Exploring Relationships in Tailoring Option, Task Category, and Effort in ERP Software Maintenance

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ABSTRACT

Maintenance to in-house applications is often done by modifying source code; however, packaged applications also enable certain maintenance to be done through changes to configurational parameters rather than through changes to the source code. This research presents preliminary evidence from the field to fill this gap in the empirical understanding of ERP maintenance. Using data from 503 ERP maintenance requests, the author's results suggest that relative maintenance effort distributions for all maintenance categories and tailoring options are not normal distributions but heavy-tailed positively skewed distributions. Comparing ERP systems to in-house developed software, the author found a large proportion of corrective maintenance requests than adaptive requests. Enhancement and corrective task categories that use the programming tailoring option show a trend of increment in relative maintenance effort per request moving median over time. In contrast, enhancement and adaptive task categories that use the configuration tailoring option show a trend of reduction in relative maintenance effort per request moving median over time. The number of maintenance requests for all tailoring options and task categories were increasingly high four months after the introduction of a new module. Comparatively, under the same period, there was relatively higher number of maintenance requests for enhancement task category than other task categories, indicating that unique or orthogonal requirements were not available in the ERP system.

Keywords: *Boxplot, Enterprise Resource Planning (ERP) Maintenance Effort, Enterprise System, Maintenance Requests, Relative Maintenance Effort Distribution, Relative Maintenance Effort Trend, Software Maintenance Effort, Tailoring Option*

INTRODUCTION

Enterprise resource planning (ERP) systems, also known as enterprise systems, are reconfigurable standard software packages. ERP integrates application programs across various business functions and typical processes such as finance, human resource management, sales and distribution, manufacturing and logistics, supply chain management, and customer relationship management. ERP provides a common standard user interface, a single database, and

DOI: 10.4018/jeis.2013040105

a real-time information system to form the necessary corporate information technology and e-business technology infrastructure. ERP originated from material requirement planning (MRP) and manufacturing resource planning (MRPII), but its application is beyond manufacturing including banking, food and beverages, and many others. In addition, the fundamental functionalities and usages associated with ERP systems do not in fact concentrate on either planning or resources capabilities, but rather on "their abilities to process transactions efficiently and to provide organized record keeping structures for such transactions" (Jacobs & Bendoly, 2003: pg. 233).

Like traditional in-house software, ERP packaged software requires maintenance (Ng & Gable, 2010). Maintenance activity represents the longest and most costly phase in a software lifecycle (Glass, 2003), and this also applies to ERP software (Lübke & Gómez, 2009). The importance of software maintenance, which has been attributed with, on average, consuming 50-70% of the total software cost (Banker et al., 1991), is recognized among researchers, and this has motivated a number of researchers to investigate the software maintenance effort (Ahn et al., 2003). Further, all of those studies had one common objective – to contain software maintenance costs and improve effort prediction capabilities. Compared to research in software development, research in software maintenance has long been considered under investigated and not given proper recognition. Similarly, while there exists quite a large amount of literature on ERP implementation issues, e.g. (Jafarnejad et al., 2012), there is a dearth of ERP maintenance research. ERP maintenance activities are the post-implementation activities, including user supports, upgrading, making changes or modifications to the system and integrating ERP system with existing information systems (Ng et al., 2002).

Traditional in-house software maintenance literature suggests that different maintenance categories demand significantly different portions of the total maintenance effort (Lientz & Swanson, 1980) and maintenance productivity (Jørgensen, 1995). These findings are generally based on small- to medium-sized standalone software packages that are specifically designed according to a company's unique requirements. As many companies are now adopting large ERP software packages, greater attention and effort will need to be diverted to maintenance, making it imperative that we examine to what extent this new phenomenon is still accountable to the existing theory of software maintenance, see (Ahn et al., 2003; Banker et al., 1991; Lientz & Swanson, 1980). More in-depth discussion on the nature of the differences between in-house software maintenance and ERP software maintenance can be found in Ng et al. (2002).

As seen in much of the ERP implementation literature, misfits between organizational specific functionality requirements and the prescribed processes and functionalities of ERP are crucial issues for most companies. Various tailoring options are available to resolve potential misfits (Brehm et al., 2001) and ERP implementing-clients must make choices among the options. The most common tailoring options consist of configurations and programming-related one. The programming-related tailoring option is associated with some sort of source codes or programming activities, e.g. the use of the original ERP programming language, writing extended reporting, workflow programming, etc. However, empirical insights into how these common tailoring options relate to ERP maintenance efforts remain unavailable.

Understanding what drives the maintenance effort and maintenance productivity is at the crux of maintenance effort estimation reliability, which is critical to making maintenance decisions under the constraints of limited resources and fluctuations in maintenance needs over time. However, management often has to make resource allocation decisions based on very limited information – often only a brief description of the maintenance request. If management are able to make educated estimates based on very early information including the task category a maintenance request belongs to and the appropriate tailoring option to adopt, together with the up-to-date information on the available maintenance support provided by the ERP vendor, it is likely that they could better plan, decide, allocate, and control maintenance resources for ERP maintenance.

The remainder of this paper is organized as follows. First, we review specific literature on factors that influence the software maintenance effort in general, and the associated research questions are presented. Then we describe the research methodology adopted in this study. Afterwards a detail the basic descriptive statistics of ERP maintenance effort. Followed by a discussion the findings and managerial implications of the study. Finally, we provides both limitations and conclusions.

LITERATURE REVIEW

Maintenance Task Category

The classical taxonomy categorizes maintenance into three main types: corrective, adaptive and perfective. The generalized definition of each category, based on a number of well-known software maintenance researchers such as Swanson (1976), Lientz et al. (1978) and Swanson and Chapin (1995) is given in Table 1. A number of studies have shown that perfective maintenance covers a major portion of the annual maintenance effort. Lientz et al. (1980) conducted a survey of application software maintenance in 487 data processing organizations in the United States and Canada, and found that more than 50% of the annual maintenance effort was devoted to perfective maintenance.

Another research project, implemented by Jørgensen (1995) in a large Norwegian organization, also found that a large proportion of the total maintenance effort, 45%, was spent on perfective maintenance. Different maintenance requests involve different maintenance activities and number of functions packaged in each maintenance request. Thus, they also require different amounts of maintenance effort (i.e. person-hour per maintenance request). For instance, we expect that perfective and adaptive requests call for a greater level of effort in terms of requirements analysis, solutions design, and coding than is usually the case for corrective requests. As for testing, more system integration testing and user acceptance test efforts are likely to be associated with enhancement requests involving new user interfaces, new functionalities and new reports than are likely for either adaptive or corrective requests.

In the existing literature, besides corrective, adaptive, perfective and preventive maintenance categories, there is another popular task category named ‘enhancement’. Swanson (1989) emphasized that enhancements could be either minor or major and had been traditionally seen as part of a new system development. Swanson in a paper published in (1995) further explained that from an exclusive view of maintenance, “… many enhancements and extensions might be reported as ‘new development’ rather perfective maintenance. However, in practice, much perfective maintenance will exist regardless of taking an exclusive view” (p. 312). Thus, in practice and from the inclusive, perfective maintenance also includes some enhancements and extensions. In fact, Chapin and others (2001) have pointed out that different researchers may have different definitions for these maintenance

Table 1. The definition of software maintenance dimensions based on Swanson (1976), Lientz et al. (1978), and Swanson and Chapin (1995)

Dimension	Definition
Corrective	Fix any defects, for example expected but missing or wrong functionality, and processing or performance problems
Adaptive	Adapt functionality, and processing or performance to anticipated changes in the data or processing environments
Perfective	Enhance processing or performance efficiency; and develop new interfaces, new functionalities and new reports

categories, depending on the perspectives from which the maintenance requests are classified. For instance, they suggested that the classical taxonomy in (Swanson, 1976) is based on the intention of the request and people's intentions are difficult to determine. However, their taxonomy (Chapin et al., 2001) is based on the actual observable evidence rather than the intention(s) involved in a particular piece of maintenance work. A more recent taxonomy of software change (Buckley et al., 2005) is based on characterizing the mechanisms of change and the factors affecting these mechanisms; it is particularly useful in helping practitioners to determine the tool and mechanism to adopt in a specific software change. All perspectives have advantages as the taxonomy in Swanson (1976) is straightforward while the one in (Chapin et al., 2001) is comprehensive. On the other hand, the taxonomy by Buckley et al. (2005) is precise and yet a bit complicated as it requires collecting more information regarding a mechanism of change. In this study, we make reference to Swanson's perspective only in classifying our task category variable because of the nature of and the limitation in our existing data, and also for simplicity purpose.

