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USAGE ANALYSIS IN SAP ERP-SYSTEMS FOR MEASUREMENT OF BUSINESS MATURITY – EXEMPLIFIED IN PURCHASING

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ABSTRACT

In business IT, empirical data is very rarely in the form of corporate usage data from system analyses. This article is based on 105 ERP-systems that have been analyzed in-depth, and whose data deliver empirical conclusions about usage and the level of maturity of business processes, and quantify the primary types of activities users are involved in. The approach is applied by comparing two groups in the database: "Automotive Industry" and "Non-Automotive Industry". Here we focus on identifying significant differences in the efficient use of business processes in purchasing between the groups. These efficiency indicators where deviated from most accepted purchasing maturity models. The research question is to validate the high evaluation of the Automotive Industry in those models against the reality we can find in the ERP-System. The usage data was gathered from usage analyses of SAP systems via RBE Plus, a reverse business engineering tool. It is based on the activities of more than 270,000 users in organizations in Europe and the USA. The findings offer enterprises a standard of comparison and reveal potential for improvement in sub-processes.

KEYWORDS

ERP, SAP usage analysis, RBE, automotive industry, purchasing.

1. ERP USAGE IN ENTERPRISES

Nowadays it is nearly impossible to imagine enterprises – especially industrial ones – without ERP systems. Even until now, when examining those business processes based on ERP-System mainly, there were only two ways to do so: by analyzing reference models and by polling users.

One option is look at the software functionality offered as it is depicted in reference models (Winkelmann 2010). But it must be assumed that for various reasons not all functions available are also used. And so it is necessary to survey specific companies to try to determine the primary types of activities users are involved in (Jones and Young 2006). However, the disadvantage of these kinds of surveys is that their quality is compromised: information is subjective and depends heavily on the knowledge and position of the person answering the questions. And because the task is labor- and time-intensive, it is difficult to sample a sufficiently large population to ensure that the data is representative.

A specific use case of business assessments is the measuremuent of business and process maturity by analyzing ERP-Systems and corresponding usage indicators (like in Table 3). Because most of these KPIs are not available in Standard-ERP-Reporting, Business Consultants spend a lot of time for interviews and workshops.

And so, in this article, we use a different – more objective – data source in order to empirically determine actual usage of purchasing processes in corporations. The source is a database that includes 105 tool-based usage analyses conducted via the RBE method (Hufgard and Wenzel-Däfler 1999). This ensures that all metrics are derived from the same pool of data.

Consequently, we can determine which of the purchasing-related functions contained in SAP ERP are used and how intensively. It also enables us to examine the oft-expressed conviction, that there are differences between the automotive and other industries that might implicate a higher average level of maturity in the former's purchasing processes (Keogh and Éamonn 1994, Rozemeijer 2003).

First, sections 1.1 and 1.2 briefly examine the current status of the ERP discussion and comparable scientific approaches to analyzing user organizations. Next, section 1.3 introduces the system-based method implemented in the SAP usage analysis. This section also describes the tool (RBE Plus) used to cull and format data from 105 user organizations. Section 2.1 discusses the research questions and method, while section 2.1 elaborates on the analyzed data from these organizations. Section 2.2 validates the data by drawing basic comparisons between the panels. Section 2.3 reveals differences in the user structure within purchasing. Section 2.4 examines whether there are differences in the subprocesses used. And section 2.5 expands on the automation of document entry throughout the purchasing process.

Section 3 summarizes the findings, answers the research questions and, based on the outcome, discusses whether further research is a worthwhile pursuit and whether it can benefit user organizations. Section 4 offers some conclusions.

1.1 Advanced ERP Systems

Many organizations have implemented enterprise resource planning systems such as SAP ERP worldwide in order to stay competitive and respond more quickly and easily to everchanging business strategies (Robey 2002, Strathman and Roth 2002). ERP systems are integrated information systems that provide business processes for a number of users on a single, integrated database (Wei 2005). While offering a wide range of functions and business processes, these systems can also be configured to the specific needs of each company (Winkelmann 2010, Klaus 2000). ERP systems therefore belong to a type of standard software (Hufgard 2001) that can be modified to meet new market demands, keep pace with organizational change in each company, and be adapted to users' evolving tasks (Davenport 2000, Shanks 2003).

They are often referred to as integrated systems, meaning that all software components must be semantically integrated with one another. State-of-the-art ERP systems are even capable of integration beyond the confines of the organization. This can be achieved, for example, by electronically linking suppliers, customers or regulating authorities with the company. When the connection goes beyond merely transmitting orders (sales orders, purchase orders…) to include some aspect of planning, it is referred to as supply chain management (SCM).

These aspects are especially important for industrial enterprises, more specifically for organizations in the automotive industry, because they enable suppliers to connect with their customers, or big OEMs with their suppliers to directly confirm delivery dates for the end customer. To be sure, the organizations themselves profit from being able to call up sales orders, purchase orders, production orders, resources or account balances anytime.

Over the past several years, more powerful hardware has led to ongoing enhancements in software functionality. In turn, SAP Business Suite has become the most extensive standard application software for companies ranging in size from small to very large. Today more than 100,000 user organizations, a number of them large-scale enterprises and DAX companies, use this software (SAP 2015). Thanks to the wide use of ERP systems in the corporate world, there is a wealth of current empirical data from which to draw conclusions about the degree of utilization and the quality of business processes.

1.2 Usage of ERP Systems

An organization may have implemented an ERP system, but this in no way means that all implemented functions are actually used, or used regularly (Hufgard 2010).

