On the Impact of a Business Intelligence System on Analysis Effort: A Case Study of Flensburg Municipality in Germany

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ABSTRACT
Background: Business intelligence provides decision sup-port to decision-makers in public administrations. So far, researchers have studied the use of business intelligence sys-tems concerning, for example, efficiency gains of the organi-zation. However, based on our literature study, researchers have yet to focus on the impact of business intelligence sys-tems on the efficiency of analytical processes in the public administration context.
Objective: This study's objective is to investigate the im-pact of introducing a business intelligence system in public administration.
Method: A case study was conducted to investigate the impact. We studied four departments at Flensburg Municipality in Germany. We used interviews and analyzed documentation to describe the analytical processes and to estimate efficiency gains.
Results: The BI system led to efficiency gains across departments. The gains varied from 1.77% to 47%. Losses were observed regarding media changes.
Conclusions: The impact on efficiency varies with the attributes of the analytical process (e.g., repetitions in the process). Hence, further investigations are needed to build theories regarding the relationship between efficiency and the use of BI systems in public administrations.

INTRODUCTION
Even though business intelligence systems are now used in various areas in public administration, this area is still seen as a relevant field of research McDonald III et al. (2022). The relevance can be emphasized by the fact that public administrations make decisions with far-reaching consequences that affect not only their own organizations, but entire administrative districts - be it states, federal states, or municipalities. The effect on entire administrative districts emphasizes the need for complete and comprehensive data for decision-making processes in public administration Abai et al. (2015).

The information silos caused by clear departmental boundaries in public administrations make it challenging to share information Teixeira et al. (2014). Business intelligence systems can make a contribution by providing relevant information to all stakeholders through a single point. This can reduce the process-related effort of information procurement and evaluation as well as the number of system breaks and thus contribute to process efficiency in public administration. However, it still needs to be determined to what extent BI systems can make a positive contribution to improving the efficiency of decision-making processes in the public administration.

Most attention in the past has been drawn to the level of organizations. Less attention has been paid to the level of individuals Trieu (2017). In this study, we examined the efficiency of BI systems at the individual level by having process participants estimate execution times.

Using a case study approach, the efficiency of BI systems in four different departments of the Flensburg city administration, focusing on the estimated and perceived impact on

time efficiency. In each department, we examined two versions of the same process. First, process experts estimated the execution time without the use of an implemented BI system. Afterward the execution time for the process with the use of an implemented BI system was estimated.

The results show that implementing a BI system in public administration can lead to efficiency gains. However, challenges with data integration and report generation have also become apparent. In both areas, there is further potential for automation and standardization.

The remainder of the paper is structured as follows: Section presents background information and related work. Section describes the methodology followed for studying the impact of the BI system. Section presents the results of our study. Section discusses practical and research implications. Section concludes the paper.

RELATED WORK

Theoretical Framework

The theoretical framework of this literature emerges from four perspectives, namely (i) the domain perspective, (ii) the impact perspective, (iii) the output perspective and (iv) the information system type perspective.

(i) Domain perspective: Competitive pressure is of secondary importance for the success of BI systems Zaied et al. (2018). This is especially true in public administration. Public administrations differ from private companies in their mission. Public administrations are not evaluated based on profits and losses Abai et al. (2015). Moreover, they perform sovereign tasks, so they are not in a competitive situation either. However, administrations are also subject to financial restrictions. Internal process efficiency is, therefore, of particular importance for public administration.

(ii) Impact perspective: The impact of business intelligence systems has been investigated for private sector companies in various studies (for a detailed literature review see Trieu 2017).

BI systems add value at both the operational and strategic level Yogev et al. (2013). Al-Eisawi et al. (2020) found a positive impact of BI system efficiency on organizational efficiency. The organizational efficiency of an organization can be defined as its ability to use resources optimally for their intended purpose Al-Eisawi et al. (2020).

Elbashir et al. (2011) identified four different types of BI systems' benefits, including (i) organizational benefits, (ii) business supplier / partner relation benefits, (iii) internal process efficiency benefits and (iv) customer intelligence benefits. While the first factor relates to benefits at the organizational level, the remaining factors relate to benefits at the business process level. Benefits related to internal process efficiency include the following items: a) improved efficiency of internal processes, increase in employee productivity, c) reduction of the cost of effective decision-making, and d) reduced operational costs. The authors found a positive relationship between business process performance and organizational performance.

These results are partly consistent with the findings of Trieu (2017). He cites (i) minimising the mistargeting of customers, (ii) transforming business processes, (iii) enriching organizational intelligence, and (iv) developing new or improving products or services as the possible positive impacts of BI systems. With regard to the tasks of public administration, it seems obvious that especially the dimension of process efficiency is of particular importance for public administration. In the context of this paper, we focus on efficiency to distinguish it from effectiveness and possibly other impacts.

(iii) Output perspective: In the past, numerous papers have been written on success factors of business intelligence systems (for comprehensive literature reviews see Gaardboe & Jonasen 2018, Magaireah, HidayahSulaiman & Ali 2019, Zaied et al. 2018). Many studies cite top management support and data quality as critical success factors for BI systems in general Zaied et al. (2018), Magaireah, HidayahSulaiman & Ali (2019). In contrast, it was also shown that data quality is of little importance for public administration Magaireah, HidayahSulaiman & Ali (2019). However, information quality has proven to be an important dimension for the success of BI systems in public administration, with the elements of security (information quality) and availability (information quality) being of utmost importance, while the elements of accuracy, comprehensibility and completeness are only of medium importance Zaied (2012). There are also divergent views on the importance of top management support, which assess its role as less important Zaied (2012).