As ERP maintenance is practically an immediate concern after implementation, it is worthwhile to examine whether the existing in-house software maintenance concepts are still applicable for this somehow different software characteristic. Unlike in-house software, the ERP literature (Ng et al., 2002) shows that ERP maintenance activities originate from both internal (within the client-organization) and external (from the software vendor) sources, whereby maintenance can be done through changes to configurational parameters and availability of maintenance support from the software vendor.

In this study, we adopt the same definitions for ERP corrective and adaptive maintenance task categories as those given in Swanson (1976) and as shown in Table 1. On the other hand, enhancement task category is confined to the inclusion of enhancing processing efficiency and performance, and developing new interfaces, new functionalities and new reports, akin to the inclusive view of perfective maintenance task category described in Swanson and Chapin (1995). We employ a very similar task category definition in this study in order to facilitate data comparison with previous in-house software maintenance studies. We then classify the company's maintenance requests based on the request's intention (i.e. our generalized definition from earlier papers for the task category as illustrated in Table 1). Also, in this study we focus on the client-organization's internal ERP maintenance requests only.

ERP Tailoring Option

As seen in much of the ERP implementation literature, ERP misfits are seen as a big issue by the majority of companies. While one good way to solve the misfits without touching the software is to change the business processes so that they are in-line with the processes enforced in the generic EPR system, other way to solve the wide variety of misfits is to apply various tailoring options suggested by vendors. However, empirical insights on how tailoring options relate to ERP maintenance efforts are as of yet unavailable. The only studies on ERP maintenance that directly relate to maintenance effort determinants are papers by Brehm et al. (2001) and Light (2001). The work done by Brehm et al. (2001) provides a comprehensive typology of the tailoring options used to make changes to an ERP system, and it is the first endeavour that discusses the relationship between ERP maintenance effort and tailoring options. Meanwhile, Light (2001) discusses the implications of a few types of customisation (which are parts of the tailoring options covered in Brehm et al.'s typology) on future ERP maintenance effort descriptively, based on two case studies.

Tailoring option defines the method used to make changes to the ERP system. According to Brehm et al. (2001), there are nine types of ERP system tailoring options: configuration, user exit, bolt-on, screen masks, extended reporting, workflow programming, ERP programming, interface development, and package code modification. They are all derived from the authors' analysis of the implementation literature and interviews with MIS directors of SAP client-organizations. Different types of tailoring options are said to impact maintenance efforts differently depending on how severely an ERP system itself is changed through tailoring and how much effort is required to employ the chosen tailoring type. Brehm et al. (2001) found that, in general, the configuration tailoring option has a lighter impact – fewer changes are made to the ERP system and less effort is required from the maintainer. On the other hand, Brehm et al. (2001) also emphasized that tailoring that involves programming, development or package code modification generally has a heavier impact – more changes are likely to be made to the ERP system and more effort is in turn required from the maintainer.

Moreover, an ERP maintenance request that employs a programming-related tailoring option that calls for the modification and/or application of custom program code (or program code provided by the vendor) is likely to involve greater amounts of effort in analysing the problem, designing a solution, developing code or conducting regression analysis between the custom program code and vendor's program code (and/or reapplying previous custom developments), and verifying and testing custom objects, as compared to an ERP maintenance request that uses the configuration option. The latter can usually be handled by setting the configuration tables provided by the vendor. Programming-related tailoring options in the present paper refer to user exit, bolt-on, screen masks, extended reporting, workflow programming, ERP programming, interface development, and/or package code modification.

In this empirical study, we aim to address the following research questions:

- What are the types of distributions in maintenance effort followed by different ERP maintenance categories and tailoring options?
- Does the level of relative maintenance effort differ across different maintenance task categories and different tailoring options?
- How does the ERP maintenance relative effort change over time across different tailoring options?

In order to tackle these research questions, actual ERP maintenance request details, such as effort per maintenance request, task category and tailoring options are collected from an ERP client-organization as described in the next section.

RESEARCH METHOD

The site for data collection is a corporate information systems service organization (hereafter referred to as "the company"). It was set up in 1996. It is an internal unit of a governmental organization and receives its budget allocation from that government organization. It is a service provider to government departments and agencies (including the company itself) in Queensland, Australia. Its objectives are to share the information system resources and to reduce their departmental IS/IT expenditures. The provision of corporate services to these departments is performed according to a Service Level Agreement (SLA). SAP R/3 is one of the information systems run and managed by the company, and the modules implemented consist of SAP R/3 finance and human resources. The SAP R/3 version 3.1H Finance (FI) module went live in November, 1998; the SAP R/3 Human Resources (HR) went up in late April, 1999, to replace the previous Human Resources Management System (HRMS), which was not Y2K compliant. Also, due to the termination of support for version 3.1H, the company upgraded the SAP system to version 4.6C in 2002.

The company is under the administration of a General Manager, and consists of three working groups: the Corporate Information System (CIS), Business Advisory Services, and Support Services. While part of CIS duties include managing and maintaining the SAP R/3, the other part calls for maintaining, monitoring and managing a number of legacy systems for its clients. CIS consists of two working teams, the development team and the technical team, which are responsible for managing software maintenance activities. The development team is the SAP R/3 development group, which consists of a senior Systems Development Manager, ten business analysts, and (at present) four contract ABAP programmers. (ABAP stands for Advanced Business Application Programming and is the SAP proprietary programming language for application development purposes.) This team is entirely devoted_to working on the R/3. The technical team, however, is the SAP R/3 operations support group, which consists of a senior Systems Operations Manager, three service desk (or BASIS or SAP technical) staff, and one system administrator. This group is responsible for ensuring the continuing operations of the R/3 and liaises with its outsourcing service provider, who provides the technical/hardware service for the R/3 operations. Although the members in this operations support group are also responsible for non-SAP R/3 related operations, 80% of their time and effort is devoted to the R/3. Further, the Business Advisory Services group provides business and improvement advice to its clients, while the Supporting Services group primarily supplies data entry services and consists of more than 200 staff members. The organization chart of this company is shown in Figure 1.

Our main source of data was the company's maintenance request database, which keeps a record of individuals (i.e. professional SAP business analysts and contract ABAP programmers) working on any maintenance request, the maintenance request details and the work-time involved. The unit of analysis in this study is a completed maintenance request. Table 2 shows the description of data used in our data analysis.

