Rebound Effects in Cloud Computing: Towards a Conceptual Framework

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Abstract. Rebound effects have been discussed in various disciplines. In the information and communication technology sector, this topic is still insufficiently studied. Basically, a rebound effect is a feedback mechanism, as a result of which savings from efficiency improvements are not or only partially realized. Due to the potential of cloud computing for efficiency improvements, not only in terms of energy efficiency, but also in terms of organizational resources in general, we describe rebound effects in this context by means of a systematic literature review and a case study. Our results provide a framework to categorize and identify potential rebound effects in cloud computing. The understanding of rebound effects and their influence on the various organizational resources (e.g., server hardware, human resources or IT know-how), is important for managers to sustainably decide for or against the adoption, integration and roll out of cloud computing services.

Keywords: Rebound Effects, Cloud Computing, Literature Analysis, Case Study, Conceptual Framework.

1 Introduction

In recent years, the cloud computing (CC) technology has emerged as a new computing paradigm and has gained increasing attention due to its remarkable advantages, e.g., reducing costs and complexity along with increasing flexibility [1, 2]. In its core, CC resorts to existing technologies like grid computing, virtualization and web services for the online delivery of scalable IT services, commonly on the basis of a pay-per-use pricing model [3]. However, when strategically outsourcing a supportive or even a core process into the cloud (so called “cloudsourcing”), it is mandatory that the management of the organization has a clear understanding of all influencing as well as influenced factors. One of these factors is the rebound effect, which diffuses alongside with the efficiency improvements of CC and which describes that expected savings resulting from these improvements cannot be realized, due to a growth in consumption of the underlying or different resources.

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Rebound effects have been discussed in various disciplines, e.g., psychology, but in the information and communication technology (ICT) sector this topic is still insufficiently investigated [4, 5]. Moore's law constitutes a commonly referenced example of rebound effects in the ICT field. It predicts that the microchip performance per cost unit doubles every 18 months, which makes ICT hardware widely affordable, but in turn leads to an increase of consumption [5, 6]. Existing literature on rebound effects in the context of CC mainly focuses on an energy saving perspective [7–9]. For example, Walnum and Andrae (2016) estimate that rebound effects possibly offset energy savings at the macro-level due to the increased amount of data transferred [8]. In the field of ICT, potential savings do not only result from energy efficiency improvements, but also from organizational resources, such as workforce [4]. Therefore, we expand the focus from a narrow energy saving perspective to efficiency improvements of general organizational resources in the context of CC. For example, if an organization outsources servers and corresponding storage into the cloud, the decreased costs as well as the enhanced provisioning of storage may lead employees to make use of the new storage facilities more extensively than before. This in turn would exhaust the expected savings, which consequently remain unrealized.

To avoid possible rebound effects that would absorb the resource-saving impact of CC, a basic understanding must be established [4]. With this in view, we conducted a systematic literature review focusing on the definition of rebound effects. Subsequently, we describe the phenomenon of rebound effects in CC by means of a case study, in which we accompany an organization during a typical outsourcing process into the cloud. Based on the findings, we provide a framework consisting of a definition of rebound effects in general (REGE) and rebound effects in CC (RECC), a conceptual model and a morphological analysis of RECC to identify, categorize and understand potential rebound effects in cloud computing. In practice, the final decision on the usage of CC services has a significant influence on the various organizational resources (e.g., server hardware, human resources or IT know-how). The understanding of surrounding factors such as the rebound effects is vitally important for decision makers to sustainably decide for or against the adoption, integration and roll out of CC services. From the scientific perspective, the framework constitutes a starting point for further investigation.

The corresponding research questions (RQs) we seek to answer are the following:

RQ1: How can rebound effects in cloud computing be conceptualized?

RQ2: Which organizational resources are potentially affected by rebound effects in cloudsourcing scenarios?

