy can be developed. As a consequence, it is of interest to assess the importance of the suggested determinants from the service provider's point of view.

Research methodology

A survey was conducted to assess the companies' perception and their priorities on those 20 determinants. In order to provide flexibility for completion, the survey was designed into different kinds of forms: e-mail-attachment, e-mail embedded, and

printouts for postal completion. In completing the survey, the respondents were requested to read through the 20 randomly distributed determinants. A brief description of each determinant was provided in the survey design so that each potential respondent may have a common and unbiased interpretation of the determinants.

Subsequently, respondents were asked to identify five determinants that were critical to their e-service operations since prioritising on three to five goals at a time allows management to have a clear focus for effective planning that would enable them to optimise the use of company's resources (Dervitsiotis, 1999). Initially, this would allow a company to focus on a narrow range of determinants that are likely to have the most significant impact on its e-service operations.

Limiting the number of determinants would also engage respondents to appropriately assess each of the determinants before selecting the critical determinants. Assigning ranks to the chosen determinants was abandoned as it would reduce the complexity of completing the survey and as a result would increase the response rate (Morrel-Samuels, 2002). In addition, since there may be an overlap between these determinants as shown in Figure 2, assigning relative importance scores or ranks is not justifiable unless the determinants are proven to be independent to one another. Moreover, when two determinants have equal overall weight (rank multiplied by frequency), it will cause a problem in deciding which determinant is more important.

The survey was sent to a balanced proportion of companies in different sectors of e-service operations that represent financial services, ICT, travel and tourism, manufacturing, wholesalers and retailers. A variety of sectors were chosen in order to present an initial overview of the importance of the determinants in e-service operations. Various directories such as Hoovers, Yahoo!, Business Link Wessex, Ukonline guide, Forbes, Eurobusiness top 500 companies, Lycos and Google were used to identify e-service providers. Companies chosen were either purely e-business and/or a combination of e-business and traditional business. During a six weeks' survey period, 283 companies acknowledge the receipt of the survey of which 40 completed the survey (14.13 per cent response rate).

Companies, which have completed the survey, include multinational companies comprising banking, financial services, airlines, telecommunications, consumer electronics, automotive, hotel, and IT products and services. The rest of the respondents represent UK based companies that include high street retailers, infomediaries, ICT service providers, and travel and tourism. These service sectors were grouped into five main areas: manufacturing, travel and tourism, infomediaries, retail and ICT as shown in Figure 4.

At the end of the survey design, the companies were also asked to add any new determinants to the existing list that were considered critical for their business operations. Since none of the companies suggested any new determinant, the breadth of the 20 determinants was confirmed. Out of total 40 responses, 35 completed surveys were received by e-mail and five by post. The response time of the 35 companies varies from minutes to weeks and shown in Figure 5. Of the 35 companies, 31 (88.57 per cent) completed the survey within a week.

Since we did not specifically ask the e-service providers to rank the determinants, all the chosen determinants are assumed of equal importance. Therefore, the frequency

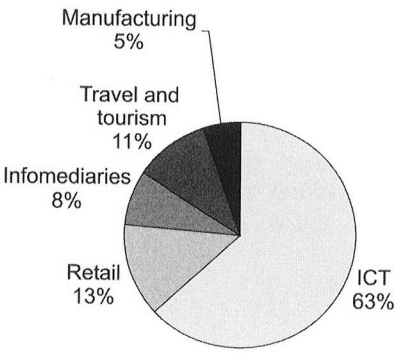


Figure 4.
E-service sector representation

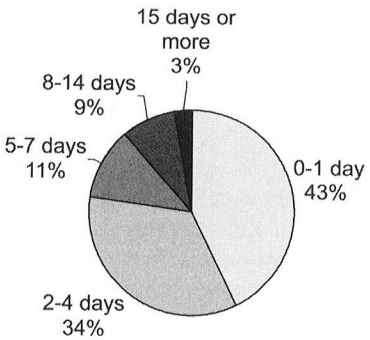


Figure 5.
Response speed of e-mail based survey

distribution is a true measure that represents the relative importance of each determinant, on which the following methods are based.

