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Service quality and ERP implementation: A conceptual and empirical study of semiconductor-related industries in Taiwan

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Abstract

This paper examines the effectiveness of the implementation of enterprise resource planning (ERP) in improving service quality in the Taiwanese semiconductor industry by assessing the expectations and the perceptions of service quality from the perspectives of both upstream manufacturers and downstream customers. The study first establishes a modified service quality gap model incorporating: (i) the downstream customers' expectations and perceptions, and (ii) the upstream manufacturers' perceptions of the customers' expectations and perceptions. An empirical study by questionnaire survey is then undertaken to investigate the gaps proposed in the research model. The results show that service quality gaps do exist in the Taiwanese semiconductor industry between upstream manufacturers that are implementing ERP and their downstream customers. The study shows that the proposed model provides valuable guidance to manufacturers with respect to the prevention, detection, and elimination of the demonstrated service quality gaps. The model thus helps manufacturers to evaluate the contribution of various ERP modules to improved customer satisfaction with service quality and also provides guidance on improvement strategies to enhance service quality by eliminating quality gaps.

Keywords: Enterprise resource planning (ERP); Semiconductor industry; Service quality gaps; ERP implementation

1. Introduction

The current business environment is undergoing dramatic change as companies face increasing competition, expanding markets, and rising customer expectations. To remain competitive, manufacturers must reduce total costs in the entire supply chain, shorten throughput times, reduce inventories, expand product choices, provide reliable delivery, ensure enhanced customer service, improve quality, and coordinate demand, supply, and production more effectively [1]. To achieve these objectives, firms must improve their own business practices and operational processes. This involves a sharing of in-house information (which has traditionally been aggressively protected) with their suppliers, distributors, and customers [2]. For timely communication and accurate information, many companies have been turning to enterprise resource planning (ERP) systems. These enterprise wide, on-line interactive systems support cross functional processes and provide seamless integration to enable prompt responses to customers' demands. Using ERP systems, the overall resources of an enterprise can be planned, managed, and integrated effectively.

A successful ERP system can help an enterprise to reduce operating costs, generate more accurate forecasts of demand, accelerate production cycles, and enhance customer service [1]. ERP also results in inventory reduction—because material management planners have access to more accurate data (such as how much inventory is already in the pipeline), and can thus achieve more accurate forecasting of future demand [3]. In addition, ERP systems lead to improved cash management, reduction in personnel requirements, and reduction in overall information technology costs by eliminating redundant information and computer systems [2,3].

Over the past two decades, the electronics industry has grown to become the dominant economic contributor and strategic business sector for many industries. According to the Industrial Technology Research Institute [38], the semiconductor industry

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has become the leading economic contributor to the Taiwanese economy. In achieving this, the Taiwan semiconductor industry has distinguished itself as a comprehensive industrial supply chain. The structure of the semiconductor industry in Taiwan consists of upstream, midstream, and downstream segments working together cooperatively in an integrated chain [50].

Although the semiconductor industry has become the largest and the most profitable manufacturing sector in Taiwan, manufacturers are nevertheless facing extremely severe competition, both domestically and globally. Material requirement planning (MRP) and manufacturing resources planning (MRP II) were both widely adopted by semiconductor manufacturers in Taiwan several years ago. However, as this traditionally 'product-oriented' market has become more 'customer-oriented' in the face of increasing competition, expanding markets, and rising customer expectations, manufacturing firms have been quick to discard the old information systems and adopt ERP in their place. The development and implementation of ERP systems are thus having a profound effect on the contemporary semiconductor industry in Taiwan.

The purpose of this paper is to assess whether the expectation and the perception of service quality dimensions, from both the upstream manufacturers' perspective and the downstream customers' perspective, are improved by ERP in Taiwan's semiconductor-related companies. This emphasis on service quality is becoming increasingly important in manufacturing industry. Indeed, in the cyber-manufacturing industry, service quality has effectively replaced traditional product quality as the main determinant of customer satisfaction. For example, to increase supply flexibility and to improve customer satisfaction and loyalty, the Taiwan Semiconductor Manufacturing Company (TSMC) has positioned itself as a 'service provider', rather than as a 'manufacturer'. It not only supplies tangible wafers to its customers, but also provides customer services—such as identifying appropriate back-end manufacturers or providing real-time production information. As Madu [4] noted, quality can be defined as "... an organization-wide effort to continuously improve products and services delivered to customers by developing supporting organizational culture and implementing statistic and management tools". The essence of ERP is closely aligned to these objectives as it seeks to enable effective management of information and the delivery of high service value [5]. Although most studies in this field have analyzed operational performance in evaluating the benefits of ERP [6–12], the present authors contend that customer satisfaction with service quality is also an important measure of the success of ERP.

Parasuraman et al. [13,14] posited that service quality could be understood as the gap between a customers' expectations of a service and his or her subsequent perception of the service providers' performance. These authors proposed a model of service quality that included five service quality gaps that were said to have a significant influence on a customers' evaluation of service quality [15,16]. In a similar vein, Zeithaml and Bitner [16] noted that it is important that management, employers, and customers all play a role in managing the gaps between expectation and perception. In particular, to manage service quality effectively, managers have to know where the gaps are, and then take effective steps to reduce (or close) them.

The present study therefore modifies the service quality model developed by Parasuraman et al. [13] in proposing a new service quality gap model that will enable service providers who have implemented ERP to evaluate their service quality in terms of customer satisfaction. In this study, four kinds of service quality gaps (SQGs) are defined and incorporated in a survey mailed to semiconductor-related companies. The results of this survey facilitate the identification of quality gaps—thus providing an opportunity to assess improvement strategies to bridge the identified gaps.

The structure of the remainder of this paper is as follows. Following this introduction, Section 2 discusses the relevant research literature that is germane to ERP evaluation and service quality. Section 3 presents the conceptual model proposed for the present study. Section 4 outlines the methodology used in this study. Section 5 presents the findings of the study. The final section summarizes the conclusions.

