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Measuring IT System Value with Entity-Specific Factors Influencing Process Runtime Efficiency

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Abstract. This empirical study explores the different factors influencing the runtime of a booking process in the middle office of a major European investment company. The study is based on mixed methods research that combines qualitative research data collection techniques with a quantitative research approach. On the basis of semi-structured interviews, we first develop and present a model of the business process and control points to assess booking runtime. We further identify relevant and IT-related factors such as process automation that may affect booking runtime. Then, we analyze a unique dataset of historical process cycles providing details on booking runtime. Our quantitative analysis of this data provides new insights into how to identify most relevant factors affecting runtime of transaction processes in the financial industry. From a methodological perspective, our study illustrates how to conduct mixed methods research in the field of process performance evaluations.

Keywords: Business Processes, Business Value of IT, Investment Management, Mixed Methods Research

1 Introduction

Dealing with information and risk is the crucial core task in the business processes of financial institutions [1]. These institutions are embedded in financial markets that are highly competitive and also often called to be the most dynamic ones [2]. That is why management of financial business processes is identified as a key component to competitive survival by understanding, analyzing and redesigning processes [3]. Brahe and Schmidt provide a qualitative analysis related to efficiency advantages by the introduction of a business process based workflow management system in a financial institution [4]. These approaches often focus on single aspects like strategy or process efficiency [5] but neglect other factors of process performance [6] including process standardization. Weitzel et al. find that efficiency along the transaction processes is influenced by the institutional ability of automated straight through processing (STP) and how involved parties interact at a communicational level [7].

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In this paper, we present an empirical performance analysis of a trade booking proces within a so-called ‘middle office‘, a department of a major European investment company with more than €150 bn. assets under management. The observed process starts when a trade actually took place at the front office and the so-called ‘trading desk‘ as well as the associated broker (i.e. a financial market intermediary) submits the trade (T) and the broker confirmation (BC) to the middle office that aggregates all information about the trade, including its fees. Then, the middle office delegates trades to the responsible departments in the back office (B). The trade booking at the middle office terminates when the trade is booked to the back office systems with all relevant fee information (SC) (s. Figure 1).

The delegation of trade information is time-critical as fund customers need to be updated about their investments and values continuously. Further, book keeping and risk management need to be informed about recent trades. If the middle office processes and the information flow between the front office and the back office departments of the investment company are interrupted, inefficiencies arise due to additional costs (e.g. because of manual processing) and risks in the trading process.

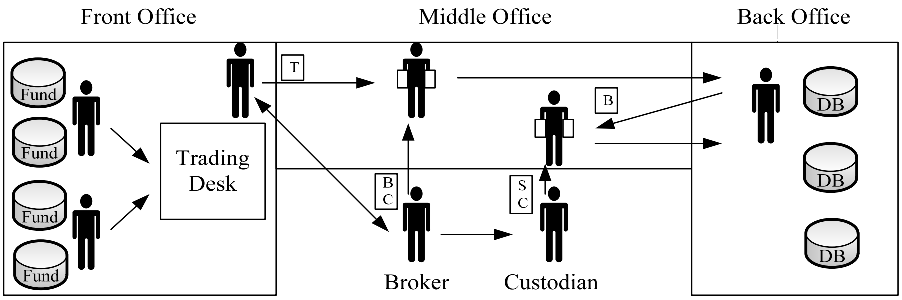

Fig. 1. Process flow in Front, Middle and Back Office of an investment company

Given the complexity of the process described, the automation efforts that were made by related investments into IT and given the diverse factors that influence process performance, we aim to address the following research questions in this paper:
How do technical and organizational factors influence process efficiency in general?
How do IT systems and personnel factors influence process efficiency in particular?
In addition, how do domain-specific and external factors influence process efficiency?

To do so, we first develop a process model of trade bookings and define control points on the basis of experts interviews. In order to explore the impact of the described factors on process efficiency, we present an empirical analysis of a unique dataset of actual trade bookings along with their processing times.

The remainder of the paper is structured as follows: Related work on modeling and measurement of IT Business Value on a process level (2) motivates our research setup and develops hypotheses on influencing factors (3). Descriptive and empirical results on factor process efficiency are presented (4), discussed (5) and concluded (6).