Although the findings may be relevant for discussing our results, they are irrelevant to the literature review. Critical success factors do not consider the impact of BI systems in general nor resource efficiency in particular. They represent input factors that are not relevant for our literature research. Therefore, publications related to input factors are considered irrelevant. However, the divergent results for public administration show that BI systems in public administration must be subjected to a separate analysis.

(iv) Information system type perspective: A BI system can be considered a type of information system. This is manifested by the fact that research on business intelligence system adoption, utilization, and success mostly uses framework models for the evaluation of information systems in general, as Ain et al. (2019) has shown in a systematic literature review. The authors Ain et al. (2019) include a total of 123 relevant essays in their analysis. They identify 16 papers that use the DeLone & McLean IS success model. A further 15 papers use the technology acceptance model. Both models are suitable for evaluating and analyzing information systems in general. This result, especially the high importance of the TAM, was confirmed in another publication Chi & Mahmud (2020).

This is also confirmed by Zakaria et al. (2011). They identified the efficiency and effectiveness of work processes as a Key Performance Indicator to deliver services for the National Registration Department (NRD), Pulau Pinang.

Even if a broad perspective is conceivable, we focus on BI systems and exclude other types of information systems.

Literature Review

The literature search comprises two steps and consists of the actual literature search and the screening of the publications found. The first step restricts the search results to the domain of public administration, the information system type Business Intelligence and resource efficiency perspective in a broad sense. In the second, the general relevance of the researched articles for the present work is examined. A distinction is made between the input-oriented and output-oriented evaluation of BI systems. In addition, we examine whether process efficiency is addressed.

Ain et al. (2019) conducted a systematic literature review on BI system adoption, utilization, and success. For this purpose, they developed a search strategy that we adapted in this analysis to search for publications on BI systems in public administration. The terms related to BI systems were adopted. We have not included the terms that contain other search terms as sub-terms. For example, we have omitted the search term "business intelligence system" because the term "business intelligence" is included as a search term. We also restricted our search on terms related to the system level and excluded terms that are only related to certain aspects of a business intelligence system (such as OLAP, data warehouse, and dashboard). We restricted the search to the domain of public administration. For this purpose, search terms related to public administration were added.
Our search strategy (see for details Table 1) aims at a high precision. Therefore, the search was limited to searching titles, abstracts, and metadata. The exact design of the search strategy depended on the possibilities and the available fields of the search interfaces. If we have not received any search results, we have dispensed with the impact related terms. This ensures that finding no results was not caused by a character limitation of the search mask. For semantic scholar, we limited our search to one term per perspective and relied on the semantic search options (public sector, business intelligence, efficency). Even though the reproducibility is limited, it adds another perspective to the literature search with standardised Boolean queries. In the case of SemanticScholar and Google Scholar, the screening was limited to the first 50 search results, whereby we relied on the relevance ranking.

The research did not lead to any evaluable results on the narrower topic of increased resource efficiency through business intelligence systems within public administration (see Table 2). Thus, no search results were obtained that systematically show how business intelligence systems affect the efficiency of work processes in terms of time saved in daily work within public administration. However, many results were obtained which highlight the input perspective (e.g. critical success factors) Magaireah et al. (2019), Hartley & Seymour (2015), Magaireah et al. (2017) or the output perspective (higher decision quality) Hočevar & Jaklič (2010), Boselli et al. (2011), Abai et al. (2015). Furthermore, we found support for the relevance of our research questions, as Fischer et al. Fischer et al. (2021) found in a systematic literature review that so far only a few studies deal with the impact of digitalisation in public administration.

METHODOLOGY

The case study was conducted as part of a research project with the city of Flensburg. The three-year research project focused on the introduction of a business intelligence system in public administration. We describe the case study following the guidelines by Runeson and Höst Runeson & Höst (2009), which were specifically designed for the software context (e.g., describing the case, units of analysis, information sources, etc.). The case study focused on the Flensburg municipality in Germany. Our units of analysis were processes involving multiple departments. The research aim was to look at the differences in process steps conducted before the introduction of the BI system and after its introduction.

Research goal and questions

The goal of the research is to determine effort savings through the introduction of a business intelligence system in municipalities. Thus, our main research question is: *What is the estimated impact on effort through the introduction of a business intelligence system in a municipality?* We provide data from a specific case and a set of analysis processes to achieve the goal. We also studied different departments. We analyzed the data from different perspectives, and hence formulated sub-questions:

1. What is the impact of the business intelligence system on the department level?
2. What is the impact of the business intelligence system on different activity categories?
3. What is the impact on individual activities required in the analysis process?

The departments, the business analysis system, and the analysis processes are described in the following.

Case and Context

We first describe the case (the city Flensburg municipality) and thereafter we briefly introduce the units of analysis (analysis process) and the departments participating in the process.

The case - Flensburg Municipality

Flensburg comprises a population of approximately 98000 people. The municipality employs 1.600 people. The municipality is organized into 12 different departments (e.g. finance, central services, education and sports office, etc.). As mentioned earlier, data collection was conducted in a total of four departments, which were involved in the analysis processes (units of analysis).