Figure 1. The organization chart of the company

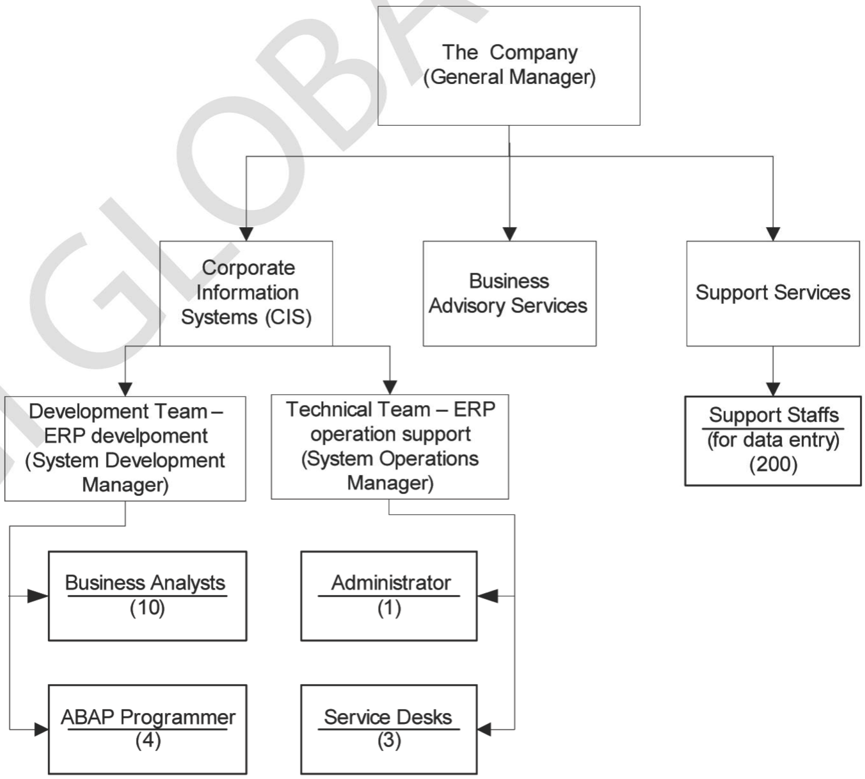


Table 2. Description of data used in this analysis

Variable	Description	How is it derived	Type
Maintenance Effort (in person-hour per maintenance request)	Effort spent to complete a maintenance request	By totalling the person-hours recorded by each individual involved in a maintenance request*	Ratio
Task Category	Type of maintenance request	Done manually (by two raters) by classifying all maintenance requests based on the intention of the request	Nominal
Tailoring Option	Method used to make changes to the system (for a maintenance request)	A direct data field from the maintenance request database	Nominal

* The effort recorded depends on how rigorous the maintainers were in doing so. Therefore, there could be a threat to this data accuracy and validity.

The total maintenance effort or work-time (of all professional SAP business analysts and contract ABAP programmers) involved in a maintenance request was calculated by adding individual time slots entered by each programmer and analyst in the database for that request. (For this, there could be some possible inaccuracies (i.e. possible threats to the validity) in time recording, e.g. the maintainers might carelessly count the time spent on the phone or in meetings.) Task category and tailoring options were nominal variables. The data used in our data analysis was nonexperimental data as all the variables were not controlled, which was not feasible within this real setting. In terms of data collection, for the SAP R/3 version 3.1H for both the financial and human resources modules, we found 503 valid completed maintenance requests (out of a total of 3611 completed maintenance requests), where a "valid maintenance request" referred to a maintenance request that recorded all the relevant data (i.e. task category, tailoring option, maintenance effort) required to conduct all of the descriptive statistical analyses in this study. From our comparison analysis between the valid and non-valid maintenance requests data, we note that the subset of maintenance requests with valid (i.e. complete) data might have been conducted with more care or by the subset of developers or programmers who are more careful with the documentation. This role bias is probably very general and not easily avoidable for observational data (Podsakoff et al., 2003). However, our dataset closely resembles the characteristics of the pool of total completed maintenance requests in terms of the relative proportions of task categories and tailoring options.

There were three main categories of maintenance requests based on the company's ERP maintenance request classification for maintenance requests initiated by the system user and IT staff: corrective, enhancement, and adaptive categories. However, in order to avoid potential inconsistencies between the company's definitions and the definitions adopted in this study for the three maintenance categories, extra precautions were taken. To ensure field study data validity and reliability, two raters/researchers manually classified all the maintenance requests independently, using a protocol (as described in Appendix A) based on the intention and/or reason for each request in the company's ERP maintenance request database. Examples of the work done in each maintenance task category is shown in Appendix B. After independent coding, the numbers of agreement and disagreement for each task category is as shown in Table 3. Based on Table 3, the raw agreement index, as suggested in (Uebersax, 2009), was calculated as 0.895. By using this raw agreement index and the expected percentage of agreement as recommended in (Wood, 2007), the Cohen coefficient of agreement (or Cohen's K) for nominal scales was computed to assess the rela-

Table 3. Summary of task category ratings by two raters

		Rater 1				
	Count (marginal)	**Adaptive**	**Corrective**	**Enhancement**	**Sum of count**	**Sum of marginal**
Rater 2	Adaptive	112	12	0	124	124/503 =0.247
	Corrective	15	166	26	207	207/503=0.412
	Enhancement	0	0	172	172	172/503=0.342
Sum of count		127	178	198	503	
Sum of marginal		127/503	178/503	198/503		
Raw agreement index (Observed % of agreement), O		marginal(1,1) + marginal (2,2) + marginal (3, 3) =(112+166+172)/503=0.895				
Expected % of agreement, E		[(124/503)x(127/503)] + [(207/503)x(178/503)] + [(172/503)x(198/503)] = 0.062 + 0.146 + 0.135 = 0.343				
Kappa		(O – E) / (1 – E) = (0.895-0.343)/(1-0.343)=0.552/0.657=0.840				

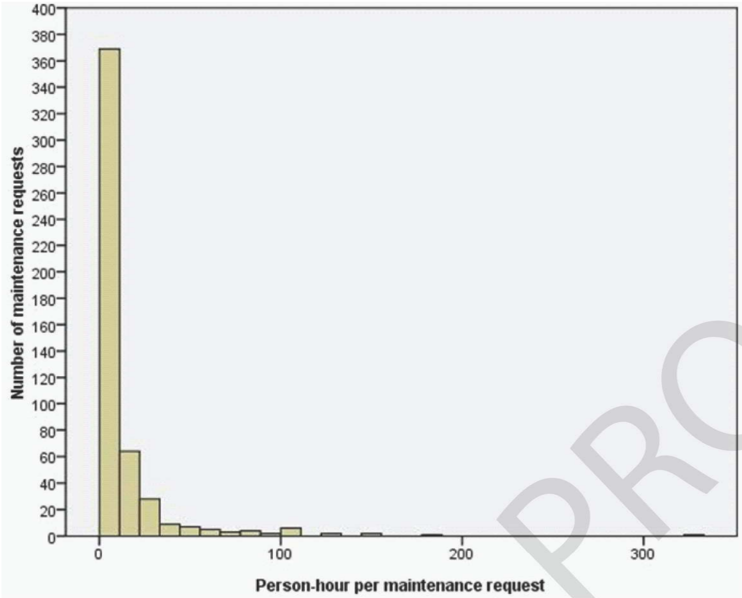
tive pairwise agreement (Cohen, 1960), i.e. the intercoder reliability, before statistical analyses were carried out. Intercoder reliability has also been applied to the same research problem, see (Kemerer & Slaughter, 1999). We obtained an average Cohen's K of 0.840 is excess of 0.72, indicating substantial agreement.

For each maintenance request, the appropriate tailoring option for conducting changes to the system was determined and assigned by the maintainer. A maintenance request that employed a configuration tailoring option resulted in the configuration tables or files being modified or changed in order to resolve a problem or complete a maintenance request. On the other hand, a maintenance request that used a programming tailoring option meant that programming activities were involved – either using code from the vendor, or by writing new or altering existing code, interfaces, reports and/or user screens. In cases where the vendor's code was used, only the relevant standard code in a patch was applied. It should be noted that the company's configuration tailoring option corresponded to Brehm et al.'s (2001) definition for the configuration tailoring option. On the other hand, the company's programming tailoring option may relate to any one of the following Brehm et al.'s (2001) tailoring options, including user-exit, extended reporting, workflow programming, ERP programming, interface development and package code modification. Thus, the tailoring option variable in this study was limited to the aforementioned two categories.

