Generativity of Business Intelligence Platforms: A Research Agenda Guided by Lessons from Shadow IT

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Abstract

To provide software platforms that are highly adjustable to users' needs, recent literature proposes *generativity*, that is, platforms that may be supplemented in order to provide functionality that the designers of the platform did not have in mind. The research stream on generative platforms features a similar phenomenon as the research stream on *shadow IT (SIT)*, because SIT also investigates supplements to integrated software-based systems that the designers of the software initially did not have in mind. Especially the domain of business intelligence (BI) is often flooded with SIT such as additional data marts and spreadsheets. However, while a wide body of literature has emerged that investigates SIT impacts, few, if any, studies examined generativity of platforms in general and BI platforms specifically. In this paper we present a literature review on positive and negative SIT impacts. Building on the results, we suggest a research agenda on generativity of BI platforms.

1 Introduction

Organizations have made large investments into implementing standardized software products with the expectations that the resulting enterprise systems integrate data and processes, allow control, reduce costs and improve their organizational performances [16], [29], [51]. However, research indicates that many software products do not achieve these goals due to numerous reasons such as insufficient fit to users' requirements, inflexibility to modifications and long implementation times necessary to change or extend the standardized application systems [28], [43]. Consequently, employees today supplement standardized enterprise systems provided by their IT departments with additional information systems that highly fit their needs – ranging from out-of-the-box cloud-based systems to self-developed macros and applications [35],[59]. These autonomously provisioned supplementary systems are commonly referred to as *supplementary IT* or *shadow IT* (SIT). Especially in the domain of business intelligence (BI) SITs are frequently created, e.g., BI platforms may be supplemented by individually tinkered spreadsheets and customized data marts that report specific financial indicators [41], [58]. However, the effects of SIT are ambivalent. On the one hand, IT professionals and many IS scholars view SIT as an undesirable phenomenon [9] for numerous reasons such as replication of functionality [42]. On the other hand, recent literature acknowledges that SIT "may be just what an organization needs" [17] (p. 124).

While the assumption persists that the concepts of software platforms and modularity were able to resolve these paradoxical tensions between standardization and flexibility by providing a possibility to add adjusted modules on top of an integrated core, recent literature demonstrates that modularity itself does not yet make software products highly evolving [39]. Rather, recently published research agendas determine *generativity* as the essential element [40], [39]. Generativity in the IS discipline refers to the ability of an information system to create some new, initially unexpected outcome [36]. It tackles a similar phenomenon as SIT, because SIT also emphasizes new developments and IS extensions that the developers of the original IS did not have in mind. However, although much effort has been devoted to identifying and explaining strengths and weaknesses of SIT and some scholars acknowledged that SIT should be "encouraged within and avoided outside defined boundaries" [43] (p. 9), only very few, if any, articles linked these findings to the currently emerging research stream of generativity. We believe that linking the two research streams improves our understanding of both streams. Hence, within this article, we focus on generativity of BI platforms, because (1) BI platforms are especially often supplemented with end-user developed extensions and (2) many standardized BI platforms try to stimulate end-user developed extensions (e.g., many reporting tools offer add-ins to spreadsheet software such as Microsoft Excel). Our work addresses this gap by investigating the following research questions:

1. What is the current state-of-the art in the literature regarding positive and negative impacts of SIT?

2. How can we exploit these impacts to balance standardization and individualization and what areas may be tackled by further research to improve a BI platform's generativity?

The following section builds terminological foundations, section 3 introduces our chosen methodology and section 4 reveals the findings of our SIT review. Finally, section 5 develops a research agenda guided by SIT findings and section 6 closes with implications and limitations of our research.

2 Terminological Foundations

2.1 Shadow IT

Shadow IT, also *supplementary IT* (SIT), refers to an IS that extends an existing IS but is maintained significantly less by the IT department than the IS that it extends [43], [54]. Reasons for this smaller degree of maintenance include, for instance, that the IS was bought or rented from another company, that it was not approved by the IT department, that it possesses various threats to data security and data integrity, that it does not work together with other IS, that the IT department lacks the resources required to maintain it and/or that the IT department simply does not know about its existence [17],[42],[43], [54],[61]. These reasons represent the needs of business departments for more flexibility, which may not be surprising considering the fact that enterprise systems typically emphasize integration and, thus, standardization. To resolve such flexibility issues, multiple studies proposed software platforms and extension modules [34], [37]. However, most of the studies highlighting the paradoxical tensions between flexibility and standardization focus on the degree to which actions are controlled and enforced. Particularly, [57] built a theoretical framework of the dynamics of change and control based on the Android and iOS platform, [47] developed strategic actions for platform owners to control their platforms while distributing design capabilities, [44] propose a model for balancing empowerment and control, [25] suggested a model for balancing platform control and external contributions and [18] focuses on the triangular tensions between opening platforms, granting access to platforms and controlling platforms. Conversely however, only few studies exist that investigate technological conditions and drivers of flexible platforms and, thus, design attributes fueling SIT. That is, [48] investigates Android to propose a framework for analyzing success factors of platform strategies and [19] focuses on drivers of external platform developers to create innovations.