Departments

The four departments are briefly described below.

Department 1 (D1) - Traffic planning and regulation: The traffic planning and regulation department is responsible for the general planning of mobility and traffic guidance in the city of Flensburg. Traffic data and routing are a central, municipal management instrument. Traffic planning is of particular importance with regard to the desired change of the type of transport in the city.

Table 1: Search Strategy

Category	Content
Business Intelligence related terms	business intelligence, BI system
Public administration related terms	public administration, public sector, public management, municipality
Impact related terms	efficiency, time saving
Sources	IEEE Xplore, ScienceDirect, EmeraldInsight, Google Scholar, SemanticScholar, Scopus
Years	2000 - 11/2022
Search Fields	Title, Abstract, Metadata (if applicable)
Language	English

Table 2: Search Results

Source	Search Query	Results
Scopus	TITLE-ABS-KEY (("business intelligence" OR "bi system") AND ("public administration" OR "public sector" OR "public management" OR municipality) AND (efficiency OR "time saving"))	16
IEEE Xplore	((("All Metadata":"Business Intelligence") OR ("All Metadata":"BI system")) AND (("All Metadata":"public administration") OR ("All Metadata":"public sector") OR ("All Metadata":"public management") OR ("All Metadata":municipality)) AND ((("All Metadata":"efficiency") OR ("All Metadata":"time saving")))	9
ScienceDirect	Title, abstract or author-specified keywords: (("Business Intelligence"OR "BI system") AND ("public administration"OR "public sector"OR "public management"OR "municipality") AND ("efficiency"OR "time saving"))	2
EmeraldInsight	((title:"Business Intelligence") OR (title:"BI System") OR (abstract:"Business Intelligence") OR (abstract:"BI System")) AND ((title:"public management") OR (title:"public sector") OR (title:"public administration") OR (abstract:"public management") OR (abstract:"public sector") OR (abstract:"public administration") OR (abstract:"municipality") OR (title:"municipality"))	35
Google Scholar	("Business Intelligence"OR "BI system") AND ("public administration"OR "public sector"OR "public management"OR "municipality") AND ("efficiency"OR "time saving")	approx. 16.800
SemanticScholar	"business intelligence""public sector""efficiency"	12.900

Department 2 (D2) - Statistics office: The statistics office of the city of Flensburg is responsible for processing and providing various statistical surveys and key figures. It acts as an internal and external point of contact for information on statistical data of the city. The business intelligence project is intended to automate and digitize the statistical data report, which the statistics office previously created.

Department 3 (D3) - Youth service planning: The youth service planning department is responsible for planning early intervention and youth services activities. In addition, an important part of the tasks is the assessment of the city's social situation. The social data prepared and presented by the department represent a strong management instrument for the city of Flensburg.

Department 4 (D4) - Education and sports office: The education and sports office is responsible for planning and coordinating schools in the city area. This includes the schools on the one hand, but also the preceding sections, such as the daycare centers, and the succeeding sections, such as the transition to work, on the other hand. The data used by the education and sports office can be used to plan the future demand for teachers, the required number of classrooms to be provided, and childcare spots, for example.

Business Intelligence System

The Business Intelligence software QlikSense was used to implement the project requirements. QlikSense offers the possibility to create interactive dashboards and thus provides a self-service business intelligence system. This includes self-service visualizations that can be examined using search, select and drill down. At each step, an immediate update of all relevant tables and charts to the current context occurs. In addition, QlikSense allows drag and drop of tables, charts

and data fields in the front end. The Business Intelligence software caters to the need for a full visual front-end, permitting the creation of basic visualizations by non-professional users without the necessity of extensive training. In the project, QlikSense is being used as a mostly off-the-shelf product with few add-ons. While the company provides a cloud solution, QlikSense is deployed through an internal server on premise due to data safety and protection regulations in the public administration of Flensburg.

In public administration, mandatory reports must be created each year. These processes require a significant amount of data preparation. The created reports are then only available in a rigid form, so any dynamic work with the contained data is not possible. The Business Intelligence System allows easy web-based access to the data, and updating the data can be done with significantly less effort.

Within the traffic planning and regulation department, the possibilities offered by the Business Intelligence System include, for example, a digitized display of all traffic monitoring stations as well as a dynamic detailed view of each station. This includes the number of vehicles, speed, type of vehicle, time and date or the direction. For the statistics office, the Business Intelligence system provides insights into the general population data of the city. For the youth service planning department, the advantage results from the fact that the preparation and presentation of the data can take place with significantly less effort. Through the Business Intelligence system it is possible to do an automated update of tables and charts each year. For the education and sports office, the Business Intelligence system offers the advantage of free exploration of the number of students over a fairly large time span. The system provides a digital location of the schools in the city area and shows in which districts pupils live, for example.

Units of analysis

The units of analysis are different analytical processes. We have selected four processes that originate from different departments and are supported by the implemented BI system within the BI-F2022 project. By choosing processes from different departments, a cross-departmental comparison becomes possible. Choosing processes that are supported by a recently implemented BI system ensures that the assessment of impact is based on initial experience. Similarly, there is still a familiarity with the previous process flows. This allows for direct comparison by the experts. We looked at the processes *Analyze traffic data* (traffic planning and regulation), *Create population statistics* (statistics office), *Create social atlas* (youth services planning) and *Create school development planning report* (education and sports office). Processes were partially interdepartmental. For these processes, only the process steps of the respective department were considered.