2 Theory and Related Work

2.1 IT Business Value

The subject of business value of IT evaluation is to analyze the contribution of Information Technology to business success. It has been an ongoing issue of Information Systems (IS) research since the 1980s [8] until today [9-10]. Different theoretical foundations, including those of production theory, competitive strategy and consumer value, have found their way in this literature stream [11]. Further, the assessment of IT business value has been explored on different aggregation levels: on higher aggregation levels such as the industry or branch or enterprise level [12-13], or on lower aggregation levels such as the process and business activity level [14-15].

As suggested by Mukhopadhyay et al. [14], these lower aggregation levels of analysis mitigate the difficulty of isolating the true effect of IT on business value, a problem that has been debated extensively in the context of the so-called 'Productivity Paradox' [16]. Consequently, various models and measurement criteria [17] in diverse contexts [18] are described to identify potential process improvement. That is why Marisio [19] argues: 'Measures are the only way to prove improvements in a process' and enable direct empirical evidence compared to indirect measurement by process simulation [20]. Resulting insights may also provide the basis to improve process efficiency [21]. Against this background, we frame our research study at the process and business activity level by collecting and analyzing enterprise process data. To do so, we start our analysis by modeling the business process and by identifying suitable control points within this process.

2.2 Modeling and Measurement of IT Value on a Process Level

'Quantifying the IT investments payoff has always been subject to debate because measurements and real value delivered some time cannot be expressed in typical IT metrics like response time' [22]. Therefore, identifying the relevant factors and the definition of control points is crucial in process management and helps 'to intervene and control processes' [23]. As highlighted by Brynjolfsson and Hitt [11] modeling and measuring the shortcomings in business environments are crucial for empirical research on IT business value. Thus, empirical analyzes being based on the modeling and measuring of problems can contribute to a better understanding of how IT affects business processes and therefore, represent an approach to assess process capabilities and shortcomings that can lead to higher productivity and higher competitiveness [24].

In the context of business processes, existing studies describe how an effective process analysis can contribute to an understanding of relevant factors as well as to the identification of shortcomings. Amadi [25] outlines how to measure the relation of process analysis and strategic alignment to business success, while Heier [26] illustrates how to setup interviews so that IT-related business value can be determined.

Niedermann [27] describes business process optimization as 'design, execution and analysis'. In addition Nissen gives insights on how to measure processes by identifying influencing factors and relevant measures. After modeling a process, the measurement configuration, the process measures and influencing factors must be defined [28]. This enables us to examine the factors that may contribute to both process efficiencies and inefficiencies [27].

Referring to the business value modeling of process views, Shen and Liu [29] connect the perspectives of entity-based activities and the superior organizational structures. In this way, two advantages can be derived: It enables to integrate multiple perspectives of a process and also concludes more generalized results [30]. In consequence, enterprise-deep views allow identifying process risks and potentials, especially in hierarchical organized structures [31].

Performance-centric monitoring of processes makes continuous process improvements possible [32-33]. Thus, models are a precondition to find control points in processes. Braunwarth et al. [34] present a simulation based approach that aims at identifying comparative advantages of manual and automated executions in business processes. In that way, advantages can be identified even in dynamic environments. Therefore, process modeling and the definition of control points can support the flexible alignment of processes, if business requirements change over time [35].

3 Methodology

3.1 General Research Setup

In our study, we followed mixed methods research by combining qualitative research data collection techniques with a quantitative research approach. The advantage of mixed methods research has been highlighted in the literature, as it provides means 'to deal effectively with the full richness of the real world' [36]. Therefore, we employ a sequential methodology by first applying qualitative data collection technique (expert interviews) to gain rich insights into the process model followed by a quantitative data collection and analysis of actual process cycles. By doing so, we are able to explore a phenomenon of interest 'that cannot be fully understood using only a quantitative or a qualitative method' [37].

To identify and explore the relevant factors that affect the middle office process of trade bookings and the total processing time of an incoming trade, we first studied the history of process models and performed a series of semi-structured interviews with the investment company's IT department as well as process and domain-specialists. The interviews were conducted by two researchers, both taking notes during the interviews. After each interview, notes were discussed and condensed, which resulted in a detailed process description.