Before we answer these RQs, we outline our methodical approach and provide theoretical background on rebound effects in general. Second, we present a definition, a conceptual model and a morphological analysis concerning rebound effects in CC on the basis of a literature analysis and a case study approach. Finally, we discuss our research findings, line out implications for theory and practice and conclude with limitations as well as future research implications.

2 Research Methods

2.1 Systematic Literature Review

In order to identify and analyze relevant research on rebound effects, we carried out a systematic literature review according to vom Brocke et al. (2009) [10]. The systematic literature review provides the basis for the definition of REGE (cf. section 3) and consequently indirectly for the conceptual modelling and the morphological analysis of RECC (cf. section 4.1). In order to achieve high-quality results, we limited the search to the top 25 (out of 109) journals included in the AIS (2014) ranking, all A- and B-ranked journals and conferences according to the VHB (2008) ranking, as well as all A-ranked journals and conferences included in the WKWI (2008) ranking [11–13]. All the above meta-rankings of international information systems journals and conferences are widely accepted. Additionally, due to their diversified programs, we also considered the well-known conferences Americas Conference on Information Systems (AMCIS) and the Hawaii International Conference on System Sciences (HICSS) to be relevant.

For the queries, we defined the following search terms and phrases (rebound effect*, rebound-effect*, reboundeffect*, rebound mechanism*, rebound-mechanism*, reboundmechanism*, boomerang*). The wildcards used ensure the identification of related terms (e.g., ‘rebound effect’ or ‘rebound effects’ for ‘rebound effect*’). In this search, we deliberately left out the refining search term cloud computing, as the achieved results will naturally already contain the contributions in this field. With the listed search terms we searched the titles and abstracts of the previously mentioned publication organs and found only one paper. Since this initial search focused on IS publication organs, the implication by Gossart (2014) that the phenomenon of rebound effects is still largely unexplored in the field of ICT is verified [4]. Due to this result, we extended the initial search to the databases EBSCOhost, SpringerLink and Google Scholar, which led to a total of 2.325 results (EBSCOhost: 293, Google Scholar: 572, SpringerLink: 1.460). As these results are sorted by relevance in the corresponding databases, we focused on the first 100 results for each query in each database. After reading the titles and abstracts, we identified 54 relevant results (EBSCOhost: 21, Google Scholar: 16, SpringerLink: 17). A forward and/or backward search based on these results was not conducted since the initial literature search already distinctly focused on IS literature.

2.2 Case Study

The case study research method aims to study a single, contemporary phenomenon (e.g., an application, a technology or a decision) within its real-life context (e.g., in an organization) by investigating multiple sources of evidence (e.g., archival records and physical artifacts) over a logical time frame [14–19]. All these characteristics are especially important when the boundaries between phenomenon and context are not clearly evident [16, 19]. Case studies facilitate the understanding of the nature and complexity of the processes taking place [14, 17, 18]. Besides, they are particularly suitable for the investigation of information systems development, implementation and use within organizations [18, 20, 21].

As case studies can be distinguished by the research objective (descriptive, explorative, explanatory), research epistemology (positivist, interpretive, critical), research method (qualitative, qualitative/quantitative), case design (single, multiple) and unit of analysis (holistic, embedded) [20, 22], a variety of approaches exist to carry out case studies [15, 17, 18]. Our study generally follows the synthesized case research procedures by Dubé and Paré (2003), Gable (1994), Newell and Simon (1972) and Recker (2013), as depicted in Figure 1 [19, 22–24]. Instead of recommending specific case study methods, these procedures define fundamental elements and sort them in order to deduce theoretical statements [25].

