Improving the efficiency of public administrations through business process reengineering and simulation: a case study

Emerald Business Process Management Journal

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Journal:	*Business Process Management Journal*
Manuscript ID:	BPMJ-06-2014-0054.R1
Manuscript Type:	Original Article
Keywords:	Business process re-engineering, Public administration, Simulation, Performance measurement

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Abstract

Purpose: this paper proposes a business process reengineering (BPR) approach to a public administration of Italy, to first assess the efficiency of the administration, then to redesign its internal processes, to improve the current performance.

Design/methodology/approach: a detailed mapping of the AS IS processes of the public administration was initially carried out, together with the collection of the relevant data. Then, a simulation model was designed to support the BPR approach. In particular, the model was exploited to assess the performance of the AS IS scenario of the organization, then to investigate numerous TO BE process configurations and evaluate the achievable performance improvements.

Findings: From the study, it emerged that the current efficiency level of the public administration examined has potentials to be significantly improved. For instance, by maintaining its current workforce, the public administration could consider the opportunity of providing additional services to the citizens or to serve citizens from the neighbouring municipalities. Otherwise, the organization could consider a reorganization and reduction of its current workforce, at the same time keeping the service level to its citizens almost unchanged.

Research limitations/implications: results of this study cannot be fully generalised, since the whole analysis is grounded on specific public administration. Moreover, although the simulation outcomes of the TO BE processes show interesting improvements compared to the AS IS scenario, the TO BE configurations were not (yet) implemented in practice. Therefore, the results provided should be confirmed in future research activities.

Practical implications: the case study allowed deriving some useful guidelines to improve the efficiency of the public administration examined, as well as to identify some TO BE configurations that could be implemented in practice.

Originality/value: scientific literature includes a limited number of studies that evaluate the efficiency of public organizations in real contexts. Moreover, no studies target public administrations in Italy. Therefore, this case study represents an interesting addition to the literature.

Keywords: public administrations, business process reengineering, simulation, performance measurement.

1 Introduction

Traditionally, the "efficiency" and "effectiveness" concepts have been typically applied to the private sector, while they have been rarely adopted in the context of the public administrations, which are almost universally designated as ineffective (Mihaiu et al., 2010). Indeed, public organizations have less market exposure than private ones and are, therefore, less motivated to reduce costs and improve their operating efficiency (Rainey et al., 1976). In recent decades, however, the need to improve competitiveness, the concerns about fiscal sustainability and the growing demands of citizens for better public services at lower costs have involved wide-ranging reforms in the public sector in the whole Europe (European Commission, 2007). In the UK, for instance, several efforts have been made to reduce waste, bureaucracy and over-government (Theakston, 1995), as well as to introduce the principles of efficiency, effectiveness and economy in the central government (Thomson, 1992), thus leading to the new public management direction (Hood, 1991, 1995; Pollitt, 1993). In Italy, several reforms to the public administration were progressively carried out starting from the '90s. Among the most recent ones, the Decreto Legislativo no. 150 (2009) has been introduced with the primary aim to enable the public administration to serve the citizens efficiently, which is a key principle of democracy. Also, such decree should boost the efficiency and productivity of the whole public sector of Italy. Outside Europe, similar reform initiatives were carried out in the US; the National Performance Review (Thompson, 2000) is an example of initiative whose main goal was organizational change in the public administration.

There are also economic reasons for improving the efficiency of public administrations. For instance, the effects of the recent economic crisis have undoubtedly exacerbated the need for more efficient public administrations (Mihaui et al., 2010). In addition, the public sector represents a large part of the economy in most of the European countries, reaching approx. 20 per cent of the payroll employment in Italy (Ragioneria Generale dello Stato, 2012); this increases the benefits of improving its efficiency to the system economy.

Overall, it is nowadays recognised that public administrations should work efficiently and effectively, and that their services should be designed to meet the need of citizens and businesses. Several actions can be undertaken to achieve this result. The increasing use of information and communication technology (ICT), coupled with the enablement of interoperability, the development of digital inclusion policies and the possibilities opened by the Web 2.0 technologies (the so-called e-government) are among of the leverages public administrations of Europe can exploit to operate more efficiently and effectively (Gil-Garcia and Pardo, 2005; Beynon-Davies, 2005; Archmann and Castillo Iglesias, 2010). An alternative, more traditional, leverage to increase the efficiency of public administrations (and of any business in general) is to streamline

the internal processes, by optimizing the allocation of resources, and getting revenue from the state budget (Muthu et al., 1999).

Rethinking the internal processes and evaluating their performance, which is formalised by the business process reengineering (BPR) approach, is actually a recommended procedure anytime innovations or modifications are introduced, either in a private or public company. In the case of public administrations, innovations can be represented, among others, by new legislations or technologies, or by the need for providing new services to the customers (Aversano et al., 2002); all those circumstances would justify a reengineering of the internal processes.

In this paper, we carry out a BPR study in a public administration of Italy, to first assess its efficiency, and then to redesign its internal processes and improve the current performance. Simulation is used in conjunction with BPR to assess the performance of the redesigned processes. With this methodological approach, we try to answer the following research questions (RQ):

RQ1: what is the current performance level of the targeted administration?

RQ2: does the current performance have potentials for improvement? In particular, is there a more efficient way to organize the administration workforce, so as to enhance the customer's service and/or decrease cost?

The reminder of the paper is organised as follows. Section 2 reviews the current literature related to the topics of this study. Section 3 outlines the main steps of the research methodology adopted in this study. Those steps are subsequently detailed in sections 4-8, along with the description of their implementation in the targeted public organization. Section 9 summarises the main findings of the work, describes the related implications and limitations and suggests possible future research steps.

2 Literature analysis

The analysis of the literature related to this study covers two main areas, namely: (1) studies applying BPR approaches in the public administrations; (2) studies describing the definition of performance measurement systems for those administrations.

With respect to the first area, a first consideration is that the studies applying BPR to the public administrations are quite limited in number. Following a chronological order, one of the first studies was carried out by Thong et al. (2000). In their work, the authors examine the case of a large public administration of Singapore. They set several goals in terms of productivity and measure the corresponding performance before and after the BPR, demonstrating the effectiveness of the reengineering. Aversano et al. (2002) present the results of a research project aimed at introducing service and technology innovation in a public administration, while transferring enabling workflow methodologies and technologies to local

small and medium enterprises. Greasley (2003) exploits a slightly different approach, i.e. business process simulation (BPS), to support process analysis at a police force. The author builds a simulation model reproducing the process of custody of prisoners, with the purpose of analysing its current performance; then, different new scenarios are examined, where police workforce is reduced. Stemberger and Jaklic (2007) propose a methodology for process change in the public administration. They examine the specific issue of introducing e-government in the public administration and discuss the necessary changes in business processes, organizational structures and information system of governmental institutions, in order to make e-governmental initiatives truly successful. Another example of a study analysing a specific issue of public administrations is the work by Zaheer et al. (2008). In this case, the authors focus on reengineering the procurement process of a public organization in Pakistan. The proposed BPR model aims at decreasing cost by 81%, time by 74% and human resources by 69%. Emmanouil and Sotirios (2009) propose a BPR tool, called ADONIS, for the analysis and simulation of processes of the public organizations. Pateli and Philippidou (2011) apply business process change (BPC) to the public sector of Greece; in particular, they target the Greek initiative of citizens' service centres. Their study covers macro-level interventions concerning inter-department and inter-agency transactions, as well as issues related to e-government deployment. More recently, McCullough and Sims (2012) describe a BPR study that targets the implementation of a human resource information management system in a civil service agency. Finally, Kassahum and Molla (2013) develop and validate a model to evaluate the BPR complementary competences in the public sector organizations in developing economies, such as Ethiopia.

All the above studies implement process reengineering in public organizations, although with different procedures and scopes. In many cases, the process reengineering is motivated by the need for introducing ICT tools, information management systems or e-government in the targeted organization. Our scope with this study is different: indeed, our work does not deal with e-government issues, but rather it examines the physical processes of the targeted organization and reorganises them to improve the efficiency of the organization. Moreover, our study is grounded on the real case of a public organization in Italy, while literature does not report BPR studies in Italian public administrations. Therefore, we think that the analysis carried out in this paper could represent an interesting addition to the literature.

As far as the measurement of performance in public administrations is concerned, it should be first recalled that public organizations differ from private ones in several ways. An important point is that public organizations rely more on appropriations, which results in less incentive for productivity and effectiveness and lower resource efficiency (Rainey et al., 1976). Consequently, the measurability (as well as the improvement) of the performance of public administrations has always caused perplexity, both on a conceptual level and from the point of view of the application potentials (Mihaiu et al., 2010; Lazzini and Zarone, 2013). A further problem is that performance evaluation systems for public administrations should

take into account not only economic (i.e., profit or loss) results, but also include the perception of the social usefulness of political-administrative action (Lazzini and Zarone, 2013). In many cases, the measurement of performance in public administrations is either carried out exploiting techniques typical of the private sector, or simply evaluating the compliance of the organizations with legal requirements (De Brujin, 2007).

Nonetheless, some studies focus expressively on performance assessment in public organizations (e.g., Sole and Schiuma, 2010; Greiling, 2006; Tampieri, 2005). In particular, Tampieri (2005) develops specific key performance indicators (KPIs) for those organizations, with a particular attention to the criteria of efficiency, effectiveness and adequacy. According to the author, effectiveness is computed as the ratio between the outcomes and the objectives (e.g., the number of practices produced and those expected) and measures the capability of the organization to achieve the planned objectives (Harrinvirta, 2000). Efficiency can be expressed as the ratio between the outcomes and the resources available (e.g., the number of practices produced and opening time) and assesses the organization's capability to use the available resources well (Boccia 2005). Finally, adequacy compares the resources used to the achievement of the planned objectives. The study by Tampieri (2005) will be used in this paper as a guideline for the definition of KPIs suitable to be adopted in the targeted public administration.

3 Research methodology

A typical BPR procedure consists of 5 steps, namely: (1) preparing for reengineering; (2) mapping and analysing the AS IS process; (3) design the TO BE process; (4) implement the reengineered process; (5) improving continuously (Hammer and Champy, 1993; Muthu et al., 2010). In this study, we exploit a slightly modified approach, which includes some of the phases listed above and, at the same time, is supported by simulation. The approach used is depicted in Figure 1 and explained below.

FIGURE 1: SCHEME OF THE APPROACH FOLLOWED

Preparing for reengineering. This step includes some preliminary activities carried out at the targeted public administration, with the purpose of evaluating the opportunity of proceeding with a process reengineering, setting up and managing the whole BPR. Related details are reported in section 4.

Analysis of the AS IS processes and criticality identification. This step consists in mapping the AS IS internal processes of the public administration. On the basis of the mapping, the critical processes to be investigated and redesigned through the BPR were identified. Results of this step are proposed in section 5.

Data collection. For the critical processes, the main figures (e.g., number of customers served, resources used, type of service provided or service time) were collected, by extracting them from the local data

warehouse. Other data, that were not available in the data warehouse, were retrieved thanks to the direct observation of the processes at the public administration. From the data collected, some preliminary statistics related to the efficiency of the AS IS processes were derived. This step is described in section 6.

Development of the simulation model. At the end of the AS IS analysis, a simulation model was built to reproduce the current processes of the public administration. As input, the model exploits the data collected during the previous step, thus allowing a faithful representation of the AS IS processes of the targeted administration. As output, it provides further relevant KPIs of the AS IS processes. Details related to the development of the simulation model, its validation and the performance level measured for the AS IS scenario are provided in section 7.

Design of the TO BE processes. Grounding on the results of the previous steps, in this phase, new operating scenarios were proposed for the targeted public administration. The simulation model mentioned above was exploited again, to investigate several alternative process configurations and different operating conditions of the public administration, as well as to assess its performance under these new scenarios. The detailed results are reported in section 8.

4 Preparing for reengineering

The public administration considered (whose name is omitted for confidentiality) is a municipality in the North of Italy. It currently serves a population of approx. 30,000 resident people, with a significant increase (+12%) since 2012. The municipality was visited the first time in November 2012, with the purpose of gaining a basic knowledge of the activities carried out, the organizational structure, the type of services provided to the citizens and the perceived inefficiencies of the current processes. The visit was led by some representatives of the municipality, namely the secretary-general and two officers.

During the first visit, a working group was set up to evaluate the opportunity to proceed with a reorganization of the some internal procedures of the municipality, as well as to support the entire reengineering process, from its design up to the analysis of the final results. The working group included:

- three academics from the University of Parma. University people were chosen among researchers with specific competences in the fields of BPR, simulation, process management and performance measurement;
- the secretary-general of the public organization, who was involved in the team on the basis of the assumption that top-level management commitment is a critical success factor of BPR implementations (Jurisch et al. 2012);
- an officer of the public organization, who was involved in the team because of his detailed knowledge of the internal processes of the municipality.

After the visit, the working group members had a quick roundtable discussion, with the purpose of evaluating the opportunity of a process reengineering and establishing its main aim, which is required before starting the BPR (Jurisch et al., 2012). The working group agreed to carry out a BPR study in the municipality, with the general aims to:

1. Improve the quality of services the public organization provides to the citizens, compared to the current service level; and
2. Assess the current efficiency of the internal workforce, optimize its use and evaluate different ways to deploy the municipality employees.

Obviously, besides the general aims listed above, further, more specific aims could emerge after the process analysis and criticality identification. Overall, the expected result of the reengineering was to make the municipality more efficient.

5 AS IS process analysis and criticality identification

This step consists of a detailed mapping of the AS IS processes of the municipality and was carried out in November 2012. In the light of the first general aim of the BPR study, the working group suggested to focus expressively on those processes that involve the final customers of the municipality, i.e. the citizens. In this regard, it emerged that the services to the customers are fulfilled by two main business units of the municipality, namely the reception and the office for relations with the public (ORP). Overall, those units employ 12 people as staff.

The reception represents the first interface for the citizens that need to access the municipality services. It is often used by customers to get preliminary or general information about the services provided by the municipality (e.g., the location of an office), as well as to get the set of forms related to these services. It employs 3 people as the direct interface for the citizens and one call centre employee.

The ORP is the unit that delivers the municipality services to the customers, by means of front-office activities. The service provided to the citizens can be categorized in the following main groups: registry; identity cards and certificates; electoral document and claim; marital status; others. The ORP employs 5 people for front-office activities, plus one manager, one supervisor and a desk clerk. However, because of the peculiarities of each service, the bureaucratic complexities and the required knowledge of laws and procedures, each front-office employee is specialized in only some (or only one) of the municipality services, for which he/she is in charge. Consequently, job rotation strategies had never been implemented, because they are expected to worsen the employee's productivity, causing delays in fulfilling the customer's request. Moreover, the working time of the front-office employees can be interrupted by

unwanted disturbances, such as the need for answering phone calls, sending email to the customers, or providing information to customers or colleagues; this causes additional delays in serving the customers.