On this basis, we first developed a cross-system process model that discloses involved systems, participants and other relevant external factors. To be able to analyze the total processing time of the process, we defined reference control points within this process, providing the basis for our empirical analysis.

We then conducted a quantitative analysis of historical transaction data that we received from the IT department of the investment company. The transaction data provided information on a high number of actual process cycles, along with total processing times and information on the relevant factors we have identified earlier.

3.2 Process Description and Model

After the occurrence of a trade and a broker confirmation, both are compared by SYSTEM A (a Middle Office Document Management System). If the confirmations are equal, they are delegated to SYSTEM B (a Document Enrichment System). If they are not equal or another problem occurs then one (and in some cases two) expert(s) has to cross-check the documents and to decide whether to re-request one of the documents or to confirm correctness and equality. The trade information is enriched by expected fees from a data warehouse. SYSTEM B delegates the needed information parts of the enriched trade to the corresponding departments before the trade is stored in the backend database. Parallel to the first booking, the corresponding custodian bank (that stores the asset testament) sends a settlement confirmation with the actual fees that is prestored asynchronously at SYSTEM A. The preprocessed trade is reloaded from the backend database and compared to the information of the settlement confirmation. If all information equals then the trade does not have to be rebooked. If it is unequal then the prebooked trade can be corrected automatically within given ranges, otherwise it is manually adjusted by one or two experts, before resending it to SYSTEM B and storing it in the backend database. Additionally, following corrections can trigger another rebooking cycle (s. Figure 2).

The predefined control points help to validate the analysis from two different perspectives. First, some of the operations in the process are triggered asynchronously (like the arrival of a settlement confirmation), so their influences overlay the effects of the total processing time within the middle office process chain. Second, we focus on process efficiency of the superordinated process. That way measuring the operational efficiency of single steps and activities within the process would give more interesting insights to the process, but limit the generalizability to these specific process steps. That is why we use these additional control points for validation and better generalizability of the results only. Focusing on our research questions we investigate influences to the middle office process and its total processing time in general.

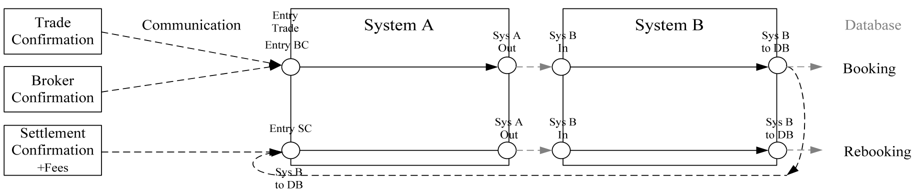

Fig. 2. Trade Booking Model

3.3 Influencing Factors and Hypotheses

We build upon previous research and aim at measuring influencing factors directly. So, we align our research model with Subramanyam and Krishnan [38] who analyze the resolution times in a call center within an academic organization on a process level. They identified four factor groups that influence the time needed by call center agent need to solve a customer problem. These are: (1) the IT system usage, (2) the personnel factors of call center agents, (3) the problem set and (4) the customer describing the problem. In the following we built upon these factor categories and adjust them to the context of the middle office of the investment company. Consequently, and compared to the original study of Subramanyam and Krishnan [38], our study explores process efficiency within a different organization (financial industry compared to academic organization) in a different application domain (transaction processing compared to customer service).

(1) IT System Usage / Automation. In general, it is assumed that IT and information systems can have positive influences on process efficiency [39]. Here, IT systems are designed to support business and information requirements, help to enhance data consistency and to reduce redundancies, which make processes more stable and reliable [40]. IT systems can enhance supportive processes for the core businesses (like production processes) if they are backed by IT systems [41]. This requires that automation and supporting systems are maintained to fit the process requirements for efficiency [42]. *That is why we expect that IT-enabled automation can decrease the trade booking time, which contributes to general process efficiency.*

(2) Personnel Factor / Brokers&Custodians. Banker and Slaughter [43] and Agrell et al. [44] find that the capabilities and the personnel experience of domain experts positively influence task performances. *That is why we expect that brokers and custodians can decrease the trade booking time and the general process efficiency.*