Methods for determining the optimum number of determinants

Significance test, Pareto analysis, and optimisation are explored and applied in order to identify a minimum number of determinants that are critical for any e-service operations. The steps involved are as follows:

(1) Constructing the relative frequency distribution table.

(2) Assessing the statistical significance of the determinants.

(3) Constructing Pareto chart.

(4) Superimposing frequency distribution curves on Pareto chart.

(5) Selecting the most appropriate intersecting curve with Pareto curve and adding the values of the intersecting curves to generate an objective function curve and determine the optimum value of the objective function. Steps 4 and 5 represent optimisation method.

Statistical significance test and Pareto analysis on determinants

The arranged determinants are plotted into a frequency distribution histogram which generated a frequency distribution curve having a skewness value of 0.026. The

skewness value of 0.026 ($\cong$ 0) indicates that the data follows a normal distribution curve (Freund *et al.*, 1988; Tabachnick and Fidell, 2001) as shown in Figure 6.

It is obvious that more determinants will be included if statistical confidence level increases. Arguably, applying 95 per cent confidence level appears to be most appropriate due to the fact that 99.7 per cent confidence level would include too many determinants whereas 68 per cent confidence level would leave out too many determinants. Given the 95 per cent confidence level ($Z = \pm 2$), mean (μ) = 10.07, and standard deviation (σ) = 3.63, the value (position) of the limits (X_1 and X_2) can be identified as follows:

$$X_{1,2} = \mu \pm (Z x \sigma)$$

$$\Rightarrow X_1 = 2.81, X_2 = 17.33$$

Hence, any determinant (X_{det}) lies in between the limits ($2.81 \leq X_{det} \leq 17.33$) are considered to be critical with 95 per cent confidence level. Consequently, five determinants representing "interactivity", "customisation", "supply chain integration", "price" and "return process" were removed. In addition, "internal communication" and "external communication" were also excluded because they had the same frequency as "return process" and "supply chain integration". Ultimately, a total of seven determinants (hatched rectangle in Figure 7) were eliminated and 13 determinants (solid rectangle in Figure 7) were retained.

Statistical significance at 5 per cent level included a long list of 13 determinants. As an alternative, Pareto analysis was used to explore and identify the most important determinants out of the 20 determinants. Based on the frequency distribution of the 20 determinants, a cumulative frequency curve is plotted. The first ten determinants (50 per cent out of 20) constitute 82.41 per cent value of all the determinants, which does

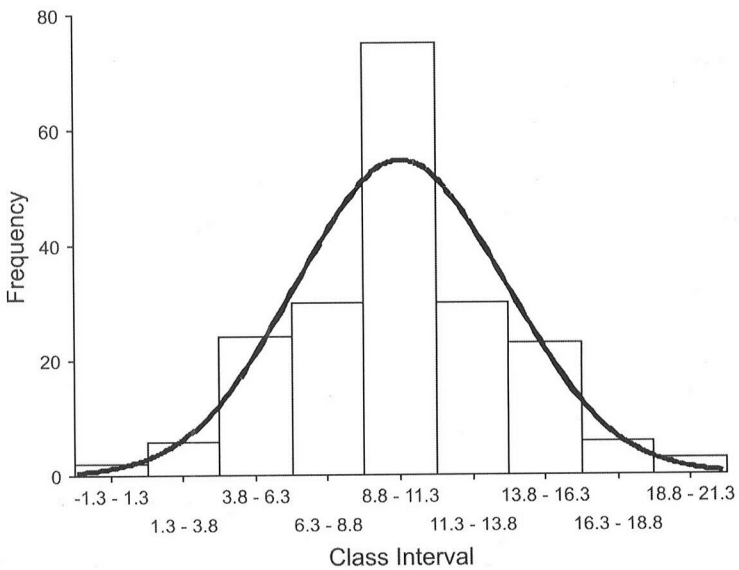
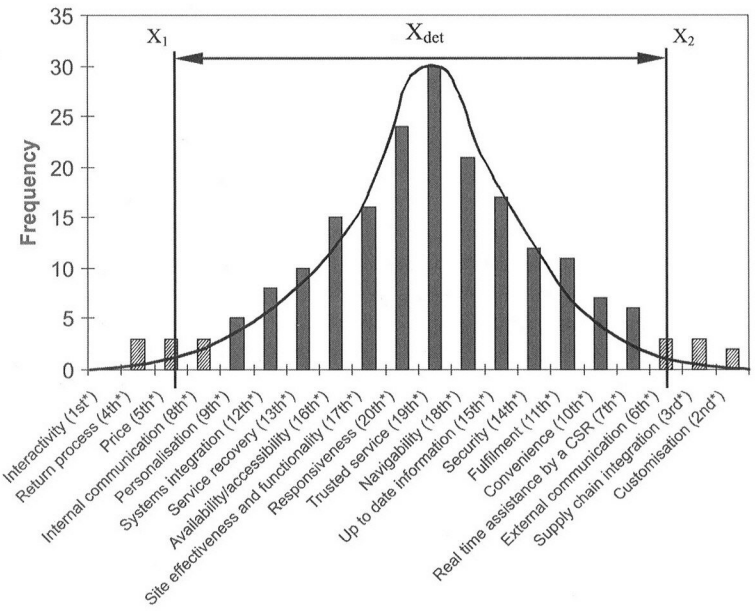


