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Analysis of Impact on ERP Customization Module Using CSR Data

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Abstract

The enterprise resource planning (ERP) system is a standardized and advanced business process that many companies are implementing now-a-days through customization. However, it affects the efficiency of operations as these customizations are based on uniqueness. In this study, we analyzed the impact of customized modules and processing time on customer service request (CSR), by utilizing the stacked CSR data during the construction and operation of ERP, focusing on small and medium-sized enterprises (SMEs). As a result, a positive correlation was found between unit companies and the length of ERP implementation; ERP modules and the length of ERP implementation; ERP modules and unit companies; and the type of ERP implementation and ERP module. In terms of CSR, a comparison of CSR processing time of CBO (customized business object) module and STD (standard) module revealed that while the five modules did not display statistically significant differences, one module demonstrated a statistically very significant difference. In sum, the analysis indicates that the CBO-type CSR and its processing cost are higher than those of STD-type CSR. These results indicate that companies planning to implement an ERP system should consider the ERP module and their customization ratio and level. It not only gives the theoretical validity that should be considered as an indicator for decision making when ERP is constructed, but also its implications on the impact of processing time suggesting that the maintenance costs and project scheduling of ERP software must also be considered. This study is the first to present the degree of impact on the operation and maintenance of customized modules based on actual data and can provide a theoretical basis for applying SW change ratio in the cost estimation of ERP system maintenance.

Keywords

Customization, ERP, Information System, Package Software, Project Cost Calculation

1. Introduction

Information systems enable technology, and an organization that is not controlled and aligned with its business strategy will cease to have a competitive advantage [1]. Many Korean and foreign management organizations responded quickly to the rapidly changing business environment and strengthened their international competitive advantage by investing heavily in enterprise resource planning (ERP) systems, to leverage technology and improve the organization's performance [2]. ERP system is a group of modules linked to a single database [3] using modular and quality software [4] that integrates key domains, including various business activities of an organization, into a simplified and integrated system. ERP system integrates all departments and functions of the company into a single computer system that

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can meet the specific needs of other departments [5].

ERP uses a comprehensive software packaging solution to standardize the organization's business processes, such that it provides standard business processes to customers based on best practices [6], and also provide unique references, consistency, and suggestions based on standard management rules [7]. However, in most cases, organizations perform their business processes in a unique way and some of its functionalities will tend to be unviable; hence, they are faced with two options to either reflect on the process or define the system [6]. ERP customization creates a difference between the capabilities provided by standardized, off-the-shelf ERP package solutions and the requirements of specific organizations [6].

ERP customization [8] is a series of activities that meet the needs of the enterprise by aligning and modifying the functions of the system to suit the company's business or production environment. ERP customization [3] requires custom coding by modifying or extending software functions to integrate with the existing ERP systems. This can improve the functionality of the existing ERP systems and primarily perform tasks that involve a specific task management process. Particularly, studies of Quiescenti et al. [9] indicated that modifying unique business processes may threaten the survival of small businesses as they create a competitive advantage to the enterprise. Khadrouf et al. [3] pointed out that an increase in the overall life cycle or unexpected challenges could increase costs, and very high levels of customized systems could result in companies relying on ERP suppliers to create a risk of task permanence and, in the long run, depend on other technical components like hardware (HW), software (SW), and operating system (OS). As a result, the data released by companies operating with ERP show unsatisfactory results, such as analysis of an entity's Information Society Index (ISI) within its group that indicate the extent to which the entity is pursuing information services [10]. Many companies that establish ERP fail more than traditional ones due to reduced initial scope of deployment, budgeting, delivery delay, education, and training [11]. Particularly, a framework [12] was proposed that could result in a failure to introduce ERP, due to its large resource investments, decline in productivity and increased maintenance costs that could put the enterprise at risk. A classification of the ERP system is considered in its implementation [5], or a framework incorporating real-time fault management applications.

As such, customizing is inevitable in the introduction of ERP, despite the high levels of technical, operational, and strategic risk to the enterprise's operation itself. Studies on how customized modules affect the operational stage of the ERP is insufficient.

Therefore, in this study, we intend to compare and analyze the impact of ERP customization and how customized modules affect customer service requests (CSRs) based on the number of CSRs and processing times.