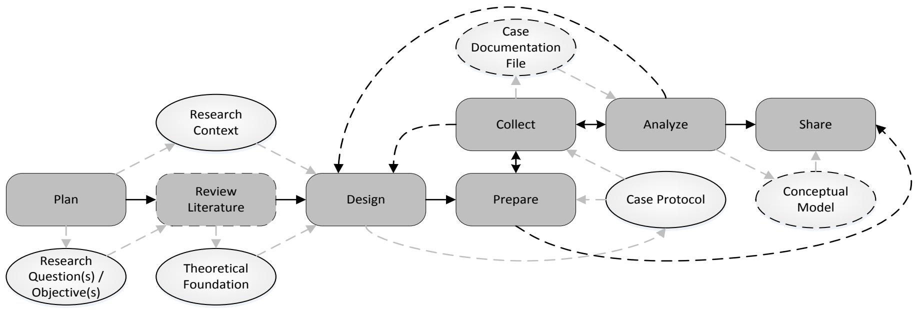

Figure 1. Synthesized case research procedure in accordance with Dubé and Paré (2003), Gable (1994), Newell and Simon (1972) and Recker (2013) [19, 22–24]

The single case study approach is particularly suitable for the investigation of previously unchallenged phenomena or issues at the beginning of theory generation. This is in line with our research objective to describe the emerging phenomenon of RECC (cf. section 1 & 2.1). A multiple case set-up, however, allows the researcher to test a theory [21, 22]. Therefore, this approach is appropriate when a theory has to be validated and a framework has to be evaluated. We try to explore the object of interest within its real-life context in an organization without defining any (in)dependent variables a priori [23, 26].

To be precise, we explore RECC at NOZ Medien, a media company in Northern Germany. NOZ Medien has more than 950 employees who are spread across nine locations. It has a daily readership of over half a million people. We have chosen NOZ Medien for our case study, since the decision makers confirmed their general interest in outsourcing processes into the cloud. Furthermore, top-level management assured full support but had not yet taken any steps towards "cloudsourcing". During the period from October 2013 until September 2014, we accompanied IT decision makers at NOZ Medien during a typical "cloudsourcing" process, which was predetermined by the company, from the (i) idea to outsource, (ii) as-is analysis, (iii) requirements definition, (iv) market analysis and (v) simulation to the point of (vi) transition or abortion. Since during the step 'transition or abortion' the IT decision makers at NOZ Medien came to the conclusion not to outsource the considered system into the cloud, the steps (vii) contract negotiations, (viii) migration, (ix) operation, (x) evaluation and (xi) optimization or discarding have not been run through. Given the fact that we factored in the possibility of cancellation of the outsourcing process when designing the case study and that we follow a conceptual approach for the definition of RECC, the impact on the conceptual framework is limited. In the present case study, the idea to outsource targets the email system at NOZ Medien. This system constitutes an autonomous unit inside the IT system landscape and is based on Microsoft Exchange 2007.

During the project steps conducted, we made use of several data collection methods in order to capture the contextual complexity and to obtain a substantial set of data [18]: (i) documentation (e.g., infrastructure plan), (ii) archival records (e.g., organization chart), (iii) interviews (e.g., with the IT decision makers) and (iv) physical artefacts (e.g., IT landscape); (v) direct observations were not included. These data are analyzed in a qualitative manner following an interpretive approach according to Myers (1997), who states that "interpretive studies generally attempt to understand phenomena through the meanings that people assign to them […]" and are "[…] aimed at producing an understanding of the context of the information system, and the process whereby the information system influences and is influenced by the context" [20, 27].

3 Rebound Effects in General

There is no uniform definition of the term rebound effect, it is rather discussed controversially [28, 29]. The primal characterization of this effect can basically be ascribed to Jevons (1865), who suggests that the efficiency improvement of coal-fired steam engines leads to a higher instead of a lower consumption of coal [30]. The reason for this is the reduction of the effective cost of coal realized through the higher efficiency [30, 31]. Sorrell et al. (2009) further distinguish between direct and indirect rebound effects, whereas economy-wide rebound effects reflect the sum of the two aforementioned [32]. The term rebound effect is not only used and discussed in disciplines related to sustainability but also in several others [32, 33], for example, in biology, physics, chemistry and psychology as well as in economic contexts, e.g., logistics. This highlights the variety of application areas on the one hand, and the multitude of existing rebound effects on the other. Gossart (2014), Plepys (2002) and Hilty et al. (2006) draw attention on the effects in the ICT sector [4, 6, 34]. They examine the existence of rebound effects in information and communication technology and their impact on the economy, whereas this topic still remains insufficiently explored in this area. Andrae (2013), Sedlacko et al. (2014) and Walnum and Andrae (2016) explore rebound effects in the context of energy savings in cloud computing [7–9].