Figure 6.
Histogram and normal curve of the frequency distribution



Note: * the ranking of the determinants from lowest to highest frequency

Figure 7.
Critical determinants within 95 per cent confidence level

not conform to the 80/20 rule. As neither statistical analysis nor Pareto incorporates the individual relative weight of the determinants, optimisation method is proposed as a final alternative which would allow the identification of an optimum number of specific determinants based on the magnitude of both individual and collective contributions.

Optimisation of the determinants

In most literature, optimisation is defined as a process of selecting a better or the best solution out of existing alternatives. In some cases, a trade-off between non-dominated solutions may be required in the process if multiple criteria that construct the objective function are contradictory (Schwefel, 1995). In a mathematical optimisation, an objective function is formulated using a number of variables (Schwefel, 1995) and it is aimed at either maximum or minimum value (Walsh, 1975; Ball, 1984). In this case, functional relation between variables must be at least approximately known (Schwefel, 1995) and variables should be quantified (Walsh, 1975) Should there be several sub-goals, relative weight should be assigned to each variable (Walsh, 1975; Schwefel, 1995). Thus, prior to applying the optimisation method, "individual relative weight", "adjusted individual weight", "overall weight", and "adjusted overall weight" scores were calculated as follows:

- Overall relative weight (x) = frequency of each determinant/total frequency.
- Cumulative frequency (C_n) = accumulated frequency of successive determinants starting from the first.
- Individual relative weight (y) = number of companies that choose the corresponding determinant/total number of companies.

- Adjusted individual weight (A_{iwt}) = individual relative weight of each determinant/individual relative weight of the determinant having the highest frequency.
- Overall weight (O_{wt}) = overall relative weight multiplied by individual relative weight. Zhang and Von Dran (2001) suggested overall weight be calculated as frequency multiplied by the ranking of importance on a 1-5 scale. The rationale behind this approach is to dampen the effect of the frequency gap of one determinant over another. Nevertheless, damping effect could result in the same value of overall weight. For instance, if "Security" (frequency = 12) has an importance value of five out of five and "Availability" (frequency = 15) has an importance value of four out of five, they will end up with identical overall weight of 60, creating a paradox of which one is more important. Therefore, applying Zhang and Von Dran's approach, one can not justify which one of the two determinants is more important.
- Adjusted overall weight (O_n) = overall weight of each determinant/overall weight of the determinant having the highest frequency.

All adjusted values were calculated using indexing method with the determinant having the highest frequency i.e. "trusted service" as the reference point so that the resulting curves could be extrapolated on an equal area. Subsequently, "individual relative weight", "adjusted individual weight", and "adjusted overall weight" curves were superimposed on Pareto curve and intersected at three different points as shown in Figure 8.