2.2 Platform generativity

While research on software platforms focuses primarily on how platforms can be extended, generativity focuses on the ability to create new output [39]. Hence, in the case of software platforms, generativity refers to (1) the ability of the platform to be changed or extended to create new output and (2) the ability of the platform to be integrated into another system to create new output. In other words, generativity encompasses what it is that makes platforms supportive to innovations based on them and why it makes them supportive to innovations.

Generativity has also been identified by multiple, recently published research agendas in the IS literature. For instance, [39] explains that modularity itself does not yet make software products highly evolving. Rather, the crucial element is *generativity*, which refers to "*the ability of any self-contained system to create, generate, or produce a new output, structure or behavior without any input from the originator of the system"* [36] (p. 750). An illustrative and easily understandable example would be a potato peeler and a knife. While a potato peeler can only be used on particular food, knives have greater versatility to tasks besides peeling as well as greater adaptability for uses outside cooking and thus have a higher degree of generativity [3]. Regarding digital products, (a) the internet [3] and (b) Google Maps [39] are two popular examples for highly generative products, because (a) the internet allows almost unlimited creation of new products and (b) Google Maps is able to be embedded into numerous systems although initially designed to provide users with satellite pictures of the earth – thus creating new types of navigation systems and weather maps.

In this article, we feature *platform generativity* defined as the *degree to which a software platform fosters emergence of new supplementary modules, organizational structures, and work practices that the originator of the software platform did not have in mind*. Multiple IS scholars recently called for greater investigation of this phenomenon. For instance, [36] argue that researchers need to "investigate social and technical elements that influence generativity" (p. 754) and [39] calls for "a more precise and nuanced understanding of the nature of digital technology that enables and constrains activities that produce generative innovations" (p. 231). To dive into this emerging research stream on platform generativity, the following subsection positions generative platforms and explains the connection to other software platforms as well as the connection to SIT.

2.3 Balancing standardization and individualization

An important boundary for our definition of *platform generativity* is its emphasis on IS that are designed as composites of one or more platforms and, optionally, multiple modules. Typically this refers to BI platforms which users may extend, e.g., through adding data marts, designing dashboards and developing queries. Based on this assumption, two abilities of generative platforms may be differentiated. First, platform generativity encompasses the ability of a platform to be extended through adding, changing and deleting supplementary modules. For example, the internet was initially developed to exchange electronic messages but then was extended to provide real-time news, view videos, provide access to servers worldwide and much more. Second, platform generativity encompasses the ability of a platform to be used as a supplementary module by another platform. An example for this would be YouTube, because YouTube was initially developed as a video platform and then became widely embedded into numerous webpages thus creating new animated webpages. In contrast to less generative platforms, highly generative platforms may additionally be extended by modules which provide capabilities that the originator of the platform did not have in mind when designing the platform. For instance, although the designers of Microsoft Excel focused on an application which supports data representation in spreadsheets and mathematical computations, Excel additionally turned out to be supplemented by modules that provide very different capabilities, e.g., generation of heat maps [60].

However, even highly generative platforms do not subsume all potential innovations and additional technologies, because they always require a connection between modules and platforms. Hence, stand-alone systems are not within the scope of generative platforms. An example for such a stand-alone system would be a database that is only used within a certain department and all data is entered manually. Such a system would be considered SIT, but not generative. On the other side, a standardized core could be considered as a part of a generative platform, but not as SIT.

The components that belong to software platforms, generative platforms and SIT vary in their degree of standardization – or, inverted, individualization – and may be classified along a respective continuum [20], [44]. Specifically, (traditional) software platforms foster standardization, while generative platforms enable a greater degree of individualization and SIT provides unlimited possibilities to personalize an IS. Figure 1 visualizes this continuum.