(3) Problem Set / Subassets. Schiefer [45] states that depending on the problem area of the process there is an additional problem-specific coordination needed within the process chain. Also dynamic approaches that cause more organizational overhead can solve such problem-specific tasks [46]. Especially in highly controlled process environments [47], detection and solving of problems may significantly increase quality [48]. So it might result in longer overall total processing times. Results strongly differ according to the type of application and problem set [49], but a strong problem-specific influence can be assumed. *That is why we expect that the problem-set (here: subasset classes) have a shortening impact to the overall trade booking time.*

(4) Customers / Fund Managers. In our case, fund managers at the front office are like customers to the middle office as they make use of their supportive services. Subramanyam and Krishnan [38] criticize in line with other studies [50] that research of customer factors influencing the IT business value is quite scarce. Cameron and Braiden [51] find that customers have a demand for lower costs and reduced processing times, so they might be willing to enhance efficiency as long as the customer needs and objectives are clearly identifiable. In the context of the investment management industry and the relation between the front and middle office, this assumption has been supported by ethnographic studies [52]. Van Zelst et al. [53] found that employees that are disturbed and interrupted by customers have reduced process efficiency and have to fulfill customer demands. *So we expect for fund managers that they can decrease as well as increase the trade booking time and the general process efficiency.*

3.4 Process Analysis

To measure the total processing time of the trade booking process, we evaluated and aggregated all log events of a single trade into a single transaction log. The total processing time is measured as time period starting when trade and broker confirmation are present and ending when the last rebooking is done. All intermediated control points are used for validation as we are just interested in the total processing time of the process. Settlement confirmations are not evaluated because of asynchronous event preprocessing in SYSTEM A.

Transactions with missing start and end events (logging errors) as well as transactions that seemed to be mixed up compared to the standard process (complex-distributed asynchronous errors) were revised from the processing time sample.

As we observe process efficiency in terms of total processing time (processing a trade with needed fee information), we select a hazard function model regression [54]. This supports the non-linear behavior of processing times as well as the strict positive characteristics of the model variables and avoids broken assumptions compared to a linear regression [54]. Designed to estimate how long an entity will stay in a certain state, these models have been applied to analyze influences strike duration, divorce rates, length of studies and pensions and mortality expectations in social science [54].

The hazard rate λ is the likelihood at which trade i did not change the state within a given period. The model estimates the likelihood with given influencing factors and allows to estimate direct influences to the processing time. That is why we expect that the processing time is dependent to their influencing factors:

Processing time = f (Automation, Subassets, Custodians, Brokers, Funds, Weekdays)(1)

As the error rates decrease over time (longer processing times are much less likely than shorter ones) we expect a Weibull distribution of the processing time (positive random variables and not normal-distributed) that is also often used in previous research [55] and validate this assumption with the descriptive statistics in the next section.

IT business value is explored by analyzing the influence of process automation, which is measured by four disjunctive dummy variables ((1) full automation, (2) partly automated in SYSTEM A and (3) SYSTEM B or (4) manual). For each occurrence of an influencing factor (assets subclass, brokers, custodians, fund managers), an entity-specific dummy variable is defined. Weekday dummy variables are added regarding assumable weekday effect. The significance of all dummy variables is tested by a Chi-squared test for each factor category as well as for the overall model.

4 Data and Empirical Results

4.1 Dataset and Descriptive Statistics

Our dataset consists of 29200 valid trade bookings including the total processing time and variables for 4 automation states, 23 subasset classes, 38 custodians, 91 broker, 561 funds and control variables for 5 weekdays. All time variables are measured in milliseconds and the average processing time is $1.001*10^8$ ms (27.7 hours). The median is $7.3815*10^6$ ms (20 hours). 82.14% of bookings are completed within two days. With one day more, namely three days, 88.61% of all transactions are booked. It takes 6.158 days to complete 99% of all transactions. On the one hand, there is the fastest transaction measured with 3.25 min (195000 ms), while on the other hand, the slowest booking took 103 days ($8.89761*10^9$ ms). The total processing time has a standard deviation of $1.47681*10^8$ ms. The difference between average and median indicates a right-skewed distribution. The histogram (5 outliers > $2.224*10^9$ ms have been discarded) depicted in figure 3 indicates a Weibull distribution that approximates the distribution of processing times best compared to other hazard models.