Next, consider that SAP Business Suite implementation often takes several months – even years – and very quickly it becomes clear that major obstacles can pose a barrier to the use of a function. By implication, this means that the use depends on the specific needs of the company, but also on whether the anticipated benefits justify the cost of implementation.

An analysis of system usage and user behavior, differentiated by activities in business processes or by the primary types of activities the user is involved in, is estimated to be very helpful but difficult to achieve (Meier 2001).

Previous studies examine usage only rudimentarily: For example, Jones und Young conducted a mail survey in which they received a valid response from only 50 of all Fortune 1000 companies. The survey contained 26 multiple choice questions, including ones about the number of users (<500, 50-1,000, 1,000-2,500, 2,500-5,000, >5,000) and the number of modules used. One problem is that the questions are not very detailed. For example, the functional scope is limited to which modules are used (Jones and Young 2006). What is more, the answers cannot be verified; nor can the question of who actually completed the questionnaire.

Recently, researchers are using business process analysis methods, such as process mining, to investigate real business operations in ERP systems (Song & van der Aalst, 2008). Process mining is a data mining method to extract detailed business process activities in terms of improving the understanding of actual system activities and business operations. Emergent process mining offers promising ideas to address the need to reveal actual process execution (Jansen-Vullers et al. 2006), discover underlying informational facts of daily business processes (Song & van der Aalst, 2008), and expose the impact of ERP configuration on

various process activities (Dreiling et al. 2005). However, currently, this method is solely used to identify issues of ERP configuration.

User's perspective of ERP systems is another topic that attracts researchers' attentions (Schlichter & Kraemmergaard, 2010). However, most of the current studies focus on system adoption and user satisfactions of the ERP systems (Chang, et al. 2008). Limited research reported in the literature are confined to areas such as use-fulness of the system from the users' perspective (Amoako-Gyampah, 2007; Jones & Young, 2006), and their conclusions solely rely on users' subjective opinions through survey questionnaires.

Analyzing user behavior with respect to activities in business processes and/or differentiating areas of focus is thought to be helpful, but extremely difficult. Conventional methods for examining user behavior within information systems include distributing questionnaires and, in rare cases, making observations. Even in international publications citing usage phases of ERP systems, justification for the creation of entire models is based on surveys of individual users (Gattiker & Goodhue, 2005) or even on customer presentations.

1.3 Usage Analysis via RBE Plus

The process of deriving models from live R/3 systems was coined Reverse Business Engineering (RBE) by Hufgard and Wenzel-Däfler (Hufgard and Wenzel-Däfler 1999). The purpose of the corresponding analysis tool, RBE Plus, is to find out which processes, functions, customization settings, master data or transactions are used – by whom, how frequently and how intensively – based on configuration- and usage data from a company's SAP software. This creates a factual basis for assessing system and process organization and actual system usage by employees (Hufgard 2001).

Usage analytics employs indicators and reference structures to identify which configuration options the customer is using for the SAP system and which ones are available but not used. Furthermore, RBE analyses can indicate which SAP solution scope has been configured (selected, customized), and where functionality has been added. In this way, analysts can reconstruct the target concept for organizational structures, business processes and their variants and compare them to their actual usage – from master- and transaction data actively used.

RBE Plus does not evaluate sales figures, stock values or other critical financial data; it concentrates solely on system configuration, metrics for processes and other structural indicators. There are major restrictions even on the use of this type of data, including mandatory deletion of the original data.

The method of data gathering implemented for this behavioral research stands in stark contrast to the data source we used for the research described in this article. Our source is an essentially reliable database consisting of the data trail of activities users leave in their standard application software. However, accessing this little used source and formatting it properly is also fraught with certain difficulties.

For an analysis, the detailed data must be identified and anonymized to comply with data protection and company requirements. German data protection laws require that it be impossible to identify individual users and the specific company the data is from. Furthermore, the raw data has to be aggregated to create meaningful usage indicators and structured to answer the research questions.

As part of the research in this paper, we adopted RBE, an advanced and more intelligent usage analysis and process mining method, to collect user activities in daily business processes in order to understand and find useful information that we hardly know before about business processes in real business operations.

1.4 Research Question and Method

The functional usage of ERP software, in particular, is a very powerful indicator of IT penetration in companies. And so, the first question to ask is:

(F1) What purchasing-related functions of ERP software must be employed and how intensively?

In the best-known maturity models for purchasing, such as Keogh and Rozemeijer's, the automotive industry is classified at the highest level with respect to purchasing (Keogh and Éamonn 1994, Rozemeijer 2003). Conditions defined for this classification include close supplier relations (e.g. via supplier contracts), a strategic approach to purchasing and a competitive selection of suppliers (e.g. thanks to bid invitations). In the empirical study, this was verified via a selection of corresponding metrics that indicated the presence of these criteria. Bruel also takes a similar approach. This publication evaluates maturity via benchmarks (Bruel and Petit 2005), though it does not describe in detail how these are measured.

Furthermore, our aim is to examine whether a greater degree of automation is indeed indicative of greater efficiency. This assumption is derived from Steghuis's maturity model, whose highest level requires a clear strategy for using IT and a commitment to and practical application of this strategy throughout the organization (Steghuis 2005).

(F2) Do the metrics for usage in ERP systems of companies in the automotive industry actually reveal better results and therefore a higher level of maturity?

To answer these questions, we will first present and describe the analyzed data (2.1), and validate the "Automotive industry" and "Other" panels (2.2). The results reveal significant differences in the primary types of tasks users are involved in (2.3), the frequency and usage of subprocesses (in terms of the quantity of documents generated) in purchasing (2.4) and in the degree of automation (2.5). These results enable us to answer the research questions. In each case, we have chosen the best method of presenting the statistics. We have kept explanations brief, including only what is necessary to aid comprehension.