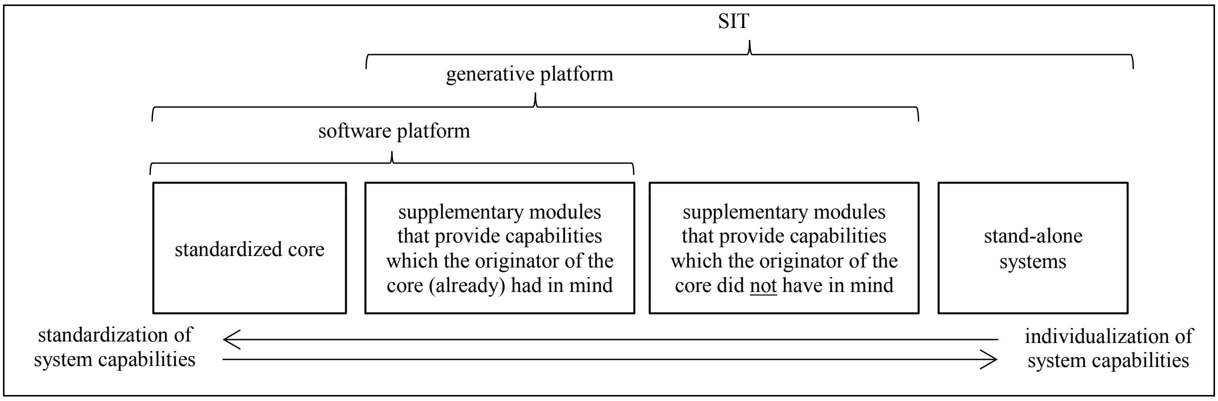

Figure 1: Software platforms, generative platforms and SIT

3 Methodology

Our literature review followed the guidelines provided by [38]. It first required (1) the development of criteria for the types of studies to be included in our analysis, (2) a literature search strategy, and (3) an analysis scheme [30]. First, we chose to limit our initial sample of articles to those which explicitly dealt with SIT or concepts which are synonymously used such as feral systems, workaround systems and rogue systems [54]. We also included literature that emphasized the similar phenomenon of end-user development (also known as end-user computing) [5]. We did not limit the results to the BI literature, because, although SIT is very common in the domain of BI, it is not unique to BI. Supplements may also be developed for other platforms such as customer relationship management platforms. We developed a search string for our database search as follows:

(feral OR workaround OR shadow OR rogue OR supplementary) AND (system OR platform OR "IT") AND (technology) OR (end-user development) OR (end-user computing)

Second, we applied multiple methods to search for appropriate literature. We searched titles, abstracts and keywords using our search string on two electronic databases, i.e., Business Source Premier (BSP) and AIS Electronic Library (AISeL). To receive search results of high quality, we limited the results from the BSP search to scholarly (peer reviewed) journals. Similarly, the AISeL search results were limited to journals and conferences sponsored by the Association for Information Systems. The BSP search yielded 422 results and the AISeL yielded 124 results published in journals and 92 results published on conferences. Next, we scanned the titles of the search results and narrowed the results down to 43 distinct articles that seemed to be relevant for our review. After that we scanned the abstracts and, if we considered them to be relevant, also the full paper. Thereby we focused on articles that highlighted identification of benefits and downsides of supplementary systems. For instance, [43] studied antecedents of such systems and how risks can be mitigated and [49] examined the rise and fall of such systems. That reduced our search results to 21 papers. After that, we read through the identified articles and added related articles to our list (backward search). Our initial review was conducted during the spring 2013 and it was not constrained to a certain time frame or a certain set of publication outlets. Eventually, our search yielded 26 articles.

Third, our method for analysis of the identified studies was to first look for impacts of SIT that had been examined by the authors. After that, the resulting impacts were grouped into categories. The following section allocates the identified articles and SIT impacts to the derived categories.

4 State-of-the-Art: Positive and Negative Impacts of SITs

Our review revealed desirable and undesirable impacts of SIT. We clustered those and distinguished two categories of SIT benefits and five categories of SIT downsides. This section first discusses the benefits of SIT and subsequently its downsides. Desirable effects of SIT are (1) improved IS utilization and (2) a greater amount of innovations. First, SIT improves utilization of ISs due to higher alignment between the IS' capabilities and users' hedonic and utilitarian needs [14],[23],[26] and thus may enhance users' operational as well as decisional activities [12],[52], and eventually increase overall satisfaction with the IS [5],[10]. Furthermore, SIT may enable IS infusion [11],[22], i.e., deep and comprehensive embedding of the IS within an individual's or organization's work system [51]. Prior literature also found improvements regarding more efficient and effective IT usage [24],[43],[50],[51].