Process 1 (P1) in D1 - Analyze traffic data: The *analyze traffic data* aims to collect, process, and analyse traffic data. As a result, processed traffic data is provided. These include, for example, time-related traffic counts and speed measurements. The process comprises five sub-processes. Four of these sub-processes describe different types of data collection in the course of traffic measurement. Traffic data is taken from a variety of sources. Manual counts by pupils, speed displays, manual counts by employees of the administration, and traffic measurement devices are used. These sub-processes comprise a total of 34 activities, which serve, for example, the preparatory organisation, data collection, data evaluation, and data communication. For the *pupil count* sub-process, these include, for example, planning with the schools, preparing the traffic count documents, hiring the necessary vehicles, briefing the pupils, sending to and receiving Excel spreadsheets from the schools, and checking the data for plausibility. The fifth sub-process contains only one activity. This serves to answer questions from colleagues and planning offices.

Process 2 (P2) in D2 - Create population statistics: The population statistics provides aggregated information on the demographic structure of the city of Flensburg. The population statistics contains, for example, information on population figures per city district, per gender and per religion. The process create population statistics is carried out to prepare, analyse and publish the corresponding data. It comprises a total of 12 activities. Current population figures and relocations are analysed. Both types of data are queried and processed for further analysis, checked for plausibility and analyzed in relation to certain characteristics. Once the data aggregation is complete, the actual report is produced.

Process 3 (P3) in D3 - Create social atlas: The social atlas provides social data for Flensburg. It covers the topics of population, labour market and employment, housing, social security, and assistance with education. The data is presented for small-scale geographical areas. The social atlas is published on the website of the municipality of Flensburg [1] and used for further planning. The process *create a social atlas* is used to map population and social data to small-scale geographical areas. The process includes a total of 72 activities, with only 26 activities directly related to the department. Therefore, only these activities were considered in the further course. Due to the numerous interfaces to the other departments, the full organisational potential may not be represented here. However, the study focuses on resource efficiency in relation to individual departments. The process includes activities such as requesting data by email, receiving relevant data by email, integrating and preparing this data, creating figures and tables, creating the document and integrating feedback from different stakeholders (e.g. responsible officer and head of department) .Finally, the social atlas is compiled and published.

Process 4 (P4) in D4 - Create school development planning report: The school development report serves to prepare a needs-based school development plan in coordination with the neighbouring offices and districts in accordance with the legal framework. The process consists of 32 activities. The process includes the integration of different data sources (PRIMUS, Statistical Office North), the preparation of the data, the creation of figures and tables, the creation and publication of the report as well as the coordination with internal and external stakeholders (e.g. school headmasters and neighbouring municipal administrations).

[1] siehe `https://www.flensburg.de/Leben-Soziales/Familie-Soziales/Sozialatlas/`

Data collection

The data collection was conducted after an initial introductory phase of the BI system so respondents had already gained some familiarity with the system. The strength of case studies is the use of data triangulation, namely collecting data of different types (e.g., interviews and documentation). We used multiple types of data for the purposes of modeling the analysis processes and collecting data about effort. First, a process analysis was carried out and the workflows were documented. In the second step, execution times were determined.

Capturing analysis processes

Unstructured interviews were conducted for data collection. Experts were interviewed about the process flows and the process times. Experts were selected who, on the one hand, have departmental and process-related expertise and, on the other hand, are familiar with the BI system that has been introduced.

For the BI-F2022 project, so-called multipliers were established in the departments. The multipliers form the interface between the BI team and the departments. The study participants work within the departments. They can therefore be seen as experts at the interfaces between the departments and the BI system. This enables a robust assessment of the impact of the BI system on process performance. Experts were interviewed in several sessions, depending on time availability and process complexity.

As part of the process modeling, a prior BI and a BI-enabled process were modeled for each of the processes under consideration. The processes were modeled collaboratively in 14 meetings. Process documentation was used as input to the meetings. A step-by-step walk-through was conducted during the meetings. The interviews lasted one to two hours.

Modeling was performed using the PICTURE method, which was developed specifically for business process management in public administration. It is based on the analysis of more than 600 process models from public administration (see here and in the following Becker et al. (2007, 2015)). The PICTURE method comprises domain-specific process building blocks that are used to map activities within an administration. Process building blocks are defined sets of reoccurring activities within a specific domain. In the following, we will refer to activities as process building blocks as part of the analytical processes. Process building block types group activities (i.e. process building blocks) belonging together. The groups are: (i) information gathering and coordination, (ii) information flows, (iii) content work, (iv) media change, and (v) documentation. Figure 1 provides an overview of the building block types and the process building blocks. We only provide examples, as a high number of process building blocks were estimated by the study participants. The figure also makes explicit what the building block type categories are about. For example, media change is about transferring data to different types, or transferring digital information to a physical representation (printing).

Effort data

After describing the processes, the process experts were asked to estimate the execution times. They were asked to estimate the duration of process execution with and without the help of the BI system. Only one person per process made the estimates. This is to be considered a weakness. However, technical familiarity and familiarity with the BI system were necessary for the estimation. Competencies in both areas and at their interface are of high importance and limited the number of possible experts. Due to the heterogeneity of the processes, the figures collected nevertheless allow us to make cross-comparisons and identify patterns.