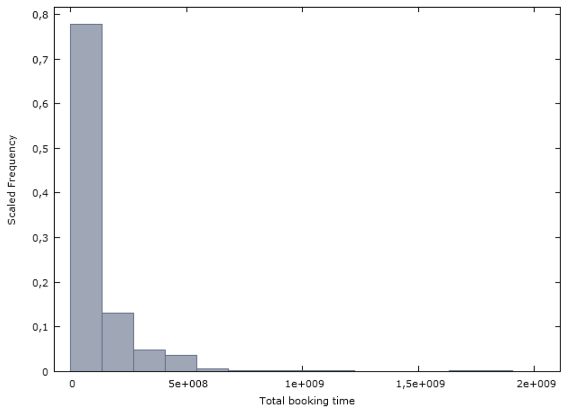

Fig. 3. Frequency distribution of total processing times measured in milliseconds

4.2 Empirical Results

The previous section illustrated that the distribution of trade bookings shows declining processing times and that times are positive, randomly ordinary and not normal-distributed. That is why we regress all 29200 trade observations as a cross-sectional dataset and investigate the influences using a Weibull-distributed hazard function model. Results of the regression analysis explain the influence of each individual entity within the four factor categories to the processing time.

Due to the complexity of the dataset, its 717 variables and the entity specific perspective to project influence, we ease the readability of the regression results by a bar chart (s. Figure 4) that highlights positive and negative influences (above/below y-axes) as well as the significance level of the results (1-3 units). Bars above the horizontal line show numerical negative influence (shorter processing times), bars below highlight numerical positive influence (longer processing times). The longest bars with 3 units length indicate high levels of significance (< 1%), mid length bars with 2 units indicate significances (< 5%) and bars with one unit length indicate significance (< 10%), but not at the conventional 5% level. Grey fields indicate no significance. An extract of the numerical results is given in Table 1.

System-specific automation variables show high significance as the *p*-values are below the 1% of significance. The rate at which the automation reduces the total processing time of the trade bookings is between -88.61% and -47.54%. Interestingly the influence with partly automated processing is even higher than with full automation (significance). Full automation has also a negative influence, but the influence is not significant compared to the other factors in the regression. These findings provide evidence for positive IT business value since the related IT investments facilitated automated processing resulting in decreased process runtimes on the process level.

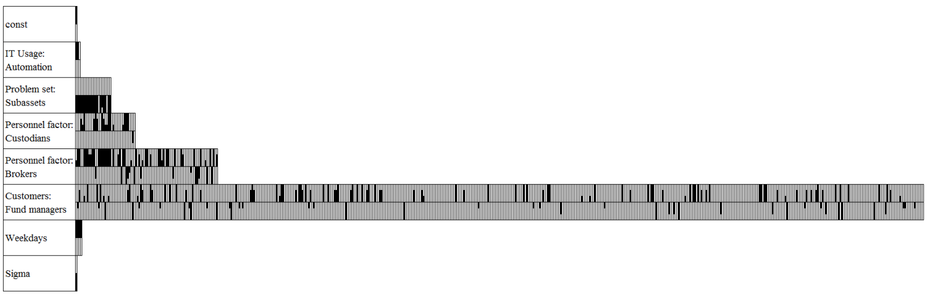

Fig. 4. Plot of directions of influences and levels of significance of each entity in the dataset

All subasset class variables are estimated with positive coefficients by the hazard model regression. That gives evidence that most assets have a prolonging influence to the total processing time of the middle office process. Significant coefficients lie in the ranges of 74.79% up to 276.15%. Except for two coefficients that are not significant (Subasset 15 and 20) all other asset sub classes show a high level of significance.