Mathematically, rebound effects can most simply be described as the quotient of the difference between expected and realized savings (numerator), which is subject to an (unintended) alteration of the consumption of the resource regarded or different resources, and the expected savings (divisor) [35–37]:

$$Rebound\ effect\ (\%) = \frac{100*(expected\ savings - realized\ savings)}{expected\ savings}$$

Figure 2. Mathematical calculation of a rebound effect

In case the realized savings are smaller than the expected savings, this results in a positive rebound effect (percentage). If no savings can be realized, the efficiency improvement even results in a surplus of consumption (backfire); the rebound effect would then be greater than 100% (full exhaustion). Mathematically, in case more savings are realized than expected, also a negative percentage is possible.

Based on the systematic literature review, we build a concept matrix according to Webster & Watson (2002) in order to summarize how rebound effects are characterized [cf. http://bit.ly/RECCWI17] [38]. Out of the initial 54 results, 47 papers contained concepts characterizing rebound effects in several ways. In order to uncover and name the underlying concepts, we applied a conceptual content analysis approach when analyzing the literature [22], placing a strong focus on the general definition of rebound effects. In total, the following eight characterizing concepts of rebound effects in general were extracted from the identified literature: efficiency improvement; growth in consumption; direct/indirect; micro/macro level; offset; unintended; short-/long term; behavioral response.

The main cause for rebound effects is an efficiency improvement, which leads to a behavioral response, namely a (unintended) growth in consumption and an offset of the initial savings on a short- or a long term [31]. The scope of rebound effects can be distinguished between micro- (single actor) as well as macro-level (interaction of several actors) and further between direct (investment in the same resource or service) as well as indirect (investment in alternative/substituting resource(s) or service(s)) [31–33]. In summary,

A rebound effect describes the unrealized [(over)exhausted] saving of a resource in consequence of a (unintentional) growth in consumption, whereas the saving of this resource could have been expected and would have been possible based on the efficiency improvement concerning the use of this resource. A distinction is made between direct and indirect rebound effects, which affect the micro- as well as macro-level in the short- or long-term.

In the context of rebound effects, the commonly considered resource is energy in the form of, e.g., electricity or gasoline. In the following, the term resources will implicitly include any other forms of resources. Since energy is indirectly affected by the (efficient) use of time, time itself and as consequence workforce can also be seen as a resource [4, 5]. In addition to the main cause for rebound effects, namely an efficiency improvement, numerous secondary causes (also called “effects”) are discussed in literature, such as financial (caused by cost savings, e.g., income, reinvestment and market price effect), material (caused by the energy that is used for the production and provision of goods and services, e.g., embodied energy, consumption accumulation and new markets effect) or psychological effects (caused by increased demand as a result of moral justification, e.g., moral hazard, moral leaking and moral licensing effect) [31].

4 Rebound Effects in Cloud Computing

4.1 Definition and Conceptualization

The efficiency increase described in Moore's law concerning the increase of computational performance per cost unit leads in turn to a broad diffusion and a higher demand of the technology and consequently to an increase in energy consumption by ICT hardware [5, 6]. Due to its characteristics like resource pooling and virtualization, the cloud computing technology has the inherent potential for efficiency gains of resources, such as energy [8, 39].