Section 3 offers a discussion and interpretation of the findings.

2. EMPIRICAL RESULTS OF THE ANALYSIS

2.1 User Organizations Analyzed

The data sets were culled from 105 RBE Plus analyses conducted between 2011 and 2015. Each set consists of approx. 4,000 values and metrics from predominantly industrial enterprises in Europe – mostly Germany – and the USA. Common to all of them are the end-to-end purchasing processes, from accounting to logistics. The data has been double anonymized to respect confidentiality and fulfill nondisclosure obligations. User data is only available in the form of aggregated metrics and all descriptive data has been eliminated to prevent identification of any one company. Differentiation by industry or country was possible despite anonymization, thanks to assigned dummy variables.

Furthermore, very specific data (such as minimum and maximum) has been rounded or described as intervals in order to protect the identity of the companies. All other statistics – such as the mean and the standard deviation – remain unchanged.

2.2 Panel Validation

The data extracted from 105 ERP systems was divided into two panels according to industry type. In other words, all 23 systems from this pool belonging to an enterprise within the automotive industry (manufacturers and suppliers) were specified as such, to enable comparison, using the "Other" as a control group. Because of inconsistencies in measuring the data (metric unavailable) and for business-related reasons (purchasing function not used) it was not always possible to use all of the 23 or 82 data sets; this is why sample sizes vary. To examine the data we used a two-dimensional ANOVA analysis to uncover disparities between the panels.

The following section presents the results in tables and figures, which depict the metric, degrees of freedom, the f- and p-values, the arithmetic mean values and the respective sizes of the samples for each of the panels. Sections 2.3 and 2.4 contain boxplots (top, dark = organizations within the automotive industry; bottom, light = organizations outside of the automotive industry). The box itself represents the median and the average 50% of the data. The whiskers are plotted at 1.5 times the interquartile range. Outliers are plotted as single, gray points. If for reasons of clarity a log plot is used, this is noted.

Using the ANOVA analysis as a research method allows the usage indicators to be viewed as independent variables, exhibiting greater variances among the groups than can be ascertained within the panels. The independent variable is the industry affiliation.

Therefore, if $F > 1$ and the p-value < 0.051, the number of degrees of freedom leads us to assume that there are significant differences between the panels.

First, the user organizations were evaluated with respect to their ERP systems' complexity (Table 1). The six factors for assessment were the number of active users, the SAP modules used, the enhancements used, the interfaces implemented, the number of active organizational units and the number of countries in which financial statements must be submitted.

Table 1. Validation factors – ERP system

Validation factors	*Measurements based on*	*Panel*	*Median*	*Mean*	*ANOVA F (df) P*
Active dialog users	SAP Transaction Monitor (ST03N)	Auto	1,129	5,912	Difference 3.0 (1.96) 0.082
		Other	1,475	3,174	
Active SAP modules	SAP Transaction Monitor (ST03N)	Auto	19	19	Difference 3.8 (1.96) 0.053
		Other	17	17	
Organizational units	SQL: Number of active company codes, sales organizations and plants	Auto	907	5,731	Significant difference 5.6 (1.95) 0.019
		Other	460	2,199	

Countries	SQL: Number of different countries in active company codes	Auto	6	7	0.6 (1.95) 0.452
		Other	2	11	
Communication interfaces	SQL: Number of transaction calls via interfaces (ALE, Batch, CPI-C, RFC) and systems sending and receiving IDOC	Auto	1,180	1,613	Significant difference 11.1 (1.96) 1.318e-3
		Other	342	720	
Enhancements	SQL: Enhanced programs, tables, customer-specific transactions used, BADI implementations and customer exits	Auto	3,765	5,380	Significant difference 31.7 (1.96) 1.76e-7
		Other	1,287	1,896	

Based on the results, three main significant differences can be identified among the panels: user organizations from the automotive industry have on average more organizational units. What is more, they use more communication interfaces (including IDOC, RFC) and have implemented more enhancements (such as customer programs and company-specific tables). Differences among the panels with respect to active dialog users and active SAP modules were also observed. However, the significance levels for both results are slightly higher than the 5% significance level adopted.

Concerning the number of countries in which a financial statement must be submitted, it was impossible to discern disparities between enterprises within and outside of the automotive industry, based on the data sets available.

We expected data regarding communication interfaces to differ significantly, because the industry is considered a pioneer of electronic data interchange. The even greater difference concerning specific enhancements can be partly explained by this; but it is also a clear indicator that an above-average number of industry-related functions were added to the SAP standard.

To validate the panels for significance with respect to purchasing, we compared purchasing organizations, number of suppliers and material master records.

Table 2. Validation results – purchasing-specific

Metric	*Median*		*Average*		*Sig-nifi-cant*
	Auto	*Other*	*Auto*	*Other*	
Purchasing organizations used	5	6	10	17	
Number of suppliers	7,032	35,154	43,889	84,131	
Purchasing records (supplier x material)	42,052	58,159	291,436	208,230	

Whereas a definite discrepancy can be seen in the median number of suppliers, when viewed in combination with the purchasing records, the data implies a close supplier relationship in purchasing, as more components are procured per supplier. But the difference between the panels is not significant in this case: F=1.4 df (1.79), P=0.232). The aggregated results in Tables 1 and 2 fully characterize these data sets and enable us to determine

significant differences, as expected for the industry. Other areas, such as the number of users and which modules were used, also revealed marked – though not really significantly more intensive – usage of ERP systems. Overall, the initial results show clearly recognizable differences, and that the panels offer a valid basis for further investigation

2.3 User Structure

For the user structure, we first compared the number of dialog users who created scheduling agreements. As anticipated, we found that in the automobile industry, a significantly greater number of employees were tasked with creating scheduling agreements (Figure 1).

