Towards Robotic Process Automation implementation: An end-to-end perspective

Abstract

Purpose - Robotic Process Automation (RPA) seeks to automate business processes, using software robots that interact with systems through their user interface, improving efficiency and reducing costs. However, some critical steps, such as identifying processes suitable for RPA automation, can have a tremendous impact in organizations if a wrong process is selected. Therefore, this research provides an approach for analyzing RPA development in business organizations.

Design/methodology/approach - This research presents a cohesive literature review about RPA, in order to identify RPA main concepts, which should be reported and considered in all RPA case studies. A model connecting the main elicited RPA concepts is presented as well as its evaluation and applicability grounded of past RPA case study (CS) analysis, using Design Science Research (DSR).

Findings - The results from this research show that most of the RPA main concepts gathered in the Literature Review are not reported in the selected RPA CSs.

Originality/value - As RPA is a recent topic, literature lacks a synthetization of RPA main topics. This research aims to fill the gap on that, by identifying and synthesize the main topics related to RPA and proposing a model that connects the main RPA concepts, which can be used by researchers as a schema for conducting and writing RPA case studies.

Keywords Robotic Process Automation, Process Automation, Business Process Management, Data Science

Paper Type Research Paper

1 Introduction

The Robots Revolution is on the rise. After the revolution that Customer Relationship Management (CRM) and Enterprise Resource Planning (ERP) created, a new term is going to revolutionize the workplace: Robotic Process Automation (RPA) (Anagnoste, 2017).

This type of automation aims to automate business processes with the goal of improving efficiency while cutting costs (Cewe et al., 2017), by reducing the time humans spend dealing with Information Systems (IS), doing repetitive tasks, such as typing, extracting, coping and moving huge amounts of data from one system to another system, meaning that these structured and manual tasks can be done by a robot, so that the workers can dedicate their time and effort to tasks that add more value (Aguirre and Rodriguez, 2017). Robots execute repetitive tasks by using Graphical User Interface (GUI) adaptors instead of Application Programming Interfaces (APIs) (Cewe et al., 2017), without changing the Information Technology (IT) infrastructure (Mindfields, 2015), meaning that the robot does repetitive tasks that used to be done by humans faster and cost efficient.

This research paper presents an approach for analyzing RPA development and application in business organizations and industries. Business units (BUs) spend a lot of time trying to improve business processes (BPs). Sometimes when IT cannot handle the requests from the BUs to modify an existing application or create custom applications, the BU must improvise (Slaby, 2012). However, by improvising data in these spreadsheets, it is not integrated into the used IT systems in the company, can be prone to error and have security vulnerabilities. Using RPA, no expensive integration with systems is required (Mindfields, 2015) and the automation of BPs can be done by the BUs (Lacity et al., 2016), without hiring offshore Full-time Equivalents (FTEs) (Slaby, 2012), with the advantage of being more familiar with the processes than the IT teams.

RPA is being increasingly adopted in companies, being used in multiple areas, such as human resources (Hallikainen et al., 2018), IT (Khramov, 2018) and insurance (Lacity and Willcocks, 2017). To illustrate this increasing adoption of RPA in companies, Forrester predicted that "by 2021, there will be more than 4 million robots doing office and administrative work as well as sales and related tasks" and that "RPA market will reach $2.9 billion by 2021 from $250 million in 2016" (Le Clair, 2018). These statistics show that the interest and adoption of RPA will continue to increase.

Despite this increase of adoption of RPA in companies and its benefits, it is important to establish guidelines in order to successfully implement RPA in organizations. One of the most important challenges is identifying processes suitable for RPA automation (Leopold et al., 2018). Selecting the right process is critical

(Sigurðardóttir, 2018), as automating a wrong process increases the inefficiency and failure speed (Gadre et al., 2017). In order to select the right process, it is necessary to establish criteria to determine if a process is suited for RPA.

As RPA is a recent topic, literature lacks a synthetization of the main topics related to RPA. Therefore, the purpose of this research is to gather RPA main topics, such as the benefits of using RPA, criteria to decide whether a process is suitable for this type of automation, among others, using these topics to develop a model on the relationship between RPA main topics, which can be used for researchers as a schema for conducting and writing RPA case studies (CSs). The research methodology followed in this research is the Design Science Research (DSR). To evaluate the proposed model, the authors selected five CSs identified in the literature to verify if the RPA main topics are present. At the end, gaps in current research are also identified, suggesting opportunities for future research, being useful for researchers that are interested in this topic, that want to find the existing knowledge about it and explore gaps related to RPA.

The remainder of this research is structured as follows. It starts with the Research Methodology section, followed by a Literature Review of RPA in terms of its benefits, disadvantages, suitable processes criteria and future challenges and opportunities. The literature review includes a comparative analysis between RPA and Business Process Management and depicts about how RPA relates with data science research. After that, a model on the relations between RPA related topics is shown, followed by an evaluation on which RPA related topics are in RPA CSs selected, along with a discussion about the findings. Finally, the last section provides conclusions, including directions for future research.

2 Research Methodology

The research methodology used in this research is the DSR. The interest in DSR started to grow in the 1990s (Peffers et al., 2007), when three papers (March and Smith, 1995; Nunamaker and Chen, 1990; Walls et al., 1992) introduced this methodology, having its roots in engineering (Simon, 1996). In contrast to behavioral research, which deals with the justification and development of theories, explaining or predicting phenomena associated to a business need, DSR deals with building and evaluating artifacts that are designed to fit a business need (Hevner et al., 2004), aiming at the "utility" (building and evaluating means-ends relations) instead of "truth" (explore and validate cause-effect relations) (Winter, 2008), building a "to-be" conception and then according to the defined model building the system, having in consideration restrictions and limitations (Österle et al., 2011).

This research seeks to build and evaluate artifacts. These artifacts include constructs, models, methods and instantiations. Constructs provide the vocabulary to define and communicate problems and solutions (Schon, 1984). Models use constructs to represent a problem (March and Storey, 2008), expressing relationships between constructs (March and Smith, 1995). Methods provide direction on how to solve problems (Winter, 2008), being a set of steps used to solve a problem (March and Smith, 1995). Instantiations are implementations of constructs, models or methods in a working system (Hevner et al., 2004). Based on these four artifacts, we will focus on constructs, which will be RPA related concepts found in literature, and a model representing the main concepts around RPA and their relationships.