Second, SIT supports introduction and implementation of innovations into organizations. The possibility of supplementing IS creates flexible IS environments that guarantee the ability to adapt in an increasingly uncertain and competitive environment [17],[18],[45],[50], because systems may be changed faster [5],[43]. If users who possess real-time awareness of changes in the respective business domains participate in the development of SIT, then the underlying IS are likely to anticipate future requirements. Similarly, from a technological perspective, SIT allows to easily implement new technology, keep up with technological changes [17],[31], and evaluate the impacts of new IS through prototyping [4],[10],[43]. Besides, SIT is also characterized by low initial costs and thus appreciated as a cost effective opportunity to update existing IS and data [43],[50]. Table 1 summarizes the benefits.

Category	SIT benefit	Sources
Utilization	IS fits better to users' practices and enhances users' operational and decisional activities	[5],[16],[43],[54]
	Usability of the IS and user satisfaction with the IS are higher	[5],[10]
	Deeper system usage (IS infusion) and more development activities	[13],[18],[51],[56]
	Improved efficiency and effectiveness regarding IT usage	[24],[43],[50],[51]
Innovation	IS is more flexible and guarantees ability to adapt in an increasingly uncertain and competitive environment	[17],[18],[45],[50]
	IS may be changed faster; especially if users who possess real-time awareness of changes in respective domains change the IS	[5],[43]
	Ability to implement new technology and keep up with technological changes	[17],[31]
	Ability to evaluate the impact of new IS through prototyping	[4],[10],[43]
	Low initial costs of new IS and cost effective update of existing IS and its data	[43],[50]

Table 1: Benefits of SIT

However, SIT does not only create benefits for organizations. Actually, its overall impact can vary tremendously which makes it so important to understand its advantages and disadvantages in order to eventually benefit from SIT. We categorized the downsides into five categories, i.e., (1) intransparency, (2) loss of security, (3) loss of synergies, (4) focus on minority groups, and (5) limited sustainability. As indicated by its name, shadow IS create intransparency within organizations. Typical examples include IS that are not (properly) approved by the IT department because they were developed by employees from the business departments or purchased from external companies [54].

Sometimes IT departments even do not know about the existence of SIT within their organizations at all [61]. Similarly, it is extremely difficult for managers to evaluate the value of such systems [33]. Although that may also apply to IS in general, it applies particularly to SIT, because users and use cases of SIT may be unknown. Hence, it is very difficult to coordinate and control actions, communication and costs [18], [55].

In addition, loss of security is a major downside of SIT, too. Since IS are no longer officially maintained by corporate IT departments they may not only expose important information to unauthorized users, but also lead to data loss, vulnerability to malware and non-compliance with laws [43],[61]. For instance, if an employee from the purchasing department saves important data in a local spreadsheet, employees from the accounting department may not be able to create correct quarterly reports, thus reducing the organization's compliance with external laws.

Furthermore, SIT creates a heterogeneous, decentralized IS environment [1],[15],[43]. This may lead to redundant and erroneous data, because data gets extracted from (integrated) data storages and then may be modified without updating the original source [42][41]. Heterogeneous IS environments may also destroy various types of synergies that would be essential to the organization, such as synergies from infrastructure, synergies from reuse of applications and synergies from expertise [21],[43]. First, SIT reduces synergies from infrastructure, because assets are likely to be purchased multiple times (e.g., hardware, software licenses). Second, SIT reduces synergies from reuse of applications, because even if applications were able to support several user groups (e.g., accountants from plant A and accountants from plant B), a central unit would be missing that could deliver the SIT developed by plant A to plant B. Third, SIT reduces synergies from expertise, because employees from multiple groups (plant A, plant B etc.) would spend time learning how to develop SIT – ranging from learning how to use complex Excel functions to learning how to write SQL statements and develop distributed software applications. Similarly, SIT also reduces expertise that may be gained from using new technology. For instance, if a particular SIT enables a change in a certain business process and thus significantly improves the process' efficiency, other departments cannot adopt the improved process because it remains unknown for them. Besides, SIT often focuses on minority groups. Since employees within an organization have different skill sets with regards to IT and are driven differently by their (intrinsic and extrinsic) motivations and preferences, the degree to which employees participate in the development of SIT varies strongly [6][10]. Hence, the capabilities provided by SIT primarily support the minority who actively participated in the development. We acknowledge that this issue applies to IS in general, because it is very difficult, if not impossible, to actually gather all user requirements equivalently. However, we believe that it particularly applies to SIT, because SIT is developed by single users or small groups who are not trained in gathering requirements from their fellow colleagues and, thus, intentionally or unintentionally, ignore their requirements.