2. Literature review

2.1. ERP

ERP has been promoted by the American Production and Inventory Control Society (APICS) since 1980 [45]. In manufacturing industries, ERP systems have superseded both material requirement planning (MRP I) systems and manufacturing resource planning (MRP II) systems. However, ERP has broader applications beyond manufacturing [17]. It integrates application programs for a range of business functions – including sales, accounting, and manufacturing – using a common database that serves as the integrating mechanism [18].

ERP provides two major benefits that do not exist in non-integrated systems: (i) a unified enterprise-wide view of the business that encompasses all functions and departments, and (ii) an enterprise-wide database in which all business transactions are entered, recorded, processed, monitored, and reported [1]. The outputs generated from this system are integrated and consistent—thus offering substantial potential for improvements in productivity, customer service, inventory management, and cost reductions [19].

ERP systems enable all functional areas in an organization to talk directly to each other and make data available to all functional departments in real-time—thus preventing any non-optimal decision-making [23]. An important characteristic of ERP systems is the ability to implement it in modules. A company does not have to perform a full-scale implementation; rather, selected modules can be implemented on the basis of the particular needs of a given company [37].

Many recent studies have focused on ERP implementation—including the critical success factors that are involved and the pitfalls and complexities that can occur. Al-Mashari and Al-Mudimigh [39] presented a case study of a failed attempt to implement ERP to reengineer business processes. Motwani

et al. [20] compared a successful implementation of ERP with an unsuccessful attempt. Olhager and Selldin [18] presented a survey of ERP implementation in Swedish manufacturing firms. Sheu et al. [40] analyzed the similarities and differences between implementation of ERP on a national basis and implementation at a multinational level. Tatsiopoulos et al. [41] proposed a risk management methodology for the successful implementation of ERP systems and illustrated the application of the proposed methodology with a case study of a company in the oil industry. Trimmer et al. [42] discussed the critical success factors involved in implementing ERP in rural health care. Voordijk et al. [43] investigated the factors that lead to the success or failure of ERP in large construction firms. Motwani et al. [44] used a case study methodology, grounded in business process change theory, to understand the factors that lead to the success or failure of ERP projects. Ehie and Madsen [46] reviewed empirical studies that have attempted to delineate the critical issues that drive successful implementation of ERP systems. Hong and Kim [24] explored the critical success factors of ERP implementation from the perspective of organizational suitability. Gale [25] explored methods of coping with organizational changes to avoid ERP failure. Xue et al. [26] analyzed the failure of ERP implementation in China.

Although some of these studies have explored the impact of ERP systems on enterprise performance, none has linked the implementation of ERP to service quality—despite the increasing importance of service quality for business success in most manufacturing industries.

2.2. Service quality gaps

Researchers and practitioners have suggested various definitions of service. In general, services are deeds, processes, and performances [30]. However, Gronroos [29] incorporated other elements into the concept of service when he defined a service as:

> . . . an activity or series of activities of more or less intangible nature that normally, but not necessarily, take place in interactions between the customer and service employees and/or physical resources or goods and/or systems of the service provider, which are provided as solutions to customer problems.

As the above definition implies with its reference to physical resources and goods, service provision is not limited to traditional service industries; manufacturers can also be involved in the provision of services to their customers.

The broad definition of a service offered above suggested that intangibility is a key factor in deciding whether an offering is a service [16]. Measuring service quality is thus a challenging task—because the concept of service quality is inherently intangible in nature and difficult to define [48]. Service quality is not like product quality, which can be objectively measured and quantified; rather, service quality is an abstract and somewhat vague concept. The customers' perception of quality has thus been a major focus of studies of service quality. In particular, service quality has often been conceptualized in terms of a comparison of customers' expectations of a service before the event with their perceptions of the actual performance after the event [31].

On an operational level, research into the measurement of service quality has been dominated by the SERVQUAL instrument, which is based on the so-called gap model (also known as the PZB model) developed by Parasuraman et al. [13]. The model posits service as a dynamic process and the cognition of service quality as a comparison between a customer's expectation of a service and that customer's actual feelings during and after the process.

Parasuraman et al. [13] identified 10 dimensions that are used by customers to evaluate a service and develop their perceptions of its quality—(i) access; (ii) communication; (iii) competence; (iv) courtesy; (v) credibility; (vi) reliability; (vii) responsiveness; (viii) security; (ix) tangibles; (x) understanding. If customers' perceptions of performance exceed that customer's expectation, the service provider is deemed to have provided a quality service.

The concept of a gap that underlies this measurement of service quality can be extended from the evaluation of a particular service, to include an evaluation of the whole service providing process. Fig. 1 illustrates this. In this model, five gaps are identified, as follows:

- *Gap 1*: the difference between customer expectation and management perception of customer expectation.
- *Gap 2*: the difference between management perception of customer expectation and service quality specifications.
- *Gap 3*: the difference between service quality specifications and the service actually delivered.
- *Gap 4*: the difference between the service actually delivered and what is communicated about the service to the customer.
- *Gap 5*: the difference between the expected service and perceptions of the service.