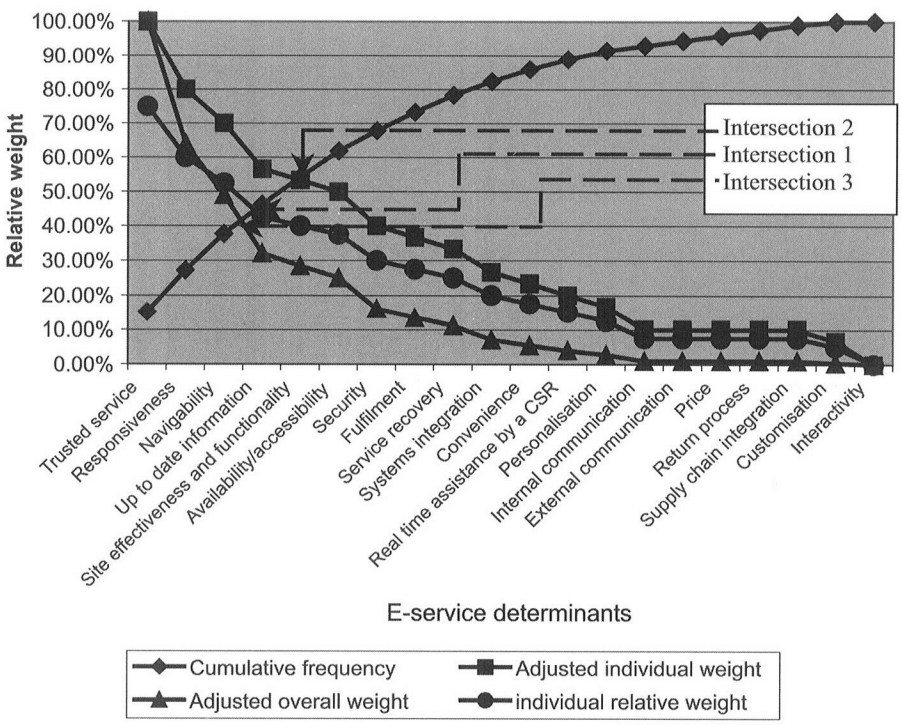


Figure 8.
Intersection points for determining the optimum number of determinants

Essential conditions for determining optimum point of intersecting curves

In order to identify the optimum point of intersecting curves, the application of intersection point must satisfy the following basic conditions:

- both curves must have the same measurement unit;
- the curves are drawn in opposite direction against each other, so that they will intersect each other at a common point (Fernandes *et al.*, 2001); and
- both curves must be continuous; hence, the intersection will point to the location of the optimum value of the objective function, which is constructed by the intersecting curves. However, discontinuity of the slope in any of the intersecting curves will create discontinuity in the objective function.

Relative frequency is used as the common measurement unit to determine the relative weight of each determinant. This process eliminates the effect of frequency distortion that may be caused due to variations in sample size. Since the other curves except Pareto (shown in Figure 8) are discontinuous, the intersection points and the optimum point do not lie on the same vertical line.

Selecting most appropriate intersecting curves to formulate objective function for optimisation

In order to find out the most appropriate intersecting curves, a distinctive intersection point needs to be selected. As shown in Figure 8, there are three possible choices of intersection:

(1) Intersection 1: Pareto and "individual relative weight".

(2) Intersection 2: Pareto and "adjusted individual weight".

(3) Intersection 3: Pareto and "adjusted overall weight".

Subsequently, a distinctive intersection point is selected based on the merits and limitations of each intersection, which is summarised in Table III.

To start with the selection process, intersection 2 is excluded because the process of transforming "individual relative weight" to "adjusted individual weight" has camouflaged the actual frequency distribution of the determinants. For example: 30 out of 40 companies (75 per cent) selected "Trusted service" and by setting 30/40 as 100 per cent reference point, this method ignored the fact that ten out of 40 companies did not select "Trusted service" as a critical determinant. This bias affects all determinants due to escalation of the value of "adjusted individual weight". Consequently, either intersection 1 or intersection 3 is proposed as the most appropriate intersection. Intersection 1 does not incorporate the "overall relative weight" of each determinant, whereas intersection 3 does. Due to this limitation, intersection 1 is considered to be inferior to intersection 3. The distinctive strength of intersection 3 is that not only do the intersecting curves have the same measurement unit but also have identical spread that incorporate the "overall weight" and "individual relative weight" of all the determinants. Therefore, intersection 3 is considered to be the most appropriate for formulating an objective function in order to seek the optimum point. Subsequently, the objective function (F_n) is formulated by summation of the intersecting curves as shown in the last column in Table IV.