This study empirically proves the impact of ERP software customization levels on operation, which not only theoretically supports the need to reflect project cost estimates for SW construction and operation, but also provides a starting point for raising policy questions about how to estimate the cost of commercial SW.

2. Preliminary Research

A recent study on ERP systems have been analyzed and classified as: studies related to the adoption of ERP packages, studies related to CSF derivation and weighting of ERP construction and operation,

studies related to ERP utilization and diffusion, studies related to ERP management strategies and performance-related factors and measurements, and studies related to ERP customizing factors and models; as shown in Table 1.

Table 1. Classification of preliminary research

	Research
ERP package selection	[1], [13], [14], [15]
CSF and weight estimation of ERP	[5], [11], [17], [18]
ERP utilization and expansion	[2], [19], [20], [21]
ERP management strategy and performance measurement	[22], [23], [24], [25], [26], [27]
ERP customizing	[3], [6], [7], [28], [29], [30], [32]

Based on typical studies of the adoption of ERP packages, Issa-Salwe et al. [1] envisaged that ERP is an essential system for improving business performance and proposed a model in terms of the degree of IT-business alignment, full integration of IT/IS strategic planning, direct support for the corporate vision in strategic IT/IS initiatives, as a basis for strategic information systems alignment (SISA); and derived key characteristics for application to Saudi Arabia's changing business environment. Kim and Kim [13] presented the importance of selecting ERP modules for consultants and domain experts in relation to the division and implementation of business applications according to enterprise size. Omar and Gomez [14] presented the problem of design science research paradigm related to the introduction of mobile ERP and proposed a model for selecting the appropriate ERP system. Tenhiala et al. [15] also conducted a study that suggested the conditions under which it was more effective to use the stand-alone enterprise applications (SEAs) set among ERP systems integrated with business function-specific. As a result, It was more effective to use the SEA when the operating environment was uncertain and functional interdependence was low. Olson et al. [16] pointed out that the web ERP system adds supply chain management (SCM) and customer relationship management (CRM), and provides a SaaS-based ERP SW targeting large and small businesses, and presented a framework around the free open source (FOS)-ERP to reflect the situation in which who directs the development process is important to the ERP system. The difference between FOS-ERP and proprietary or private ERP (P-ERP) in terms of business model, selection, customizing, and evolution was also analyzed.

The study on critical success factor (CSF) derivation relating to ERP construction and operation, Kim [17] obtained three CSFs from various literature through compilation in order to manage the risks inherent in the ERP system construction and confirmed that customization has the highest importance, by measuring the relative importance of content analysis and dividing the CSF categories into four. Lee and Kim [5] identified differences in the success factors for each industry by drawing success metrics and comparing them to each of the 10 industry categories. Yi and Kim [11] divided the success factors into organizational, technological, and supplier aspects, classified the sub-success factors, and analyzed the importance using AHP techniques. Li et al. [18] derived customer service (CS) by life cycle of the ERP system from the information technology governance (ITG) point of view, classified the life cycle of the ERP system into five stages, analyzing the impact of CSF and presenting a way to manage and predict each life-cycle stage by exploring the performance of the ITG derived by the ERP.

Based on the studies related to ERP utilization and diffusion, Ha and Ahn [19] reported through a usability study that examines whether there are differences in CSR with companies that actively utilize

ERP having a high percentage of work and system improvements, to that of groups that do not have them. Maas et al. [2] demonstrated that organizational control and one grant level are positively related to the use of ERP system through the study of the association between ERP system utilization and organizational control and authorization of the ERP system, and it can also be linked to ERP system success. Kumar et al. [20] proposed that ERP usability problems are factors that greatly affect adaptability, and presented a fuzzy model using the Mamdani fuzzy inference approach to assess the usefulness associated with ERP systems such as navigation, presentation, learnability, user-defined task support by using incorrect and ambiguous usability indicators. Shi and Wang [21] proposed a SIST (Strategic alignment, Intellectual and Social capital integration, and Technology integration)-integrated portfolio model that can evolve to a level of business maturity, including strategic coordination for integration, intellectual, social capital integration, and technology integration along with the importance of integrating big data with existing ERP transaction data, with the integration of big data streaming from various social media platforms and Internet of Things (IoT), and with the integration of big data and business analytics (BA).