The relative maintenance effort (i.e. person-hour per maintenance request) distribution is shown in Figure 2. The relative maintenance effort distribution, with the right-hand tail being more pronounced, did not appear to be a normal distribution. Depending on the purpose of a study, this data distribution may require data transformation into normal or the use of non-parametric statistical techniques. In addition, in this situation, the means and standard deviation of the sample/population are "not representative of the system entity values" (Concas et al., 2007; pg. 703). Therefore, this study did not emphasize much on the mean and standard deviation statistics. The median was indeed used as the central tendency measure, as not only the relative maintenance effort data distribution in this study was not normally distributed, but also showed evidence of skewed distribution due to a lack of symmetry (Wilcox, 1996) together with the presence of outlier values.

To further analyse this type of data distribution and to explore the frequency counts, median and interquartile of relative maintenance effort expended by each ERP task category and tailoring option, 'box and whisker' plot (or boxplot) was used. The SPSS statistical

Figure 2. Relative maintenance effort data distribution



software used in this study defines outlier in a boxplot as data point that lies between 1.5 and 3 times the interquartile range (IQR – the box width in the plot) away from the lower quartile (the lower end of the box) or from the upper quartile (the upper end of the box); extreme value is data point that lies more than 3 times the IQR away from the lower quartile or upper quartile; and the horizontal line in IQR or the box represents the median of the sample dataset (Kinnear & Gray, 2004

RESULTS

ERP Maintenance Effort and Task Categories

Thirty-nine percent of the maintenance requests were corrective work. In contrast, adaptive task category covered the smallest part (25%) of the maintenance requests. In total, 61% of the total maintenance effort was spent on enhancement activities; whereas 28% was spent on corrective activities (see Table 4). The maintenance effort per maintenance request median value for enhancement maintenance requests was larger (i.e. took longer to satisfy) than any other task category; its median value was more than double that of the corrective task category. In comparison, the median value of effort per request to service adaptive task category was slightly more than half of the median value for corrective task category. However, the interquartile range and range for enhancement task category is also the largest, indicating the largest maintenance effort variability than the other maintenance task categories.

The boxplot for relative maintenance effort versus maintenance task categories is given in Figure 3. Based on the boxplot in Figure 3, we can observe that there are a number of outliers and extreme scores for all the three maintenance task categories. The numbers of outliers and extreme scores for – adaptive are 14 and 8, corrective are 19 and 21, and enhancement are 12 and 18 respectively. In Figure 3, the medians for the three maintenance task categories are relatively close to the lower fourth quartile, indicating that the data points are skewed to the right or positively skewed. Based on the

Table 4. Task category and maintenance effort (unit: person-hour per maintenance request)

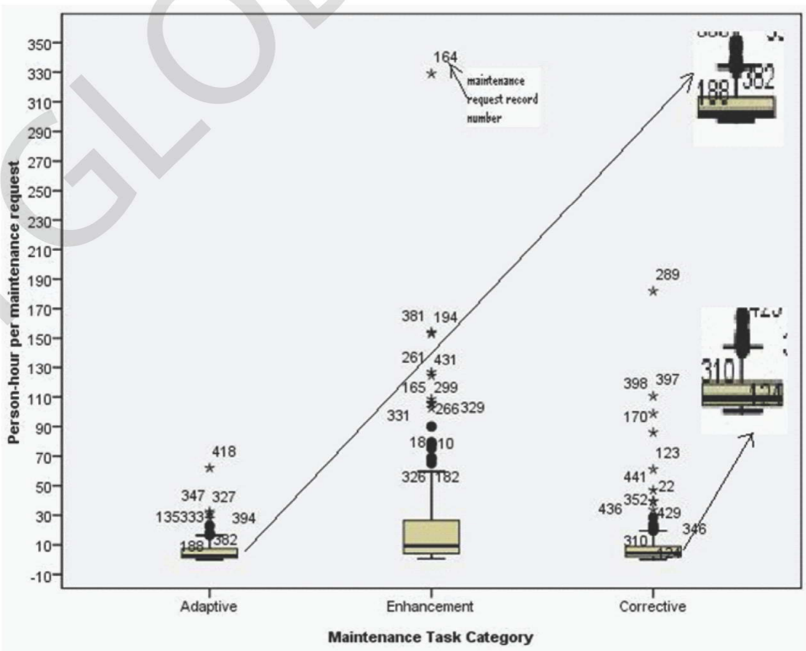
	Adaptive	Corrective	Enhancement
Mean	5.62	9.50	23.30
Median	2.75	4.53	9.36
Variance	61.85	351.30	1393.04
Minimum	.08	.1824	.66
Maximum	62.00	181.86	328.95
Range	61.92	181.68	328.29
Interquartile Range	6.25	7.04	22.35
Skewness	3.92	5.90	4.25
Standard deviation	7.86	18.74	37.32
Kurtosis	21.97	43.48	26.58
% of total effort (person-hours)	11	28	61

interquartile range, we can observe that the relative maintenance efforts per request in the enhancement task category appear to be more variable than the corrective and adaptive task categories.

ERP Maintenance Effort and Tailoring Options

The median value of maintenance effort per request for maintenance task category that used a programming tailoring option was 52%

Figure 3. Boxplots – Relative maintenance effort for different maintenance task categories



greater than for maintenance requests that used the configuration tailoring option. Overall, the company expended 53% of its maintenance effort (total person-hours) on programming tailoring option maintenance requests and 47% on configuration tailoring option maintenance requests. This is illustrated in Table 5. Also, based on the range and interquartile range statistics, we can say that there is a higher variability in maintenance effort for the programming tailoring option than the configuration option.

The boxplot for relative maintenance effort (i.e. person-hour per maintenance request) versus the tailoring option is given in Figure 4. Similar to the maintenance task categories, both tailoring options of configuration and programming have several outliers and extreme scores (see Figure 4). The numbers of outliers and extreme scores for programming are 30 and 23 respectively, and configuration tailoring option are 18 and 22 respectively. Relative maintenance efforts that are high relative to the bulk of the data can arise as a result of positive skewness of the distributions.

Comparing the Tails in Each Task Category and Tailoring Option

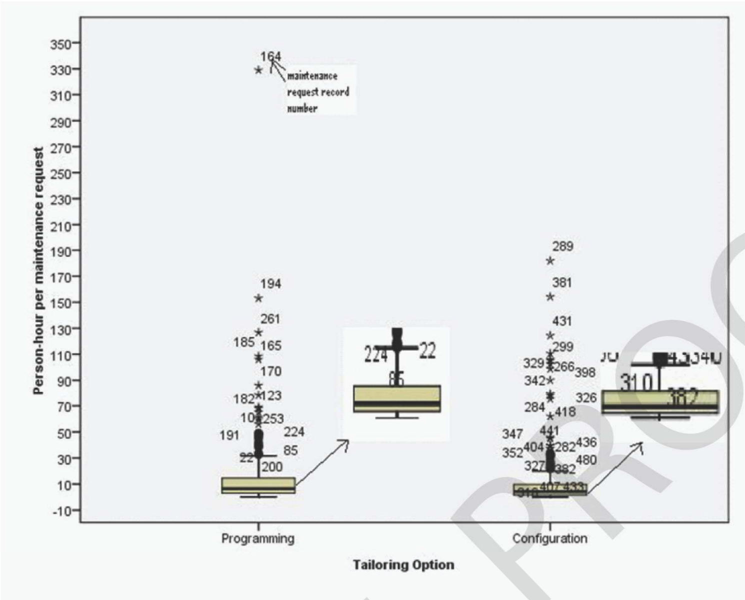
As abovementioned, the data sets have quite a few outliers and extreme points. This is very common in most research project involving data collection in the social sciences (Wilcox, 1996). However, they do not necessarily have to be removed as outliers may indicate an interaction with other possible predictor variable (Neter et al., 1999) and "possible dependencies" (Concas et al., 2007). In our case here, the maintenance requests "in the tail" may represent the largest chunks of work, which are more difficult to manage, risky and introduce more complexity to the ERP system.