Most custodian and broker variables show significant influences to the total processing time in the middle office with levels of significance at 1, 5 and 10%. The bar chart easily highlights positive bars above the horizontal line that indicate that the influences of brokers and custodian banks are numerical negative (shortening processing times in the middle office). The best custodian bank (Custodian 33) influences processing times that way that it is 2.59 times faster than the average, while the worst custodian bank (Custodian 36) has a slowing effect that is 110% longer than the average. Broker coefficient ranges lie between factors of 1.13 faster (Broker 42) and 1.58 (Broker 61) slower than the average. These outliers decelerating the process are also detectable as 'bars below the horizontal line'. Compared to all other broker and custodian banks, these negative influences are occasionally.

Some funds specific variables show significant influences, but those significances were observed less frequently than in the other factor groups. In addition, the directions of the influences vary: Some fund managers have an accelerating influence to the trade booking, while others are decelerating the process. The range of coefficients lies between -2.58 and 2.56, which means that some fund managers are two and a half times faster or slower than the average. Compared to other factor groups in Figure 4, it is easy to see that the fund-specific factor have the lowest relative significance.

Control variables on weekdays show the expected highly significant influences. While Fridays show a positive influence as processes might block or stop during the weekend, all other weekdays have a negative influence. These weekdays show coefficients that indicated a decrease in processing times during the work week. Starting with Mondays that are up to 70% faster than Fridays, the processing time decreases to being 50% faster on Thursdays. A Chi-squared test indicates overall model validity.

Table 1. Extract of regression results for total processing time with the first two significant variables of each factor category

	Coefficient	**Std. Error**	**z**	***p*-Value**	
Constant	18.86060	0.46416	40.63350	<0.00001	***
Just Sys A Auto	- 0.88163	0.17460	- 5.04930	<0.00001	***
Just Sys B Auto	- 0.47541	0.18145	- 2.62010	0.00879	***
All Auto	- 0.28386	0.18882	- 1.50330	0.13276	
Subasset 1	1.05527	0.22396	4.71180	<0.00001	***
Subasset 2	0.83046	0.22427	3.70300	0.00021	***
…	…	…	…	…	…
Custodian 4	- 1.04503	0.42224	- 2.47500	0.01332	**
Custodian 5	- 1.13403	0.64595	- 1.75560	0.07916	*
…	…	…	…	…	…
Broker 1	- 0.13079	0.07870	- 1.66190	0.09654	*
Broker 2	- 0.33210	0.11916	- 2.78710	0.00532	***
…	…	…	…	…	…
Fund 2	2.00083	1.07391	1.86310	0.06244	*
Fund 3	- 0.75065	0.36130	- 2.07760	0.03774	**
…	…	…	…	…	…
Monday	- 0.70196	0.02515	-27.91270	<0.00001	***
Tuesday	- 0.62772	0.02386	-26.30890	<0.00001	***
Wednesday	- 0.58743	0.02348	-25.01860	<0.00001	***
Thursday	- 0.50146	0.02536	-19.77730	<0.00001	***
sigma	1.20606	0.00559	215.67620	<0.00001	***
Chi-square (679)	7,165.40		*p*-Value	0.00	***

*/**/*** = significant at a 10%/5%/1% level.

Given the above statistics, we would like to highlight that it is not our main research objective to identify individual Custodian or Broker contributions to process performance but to identify the general influences and direction of each entities group.

5 Discussion

5.1 Implications on Theory

The empirical results give evidence that the hypotheses extracted from Subramanyam and Krishnan's call center setup can also be supported with processes from other domains like the financial industry and in other contexts like transaction processing processes. Additionally, we enhanced the quality of research by building upon qualitative data collection techniques and by adding a control variable for week day influences. In general this measurement setup is an extension to well-established process analysis methods. Descriptive research (like literature reviews) and qualitative research results (like case studies) can be cross-validated with precisely measured real world data. This approach is scalable. In the given setup we focused on a central cross-system process and included the involved entities like systems, employees, customers (fund managers) and products (subasset classes) as possible multiple influencing factors. Additionally, we manage the complexity of the process and its efficiency so that results stay generalizable. Additional information about sub processes is included to validate the correctness of the main process. That way we measure the direct influence of each entity and groups of entities to the overall processing time and results are not blurred by a subprocess-specific measurement. As a result, process models from previous research can be used to define control points for each involved entity and evaluated the specific influence of each entity to the overall process efficiency. This approach is not restricted to process runtimes, but can also be extended to error or cost measures and helps closing the deduction-induction research cycle for process modeling.