Based on studies related to the assessment and measurement of ERP management strategies and performances, Kim and Choi [22] derived management support, competition, management innovation, provider capabilities, technology compatibility, information system maturity factors through empirical studies of factors affecting the introduction performance of the ERP system in SMEs, and Yang et al. [23] analyzed the post-site implementation effects of the deployed ERP system; empirically analyzed the effects of the user's rejection and operational efficiency of the system, as well as the operational difficulties found after the system's on-site application.

A dissertation of on the measurement of non-financial performance [24], studied the adjustment effect of internal performance in the course of ERP system, introduction factors affecting business performance, confirming decentralization, concentration, standardization of tasks, and interdependence among departments have become variables of internal performance control in the measurement of management performance. Seo and Kim [25] analyzed the causation between quality factors to present a research model for measuring ERP service quality, as productivity, convenience, satisfaction, quality of service, and acceptance of the system were derived as the main factors for measuring the most appropriate quality of service. Kwon and Chae [26] conducted a study on performance assessment indicators and impact analysis for businesses and public companies in their peer group that performed customization; and Mohanta and Patnaik [27] presented a step-by-step process flowchart with performance parameters and cost-effectiveness that took into account customization, performance assessment, success factors, and the need for ERP.

Most of the studies regarding customization in relation to ERP, was mainly done by analyzing [3] why ERP customization was needed, and theses that presented a customization model [6,7] that analyzed the risk of customizing [3], or that provided a stable and maximum meeting the requirements. Particularly, regarding the reasons for ERP customization, Rothenberger and Srite [28] drew results in excessive customization of ERP SW due to unnecessary redevelopment, cultural issues, and resistance to changes in acceptance of projects, insufficient weighting of the implementation team's recommendations, and lack of opposition from the implementation team; and Zach and Erik Munkvold [29] divided the ERP life cycle into pre-customization and derived resistance to change, unique business processes, functional misfit, ownership type and motivation for the ERP implementation as pre-ERP customization factors and organizational stage of growth, maturity of ERP systems as post-ERP customization factors. On the other hand, Lee et al. [30] presented factors to consider in ERP customization to minimize the risk posed by

GAP between the functions of the ERP package and the requirements of the enterprise, and guidelines for decision tree models [31], which are complex rules and techniques for modeling its behavior; and Li et al. [32] presented a solution to the risks arising from inconsistencies in strict administrative law and flexible market law by analyzing the basic conditions for deployment at the time of ERP adoption.

So far, despite many customizing-related studies in relation to ERP, there is no measurement study on how much customizing in actual deployment affects users, and there is no study on how the effects of customizing should be considered in operations during deployment. Therefore, this study proposes a method to measure the effect that customizing has on operations by comparing the customizing modules with the modules derived from operation CSR data and suggests ways to reflect the measured relationships in practice.

3. Analysis of Impact on ERP SW Customizing Module

3.1 Overview

Upon implementation of an ERP system, it is classified as a commercial SW in SW operation and maintenance and the maintenance costs are calculated by reflecting only business importance and maintenance characteristics. Since there are no explicit indices for change and expansion rates for every module, we assumed that STD (standard) and CBO (customized business object) modules have equal weights. Then, we analyzed the assumption of equal weights by comparing the difference in CSR while operating the system according to the levels of STD and CBO modules.

The purpose of this study is to analyze how the customizing module affects operations and use the resulting significance levels and correlations to propose practical alternatives. Also, to examine the practical applicability of the empirical analysis, this paper presents an improved model to estimate costs for ERP SW operation and maintenance based on customizing risk premiums.

3.2 Research Design

For this study, the same ERP system was introduced, at which point the output and operational CSR data were collected from six SMEs that had been customized at the time of implementation, and the CSR rates and processing times were compared. The detailed research procedure and method are shown in Fig. 1. In relation to the first stage of enterprise selection, the study found that Samsung SDS targets SMEs that have adopted UNIERP, Korea's first ERP solution developed for SMEs companies. In consideration of the studies that SMEs companies have high customization impact and sensitivity in the enterprise [3], a total of six companies were selected as public, semiconductor manufacturing, and chemical manufacturing companies. However, the number of employees and sales were not considered in candidate companies of the same industry, reflecting the results of the research [22] that firm size does not have a significant effect on the introduction of ERP system and its performance. Second, after establishing ERP to secure consistent and reliable operational data, we selected companies that were evaluated for high utilization and success in terms of operation. Third, analytical data are extracted from each company, and purification is performed to exclude data that are not suitable for comparative analysis.