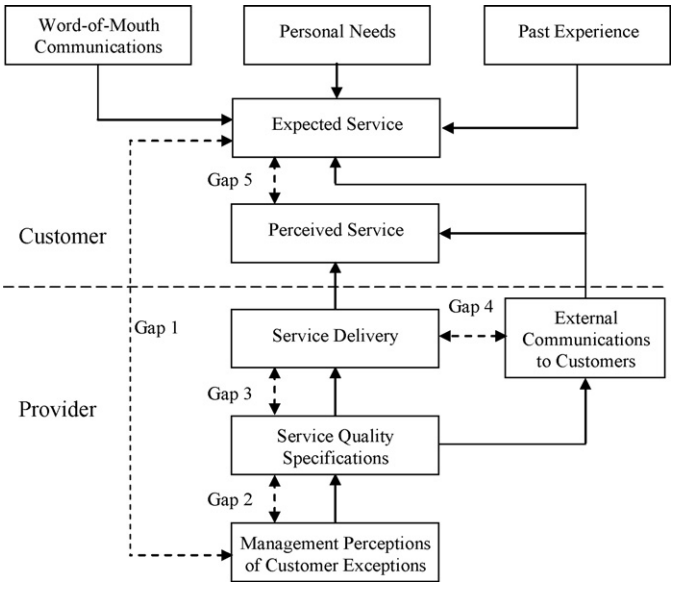

Fig. 1. PZB service quality model [13].

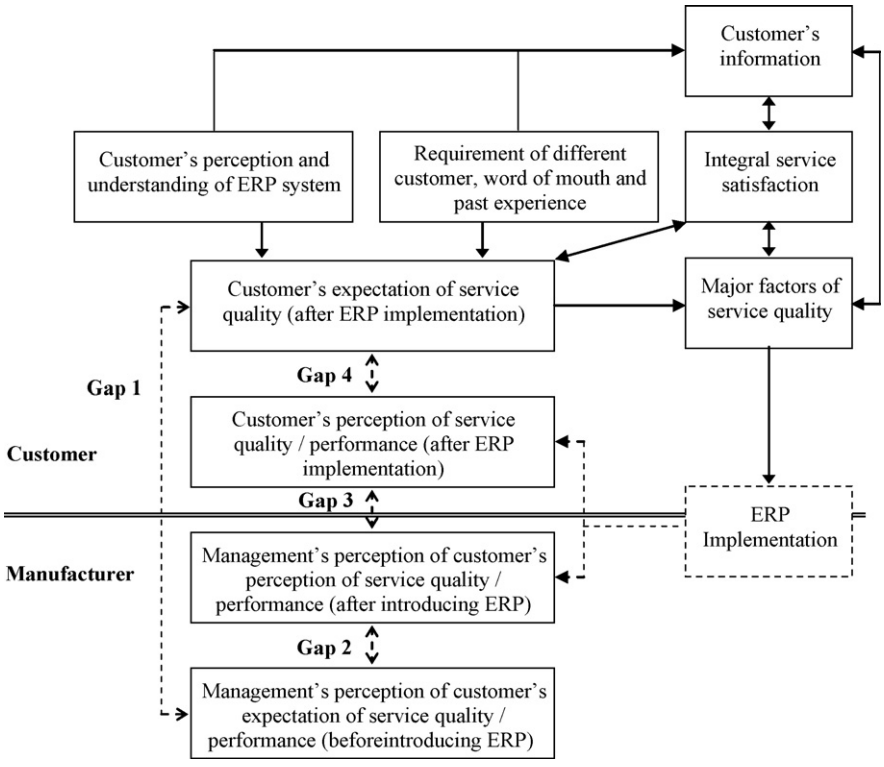

Fig. 2. Modified gap model of service quality for ERP implementation.

3. Conceptual framework and hypotheses

To investigate whether the implementation of an ERP system improves overall service quality, the present study proposes a modified gap model of service quality (see Fig. 2).

As can be seen in the diagram, four service quality gaps (SQGs) are proposed in the model:

- *SQG 1*: the difference between customer expectation of service quality and management perception of customer expectation of service quality.
- *SQG 2*: the difference between management perception of customer expectation of service quality before ERP implementation and customer perception of service quality performance after ERP implementation.
- *SQG 3*: the difference between management perception of customer perception of service quality after ERP implementation and customer perception of service quality.
- *SQG 4*: the difference between customer expectation of service quality and customer perception of service quality.

The null hypotheses for the various gaps are formally proposed as follows.

- $H1_0$: the means of management perception of customer expectations of service quality on quality measurements M_i before ERP implementation are equal to customer expectation of service quality on quality measurement M_i after ERP implementation, for $i = 1–10$.
- $H2_0$: the means of management perception of customer expectations of service quality on quality measurement M_i before ERP implementation are equal to management perception of customer perception of service quality on quality measurement M_i after ERP implementation, for $i = 1–10$.
- $H3_0$: the means of management perception of customer perception of service quality on quality measurement M_i after ERP implementation are equal to those of customer perception of service quality on quality measurement M_i after ERP implementation, for $i = 1–10$.
- $H4_0$: the means of customer expectation of service quality on quality measurement M_i after ERP implementation are equal to customer perception of service quality on quality measurement M_i after ERP implementation, for $i = 1–10$.

4. Methodology

A questionnaire survey via email was used to test the gaps proposed in the modified model presented above. To develop the questionnaire, several experienced ERP professionals and their customers in semiconductor-related companies in Taiwan were interviewed to identify the key measurements of service quality. Preliminary survey instruments were then developed on the basis of the suggestions made by these persons, together with information gleaned from a review of the related literature. These preliminary instruments were then reviewed for content validity and clarity by two leaders of ERP projects in upstream manufacturers and three downstream customers whose suppliers had implemented ERP for at least 12 months. On the basis of feedback from these persons, the preliminary questionnaires were revised. The revised questionnaires were then sent to 10 subjects in a

pilot test. The survey instruments were then finalized on the basis of this pilot test.

As noted in Section 2, in assessing the overall delivery of service quality, some service quality gaps represent the difference between customer expectations and management perceptions of customer expectations [34]. The measure of service quality thus required a comparison of responses from two samples—downstream customers and upstream manufacturers. Two forms of the questionnaire were therefore developed for different market participants—(i) form A to assess downstream customers' expectations and perceptions of service quality (and their levels of satisfaction) and (ii) form B to assess upstream manufacturers' perceptions of customers' expectations and perceptions of service quality. Each form had two sections—(i) general information and (ii) service quality evaluation.