The ORP and the reception are located at two different entrances of the municipality, each opposite to the other (Figure 2). An ideal (i.e., without exceptions) flow of the municipality customers in the AS IS scenario would be as follows:

i. An uninformed citizen, who needs some preliminary information about the municipality services, will first access the reception, to ask about the service he/she requires;

ii. Depending on the kind of service required, the citizen will receive the set of forms to be preliminary filled;

iii. The citizen will then access the ORP;

iv. He/she will be located in the queue of customers waiting to be served;

v. When his/her turn arrives, the citizen will be served;

vi. The citizen will leave the municipality.

INSERT HERE FIGURE 2: LOCATION OF ORP AND RECEPTION AND IDEAL FLOW OF CUSTOMERS.

An informed citizen could avoid visiting the reception, thus skipping steps (i) and (ii). Given the location of the ORP and reception, however, it is quite frequent that the flow of customers to the municipality is not optimized; for instance:

- customers may erroneously access the reception, instead of the ORP, although they do not need any preliminary information; or
- customers access the ORP, then should move to the reception to get the set of forms required for the service they need.

Those circumstances may involve delays in fulfilling the customer's requests.

Also, the working time of the reception and the ORP is different, as well as the customers that can be served by those units. Indeed, the reception is intended to accept any kind of users (even if completely uninformed), that will be redirected to the various municipality offices as a function of their request. The reception, therefore, operates from 8 a.m. to 6 p.m. from Monday to Friday, and from 8 a.m. to 1 p.m. on Saturday. Conversely, the ORP is expected to receive users who need a specific service by the municipality; its opening time for front-office activities is from 8 a.m. to 6 p.m. on Monday and Thursday, from 8 a.m. to 2 p.m. on Tuesday and Wednesday, and from 8 a.m. to 1 p.m. on Friday and Saturday. Back-office activities are carried out both during the opening time (taking advantage of the low-demand periods) and on

Tuesday, Wednesday and Friday, starting from the end of the opening time until 6 p.m. The work shifts of the 5 front-office employees are reported in Table 1.

INSERT HERE TABLE 1: WORK SHIFTS OF THE FRONT-OFFICE EMPLOYEES.

Focusing on the ORP, here the ideal flow of customers of the AS IS scenario should be as follows (see Figure 3):

i. When accessing the ORP, the uninformed citizen could first ask the desk clerk to get some preliminary information about the service required;
ii. the citizen will move to the ticket emission terminal, where he/she will pick a ticket containing all the information related to the service he/she is accessing. Such information includes date and time of access, a progressive number and a code describing the service required, according to the following nomenclature: *A* for "registry", *C* for "certificates and identity cards", *E* for "electoral document and claim", *S* for "marital status", *V* for "other";
iii. the citizen will be located in a queue of waiting customers (if any) and will wait for his/her turn in the waiting area;
iv. on the basis of the ticket number, citizens are called by the front-office employees. Ideally, these latter will fulfil the citizen's request, helping him/her to fill the set of forms necessary to obtain the service required; nonetheless, it is also possible that citizens are transferred to another, more competent office to be served;
v. the citizen will leave the ORP.

INSERT HERE FIGURE 3: CUSTOMERS' FLOW AT THE ORP.

As per the previous case, the informed citizen could skip step (i). As regards the information flow, anytime a new ticked is emitted (i.e., a new customer accesses the ORP unit), the corresponding information is sent to the front-office employees; therefore, these employees can real-time monitor both the citizens queue, the kind of service required and the time spent to fulfil the customer's requests. Moreover, citizens are aware of the number of other customers in queue (if any), since a screen placed in the waiting room shows the real-time state of the waiting list and the number of users waiting for each service. Related to this latter point, and in line with RQ2, a relevant issue of the municipality is the adequacy of the quantity of resources of the ORP compared to the number of customers served and the service provided; this represents a main concern to both the directors and the general-secretary of the municipality.

On the basis of the process analysis described above, it is evident that both the ORP and the reception suffer from some criticalities that could be optimized through a process reengineering. Nonetheless, some of the working group members (specifically, the municipality representatives) suggested to start the BPR from the ORP, because of two main reasons. First, the ORP has relevant potential for improvements, due to the following criticalities of the AS IS scenario:

- unexplored job rotation opportunities;
- non-optimized customers' flow;
- disturbances affecting the front-office employees;
- lack of any analysis about the adequacy of the quantity of resources (i.e., people) used and related efficiency.

Second, recalling RQ2 and the second main aim of the BPR (i.e., to optimize the use of internal workforce), the OPR employs more people than the reception; therefore, there is greater potential for reorganizing the related workforce and, in the case, decreasing it, e.g. moving some employees to a different municipality office. The same possibility does not hold for the reception, because a minimum number of employees should be necessarily maintained in this unit, being the contact point of citizens. On the basis of these considerations, the BPR study was focused on the ORP.

6 Data collection

6.1 Data extraction

The collection of data related to the ORP was carried out by exploiting the municipality data warehouse, stored in a local server. This data warehouse includes all the relevant pieces of information related to the service the employees provide to the citizens. Specifically, whenever a front-office employee logs in or out the municipality's information system, that operation is registered in the data warehouse; therefore the working time can be easily monitored. The same happens when the employee serves a customer: in that case, the time the citizen accessed the front-office desk and the kind of service requested are recorded. The data warehouse contains sufficient data to allow performing some queries to derive the employees performance (e.g., the number of citizens served per day, the working time, the service time, etc.), or the kind of service requested by citizens.

The data extraction from the data warehouse was carried out approx. from late November 2012 to the beginning of January 2013. The data extracted concerns: the working time of employees, the service requested by customers and the access time of customers. From those data, we derived an estimate of the employee performance, in terms of mean and standard deviation of the time required to serve a customer, as a function of the service required. The data available cover a 294 working days horizon, i.e. the whole

2012, with an average of 24.5 days examined per months. As regards the service provided, only 4 out of the 5 services supplied by the municipality were monitored in this study; specifically, services related to the "electoral documents" were not considered, because this service is requested seldom across the year.

The relevant statistics obtained from the data extracted refer to the average distribution of the customer's arrival time during the day (Table 2 and Figure 4), the corresponding distribution as a function of the weekday (Figure 5 and Table 3)[1], the kind of service requested (Figure 6) and the employee productivity, in terms of the average service time (Table 4).

INSERT HERE TABLE 2: DISTRIBUTION OF THE CUSTOMERS' ARRIVALS AS A FUNCTION OF THE WORKING HOUR AND MONTH.
INSERT HERE FIGURE 4: DATA EXTRACTED – DISTRIBUTION OF THE CUSTOMERS' ARRIVALS AS A FUNCTION OF THE WORKING HOUR.

Overall, the front-office employees fulfilled 28,085 customer's requests in 2012, with approx. 2,340 citizens served per month, on average, corresponding to approx. 97 citizens per day, considering 6 working days per week (corresponding to 24 working days per month and 288 per year).

Outcomes in Table 2 and Figure 4 suggest that the data extracted can be somehow prone to errors. For instance, it can be seen from Table 2 that 34 customers were served between 6 p.m. and 7 p.m. and 6 customers were served before 8 a.m. In these moments, however, the front-office desks are closed. So, why did we find this information in the municipality database? There are two possible explanations for this. Let us consider the case of a customer served before 8 a.m.; this may be occurred because:

- the customer was actually served the day before, during the last time slot; however, the employee did not logout from the municipality information system. In the morning of the day after, the employee comes back to his/her office some minutes before the opening time, finds the information system still running and closes the application. This completes (formally) the service, which is recorded on the municipality database in the morning of the day after; or
- the employee came to his/her office some minutes earlier than the normal opening time and started serving the customers.

The two situations described above differ significantly. Indeed, the first one is obviously an incorrect representation of the AS IS scenario, stemming from an error of the employee, who forgot to logout. As indicated by the municipality representatives, it is not unlikely that the time of employee login and logout

[1] As will be detailed later, it is worth remarking that the municipality database provides the exact data, in terms of customers' arrivals, for each weekday. Only for visualization purpose, as well as to avoid an excessive number of tables and figures in the paper, we have grouped the weekdays on the basis of the similarities in the opening time (i.e., Monday and Thursday, Friday and Saturday, Tuesday and Wednesday) in Table 3 and Figure 5.

from the information system (and therefore, the data derived from that information) is falsified; for instance, during the lunch time or coffee breaks, the operators usually do not logout from the information system. The second situation, instead, describes an exceptional circumstance, where the employee anticipated the opening time of the front-office desks to start serving the customers. In that case, the information included in the data base (i.e., the customer served between 7.00 and 7.59) is correct. Unfortunately, there is actually no way to discern among the first and the second situation described above, since the data retrieved in the municipality database are exactly the same. Therefore, to avoid wrong input in the subsequent analyses and prevent errors in future elaborations, the AS IS data were properly cleaned by means of manual corrections. Specifically, the service data which referred to a time slot where the municipality offices are closed were removed from the original dataset[2].

From Figure 4, it can also be appreciated that more than 60% of the customers access the front-offices between 9 a.m. and 12 a.m., with a peak (23%) between 10 and 11 a.m.; it is, therefore, important to assess whether the ORP workforce is able to satisfy the customers' needs in these time intervals. Conversely, the remaining time slots do not seem to highlight critical situations.

INSERT HERE TABLE 3: DATA EXTRACTED – DISTRIBUTION OF THE CUSTOMERS' ARRIVALS AS A FUNCTION OF THE WORKING HOUR AND WEEKDAY
INSERT HERE FIGURE 5: DATA EXTRACTED – DISTRIBUTION OF THE CUSTOMERS' ARRIVALS AS A FUNCTION OF THE WORKING HOUR AND WEEKDAY

As regards the distribution of the customer's arrivals as a function of the weekday (Figure 5 and Table 3), it is expected that the arrivals vary during the week, reflecting the different opening time of the municipality. More precisely, on Monday and Thursday, when the municipality offices are opened until 6 p.m., the distribution of the arrivals is bimodal, with a first peak during the morning (from 10 to 11 a.m.) and a second peak in the afternoon (from 4 to 5 p.m.). During the remaining days, the only peak of arrivals, as already mentioned, is observed from 10 to 11 a.m. and the arrivals distribution is similar for all days. Moreover, on Monday and Thursday, very few customers are served during the lunch break: 3.57% from 1 to 2 p.m. and 3.63% from 2 to 3 p.m. A similar result is observed on Tuesday and Wednesday: in those days, approx. 4.77% of customers are served between 1 and 2 p.m., while this percentage is significantly lower (0.68%) from 2 to 3 p.m. Even on Friday and Saturday, the percentage of customers served from 1 to 2 p.m. is low (0.94%).

[2] Looking at the data extracted from the municipality data warehouse (Table 3), one can also see that the customers that fall outside the opening time of the municipality are approx. 40 out of 28,058 citizens served during the year (0.142%). Therefore, such cleaning up of the data of the AS IS scenario is not expected to alter the original scenario of the municipality to an appreciable extent.

With respect to the service required, “certificates” are by far the service most frequently requested by the citizens (47% of the requests fulfilled), followed by “other” (28%), “registry” (14%) and “marital status” (11%). Their distribution during the day does not differ from the previous distributions (Figure 6).

INSERT HERE FIGURE 6: DATA EXTRACTED – DISTRIBUTION OF THE CUSTOMERS’ ARRIVALS AS A FUNCTION OF THE SERVICE REQUESTED AND WORKING HOUR.

As far as the employee performance is concerned, Table 4 shows the mean and standard deviation of the service time for each employee of the municipality, as a function of the service provided to the citizen. From that table, it is immediate to observe that each employee typically performs only some activities of the municipality, reflecting his/her competences in fulfilling specific customers’ requests. For instance, employee 1 can fulfil requests related to registry, certificates or other, while employee 3 is dedicated only to requests related to the marital status. Employee 5, who is the most expert one, is able to fulfil all kinds of customer’s requests.

INSERT HERE TABLE 4: DATA EXTRACTED – MEAN AND STANDARD DEVIATION OF THE CUSTOMERS’ SERVICE TIME AS A FUNCTION OF THE SERVICE REQUESTED AND EMPLOYEE.

6.2 In-field data collection

Besides the data that could be retrieved from the municipality data warehouse, further data were collected by means of direct investigations of the municipality activities. More precisely, the following data were directly collected:

- *Interruptions of the front-office activities*. We have previously mentioned that the work of front-office employees can be interrupted by unwanted disturbances, such as the need for answering phone calls, sending email to the customers, or providing information to customers or colleagues. Front-office employees were directly monitored for 2 weeks (12 working days), to derive an estimate of the number of interruptions during the working time, their distribution and the average duration. We found that disturbances occur, on average, every 0.2 hours (12 minutes), and can be solved, on average, in 0.035 hours (2.1 minutes);
- *Access to the reception*. As previously stated, some ORP customers access the reception, either erroneously (i.e., they do not need any preliminary information), or because they need information about the service they are seeking for, or, finally, because they need the set of forms to be filled to get the service required. The reception activities were directly monitored for about 1 month, to get an estimate of the number of customers accessing the reception and of the time required to redirect them to the ORP. We found that approx. 20% of the customers served by the municipality

have accessed the reception, and that each customer was redirected to the ORP in approx. 0.011 hours (39.6 seconds) on average, with a standard deviation 0.0055 hours.

7 Development of the simulation model

7.1 General overview

The AS IS status of the ORP unit was reproduced in a simulation model. The model was developed *ad hoc* exploiting the commercial software Simul8™ (Visual Thinking International Ltd.). Simul8™ uses dynamic discrete simulation and is commonly exploited to simulate systems that involve processing of discrete entities at discrete times. Examples of those systems are production, manufacturing, logistic or service provision systems. As output, it generates statistics of performance parameters and metrics of the production system examined (Concannon et al., 2007).

The model of the AS IS scenario of the municipality consists of several different Simul8™ files, each one reproducing the flow of the citizens accessing the ORP, as well as the front-office operations performed to provide the citizens with the required service. The overall number of Simul8™ files is obtained coupling two design factors, namely:

i. the weekday;
ii. the operating conditions of the ORP.

With respect to the former factor, each weekday is characterized by a defined opening time of the front-office desks and by a given customers' flow, as previously discussed; therefore, each day was reproduced separately, generating 6 scenarios. As far as the operating conditions are concerned, we consider a "real" operating environment, where the work of employees can be interrupted by unwanted disturbances, and an "ideal" one, where those interferences are absent. In the simulation model, disturbances are introduced by defining two variables, namely the average time between two interferences and the average time to solve an interference, whose values were set at those measured in field. Coupling the two design factors, we have 6x2=12 Simul8™ files for the AS IS scenario.