Finally, SIT may be characterized by limited sustainability, because developers of SIT usually have an IS in mind which supports their work practices right away. They focus on the short and medium term and may not adequately consider long-term effects [5] – although this would be required to develop a durable software asset for the organization. For instance, lack of code reuse and insufficient documentation [17] complicate maintenance and lead to an inability of the corporate IT departments to guarantee support [43],[61]. Furthermore, if additional users intend to use a particular SIT, it may reach its boundaries quickly since scalability has been ignored during the development and design phases [5]. Similarly, scalability may also limit the system's sustainability as soon as users continue to access and extract more and more data from connected IS. Eventually, sustainability of SIT is also limited because of its strong dependence on key individuals [17]. If these individuals leave the organization or are not able to maintain the SIT anymore, the SIT may quickly become valueless to the organization. Table 2 summarizes the downsides of SIT which our literature review revealed.

Category	SIT downside	Sources
Intransparency	No (proper) IT approval; IT sometimes even does not know about the existence of SIT at all	[54],[61]
	Extremely difficult to assess the value of SIT because users and use cases may be unknown to managers	[33]
	A lack of transparency hinders control of costs and actions	[17],[18],[42],[45],[51]
	Ineffective communication; difficult to coordinate activities	[55]
Loss of security	Huge, intransparent risks, such as exposure to unauthorized users, data loss, non-compliance with laws (e.g., SOX)	[43],[61]
Loss of synergies	Heterogeneous, decentralized IS environment	[1],[15],[43]
	Loss of synergies with regards to infrastructure, reuse, expertise, and “best-practices”	[21],[43]
	Redundant and erroneous data	[42]
Focus on minority groups	SIT does not support all employees’ work practices equally well, because it strongly focuses on practices of people who were actively involved in the development. Thus it only supports a minority and may neglect general requirements of entire groups.	[6],[10]
	Huge differences in end-users knowledge, motivation, and preferences lead to only a minority who actively develops SIT.	[6],[10]
Limited sustainability	No durable software asset for the organization; focus is on short and medium term	[5]
	Inability of the IT department to guarantee (long-term) support	[43],[61]
	Often bad software quality regarding performance, code, reusability	[7],[8]
	Limited scalability and limited support for growing number of users	[5]
	Insufficient documentation	[17]
	Strong dependence on key individuals	[17]

Table 2: Downsides of SIT

5 A Research Agenda for BI Platform Generativity

At the core of our definition of platform generativity (see section 2.2) is a strong link to the *Supplementary IT* research stream and the *software platforms and modularity* research stream. While recent literature explains that generativity is supported through modularity, there are only few, if any, articles examining the links between SIT and generativity. However, drawing lessons from SIT provides important knowledge, because, as our review revealed, in order to assure desirable overall effects of SIT, awareness about its benefits and downsides needs to be established across IS users and developers.

Due to the overlap between generative platforms and SIT (see section 2.3), we believe that the discovered benefits and downsides of SIT are almost equally likely to apply to highly generative BI platforms, because platforms, in contrast to embedded and integrated systems, provide a certain amount of flexibility and thus may similarly be aligned to fit to users’ needs. However, effects of SIT are slightly less pronounced within the context of software platforms, because platforms draw boundaries around their core capabilities. Even highly generative BI platforms which attempt to support development of further, unlimited IS based on them, slightly limit such development, because they require developers to learn how to work with the specific platform.

Category	**Relevant research questions**
Utilization	How can we assure ease-of-use of new statistical tools that enable real-time data analyses based on IMDB? What are design criteria for user-friendly, powerful data analysis tools?
Innovation	How can we use data marts and supplementary modules of individual departments as innovative prototypes for further departments and locations? How should a BI platform be designed that supports efficiently low response times to change requests while assuring reliability and robustness and, thus, also a high innovation capacity in the long run?
Transparency	How can we create transparency over supplementary modules across departments/locations? How does real-time visibility and analyzes of processes affect the execution and performance of these processes? How should governing units such as BICCs control and monitor agility in BI platforms?
Security	In which use-cases, if any, and how may real-time analyzes reduce security risks? Which additional security threats, if any, arise from cloud-based BI?
Synergies	How should governing units such as BICCs integrate and promote supplements to realize synergies across departments without reducing their alignment to users' tasks? How may synergies across teams/departments be gained if users are provided with dedicated BI sandboxes for performing exploratory analyses?
User participation	How can employees be motivated to exploit possibilities for self-service reporting and develop their own data marts and tinker their own reports within pre-defined boundaries? How should employees with little IT skills be taught in the use of self-service reporting options? What are the most effective training methods?
Sustainability	Which design principles lead to durable, highly generative BI platforms? How may organizations tackle the tensions between standardization and individualization? How can organizations simultaneously manage the tensions within the software application (i.e., standardization vs. individualization) and the tensions within user enablement (i.e., control vs. empowerment)?