As suggested by (March and Smith, 1995), the applied research methodology is divided in two processes, build (process of construction of an artifact) and evaluate (determine how well the artifact behaves). The build process is divided in two steps whereas the evaluation process is composed by only one (Table 1).

Table 1. Research Methodology

Build		Evaluate
Constructs Definition	Model Construction	Evaluation
- RPA Related Concepts	- RPA conceptual model based on the constructs	- RPA CS analysis and evaluation

In this research, the artifacts were evaluated by selecting five CSs identified in the literature to verify if the RPA main topics are present.

The research process can be explained by the diagram represented in Figure 1.

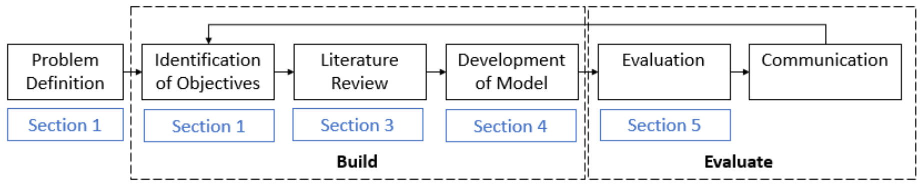

Figure 1. Research Process

In order to elicit constructs and use them to build our model on the relationship between RPA main concepts, it is essential to review relevant literature about RPA. The approach used in this research follows the concept-centric approach proposed by Webster and Watson (Webster and Watson, 2002).

3 Literature Review

As RPA is a recent and an unexplored area in terms of literature, performing a Literature Review is adequate, because it can identify any gaps in the existing research in RPA to suggest areas for future research, can summarize the existing knowledge about a RPA and can provide a framework to position new research areas (Kitchenham, 2004). Plus, this research follows a concept-centric approach proposed by Webster and Watson (Webster and Watson, 2002), as the review is guided by concepts, presented and discussed grounded on most relevant concepts related with RPA.

To elaborate this Literature Review, we started by searching studies about in major databases, such as Springer, IEEE, ACM, Google Scholar and ResearchGate between June and October. The papers were collected based on their title, keywords and abstract. The results are represented in Table 2.

Table 2. Number of papers collected by database and keyword

Database	Keyword	Number of papers collected
Springer	Robotic Process Automation	7
	Robotic Process Automation RPA	0
	Process Automation	0
Google Scholar	Robotic Process Automation	12
	Robotic Process Automation RPA	34
	Process Automation	0
IEEE	Robotic Process Automation	2
	Robotic Process Automation RPA	3
	Process Automation	0
ACM	Robotic Process Automation	2
	Robotic Process Automation RPA	0
	Process Automation	1
ResearchGate	Robotic Process Automation	4
	Robotic Process Automation RPA	0
	Process Automation	0

Then, the findings were narrowed down according to the following criteria:

- Papers that address specifically RPA;
- Papers published in English;
- Papers electronically available on the internet.

To resume the search strategy applied, Figure 2 presents the process for paper selection.

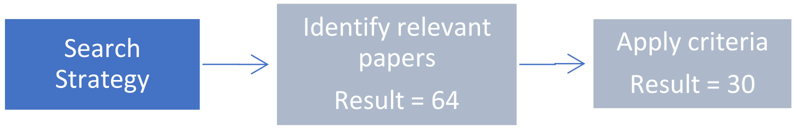

Figure 2. Paper selection strategy

As far as the authors could understand from the research performed, RPA research is a very recent topic and few researches exist, as can be seen in Figure 3. Nevertheless, one can see that the interest in RPA has been growing.

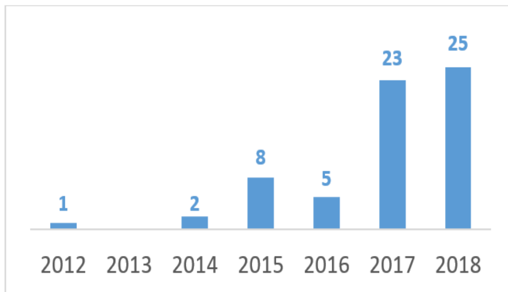

Figure 3. Evolution of papers about RPA

Based on Figure 3, from 2017 on, the number of papers about RPA have grown rapidly. The tendency for the end of 2018 is to increase the number of RPA papers, as the number of papers from 2018 searched is from January to October.

In terms of Google searches, the number of searches about RPA has been increasing, as can be seen in Figure 4.

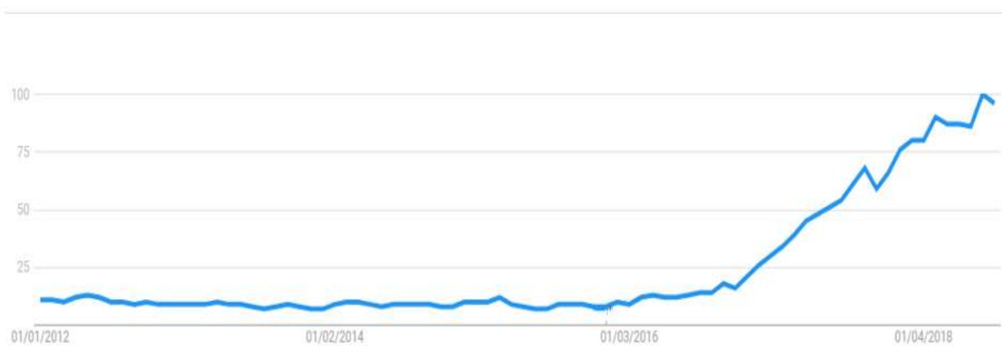

Figure 4. Interest in RPA in terms of Google searches (retrieved from Google Trends)

From the end of 2016 on, the number of searches about RPA has rapidly increased and simultaneously the number of papers about RPA also increased, which demonstrates the increasing importance of RPA.

3.1 RPA overview

RPA can be defined as "the concept of using a software platform of virtual robots to manipulate existing application software in the same way that a human does to a process or transaction" (Suri et al., 2017). This means that RPA uses robots to imitate repetitive tasks that humans have to perform. These robots are not physical robots, but software robots, meaning that a robot equals one software license (Lacity et al., 2016).

To interact with multiple systems like a human would do, robots use GUI automation adaptors instead of APIs, as used in traditional automation (Cewe et al., 2017), without changing the IT infrastructure, meaning that robots can interact with elements on the screen via front-end, just like a human.