In the presence of outliers and extreme points, the relative maintenance effort distributions for each task category and tailoring option are long-tailed distribution and positively skewed. According to Concas et al. (2007: pg. 693), the fat-tail property is "demonstrated by the high value of the standard deviation and kurtosis with respect to the mean and to the median. Also, the maximum values are always order of magnitudes larger than the mean." Our descriptive statistics for each task category and tailoring option as shown in Table 4 and Table 5 satisfy these conditions. Thus, these relative maintenance effort distributions also possess the fat-tail property.

Table 5. Tailoring option and maintenance effort (unit: person-hour per maintenance request)

	Configuration	Programming
Mean	12.44	14.27
Median	4.28	6.49
Variance	624.96	770.18
Minimum	.0800	.1824
Maximum	181.86	328.95
Range	181.78	328.77
Interquartile Range	8.15	11.63
Skewness	3.93	6.87
Standard deviation	24.00	27.75
Kurtosis	17.39	66.33
% of total effort (person-hours)	47	53

Figure 4. Boxplots – Relative maintenance effort for different tailoring options



Cross-Tabulation Between Maintenance Task Category and Tailoring Option

As shown in Table 6, a cross-tabulation was run between maintenance task category and tailoring option to determine whether there was any consistent pattern regarding how the various task categories were serviced. Results indicate that the majority of the adaptive task category (83%) were serviced using the configuration tailoring option (Table 6). As expected, a significant proportion of the enhancement task category (75%) was satisfied by the programming tailoring option. Finally, both programming and configuration tailoring options were applied almost equally for corrective task category.

Changes in Relative Maintenance Effort over Time

The trend in relative maintenance effort for different tailoring options, calculated using moving median based on a window of two months over a 15-month period (starting from April 1999 to June 2000) is shown in Figure 5 and Figure 6. A window of two months were chosen because the number of monthly data points was small; also, with a smaller window size more moving medians can be computed, and then trend line can be plotted. Trend line (or the best fit line) was drawn in each figure except in Figure 5a. Figure 5a shows the relative maintenance effort for adaptive task category that adopt programming tailoring option, and its trend line was not shown because its number of data points was small. In general, it showed, firstly, a large increase, followed by a large decrease, and then a larger increase, and followed by a larger decrease, and finally followed by no change. This trend is difficult to summarize. In both Figure 5b (enhancement through programming) and Figure 5c (corrective through programming), we observe a trend of increment in the relative maintenance effort per request.

In contrast to the programming tailoring option, enhancement task category that uses the configuration tailoring option (Figure 6b) shows a general trend of reduction in the relative maintenance effort per request moving median. This is also the case for the adaptive

Table 6. Cross-tabulation between maintenance task category and tailoring option

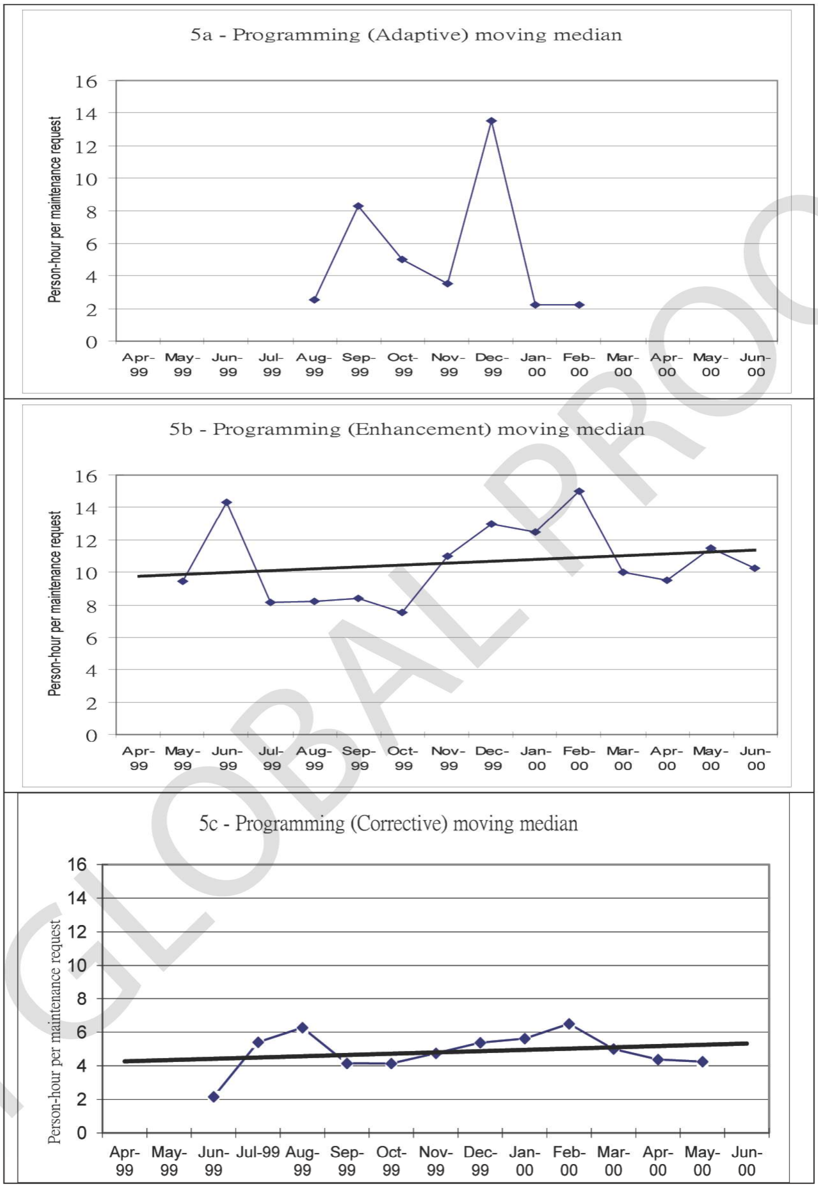
Maintenance task category		Tailoring option		Total
		Programming	Configuration	
Adaptive	Count	22	105	127
	% within request type	17%	83%	100%
	% within tailoring option	8%	44%	25%
Enhancement	Count	133	45	178
	% within request type	75%	25%	100%
	% within tailoring option	50%	19%	35%
Corrective	Count	109	89	198
	% within request type	55%	45%	100%
	% within tailoring option	41%	37%	39%
Total	Count	264	239	503
	% within request type	52%	48%	100%
	% within tailoring option	100%	100%	100%

task category (as in Figure 6a). However, the negative delta for enhancement through configuration (decreasing trend) is much larger than for adaptive through configuration. In overall, these decreasing relative maintenance effort trends could probably cause by the increasing familiarities of the programmers (or maintainers) with the ERP system's configuration tables and settings which result in relatively lesser person-hour per request required over time. An interesting observation is obtained for corrective task category that adopts configuration tailoring option (Figure 6c) as its relative maintenance effort per request moving median shows a slight increasing trend. This could probably be because of more time was in fact required to find and service the errors as the ERP system complexities increased (when more changes and customizations were done to the system).