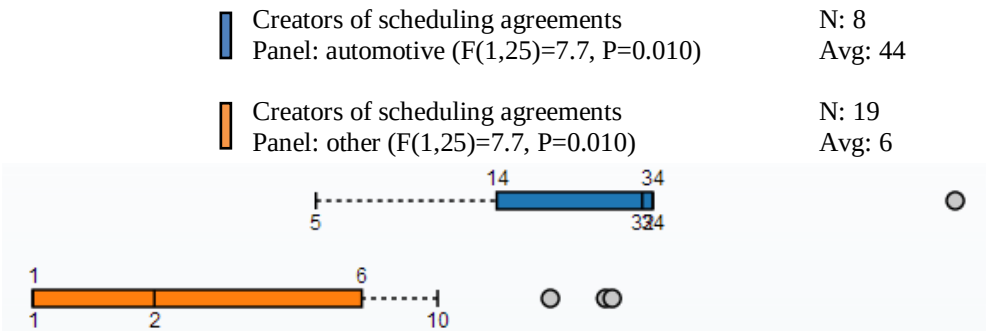

Figure 1. Creators of scheduling agreements (log plot)

Whereas the median for the other 19 companies using scheduling agreements is two, the available data sets for the automotive industry show the median to be 32. The average of 44 employees is a little less significant in this case because it's such an extreme outlier. This metric was updated, so that only 27 data sets were available, because this functionality is mainly used by the manufacturers and large system suppliers (tier 1 and 2). The four in the other group are manufacturers of consumer goods.

At the beginning of the purchasing process, employees create or edit purchase requisitions. Comparison of both panels reveals a highly significant difference (Figure 2). While in the automotive industry an average of 1,044 employees work in this area, in other industries, the number is a mere 172. What is more, the median in the other organizations – 70 employees – is much lower than the 322 employees from the automotive industry panel.

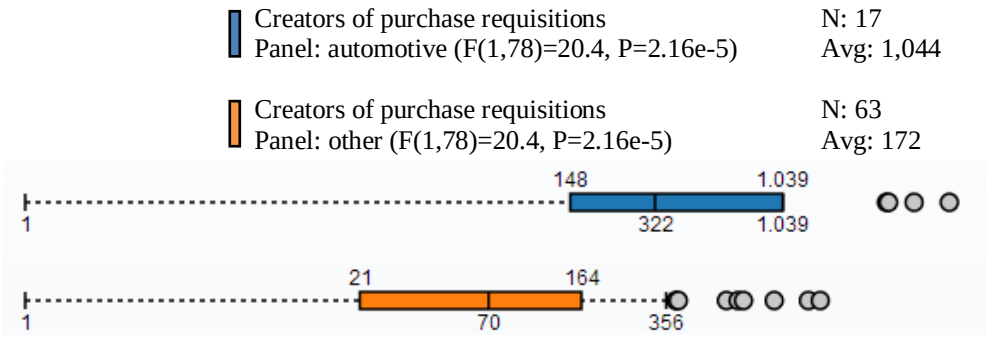

Figure 2. Creators of purchase requisitions (log plot)

The same is true for employees who create contracts (Figure 3). In organizations within the automotive industry, on average more than twice as many employees create contracts than in enterprises in other industries. The divergence between the medians does not quite correspond to this factor, but the correlatively low probability of error leads us to conclude that the difference can be considered significant.

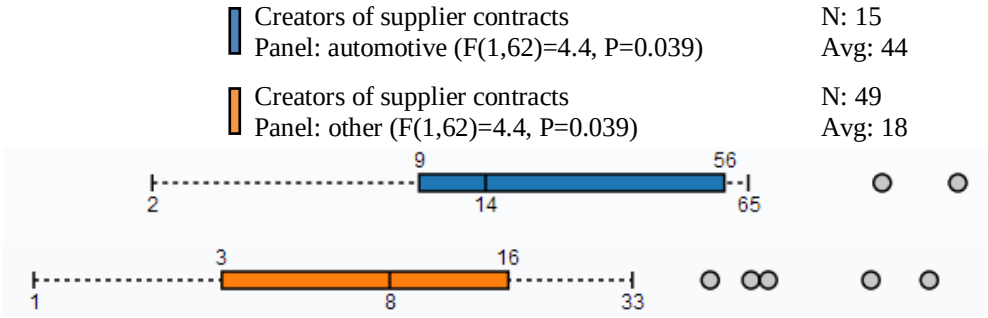

Figure 3. Creators of supplier contracts (log plot)

With respect to the number of users involved in the following process steps like the creation of purchase orders, no significant differences could be discerned between the panels. Although the data implies a difference in the number of users who create and edit purchase orders (data set shows an average in the automotive panel which is twice as high as the average in the other panel because of an outlier with almost 2,500 users. In contrasts the medians differ to the other direction), it is not significant in this case: F=2.0, P=0.156 (Figure 4).

Same can be stated about the users who create or edit deliveries: the dataset implies a difference regarding the average which is almost twice as high and the median which is more than three times higher in the automotive panel. But the propability of error is too high and the assumption has to be declined because of missing the significance threshold (Figure 5).