RPA is used in almost every industry, such as insurance (Lacity and Willcocks, 2017), human resources (Hallikainen et al., 2018) and IT (Khramov, 2018). This type of automation is suited for "swivel chair" processes, where workers take inputs from many systems, process them and then add the processed inputs to other systems, like ERP and CRM (Lacity et al., 2016). Among the most performed tasks by robots are filling forms, logging into many systems, monitoring events, performing checks, sending emails and extracting data from many file types (Anagnoste, 2017).

To automate processes, there are many RPA vendors, such as UiPath, Automation Anywhere and Blue Prism (Anagnoste, 2018). These vendors offer different features and some of them can be connected to other tools to add more functionalities of Process Mining, Machine Learning and Artificial Intelligence (Tornbohm and Dunie, 2017).

Plus, effective data analysis and knowledge management practices in organizations are focused on knowledge creation and knowledge transfer activities. Business intelligence and competencies matter in the organizational workplace and enable organizations to become more intelligent, productive and innovative (Vasconcelos and Rocha, 2018). In this context, RPA is a leading process technology and research issue in today's organizations and industries.

Corporations and businesses apply process automation to optimize operations and costs and maximize human resources actions and results. Therefore, since RPA addresses the automation of rule-based routine tasks using intelligent algorithms, some authors are already applying artificial intelligence and machine learning technologies to create software solutions that can understand user behavior and automate their tasks (Khramov, 2018).

3.2 Differences between RPA and Business Process Management (BPM)

Despite RPA being a kind of BPM (Aalst et al., 2018; Cewe et al., 2017), it is important to distinguish BPM from RPA. RPA does not replace BPM, but complements it (Lacity et al., 2016), as each is suited to automate a certain type of business process. Table 3 presents the differences between BPM and RPA according to the literature.

The business goal of BPM is to reengineer processes (Forrester, 2014; Lacity et al., 2016). Once the process is reengineered, it is necessary to create a new application, as BPM interacts with other applications using APIs and interacting with the business logic and data access layers. RPA, on the other hand, has the goal to automate existing processes (Lacity et al., 2016), processes that are already defined and performed by humans, using a robot to replace them. RPA integrates with systems through the user interface, not requiring the creation of a new application to integrate with these systems, with the advantage of not requiring expensive integrations. By interacting with the user interface through the presentation layer, it does not change the logic of underlying systems and does not store transactional data (Lacity et al., 2016; Lacity and Willcocks, 2015).

As RPA interacts via front-end, it can be described as lightweight IT, whereas BPM can be described as heavyweight IT. Heavyweight IT can be described as back-end software that is IT owned, whereas lightweight IT can be described as front-end software owned outside IT (Sigurðardóttir, 2018).

BPM development may require integration with IT systems, such as ERP and CRM (Mindfields, 2015). As BPM integrates with these systems, it takes a long time to implement, therefore being best suited for processes that require expertise from IT and investments with high value (Suri et al., 2017). As BPM is IT owned, the automation development is done by programmers, requiring programming skills (Cewe et al., 2017; Khramov, 2018; Lacity and Willcocks, 2015). On the other hand, RPA is business owned and the development is made by the BU (Lacity et al., 2016), being suitable for processes that require business and process expertise (Lacity et al., 2016; Suri et al., 2017). Despite not having as much programming skills as programmers, it is not necessary as RPA software uses drag and drop (Lacity and Willcocks, 2015). Because all interactions with the applications are done through the user interface (Cewe et al., 2017), no complex integration is required and no change in IT infrastructure is needed, with the advantage of having a lower cost and fast development times (Mindfields, 2015).

Table 3. Differences between BPM and RPA

Domain	BPM	RPA
Business goal	Process reengineering (Forrester, 2014; Lacity et al., 2016)	Automation of existing processes (Lacity et al., 2016)
Application	Creation of a new application (Forrester, 2014; Khramov, 2018; Lacity et al., 2016; Lacity and Willcocks, 2015)	Use of existing applications (Aguirre and Rodriguez, 2017; Lacity et al., 2016)
Integration Method	Interacts with business logic and data access layers (Khramov, 2018; Lacity et al., 2016; Lacity and Willcocks, 2015)	Interacts with systems through the presentation layer (Aguirre and Rodriguez, 2017; Lacity et al., 2016; Lacity and Willcocks, 2015)
Process Suitability	Best suited for processes requiring IT expertise on high-valued IT investments (Suri et al., 2017)	Suitable for processes that require business and process expertise (Lacity et al., 2016; Suri et al., 2017)
Programming Requirements	Requires programming skills (Cewe et al., 2017; Khramov, 2018; Lacity and Willcocks, 2015)	Does not require programming skills (Aguirre and Rodriguez, 2017; Khramov, 2018; Lacity et al., 2016)
Development Responsibility	Development by programmers (Lacity et al., 2016; Suri et al., 2017)	Development by the business unit (Lacity et al., 2016)
Development Times	Long development times (Mindfields, 2015)	Fast development times – no complex integration required (Mindfields, 2015)

3.3 RPA Benefits

When implemented in a right manner, RPA can have multiple advantages. After analyzing the literature, the authors have synthesized and summarized the main RPA benefits, described in Table 4. A more detailed and critical analysis of each elicited benefit is also presented in this section.

One of biggest advantages and the reason why companies are starting to use this technology massively is because of the fact that robots can work 24/7, replacing the work of 1.7 humans (Slaby, 2012), cutting entry costs to 70% (Anagnoste, 2017), therefore allowing FTE savings (Lacity and Willcocks, 2015; Suri et al., 2017; Tran and Ho Tran Minh, 2018). By replacing humans with robots to do repetitive work, allows workers to focus on more important tasks that involve problem solving and exception handling, improving job satisfaction and employee retention (Slaby, 2012). It can also create new jobs such as robot management, consulting and sophisticated data analytics (Asatiani and Penttinen, 2016) and reduce the dependence on offshore FTEs, using it to hire new FTEs (Slaby, 2012). To highlight this, an offshore FTE that costs $30000 can be replaced by a robot that can cost $15000 (Slaby, 2012).

Compared to humans, robots make less errors and work faster with more quality, therefore being more productive (Alberth and Mattern, 2017) and having a faster ROI (Lacity and Willcocks, 2017; Suri et al., 2017). This improves customer service, as customers are more satisfied with the job done by robots.