In overall (as in Figure 5 and Figure 6), we observe that the relative maintenance effort (person-hour per request) for adaptive task category that uses configuration tailoring option increases sharply in the first four months after the introduction of the new HR module. Similarly, the relative maintenance effort for enhancement task category that uses both configuration and programming tailoring options also increases during the same period. On the other hand, relative maintenance effort moving median for corrective task category that uses both configuration and programming tailoring options is at the lowest in the first three months after the introduction of the new HR module. This indicates that, in the first few months after the introduction of the new ERP module, more relative maintenance effort is spent on enhancement and adaptive maintenance categories compared to corrective task category. However, as time goes by and the ERP system gets older and more changes are incorporated, the relative maintenance effort (per maintenance request) for corrective task category appears to be relatively higher than the adaptive and enhancement work.

Figure 7a illustrating the programming productivity (all categories added) showed a straight line trend with zero delta, whereas Figure 7b demonstrating the configuration productivity (all categories added) showed a decreasing trend of relative maintenance effort per request. This implied that the relative maintenance effort per request done through configuration decreases over time. However,

Figure 5. Trends in maintenance effort (person-hour) for "programming" option for different maintenance task categories



the relative maintenance effort per request done through programming (for all categories added) appeared to remain the same (or stagnant with no increase or decrease in relative maintenance effort per request) over time.

From Figure 8a and Figure 8b, we observe that the number of maintenance requests for all tailoring options and task categories are increasingly high from April to July 1999, and then decreases after that. This was due to the introduction of a new module, i.e. HR module,

Figure 6. Trends in maintenance effort (person-hour) for "configuration" option for different maintenance task categories

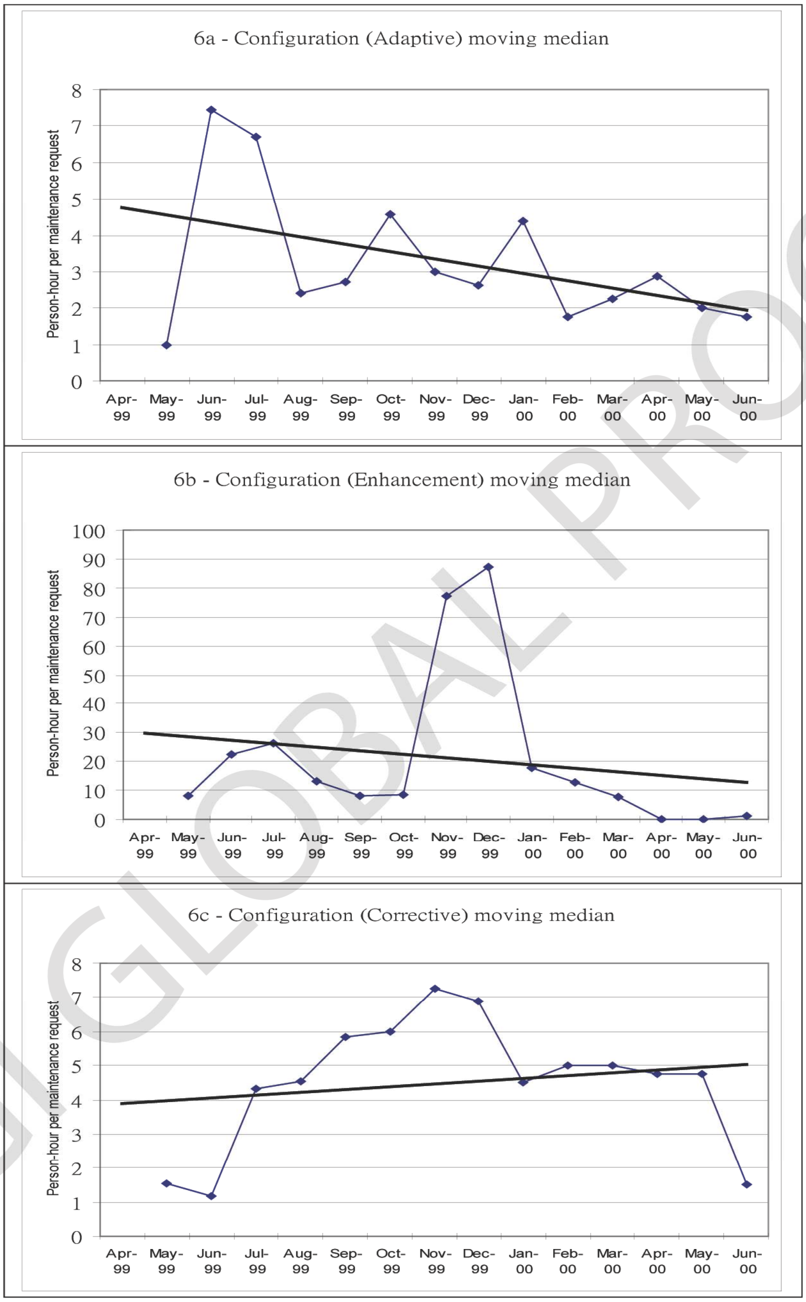
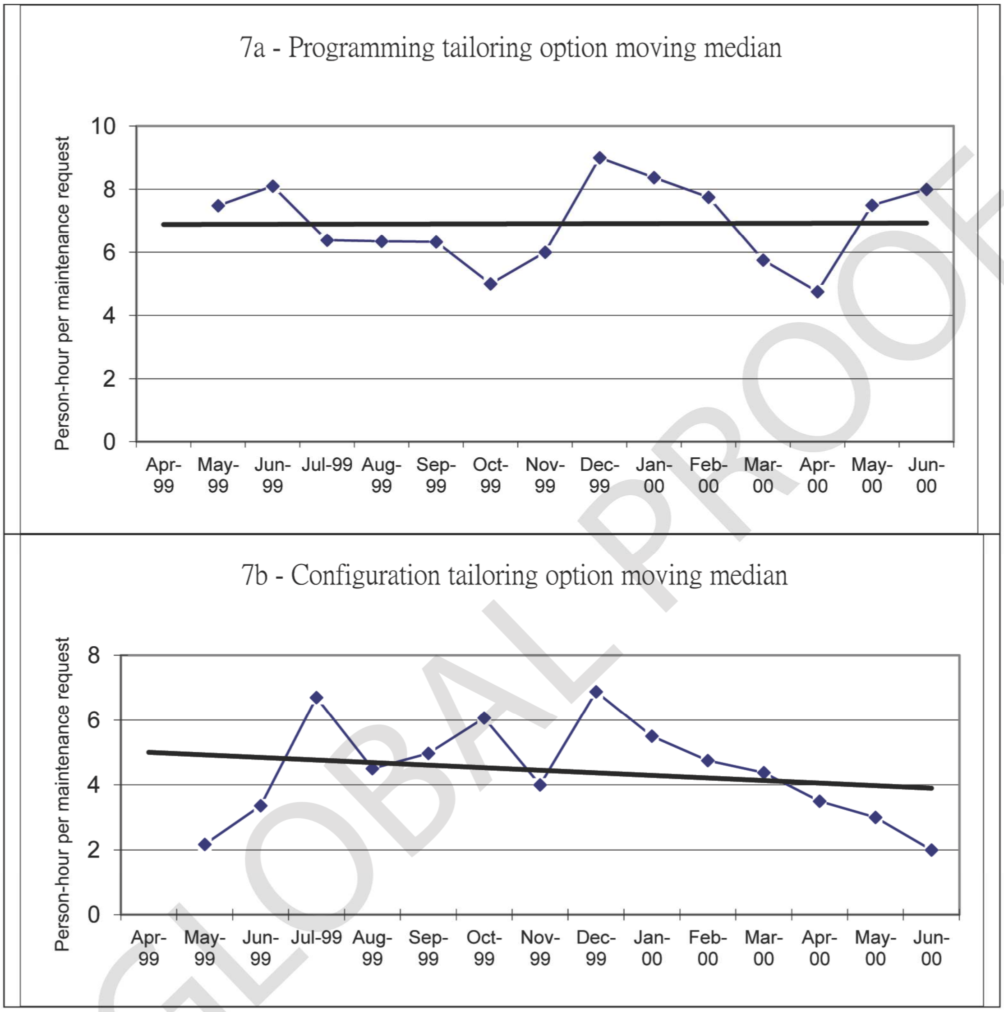