Table 3: Number of process building blocks estimated per building block type

Process building block type	prior Bi	BI-enabled	Total
Information gathering	5	5	10
Information flows	33	27	60
Content work	37	30	67
Media change	3	9	12
Documentation	26	13	39
Total	150	99	249

The activities were broken down to a low level of granularity, so that estimations became easier as the activities were less complex. At the same time, a high number of activities needed to be estimated. Table 3 shows the number of activities for each process building block type. In order to make assessments on a higher level of abstraction, we used the grouping of activities on various levels of abstraction (see e.g. Figure 1).

The estimates were extrapolated to the annual effort for each process to account for the fact that each process was performed multiple times and to ensure comparability. The annual times were summed and compared.

Data analysis

The data were analyzed from different perspectives, mapping to the research questions. First, analyses were carried out in relation to the different departments. Then analyses were made in relation to the building block type categories (see Figure 1). Finally, a detailed evaluation is carried out for the process building blocks, whereby we also look at individual activities. The measurement unit to capture the impact on time is captured in minutes. We present the data in tabular form and calculate the difference between the analysis processes without (referred to as prior BI process) and with the BI system (referred to as BI-enabled).

Threats to validity

In this section, we discuss different threat types, namely descriptive validity (factual accuracy), theoretical validity, generalizability (external and internal), and interpretive validity (objectivity of the researcher).

Descriptive validity (factual accuracy): Factual accuracy is concerned with our ability to accurately describe the truth. In this study, actual measurements of efficiency gains would have been preferred. Due to the lack of available historical data and ongoing measurements of the efficiency of the analytical process, we needed to rely on estimates. To get accurate estimates, we modeled the process on a low granularity level so that the estimated activities were not

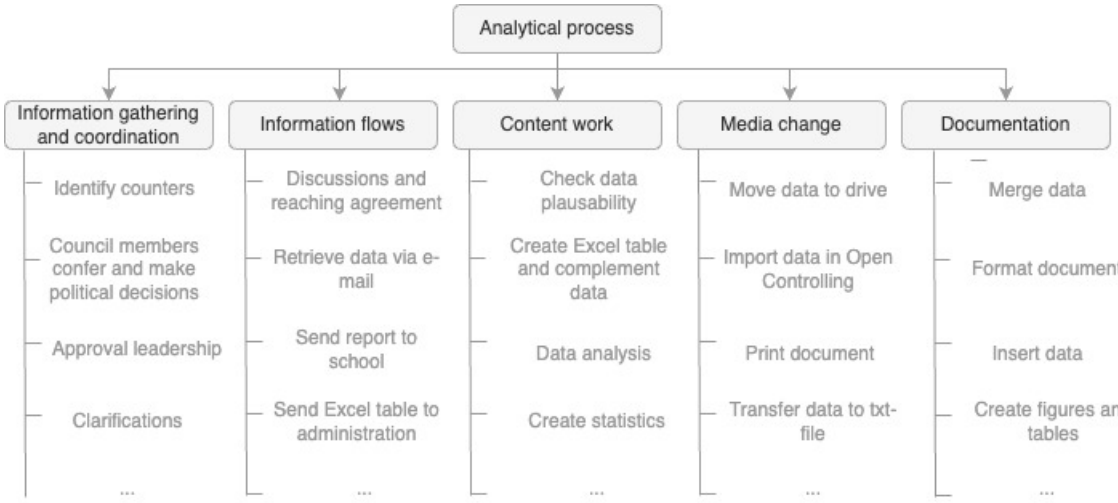

Figure 1: Overview of process building block types and process building blocks

too complex. Later, we grouped/aggregated activities to understand where efficiency gains and losses occur.

Theoretical validity: Theoretical validity is concerned with factors that influence the outcome (impact on efficiency due to the introduction of a BI system) without the researcher being able to control them. The study was conducted with the multipliers working on the project. However, the employees hired or released for the project often do not yet have a great deal of experience in public administration and also in the processes they assessed. This can lead to inaccuracies in the estimation of the implementation times. Likewise, the implementation frequencies of the traffic analysis are based on empirical values, so the actual frequencies may deviate from the frequencies assumed here.

Genearlizability: Internal generalizability is concerned with whether findings are transferable to other units of analysis within the same organization. We studied multiple departments to reduce the threat. We found that, for the organization studied, the efficiency gains and losses varied between departments concerning building block type categories. We also found that all departments achieved efficiency gains, even though the magnitude varied. Given that we studied a single organization, we cannot claim generalizability concerning other organizations. As it is more likely that similar contexts yield similar findings (cf. Ghaisas et al. (2013)), we reported contextual information regarding processes and the public administration organization.

Interpretive validity (objective researcher): Threats to interpretive validity lead to limitations in the conclusions drawn by the researchers (e.g. due to biases). The threat to interpretive validity is low as the researchers did not have a personal stake as they were external evaluators. In addition, the data was interpreted by multiple researchers looking at the data (observer triangulation).

Results

The results of the analysis of resource efficiency are presented below. This is first considered in relation to the departments and the processes mapped there. This is followed by analyses with regard to the phases as well as the process building blocks.