As robots interact with the application user interface, they can integrate with every software, unconcerned of the openness to third party integration (Asatiani and Penttinen, 2016). Because the robot interacts with the user interface, the applications are not modified, having more security (Suri et al., 2017). This means that they can deploy new functionalities faster than other IT solutions that use APIs to integrate with systems, being implemented in 2-4 weeks, rather than months or years (Asatiani and Penttinen, 2016).

Robots can also adapt to service demand, being scalable, resizing fast without investing too much in development (Tran and Ho Tran Minh, 2018) and also can re-use components to help automating other tasks (Slaby, 2012).

Table 4. RPA Benefits

Benefit	References
Can work 24/7 every day	(Alberth and Mattern, 2017; Anagnoste, 2017; Lacity and Willcocks, 2015, 2017; Slaby, 2012; Tran and Ho Tran Minh, 2018)
Highly scalable/extensible/reusable solutions to meet peaks in service demand	(Lacity and Willcocks, 2015, 2017; Slaby, 2012; Suri et al., 2017; Tran and Ho Tran Minh, 2018; Vishnu et al., 2017)
Performs tasks faster	(Lacity and Willcocks, 2015, 2017; Slaby, 2012; Suri et al., 2017; Vishnu et al., 2017)
Less errors and consistent quality	(Alberth and Mattern, 2017; Lacity and Willcocks, 2015; Suri et al., 2017; Tran and Ho Tran Minh, 2018)
Allows employees to focus on more important tasks	(Lacity and Willcocks, 2015; Slaby, 2012; Suri et al., 2017; Tran and Ho Tran Minh, 2018)
FTE savings	(Lacity and Willcocks, 2015; Suri et al., 2017; Tran and Ho Tran Minh, 2018)
Deploys new functionalities faster than other IT solutions	(Asatiani and Penttinen, 2016; Lacity and Willcocks, 2015)
Integrates with systems through the application user interface	(Asatiani and Penttinen, 2016; Lacity et al., 2016)
Fast Return on Investment (ROI)	(Lacity and Willcocks, 2017; Suri et al., 2017)
More productivity	(Alberth and Mattern, 2017)

3.4 RPA Disadvantages

Not only benefits are reported by the literature. It is also pointed some RPA disadvantages that companies must have into account when adopting RPA to automate processes. These disadvantages are synthesized and summarized in Table 5 and a more detailed analysis is presented further ahead.

One of the main disadvantages is that RPA is only suited for processes that are rule-based, because it is executed by a robot that lacks cognitive skills, needing rules in order to successfully execute its tasks. If the process contains a lot of exceptions, it must be handed to workers, increasing process complexity, as robot and human must be synchronized in order execute the tasks sequentially without any mistakes.

Table 5. RPA Disadvantages

Disadvantage	References
Only suitable for processes that include rule-based tasks	(Alberth and Mattern, 2017; Asatiani and Penttinen, 2016)
May be a temporary solution, which automates manual processes based on legacy IT systems	(Asatiani and Penttinen, 2016)
Increased process complexity when a part of the process still needs to be serviced by human workers	(Alberth and Mattern, 2017)
Creation of new tasks for the workers, as robots need to be supervised	(Alberth and Mattern, 2017)

As robots need to be supervised, there will be created new tasks for the workers to monitor the robot and guarantee that the outcomes of the execution are correct, which can reduce their time to execute tasks that add more value.

RPA can be a temporary solution to automate processes based on legacy systems, but in the long term it may be more appropriate to scrap the legacy system and build a new system (Asatiani and Penttinen, 2016).

3.5 RPA Suitable Processes Criteria

A critical information that may influence the success of the RPA implementation is the appropriateness of the process to be automated. It is important for organizations to know if a process is suitable for RPA implementation. Therefore, the authors have looked in the literature for main criteria that a process must fulfill to be successfully automated (Table 6). The degree of the alignment between the process and the criteria is not in the scope of this research. It is not the authors goal to argue that a process should fulfill all, half or just one criteria to be successfully automated. That should be further explored in future researches.

A more detailed description of each elicited criteria is also present in this section so readers can better understand the boundaries of each criteria according to the literature.

First, it is important that the process can be decomposed into unambiguous rules, as RPA is only suited for rule-based tasks. Standardize the process before automating is also necessary because the more standardized the process is, the fewer exceptions happen (Lintukangas, 2017). Having not many exceptions to handle is a key factor, because having a lot of exceptions makes it time-consuming for the robot to automate (Slaby, 2012). Then, it is also important that the process is mature because a mature process can be easily measured, documented and stable, with a better current cost awareness.

Voluminous transactions are suitable for RPA automation because high volume (amount of repetition or time to complete the task) is considered as an opportunity for cost reduction (Lintukangas, 2017). Also, if the tasks are repeated often, it means that can be done by robots faster and with less errors.

Frequent interactions with multiple systems is also a good candidate for automation, as RPA interacts with systems through the presentation layer, whereas doing the same thing with traditional automation would be more expensive and time-consuming. Another important feature is interacting with stable systems that do not change very often, so that the robot can interact with the interface without throwing exceptions that would be costly. A period of 12 to 18 months with no changes in the systems is excellent (Slaby, 2012).

Table 6. RPA Suitable Process Criteria

Criteria	References
Voluminous transactions	(Asatiani and Penttinen, 2016; Fung, 2014; Kasslin, 2017; Kyheröinen, 2018; Lacity and Willcocks, 2015, 2017; Lintukangas, 2017; Slaby, 2012)
Frequent interaction with multiple systems	(Asatiani and Penttinen, 2016; Fung, 2014; Kasslin, 2017; Khramov, 2018; Lacity and Willcocks, 2015, 2017; Slaby, 2012)
Use of systems with a stable environment	(Anagnoste, 2017; Asatiani and Penttinen, 2016; Fung, 2014; Kasslin, 2017; Khramov, 2018; Lacity and Willcocks, 2015; Slaby, 2012)
Ease of decomposition into unambiguous rules	(Asatiani and Penttinen, 2016; Fung, 2014; Khramov, 2018; Lacity and Willcocks, 2015; Slaby, 2012)
No need or limited work intervention	(Fung, 2014; Lacity and Willcocks, 2017; Lintukangas, 2017; Slaby, 2012)
Limited need to handle exceptions	(Asatiani and Penttinen, 2016; Fung, 2014; Lacity and Willcocks, 2015; Slaby, 2012)
Awareness of current costs	(Asatiani and Penttinen, 2016; Fung, 2014; Lacity and Willcocks, 2015; Slaby, 2012)
Tasks prone to human errors	(Asatiani and Penttinen, 2016; Fung, 2014; Khramov, 2018)
High process maturity	(Kyheröinen, 2018; Lacity and Willcocks, 2017; Lintukangas, 2017)
High level of process standardization	(Kyheröinen, 2018; Lacity and Willcocks, 2017; Lintukangas, 2017)
High quality of data	(Anagnoste, 2017; Lintukangas, 2017)
Low need of cognitive requirements	(Asatiani and Penttinen, 2016; Khramov, 2018)
High availability of digital data	(Anagnoste, 2017)

Tasks that are prone to human error are suited for automation because it allows the reduction of costs and the increase of performance, as robots do less mistakes than humans. Also, tasks with no need or limited need for worker intervention and low cognitive requirements are an important aspect, because robots lack analytical and creative skills. Without the intervention of humans, the complexity of the process would increase.