7.2 Model development under Simul8™

A scheme of the model, as it was designed under Simul8™, is reported in Figure 7.

INSERT HERE FIGURE 7: SCHEME OF THE SIMUL8™ SIMULATION MODEL.

The simulation model consists of several building blocks, with different functions, as described in the following. The first block (*starting point*) is used to generate the users entering the system. In this regard, as

mentioned in the previous sub-section, the simulation model has been set to reproduce each weekday in a different way, according to the front-office opening time and to the flow of users resulting from the data analysis. The time between two consecutive arrivals of customers was modelled as a stochastic exponential variable, which is typically adopted in the queuing theory (Hillier and Lieberman, 2010). Indeed, the stochastic exponential distribution is characterized by absence of memory, which allows well reproducing the arrival time where one arrival is independent of the next one. The mean of the exponential distribution was set at different values as a function of the working hour, according to the results obtained during the data collection phase. For instance, looking at Table 3, it can be seen that the municipality served overall 1,802 citizens on Monday and Thursday from 9 to 10 a.m. From the data warehouse, we found that the exact sharing of those citizens between the two weekdays is 899 on Monday and 903 on Thursday. This is the aggregated number of citizens served across the year 2012. Considering 288 working days per year (i.e., 48 weeks), we can estimate that approx. 903/48≈18.8 citizens/hour were served on Thursday, and that 899/48=18.7 citizens per hour were served on Monday, from 9 to 10 a.m, on average each week. The average interval between two subsequent customers' arrivals is almost the same: it accounts for approx. for 1/18.8≈0.053 hours on Thursday and 1/18.7≈0.053 on Monday. These values were set for the inter-arrival time of citizens from 9 to 10 a.m., in the respective day. The computational procedure described above to set the inter-arrival time as a function of the working hour and weekday was repeated for all the remaining time slots.

The next block (*municipality entrance*) is a dummy work centre, included in the model to assign two different labels to the citizens, so as to distinguish between customers who access the reception and customers who directly enter the ORP. Label 1 is assigned to those customers that access the reception (i.e., 20% of the total number of customers served, as described in section 6.2) and should describe the uninformed citizens, who need preliminary information about the municipality offices, their competences and the service provided. These users are inserted in the *reception queue*, reflecting the fact that they should wait in queue to get some preliminary information about the municipality services. Then, their requests are fulfilled by an operator (*reception employee*) and the customers can move to the ORP (*ORP waiting room*). Conversely, label 2 is assigned to the informed customers, who directly access the ORP *waiting room*.

The next block (*customers sorting*) is a dummy work centre, used to cluster the citizens as a function of the service required, according to the distribution resulting from the data collection. The *customers sorting* block thus assigns the users a new label, describing the service required. These labels are assigned on the basis of the probability that a given service is requested by the citizen (cf. Figure 6). On the basis of their label (and therefore, of the service they are requesting), customers are sorted into four separate *front-office queues*, one for each kind of service needed. Keeping the customers' queues separated is a

simulation artifice that allows setting different service time and to have separate statistics (e.g., number of users in queue) for each service provided by the municipality.

Customers are then routed out the front-office queues according to the employee call, reaching the *front-office employees*. These latter represent the 5 operators of the front-office desks and are reproduced by means of as many basic work centres, whose input data are the employees service time and skills, i.e. the capability to fulfil one or more services required (cf. Table 4). Depending on the weekday simulated, those work centres can be activated or deactivated, according to the employees work shifts (cf. Table 1). Each front-office employee is finally linked to an exit queue (*customers served*), reflecting the customers that exit the municipality.

The simulation model was run with a time step of a minute, meaning that the simulation results are updated each minute. For instance, if an event (e.g., the arrival of a new customer) occurs at minute 2:22, the result will be seen in the model at minute 3:00, when the simulation results are updated. Conversely, the simulation duration depends on the weekday; specifically, for each day, it is set at the opening time of the front-offices desks.

7.3 KPIs measured

Once the simulation model was built, the working group members were involved in a roundtable discussion to deal with the issue of measuring the municipality performance, on the basis of the simulation outcomes. During the discussion, some of the working group members (i.e., the university representatives) illustrated the KPIs proposed in literature to evaluate the performance of public administrations, with a particular attention to the work of Tampieri (2005). The university representatives also showed the outcomes that could be directly obtained from the simulation model and that could be used to assess the performance of the municipality. The remaining group members, on the basis of their knowledge of the municipality, proposed three KPIs that could be computed exploiting the simulation outcomes and could be useful to evaluate the efficiency of the ORP, i.e.:

i. the maximum number of users in queue: it is derived as the maximum number of users in the ORP waiting room during the day and is expressed in [users]. The number of users in queue in the ORP waiting room was used instead of the number of users in queue at each front-office queue to derive the aggregated amount of citizens waiting for a service[3];
ii. the total average waiting time: it is computed as the average waiting time for all services provided by the municipality and could be expressed in [minutes] or [seconds];
iii. the average employee saturation: for each employee, the saturation is derived as the ratio between the time spent daily in his/her working activities and the total working time; it is

[3] Conversely, as mentioned previously, the front-office queues were exploited to calculate the waiting time of customers and the number of users in queue, as a function of the service required.

expressed in [%]. As an aggregate KPI of the municipality, the average saturation of all the front-office employees was evaluated. Obviously, when simulating the scenarios with "disturbances", the working activities include also the time spent to solve those disturbances.

7.4 Determination of the number of replicates and validation

Before running the model to reproduce the AS IS scenario and the TO BE one, the number of replicates required to ensure sufficient reliability of the results was estimated. To this extent, we exploited the simulation model reproducing the configuration of Monday, with disturbances. We manually launched 20 times the simulation model and assessed the stability of the outcomes, i.e. the maximum number of users in queue, the average waiting time and the average employee saturation. Specifically, starting from replicate 2 and as a function of the number of replicates *n*, we computed the mean $\bar{x}$ and variance σ^2 of each output observed, as well as the confidence interval at p=95% (α=0.05) of the output. The following formulae were adopted for the computation of the confidence interval (cf. Field, 2013):

$$\text{CI–lower} = \bar{x} - T(\alpha/2, n-1) * \frac{\sigma}{\sqrt{n}} \quad (1)$$

$$\text{CI–upper} = \bar{x} + T(\alpha/2, n-1) * \frac{\sigma}{\sqrt{n}} \quad (2)$$

where CI-lower and CI-upper denote the lower and upper bound of the confidence interval of the result and $T(\alpha/2, n-1)$ is the *T*-distribution with *n-1* degrees of freedom. The trend of the confidence interval as a function of the number of replicates is shown in Figure 8. The detailed outputs of the 20 replicates and the corresponding mean, variance and confidence intervals, are reported in Appendix I (Table A-1). From Figure 8, it can be seen that the simulation outcomes reach sufficient stability after 15 replicates, which, therefore, was set as the number of runs in the "Conduct trial" feature of Simul8™ (Concannon et al., 2007) for subsequent analyses.

INSERT HERE FIGURE 8: CONFIDENCE INTERVAL OF SIMULATION OUTCOMES AS A FUNCTION OF THE NUMBER OF REPLICATES IN AN EXAMPLE SCENARIO (I.E., MONDAY, WITH DISTURBANCES).

As a final step, before using the simulation model for performance evaluation, we tested its accuracy compared to the real scenario. We therefore conducted a trial with 15 replicates for each weekday, under the "real" operating environment (i.e., with possible disturbances) and derived the resulting number of customers served per day by each employee. That outcome was compared to a similar performance parameter computed independently by the municipality officer, before the study described in the paper

was carried out. The comparison showed that those data differed less than 1%; therefore, the model was considered as validated by the municipality representatives[4].

7.5 AS IS performance analysis

The KPIs listed in sub-section 7.3 were computed for all 12 scenarios describing the AS IS configuration of the ORP, exploiting, as mentioned, trials of 15 simulation runs for each scenario; a summary of the outcomes is proposed in Table 5, while the detailed results are proposed in Appendix II (Table A-2)[5]. Figure 9 shows an example of the detailed performance of one employee, as it can be obtained from the simulation, in terms of the percentage of time spent working, awaiting and disturbed (stopped). The example refers to a specific AS IS configuration, i.e. Monday, with disturbances.

INSERT HERE TABLE 5: PERFORMANCE OF THE AS IS CONFIGURATION OF THE MUNICIPALITY.

INSERT HERE FIGURE 9: PERFORMANCE OF THE AS IS SYSTEM IN AN EXAMPLE SCENARIO (I.E. MONDAY, WITH DISTURBANCES) – SHARING OF THE TIME SPENT BY EMPLOYEES INTO DIFFERENT CATEGORIES.

From Table 5, it is immediate to see that there are always no more than 5 users is queue at the municipality. Those users are requesting different services, so that there are at most 2 users in queue for each of the service provided by the municipality (cf. Table A-2); consequently, the waiting time of citizens is always very limited. At first glance, this could seem a good outcome. However, when considering the operators' efficiency, it emerges that the saturation is lower than approx. 53% under the real operating conditions (i.e., with disturbances), while its value is lower than 43% when considering absence of disturbances. Indeed, the "awaiting time" of the employees is always quite high compared to the "working time", as shown in the example in Figure 9. Thus, in response to RQ1, the municipality efficiency in the AS IS scenario turns out to be, overall, scarce. We recall that one of the reasons why the BPR study was carried out was to evaluate the adequacy of the ORP workforce, compared to the users' requests. Under this

[4] Because of confidentiality and privacy reasons, we cannot include in the paper the (real) performance of the front-office employees, as they were computed by the municipality officers. Accordingly, the presentation of the results is limited to our (simulated) outcomes.

[5] For the sake of clarity, it should be mentioned that the outcomes proposed in Table A-1 and Table A-2 cannot be directly compared. To be more precise, to build Table A-1 we have manually launched 20 simulation runs of an example scenario (Monday, with disturbances). For each launch, we recorded the simulation outcomes and computed (manually) the mean, variance and confidence interval of the outcomes. Conversely, to build Table A-2, we used the "Conduct trial" feature of Simul8™, with 15 trials. With this feature, the software launches automatically 15 replicates of the scenario and reports, as results, the average values of the performance parameter over all 15 replications. Because of the difference in the number of replicates and in the software feature used, results in Tables A-1 and Table A-2 are not directly comparable.

perspective, it is clear that there is room for improving the current efficiency of the municipality workforce; hence, the TO BE scenarios were designed in line with this purpose.

8 Design of the TO BE processes

8.1 Definition of the TO BE scenarios

The TO BE scenarios were designed with the aim to increase the efficiency of the municipality workforce, which appeared to be oversized compared to the current requests of services by the citizens. In this regards, two operating leverages were identified by the working group, namely:

i. the number of users accessing the municipality daily; and
ii. the number of employees working each day.

Those leverages were combined with the two operating conditions used in the AS IS scenario, reflecting the presence or absence of disturbances during the working time.

As regards the number of users accessing the municipality, in the TO BE scenario it was increased by 20%, 40% and 60% compared to the AS IS situation. The rationale behind this choice is twofold. First, it aims to check the ability of the municipality workforce to handle a growth of the workload, or the presence of working peaks. Moreover, an increased number of customers could reflect the situation where the municipality will provide additional services to the citizens or it will serve citizens from foreign municipalities, under a "cost and service sharing" policy. By coupling the increase in the customers' arrivals with the weekdays and the operating conditions, we obtain 3x6x2=36 TO BE configurations that investigate this operating leverage, reproduced by as many Simul8™ files.

As regards the number of employees operating each day, other TO BE scenarios were designed by changing the "employees mix". Since the ORP employs 5 people for front-office activities, numerous TO BE configurations could be obtained by combining the employees working each day. In this regard, the working group defined the following constraints the TO BE scenarios should meet, i.e.:

(1) ensuring that the kind of services provided by the municipality is the same as the AS IS scenario, meaning that all the services currently provided should be guaranteed to the customers;
(2) maintaining the current opening time of the front-office desks;
(3) respecting the employees work shifts;
(4) being applicable for at least three weekdays, so as to represent a realistic option for redistributing the municipality workforce.

The working group identified 8 TO BE configurations for the "employees mix" that met the above constraints; they are listed and described in Table 6. These configurations were obtained by removing one,

or more, employees from the ORP workforce; these employees can be allocated to a different municipality office. On the basis of the constraints listed above and, in particular on the competences and work shifts of the employees removed, it is easy to see that a configuration can be either suitable for implementation each weekday, or can be adopted only in some weekdays. However, as mentioned, configurations whose feasibility is extremely limited (e.g., only one weekday) were not considered, because they fail to meet the fourth criterion listed above.

For instance, configuration 1 was obtained by removing employee 1 from the ORP workforce. Taking into account his/her competences (Table 4) and work shift (Table 1), it emerges that this configuration cannot be deployed on Monday, Tuesday and Thursday. Indeed, removing employee 1 does no allows respecting the front-offices opening time of the AS IS scenario in those days, since no operators will be working between 1 and 2 p.m. For the remaining three weekdays, configuration 1 can be implemented without jeopardizing the service offered by the municipality. The same considerations can be easily repeated for configurations 2 to 5.

As regards configurations 6 to 8, they were designed removing more than one employee from the ORP workforce. Specifically, employee 5 was never removed, because it is the only employee able to fulfil any kind of customers' request. Employee 2 and 4 own similar characteristics in terms of skills, which, in turn, are similar to those of employee 1; therefore, one of them (or both) could be removed from the ORP workforce if employee 1 is working. Employee 3 has a specific skill for requests related to "marital status", that can, however, be fulfilled also by employee 5; therefore, employee 3 could be removed provided that employee 5 is working.

INSERT HERE TABLE 6: TO BE CONFIGURATIONS FOR EMPLOYEES MIX.

By combining those configurations with the operating conditions, we obtain 8x2=16 scenarios for the employees mix, and 16+36=52 TO BE scenarios overall; for all those scenarios, a trial of 15 simulation runs was conducted. It should be specified that the working group suggested not to consider, at this stage, a combination of the two operating leverages, i.e. an increase in the number of customers coupled with a contemporary decrease in the municipality workforce. Indeed, from the practical perspective, combining those leverages would reflect the situation where the municipality tries to increase the service delivered to the customers (either providing additional services or starting serving customers of the neighbour municipalities) and at the same time reduces its workforce; this does not seem to be a realistic option for the municipality.