Service quality was computed by subtracting the score for customers' expectations from that of the manufacturers' perceptions of their clients' expectations. The respondents from upstream manufacturers were people responsible for (or involved with) ERP project planning and evaluation in semiconductor-related firms. The respondents from downstream customers were people responsible for supplier management or evaluation in semiconductor-related firms.

The respondents were selected from a list of 174 semiconductor-related manufacturers provided by the Taiwan Semiconductor Industry Association [51]. No two individuals were from the same organization. Having distributed the questionnaires by email, follow-up telephone calls were made to encourage participation and to clarify any queries about the survey questions. In all, 96 copies of the questionnaire were sent to upstream manufacturers, of which 39 were returned. Three returned questionnaires were invalid, leaving 36 valid copies for analysis (a valid response rate of 37.5%). With respect to downstream customers, 156 copies of the questionnaire were issued, of which 52 were returned. Five returned questionnaires were invalid, leaving 47 valid copies for analysis (a response rate of 30%).

5. Results

5.1. Characteristics of respondents

The upstream manufacturers who had implemented ERP had annual revenue of $2.6–950 million US dollars, and the number of employees in these firms ranged from 90 to 25,000. A detailed breakdown of the characteristics of the responding companies is shown in Table 1. Of the individual respondents, 75% were at the level of manager or above, with more than 35% listing their job titles as director or vice-president.

The characteristics of the downstream customers of ERP implementers are summarized in Table 2. It should be noted that more than 41% of individual respondents listed their job titles as director or vice-president.

5.2. ERP modules implemented by firms

ERP system providers (such as SAP, JD Edward, Baan, Oracle and Peoplesoft) provide sets of standardized business systems for enterprise management, and promote their packaged ERP applications as means of improving business performance [35]. The ERP application modules contained in these sets vary with individual system suppliers. A survey of SAP, Oracle, and several other ERP system suppliers in Taiwan indicates that there are 12 ERP modules available including: (i) a sales management module; (ii) a materials management module; (iii) a personnel/human resources module; (iv) a production planning/control module; (v) a quality management module; (vi) a project management module; (vii) a financial control module; (viii) a financial accounting module; (ix) an

Table 1
Characteristics of upstream ERP implementers

Company's primary business	Percent (%)	Firm's annual revenue ($ in millions)	Percent (%)	Number of employees	Percent (%)
Foundry	17	<3	6	<100	36
IC design	38	3–15	33	101–500	22
Packaging and testing	14	15–30	17	501–1000	14
Mask	3	30–60	8	1001–3000	11
Equipment/material provider	22	60–300	14	3000–5000	8
Others	6	>300	22	>5000	9

Table 2
Characteristics of downstream customers

Company's primary business	Percent (%)	Firm's annual revenue ($ in millions)	Percent (%)	Number of employees	Percent (%)
Electronic application hardware provider	39	<15	12	<100	22
IC design	25	15–30	17	101–500	23
Foundry	18	30–60	24	501–1000	16
Packaging and testing	10	60–300	17	1001–3000	14
Others	8	>300	30	3000–5000	9
				>5000	15

Table 3
ERP modules implemented by responding firms

Module	Implementation frequency (%)	Number of companies
Sales management	64	23
Materials management	72	26
Personnel/human resources	78	28
Production planning/control	75	27
Quality management	75	27
Project management	53	19
Financial control	69	25
Financial accounting	69	25
Enterprise strategy	53	19
Applied technology	53	19
Supply chain management	42	15
Customer relationship management	47	17

enterprise strategy module; (x) an applied technology module; (xi) a supply chain management' module; (xii) a customer relationship management module.

Table 3 specifies the incidence of implementation of each module among the responding manufacturers. As can be seen in the table, the most frequently implemented modules were the 'personnel/human resources' module, the 'production planning' module, the 'quality management' module, and the 'materials management' module. The 'supply chain management' module and the 'customer relationship management' module were implemented less frequently (less then 50%). Compared with the frequency of module implementation as reported in related studies, the semiconductor-related companies in this study adopted more modules that deal with internal processes to improve internal efficiency but fewer modules communicating with suppliers or customers. The implications of these findings are discussed in more detail in Section 6 (below).

5.3. Factor analysis and construct validation

The items used to measure the level of service quality after implementing ERP are listed in Table 4. As previously noted, the 10 items listed in the table were derived from a combination of a review of the literature and the interviews conducted with upstream manufacturers and their downstream customers.

Three principal components were extracted from these items by exploratory factor analysis:

Table 4
Items used to measure service quality level after implementing ERP

Item	Service quality measurements
M1	Product quality
M2	Delivery time
M3	Product price
M4	Product defect rate
M5	Completeness of delivered documents
M6	Emphasis on customer's interests
M7	Professionalism of service personnel
M8	Customers' satisfaction with fulfilment of requirements
M9	Commitment to meeting customers' requirements
M10	Handling of customers' complaints

Table 5
Service quality factors

Factor	Item description	Factor loading	Cronbach's α
Factor 1: quality of human resources (eigenvalue: 4.1249)			
M5	Completeness of delivered documents	0.8749	0.7689
M7	Professionalism of service personnel	0.7128	0.6611
M8	Customers' satisfaction with fulfilment of requirements	0.8129	0.8134
M9	Commitment to meeting customers' requirements	0.6500	0.8813
M10	Handling of customers' complaints	0.8933	0.7892
Factor 2: quality of products (eigenvalue: 2.0928)			
M1	Product quality	0.8959	0.7905
M3	Product price	0.8537	0.6947
M4	Product defect rate	0.9126	0.8652
Factor 3: customer service (eigenvalue: 1.3131)			
M2	Delivery time	0.9228	0.8216
M6	Emphasis on customer's interests	0.6648	0.7954

- *Factor 1*: quality of human resources (items M5, M7, M8, M9, M10).
- *Factor 2*: quality of products (items M1, M3, M4).
- *Factor 3*: customer service (items M2, M6).