Figure 7. Overall trends in maintenance effort (person-hour) for the two tailoring options

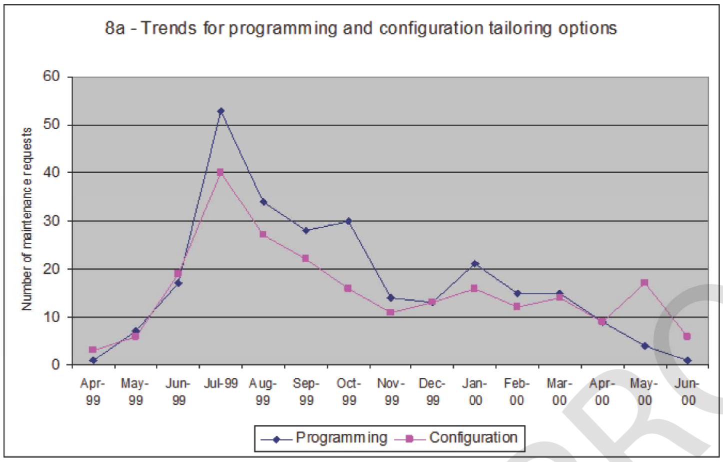


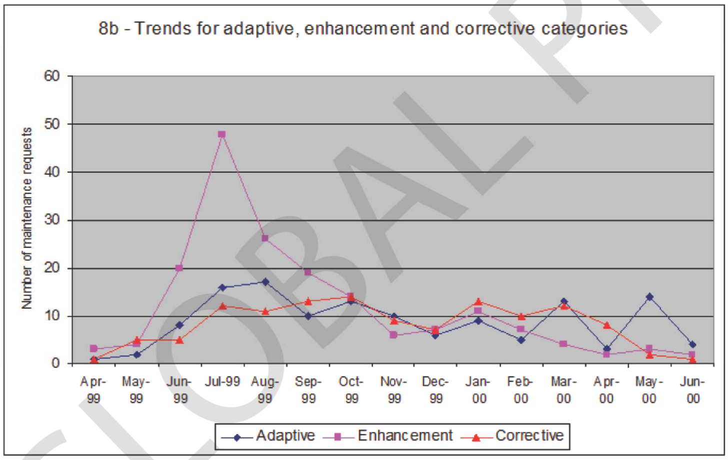
in April 1999, and the case company required more functionalities than those provided in the HR module and/or the ERP system. Thus, these caused more maintenance requests. Comparatively, there is a relatively higher number of maintenance requests for the programming than configuration tailor option, especially in July (see Figure 8a); and a relatively higher number of maintenance requests for enhancement task category than other task categories under the time slot between April and July 1999 (see Figure 8b). This indicates that the ERP system did not fully meet the case company's local requirements. And also, the case company had unique or "orthogonal" requirements not available in the ERP system and that simple configuration was not enough to fulfill the evolution of requirements based on our dataset at that point in time.

DISCUSSION AND MANAGERIAL IMPLICATIONS

Based on the maintenance effort distribution of ERP packaged software across various maintenance task categories, we discover that

Figure 8. Overall trends in number of maintenance requests for all tailoring options and task categories





enhancement is the dominant request type, similar to in-house software (as shown in Table 7). It is interesting to note that, contrary to previous beliefs, relatively more corrective requests are made for ERP software as compared to the numbers generally given in the in-house software maintenance literature. This is probably because in-house software is specifically designed, built and tested to operate in an intended environment and is smaller in software size, leading to fewer mismatches and errors – in particular for in-house software that is built on high quality system analysis, programming and system testing. On the other hand, more adaptive requests exist in the in-house software as compared to ERP packaged software. Regardless, we should remember that part of this task category is in fact done by the ERP vendor and is incorporated in patches, updates and/or new version.

As in Figure 6a, we observe that the relative maintenance effort (person-hour per request) for adaptive task category that uses configuration tailoring option increases sharply in the first four months after the introduction of the new HR module. Similarly, the increasing trend of the relative maintenance effort (person-hour per request) for configuration tailoring op-

Table 7. Maintenance effort distribution (%) across different maintenance categories

Task category	ERP packaged software (this study)	In-house software (Jørgensen, 1995; Lientz & Swanson, 1980)
Corrective	28	22
Enhancement	61	51
Adaptive	11	27
Total	100	100

tion (in Figure 7b) indicates that the relative maintenance effort is relatively higher in the first few months (compared to the subsequent months). This coincides with the early months of the introduction the new HR module. This is especially true when we consider that the version of the SAP system studied, for example, has more than 8,000 configuration tables (Gulla & Brasethvik, 2000). Further, the complexity of the configuration may depend on the type of configuration as some are more complicated than others. This area deserves more empirical research attentions in the future. According to Bancroft et al. (1998), the SAP R/3 configurable elements that can be accessed through the implementation guide (IMG) include central functions (i.e. related to the operating environment of a company, such as currency, country, rounding rules, calendar year and unit of measure); organizational elements (associated with the organization or structure of a company, such as company code, controlling area, and functional area); control elements (such as programs and configuration tables used to configure documents or operations); data validation (a simple configuration table for maintaining text information that appears as straight output only); and system control (an element for configuring the Basis System of R/3, such as the ABAP/4 development environment, user authorizations, and printer setup). While data validation is relatively simple, the control element is the most challenging part of configuring the SAP R/3, as reported in Bancroft et al. (1998). The large number of configuration tables and the associated complexities may require a significant amount of time for the programmer and business analyst to become familiar with in order to be more efficient.

The plots of maintenance effort (per request) moving median for the two types of tailoring option over time (in Figure 5 and Figure 6) exhibit a trend of practically significant decrement in relative maintenance effort (person-hour per maintenance request) for configuration tailoring option (particularly for both enhancement and adaptive task categories) and a trend of very slight increment in the relative maintenance effort per request for programming tailoring option (particularly for both enhancement and corrective task categories). This indicates that generally the configurability of the ERP is still beneficial in the long run compared to programming tailoring option. On the other hand, both trends in Figure 5b and 5c empirically proves the suggestion by Light (2001) that the ERP programming option may have penalties in the long term.

Even if, our study may suggest the benefits of configuration, what to do in a real situation is uncertain. More deeply, the proportion of adaptation and enhancement may depend on the evolution pressures, the actual maturity of the ERP and how the needs of an organization match the roadmap established by the ERP supplier. For example, listed companies (at the point of this writing) are required to meet the new global accounting standards – International Financial Reporting Standards (IFRS) in many major countries around the world at different predetermined timeline. ERP vendor such as SAP has been able to provide the adaptations required in the ERP system to help ERP client-organizations to adapt to their new business operation needs. Thus, no customized enhancement is needed by SAP client-organizations to meet the mentioned government regulations.

Our findings also show that the enhancement task category is the most commonly associated with the programming tailoring option and the adaptive task category with the configuration tailoring option. However, the corrective task category is not particularly associated with any of the two tailoring options. In our observation of the evolution of the maintenance requests, we found that the requirements for enhancement decreased over time compared to adaptation maintenance requests. Likewise, the use of programming tailoring options also decreased over time compared to configuration tailoring option. The rule of thumb is that in order to better plan and contain maintenance cost and control maintenance resources, maintenance manager is also required to continuously monitor the latest available maintenance support items, updates and patches provided by the ERP vendor. Some enhancement needs can also be submitted to the vendor as requests for improvements to be incorporated in the future versions of the ERP system. Alternatively, programming tailoring option should be used with careful consideration and sporadically. This can be achieved by first investigating whether the enhancement request is necessary and/or can be satisfied by implementing new patches or updates, usually provided by the vendor as part of the ERP system maintenance support services.