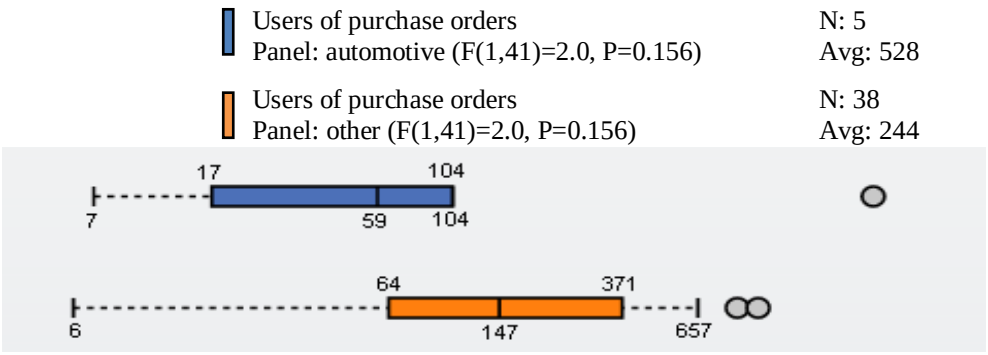

Figure 4. Users of purchase orders (log plot)

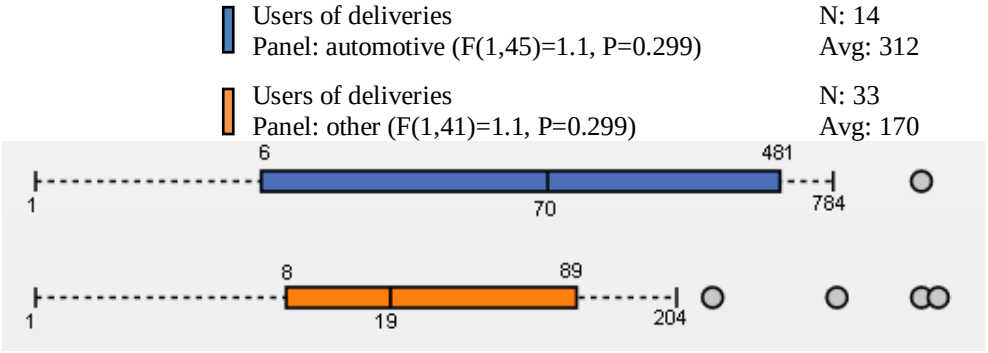

Figure 5. Users of deliveries (log plot)

Significant differences showed up in the following process steps again: when we looked at invoice verification we did again see on average more employees tasked with this process in the automotive industry (Figure 6): an industry average of 93 contrasts with 53 in non-automotive industries. In addition, the first panel's median differs from the second panel's by approximately a third.

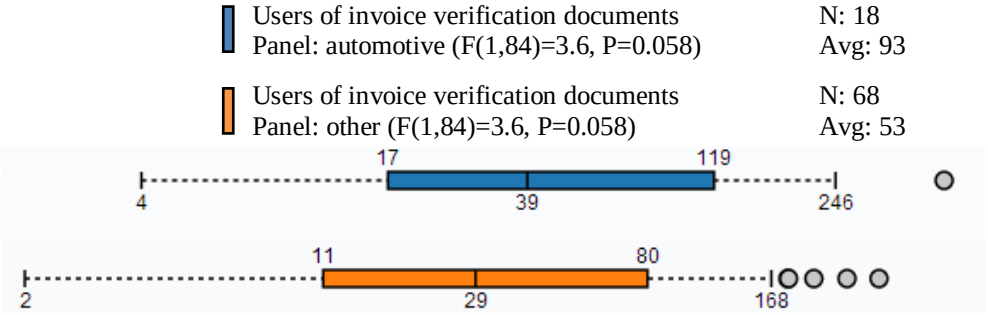

Figure 6. Users of invoice verification documents (log plot)

Finally, we can conclude that in the automotive industry more users are active – particularly in strategic purchasing (Figure 7). An average of 68 users in the first panel contrasts with 26 strategic purchasers in the second. The medians also differ. The available data sets show with a very low probability of error that on average, both the arithmetic mean and the median are nearly three times as high. What is more, in the non-log plot, it is clear that the distribution of the panels is similarly right-skewed.

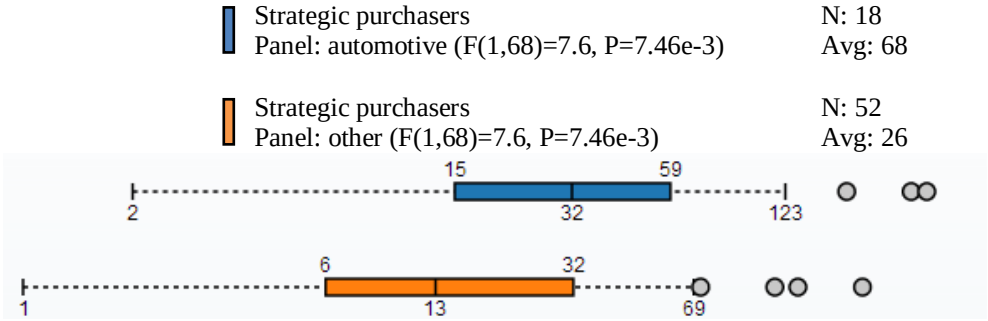

Figure 7. Strategic purchasers (log plot)

2.4 Process-related Divergence

We observed data from a different perspective to obtain the results presented in the following section. We examined the process data. First, we analyzed the share of supplier invoices from purchasing (Figure 8). This means that the metric shown reflects the share of purchasing transactions in relation to all supplier operations. And just as with the number of purchase order creators, we were unable to detect any significant differences.