The principal component analysis thus resulted in a three-factor model that explained 92.89% of the variance. The extracted factors all had eigenvalues value greater than 1 (see Table 5).

Cronbach's α was used to assess the internal consistency of the factors. The results of reliability analysis revealed coefficients in Table 5, which according to Guieford [36] and Nunnally and Berstein [47] indicate high reliability.

5.4. ERP modules and service quality

A paired *t*-test was used to assess the effect of various introduced ERP modules (as listed in Table 3) upon the designated service quality items (as listed in Table 4). The results are shown in Table 6. A *p*-value of greater than 0.01 but less than 0.05 was designated as indicating a significant effect; a *p*-value of greater than 0.05 but less than 0.1 was designated as indicating a moderate effect.

As can be seen in the table, the 'quality management' module had significant effects on most of the service quality items. It had a significant effect on 'product quality', 'delivery time', 'product defect rate', 'completeness of delivered documents', and 'customer's satisfaction with fulfilment of requirements'. The 'quality management' module also had moderate effects on the service quality items of 'emphasis on customers' interests', 'professionalism of service personnel', 'commitment to meeting customers' requirements', and 'handling of customers' complaints'.

Table 6
Paired *t*-test results of effects of ERP modules on service-quality measurements

Measures of service quality	*p*-Value											
	Sales management	Material management	Human resources	Production planning	Quality management	Project management	Cost control	Financial accounting	Enterprise strategy	Technology applied	CRM	SCM
M1: Product quality	0.193	0.037**	0.322	0.593	0.023**	0.063*	0.438	0.411	0.047**	0.045**	0.182	0.014**
M2: Delivery time	0.082*	0.021**	0.096*	0.061*	0.042**	0.071*	0.385	0.415	0.073*	0.315	0.296	0.034**
M3: Product price	0.196	0.052*	0.482	0.369	0.194	0.052*	0.078*	0.072*	0.065*	0.050**	0.110	0.045**
M4: Product defect rate	0.015**	0.195	0.126	0.023**	0.036**	0.041**	0.114	0.179	0.143	0.221	0.296	0.181
M5: Completeness of delivered documents	0.034**	0.447	0.051*	0.301	0.027**	0.058*	0.162	0.064*	0.271	0.124	0.062*	0.168
M6: Emphasis on customer's interests	0.045**	0.246	0.266	0.162	0.092*	0.042**	0.199	0.257	0.026**	0.072*	0.031**	0.129
M7: Professionalism of service personnel	0.032**	0.277	0.055*	0.038**	0.081*	0.148	0.113	0.314	0.287	0.167	0.023**	0.392
M8: Customers' satisfaction with fulfilment of requirements	0.059*	0.024**	0.067*	0.156	0.029**	0.033**	0.198	0.281	0.039**	0.332	0.092*	0.062*
M9: Commitment to meeting customers' requirements	0.1863	0.161	0.050*	0.361	0.088*	0.028**	0.275	0.332	0.021**	0.456	0.142	0.057*
M10: Handling of customers' complaints	0.064	0.078*	0.055*	0.456	0.093*	0.395	0.208	0.184	0.367	0.489	0.019**	0.068*

$^{*}0.05 < p\text{-value} < 0.1$; $^{**}0.01 < p\text{-value} < 0.05$.

The 'project management' module also has significant effects on service quality. It had significant effects on 'product defect rate', 'emphasis on customers' interests', 'customers' satisfaction with fulfilment of requirements', and 'commitment to meeting customers' requirements'. This module had moderate effects on 'product quality', 'delivery time', 'product price', and 'completeness of delivered documents'.

As can be seen in Table 6, the modules of 'sales management', 'personnel/human resources', 'enterprise strategy', 'customer relationship management', and 'supply chain management' were also prominent modules that had significant or moderate effects on various service quality items.

The modules of 'financial control' and 'financial accounting' were the only modules to have few effects on the service quality items. Their only effect was a moderate influence on the item of 'product price'.

5.5. *Service quality gap analysis*

5.5.1. *SQG1*

The *t*-test results for SQG1 are shown in Table 7. It is apparent that the means of customer expectation of service quality after ERP implementation were significantly higher than the means of management perception of customer expectation before ERP implementation on most service quality items. Null hypothesis $H1_0$ is thus not supported for every measurements of service quality.

It is apparent that a gap existed between the customers' expectation of service quality after ERP implementation and the manufacturers' perception of the customers' expectation. This is a significant problem, which has ramifications for the requirements and implementation of ERP systems.

5.5.2. *SQG2*

The *t*-test results for SQG2 are shown in Table 8. It is apparent that the means of management perception of customer perception of service quality after ERP implementation were higher than the means of management perception of customer expectation of service quality before ERP implementation for all service quality items. Null hypothesis $H2_0$ is thus not supported for every measurements of service quality.

It is apparent that the most significant differences occurred with respect to six service quality items—'product quality', 'product defect rate', 'emphasis on customer's interests', 'professionalism of service personnel', 'customers' satisfaction with fulfilment of requirements', and 'commitment to meeting customers' needs'. It would seem that management was of the opinion that service quality would be improved after implementation of ERP—particularly with respect to accurate real-time information providing all personnel with a better understanding of operational flow and their individual roles in meeting customers' requirements.