Therefore, in a first step, the definition of rebound effects is transferred to CC. Starting point is the definition of REGE, which was derived based on the concept matrix resulting from the literature analysis (cf. section 3). Equally important is the de-facto definition for CC by Mell and Grance (2011), who define CC as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" [40]. Furthermore, cloud computing can be distinguished between three service models (Software, Platform and Infrastructure as a Service) and different deployment models, such as private, community, public or hybrid clouds [40]. The results of the case study constitute another starting point for the definition of RECC. The cause for a REGE is an efficiency improvement. CC can lead to such efficiency improvements in various respects. In the following, one example for each of the five essential characteristics of CC [40] will be given: (i) on-demand self-service leads to time savings in the provision of computing capabilities; (ii) broad network access leads to independencies for using CC services via heterogeneous client platforms; (iii) resource pooling leads to savings in terms of maintenance, replacement and repair; (iv) rapid elasticity leads to a constant, appropriate performance; (v) measured service leads to a full control of costs.

The resource underlying a rebound effect can be of various natures: concerning REGE, the focus is generally put on the resource energy. In CC, the efficiency increase results from the use of cloud computing services, which in turn affects resources that are specific to the organization, e.g., liquid funds, working time and corresponding assets like hardware. Moreover, when evaluating a RECC, the overall corporate objectives (organizational perspective) have to be considered. Assuming that an organization outsources its servers into the cloud using Infrastructure as a Service (IaaS) in the form of virtualized resources from a CC provider, the servers used so far as well as the human resources, who administrated these servers (e.g., technicians and to some extent the former administrators), are no longer required. The residual value of the hardware and the monetized released working time, after deducting the costs for the CC service, can be interpreted as savings. Depending on the corporate objectives, these savings can or better should be used continuously. If the objectives comprise the steady growth of human resources [41], the investment of the residual value of the hardware as well as the transformation of the released working time into a new position, will mathematically lead to a positive rebound effect (exhaustion of the savings). However, only if these reinvestments are directly caused by or related to the adoption of CC services and diminish the realized savings in comparison to the expected savings, the result is a RECC. In case the investments are made based on the realized savings generated through the efficiency improvement of the adoption of CC, e.g., in order to increase production by means of new employees and production machinery, the savings were already realized and therefore do not result in a RECC. As long as the consumption of or investment in the same or (an) alternative resource(s) is in line with the corporate objectives, the rebound effect can be seen as positive from an organizational perspective. The situation would be different, however, if the corporate objectives comprised the gradual build-up of capital reserves and a high degree of automation. In this case, the said investments would mathematically still lead to a positive rebound effect, but as not in line with the corporate objectives, it would have to be assessed negatively from an organizational perspective.

Consequently, a RECC is depended on the context of an organization’s intention or expectation. This interplay between the intentions or the expectations of an organization and the actual effect can be seen in Table 1.

Table 1. Rebound effects in cloud computing in the context of intention or expectation and effect in accordance with Hilty (2008) [41]

		intention or expectation	
		reduce input	***increase output***
effect	***input does not fall***	rebound effect in the narrow sense	intended growth
		rebound effect in the broad sense	
	output does not rise	saving of input	unintended stagnation

Depending on the point of view of an economic actor (private households, organizations, state), the intentions or expectations that cause rebound effects differ. Since an organization is generally interested in growth (increase in output), rebound effects in the narrow sense occur if an organization has the intention or expectation to accumulate savings (reduce input). Rebound effects in the broad sense arise under the intention of growth, leading to a disproportional resource consumption [41].

In addition, RECC can be distinguished between direct and indirect effects. For example, savings resulting from outsourcing a process into the cloud can directly be reinvested in the underlying resource saved or indirectly, e.g., in additional workforce managing the outsourced service. Furthermore, the effect level can be distinguished between micro (within the organization) and macro (outside the organization).