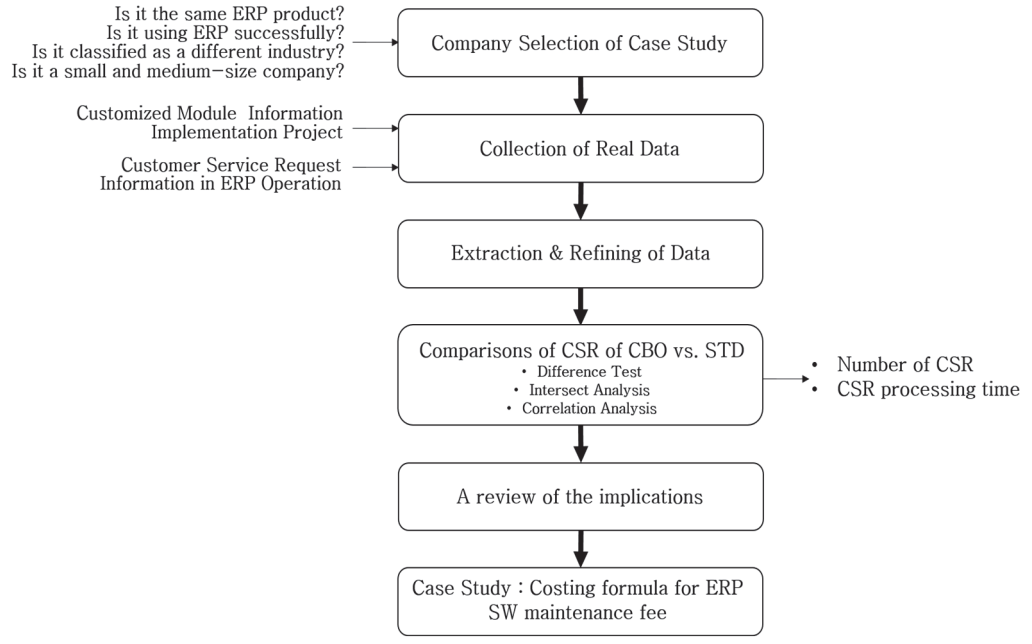

Fig. 1. Research design.

Using the refined data, difference test, intersect analysis, and correlation analysis are conducted to understand the number of CSR cases depending on whether a module is customized for operation. To this end, a difference test and intersect analysis are executed for four years of data since ERP implementation. Based on the results, the Phi correlation coefficients among individual companies, ERP modules, and ERP construction types are used to compare the correlation among them. Lastly, differences in the amount of time required for CSR processing and the results of correlation analysis are summarized. After this, the implications of the produced results are reviewed and applied to calculate the commercial software costs in Korea to validate their practical utility.

3.3 Overview of Case Study Information

An overview of the companies covered is shown in Table 2. The name of each company is written in English initials, and the overview of the company is summarized in terms of industry, industry classification, annual sales, company characteristics, project cost, year of completion, operation period after completion, and applied ERP module. Each module has a sub module, and the effect of the customizing of each sub module on the cohesion and coupling of each module may vary depending on the design. In view of this, CSR was measured in UNIERP's top-level business modules. Therefore, among the Implemented Modules in Table 2, the module without customization in the enterprise, the quality management module to indicate only good or bad through ERP, and the master data management module which is the metadata of ERP SW itself were excluded from the analysis data. Finally, seven modules including Controlling, Financial accounting, Inventory management, Material management, Personnel/PayRoll management, Production planning, and Sales & distribution were selected.