LIMITATIONS AND CONCLUSIONS

Conclusion – This study presents the first empirical insights into the nature and distribution pattern of the ERP maintenance effort, an increasingly important subject of research, especially as packaged software such as ERP increasingly gain dominance over in-house software. It contributes to our initial understanding of the relationships between the ERP task category, tailoring option, and maintenance effort. It also investigates the changes in maintenance effort for different maintenance task categories that use different tailoring options over time within the ERP maintenance environment.

Limitations and threats to validity – Being an early attempt, there are several limitations. Firstly, while the data are from a real case, there is still a threat to external validity as the findings reported may be limited only to SAP R/3 3.1H for both the financial and human resources modules. In particular, the results may be readily applicable only to organizations with characteristics similar to those of the company in this study as described in the case description section. Also, the maintenance time/effort recorded by each maintainer in servicing a maintenance request depended on how rigorous the maintainers were in doing so. Therefore, there could be a threat to this data accuracy and validity. Another threat to the validity is the possible inaccuracy/imprecision in the classification of tasks, especially when there is disagreement in classifying a particular request between two raters. In addition, technical factors such as software platform (e.g., client-server vs. mainframe), software from different vendors, application modules, application logic, and quality of the documentation have varying effects on the amount of effort required. Moreover, personnel factors, for instance application knowledge, domain (functional area) knowledge, ERP programming knowledge and business analyst or programmer experience; and software factors such as change in maintainability, application age and application size may have influenced the overall shapes of the maintenance effort distributions.

Secondly, while the data used in the analysis is collected from the field and provides some basis for the external validity of the results, they suffer from the shortcomings of any field data. According to Neter et al. (1999), a major drawback of this type of data is that there is a threat of inadequate information regarding the cause-and-effect relationship. However, this is not a key concern in this study as it is not directly investigating the cause-and-effect relationship. Also, this paper covers only two types of tailoring options that are available at the data collection site. While the scope of the configuration option is well-defined, the programming-related option covers a wider scope as it can be used for bolt-on, workflow programming, ERP programming, interface development, and/or package code modification. This may cause imprecision in understanding the detailed-level of the actual relationship between each tailoring option and ERP maintenance effort.

Thirdly, this study is limited to internal maintenance requests; it does not cover patch-maintenance or upgrades (that originate from the vendor), both of which are prevalent types of ERP maintenance requests and as a result deserve careful consideration. Fourth, the effort of communicating maintenance requests to the helpdesk and the initial investigation of the request's nature, or so-called Support Line 1 and 2 (Jorgensen, 1988), are not included in the maintenance effort per request as described in this paper. Rather, we choose to focus on the effort after a maintenance request has been approved for maintenance service (i.e. for the Support Line 3 effort) only.

Lastly, old dataset presented here is another limitation, as technology and processes have changed in the last 10 years. However, the data collected from the case company was rare as its maintainers recorded their maintenance effort very precisely in minutes and/or hours spent rather than in number of days, which meant that their maintenance effort spent could be relatively more accurate for data analysis than the other; and the data presented here did produce interesting observations and discussions on the ERP maintenance effort distribution and trends in relative maintenance effort per request for different task categories and tailoring options.

Further work – Despite the above limitations, we can draw several implications for future extensions from this study. Existing beliefs in the ERP maintenance effort and tailoring options leave a lot of room for refinement and further validation. A more complete and detail tailoring option categorization as suggested by Brehm et al. (2001) can be adopted in practice in order to provide a better indication of the amount of effort required to perform maintenance job and produce more accurate maintenance cost estimation. Similar to all previous studies on software maintenance effort, the maintenance task categories in this study include only three types; future studies should attempt to adopt a more comprehensive and simple maintenance request classification in order to minimize the possible validity threats given in Chapin et al. (2001).

Moreover, in order to understand more of the ERP maintenance effort drivers, more empirical studies testing of the various technical, personnel and software characteristics of ERP maintenance requests affecting maintenance effort are required. A longitudinal study on the possible relationships of both the programmer's familiarity and experience with an ERP system on large ERP packaged software maintenance effort also worth future research endeavors as the assumption that programmer's experience is increasing over the evolution is not always valid since from time to time, experienced programmers leave the organization. In addition, ERP client-organizations may perform minor and major ERP version upgrades from time to time, which may create changes in the programmer's familiarity and experience with a different version of an ERP system.

Finally, more studies on researching for a more general measure (e.g. function point counting) applicable to both configuration and programming-related tailoring options for ERP maintenance are needed. Besides, a revised version of the existing COCOMO II model (Boehm et al., 2000) and/or function point analysis method (Ahn et al., 2003) that takes configuration tailoring option into consideration is required. Additionally, given that 'maintenance request' could be a more or less arbitrary 'packaging' of work that needs to be done, a better study would involve measuring the 'size' of each maintenance request (e.g. some sort of maintenance function points) and then evaluating the productivity as person-hours per size unit. Furthermore, it would be interesting to perform an empirical analysis to discover what factors influence the patch maintenance decision and effort, and identify how these factors differ across various ERP software packages and functional areas.

ACKNOWLEDGMENT

The author would like to thank the anonymous reviewers and editor for their constructive and helpful comments and suggestions to improve an earlier version of this manuscript. This study was partially supported by NSC 93-2416-H-155-008.

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APPENDIX A

Protocol for Classifying Maintenance Request

The maintenance request classification protocol is primarily based on the intention and/or reason for the maintenance request – as in Table A. This information was available in case company's maintenance request database. In any case, when two raters have a disagreement in the classification for a request, an additional piece of information – the problem description (i.e. activities required to be performed to satisfy the request) is also referred, and discussion is made until consensus is achieved between the two raters.

Table 8. Problem description classification

Definition (Reason) – as in Table 1	Task category	Additional information - Activities required to be performed – based on Chapin et al. (2001)
Fix any defects, for example expected but missing or wrong functionality, and processing or performance problems	➔Corrective	Fixing detected bugs, adding more defensive programming, and changing the handling of exceptions
Adapt functionality, and processing or performance to anticipated changes in the data or processing environments	➔Adaptive	Porting/adapting the custom-built software to a new platform, increasing Commercial off-the-shelf(COTS) utilization, and moving to object-oriented technologies
Enhance processing or performance efficiency; and develop new interfaces, new functionalities and new reports	➔Enhancement	Adding or replacing business rules to extend or expand the system's functionality accessible to the customer, and adding data flows into or out of the software

APPENDIX B

Table 9. Examples of the work done in each maintenance task category

Task category	Examples
Corrective	Fixing of errors in page formats, report contents, error-messages, user interfaces, and program (e.g. investigate the accuracy of leave balances and accrual rates, correct formatting in multiple page statements, fix error in treasury program, fix error in Payroll interface, mending incomplete error-message, fix leave balances error in report, correct payslip formatting, fix bug in standard LSL provisions code)
Adaptive	Maintenance of data accuracy and consistency in the master data files in the SAP system, and the adaptation of existing business operations to meet existing (or new) business environment (e.g. update the change in payroll on-cost rates, set up new pay scale type and level, amend consultancy report, modify report to allow a single company printing, add additional option for Investment Reason field)
Enhancement	Improve the performance of the system, add new features to the system, enhance business processes performance, add new report, and add new interface (e.g. create a new report of listing of unposted assets, create a new feature to download leave balances, change Receipt Interface program, modify the program to add Trading Partner, improve performance of Payment run job, modify HR/FI interface, develop electronic stocktaking system)