Based on the definition of REGE (cf. section 3) and the previous discussion, the following definition for RECC is derived:

A rebound effect in cloud computing describes the unrealized [(over)exhausted] saving of an organizational resource in consequence of a (unintentional) growth in consumption, whereas the savings could have been expected and would have been possible based on the efficiency improvement resulting from the use of cloud *computing services. The organizational assessment of the effect is depending on the corporate objectives. A distinction is made between direct and indirect cloud computing rebound effects, which affect the micro- as well as macro-level in the short- or long-term.*

Concerning RECC, the organizational context as well as internal decisions are focused, which are basically influenced by the corresponding corporate objectives. The conceptual model depicted in Figure 3, which is based on the literature analysis and the results of the case study, summarizes the components of a RECC.

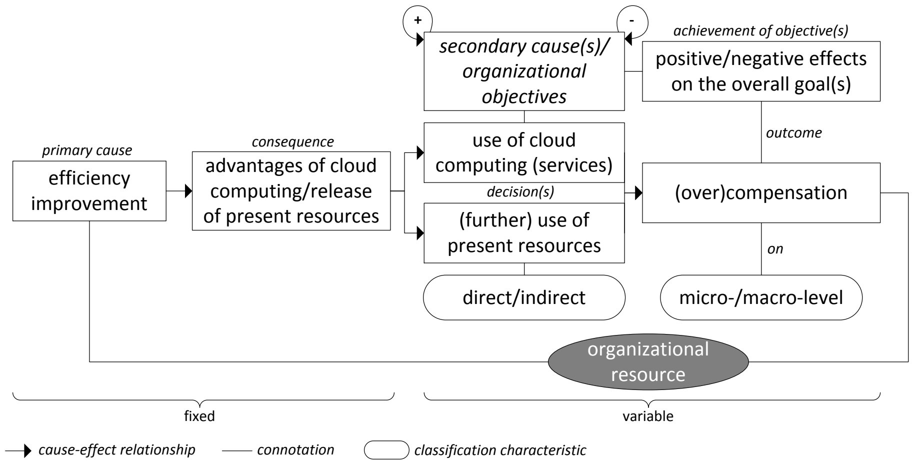

Figure 3. Conceptual model of a rebound effect in cloud computing

Finally, a morphological analysis has been conducted which combines the results of the concept matrix resulting from the literature analysis and the case study in order to investigate the "totality of relationships contained in multi-dimensional, usually non-quantifiable problem complexes", in this case RECC [42] (cf. Table 2). The morphological analysis allows for the categorization of potential RECC, whereas the conceptual model primarily depicts connotations and causalities.

Table 2. Morphological analysis of rebound effects in cloud computing

cause and effect	Saving (of an organizational resource) due to the use of a cloud computing service (IaaS, PaaS, SaaS), leading to an unintended effect on (other) organizational resources (growth in consumption)			
(further) use of resources	direct		indirect	
effect level	micro		macro	
compensation	negative	partially		backfire
period	short-term		long-term	
assessment	mathematical		organizational (corporate objectives)	

In summary, RECC are unrealized savings of an organizational resource caused by efficiency improvements, which arise from the migration to CC services as well as from the (unintended) effects on (other) organizational resources. Since the case study targets a SaaS solution and no distinction in existing literature on RECC could be identified, no further differentiation of RECC concerning service and deployment models could be made. Regarding the assessment of a RECC, a mathematical and an organizational viewpoint need to be distinguished. For example, it may be the case that a mathematically calculated partial compensation, thus a partial rebound effect, does not, only partially or disproportionately affect the corporate objectives. However, a mathematically calculated compensation can be negative (realization of more savings than expected), which can in turn lead to a disproportionate effect on the organizational goals, e.g., if the overall goal of an organization was a complete reinvestment or growth or to retain jobs.