Finally, data is important, in terms of digital availability and quality. To execute the tasks correctly, the data must be correct, so that the robot does not make mistakes and must be available digitally, to be accessible to the robot.

3.6 RPA Future Challenges

Another important aspect to have into account is the challenges that organizations may face during and after RPA implementation. Grounded on the literature, there are many challenges (Table 7) that should be addressed, so that in the future the adoption and implementation of RPA solutions can be more widespread. This section also presents a more detailed description of each challenge.

One the main challenges is robot maintenance, as user interfaces change more often than the data structures behind it (Kasslin, 2017; Stople et al., 2017). When systems change, sometimes the robot must be reconfigured, which is costly and time consuming.

Table 7. RPA Future Challenges

Challenge	References
Robot maintenance	(Kasslin, 2017; Stople et al., 2017)
Competition between robots and humans	(Asatiani and Penttinen, 2016; Suri et al., 2017)
Can make mistakes faster	(Kirchmer, 2017)
Robot having wide access rights	(Kasslin, 2017)
Unclear division of responsibilities between IT and BUs	(Suri et al., 2017)
Lack of understanding of what RPA means and its application	(Suri et al., 2017)

There is also lack of understanding of what RPA means and its application, because the term itself is confusing as it suggests that is connected to robotics, but instead, it is related to software robots.

As there is no human checking before executing a task, the robot can make mistakes faster, not waiting for the responses from the applications, like a human would do and not being able to check connection problems, performing only a part of its tasks. Also, a robot can have wide access rights to interact with other systems, having as many accesses as a super user, which can arise security issues.

The responsibility of implementing RPA is on the business side, but sometimes there is an unclear division between this side and the IT side. This happens because RPA is an IT tool, but at the same time automates processes that belong to the business side.

The last challenge is the impact on employees. Many companies allocate their workers into other tasks, while others just replace their workers with robots. Despite the positive feedback without many job losses, employees are still reluctant and see robots as their opponents for a job, which creates tension on the workplace, so it is important to address these issues with workers before introducing robots into the workplace (Asatiani and Penttinen, 2016).

3.7 RPA Future Opportunities

It is not only interesting to explore the benefits, disadvantages, main criteria and challenges but also possible opportunities to improve the final results of RPA implementation. The combination of different techniques/domains is actually seen as a suitable opportunity. Moreover, it may even solve some of the RPA disadvantages aforementioned (Table 5). There are many opportunities that, if well applied, can leverage the adoption of RPA to another level. This section also provides a more detailed description of each opportunity found in the literature.

The most obvious is the integration with machine learning and artificial intelligence. As RPA is only suited for rule-based processes, this integration can help handling with a higher range of BPs, overcoming this limitation. There are RPA vendors with Artificial Intelligence (AI) integration. Some of them incorporate their own algorithms in their software, such as WorkFusion and Pegasystems, while others (e.g. Blue Prism and Kryon) link to other platforms, such as IBM Watson or Microsoft Azure ML (Le Clair et al., 2017). There will also be an integration with text mining, enhancing the value of RPA by being able to handle with unstructured content and extract features like intentions and sentiments (Le Clair, 2018).

Table 8. RPA Future Opportunities

Opportunity	References
Integration with Machine Learning/Artificial Intelligence	(Aalst et al., 2018; Anagnoste, 2017; Khramov, 2018; Le Clair et al., 2017; Tornbohm and Dunie, 2017)
Integration with Analytics	(Anagnoste, 2017; Le Clair, 2018; Le Clair et al., 2017)
Integration with Process Mining	(Aalst et al., 2018; Tornbohm and Dunie, 2017)
Integration with Text Mining	(Le Clair, 2018)

Also, analytics with RPA can be advantageous, because robots will be able to use data and also interpret it like humans would do, detecting patterns faster and without making mistakes. By analyzing data, RPA combined with process mining can detect processes suited for automation. There are already collaborations between process mining and RPA vendors, such as UiPath and Celonis, to select processes and then build robots driven by the selected processes (Aalst et al., 2018).

4 Proposal - RPA Conceptual Model

A conceptual model provides a scheme with the relationship between major concepts (Järvelin and Wilson, 2003), facilitating the representation of knowledge in a non-ambiguous form (Schermann et al., 2009). Plus, conceptual models can be used to guide research by systematizing knowledge and mapping a fraction of reality (Bunge, 1967), therefore being appropriate for representing the main concepts around RPA and their relationships, as represented in Figure 5.

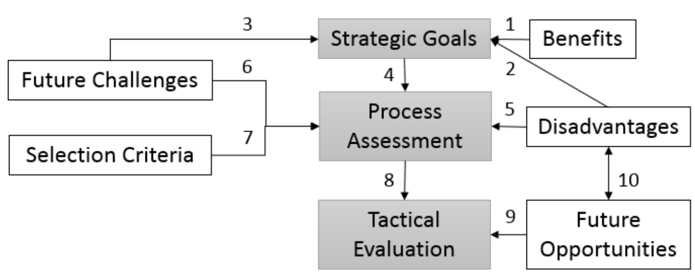

Figure 5. RPA Conceptual Model

To successfully conducting RPA CS, there are several factors that must be considered. In (Kyheröinen, 2018), the success factors in RPA implementations were identified, such as communication, change management, top management support, clear goals, business process re-engineering and user satisfaction. In addition to these success factors, there is a need of understanding conceptually what RPA is, what are its advantages, disadvantages, suitable process criteria, challenges and opportunities, as there is a lack of understanding of what RPA means and its application (Suri et al., 2017), in order to successfully conduct a CS. These concepts provide information that may be critical for implementation success and despite being theoretical, can be observed and applied in RPA implementations.