8.2 TO BE performance evaluation

To compare the performance of the TO BE scenarios with those of the AS IS one, the same KPIs were computed starting from the simulation outcomes. Results are summarized in Tables 7-8, respectively for the scenarios where we examine the increase in the number of customers and the modifications of the employees work shifts; for detailed outcomes, the reader is referred to the Appendix II (Tables A-3 and A-4).

Looking at Table 7, one can appreciate that the current municipality workforce would be able to deal efficiently with an increase in the number of customers served. As a matter of fact, with a 40% increase in the customers' arrivals, the maximum number of users in queue is 18 (=1+4+1+12) people, while, with a 60% increase, the users queue reaches 35 (=1+11+1+22) people. Both peaks are observed on Saturday, under the real scenario with disturbances, and are probably due to the reduced workforce available at the municipality on that day. Nonetheless, even with 60% customers increase, the average waiting time is always limited (less than 15 minutes), suggesting that the municipality would be able to fulfil the requests by the citizens in an acceptable time. Obviously, when increasing the number of customers served, the average employees saturation increases as well, reaching a peak of 74.62% in presence of disturbances (62.61% under absence of disturbances). This figures highlight a relevant improvement compared to the AS IS scenario; at the same time, those saturation values are sufficiently far from 100% and are, therefore, expected to be well supported by the front-office employees.

INSERT HERE TABLE 7: SUMMARY OF THE RESULTS FOR THE TO BE SCENARIOS WITH INCREASE IN THE CUSTOMERS' ARRIVALS.

As regards the employee mix, from Table 8 it can be observed that most of the configurations proposed are able to fulfil the customer's requests efficiently. In fact, the only peak of users in queue is observed on Saturday, under configuration 8, and accounts for 46 users (with disturbances) or 44 users (without disturbances). This result is obviously due to the fact that, under configuration 8, the municipality workforce is extremely reduced, including only 2 out of 5 front-office employees. All the remaining configurations generate a number of users in queue lower than 22 people (with disturbances) or 19 people (without disturbances), which could be efficiently handled by the municipality front-office employees. The maximum waiting time accounts for approx. 26 minutes (with disturbances) and 20 minutes (without disturbances), with an average of 5:05 and 2:40 minutes in presence or absence of disturbances, respectively. Those values indicate that all configurations ensure an acceptable service level to the customers. With respect to the employee saturation, its value improves, compared to the AS IS scenario; the average value across all the configurations accounts for 61.54% (with disturbances) and 48.66%

(without disturbances). Peaks of saturation, ranging approximately from 80% to 92%, are observed on Saturday, under configurations 6, 7 and 8; because of the very high saturation, those configurations are probably unsuitable for a real implementation on that day. Nonetheless, recalling RQ2, the considerations above lead to the conclusion that there are several new configurations of the municipality workforce that would improve the current performance of the system.

One specific configuration, i.e. configuration 2, turned out to be particularly interesting to the workgroup (and specifically, to the municipality representatives), for several reasons. First, it is the only configuration that could be implemented each weekday, without the need for modifying the ORP opening time compared to the original scenario. This is a crucial point in the case the municipality officers would like to ponder the practical implementation of this new configuration. Similarly, the service provided by the municipality would not change, compared to the AS IS configuration. Also, configuration 2 was obtained by removing employee 2 from the front-office workforce. This means that the employee removed could be permanently allocated to a different municipality office, resulting in a new organization of the workforce.

As regards the performance, under configuration 2 the number of users in queue is limited to 9 people (observed on Saturday, with disturbances), while the corresponding waiting time accounts for less than 4:30 minutes. Most of the remaining configurations generate a significantly greater number of users in queue and a corresponding higher waiting time; the only exceptions in this regard are configurations 1 and 3, whose applicability during the week, however, is more limited. Moreover, under configuration 2, the employee saturation ranges from a maximum of 62.64% (on Saturday, with disturbances) to a minimum of 30.66% (on Monday, without disturbances). Moreover, although one employee is removed, the employee saturation obtained for configuration 2 is in line with that of the AS IS scenario, thus confirming the improved workforce organization.

INSERT HERE TABLE 8: SUMMARY OF THE RESULTS FOR THE TO BE SCENARIOS WITH MODIFICATIONS OF THE EMPLOYEES' MIX.

9 Conclusions

9.1 Summary of findings and practical implications

This paper has dealt with the assessment and improvement of the performance of the ORP of a public organization in Italy. A combination of BPR and simulation was exploited to first assess the current efficiency of the organization, then to redesign its internal processes to increase its performance. The main weakness of the ORP of the public administration, as it emerged from the analysis of the AS IS scenario, was the very limited employee saturation, always lower than approx. 53%, reflecting the fact that employees

are actually unemployed for most of their working time. Therefore, after the AS IS analysis, it became evident that the quantity of resources of the ORP were not adequate to the number of customers served by the municipality, resulting in underused workforce. Hence, a fundamental question that arose was whether the workforce efficiency can be somehow improved. To answer this question, numerous TO BE scenarios were designed to increase the municipality efficiency and the corresponding performance level was assessed through simulation.

From the practical perspective, the TO BE scenarios examined provide the municipality with some interesting suggestions to improve the current performance of the system. Those results are obviously specific to the municipality we analysed in this study; nonetheless, with adaptations, their rationale could be applied to the whole public administration sector. Specifically, it is first evident that, by maintaining the current workforce, the municipality ORP would be able to deal with a number of customers significantly higher than that served in the AS IS scenario. Specifically, an increase up to 60% in the number of citizens served by the municipality would not worsen the performance of the municipality to an appreciable extent. Therefore, the municipality officers could consider the opportunity of providing additional services to the citizens or to serve also the neighbouring municipalities, to enhance the employee saturation.

As a second guideline, the municipality officers could decide to modify the ORP workforce and, in particular, to reduce it, by reallocating one or more employees to a different office. Findings from our study indicate that this choice would be potentially feasible, since several configurations of employee mix we examined provide satisfactory results in terms of employee saturation, number of users in queue and waiting time of customers. Configuration 2, in particular, seems to be quite interesting for a practical implementation. According to this configuration, employee 2 could be permanently reallocated to a different office; this reallocation would not affect the ORP opening time or the services provided by the municipality. This is an important consideration in the case the municipality officers would ponder the real implementation of this new configuration in practice. Also, this configuration allows balancing the employee saturation, which will range from 30.66% to 62.64% for all the remaining employees and thus could be well supported by them.

9.2 Theoretical contributions

With respect to the theoretical contributions, we have mentioned that scientific literature has widely debated the issue of public administration efficiency. At the same time, however, “in field” studies of BPR in the public organizations are not so numerous and are often motivated by the introduction of innovations (e.g., ICT tools or e-government) in the public sector. Moreover, literature does not report BPR studies targeting public administrations in Italy, despite the relevance of the public section in this country (Ragioneria Generale dello Stato, 2012). By taking a different perspective, focused on improving the

performance of the public administration, and by analysing an Italian organization, our BPR study is expected to be an interesting addition to the literature.

As regards the methodology adopted, BPR and simulation are not new techniques. Nonetheless, this study suggests that simulation could be very useful to support BPR analyses: in our study, by means of simulation, we were able to analyse more than 50 TO BE scenarios of the targeted municipality and to assess the related performance, without the need of implementing them in practice. Applying simulation in BPR studies, therefore, can be an interesting strategy whenever the process reengineering cannot be immediately implemented in practice, or when there is the need for assessing the expected performance before implementing any reengineering. This is exactly the case of public administrations: here, managers have less decision-making autonomy, compared to the private sector, making it more difficult to implement changes in the work settings (Rainey et al., 1976; Thong et al., 2000).

9.3 Limitations and future research directions

Some limitations of this work should also be mentioned. We have just recalled that, in public organizations, it is often difficult to implement changes in the work settings. This is the reason why, in our study, the reengineering of the municipality processes was only simulated, without being implemented in practice. Although the simulated model was validated, our outcomes would need to be substantiated by a real "in field" implementation of one TO BE scenario and by the direct observation of the resulting outcomes. This is, obviously, the natural future step of this research. With respect to the choice of the TO BE scenario, our results suggest that configuration 2, as already mentioned, is the most suitable one for a practical implementation. Care must be taken, however, when approaching the real implementation of the reengineered scenario. Indeed, the TO BE scenarios considered in this study are only examples of possible reorganizations of the municipality workforce; their real applicability in the context examined was not tested in this study. Additional research is needed, for instance, to assess the cost of the TO BE scenario, in terms of the resources required to implement it or the time required to have the new scenario working at full speed. As a final point, earlier in the paper we have stated that the municipality examined consists of two main units, i.e. the ORP and the reception, while this study targeted only one of those units. Although this choice was motivated, it is evident that, to assess the overall performance of the municipality, the same analysis carried out in this paper should be extended also to the reception. This is left for further studies.

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Appendix I

KPI	Number of replicates																			
Maximum number of users in queue	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Registry	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
mean		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
variance		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CI - lower		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CI - upper		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Certificates	2	2	2	3	1	2	2	1	1	1	1	1	1	1	1	2	1	2	5	1
mean		2.00	2.00	2.25	2.00	2.00	2.00	1.88	1.78	1.70	1.64	1.58	1.54	1.50	1.47	1.50	1.47	1.50	1.68	1.65
variance		0.00	0.00	0.25	0.50	0.40	0.33	0.41	0.44	0.46	0.45	0.45	0.44	0.42	0.41	0.40	0.39	0.38	1.01	0.98
CI - lower		2.00	2.00	2.00	1.69	1.75	1.79	1.65	1.56	1.49	1.44	1.39	1.36	1.33	1.30	1.34	1.32	1.36	1.46	1.43
CI - upper		2.00	2.00	2.50	2.31	2.25	2.21	2.10	2.00	1.91	1.84	1.77	1.72	1.67	1.63	1.66	1.62	1.64	1.91	1.87
Marital status	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
mean		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
variance		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CI - lower		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CI - upper		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Other	3	3	1	5	5	1	2	1	1	1	1	1	1	1	1	2	2	1	2	3
mean		3.00	2.33	3.00	3.40	3.00	2.86	2.63	2.44	2.30	2.18	2.08	2.00	1.93	1.87	1.88	1.88	1.83	1.84	1.90
variance		0.00	1.33	2.67	2.80	3.20	2.81	2.84	2.78	2.68	2.56	2.45	2.33	2.23	2.12	1.98	1.86	1.79	1.70	1.67
CI - lower		3.00	1.68	2.20	2.67	2.28	2.24	2.04	1.90	1.79	1.71	1.64	1.58	1.54	1.50	1.53	1.56	1.52	1.55	1.62
CI - upper		3.00	2.99	3.80	4.13	3.72	3.48	3.21	2.99	2.81	2.66	2.53	2.42	2.32	2.24	2.22	2.21	2.14	2.13	2.18
KPI	4	6	6	7	5	7	6	4	5	4	4	4	4	5	4	6	5	5	9	6
mean		5.00	5.33	5.75	5.60	5.83	5.86	5.63	5.56	5.40	5.27	5.17	5.08	5.07	5.00	5.06	5.06	5.06	5.26	5.30
variance		2.00	1.33	1.58	1.30	1.37	1.14	1.41	1.28	1.38	1.42	1.42	1.41	1.30	1.29	1.26	1.18	1.11	1.87	1.80
CI - lower		4.02	4.68	5.13	5.10	5.37	5.46	5.21	5.19	5.04	4.92	4.83	4.75	4.77	4.71	4.79	4.80	4.81	4.96	5.01
CI - upper		5.98	5.99	6.37	6.10	6.30	6.25	6.04	5.93	5.76	5.62	5.50	5.40	5.37	5.29	5.34	5.32	5.30	5.57	5.59
Average waiting time	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Registry	0.00	0.00	0.00	0.00	0.00	0.00	18.00	0.00	18.00	0.00	0.00	0.00	0.00	0.00	0.00	72.00	0.00	0.00	0.00	18.00
mean		0.00	0.00	0.00	0.00	0.00	2.57	2.25	4.00	3.60	3.27	3.00	2.77	2.57	2.40	6.75	6.35	6.00	5.68	6.30
variance		0	0	0	0	0	46.29	40.5	63	57.6	53.02	49.09	45.69	42.73	40.11	340.2	321.62	304.94	289.89	282.22
CI - lower		0.00	0.00	0.00	0.00	0.00	0.05	0.04	1.41	1.25	1.12	1.02	0.93	0.86	0.80	2.23	2.09	1.96	1.85	2.62
CI - upper		0.00	0.00	0.00	0.00	0.00	5.09	4.46	6.59	5.95	5.43	4.98	4.61	4.28	4.00	11.27	10.62	10.04	9.51	9.98
Certificates	36.00	54.00	72.00	72.00	18.00	360.00	144.00	180.00	72.00	18.00	0.00	0.00	0.00	18.00	54.00	198.00	72.00	36.00	144.00	72.00
mean		45.00	54.00	58.50	50.40	102.00	108.00	117.00	112.00	102.60	93.27	85.50	78.92	74.57	73.20	81.00	80.47	78.00	81.47	81.00
variance		162	324	297	550.8	16416	13932	12589.71	11241	10875.60	10745.018	10493.18	10181.08	9663.03	9001.03	9374.40	8793.26	8385.88	8149.26	7724.84
CI - lower		36.14	43.79	50.04	40.10	50.69	64.24	78.09	77.34	70.26	62.63	56.51	51.48	48.81	49.18	57.27	58.17	56.84	61.17	61.73