5.2 Practical Implications

Reflecting the research questions from the introduction our results show that processes and their efficiency in the dimension of runtime are not only influenced by technical and personnel factors. Especially domain-specific influences, like the processed subasset class, show that problem-specific influence has a clearly negative impact on duration of the trade booking. It is also showing that external factors, like fund managers that are customers of this service, have mixed influences to the process. Some fund managers decelerate the process, while others accelerate it. In general there is no consistency in the influence of external factors as some entities are significant and others are not. So evidence is given for the third research question, i.e. how domain-specific and external factors influence process efficiency: domain and problem-specific influences have a negative effect on efficiency, which results in longer processing times (hypothesis 1), while the influence of external factors depends on the specific entity (like a specific customer / fund managers in hypothesis 4).

After filtering external factors and problem-specific influences from our data by explaining their influence to efficiency of processing times, it becomes possible to discuss the influences from the technical and personnel influences within the measured process. Results show high significance for system-specific influences. Interestingly this influence is not statistical significant with regard to full-automation processes. One interpretation of the results is that influences from personnel factors cannot be neglected. As coefficients show that automation has always a negative (accelerating) effect to processing time, results also indicate that the full-automation effect is less important (significant) than other influences from the model. This is confirmed by other human/ personnel factors like the corresponding broker and the staff at the custodian banks. Their domain-specific knowledge seems to have also negative (accelerating) effects that counteract the external and problem-specific influences from the previous section. In general, we answer the second research question on IT systems (hypothesis 2) and personnel factors (hypothesis 3) by confirming a negative (accelerating) influence on the efficiency of processing time.

In general, we see for the first research question that technical and organizational factors have significant influence on the time efficiency of the process. We also see that there are positive influences by technical and personnel factors, negative influence by domain and problem-specific factors and mixed influences by external factors like fund managers/customers. Our measurement setup gives not only insights into the direction and the significance level of the analyzed factor groups. Individual and specific influences give detailed information on which organizational and which technical entities can and should be improved. That way it supports decision making, modeling of future process restructuring and measurement for potentially implemented improvements.

5.3 Limitations

While our dataset covers a period of 12 months with multi-dimensional influences like fund manager, subasset-specific influences, broker and custodians as well as the influence of technological support, our research perspective is limited to a single case. This case has a data-intensive setup with extensive automation and support potential within the financial domain, but on the other hand, our case might have a domain-specific bias. Our dataset shows data for different subasset classes, but because of legal issues, our current perspective is restricted to the booking process of bonds and lacks of less standardized financial assets. In addition, we had to remove incomplete process cycles and those where the logging chronology did not fit the assumed process model. Due to the nature of asynchronous event processing, this is not surprising, but it discards events that do not fit the assumed process definition, which may limit the results, too. Multiple control and validation methods have been applied to check the robustness of the results and to avoid a bias resulting from dataset characteristics.

6 Conclusion

Our three research questions concerning process efficiency, technical, personnel, domain-specific and external factors are analyzed following as mixed methods research that combines qualitative research data collection techniques with a quantitative research approach. Using interview and modeling techniques we identified measurement points and influencing entities within a middle office process of a major European investment company. We measured the trade booking times of 29200 transactions and the influence of entities that are related to these specific transactions. As a result, we found evidence that IT system usage and personnel factors like brokers and custodians have a shorting influence to processing, while problem-specific influences like subasset classes extend the processing time. We found mixed influences by process customers like fund managers. From a methodological perspective our study illustrates how to conduct mixed methods research in the field of business process performance evaluation.

For further research, we plan to address the identified limitations of the current research setup and aim to extend the dataset. A larger sample size and may help to evaluate our findings. To upgrade our research, it is also possible to validate our findings in other domains. This would enable to compare the influences to transaction processing time in different domains. During the research, there is also the opportunity to take other aspects of influence into account, such as motivational constraints, team and communication structures as well as the clarity of the process improvement purposes and the expectations of participants. We thankfully acknowledge the support of the E-Finance Lab, Frankfurt and its research partners for this work.

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