Research Question 1: Impact on effort on department level

Table 4 shows a comparison of the time saved by the department processes. It can be seen that the impact of the BI system varies. However, it should be noted in this context that this can also be due to the selection of processes. This will become clear in the further course of the detailed examination. The BI system achieves a particularly high impact in creating the social atlas (47.4% effort saving). Likewise, the effects of the analysis of traffic data and the creation of the population statistics can be rated as positive (15.3% and 16.6%, respectively). The increase in efficiency creating the report on school development planning is rather negligible (1.8% effort saving).

In the following, we discuss the processes and impact on effort in further detail for each department.

Traffic planning and regulation

Manual counts by pupils generate a large amount of data because counts are conducted by students on one day a year. The data collection is not affected by the BI system. After introducing the BI system, the data is no longer imported and processed by the clerical staff. This is expected to save 4 hours and 45 minutes of work time per year.

The manual counts by employees of the administration are only performed in special cases and therefore take place irregularly, estimated ten times a year. The sub-process is similar to the manual counts by pupils and changes with the BI system only after the data is received. After the traffic count data is received, the data can be sent to the statistical office. Thus, Excel evaluations no longer take place. This results in a time saving of 20 minutes per run, i.e. 3 hours and 20 minutes per year.

Table 4: Estimated and aggregated total process times in minutes in the departments for prior BI and BI-enabled processes.

Department	Analytical processes	Prior BI Process Estimation	BI-enabled Process Estimation	Difference	%
Traffic Planning and regulation	Analyze traffic data	5900	5000	900	15.25
Statistics Office	Create population statistics	7211	6011	1200	16.64
Youthe Services Planning	Create social atlas	3162	1662	1500	47.44
Education and sports office	Create school development planning report	13578	13338	240	1.77
Sum	-	298518	26011	3840	8.1

Speed displays change locations every two to three weeks. The data is sent to the clerk's office by the Technisches Betriebszentrum Anstalt öffentlichen Rechts (TBZ), a service provider for the city of Flensburg, an estimated seven times a year. The data must then be uploaded to the speed display manufacturer's website. Through the BI system, the data can be downloaded directly from the manufacturer's site and transferred to the statistics office. Separate evaluation of the data, as was necessary before the BI system, is no longer necessary. This allows a time saving of 25 minutes per run, which amounts to an annual time saving of 2 hours and 55 minutes.

Traffic measurement devices change location weekly from March to October. Once a month, the last four locations are evaluated. The data can be found on the manufacturer's website. After the data is downloaded from the website, it is integrated into the BI system. The data can then be analyzed and further processed by the BI system. A time saving of 20 minutes per run is expected. The annual time saving is estimated at 4 hours.

In summary, this results in an annual time saving of 15 hours for the clerical staff in the process of traffic data analysis. In addition, it should be noted that the data is located in the BI system and can therefore be viewed by colleagues or planning offices at any time. Therefore, weekly queries will be reduced. Since not all parties involved have access to the BI system yet, the total time savings due to the omitted queries cannot yet be estimated. Therefore, this activity was excluded from the analysis.

Statistics Office

The population statistics is created annually in the statistics office. The population statistics are published on the website of the city of Flensburg. Working in different software applications such as EwoPEaK or Migrapro remains unchanged. The individual activities change in the last steps of the process. As soon as the data is derived by the clerks for plausibility and according to various criteria, the manual creation of the numerical summary takes place, which is taken over by the BI system in the TARGET process. An annual time saving of 20 hours is expected.

Early Intervention and Youth Assistance and Youth Services Planning

The social atlas is compiled in the youth services planning department. For the compilation of the social atlas, comprehensive data must be systematised and analysed. The first step in the process is to request data from seven different departments. The requesting, waiting, and merging of different data formats is greatly reduced in the new BI-enabled process. Almost all data is available in the BI system. Currently, the data is loaded manually into the BI system by the BI team, which is expected be converted in the near future. After the data has been received in the BI system, the process can be continued in the department of youth services planning.

During the project phase, a typesetting system for professional document generation (LATEX) was used for report generation. The BI system generates needed graphics and figures, and text generation in Latex reduces formatting work. These points, together with the existing data base (quality assured and up-to-date) in the BI system, provide an estimated annual time savings of 25 hours. At this point in time, it is only possible to speak of an estimated time saving, as the social atlas is an annual product and is, therefore, only being created for the second time using the BI system.

Education and Sports Office

The report for the school development planning is created annually. In this process, the BI system handles the calculations and the generation of graphics and tables. It should be noted that prior to the BI system, the graphics were generated by PRIMUS. According to the staff, the graphics can now be generated more in line with requirements, since the scope for adaptation by PRIMUS was very small.

In addition, as with the social atlas, the typesetting system LATEX was used for report generation. The time saved by the calculations and generated figures/graphs, as well as in the reduced formatting work, amounts to 4 hours annually. The data fed into the BI system can also be used for further inquiries, resulting in synergy effects for the clerical staff.

Research Question 2: Impact on effort on building block type categories

Five building block type categories were distinguished in the process models. The result of the process comparison for the building block categories can be seen in Table 5. Negative time differences indicate that more time must be spent on these phases when using the BI system. Positive values indicate a gain in efficiency.

The BI system provides support for the processes under consideration, particularly in terms of content-related administrative work and in terms of writing and documentation. Information flows are also made more efficient. No increase in efficiency can be seen in information procurement and coordination.