These concepts can be incorporated in a roadmap for RPA implementation. The steps for a successful RPA implementation were identified in (Sigurðardóttir, 2018). First, it is necessary to identify the business problem, challenges and tasks that are repetitive. Then, trying to find out if RPA is the right solution by assessing the processes, choosing the ones that are suited by establishing criteria to assess if the processes are suited for RPA automation. After that, design and implementation take place, followed by testing and evaluation in terms of FTEs, error rate, ROI, user satisfaction and automation potential.

These steps can be mapped into the following concepts: “Strategic Goals”, “Process Assessment” and “Tactical Evaluation”.

The first step, “Strategic Goals”, is establishing automation objectives, which are aligned with the company goals. Establishing objectives is important, because it guides the process and gives motivation to successfully automate a process, helping to evaluate the performance by measuring if the objectives are achieved. These goals must have into account the benefits of using RPA (1), as knowing what the benefits are may help to understand what advantages the automation may bring. Knowing what the disadvantages (2) are may help to know the limitations of RPA automation, avoiding establishing unrealistic and unattainable objectives. Future challenges (3) must also be considered in order to set appropriate goals, having in mind a long-term perspective with actions to address these challenges.

After establishing goals, it is necessary to assess the process (4), by selecting the right processes. Selecting a bad process may have a major impact, in terms of costs, resources and efficiency. When the process characteristics are identified, the disadvantages identified in the literature must be considered (5), in order to avoid automating a process that contains a low number of rules, for instance, which is one the disadvantages identified in the literature. Future challenges (6) is one of the factors that influence the assessment of a process, as picking a process that interacts with many systems that change very often, for instance, may require a lot of maintenance, which is one of the future challenges identified. Considering disadvantages and future challenges of RPA is important when assessing a process but having criteria to select a process (7) is critical, as having a checklist with the features that a process should have can help identifying the most suited process. If a process fulfills most of the criteria identified in the literature, then there is more certainty about being the most suited process for RPA automation.

After picking the most suited process, there should be a tactical evaluation on how to implement RPA automation (8). According to the characteristics of the process, an integration with other technologies may be required, taking advantage of RPA future opportunities (9), in order to overcome the limitations and disadvantages of RPA (10). As an example, identifying that a process needs integration with machine learning will help overcome some of the RPA disadvantages identified in the literature, such as RPA being suited for process that only include rule-based tasks.

This conceptual model can be used for researchers as a schema for conducting and writing RPA CSs.

5 Evaluation

To illustrate the application of our proposal, the authors selected five RPA CS articles from journals/conferences (Aguirre and Rodriguez, 2017; Hallikainen et al., 2018; Khramov, 2018; Lacity et al., 2016; Lacity and Willcocks, 2017). Our goal is not to propose a critical evaluation of the quality of the research contributions, but shed some light on our proposal. This kind of evaluation has been applied in other studies (Hevner et al., 2004; Pereira et al., 2013). The CSs analysis can be seen in Table 9.

6 Discussion

In terms of benefits reported, all the CSs reported that the tasks performed by the robot are being executed faster than when manually. Two CSs refer that the automated process has less errors than before and that the productivity has increased. There are probably more benefits of the automation of processes with RPA in these CSs, but there were not present or clear. Comparing with the benefits gathered in the Literature Review, 70% were present in the CSs, which shows that the benefits gathered in the Literature Review are reflected in CSs.

Table 9. RPA Case Studies Analysis

Paper	Benefits	Disadvantages	Process Criteria	Future Challenges	Future Opportunities
(Khramov, 2018)	More productivity Performs tasks faster Allows employees to focus on more important tasks	Not present	Voluminous transactions Tasks prone to human errors Ease of decomposition into unambiguous rules	Not present	Integration with Machine Learning
(Aguirre and Rodriguez, 2017)	More productivity Performs tasks faster	Not present	Ease of decomposition into unambiguous rules	Not present	Not present
(Lacity and Willcocks, 2017)	Less errors Performs tasks faster	Not present	High availability of digital data	Not present	Not present
(Hallikainen et al., 2018)	Less errors Performs tasks faster	Not present	Ease of decomposition into unambiguous rules	Not present	Not present
(Lacity et al., 2016)	FTE savings Performs tasks faster Highly scalable solution to meet peaks in service demand Fast ROI	Not present	Ease of decomposition into unambiguous rules Voluminous transactions High process standardization	Not present	Not present

The CSs, in terms of the criteria for choosing if a process is suitable for RPA automation, do not present the reasons why they have chosen that process, but by the description of the process, there is a relationship between what is reported in that CS with the criteria gathered in the Literature Review. For instance, in (Khramov, 2018), it is said that "A number of times, tickets could be mistakenly assigned to the inappropriate group", which reflects that this process has tasks prone to human errors, such as the wrong assignment of tickets to groups. All the CSs show that the most important criteria is choosing processes that can be decomposed into unambiguous rules, as RPA is suited for processes whose tasks have well defined rules. Comparing the criteria gathered in the Literature Review with the criteria found in the CSs, less than 50% are present in the Literature Review, which is normal as the only way to identify criteria in the CSs was the description of the process.

In terms of disadvantages and future challenges reported, none of the papers reported any disadvantages or challenges, whereas in terms of future opportunities, one paper (Khramov, 2018) used machine learning and RPA to automate a process.

7 Conclusion

RPA is revolutionizing the workplace, using software robots that replace humans by interacting with systems through the user interface, being faster and more efficient than a human. A robot is capable of doing repetitive tasks that used to be done by humans, such as filling forms, logging into many systems, monitoring events, performing checks, sending emails and extracting data from many file types (Anagnoste, 2017), so that the workers can dedicate their time and effort to tasks that add more value (Aguirre and Rodriguez, 2017).

Despite being recent, this type of automation is being progressively adopted in companies, but as it becomes widespread, there are some challenges that companies must have into account in order to successfully automate a process. One of the challenges is the identification of processes suitable for RPA automation (Leopold et al., 2018), as selecting a wrong process increases the failure speed and inefficiency (Gadre et al., 2017).