CI - upper		53.86	64.21	66.96	60.70	153.31	151.76	155.91	146.66	134.94	123.92	114.49	106.36	100.33	97.22	104.73	102.77	99.16	101.78	100.27
Marital status	0.00	90.00	0.00	0.00	0.00	54.00	0.00	0.00	0.00	0.00	0.00	36.00	0.00	0.00	0.00	0.00	36.00	0.00	0.00	0.00
mean		45.00	30.00	22.50	18.00	24.00	20.57	18.00	16.00	14.40	13.09	15.00	13.85	12.86	12.00	11.25	12.71	12.00	11.37	10.80
variance		4050.00	2700.00	2025.00	1620.00	1512.00	1342.29	1203.43	1089.00	993.60	913.09	873.82	818.31	769.05	725.14	685.80	678.97	648.00	619.58	593.43
CI - lower		0.72	0.53	0.41	0.34	8.43	6.99	5.97	5.21	4.63	4.16	6.63	6.07	5.59	5.18	4.83	6.51	6.12	5.77	5.46
CI - upper		89.28	59.47	44.59	35.66	39.57	34.15	30.03	26.79	24.17	22.02	23.37	21.63	20.12	18.82	17.67	18.90	17.88	16.97	16.14
Other	108.00	216.00	180.00	360.00	108.00	0.00	36.00	0.00	54.00	144.00	162.00	36.00	0.00	0.00	54.00	108.00	36.00	90.00	180.00	72.00
mean		162.00	168.00	216.00	194.40	162.00	144.00	126.00	118.00	120.60	124.36	117.00	108.00	100.29	97.20	97.88	94.24	94.00	98.53	97.20
variance		5832	3024	11232	10756.8	14904	14688	15181.71	13860	12387.60	11304.65	10927.64	11070	11051.60	10405.03	9718.65	9336.44	8788.24	8689.26	8267.12
CI - lower		108.86	136.81	163.98	148.89	113.11	99.07	83.28	79.52	86.09	92.93	87.41	79.39	72.74	71.38	73.71	71.26	72.34	77.56	77.27
CI - upper		215.14	199.19	268.02	239.91	210.89	188.93	168.72	156.48	155.11	155.80	146.59	136.61	127.83	123.02	122.04	117.21	115.66	119.49	117.13
KPI	36.00	90.00	63.00	108.00	32.00	103.00	49.00	45.00	36.00	41.00	41.00	18.00	0.00	5.00	27.00	95.00	36.00	32.00	81.00	41.00
mean		63.00	63.00	74.25	65.80	72.00	68.71	65.75	62.44	60.30	58.55	55.17	50.92	47.64	46.27	49.31	48.53	47.61	49.37	48.95
CI - lower		36.43	47.69	58.79	51.24	58.65	56.98	55.18	52.58	51.23	50.16	46.83	42.20	38.95	38.06	41.08	40.75	40.23	42.17	42.11
CI - upper		89.57	78.31	89.71	80.36	85.35	80.45	76.32	72.31	69.37	66.93	63.51	59.65	56.34	54.47	57.55	56.30	55.00	56.56	55.79
Employee saturation	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Employee1	43.76%	42.38%	44.98%	47.94%	35.23%	41.43%	46.24%	42.67%	37.72%	41.60%	37.20%	40.38%	33.61%	41.60%	42.26%	38.69%	41.42%	41.31%	40.06%	41.56%
mean		43.07%	43.71%	44.77%	42.86%	42.62%	43.14%	43.08%	42.48%	42.40%	41.92%	41.79%	41.16%	41.20%	41.27%	41.11%	41.12%	41.13%	41.08%	41.10%
variance		0.01%	0.02%	0.06%	0.22%	0.18%	0.17%	0.15%	0.16%	0.14%	0.15%	0.14%	0.18%	0.17%	0.16%	0.15%	0.14%	0.13%	0.13%	0.12%
CI - lower		42.39%	42.97%	43.60%	40.78%	40.91%	41.60%	41.75%	41.17%	41.22%	40.76%	40.73%	40.01%	40.12%	40.27%	40.16%	40.23%	40.29%	40.28%	40.35%
CI - upper		43.75%	44.44%	45.93%	44.93%	44.33%	44.67%	44.41%	43.79%	43.57%	43.08%	42.86%	42.32%	42.27%	42.27%	42.05%	42.02%	41.98%	41.88%	41.86%
Employee2	42.62%	40.66%	38.22%	41.28%	41.96%	42.72%	41.81%	40.39%	37.96%	40.42%	38.36%	38.83%	32.83%	37.11%	40.77%	39.63%	40.83%	36.67%	38.50%	40.24%
mean		41.64%	40.50%	40.70%	40.95%	41.24%	41.32%	41.21%	40.85%	40.80%	40.58%	40.44%	39.85%	39.66%	39.73%	39.72%	39.79%	39.62%	39.56%	39.59%
variance		0.02%	0.05%	0.03%	0.03%	0.03%	0.02%	0.02%	0.03%	0.03%	0.03%	0.03%	0.07%	0.07%	0.07%	0.06%	0.06%	0.06%	0.06%	0.06%
CI - lower		40.68%	39.25%	39.79%	40.21%	40.57%	40.75%	40.70%	40.27%	40.29%	40.07%	39.95%	39.12%	38.95%	39.07%	39.11%	39.21%	39.04%	39.01%	39.07%
CI - upper		42.60%	41.75%	41.60%	41.69%	41.92%	41.90%	41.72%	41.42%	41.32%	41.09%	40.93%	40.58%	40.36%	40.39%	40.34%	40.37%	40.19%	40.10%	40.11%
Employee3	24.14%	29.42%	26.65%	33.96%	25.81%	32.41%	29.07%	28.98%	25.48%	26.32%	27.32%	29.93%	28.04%	27.23%	26.52%	28.37%	25.55%	23.42%	23.48%	23.74%
mean		26.78%	26.74%	28.54%	28.00%	28.73%	28.78%	28.81%	28.44%	28.22%	28.14%	28.29%	28.27%	28.20%	28.09%	28.10%	27.95%	27.70%	27.48%	27.29%
variance		0.14%	0.07%	0.18%	0.15%	0.15%	0.13%	0.11%	0.11%	0.10%	0.09%	0.08%	0.08%	0.07%	0.07%	0.06%	0.06%	0.07%	0.08%	0.08%
CI - lower		24.18%	25.24%	26.48%	26.31%	27.18%	27.47%	27.67%	27.37%	27.25%	27.25%	27.47%	27.51%	27.49%	27.42%	27.48%	27.35%	27.08%	26.85%	26.67%
CI - upper		29.38%	28.23%	30.61%	29.68%	30.29%	30.09%	29.94%	29.50%	29.20%	29.03%	29.11%	29.03%	28.90%	28.75%	28.73%	28.56%	28.32%	28.10%	27.91%
Employee4	42.13%	51.75%	50.71%	58.90%	44.78%	50.66%	59.50%	46.25%	41.61%	44.30%	42.72%	47.69%	36.06%	47.57%	55.67%	58.40%	45.21%	68.85%	55.84%	43.77%
mean		46.94%	48.20%	50.87%	49.65%	49.82%	51.20%	50.59%	49.59%	49.06%	48.48%	48.42%	47.47%	47.47%	48.02%	48.67%	48.47%	49.60%	49.93%	49.62%
variance		0.46%	0.28%	0.47%	0.43%	0.34%	0.42%	0.39%	0.43%	0.41%	0.41%	0.37%	0.46%	0.42%	0.44%	0.48%	0.45%	0.66%	0.64%	0.63%
CI - lower		42.21%	45.20%	47.50%	46.78%	47.47%	48.80%	48.42%	47.44%	47.07%	46.60%	46.69%	45.63%	45.77%	46.35%	46.98%	46.87%	47.73%	48.13%	47.88%
CI - upper		51.67%	51.19%	54.25%	52.53%	52.17%	53.61%	52.75%	51.74%	51.05%	50.37%	50.14%	49.31%	49.18%	49.69%	50.36%	50.06%	51.47%	51.73%	51.35%
Employee5	45.87%	49.06%	52.29%	58.26%	47.55%	51.68%	56.77%	54.34%	44.72%	50.73%	46.95%	51.46%	43.32%	51.84%	49.84%	63.61%	55.65%	60.43%	52.64%	54.79%
mean		47.47%	49.07%	51.37%	50.61%	50.79%	51.64%	51.98%	51.17%	51.13%	50.75%	50.81%	50.23%	50.35%	50.31%	51.14%	51.41%	51.91%	51.95%	52.09%
variance		0.05%	0.10%	0.28%	0.24%	0.19%	0.21%	0.19%	0.23%	0.20%	0.20%	0.18%	0.21%	0.19%	0.18%	0.28%	0.27%	0.30%	0.29%	0.27%
CI - lower		45.90%	47.25%	48.77%	48.46%	49.03%	49.93%	50.46%	49.62%	49.74%	49.44%	49.61%	48.99%	49.19%	49.24%	49.85%	50.17%	50.64%	50.75%	50.94%
CI - upper		49.03%	50.89%	53.97%	52.75%	52.54%	53.35%	53.49%	52.72%	52.52%	52.06%	52.00%	51.47%	51.50%	51.38%	52.44%	52.65%	53.18%	53.15%	53.24%
Employee saturation -	39.70%	42.65%	42.57%	48.07%	39.07%	43.78%	46.68%	42.53%	37.50%	40.67%	38.51%	41.66%	34.77%	41.07%	43.01%	45.74%	41.73%	46.14%	42.10%	40.82%

average																			
mean	41.18%	41.64%	43.25%	42.41%	42.64%	43.22%	43.13%	42.50%	42.32%	41.98%	41.95%	41.40%	41.37%	41.48%	41.75%	41.75%	41.99%	42.00%	41.94%
variance	0.04%	0.03%	0.12%	0.13%	0.10%	0.11%	0.10%	0.12%	0.11%	0.11%	0.10%	0.13%	0.12%	0.12%	0.12%	0.11%	0.12%	0.11%	0.10%
CI - lower	39.73%	40.69%	41.53%	40.85%	41.35%	41.99%	42.06%	41.38%	41.30%	40.99%	41.05%	40.41%	40.46%	40.62%	40.90%	40.95%	41.21%	41.25%	41.23%
CI - upper	42.63%	42.60%	44.96%	43.97%	43.93%	44.45%	44.20%	43.63%	43.34%	42.96%	42.85%	42.39%	42.29%	42.34%	42.59%	42.54%	42.78%	42.74%	42.65%

Table A-1: mean, variance and confidence interval of the simulation outcomes as a function of the number of replicates in an example scenario (i.e., Monday, with disturbances).

Appendix II

Operating condition	**with disturbances**						**without disturbances**						
Maximum number of users in queue	Mon	Tue	Wed	Thu	Fri	Sat	**Maximum number of users in queue**	Mon	Tue	Wed	Thu	Fri	Sat
Registry	1	1	1	1	1	1	**Registry**	1	1	1	1	1	1
Certificates	1	1	1	1	1	1	**Certificates**	1	1	1	1	1	1
Marital status	1	1	1	1	2	1	**Marital status**	1	1	1	1	2	1
Other	1	1	1	1	1	1	**Other**	1	1	1	1	1	1
Average waiting time	Mon	Tue	Wed	Thu	Fri	Sat	**Average waiting time**	Mon	Tue	Wed	Thu	Fri	Sat
Registry	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	**Registry**	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00
Certificates	00:00:18	00:00:00	00:00:36	00:00:00	00:00:00	00:01:30	**Certificates**	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:01:12
Marital status	00:00:00	00:00:00	00:00:00	00:00:00	00:05:24	00:00:00	**Marital status**	00:00:00	00:00:00	00:00:00	00:00:00	00:05:24	00:00:00
Other	00:00:00	00:00:36	00:01:06	00:03:36	00:00:00	00:01:12	**Other**	00:00:54	00:00:00	00:01:30	00:00:36	00:00:00	00:00:36
Employee saturation	Mon	Tue	Wed	Thu	Fri	Sat	**Employee saturation**	Mon	Tue	Wed	Thu	Fri	Sat
Employee1	41.60%	56.94%	58.81%	38.46%	49.41%	-	**Employee1**	28.51%	34.52%	37.88%	25.91%	32.47%	-
Employee2	37.11%	56.49%	61.78%	39.99%	57.36%	70.63%	**Employee2**	31.08%	36.96%	44.95%	26.63%	38.22%	63.24%
Employee3	27.23%	26.22%	26.59%	29.51%	26.26%	34.03%	**Employee3**	13.06%	11.99%	16.33%	13.88%	11.02%	17.61%
Employee4	47.57%	50.12%	51.48%	54.88%	47.92%	57.19%	**Employee4**	44.36%	25.29%	30.32%	41.66%	23.82%	47.68%
Employee5	51.84%	49.37%	50.31%	60.95%	47.35%	50.23%	**Employee5**	36.38%	33.06%	41.35%	48.65%	30.36%	41.64%

Table A-2: detailed performance of the AS IS scenario.

Operating condition	**with disturbances**						**without disturbances**						
Maximum number of users in queue													
Customer's increase: +20%	Mon	Tue	Wed	Thu	Fri	Sat	**Customer's increase: +20%**	Mon	Tue	Wed	Thu	Fri	Sat
Registry	1	1	1	1	1	1	**Registry**	1	1	1	1	1	1
Certificates	2	1	1	4	1	2	**Certificates**	1	1	1	2	1	1
Marital status	1	1	1	1	2	1	**Marital status**	1	1	1	1	2	1
Other	1	1	1	1	1	2	**Other**	1	1	1	1	1	1

Customer's increase: +40%	Mon	Tue	Wed	Thu	Fri	Sat	Customer's increase: +40%	Mon	Tue	Wed	Thu	Fri	Sat
Registry	1	1	1	1	1	1	Registry	1	1	1	1	1	1
Certificates	3	1	2	3	1	4	Certificates	1	1	2	2	1	1
Marital status	1	1	1	1	2	1	Marital status	1	1	1	1	2	1
Other	4	1	1	1	1	12	Other	1	1	1	1	1	4
Customer's increase: +60%	Mon	Tue	Wed	Thu	Fri	Sat	Customer's increase: +60%	Mon	Tue	Wed	Thu	Fri	Sat
Registry	1	1	1	1	1	1	Registry	1	1	1	1	1	1
Certificates	4	3	6	4	1	11	Certificates	4	2	3	2	1	9
Marital status	1	1	1	1	2	1	Marital status	1	1	1	1	2	1
Other	10	7	14	10	1	22	Other	4	2	4	7	1	21
Average waiting time													
Customer's increase: +20%	Mon	Tue	Wed	Thu	Fri	Sat	Customer's increase: +20%	Mon	Tue	Wed	Thu	Fri	Sat
Registry	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	Registry	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00
Certificates	00:03:00	00:00:00	00:00:48	00:00:36	00:01:30	00:00:36	Certificates	00:00:36	00:00:00	00:00:00	00:03:36	00:00:00	00:01:48
Marital status	00:00:00	00:00:00	00:00:00	00:00:00	00:06:00	00:00:36	Marital status	00:00:00	00:00:00	00:00:00	00:00:00	00:06:00	00:00:00
Other	00:00:36	00:00:00	00:02:06	00:04:48	00:01:30	00:01:48	Other	00:01:30	00:00:00	00:01:48	00:01:12	00:00:00	00:00:36
Customer's increase: +40%	Mon	Tue	Wed	Thu	Fri	Sat	Customer's increase: +40%	Mon	Tue	Wed	Thu	Fri	Sat
Registry	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:54	Registry	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00
Certificates	00:00:36	00:01:12	00:00:36	00:00:36	00:00:00	00:01:48	Certificates	00:02:24	00:00:00	00:00:36	00:03:00	00:00:00	00:02:06
Marital status	00:00:00	00:00:00	00:00:00	00:00:36	00:05:24	00:00:00	Marital status	00:00:00	00:00:00	00:00:00	00:00:36	00:05:24	00:00:36
Other	00:04:12	00:00:36	00:03:36	00:00:36	00:01:12	00:21:36	Other	00:03:36	00:00:18	00:01:12	00:01:30	00:01:30	00:03:36
Customer's increase: +60%	Mon	Tue	Wed	Thu	Fri	Sat	Customer's increase: +60%	Mon	Tue	Wed	Thu	Fri	Sat
Registry	00:00:00	00:00:00	00:00:00	00:01:48	00:00:00	00:00:36	Registry	00:00:00	00:00:00	00:00:00	00:00:18	00:00:00	00:00:00
Certificates	00:00:36	00:00:36	00:02:24	00:02:24	00:01:12	00:16:12	Certificates	00:00:36	00:02:24	00:00:36	00:00:36	00:00:00	00:18:36
Marital status	00:01:12	00:00:54	00:00:00	00:00:00	00:05:24	00:00:00	Marital status	00:00:00	00:00:54	00:00:00	00:00:00	00:05:24	00:00:36
Other	00:07:12	00:06:00	00:16:12	00:18:36	00:03:36	00:43:12	Other	00:02:24	00:00:36	00:01:48	00:04:12	00:00:54	00:38:48
Employee saturation													
Customer's increase: +20%	Mon	Tue	Wed	Thu	Fri	Sat	Customer's increase: +20%	Mon	Tue	Wed	Thu	Fri	Sat
Employee1	45.36%	57.86%	60.73%	48.40%	59.64%	-	Employee1	30.71%	44.10%	48.53%	32.86%	47.57%	-
Employee2	45.53%	57.88%	63.01%	45.09%	68.82%	83.20%	Employee2	32.10%	42.18%	57.45%	28.90%	53.48%	72.33%
Employee3	33.99%	31.42%	32.81%	34.96%	32.28%	37.59%	Employee3	16.52%	18.44%	20.87%	18.70%	13.79%	22.93%
Employee4	55.63%	44.24%	53.58%	62.21%	58.39%	75.83%	Employee4	39.79%	25.78%	35.26%	41.06%	48.47%	56.66%