Intersection	Rationale	Limitations
1	Both curves are based on relative frequencies. The overall relative frequency value of the first curve is decreasing while the curve moves upwards. In contrast, the frequency value of the second curve (individual relative weight) is decreasing while the curve moves downwards. Thus the intersection gives a balance between overall relative frequency represented by the first curve and the individual relative weight represented by the second curve	Unequal spread of the range (0-100 per cent in the first and 0-75 per cent in the second). The second curve does not incorporate the overall weight of the determinants
2	Ideally, if the first determinant positioned on the individual relative weight curve has a 100 per cent individual frequency value, it will result in equal band of frequency spread; hence a precise balance between cumulative frequency curve and individual relative frequency curve could be achieved. To do so, individual relative weight value is adjusted by making the value of the first determinant as 100 per cent as a reference point by indexing method. Since the values of each curve move in opposite directions, intersection is the optimum point	Transforming the value of individual relative weight to adjusted individual weight may cause amplification of the gap between two consecutive determinants. The second curve does not incorporate the overall weight of the determinants
3	Both curves are based on relative frequency that incorporate the overall weight of each determinant. To be able to plot the overall weight values, they are adjusted by setting the overall weight of the first determinant to 100 per cent as a reference point by indexing method. Consequently, It will create an equal band (0-100 per cent) of frequency distribution of each curve. Since the values of each curve move in opposite directions, intersection is the optimum point	Transforming the overall weight into adjusted overall weight may cause amplification of the weight gap of two consecutive determinants

Table III.
Rationale and limitation of the three intersection points

Based on the objective function (F_n), it was found that "Up to date information" has the minimum value, thus it is the optimum point (illustrated in Figure 9). This process isolated four determinants, namely "Trusted service", "Responsiveness", "Navigability", and "Up to date information". Up to date information is located to the right of intersection 3 due to the discontinuity of the curves forming the objective function.

Mathematical modelling of the optimisation process

Mathematical modelling of an optimisation process starts with an objective function, which is formed by the summation of two curves: "cumulative frequency" curve and

	F*	x (%)	C_n (x) (%)	y (%)	A_{iwt} (%)	O_{wt}	O_n (x,y) (%)	F_n (x,y) (%)
Trusted service	30	15.08	15.08	75.00	100.00	0.1131	100.00	115.08
Responsiveness	24	12.06	27.14	60.00	80.00	0.0724	64.00	91.14
Navigability	21	10.55	37.69	52.50	70.00	0.0554	49.00	86.69
Up to date information	17	8.54	46.23	42.50	56.67	0.0363	32.11	78.34
Site effectiveness and functionality	16	8.04	54.27	40.00	53.33	0.0322	28.44	82.72
Availability/accessibility	15	7.54	61.81	37.50	50.00	0.0283	25.00	86.81
Security	12	6.03	67.84	30.00	40.00	0.0181	16.00	83.84
Fulfilment	11	5.53	73.37	27.50	36.67	0.0152	13.44	86.81
Service recovery	10	5.03	78.39	25.00	33.33	0.0126	11.11	89.50
Systems integration	8	4.02	82.41	20.00	26.67	0.0080	7.11	89.52
Convenience	7	3.52	85.93	17.50	23.33	0.0062	5.44	91.37
Real time assistance by a CSR	6	3.02	88.94	15.00	20.00	0.0045	4.00	92.94
Personalisation	5	2.51	91.46	12.50	16.67	0.0031	2.78	94.24
Internal communication	3	1.51	92.96	7.50	10.00	0.0011	1.00	93.96
External communication	3	1.51	94.47	7.50	10.00	0.0011	1.00	95.47
Price	3	1.51	95.98	7.50	10.00	0.0011	1.00	96.98
Return process	3	1.51	97.49	7.50	10.00	0.0011	1.00	98.49
Supply chain integration	3	1.51	98.99	7.50	10.00	0.0011	1.00	99.99
Customisation	2	1.01	100.00	5.00	6.67	0.0005	0.44	100.44
Interactivity	0	0.00	100.00	0.00	0.00	0.0000	0.00	100.00
Total	199	100.00						