4.2 Identification of Affected Resources

Since a REGE describes the efficiency improvement with respect to resources such as energy or the saving of these, organizational resources have been derived for the discussion of RECC. Basic IT-related resources, which are typically used in an organization, have been identified by means of a classification of accounts for industrial enterprises [43]. Due to the fact that this classification is directed towards the documentation and structuring of organizations' assets, it is well suited for our purpose. We concentrated on those basic resources that can directly or indirectly be influenced by changes in IT. For example, the outsourcing of servers might have a definable influence on the expenses for (external) maintenance; however, there are other effects, e.g., on expenses for advertising, that are difficult to assess. In order to expand the identified basic resources by special resources, that are also affected by CC, the three CC service models – Infrastructure (IaaS), Platform (PaaS) and Software as a Service (SaaS) – have been investigated [40]. Additionally, we held workshops with IT-management and conducted two expert interviews in May 2014 during the case study to identify potentially affected resources. Furthermore, the transcripts and the company's documentation (e.g., IT landscape, infrastructure plans, balance sheets) were analyzed qualitatively via inductive category development. Finally, all results have been aggregated (cf. Table 3).

Table 3. Organizational resources that are potentially (directly or indirectly) affected by changes in IT (in the short- or long-term)

Aggregated Category	Organizational Resources
IT related	employees, IT know-how, space, server software, energy, repair material, internal data and information, maintenance
Hardware & Systems	backup and recovery, server hardware, adjacent assistive systems, infrastructure and connection, air conditioning, devices and clients
General	money, customers and reputation, suppliers and partners, non-IT know-how

The categories and underlying organizational resources depicted in Table 3 are directly or indirectly affected by changes in IT, e.g., resulting from a possible cloudsourcing decision, and are therefore subject to potential RECC. For example, one expert states that migrating to the cloud would "save maintenance workload and costs". The major resource that is expected by the experts to be directly affected is money ("outsourcing to the cloud is way cheaper in comparison to an in-house solution"). If the expectation or intention regarding an organizational resource, in this case, to save money or maintenance, cannot or only partially be realized by an adoption of cloud services, this would lead to a rebound effect. Furthermore, depending on the organizational goals, resource saving potentials might be evaluated negatively from an organizational point of view. For example, the saving potential of workforce or rather employees contradicts the overall social goal of NOZ Medien to provide stability for employees and to safeguard jobs. Therefore, the experts at NOZ Medien explain that affected employees would be entrusted with other responsibilities in order to retain jobs and to prevent the loss of valuable IT know-how.

On the foundation of the organizational resources presented in Table 3 and specifically for the present case study at NOZ Medien, expected effects on organizational resources and goals resulting from a cloudsourcing decision were identified. In the case study, the existing email system is to be replaced by a user- or better to say mailbox-based service from a CC provider (SaaS). Therefore, the expected effects have only been derived and evaluated a priori. First, the corporate objectives at NOZ Medien were identified in an interview with the management and mapped against the organizational resources (e.g., the economic factor "the highest profit possible" is connected to the general organizational resource "money"). Second, expected effects on organizational resources were identified and evaluated together with the experts in workshops. The resulting analysis can be found in Table 4. As a result of the case study, effects have to be assessed depending on the organizational goal, as elucidated by the resource "employees".

Table 4. Expected effects of cloudsourcing on organizational resources at NOZ Medien

organizational goals	organizational resource (goal/expected effect)
"highest profit possible"	• money (+/+)
"continued growth of the company" & "provide a perspective and future for Employees" & "provide stability for employees and safeguard jobs"	• employees (+/-)
"efficiency and sensible use of resources"	• hardware & systems (-/-) • server software (-/-) • employees (-/-) • space (+/+) • energy (-/-) • maintenance (-/-) • money (+/+) • IT know-how (o/-)

5 Discussion and Conclusion

Potential RECC can arise in any area of an organization in which outsourcing into the cloud results in resource saving potentials. In contrast to the traditional view on rebound effects, which generally focuses on a narrow energy saving perspective [7–9], we expanded the focus and added an organizational perspective [41], in which the adoption process of a cloud service takes place. In this context, the intentions or expectations of organizations can lead to different assessments of rebound effects from a mathematical (compensation of the savings) in comparison to an organizational (compliance with the corporate objectives) perspective. Furthermore, rebound effects in CC do not necessarily arise from energy savings. Rather, the effects can be the results of savings of any organizational resource, which is subject to expected efficiency improvements in a cloudsourcing scenario (cf. RQ2).