Employee5	60.21%	56.44%	57.71%	61.22%	58.31%	68.91%	**Employee5**	42.41%	33.51%	49.69%	48.60%	40.11%	51.55%
Customer's increase: +40%	Mon	Tue	Wed	Thu	Fri	Sat	**Customer's increase: +40%**	Mon	Tue	Wed	Thu	Fri	Sat
Employee1	50.92%	70.62%	69.95%	52.67%	63.49%	-	**Employee1**	34.51%	54.13%	63.59%	39.17%	54.15%	-
Employee2	52.00%	69.17%	69.68%	47.31%	79.38%	69.92%	**Employee2**	35.36%	47.69%	58.30%	33.16%	66.63%	70.98%
Employee3	34.74%	37.89%	38.55%	34.19%	31.85%	34.89%	**Employee3**	20.25%	21.90%	23.16%	16.71%	14.23%	35.29%
Employee4	57.56%	66.52%	56.95%	60.94%	57.66%	71.06%	**Employee4**	40.26%	35.36%	41.90%	43.05%	49.05%	70.61%
Employee5	63.05%	67.44%	69.24%	66.40%	63.56%	67.41%	**Employee5**	48.59%	53.34%	58.28%	53.54%	52.94%	70.12%
Customer's increase: +60%	Mon	Tue	Wed	Thu	Fri	Sat	**Customer's increase: +60%**	Mon	Tue	Wed	Thu	Fri	Sat
Employee1	53.20%	77.05%	75.60%	60.04%	76.79%	-	**Employee1**	36.63%	62.25%	72.41%	41.33%	62.27%	-
Employee2	45.95%	74.98%	73.78%	52.59%	77.61%	91.68%	**Employee2**	40.44%	55.34%	67.94%	40.60%	65.98%	82.81%
Employee3	33.06%	39.87%	32.74%	36.62%	36.73%	42.79%	**Employee3**	22.72%	29.33%	29.16%	22.01%	18.77%	32.85%
Employee4	61.24%	66.18%	69.20%	73.87%	68.19%	86.19%	**Employee4**	53.76%	45.24%	58.25%	55.10%	45.26%	73.67%
Employee5	63.76%	75.64%	73.84%	75.82%	67.02%	77.81%	**Employee5**	59.78%	59.43%	70.38%	61.40%	52.35%	61.10%

Table A-3: detailed performance of the TO BE configuration with increased number of customers.

Operating condition	**with disturbances**							**without disturbances**					
Maximum number of users in queue													
Configuration 1	Mon	Tue	Wed	Thu	Fri	Sat	**Configuration 1**	Mon	Tue	Wed	Thu	Fri	Sat
Registry			1		1	1	**Registry**			1		1	1
Certificates			1		1	1	**Certificates**			1		1	1
Marital status			1		2	1	**Marital status**			1		2	1
Other			1		1	1	**Other**			1		1	1
Configuration 2	Mon	Tue	Wed	Thu	Fri	Sat	**Configuration 2**	Mon	Tue	Wed	Thu	Fri	Sat
Registry	1	1	1	1	1	1	**Registry**	1	1	1	1	1	1
Certificates	2	2	1	1	2	5	**Certificates**	1	1	1	1	1	1
Marital status	1	1	1	1	1	1	**Marital status**	1	1	1	1	2	1
Other	2	2	1	1	1	2	**Other**	1	1	1	1	1	1
Configuration 3	Mon	Tue	Wed	Thu	Fri	Sat	**Configuration 3**	Mon	Tue	Wed	Thu	Fri	Sat
Registry		1	1	1	1	1	**Registry**		1	1	1	1	1
Certificates		1	2	1	1	1	**Certificates**		1	1	1	1	1
Marital status		1	1	1	2	2	**Marital status**		1	1	1	2	2
Other		1	1	1	1	1	**Other**		1	1	1	1	1
Configuration 4	Mon	Tue	Wed	Thu	Fri	Sat	**Configuration 4**	Mon	Tue	Wed	Thu	Fri	Sat

Registry		1	1	1	1	1	**Registry**		1	1	1	1	1
Certificates		1	1	6	1	4	**Certificates**		1	1	4	1	4
Marital status		1	1	1	2	1	**Marital status**		1	1	1	2	1
Other		1	1	10	1	8	**Other**		1	1	10	1	6
Configuration 5	Mon	Tue	Wed	Thu	Fri	Sat	**Configuration 5**	Mon	Tue	Wed	Thu	Fri	Sat
Registry	1	1	1			1	**Registry**	1	1	1			1
Certificates	4	1	1			7	**Certificates**	3	1	1			6
Marital status	1	1	1			1	**Marital status**	1	1	1			1
Other	3	1	1			9	**Other**	1	1	1			9
Configuration 6	Mon	Tue	Wed	Thu	Fri	Sat	**Configuration 6**	Mon	Tue	Wed	Thu	Fri	Sat
Registry		1	1	1	1	1	**Registry**		1	1	1	1	1
Certificates		1	1	6	1	4	**Certificates**		1	1	4	1	4
Marital status		1	1	4	2	4	**Marital status**		1	1	4	2	2
Other		1	1	10	1	10	**Other**		1	1	10	1	8
Configuration 7	Mon	Tue	Wed	Thu	Fri	Sat	**Configuration 7**	Mon	Tue	Wed	Thu	Fri	Sat
Registry		1	1	1	1	1	**Registry**		1	1	1	1	1
Certificates		2	1	1	1	8	**Certificates**		1	1	1	1	6
Marital status		1	1	1	2	4	**Marital status**		1	1	1	2	3
Other		2	1	1	1	9	**Other**		1	1	1	1	9
Configuration 8	Mon	Tue	Wed	Thu	Fri	Sat	**Configuration 8**	Mon	Tue	Wed	Thu	Fri	Sat
Registry		1	1	1	1	1	**Registry**		1	1	1	1	1
Certificates		2	3	6	2	21	**Certificates**		1	1	4	1	19
Marital status		2	4	4	2	8	**Marital status**		1	1	4	2	8
Other		5	7	14	4	16	**Other**		1	1	10	1	16
Average waiting time													
Configuration 1	Mon	Tue	Wed	Thu	Fri	Sat	**Configuration 1**	Mon	Tue	Wed	Thu	Fri	Sat
Registry			00:00:00		00:00:00	00:00:00	**Registry**			00:00:00		00:00:00	00:00:00
Certificates			00:01:30		00:01:12	00:01:30	**Certificates**			00:01:30		00:00:54	00:01:12
Marital status			00:00:00		00:05:24	00:00:00	**Marital status**			00:00:00		00:05:24	00:00:00
Other			00:00:36		00:00:36	00:01:12	**Other**			00:00:36		00:00:36	00:00:36
Configuration 2	Mon	Tue	Wed	Thu	Fri	Sat	**Configuration 2**	Mon	Tue	Wed	Thu	Fri	Sat
Registry	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	**Registry**	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00
Certificates	00:02:24	00:02:06	00:01:30	00:01:30	00:00:36	00:07:48	**Certificates**	00:00:00	00:00:00	00:00:00	00:00:54	00:00:00	00:00:54
Marital status	00:00:00	00:00:00	00:00:00	00:00:00	00:00:54	00:01:12	**Marital status**	00:00:00	00:00:00	00:00:00	00:00:00	00:05:24	00:00:00
Other	00:01:12	00:01:48	00:00:36	00:01:12	00:00:00	00:08:24	**Other**	00:00:36	00:00:18	00:00:36	00:00:18	00:00:18	00:01:30
Configuration 3	Mon	Tue	Wed	Thu	Fri	Sat	**Configuration 3**	Mon	Tue	Wed	Thu	Fri	Sat

Registry		00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	**Registry**		00:00:00	00:00:00	00:00:00	00:00:00	00:00:00
Certificates		00:00:00	00:00:36	00:00:36	00:00:00	00:00:54	**Certificates**		00:00:00	00:00:00	00:00:00	00:00:00	00:00:00
Marital status		00:01:12	00:01:12	00:01:48	00:06:00	00:06:00	**Marital status**		00:00:36	00:00:36	00:00:54	00:05:24	00:06:00
Other		00:00:36	00:02:06	00:01:48	00:00:00	00:00:18	**Other**		00:00:00	00:00:18	00:00:36	00:00:00	00:00:36
Configuration 4	Mon	Tue	Wed	Thu	Fri	Sat	**Configuration 4**	Mon	Tue	Wed	Thu	Fri	Sat
Registry		00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	**Registry**		00:00:00	00:00:00	00:00:00	00:00:00	00:00:00
Certificates		00:01:12	00:01:48	00:07:48	00:01:12	00:09:24	**Certificates**		00:00:00	00:00:18	00:03:36	00:00:00	00:03:00
Marital status		00:00:00	00:00:00	00:00:00	00:05:24	00:00:54	**Marital status**		00:00:00	00:00:00	00:00:00	00:05:24	00:00:00
Other		00:01:12	00:01:30	00:02:24	00:01:12	00:51:36	**Other**		00:01:12	00:01:30	00:01:30	00:01:12	00:25:48
Configuration 5	Mon	Tue	Wed	Thu	Fri	Sat	**Configuration 5**	Mon	Tue	Wed	Thu	Fri	Sat
Registry	00:00:00	00:00:00	00:00:00			00:00:00	**Registry**	00:00:00	00:00:00	00:00:00			00:00:00
Certificates	00:02:24	00:00:54	00:00:36			00:10:12	**Certificates**	00:01:12	00:00:00	00:00:00			00:07:48
Marital status	00:01:30	00:00:36	00:00:36			00:00:36	**Marital status**	00:03:00	00:00:00	00:01:30			00:00:00
Other	00:01:48	00:01:12	00:02:42			01:00:00	**Other**	00:01:12	00:00:18	00:00:54			00:49:12
Configuration 6	Mon	Tue	Wed	Thu	Fri	Sat	**Configuration 6**	Mon	Tue	Wed	Thu	Fri	Sat
Registry		00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	**Registry**		00:00:00	00:00:00	00:00:00	00:00:00	00:00:36
Certificates		00:00:36	00:01:48	00:07:48	00:01:12	00:09:00	**Certificates**		00:00:36	00:00:54	00:03:24	00:00:00	00:04:12
Marital status		00:03:36	00:01:12	00:08:24	00:06:00	00:38:24	**Marital status**		00:00:00	00:02:24	00:01:48	00:05:24	00:16:12
Other		00:00:54	00:01:12	00:02:24	00:01:12	00:55:48	**Other**		00:01:12	00:01:30	00:03:00	00:01:12	00:01:36
Configuration 7	Mon	Tue	Wed	Thu	Fri	Sat	**Configuration 7**	Mon	Tue	Wed	Thu	Fri	Sat
Registry		00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	**Registry**		00:00:00	00:00:00	00:00:00	00:00:00	00:00:00
Certificates		00:00:36	00:01:30	00:01:30	00:00:18	00:09:00	**Certificates**		00:00:00	00:00:00	00:01:30	00:00:00	00:07:12
Marital status		00:03:36	00:01:12	00:01:12	00:06:00	00:28:48	**Marital status**		00:00:36	00:01:12	00:00:36	00:05:24	00:19:48
Other		00:06:36	00:00:36	00:01:12	00:01:12	00:55:12	**Other**		00:00:18	00:00:36	00:02:42	00:00:36	00:54:36
Configuration 8	Mon	Tue	Wed	Thu	Fri	Sat	**Configuration 8**	Mon	Tue	Wed	Thu	Fri	Sat
Registry		00:00:00	00:01:12	00:00:54	00:00:00	00:00:00	**Registry**		00:00:00	00:00:00	00:00:00	00:00:00	00:00:54
Certificates		00:01:12	00:02:24	00:10:48	00:01:12	01:24:00	**Certificates**		00:00:54	00:00:36	00:03:36	00:00:36	01:19:00
Marital status		00:09:36	00:13:12	00:23:24	00:09:00	00:00:00	**Marital status**		00:01:12	00:03:36	00:21:00	00:05:24	00:00:00
Other		00:19:12	00:43:12	00:41:24	00:18:00	00:00:00	**Other**		00:01:30	00:00:36	00:01:48	00:00:36	00:00:00
employee saturation													
Configuration 1	Mon	Tue	Wed	Thu	Fri	Sat	**Configuration 1**	Mon	Tue	Wed	Thu	Fri	Sat
Employee1							**Employee1**						
Employee2			67.85%		77.97%	70.63%	**Employee2**			57.98%		57.39%	63.24%
Employee3			33.71%		29.13%	34.03%	**Employee3**			16.33%		11.02%	17.61%
Employee4			52.70%		55.45%	57.19%	**Employee4**			35.42%		46.05%	47.68%
Employee5			65.51%		61.85%	50.23%	**Employee5**			56.47%		51.11%	41.64%