Note: F* = frequency

Table IV.
The frequency distribution and objective function of e-service determinants

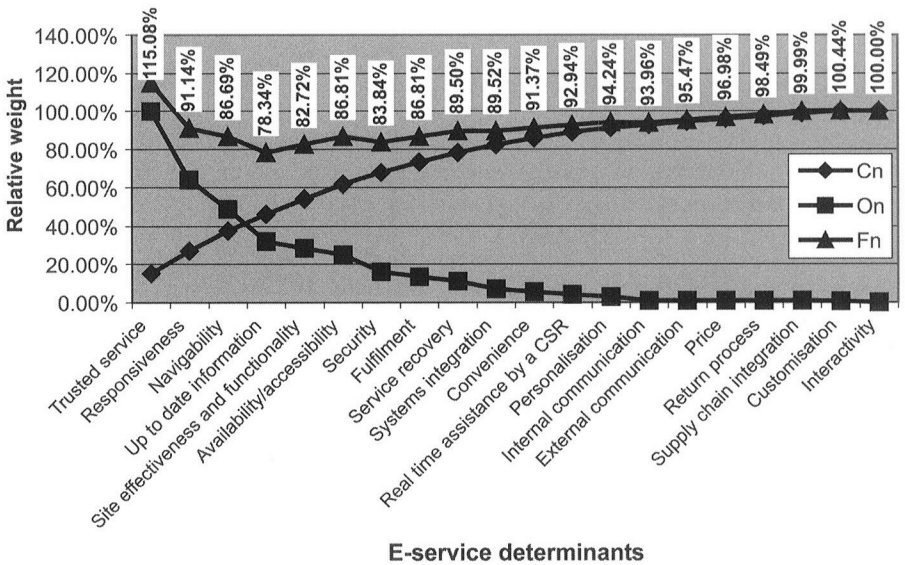


Figure 9.
Graphical representation of the optimisation process and its objective function

"adjusted overall weight curve" in order to identify optimum number of critical determinants. "Cumulative frequency" curve is a function represented by C_n (x), "adjusted overall weight" curve as O_n (x,y), and objective function as F_n (x,y); where x represents the overall relative weight, y represents the individual relative weight and $n = 1$ to 20 representing the determinants in sequential order from "Trusted service" to "Interactivity" as shown in Table IV.

Hence:

$$F_n(x,y) = C_n(x) + O_n(x,y) \tag{1}$$

where:

$$C_n(x) = \sum_{i=1}^{n} x_i \tag{2}$$

$$O_n(x,y) = \frac{x_n \cdot y_n \cdot 100}{x_1 \cdot y_1}. \tag{3}$$

Therefore:

$$F_n(x,y) = \sum_{i=1}^{n} x_i + \frac{x_n \cdot y_n \cdot 100}{x_1 \cdot y_1} \tag{4}$$

In static optimisation, the optimum is time invariant and its purpose is to determine the location of the extremum and its size once and for all (Schwefel, 1995). The above mathematical function has found the number of determinants to be four and the location of the extremum at "Up to date information" and its corresponding optimum value is 78.34 per cent. In this case, it can be readily shown from equation (4) that F_n will have a minimum value when "n" equals to 4.

Research findings and conclusions

Optimisation method was found to be the most effective in isolating critical determinants when compared to Pareto and statistical significance test. Mathematical modelling of the optimisation process was developed in which an objective function was formulated. Based on the objective function, the location of the optimum point was determined which extracted the optimum number of critical determinants. The critical determinants identified by optimisation method are "Trusted service", "Responsiveness", "Up to date information", "Navigability" and together they may form the foundation of successful e-service operations. These four determinants encompass three processes of e-service operations and they are most likely to have a significant impact on customer's perception of service quality. Moreover, the research finding also suggests that "trusted service" is the most influential determinant of e-service operations, which strengthens the extensive view of academics and practitioners on the effect of trust in e-service operations (Barua *et al.*, 2001a; Voss, 1999; Fellenstein and Wood, 1999).