Table 2. Overview of case companies and information

	Company A	Company B	Company C	Company D	Company E	Company F
Business	Medical & antibiotics	Healthy & bio	Home appliances components	Sound equipment	Economic policy	Forestry promotion agency
Industry type	Chemical manufacturer	Chemical manufacturer	Electronics manufacturer	Electronics manufacturer	Public sector	Public sector
Annual sales	$162,620,519	$24,044,051	$9,824,451	$91,350,159	$28,439,200	$53,099,166
Company characteristics	Manufacture of medicinal compounds and antibiotics	Plant factory, natural raw materials, health functional food manufacturing (OEM, ODM)	Manufacturing films, condenser and power supplies that are essential for LCD, PDP, LED TV and STB, LED lighting and home appliances	ODM Bluetooth earphone manufacture and delivery	A government-affiliated research institution	A government-affiliated institution
Project cost (million)	2.5	2.0	2.0	3.0	2.2	2.5
Time of "going live"	2010.08	2014.09	2014.03	2015.05	2014.12	2012.12
Experience since "going live"	2010.09–2014.08	2014.10–2018.09	2014.04–2018.03	2015.06–2019.05	2015.01–2018.12	2013.01–2016.12
Implemented Module	Configuration Controlling EIS Financial accounting Inventory management Master data management Material management Personel/PayRoll management Production planning Quality management Sales & distribution System management Electronic tax invoice	Configuration Controlling Financial accounting Inventory management Master data management Material management Personel/PayRoll management Production planning Quality management Sales & distribution System management Electronic tax invoice	Configuration Controlling Financial accounting Inventory management Master data management Material management Personel/PayRoll management Production planning Quality management Sales & distribution SCM System management Electronic tax invoice	Configuration Controlling EIS Financial accounting Inventory management Master data management Material management Multi company Personel/ PayRoll management Production planning Quality management Sales & distribution System management Electronic tax invoice TAX	Configuration Financial accounting Master data management Personel/PayRoll management System management Electronic tax invoice	Financial accounting Master data management Personel/PayRoll management Sales & distribution System management Electronic tax invoice TAX

3.4 Comparison Analysis between Customizing Module in ERP Implementation and Operational CSR

We analyzed the ratio of CBO and CSR module cases in each module. The number of CSR cases generated for 4 years since the introduction of ERP was used to conduct an in-depth analysis of the difference between STD and CBO modules, upon implementation, ERP modules were categorized into CBO and STD types, and the number of CSR cases during the operation of each model was determined using business data collected over 4 years in the field. To this end, we defined the following four alternative hypotheses, and verified their differences and relationships via difference analysis, cross analysis, and regression analysis.

H1: There will be yearly differences in the number of CSR cases after ERP implementation.
H2: There will be differences in the number of CSR cases by company depending on the ratio of implementation types (CBO and STD).
H3: There will be differences in the number of CSR cases by module depending on the ratio of implementation types (CBO and STD).
H4: The higher the proportion of CBO type, the more the number of CSR cases will become.

In other words, we analyzed differences in the number of CSR cases during the 4 years of operation after ERP implementation using difference analysis. We also analyzed the differences between companies and between modules using cross analysis. Ultimately, we verified if there is a difference in the total number of CSR cases between CBO and STD types using cross analysis.

3.4.1 Difference test on the number of CSR cases in each year after ERP implementation

A χ^2 difference test on the number of CSR cases was executed, and the results indicated statistical significance, as shown in Table 3 (χ^2=27.799, p<0.001). More specifically, there were a total of 2,810 CSR cases for four years, with the most taking place in the first year, at 771 cases (27.4%). The number of CSR cases rapidly decreased in the second year, with just 587 cases (20.9%), but it increased to a certain level in the following years, with 712 cases (25.3%) in the third year seeing and 740 cases (26.3%) in the fourth year. Therefore, we adopt the alternative hypothesis H1.

Table 3. Results of difference test after ERP implementation by year

	Total	1st year	2nd year	3rd year	4th year
CSR cases	2,810	771	587	712	740
Ratio (%)	100	27.4	20.9	25.3	26.3
			χ^2=27.799, p<0.001		

3.4.2 Intersect analysis between the annual number of CSR cases and individual companies after ERP implementation

As shown in Table 4, for four years after implementing ERP, there were statistically significant differences in the number of CSR cases by company and by year (χ^2=264.404, p<0.001).

More specifically, all companies except for Bluecom experienced significantly less CSR cases in their second year compared to their first year, but the number increased again in the third year. This trend implies that the system is stabilized for the first year after newly implementing an information system in the process of resolving numerous errors. It can be assumed that in the second year, the users are able to conduct their jobs seamlessly using the stabilized system as they become familiar. In the third year and beyond, however, the number of CSR cases increased as the familiarized users ask for system enhancements to reflect changes in the work environment, as well as new requirements for system optimization. This is similar to circumstances seen in field operations. Meanwhile, Bluecom is a company that implemented the existing UNIERP system. The current study conjectured that the results for Bluecom were different from those of other companies because the company is a special case in which existing ERP software already in operation was upgraded in addition to additional developments. As such, Bluecom was judged to be an exceptional case. Therefore, we adopt the alternative hypothesis H2.