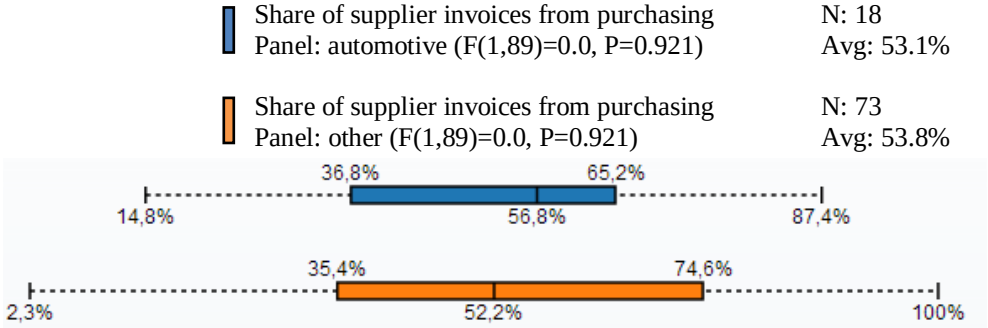

Figure 8. Share of supplier invoices from purchasing

The findings concerning bid invitations – measured by the number of valid request- and bid packages – were much different (Figure 9). Here we identified quite significant differences. Whereas the second panel revealed an average of 2,379 request items, the automotive industry showed an average of 11,686. Furthermore, the medians of both distributions differ greatly – by 387 and 8,035, respectively. The contrast can also be seen in

the boxplots. The top whisker of the non-automotive companies is still significantly below the median of those in the automotive industry.

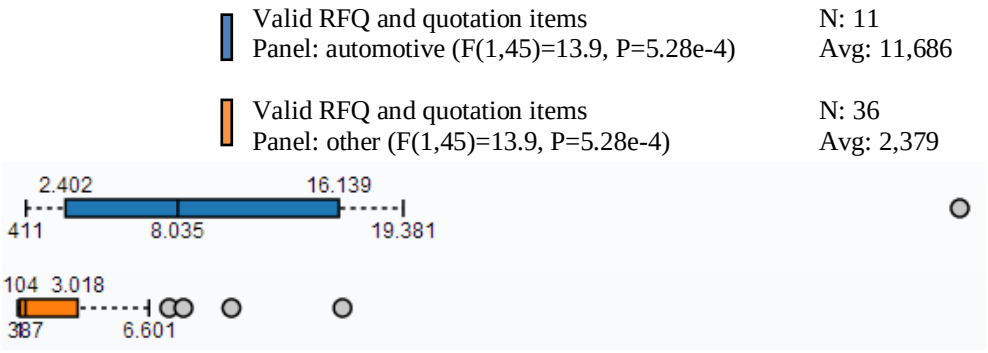

Figure 9. Valid RFQ and quotation items

As anticipated, the valid items for which there is release documentation from scheduling agreements are every bit as extreme. Although the sample size was so small, the results are significant (Figure 10). Both medians and means, which differ by a factor of two or more, indicate a marked difference in the use of this process step.

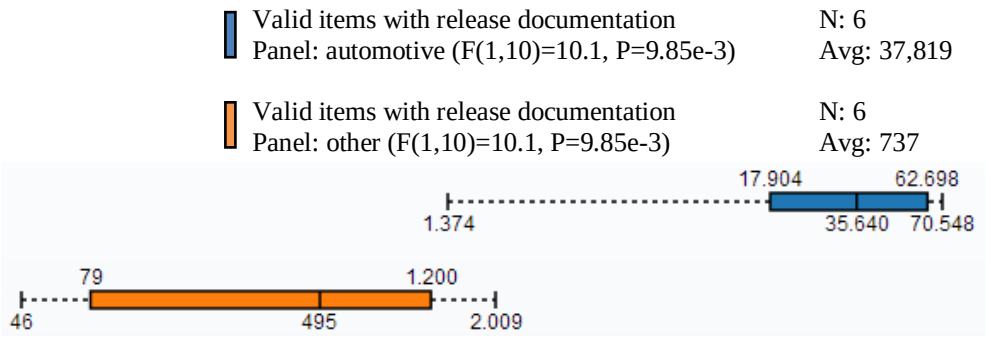

Figure 10. Valid items with release documentation (log plot)

With these findings in mind it wasn't very surprising to detect significant differences in the number of created documents per month related to outline agreements too (Figure 11). While the median in the automotive industry is more then ten times higher than in the other panel, around 34k documents per month in average contrasts 9k in the control group.

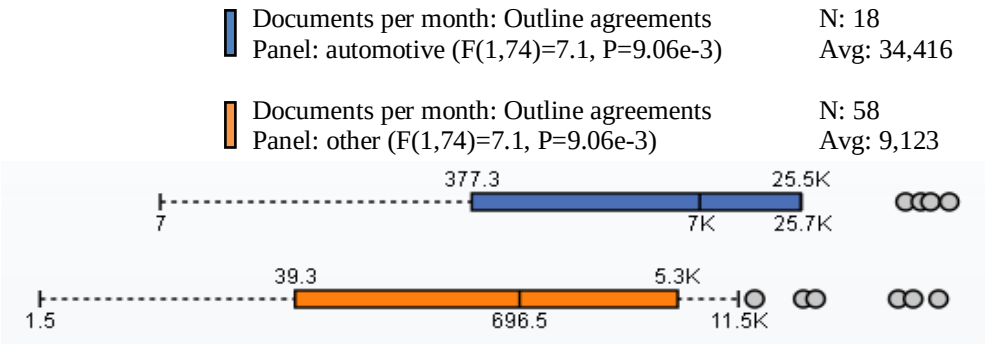

Figure 11. Documents per month: Outline agreements (log plot)

Further significant differences showed up when we looked at the average lead time between the creation of purchase orders and goods receipts (Figure 12). The median of the automotive panel is 50% higher than the median in the control group. The lead times differ by two weeks in average. This could indicate a more efficient long time planning in the automotive industry.