Most of the academic literatures (Voss, 2002; Srinivasan *et al.*, 2002; Ahmad, 2002; Wolfinbarger and Gilly, 2002; Zhang and Von Dran, 2001; Zeithaml *et al.*, 2000;

Symanski and Hise, 2000; Li *et al.* 1999) have focused on identifying essential determinants of e-service operations from customers' perspective but few (Duffy and Dale, 2002; Singh, 2002; Jeffcoate *et al.*, 2002) studied the determinants from companies' point of view. In general, they all confirmed the importance of the 20 determinants identified in the present study.

In particular, the determinants isolated by optimisation technique are well supported by the findings of Singh (2002). Her findings suggested e-search, e-response, e-transaction and e-payment, e-assurance and trust, and e-help and e-technologies as the key determinants in e-service operations. "Navigability" and "Up to date information" are part of e-search; similarly, "Fulfilment" falls within e-transaction and e-payment. In addition, "Trusted service" is part and parcel of e-assurance and trust whereas "Responsiveness" is literally represented as e-response. In addition to our optimised determinants, e-help and e-technologies include other essential determinants identified in the literature such as "CSR", "interactivity" and "site functionality".

The 20 identified determinants of e-service operations were incorporated into the service processes (design, marketing, and delivery) based on the definition of each determinant. Five determinants were established as the core determinants in the Venn diagram (Figure 2). It is important to note that the critical determinants, found through optimisation method and by using Set Theory of the Venn diagram, are in close agreement. However, "Service recovery" isolated by Set Theory as one of the five determinants in the overlapping common area of the three service processes (Figure 2) did not come out as a critical determinant when companies' responses were evaluated using optimisation method. It is argued that if service is delivered right first time and service consumption generates satisfaction, there is no requirement of service recovery. However, in the real world, there is always a chance of a service failure starting from service delivery to the entire service consumption period. Hence, service recovery could be vital in e-service operations.

In addition to the optimisation technique, the conceptual framework of e-service operations integrating three service processes, service consumption and service quality would provide better insights and understanding for e-service providers in developing their e-service operations. By incorporating both overall and individual weight of the determinants, optimisation technique gives a more comprehensive picture of the actual weight of the determinants and offers a sound and reasonable solution on deciding what and how many critical determinants to concentrate. Subsequently, few sector specific determinants should be added on top of those critical determinants for successful e-service operations. Finally we conclude that the application of optimisation method may assist companies in isolating the optimum number of critical determinants, which would provide management a clear focus and enable them to deploy valuable resources judiciously in their e-service design, development and deployment.

Limitations and future research directions

This research has few limitations, in which future research may be carried out:

- Although different sectors have been accommodated, identification of sector-specific determinants was not possible due to relatively small sector-specific sample representation. Hence, the similarities/dissimilarities of the determinants across different sectors could not be assessed. The finding of this study is likely

to be biased to the ICT sector due to the majority representation of the ICT companies participating in the survey. Majority of the companies responded to the survey were in ICT sectors and as a result findings may reflect (more towards) this sector.

- The correlation between the determinants was not explored. Hence, the interdependence or otherwise of the determinants could not be evaluated.
- The respondents' view may not represent the company's view as a whole although their selections of the determinants were regarded as the view from the service provider's perspective.
- The generalisation of empirical findings of this study is considerably limited due to the poor response rate, hence sample size. This would affect the overall results of all the applied techniques. A change on the sample size would alter the frequency distribution of the determinants and eventually change the order of the determinants. It may also shift the cut-off point of the critical determinants in the optimisation process.

Future work could explore any of the above mentioned limitations and finally, a study comparing the critical determinants from the service provider's view and those of customer's will identify the common critical user-provider determinants on which any e-service providers should prioritise to deliver successful e-service operations. Further empirical research could also explore the relationships (if any) between the determinants.

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