Table 4. Results of intersect analysis on the number of CSR cases in various companies by year

		Total	1st year	2nd year	3rd year	4th year
Company E	CSR cases	313	73	53	93	94
	Ratio (%)	100	23.3	16.9	29.7	30.0
Company D	CSR cases	399	155	140	51	53
	Ratio (%)	100	38.8	35.1	12.8	13.3
Company C	CSR cases	90	25	2	10	53
	Ratio (%)	100	27.8	2.2	11.1	58.9
Company B	CSR cases	875	223	184	304	164
	Ratio (%)	100	25.5	21.0	34.7	18.7
Company A	CSR cases	212	56	49	54	53
	Ratio (%)	100	26.4	23.1	25.5	25.0
Company F	CSR cases	921	239	159	200	323
	Ratio (%)	100	26.0	17.3	21.7	35.1
			$\chi^2 = 264.404$, $p<0.001$			

3.4.3 Intersect analysis on the number of CSR cases and the CBO ERP modules after ERP implementation

As shown in Table 5, the intersect analysis of the number of CSR cases generated for 4 years after ERP implementation and the ERP modules indicated statistically significant differences (χ^2=81.758, p<0.000). More specifically, the Financial accounting module generated the most CSR cases, at 1,167 cases for 4 years. The Personel/PayRoll management module had 1,015 cases, making it the module with the second largest number of CSR cases. It can be considered that this reflects the practical trend in which statistical and analytical demands on management performance and profits at the planning level are particularly high as the ERP system stabilizes, financial transparency and accounting become easier. Therefore, we adopt the alternative hypothesis H3.

Table 5. Results of intersect analysis on the number of CSR cases and ERP modules

		Total	1st year	2nd year	3rd year	4th year
Controlling	CSR cases	77	19	20	17	21
	Ratio (%)	100	24.7	26.0	22.1	27.3
Financial accounting	CSR cases	1,167	356	245	250	316
	Ratio (%)	100	30.5	21.0	21.4	27.1
Inventory management	CSR cases	120	21	41	33	25
	Ratio (%)	100	17.5	34.2	27.5	20.8
Material management	CSR cases	136	44	30	41	21
	Ratio (%)	100	32.4	22.1	30.1	15.4
Personel/PayRoll management	CSR cases	1,015	238	177	294	306
	Ratio (%)	100	23.4	17.4	29.0	30.1
Production planning	CSR cases	159	58	37	33	31
	Ratio (%)	100	36.5	23.3	20.8	19.5
Sales & distribution	CSR cases	136	35	37	44	20
	Ratio (%)	100	25.7	27.2	32.4	14.7
				χ^2=81.758, p<0.000		

3.4.4 Intersect analysis on the number of CSR cases and ERP construction types

As shown in Table 6, the results of intersect analysis on the number of CSR cases and ERP construction types in 4 years after ERP implementation indicated statistically significant differences, with significance levels within 10% (χ^2=7.769, p<0.051). More specifically, ERP modules implemented with STD generated 1,122 cases of CSR for 4 years, while ERP modules implemented with CBO generated 1,688 CSR cases, indicating that ERP modules implemented with CBO created more CSR cases than those built with STD. Also, ERP modules implemented with STD had fewer CSR cases in the second year, with that number rising in the third year and falling again in the fourth year. On the other hand, the CBO ERP saw fewer CSR cases in the second year like the STD ERP, but its CSR cases increased in both the third and fourth years. Therefore, there were statistically significant differences in CSR cases between STD and CBO types. So, alternative hypothesis H4 is adopted.

Table 6. Results of intersect analysis on the number of CSR cases and ERP implementation types by year

Construction type		Total	1st year	2nd year	3rd year	4th year
CBO	CSR cases	1,688	470	338	409	471
	Ratio (%)	100	27.8	20.0	24.2	27.9
STD	CSR cases	1,122	301	249	303	269
	Ratio (%)	100	26.8	22.2	27.0	24.0
				χ^2=7.769, p<0.051		

3.4.5 Correlation analysis

The current study analyzed the correlation among annual number, unit companies, ERP modules, and ERP construction types. Because all analyzed variables are nominal variables, the correlation was analyzed based on Phi coefficient. The results are as shown in Table 7, which confirms that there is a

statistically significant correlation between all items such as {Unit Company, Annual number}, {ERP Module, Annual Number}, {ERP Module, Unit Company}, {ERP Construction Type, Unit Company}, and {ERP Construction Type, ERP Module} except for the correlation between ERP construction method and the number of annual CSR.