In this research, a synthetization of the main topics related to RPA was created, such as the benefits, disadvantages, suitable processes criteria, future challenges and opportunities. Then, a conceptual model on the relationships between RPA main topics was performed, providing a schema for conducting CSs. In the conceptual model, three steps were identified (Strategic Goals, Process Assessment and Tactical Evaluation) and the factors that influence them (Benefits, Disadvantages, Selection Criteria, Future Challenges and Future Opportunities). These factors must be considered, so that the implementation of a process automation with RPA can be successful. Finally, five CSs identified in the literature were selected and a presence of the RPA main topics was verified, in order to evaluate the model. The results reported show that most of the benefits in the Literature Review are also reported in the CSs, such as reduction of errors, increase of productivity and the robot performing tasks faster. There is a relationship between what is reported in CSs in terms of processes suitable criteria with the criteria gathered in the Literature Review, by the description of the processes, despite the CSs not presenting the reasons why they have chosen that process. The other topics were not identified in CSs, except for the topic "Future Opportunities", where a CS used machine learning combined with RPA to automate a process.

Future research should focus on applying the proposed model on conducting a CS, by using the steps identified and considering RPA main topics and then refine the model based on the experience of conducting a CS, if needed. Another opportunity for future studies can be combining RPA with the technologies referred in the section "RPA Future Opportunities", as they are not much explored areas and help to overcome some of the RPA disadvantages, handling with a higher range of BPs. Plus, it can be interesting to find and explore more opportunities as more appear in the future. Future research should also explore the relationship between RPA suitable processes criteria and RPA success and discover whether a process should fulfil all, half or just one criteria in order to be successful, establishing the degree of the alignment between the process and the criteria gathered in the literature. The next step and further research is to explore the relation between RPA research and data science research since it seems to be a partnership for the future.

References

Aalst, W.M.P. van der, Bichler, M. and Heinzl, A. (2018), "Robotic Process Automation", *Business & Information Systems Engineering*, pp. 1–4.

Aguirre, S. and Rodriguez, A. (2017), "Automation of a Business Process Using Robotic Process Automation (RPA): A Case Study", *Applied Computer Sciences in Engineering*, presented at the Workshop on Engineering Applications, Springer, Cham, pp. 65–71.

Alberth, M. and Mattern, M. (2017), "Understanding robotic process automation (RPA)", *The CAPCO Institute Journal of Financial Transformation*, November, Vol. Automation No. 46, available at: https://www.capco.com/-/media/CapcoMedia/Capco-Institute/Journal-46/JOURNAL46_full_web.ashx#page=104.

Anagnoste, S. (2017), "Robotic Automation Process - The next major revolution in terms of back office operations improvement", *Proceedings of the International Conference on Business Excellence*, Vol. 11, available at:https://doi.org/10.1515/picbe-2017-0072.

Anagnoste, S. (2018), "Setting Up a Robotic Process Automation Center of Excellence", *Management Dynamics in the Knowledge Economy*, Vol. 6 No. 2, pp. 307–322.

Asatiani, A. and Penttinen, E. (2016), "Turning robotic process automation into commercial success – Case OpusCapita", *Journal of Information Technology Teaching Cases*, Vol. 6 No. 2, pp. 67–74.

Bunge, M. (1967), *Scientific Research I: The Search for System*, Springer-Verlag, Berlin Heidelberg, available at: //www.springer.com/gp/book/9783642481376 (accessed 23 November 2018).

Cewe, C., Koch, D. and Mertens, R. (2017), "Minimal Effort Requirements Engineering for Robotic Process Automation with Test Driven Development and Screen Recording", *Business Process Management Workshops*, presented at the International Conference on Business Process Management, Springer, Cham, pp. 642–648.

Forrester. (2014), *Building A Center Of Expertise To Support Robotic Automation*, Forrester, available at: http://neoops.com/wp-content/uploads/2014/03/Forrester-RA-COE.pdf (accessed 20 July 2018).

Fung, H.P. (2014), *Criteria, Use Cases and Effects of Information Technology Process Automation (ITPA)*, SSRN Scholarly Paper No. ID 2540023, Social Science Research Network, Rochester, NY, available at: https://papers.ssrn.com/abstract=2540023 (accessed 26 June 2018).

Gadre, A., Jessel, B. and Gulati, K. (2017), "Rethinking robotics? Take a step back", *The CAPCO Institute Journal of Financial Transformation*, November, Vol. Automation No. 46, available at: https://www.capco.com/-/media/CapcoMedia/Capco-Institute/Journal-46/JOURNAL46_full_web.ashx#page=104.

Hallikainen, P., Bekkhus, R. and Pan, S.L. (2018), "How OpusCapita Used Internal RPA Capabilities to Offer Services to Clients.", *MIS Quarterly Executive*, Vol. 17 No. 1.

Hevner, A.R., March, S.T., Park, J. and Ram, S. (2004), "Design Science in Information Systems Research", *MIS Quarterly Executive*, Vol. 28 No. 1, p. 32.

Järvelin, K. and Wilson, T.D. (2003), "On Conceptual Models for Information Seeking and Retrieval Research", *Information Research*, Vol. 9 No. 1, available at: https://www.researchgate.net/publication/220468732_On_Conceptual_Models_for_Information_Seeking_and_Retrieval_Research (accessed 17 November 2018).

Kasslin, H. (2017), *Heavyweight and Lightweight Process Automation - How Do Companies Select between RPA and Back-End Automation?*, Master's Thesis, Aalto University, available at: https://aaltodoc.aalto.fi:443/handle/123456789/26827 (accessed 2 August 2018).

Khramov, D. (2018), *Robotic and Machine Learning: How to Help Support to Process Customer Tickets More Effectively*, Bachelor's Thesis, Metropolia University of Applied Sciences.

Kirchmer, M. (2017), "Robotic Process Automation–Pragmatic Solution or Dangerous Illusion?", *BTOES Insights*.

Kitchenham, B. (2004), *Procedures for Performing Systematic Reviews*, Keele University, United Kingdom, p. 33.

Kyheröinen, T. (2018), *Implementation of Robotic Process Automation to a Target Process – a Case Study*, Master's Thesis, Aalto University, 9 May, available at: https://aaltodoc.aalto.fi:443/handle/123456789/31518 (accessed 2 August 2018).

Lacity, M. and Willcocks, L. (2015), "Robotic Process Automation: The Next Transformation Lever for Shared Services", *The Outsourcing Unit Working Research Paper Series*.