5.5.3. *SQG 3*

The *t*-test results for SQG3 are shown in Table 9. According to this table, the means of management's perception of customer perception of service quality were all higher than the

Table 7
Test results for SQG1

Measurements of service quality	Management's perception of customer's expectation of service quality before ERP implementation ($N = 39$)		Customer's expectation of service quality after ERP implementation ($N = 47$)		p-Value
	Mean	S.D.	Mean	S.D.	
1. Product quality	3.7114	0.5280	4.2218	0.4184	0.026*
2. Delivery time	3.5604	0.3027	4.0983	0.4171	0.027*
3. Product price	3.6100	0.6893	3.8709	0.3539	0.121
4. Product defect rate	3.6300	0.5195	4.0097	0.5210	0.049*
5. Completeness of delivered documents	4.2310	0.4555	4.4128	0.4301	0.062
6. Emphasis on customer's interests	3.7642	0.6384	4.3354	0.3635	0.023*
7. Professionalism of service personnel	4.0895	0.4299	4.5646	0.5989	0.007**
8. Customers' satisfaction with fulfilment of requirements.	3.9000	0.3943	4.2967	0.5093	0.027*
9. Commitment to meeting customers' requirements	3.8501	0.5241	4.3354	0.4448	0.012*
10. Handling of customers' complaints	4.2503	0.6540	4.5793	0.5856	0.039*

*p-value < 0.05; **p-value < 0.01.

Table 8
Test results for SQG2

Measurements of service quality	Management's perception of customer's expectation of service quality before ERP implementation ($N = 39$)		Management's perception of customer's perception of service quality after ERP implementation ($N = 39$)		p-Value
	Mean	S.D.	Mean	S.D.	
1. Product quality	3.7114	0.5280	4.1871	0.5210	0.018*
2. Delivery time	3.5604	0.3027	3.7790	0.5989	0.053
3. Product price	3.6100	0.6893	3.6700	0.5856	0.292
4. Product defect rate	3.6300	0.5195	3.8951	0.4184	0.044*
5. Completeness of delivered documents	4.2310	0.4555	4.3499	0.5093	0.162
6. Emphasis on customer's interests	3.7642	0.6384	4.2499	0.4925	0.028*
7. Professionalism of service personnel	4.0895	0.4299	4.4201	0.4171	0.012*
8. Customers' satisfaction with fulfilment of requirements.	3.9000	0.3943	4.2499	0.4301	0.045*
9. Commitment to meeting customers' requirements	3.8501	0.5241	4.2699	0.4946	0.021*
10. Handling of customers' complaints	4.2503	0.6540	4.3700	0.3539	0.076

*p-value < 0.05

Table 9
Test results for SQG3

Measurements of service quality	Management's perception of customer's perception of service quality after ERP implementation ($N = 39$)		Customer's perception of service quality after ERP implementation ($N = 47$)		p-Value
	Mean	S.D.	Mean	S.D.	
1. Product quality	4.1871	0.5210	3.8174	0.5032	0.096
2. Delivery time	3.7790	0.5989	3.3938	0.4363	0.019*
3. Product price	3.6700	0.5856	3.6600	0.6418	0.317
4. Product defect rate	3.8951	0.4184	3.5983	0.5032	0.022*
5. Completeness of delivered documents	4.3499	0.5093	4.0998	0.5963	0.028*
6. Emphasis on customer's interests	4.2499	0.4925	3.9742	0.6418	0.037*
7. Professionalism of service personnel	4.4201	0.4171	4.2851	0.5083	0.191
8. Customers' satisfaction with fulfilment of requirements	4.2499	0.4301	4.1542	0.6428	0.258
9. Commitment to meeting customers' requirements	4.2699	0.4946	4.1082	0.4629	0.085
10. Handling of customers' complaints	4.3700	0.3539	4.0128	0.6519	0.017*

*p-value < 0.05

Table 10
Test results for SQG4

Measurements of service quality	Customer's expectation of service quality after ERP implementation ($N = 47$)		Customer's perception of service quality after ERP implementation ($N = 47$)		p-Value
	Mean	S.D.	Mean	S.D.	
1. Product quality	4.2218	0.4184	3.8174	0.5032	0.046*
2. Delivery time	4.0983	0.4171	3.3938	0.4363	0.019*
3. Product price	3.8709	0.3539	3.6600	0.6418	0. 118
4. Product defect rate	3.9097	0.5210	3.5983	0.5032	0.044*
5. Completeness of delivered documents	4.4128	0.4301	4.0998	0.5963	0.046*
6. Emphasis on customer's interests	4.3354	0.3635	3.9742	0.6418	0.043*
7. Professionalism of service personnel	4.5646	0.5989	4.2851	0.5083	0.134
8. Customers' satisfaction with fulfilment of requirements	4.2967	0.5093	4.1542	0.6428	0.103
9. Commitment to meeting customers' requirements	4.3354	0.4448	4.1082	0.4629	0.281
10. Handling of customers' complaints	4.5793	0.5856	4.0128	0.6519	0.022*

*p-value < 0.05

means of customer perception of actual service quality after ERP implementation. Null hypothesis $H3_0$ is thus not supported for every measurements of service quality.

Six items showed a significant difference. It is apparent that manufacturers overestimated the customers' perceptions of actual service quality. This result has potential implications for the accuracy of suppliers' assessments of appropriate improvement actions.

5.5.4. SQG 4

Table 10 shows the t-test results for SQG4. According to Table 10, the means of customer expectation of service quality were all higher than the means of customer perception of service quality. Null hypothesis $H4_0$ is thus not supported for every measurements of service quality.

Six items showed a significant difference: 'product quality', 'delivery time', 'product defect rate', 'completeness of delivered documents', 'emphasis on customers' interests', and 'handling of customers' complaints'. These results indicate that manufacturers need to make more efforts to provide better service quality with respect to these items. In addition, as shown in Table 10, customer satisfaction with other items were lower than customer expectation—albeit not significantly. Manufacturers also need to consider improvements in these items.