The efficiency gains are offset by efficiency losses in the phase *media change*. Over the entire year, efficiency gains are estimated to be 3840 minutes.

A comparison of processes and phases (see Table 6) with regard to time savings shows a differentiated picture for the individual processes. While the process population statistics benefits in particular in the content-related administrative work, in the process of creating the social atlas an increase in efficiency can be seen in particular in the area of writing / documentation. Furthermore, challenges can be seen in the phase media change. This applies in particular to the creation and publication of the social atlas and the analysis of traffic data.

Research Question 3: Impact on effort on process building block level

The evaluation in terms of process building blocks (Figure 7) shows from a further perspective the areas in which efficiency gains can be realized by introducing and making the BI system permanent. Note that, due to the high number of activities captured, the process building blocks in Table 7 were grouped. However, there are also areas where efficiency losses have to be accepted.

The highest efficiency gains can be achieved in the execution of specific activities. Overall, a time saving of 1185 minutes can be realized. However, a detailed analysis of the processes shows that in particular the preparation of the population statistics can be shortened by 1200 minutes. However, the execution of special activities in the creation and publication of the social atlas is extended by 15 minutes. In this process, the times for the creation of figures and tables are reduced by 45 minutes. However, exporting figures and tables from the BI system will require 60 minutes in the future.

For the process building block *Edit document/information*, a total time saving of 910 minutes is identified. In the following, we highlight how the savings were achieved by looking at the individual activities associated with *Edit document/information*. In particular, for the creation of the social atlas, efficiency gains are realized due to the shortening or elimination of the activities *inserting data into Excel spreadsheet* (300 minutes), *creating figures and tables/checking references and tables* (180 minutes), *formatting document* (90 minutes), *insert data into table* (30 minutes), *insert data* (15 minutes), and *copy Excel table from previous year, rename and adjust* (10 minutes) will be achieved. There are also 285 minutes of efficiency gained in the traffic data analysis process. These result from the elimination of *saving and analyzing Excel tables* (250 minutes) and the elimination of *saving PDF files* (35 minutes).

The third highest efficiency gains are realized for the process building block *create document/information* (860 minutes). Especially for the Education and Sports Office and Youth Services Planning department, this activity is positively influenced. For the activity *insert figures, create tables and charts* in the municipal education planning process (Education and Sports Office), a time saving of 240 minutes is assumed. A comparable activity (*document creation (texts and tables)*) allows for a time saving of 1575 minutes in the creation of the social atlas (Department of Youth Services Planning). This is contrasted with the new activity *create / generate social atlas / write texts (LaTeX)*, which causes a time expenditure of 1080 minutes. Thus, taking into account the new effort, a time saving of 495 minutes is realized. in the process of traffic analysis, the annual effort in document creation is reduced by 120 minutes.

A time saving of 385 minutes is expected for the process building block *Check content/Make decisions*. Efficiency gains are expected in the processes *Create and publish social atlas* (325 minutes) and *Analyze traffic data* (300 minutes). However, increased effort is also expected for the school development planning report (an additional 240 minutes). The comparison of the areas indicates different expectations: While in the processes for analyzing traffic data and creating the social atlas, it is assumed that there will be an efficiency gain in the plausibility of the data, in the course of the report for education planning, it is assumed that there will be an increase in the time required to verify the data in the dashboard. For traffic data analysis, it is estimated that the activities *check data for plausibility* and *look through excel spreadsheet and correct if necessary* will no longer be necessary in the future. On the other hand, the activity *check data for plausibility and correct if necessary* will be required, but it can be done 300 minutes faster.

The added value of a central data pool becomes particularly clear for the process building block *Send document/information*: Requests to the statistics office for special evaluations in the course of compiling the social atlas can reduce the time required by 60 minutes. In total, a time saving of 105 minutes is assumed.

An additional effort is identified for the activity *to adopt data in EDP*. The additional effort, as well as the challenges of integrating the data, is again evident here. The additional effort is estimated at 450 minutes.

DISCUSSION

Summary of key findings

Comparison of departments (overall): Time effort savings from 1.77 to 47.44 % of the total effort were achieved across the departments. That is, we observe that the introduction of the BI system had varying effects on the efficiency of the analytical processes.

To understand the effects, we looked at different activity categories (referred to as Building Block Type Categories in the PICTURE method). The largest savings can be seen for

Table 5: Estimated total process times in minutes by application phase for prior BI and BI-enabled processes (negative values mean a negative effect)

Building Block Type Category	Prior BI Process Estimation	BI-enabled Process Estimation	Difference	%
Information gathering and coordination	1980	1980	0	0.00
Information flows	1286	1171	115	8.94
Content work	13370	11050	2320	17.35
Media change	185	635	-450	-243.24
Documentation	13030	11175	1855	14.24
Sum	29851	26011	3840	12.86

Table 6: Comparison of the time difference in minutes between prior BI process and BI-enabled processes in relation to the application phase (negative values mean a negative effect)

Building Block Type Category	Create school development report	Create social atlas	Analyze traffic data	Create population statistics
Information gathering and coordination	0	0	0	0
Information flows	0	115	0	0
Content work	0	310	810	1200
Media change	-5	-45	-400	0
Documentation	245	1120	490	0

content work (17.35% savings) and documentation (14.24% savings). A negative impact was mainly observed for media changes. Media changes occur repeatedly when information is transformed into different formats or transferred to different locations.