Table 7. Results of correlation analysis of unit companies, ERP modules, and ERP construction types

	Annual number	Unit company	ERP module	ERP construction type
Annual number	1	-	-	-
Unit company	0.307***	1	-	-
ERP module	0.171***	0.600***	1	-
ERP construction type	0.053	0.474***	0.264***	1

***p<0.001.

These results indicate the level of mutual effects between how STD and CBO modules are introduced and CSR by year, company, and module after ERP implementation. As the annual number of CSR cases increases, the effect of CSR can increase due to the characteristics of each company. In particular, it is a crucial finding that there is a high correlation between the ERP module introduction type and the number of CSR module and construction type by unit company, and this must be taken into account during ERP implementation.

3.5 Analysis of CSR Processing Time Difference in STD and CBO Modules

The calculation of current maintenance costs is based on the assumption that STD and CBO modules have equal weights. We tested whether the two modules incur differences in the processing time of customer requests. To this end, we established the following alternative hypothesis (H5) and verified if the equal weight assumption has a significant effect on the CSR processing time through difference analysis:

H5: The module type (STD vs. CBO) will incur differences in the CSR processing time.

For all CSR cases generated for 4 years after ERP implementation, an analysis was conducted to understand if the CSR processing time (unit: day) is different in CBO and STD types.

The results are outlined in Table 8. The analysis results indicated that it required 3.58 days on average to process a CSR case of the STD type, while 3.94 days on average was required to process a CSR case of the CBO type. These differences were also confirmed to be statistically significant (T=-1.691, p=0.091). There were no statistically significant differences in the time required to process CSR cases between STD and CBO types. Therefore, we confirmed that the module type has no effect on the CSR processing time and adopted the null hypothesis H0.

However, there was an exceptional analysis result. A separate analysis on the CSR processing time for STD and CBO for each industry showed that in the electric and electronic industry, 2.8 days on average was required to process a CSR case of the STD type, whereas 5.2 days on average was required to process a case of CSR of the CBO type, and this difference was statistically significant (T=-4.469, p=0.000). Furthermore, an analysis on the difference between the processing time for CSR of STD and CBO for each module showed that in the case of the Sales & distribution module, 2.1 days on average was required

to process a case of CSR of the STD type, whereas 4.9 days on average was required to process a case of CRS of the CBO type, and this difference was statistically significant (T=-2.875, p=0.005). We cannot generalize that CBO requires more time to process than STD, but these exceptional cases imply that it can have a negative impact on the processing time.

Table 8. Analysis of CSR processing time in STD and CBO by module

Type	N	Min	Max	Mean	SD	T-value	*p*-value
STD	1,122	1	31	3.580	5.373	-1.691	0.091
CBO	1,688	1	31	3.942	5.669		

3.6 Conclusions and Implications

To summarize the overall analysis results, χ^2 difference test on the number of CSR cases for 4 years after ERP implementation showed that the number of CSR cases increased for 1 year during stabilization, rapidly falling in the second year and consistently increasing in the third year and beyond. Such trends in the number of CSR cases were used to execute intersect analysis among individual companies, among ERP modules, and among ERP construction types. The results indicated significant correlation for {Unit Company, Year Number}, {ERP Module, Unit Company}, {ERP Construction Type, Unit Company}, and {ERP Construction Type, ERP Module}. Also, an analysis of all CSR cases generated for 4 years after ERP implementation was conducted to see if the STD type and CBO type required different amounts of time to process CSR cases. The results revealed that the amounts of time were similar, while in some modules, the processing time was twice as long for CBO ERP than for STD ERP. Synthesizing these analysis results, it can be understood that even with the same CSR processing time, more resources are required to process CSR cases of the CBO type regardless of individual company's business characteristics, because they have more CSR cases per module and their CSR increase rates are higher as well. In practical terms, this means that the CSR costs for CBO is higher than those for STD. This is a reasonable ground for requiring a consideration of ERP implementation type in calculating ERP software project costs. In sum, the costs for STD and CBO types must be differently calculated when planning for ERP system implementation, as well as for ERP system operation and maintenance.