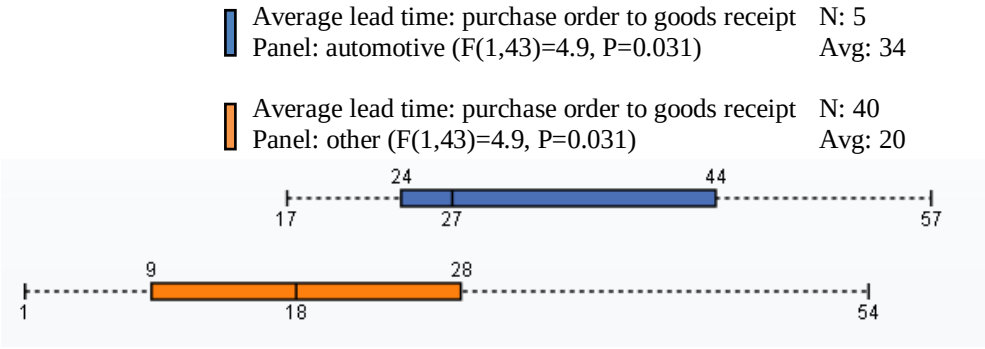

Figure 12. Average lead time: purchase order to goods receipt

2.5 Degree of Automation

The following section deals with the degree of automation, which serves as an indicator of productivity. It measures automated entry and processing via workflows that control routing business processes within the system. Normally, these activities are represented by documents automatically generated by the ERP system rather than ones created by dialog users.

Whereas the purchase order requests and purchase orders did not reveal significant differences in the degree of automation, significant differences can be discovered in the upstream process steps. In particular, outline agreements are more highly automated in the automotive industry than outside of it. The means differ by more than 21, the medians by more than 33 percentage points (Figure 13).

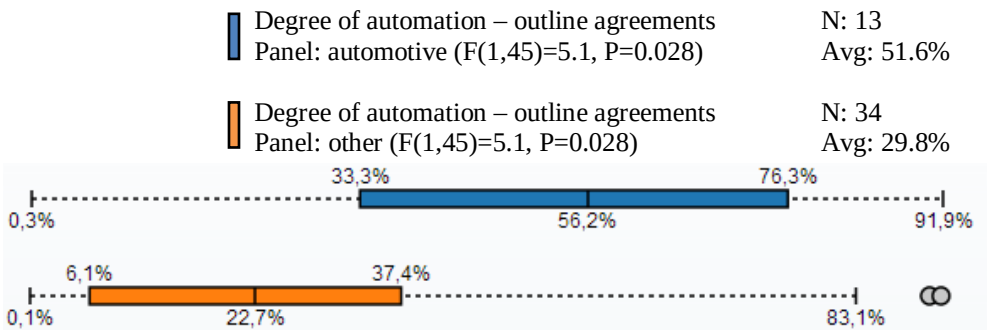

Figure 13. Degree of automation – outline agreements

Invoice verification also showed distinct differences (Figure 14). In the automotive industry an average of 54% of invoice verification documents were generated automatically, whereas this figure was about a third lower in the other companies. The median of the first panel, 61.2%, is more than twice that of the median in the "Other" companies.

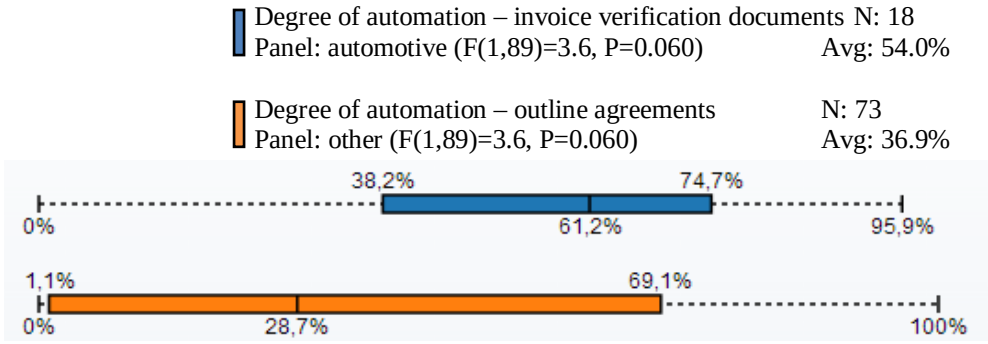

Figure 14. Degree of automation for invoice verification documents

3. DISCUSSION OF RESULTS AND RESEARCH QUESTIONS

The results, including those summarized in Table 3, clearly show that the above-mentioned SAP usage analysis enables us to answer the research question F1, concerning usage intensity of purchasing-related ERP software capabilities. This can be done systematically from three perspectives: user activities (2.3), process indicators (2.4) and process automation (2.5.).

Table 3 summarizes the results of hypotheses testing for 14 usage indicators. As demonstrated by the data analysis above, this empirical study shows significant differences between the "automotive group" and "other" user companies for 10 indicators, while for 4 no difference could be found.