We found that information gathering and coordination were not affected for any of the studied departments. For the remaining building block type categories, it was evident that some departments were not affected by the introduction of the BI system (see Table 6). In addition, the degree by which the departments were affected varied substantially. Overall, the study shows that depending on the context, the impact of introducing a BI system can vary greatly.

To understand where time savings occur, we analyzed the process building blocks and looked at the individual activities and sub-activities. Based on the time saved in the statistics office, the education and sports office, and the department of youth services planning, it is clear that the BI system supports reporting tasks in particular. However, processes were selected that have a strong focus on reporting. This is evident from the process models and also the analysis in terms of activities. In the prior BI processes, reporting-related activities take up much time. The process building blocks *Edit Document / Information* (7305 minutes) and *Create Document / Information* (5640 minutes) take up 43,37% of the total time of the prior BI processes.

In the prior BI process, more time is only spent on *special activities* (8825 minutes), whereby clear references to the preparation of reports can also be seen here (e.g. the elements *publication (digital, print) of school development plan* and *preparation of population statistics* in the processes *Create school development planning report* and *create population statistics*).

We found a perceived positive impact on tasks that have a comprehensive reporting function.

Practical implications

We found that the gains and losses concerning efficiency varied between departments. This shows that the gains highly depend on the process being studied. The processes of the departments were heterogeneous, and may also be affected by the classification of the activities done during the modeling of the processes in the organization. Also, how many times certain activities are repeated, played a role. Thus, when wanting to assess the potential of efficiency gains due to BI systems, we still have to conduct individual assessments.

The estimation of impacts was possible with relatively little effort from the perspective of data collection (14 interviews). When having fine-granular activities of low complexities, we suggest assessing potential efficiency gains as part of introducing a BI system using the PICTURE method.

Research implications

The study of the related work showed that we did not find studies on the effect of business intelligence systems in the public administration context. Hence, to the best of our knowledge this is the first investigation with the main focus on BI system effects on efficiency in the public administration context. Therefore, further studies in different contexts are needed. We studied public administration in Germany, and suggest studying organizations in different countries. Also, as the study focused on a medium-sized municipality, administrations of larger and smaller cities should be studied.

We also would like to highlight the need for measurement programs that allow us to easily record efficiency data as, in

Table 7: Overview of resource efficiency by process building block in minutes (negative values mean a negative effect).

Process building block - grouped	Estimated prior BI duration	Estimated BI-enabled duration	Difference
Discussion and reaching agreements	600	600	0
Change work place for data collection	780	780	0
Consult	300	300	0
Calculate	750	0	750
Transfer data to IT	125	575	-450
Print document	60	60	0
View document	120	120	0
Edit document/information	7305	6395	910
Receive document/information	384	374	10
Create document/information	5640	4780	860
Send document/information	902	797	105
Formal check	20	20	0
Content check/plausibility check	2875	2490	385
Clarification questions	1080	1080	0
Execution of specific administrative tasks	8825	7640	1185
File process outcome	85	0	85

our case, no historical data was available. Thus, we needed to rely on estimates.

CONCLUSIONS

In this study, we investigated the impact of introducing a BI system in public administration. We investigated the case of Flensburg municipality. Our research question was: *What is the estimated impact on effort through the introduction of a business intelligence system in a municipality?*

Overall, a perceived positive effect of the introduction of the BI system on ressource efficiency can be observed. These positive effects can be increased in the future by mapping further processes and taking other departments into account. Especially in areas where reporting is of high importance, the BI system is expected to add value to the daily work. However, challenges in report generation were also identified. For example, a new time effort of 1,080 minutes is expected in the creation of the social atlas using LaTeX, the tool chosen for documentation as part of the project.

This challenge was addressed early in this project, and work began on developing a reporting tool that was used prototypically in the creation of the social atlas. However, the reporting tool was not yet considered at the time of the time estimates. It should be noted here that in the process *create social atlas* the previous time required for document creation was estimated at 1,575 minutes. Thus, a time saving of 495 minutes is expected even without the reporting tool.

Further potential can be expected in relation to the processes described in the other departments involved. For example, the statistics office, the immigration office, and the economic youth welfare office are among the departments involved in the creation of the social atlas. Efficiency gains can be expected here as well. Data integration is a challenge. Further automation potential should be examined here, and data integration should be further simplified.

For this study, four processes were selected that are primarily designed to prepare reports. These processes do not cover the complexity and diversity of the operational and strategic decision-making processes of a public administration. Rather, they only give a first impression of the efficiency gains that can be realised through a BI system. This gives rise to the need for research to analyse further decision-making processes in public administration. Large-scale quantitative studies are challenging due to the diversity of processes and their concrete implementations.
The efficiency gains were not compared with the costs within the scope of this study. However, this is necessary for an economic decision. Since the BI system has only been introduced in four departments so far, an ex-post economic analysis is not possible at this time. This results in a need for further research that includes the business cost perspective. In this context, it should also be noted that this study only measured efficiency, as the name suggests, but not the effectiveness of the BI system. When cost factors are taken into account, they should be contrasted not only with the efficiency of the decision-making processes, but also with the quality of the decisions.

Given the lack of studies focusing on the impact of BI systems on efficiency in public administration, we suggest replicating this study in different contexts.

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