Table 3: Research agenda for BI platform generativity

Thus, we propose that the seven impacts of SIT should also be examined within the context of highly generative BI platforms. Therefore we suggest potential research questions for each category (Table 3). For instance, since the emergence of in-memory databases (IMDB) provides significantly faster data analyzes, users are not limited to descriptive analytics anymore (e.g., alerts, drill downs, ad-hoc reports, standard reports) but may also perform a wide range of predictive analytics (e.g., optimization, modeling, forecasting, extrapolation) [1]. However, such powerful analytics tools tend to require strong statistical skills and a long usage experience. Hence, we suggest that further research develops design criteria highlighting the ease-of-use of these tools. Without considering usability of these complex, real-time statistical tools, organizations will not be able to realize the full potentials of IMDB.

Some of the potential research questions would also improve our understanding of BI agility, because by "lowering response times to change requests" [41] (p. 1) agile BI also aims at frequent innovations and, thus, aims at fostering the BI platform's generativity. We believe that an improved understanding of generativity would particularly strengthen our understanding of the appropriateness of agile process methods within the context of Agile BI [53], because it targets a platform that balances complex, standardized processes in which individuals are controlled on the one hand and lean, agile processes in which individuals are empowered (e.g., provided with dedicated BI sandboxes [58] or self-service possibilities [27],[32]) on the other hand.

The paradoxical tensions within software applications (i.e., standardization vs. individualization) are a highlighted research area of the generativity research stream. They complement prior literature which primarily focused on paradoxical tensions within user enablement (i.e., control vs. empowerment) as indicated in section 2.1. Similarly, a consideration of both paradoxes simultaneously would also improve our knowledge of BI platform generativity and support our understanding of BI governance, i.e., steering and controlling BI platforms and the role of a Business Intelligence Center of Competence (BICC) [41].

Table 3 assigns potential research questions regarding BI platform generativity to each area that was influenced by SIT. Due to the illustrated overlap between generativity and SIT, we believe that studies on how BI platforms could improve these areas would also improve the BI platform's generativity. For instance, in order to increase the benefits from user-developed supplements, a central organizational unit (e.g., corporate IT, BICC) may promote reuse of supplements and provide them as prototypes to additional teams and/or departments. By doing so, the organization could achieve scale effects because different teams would not need to develop the same supplements anymore. Besides, more teams and departments would access a certain supplement and, thus, be able to advance and refine it and develop new innovations based on it. Therefore, two potential research questions are: How can we use data marts and supplementary modules of individual departments as innovative prototypes for further departments and locations? How may synergies across teams/departments be gained if users are provided with dedicated BI sandboxes for performing exploratory analyses? Summary

This paper set forth to review the current state-of-the-art on SIT literature and derive a research agenda for BI platform generativity. First, our review revealed two categories of desirable SIT impacts and five categories of undesirable SIT impacts for organizations. Specifically, while utilization of IS is likely to be improved and the amount of innovations is likely to be increased, SIT may also lead to intransparency across the organization, loss of security, loss of synergies and a focus on minority groups. In addition, SIT pursues short-term objectives and thus has limited sustainability in terms of creating a durable software asset. Besides, we defined and distinguished SIT and platform generativity, discussed whether findings from the SIT literature stream could similarly be found when investigating highly generative BI platforms, and proposed a research agenda for highly generative BI platforms.

Our research is limited in that this review is based on a restricted number of electronic databases as publication sources. Although major contributions are likely to be found in one of these sources or to be referenced by them, potentially important publications may have been omitted. Similarly, publications that do not include any of the search terms may also have been omitted. Thus, future research may address these gaps by using additional databases, adding additional search terms to the search string or manually scanning the tables of content of suitable journals and conference proceedings. In addition, further research may examine the questions raised by our proposed research agenda.

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