Configuration 2	Mon	Tue	Wed	Thu	Fri	Sat	Configuration 2	Mon	Tue	Wed	Thu	Fri	Sat
Employee1	47.40%	60.66%	63.14%	43.39%	50.20%		Employee1	28.73%	42.05%	46.09%	31.21%	46.17%	
Employee2							Employee2						
Employee3	29.87%	26.22%	33.71%	28.07%	23.26%	30.25%	Employee3	14.08%	16.70%	19.05%	14.89%	11.02%	17.61%
Employee4	60.35%	59.14%	48.87%	55.03%	44.23%	85.53%	Employee4	39.73%	29.86%	32.65%	43.42%	46.84%	62.31%
Employee5	61.28%	56.26%	62.09%	63.73%	49.74%	72.13%	Employee5	40.08%	39.62%	47.64%	53.84%	43.23%	56.93%
Configuration 3	Mon	Tue	Wed	Thu	Fri	Sat	Configuration 3	Mon	Tue	Wed	Thu	Fri	Sat
Employee1		57.08%	57.58%	36.65%	53.46%		Employee1		38.06%	42.41%	25.40%	33.48%	
Employee2		53.40%	61.75%	42.43%	54.76%	71.26%	Employee2		37.25%	46.22%	26.11%	40.12%	56.71%
Employee3							Employee3						
Employee4		48.53%	51.54%	55.32%	45.12%	57.19%	Employee4		21.90%	37.12%	41.56%	24.62%	42.45%
Employee5		55.04%	59.67%	64.79%	53.67%	57.22%	Employee5		35.72%	47.22%	52.71%	36.20%	45.41%
Configuration 4	Mon	Tue	Wed	Thu	Fri	Sat	Configuration 4	Mon	Tue	Wed	Thu	Fri	Sat
Employee1		58.26%	66.83%	49.67%	60.49%		Employee1		51.25%	56.10%	31.47%	48.26%	
Employee2		63.48%	66.48%	47.69%	76.77%	99.90%	Employee2		46.28%	51.80%	33.19%	58.53%	92.70%
Employee3		26.22%	33.71%	29.73%	26.26%	37.51%	Employee3		16.70%	19.05%	16.55%	11.02%	23.39%
Employee4							Employee4						
Employee5		53.73%	57.21%	77.64%	54.68%	84.59%	Employee5		43.28%	52.23%	69.07%	42.35%	75.89%
Configuration 5	Mon	Tue	Wed	Thu	Fri	Sat	Configuration 5	Mon	Tue	Wed	Thu	Fri	Sat
Employee1	45.90%	57.37%	60.73%				Employee1	30.56%	44.88%	46.69%			
Employee2	45.60%	58.74%	64.53%			92.82%	Employee2	29.94%	43.84%	51.82%			85.99%
Employee3	32.12%	34.28%	36.63%			40.05%	Employee3	17.51%	19.62%	21.98%			23.39%
Employee4	61.55%	46.23%	46.01%			86.40%	Employee4	47.75%	30.63%	32.69%			80.38%
Employee5							Employee5						
Configuration 6	Mon	Tue	Wed	Thu	Fri	Sat	Configuration 6	Mon	Tue	Wed	Thu	Fri	Sat
Employee1		65.35%	65.93%	50.63%	63.19%		Employee1		51.99%	54.84%	31.78%	51.10%	
Employee2		60.42%	61.95%	47.47%	79.96%	99.90%	Employee2		46.95%	51.89%	67.28%	60.66%	99.90%
Employee3							Employee3						
Employee4							Employee4						
Employee5		66.21%	66.01%	83.16%	60.80%	84.59%	Employee5		47.46%	55.20%	72.20%	46.97%	80.77%
Configuration 7	Mon	Tue	Wed	Thu	Fri	Sat	Configuration 7	Mon	Tue	Wed	Thu	Fri	Sat
Employee1		69.80%	64.83%	45.05%	58.06%		Employee1		42.92%	45.56%	32.54%	48.68%	
Employee2							Employee2						
Employee3							Employee3						
Employee4		62.45%	50.47%	57.36%	55.25%	91.70%	Employee4		31.36%	33.08%	49.27%	52.14%	88.69%
Employee5		64.12%	67.92%	70.67%	60.90%	81.38%	Employee5		44.04%	54.00%	58.31%	47.87%	73.36%
Configuration 8	Mon	Tue	Wed	Thu	Fri	Sat	Configuration 8	Mon	Tue	Wed	Thu	Fri	Sat

Employee1	81.11%	93.56%	61.73%	91.72%		**Employee1**	66.15%	75.36%	47.80%	77.77%	
Employee2						**Employee2**					
Employee3						**Employee3**					
Employee4						**Employee4**					
Employee5	78.18%	81.36%	90.01%	74.56%	84.59%	**Employee5**	64.67%	70.93%	81.64%	62.05%	80.77%

852 **Table A-4: detailed performance of the TO BE configuration with modifications of the employees mix.**

Figures

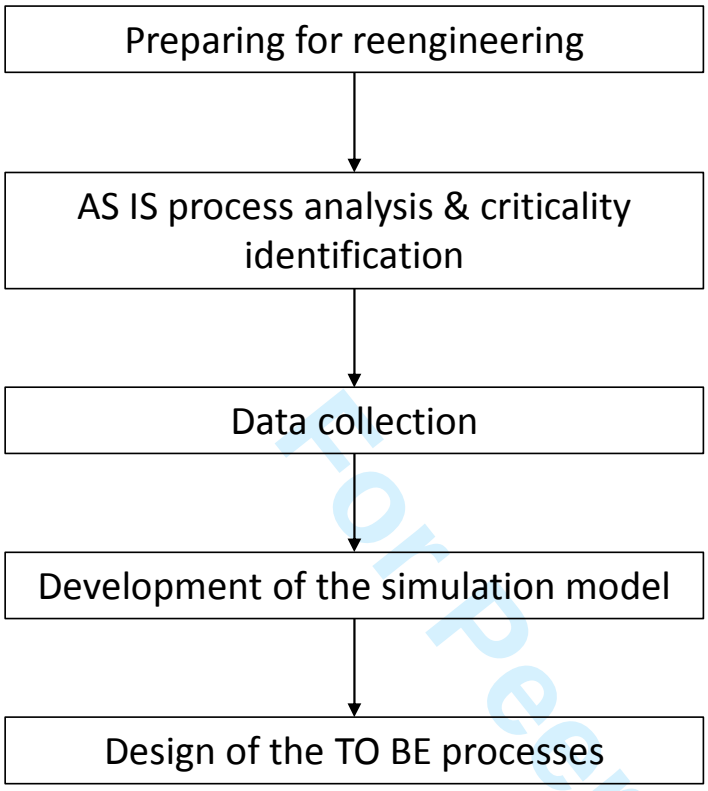


Figure 1: scheme of the approach followed.

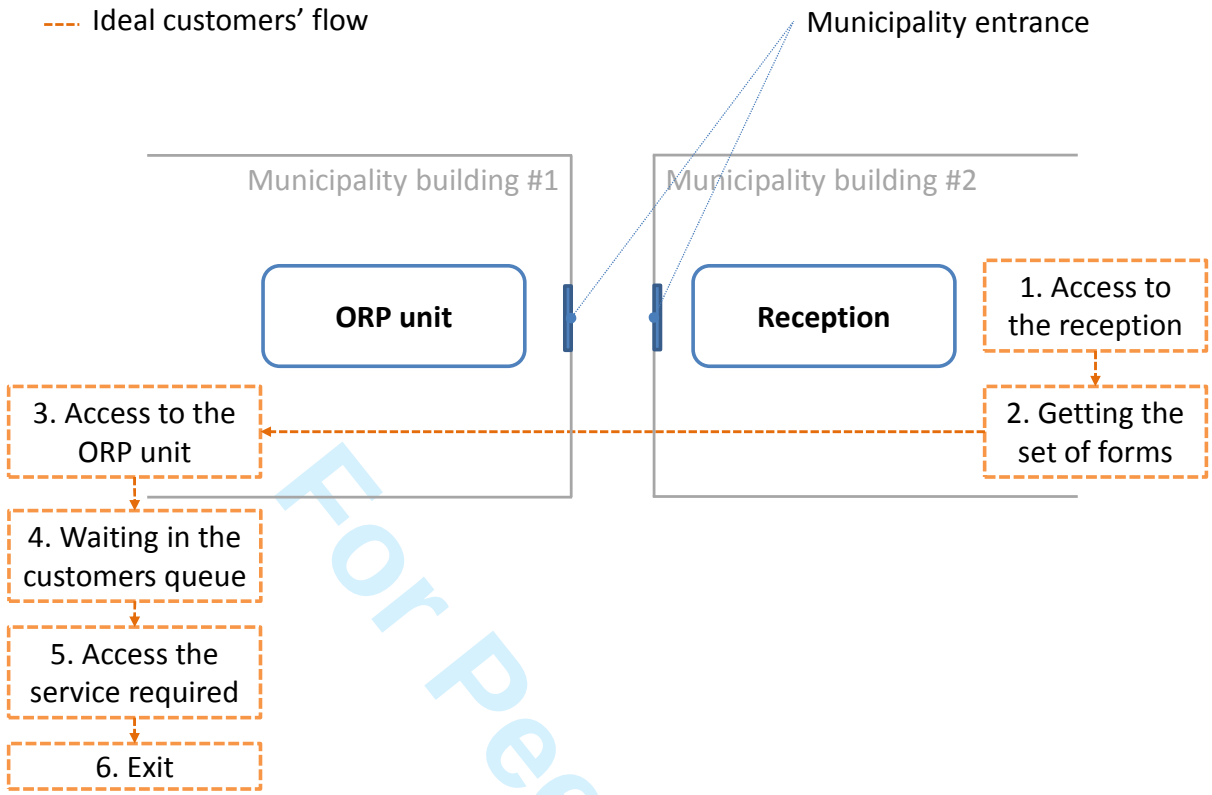


Figure 2: location of ORP and reception and ideal flow of customers.

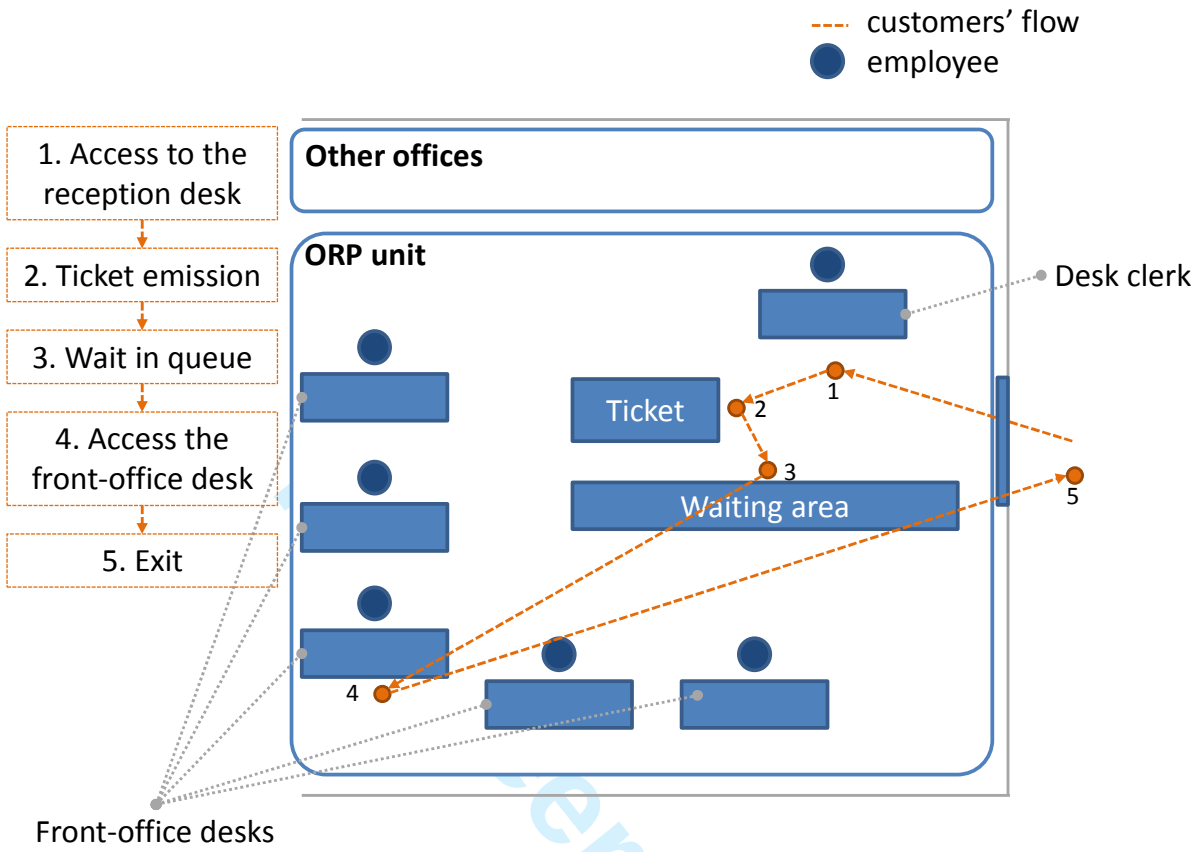


Figure 3: customers' flow at the ORP.

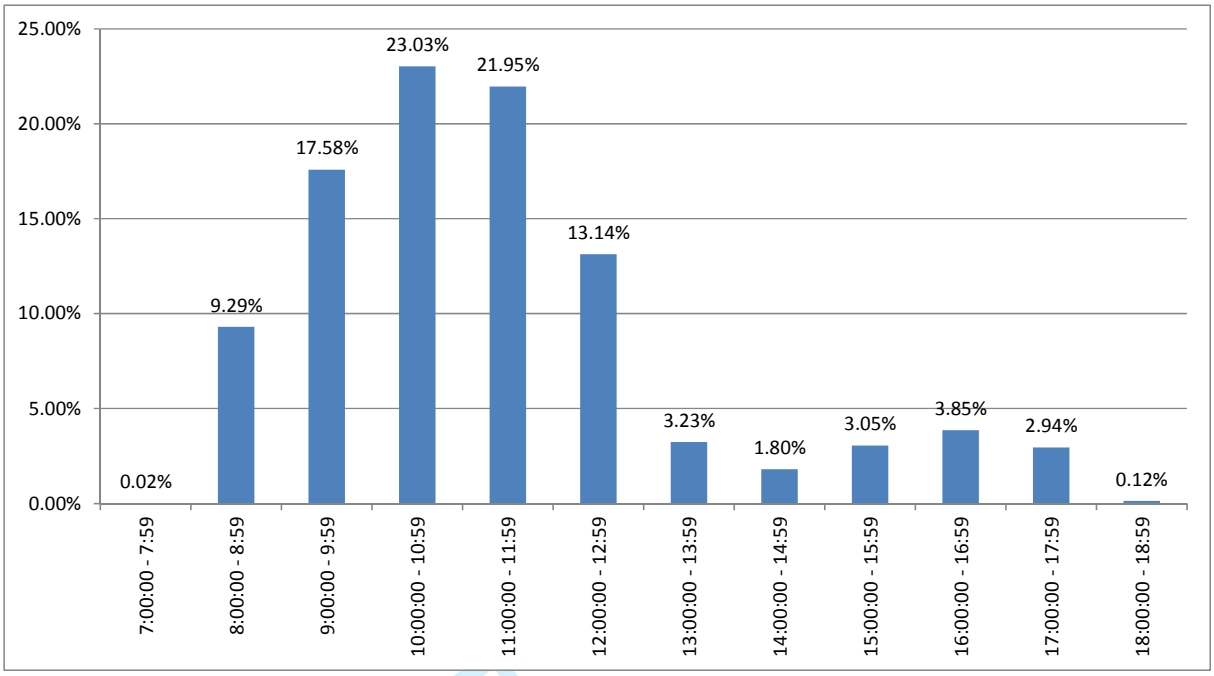


Figure 4: data extracted – distribution of the customers' arrivals as a function of the working hour.