Table 3. Summary

	Metric	*Median*		*Mean*		*Significant*
		Auto	*Other*	*Auto*	*Other*	
1	Creators of schedule lines	32	2	44	6	X
2	Users of purchase order requisitions	322	70	1,044	172	X
3	Creators of supplier contracts	14	8	44	18	X
4	Users of purchase orders	59	147	528	244	
5	Users of deliveries	70	19	312	170	
6	Users of invoice verification documents	39	29	93	53	X
7	Strategic purchasers	32	13	68	26	X
8	Share of supplier invoices from purchasing	57%	52%	53%	54%	
9	Valid request items	8,035	387	11,685	2,379	X
10	Valid items with release documents	35,640	495	37,819	495	X
11	Documents per months: Outline agreements	6,992	697	34,416	9,123	X
12	Avg. lead time: purchase order to goods rec.	27	18	34	20	X
13	Degree of automation: Outline agreements	56%	22%	52%	30%	X
14	Degree of automation: invoice verific. doc.	61%	29%	54%	37%	

The following can be said about research question F2: strategic purchasing in particular reveals much more intensive usage of ERP software functionality and therefore far greater maturity of business processes in purchasing than in the "Other" panel. This includes the conclusion of outline- and scheduling agreements and procurement of goods via these agreements. Bid invitations with supplier RFQs and quotations are also used on a much larger scale. And on average, more users work in these areas. The same is true for purchase order requisitions, which are much less often created from a central point.

Not until later stages of routine purchasing is it impossible to find any more significant differences. This applies especially to purchasing transactions, logistical activities such as delivery and invoice processing. However, invoice verification deploys more employees in the automotive industry, on average.

The degree of automation is also far higher in some areas, thus implying more effective and efficient use of the ERP system, with its embedded workflow management.

As regards the research question F2, these findings allow us to conclude that the automotive industry has more integrated processing in the strategic purchasing activities. Above all, the order planning and initiation phase, and then invoice verification lead one to conclude that purchasing is "better" in the automotive industry. But this applies only selectively – not to the purchasing process as a whole. With respect to maturity models – depending on which definition is applied – it can be said that the automotive industry makes better use of IT – at least in purchasing, where the ERP system functions are almost fully utilized. Integration across sub-processes – as commonly postulated – can also be identified. It might be worthwhile to study the connectivity to other systems and company relationships in the automotive industry.

4. CONCLUSION, CAVEATS AND RECOMMENDATIONS

As one of the most important developments in information technology, ERP software packages have the potential to streamline organizational data flows, reduce operational cost, increase market responsiveness, and thus sharpen the organization's competitive edge. However, the risks they carry are equally great. Adoption of these systems is not only a technical project demanding heavy investment and lasting commitment, but also a business endeavor challenging business processes and organizational behavior. Kirchmer (1998) pointed out that many companies think that after the completion of the implementation project, implementation activities would be over. This however is certainly not the case because business process improvements require continuous monitoring and updating of the ERP software to reach the most effectiveness and efficiency. This study adopted process mining to take an internal perspective, investigate the detailed activities within the process, and thus uncover differences between envisioned processes and actual process execution.

Our study provides substantive conclusions about the effects of differences in ERP usage in organizations. We formulated a number of hypotheses regarding the influences of industry. According to our data analysis, we found evidence to support most of our hypotheses. We conclude that this paper by adopting RBE Plus to conduct usage analytics contributes with new ideas of using available user activity data in ERP and new knowledge of improving effectiveness and efficiency of ERP systems.

The main contribution of the study are the application of objective perspectives on the use of ERP that directly and accurately demonstrate the actual usage of business processes in daily operations and distinguish ERP usage differences between industries. First, the study findings clearly show that there are ERP users whose operation capacity are not reached full enough. In other words, the user's efficiency of ERP applications can be optimized. Our study suggests that organizations could find those users, whose jobs need to be optimized by running RBE Plus analysis tool, balance user tasks and responsibilities, and thus improve the efficiency and lower the operating costs of ERP.

Second, according to the usage analysis, the results indicate the need for optimizing distribution of tasks for certain business processes. Third, our study contributes to emphasize the need for continuously optimize and automate business processes in ERP to reach the best daily business operations and reduce the operational costs. ERP usage analysis is a good method/tool for organizations to continually identify those business processes which could be further optimized with higher degree of automation after the initial implementation. Finally, our findings suggest that attention should be paid to differences: Is it problem to be solved or are there reasons like different management styles and methods to define and apply business processes in ERP systems. Through usage analysis, organizations could compare the differences, learn from each other and define their own methods to improve the efficiency and effectiveness of the ERP systems. For large international companies, they could also customize the ERP usage in different industries to localize their ERP systems and build a more comfortable environment under each individual circumstance. Even more, the results from this study can help organizations to adjust their strategies regarding to the information systems applications according to each industry traits.

This empirical study would also provide theoretical background to researchers who are working on Post-implementation ERP areas. This research not only provides a useful analysis method for researchers to study the ERP usage in daily business, but also emphasizes the

importance of differences in ERP usage in organizations. Industry issue could be an additional dimension in many other Post-implementation ERP studies. Researchers therefore can further expend their research models to more generalized applications.

In this study, we only focus on two different industry areas in the ERP usage analysis. In the future, we are planning to expend to other industries, such as utilities or consumer goods to further test the relationship between industry and their ERP usages. Future research could also adopt usage analysis to explore the significant impact of variables including levels of system integration, knowledge distribution, and user efficiency on individual activities and performance.

The data pool introduced here provides initial insight in response to the subject matter examined. Nearly every one of the aspects illustrated can be enlarged on and linked to further issues. Discussions within the user community should address new issues, and partners in research and industry are encouraged to expand the metrics base.

The challenge of usage analytics lies in leveraging the insight gained to promote and secure improvements to the greatest extent possible. The ever growing data pool gathered from live SAP ERP systems and presented in this article will be the source of further publications. But discretion, confidentiality and protection of sensitive data must remain the highest priority.

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