4. ERP SW Maintenance Cost Calculation

Many previous studies have demonstrated the risk of ERP SW customizing [3,5,7,11,12,17,19,24] as well as other problems such as difficulty in integrating with other functions or modules [11,15,17, 19,24,27,30]. However, there have been no quantitative measures against the negative impacts of empirical data on problems such as increased risk or increased difficulty. Therefore, for the practical use of these findings, we propose to apply the findings to the calculation of the cost of commercial software maintenance projects suggested by Korea SW project estimation guide.

In the Republic of Korea, the cost of maintaining a commercial software is calculated by multiplying the maintenance rate determined by the maintenance level from the initial license purchase contract and the evaluation score for that maintenance level. At this time, the evaluation for determining the maintenance level is largely classified in terms of work business importance and maintenance

characteristics as shown in Table 9. The business importance is measured by the scope of work impact, the importance of data, the number of users, or the number of processes, and the maintenance characteristics are measured by the maintenance difficulty and maintenance items.

According to the study, we propose that it is to add the commercial SW customization ratio as a detailed measurement item in the field of measuring maintenance characteristics when calculating the evaluation score for maintenance by reflecting the specificity of the commercial ERP SW. Since the ERP SW customization ratio can be measured very accurately in all commercial SW modules, it is expected to correct the subjectivity of the maintenance difficulty indicator with the highest score among the detailed measurement items in the current maintenance characteristic measurement field. With regard to the scores assigned by actual measurement indicators, we suggest a method of assigning scores by multiplying the ratio of SW customization ratio based on the maintenance difficulty score of 70 points. For example, assuming a 35% customization ratio, the point of ERP SW customization ratio evaluation index is 24.5 points (70 × 35%), so the maintenance difficulty is 45.5 points. This calculation is an example of scoring, and further research may define a standard point that can be applied to the ERP SW customization ratio metric.

Table 9. Suggestion for maintenance cost evaluation metric of off-the-shelf SW considering customization premium

Evaluation classification	Weight	Metric	Points	Etc.
Business importance	60	Scope of work impact	60	-
		Importance of data	10	-
		The number of users/processes	30	-
Maintenance characteristics	40	Maintenance difficulty	70	*Existing metric*
		Maintenance items	30	
		ERP SW customization ratio	*TBD*	*Added metric*

TBD=to be determined.

5. Conclusion

Many companies are introducing ERP systems to gain an edge in the competitive environment and to strengthen their competitiveness through rapid decision-making. However, numerous companies do not achieve the expected results due to the risks of customizing and operational problems. Particularly, customizing is essential when building ERP SW to reflect the company's unique business characteristics, management strategy, and technical aspects. However, numerous studies have demonstrated that it greatly affects the post-construction operation and maintenance stages, which ultimately negatively affects operation, representing the greatest failure in the introduction of ERP. Therefore, while many studies on customizing ERP SW have been conducted, there is no quantitative research on the operational aspect of how the customized module affects the operation stage when ERP is introduced. This study empirically analyzed the effect of the customization module on the CSR ratio and CSR processing time during construction by utilizing the customization module information and CSR data generated during the implementation of ERP for 6 SMEs. As a result, statistically significant positive correlation was found for {Unit Company, Year Number}, {ERP Module, Year Number}, {ERP Module, Unit Company},

{ERP Construction Type, Unit Company}, and {ERP Construction Type, ERP Module}. Also, while five modules showed no statistically significant differences in CSR processing time between CBO and STD, but a statistically very significant difference was found in the Sales & Distribution module. This indicates that the cost for processing CSR from CBO is higher than that for processing CSR from STD, and serves as a reasonable ground for requiring different cost ratios for STD and CBO modules when calculating the overall cost for ERP software projects. To confirm the necessity in practical terms, the current study applied the results to the method for calculating the maintenance costs of ERP software in the Republic of Korea.

The current study provides a theoretical foundation leading to the implication that customization ratios of modules are critical factors to consider when estimating for implementing an ERP system and especially, that the customization ratios of ERP modules must be more precisely and accurately reflected in the overall cost when planning and implementing ERP system maintenance or operation projects.

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