The framework consisting of a REGE/RECC definition, a conceptual model, and a morphological analysis of RECC provides a foundation to identify, categorize and understand potential rebound effects in cloud computing (cf. RQ1). Furthermore, our results confirm the complex dependencies that are not always identifiable at first glance, which can involve many possible causes and manifestations of RECC. Consequently, there is an urgent need to research the existence and impact of RECC. In line with Gossart (2014), we argue that future research should focus on rebound effects in the ICT context in order to understand and mitigate the underlying causalities [4]. This broadened understanding can be very helpful when exploring the decision-making process as well as the involved influencing and influenced factors. Consequently, future research should also comprise the investigation of RECC in the short- as well as long-term. In order to accomplish this requirement, we provided a fundamental framework. For practice, the awareness of RECC can facilitate to (at least approximately) assess the impact of rebound effects even prior to outsourcing, since various organizational resources are significantly affected by a cloudsourcing decision. The awareness of factors surrounding such a decision is vital for making a sustainable judgement.

As any research endeavor, our findings also need to be viewed in the light of some limitations. First and foremost, the decision process for resource allocation underlying a rebound effect in an organization differs – at least to some extent – from other research areas of rebound effects cited. Unlike what is the case in, e.g., natural sciences, the decisions in organizations cannot always be fully predicted and do not necessarily follow general principles. Organizational decisions are mostly based on individual or community decisions and are limited by given budgets [6]. To consider this, these organizational goals were taken into account when developing the framework in accordance to Hilty (2008), who further differentiates between rebound effect perspectives of private households, enterprises and states [41].

The overall target of the paper is to present the results obtained from the systematic literature review as well as the case study.[1] Although case studies are considered to be an appropriate method to capture the richness of organizational contexts – in this case

[1] The case documentation file (cf. Figure 1) will be provided to interested readers.

of a German media company – the conclusions drawn cannot be unreservedly generalized [23]. Neither do we assert that the understanding of RECC would substitute a decision-making process for any given "cloudsourcing" project. Instead, the intention of our research is to arouse awareness that unintended rebound effects potentially exist in CC, which can affect organizational resources. By generalizing our results in the forms of definitions, a conceptual model as well as a morphological analysis of RECC, we already mitigate this limitation to some extent. Moreover, since the focus of the single case study was put on outsourcing an email system, further results may arise when investigating the outsourcing of other systems into the cloud. Therefore, rebound effects in different systems, application areas and organizations in the context of cloud computing or else in other ICT contexts are subject to future research. Especially regarding the various cloud service or deployment models, potential differences and unique characteristics concerning rebound effects need to be investigated.

Moreover, since NOZ Medien at the point of transition or abortion decided not to outsource the email system into the cloud, we have not been able to verify potential rebound effects by means of direct observation. Our study rather presents implications of RECC, however, they have only been derived a priori. Hence, our conceptual framework requires further validation and evaluation, for example via a multi case setting, to measure occurring RECC. Multiple case study setups allow for the testing of theories, whereas single case setups are preferable to identify and describe previously unchallenged or emerging phenomena, as executed in this study [22]. Furthermore, potential single case biases could be eliminated and multiple CC service models and the variety of factors influencing RECC could be investigated. To this point, our work provides the basis for future quantitative measurement of RECC. All in all, in order to improve the understanding of CC and all surrounding factors, we encourage researchers to extend the focus on technical advancements to take other influencing and influenced factors into account.

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