Lacity, M., Willcocks, L.P. and Craig, A. (2016), "Robotic process automation at Telefonica O2", *MIS Quarterly Executive*, Vol. 15 No. 1.

Lacity, M.C. and Willcocks, L.P. (2017), "A new approach to automating services", *MIT Sloan Management Review*, Vol. Fall, available at: http://sloanreview.mit.edu/ (accessed 26 June 2018).

Le Clair, C. (2018), *The Forrester Wave^{TM}: Robotic Process Automation, Q2 2018 The 15 Providers That Matter Most And How They Stack Up*.

Le Clair, C., Cullen, A. and King, M. (2017), *The Forrester Wave^{TM}: Robotic Process Automation, Q1 2017*, Forrester, available at: https://www.forrester.com/report/The+Forrester+Wave+Robotic+Process+Automation+Q1+2017/-/E-RES131182.

Leopold, H., Aa, H. van der and Reijers, H.A. (2018), "Identifying Candidate Tasks for Robotic Process Automation in Textual Process Descriptions", *Enterprise, Business-Process and Information Systems Modeling*, pp. 67–81.

Lintukangas, A. (2017), *Improving Indirect Procurement Process by Utilizing Robotic Process Automation*, Master's Thesis, LAPPEENRANTA UNIVERSITY OF TECHNOLOGY - School of Business and Management, available at: https://core.ac.uk/download/pdf/84594991.pdf (accessed 2 August 2018).

March, S.T. and Smith, G.F. (1995), "Design and natural science research on information technology", *Decision Support Systems*, Vol. 15 No. 4, pp. 251–266.

March, S.T. and Storey, V.C. (2008), "Design Science in the Information Systems Discipline: An Introduction to the Special Issue on Design Science Research", *MIS Quarterly*, Vol. 32 No. 4, p. 725.

Mindfields. (2015), *Robotic Process Automation Driving the next Wave of Cost Rationalisation*, Mindfields, available at: https://www.scribd.com/doc/296828726/Robotics-Process-Automation-September-2015-v17-1 (accessed 22 July 2018).

Nunamaker, J.F. and Chen, M. (1990), "Systems development in information systems research", *Twenty-Third Annual Hawaii International Conference on System Sciences*, Vol. 3, presented at the Twenty-Third Annual Hawaii International Conference on System Sciences, pp. 631–640 vol.3.

Österle, H., Becker, J., Frank, U., Hess, T., Karagiannis, D., Krcmar, H., Loos, P., et al. (2011), "Memorandum on design-oriented information systems research", *European Journal of Information Systems*, Vol. 20 No. 1, pp. 7–10.

Peffers, K., Tuunanen, T., Rothenberger, M.A. and Chatterjee, S. (2007), “A Design Science Research Methodology for Information Systems Research”, *Journal of Management Information Systems*, Vol. 24 No. 3, pp. 45–77.

Pereira, R., Almeida, R. and da Silva, M.M. (2013), “How to Generalize an Information Technology Case Study”, in vom Brocke, J., Hekkala, R., Ram, S. and Rossi, M. (Eds.), *Design Science at the Intersection of Physical and Virtual Design*, Vol. 7939, Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 150–164.

Schermann, M., Böhmann, T. and Krcmar, H. (2009), “Explicating Design Theories with Conceptual Models: Towards a Theoretical Role of Reference Models”, in Becker, J., Krcmar, H. and Niehaves, B. (Eds.), *Wissenschaftstheorie und gestaltungsorientierte Wirtschaftsinformatik*, Physica-Verlag HD, Heidelberg, pp. 175–194.

Schon, D.A. (1984), *The Reflective Practitioner: How Professionals Think In Action*, Basic Books.

Sigurðardóttir, G.L. (2018), *Robotic Process Automation: Dynamic Roadmap for Successful Implementation*, Master’s Thesis, Reykjavík University, 20 June, available at: https://skemman.is/handle/1946/31385 (accessed 2 August 2018).

Simon, H.A. (1996), *The Sciences of the Artificial*, 3. ed., MIT Press, Cambridge, Mass.

Slaby, J.R. (2012), *Robotic Automation Emerges as a Threat to Traditional Low-Cost Outsourcing*, available at: https://www.horsesforsources.com/wp-content/uploads/2016/06/RS-1210_Robotic-automation-emerges-as-a-threat-060516.pdf.

Stople, A., Steinsund, H., Iden, J. and Bygstad, B. (2017), “Lightweight IT and the IT function”, Vol. 25, presented at the NOKOBIT, Oslo, available at: https://ojs.bibsys.no/index.php/Nokobit/article/view/405 (accessed 2 August 2018).

Suri, V.K., Elia, M. and Hillegersberg, J. van. (2017), “Software Bots - The Next Frontier for Shared Services and Functional Excellence”, *Global Sourcing of Digital Services: Micro and Macro Perspectives*, presented at the International Workshop on Global Sourcing of Information Technology and Business Processes, Springer, Cham, pp. 81–94.

Tornbohm, C. and Dunie, R. (2017), *Market Guide for Robotic Process Automation Software*, Gartner, p. 35.

Tran, D. and Ho Tran Minh, T. (2018), *Workflow Methodology Development of RPA Solution for A Vietnamese Bank: A Case Study of Korkia Oy*, Bachelor’s Thesis, Laurea University of Applied Sciences, available at: http://www.theseus.fi/handle/10024/148869 (accessed 2 August 2018).

Vasconcelos, J.B. and Rocha, Á. (2018), “Guest Editorial. Special section on Business analytics and big data”, *International Journal of Information Management*, available at:https://doi.org/10.1016/j.ijinfomgt.2018.10.019.

Vishnu, S., Agochiya, V. and Palkar, R. (2017), “Data-centered Dependencies and Opportunities for Robotics Process Automation in Banking”, *Journal of Financial Transformation*, Vol. 45, pp. 68–76.

Walls, J.G., Widmeyer, G.R. and El Sawy, O.A. (1992), “Building an Information System Design Theory for Vigilant EIS”, *Information Systems Research*, Vol. 3 No. 1, pp. 36–59.

Webster, J. and Watson, R.T. (2002), “Analyzing the Past to Prepare for the Future: Writing a Literature Review”, *MIS Q.*, Vol. 26 No. 2, pp. xiii–xxiii.

Winter, R. (2008), “Design science research in Europe”, *European Journal of Information Systems*, Vol. 17 No. 5, pp. 470–475.