6. Management implications

Most firms in semiconductor-related industries in Taiwan are manufacturers; they adopted the modules ''personnel/human resources'', ''production planning/control'', ''quality management'', and ''materials management'' in the early stage, in order to improve the production efficiencies and process quality. It is therefore that the aforecited modules are with high implementation frequency. But the other modules are with low incidence of implementation. Among the ERP modules adopted by the manufacturers, some had a more significant effect on service quality than others. These included: ''quality management'', ''project management'', ''enterprise strategy'', ''customer relationship management'', ''supply chain management'', ''sales management'', and ''personnel/human resources''.

In an era where global competition is highly intense, a customer-orientation business is vital for these companies. They need to be responsible to the customers' requirements and expectations quickly and completely. The firms must enhance the applications of those modules with significant effects on the service quality, especially the modules ''customer relationship management'', ''supply chain management'', ''project management'', and ''enterprise strategy'', which are somewhat neglected by the industries before. Besides, the semiconductor-related firms also need to put more attention on the implementation of the modules ''material management'', ''production planning'', and ''technology applied'', since these modules significantly affect on the ''product quality'', ''delivery time'', and ''product price''. These measures of service quality are very concerned by the customers.

The ERP modules indeed have significant impacts on service quality. But the suppliers will under-estimate the customers' requirements and expectations before the implementation of ERP systems. This situation prevents the firms to provide the fulfilment level of service quality to customers. On the other hand, the firms may over-estimate the customers' perception of service quality after the implementation of ERP systems. This status will influence the firms to find out the shortages of service quality, which should be improved by the suppliers. As a result, the gaps of service quality model for ERP implementation are very serious, which cause the reduction of the degree of effectiveness of the ERP implementation. It is therefore that the finding of this research can adduce the problems of the implementation of ERP systems for the industries. If the firms will ascertain the serious problems, and adopt the perceptions of customers' requirements and expectations, and then take actions to improve the shortages of the implementation on the critical modules, the suppliers will improve the effectiveness of the ERP implementation significantly. Eventually, the customer satisfaction and customer loyalty will be raised.

The modules of 'financial control' and 'financial accounting' had only moderate incidence of implementation. Although

their effects on service quality are small, they do contribute effectively to a reduction in costs, which are very concerned by the industries. As business competition escalates and corporate resources shrink, the reduction of total costs is the strategic initiative for the suppliers. Suppliers therefore need to maintain effective usage of these two modules, in order to raise the competitive advantage.

The failure rate of the implementation of ERP systems in Taiwan is very high, due to the inappropriate introduction and implementation. In this research, we find out some critical problems of the implementation of ERP systems, which can induce the suggestions of improvement strategies for the industries. If the firms take the suitable improvement actions, the effectiveness and service quality of ERP systems can be raised. As a result, industries will improve the success rate of the ERP implementation.

7. Conclusions

In this research, we develop a useful research model, named as ''modified gap model of service quality for ERP implementation'', by referring the PZB service quality model. Base on this modified model, we design the related questionnaire and conduct the survey for the semiconductor-related industries in Taiwan. The analytic results provide many valuable findings involving the implementation of ERP systems.

One of the aims of the implementation of ERP is to raise the level of service quality, which is evaluated by the customers. It can be concluded from the present study that the implementation of ERP systems did improve service quality, and that customers did perceive an actual improvement in service quality. However, it is also apparent from the present study that the manufacturers tended to underestimate their customers' expectations of service quality and to overestimate their customers' perceptions of actual service quality. Taken together, these findings suggest that manufacturers need to make changes if they are to meet their customers' expectations and undertake improvement strategies to enhance their satisfaction.

In summary, the present study finds that manufacturing firms in the Taiwanese semi-conductor industry need to adjust both their underestimation of their customers' expectations and their overestimation of their customers' perceptions. In addition, manufacturing firms need to be discerning in their introduction and implementation of their ERP systems to ensure that they implement the more important ERP modules—that is, those that can make a significant contribution to the improvement of service quality. In particular, Taiwanese semiconductor manufacturers should be more proactive in implementing the ERP modules of 'supply chain management', 'customer relationship management', 'project management' and 'enterprise strategy'.

Besides the semi-conductor related industries, there are some other industries, e.g. personal computer, note-book computer, car manufacturers, etc. They also implement the ERP systems more popularly. They also have the same problems in the implementation of ERP, as encounter by the semi-conductor related industries. It is therefore that the analytic results and managerial implications of this research are the good guidelines for these industries.

For the academic research, the modified service quality model developed in this study can be a good reference for the study of performance analysis of the implementation of a management system on the introduction of a technologic system. It is sure that the extended researches will have important results, which are also guidelines for the industries.

References

[1] E.J. Umble, R.R. Haft, M.M. Umble, Enterprise resource planning: implementation procedures and critical success factors, European Journal of Operational Research 146 (2003) 241–257.
[2] C. Loizos, ERP: is it the ultimate software solution, Industry Week 7 (1998) 33.
[3] T. Stein, Making ERP add up—companies that implemented enterprise resource planning systems with little regard to the return on investment are starting to look for quantifiable results, Information Week 24 (1999) 59.
[4] C.N. Madu, Introduction to Quality, Handbook of Total Quality Management, Kluwer Publisher, Boston, MA, 1998.
[5] C.N. Madu, A.A. Madu, E-quality in an integrated enterprise, The TQM Magazine 13 (3) (2003) 127–136.
[6] T.H. Davenport, Putting the enterprise into enterprise system, Harvard Business Review 76 (4) (1998) 121–130.
[7] W.R. Jeanne, Surprising facts about implementing ERP, IEEE IT Pro, July/August, 1999, 65–68.
[8] R.L. Jeson, I.R. Johnson, The enterprise resource planning system as a strategic solution, Information Strategy: The Executive Journal (1999) 28–33.
[9] S. Tom, ROI making ERP add up, Information Week (1999) 59–68 (May).
[10] T.H. Davenport, Mission Critical: Realizing the Promise of Enterprise Systems, Harvard Business School Press, Boston, MA, 2000.
[11] P. Poston, S. Grabski, The impact of enterprise resource planning systems on firm performance, in: Proceedings of the First International Conference on Information System, Philadelphia, PA, 2001.
[12] L.L. Hsu, M. Chen, Impacted of ERP systems on the integrated-interaction performance of manufacturing and marketing, Industrial Management & Data Systems 104 (2004) 42–55.
[13] A. Parasuraman, V.A. Zeithaml, L.L. Berry, A conceptual model of service quality and its implications for future research, Journal of Marketing 49 (1985) 41–50.
[14] A. Parasuraman, V.A. Zeithaml, L.L. Berry, Understanding customer expectation of service, Sloan Management Review 32 (3) (1991) 39–48.
[15] C.W. Lamb, J.F. Hair, C. McDaniel, Marketing, 5th ed., South-Western College Publishing, Ohio, 2000.
[16] V.A. Zeithaml, M.J. Bitner, Service Marketing: Integrating Customer Focus Across the Firm, McGraw-Hill, NY, 2003.
[17] S.H. Chung, C.A. Synder, ERP adoption: a technological evolution approach, International Journal of Agile Management Systems 2 (1) (2000) 24–32.
[18] J. Olhager, E. Selldin, Enterprise resource planning survey of Swedish manufacturing firms, European Journal of Operational Research 146 (2) (2003) 365–373.
[19] T.C. Loh, C.L. Koh, Critical elements for a successful enterprises resource planning implementation in small- and medium-size enterprises, International Journal of Production Research 42 (17) (2003) 3433–3455.
[20] J. Motwani, D. Mirchandani, M. Madan, A. Gunasekaran, Successful implementation of ERP projects: evidence from two case studies, International Journal of Production Economics 75 (1–2) (2002) 83–96.

[23] E. Bendoly, F.R. Jacobs, ERP architectural/operational alignment for order-processing performance, International Journal of Operations & Production Management 24 (1) (2004) 99–117.
[24] K.K. Hong, Y.G. Kim, The critical success factors for ERP implementation: an organizational fit perspective, Information and Management 40 (1) (2002) 25–40.
[25] S.F. Gale, For ERP success, create a culture change, Workforce 81 (9) (2002) 88–91.
[26] Y. Xue, H. Liang, W.R. Boulton, C.A. Snyder, ERP implementation failures in China: case studies with implications for ERP vendors, International Journal of Production Economics 97 (2005) 279–295.
[29] C. Gronroos, Relationship approach to marketing in service contexts: the marketing and organizational behavior interface, Journal of Business Research 20 (1) (1990) 3–11.
[30] P.M. Lau, Service quality: a study of the luxury hotels in Malaysia, Journal of American Academy of Business 7 (2) (2005) 46–55 (Cambridge).
[31] R.D. Buzzell, B.T. Gale, The PIMS Principle: Linking Strategy to Performance, Free Press, New York, 1987.
[34] N.Y.M. Siu, J.T.H. Cheung, A measure of retail service quality, Marketing Intelligence & Planning 19 (2) (2001) 88–96.
[35] V.A. Mabert, A. Soni, M.A. Venkataramanan, Enterprise resource planning survey of U.S. manufacturing firms, Production and Inventory Journal 41 (2) (2000) 52–58.
[36] J.P. Guieford, Fundamental Statistics in Psychology and Education, 4th ed., McGraw-Hill, New York, 1965.
[37] A. Gupta, Enterprise resource planning: the emerging organization value systems, Industrial Management and Data Systems 100 (3) (2000) 114–118.
[38] Industrial Technology Research Institute, 2003, I.E.K., http://iek.itri.org.tw/industrialanalysis.html.
[39] M. Al-Mashari, A. Al-Mudimigh, ERP implementation: lessons from a case study, Information Technology and People 16 (1) (2003) 21–33.
[40] C. Sheu, H. Rebecca Yen, D. Krumwiede, The effect of national differences on multinational ERP implementation: an exploratory study, Total Quality Management and Business Excellence 14 (6) (2003) 641–657.
[41] I. Tatsiopoulos, N. Panayiotou, K. Kirytopoulos, K. Tsitsiriggos, Risk management as a strategic issue for the implementation of ERP systems: a case study from the oil industry, International Journal of Risk Assessment and Management 4 (1) (2003) 20–35.
[42] K. Trimmer, L. Pumphrey, C. Wiggins, ERP implementation in rural health care, Journal of Management in Medicine 16 (2–3) (2002) 113–132.
[43] H. Voordijk, A. Van Leuven, A. Laan, Enterprise resource planning in a large construction firm: implementation analysis, Construction Management and Economics 21 (5) (2003) 511–521.
[44] J. Motwani, R. Subramanian, P. Gopalakrishna, Critical factors for successful ERP implementation: exploratory findings from four case studies, Computers in Industry 56 (6) (2005) 529–544.
[45] C. Berchet, G. Habchi, The implementation and deployment of an ERP system: an industrial case study, Computers in Industry 56 (6) (2005) 588–605.
[46] I.C. Ehie, M. Madsen, Identifying critical issues in enterprise resource planning (ERP) implementation, Computers in Industry 56 (6) (2005) 545–557.
[47] J.C. Nunnally, I.H. Berstein, Psychometric Theory, McGraw-Hill, NY, 1994.
[48] J. Kandampully, B. Menguc, Managerial practices to sustain service quality: an empirical investigation of New Zealand service firms, Marketing Intelligence and Planning 18 (4) (2000) 175–184.
[50] Y.C. Peng, C.V. Trappey, N.Y. Liu, Internet and e-commerce adoption by the Taiwan semiconductor industry, Industrial Management and Data System 105 (4) (2005) 476–490.
[51] Taiwan Semiconductor Industry Association (TSIA), 2003, http://www.tsia.org.tw/tsia_en/service/member.asp.

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