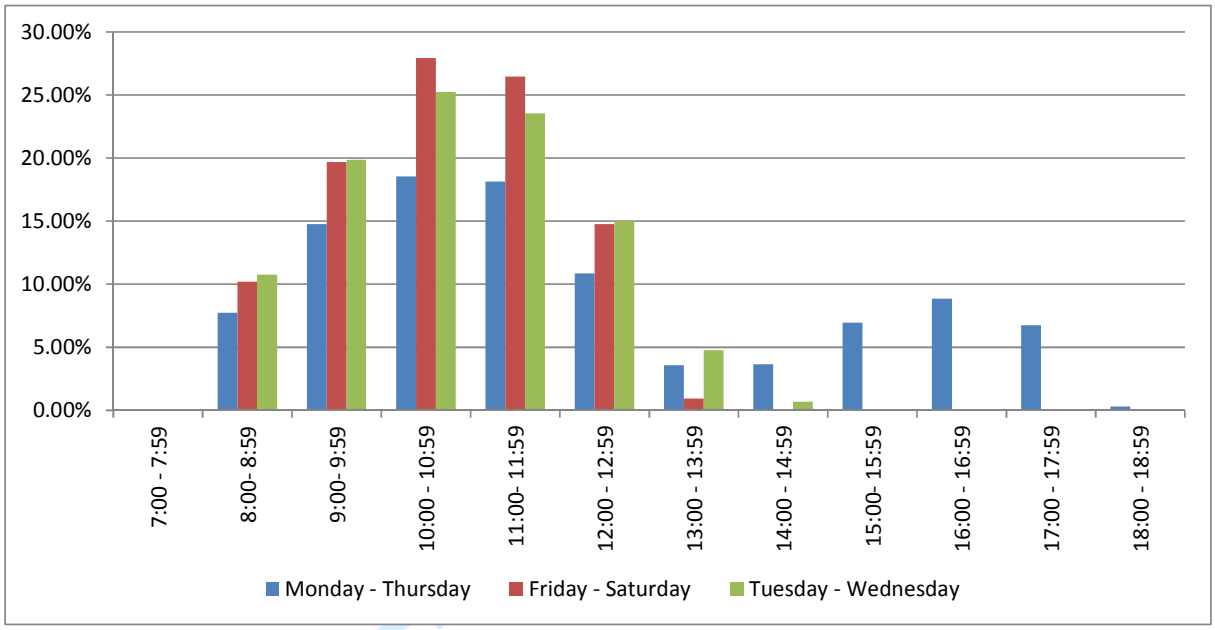


Figure 5: data extracted – distribution of the customers' arrivals as a function of the working hour and weekday.

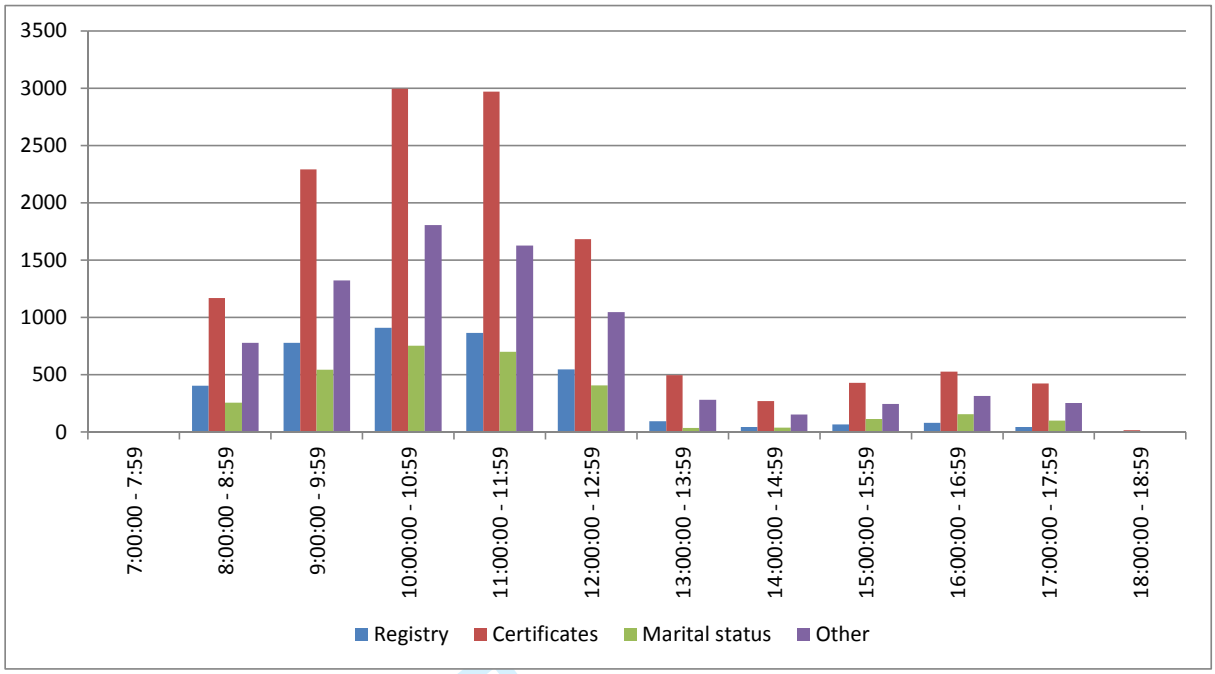


Figure 6: data extracted – distribution of the customers' arrivals as a function of the service requested and working hour.

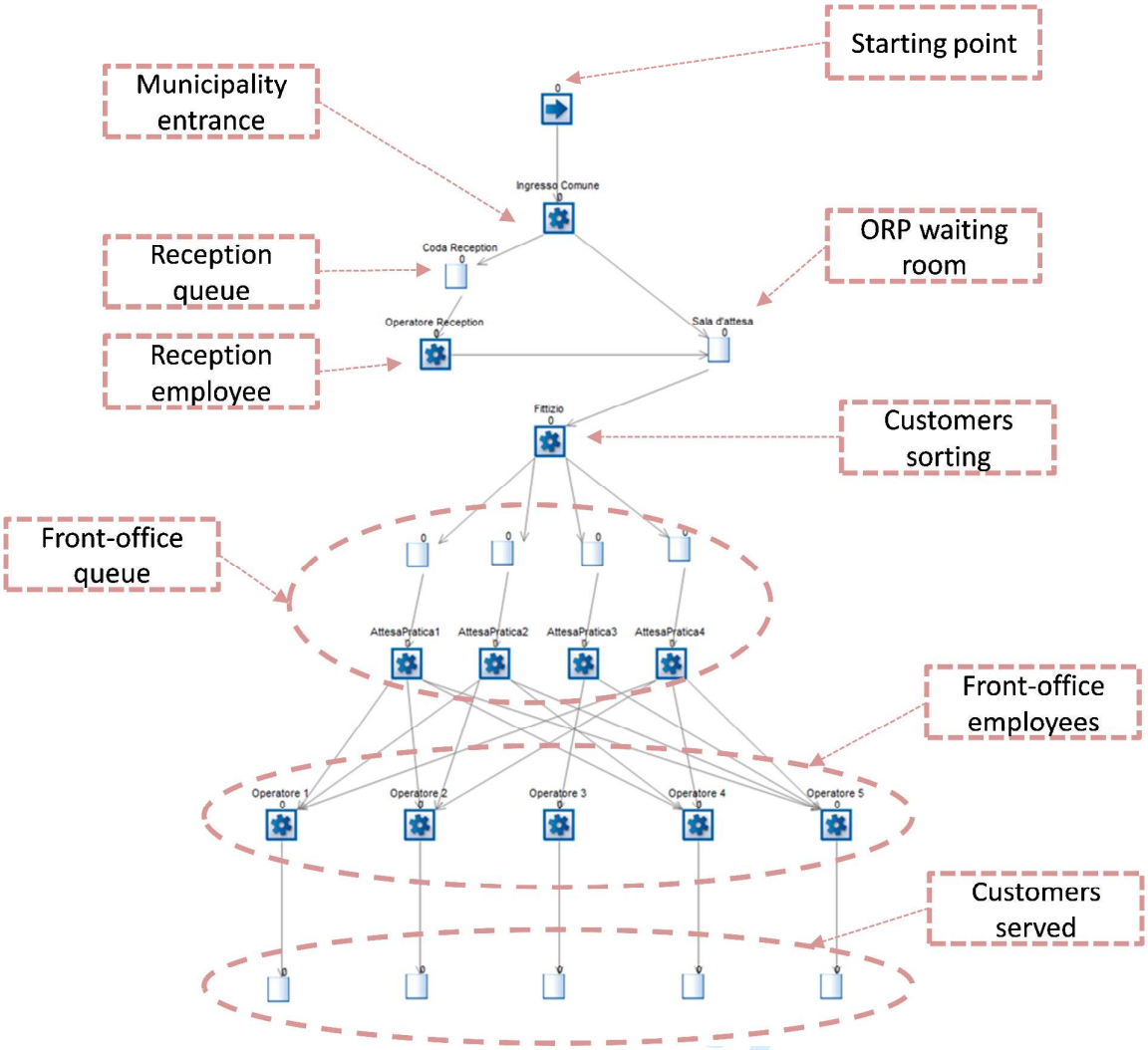
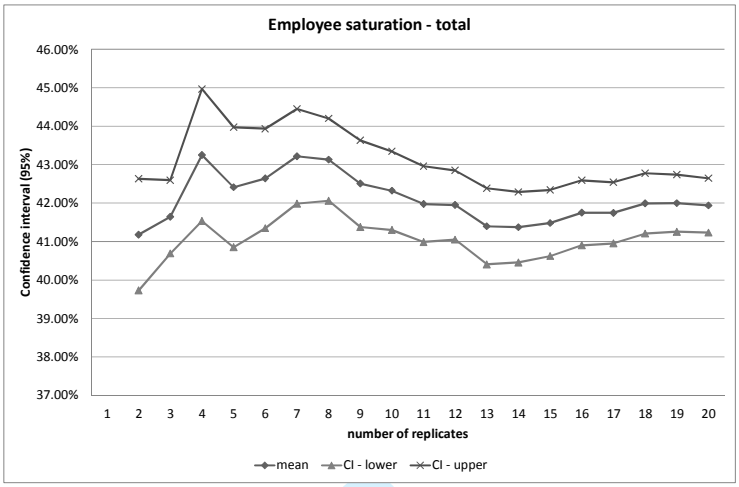
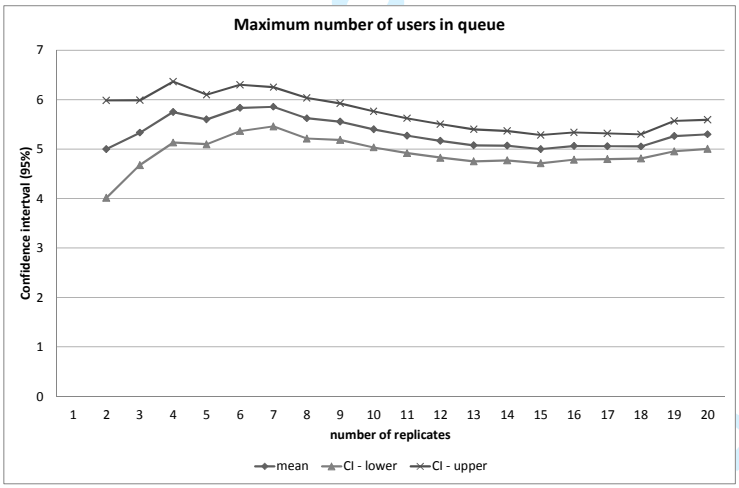


Figure 7: scheme of the Simul8™ simulation model.





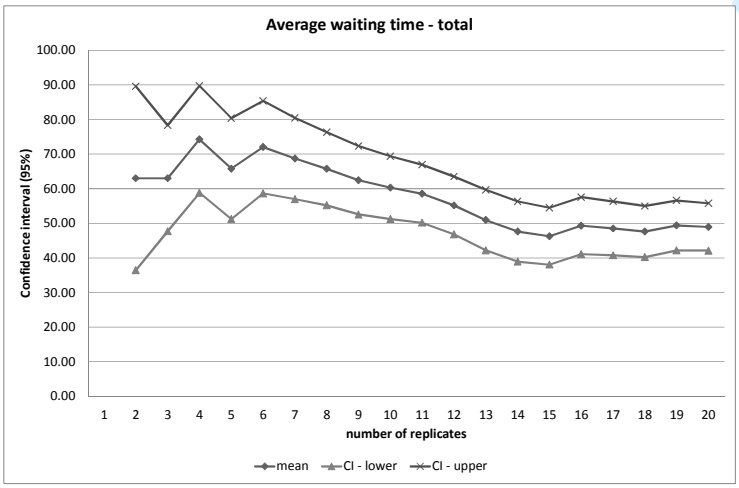


Figure 8: confidence interval of simulation outcomes as a function of the number of replicates in an example scenario (i.e., monday, with disturbances).

Employee	Working	Awaiting	Stopped	Saturation (working + stopped)
Employee1	26.22%	58.40%	15.38%	41.60%
Employee2	21.71%	62.89%	15.40%	37.11%
Employee3	12.61%	72.77%	14.62%	27.23%
Employee4	32.77%	52.43%	14.80%	47.57%
Employee5	37.00%	48.16%	14.84%	51.84%
Average				**41.07%**

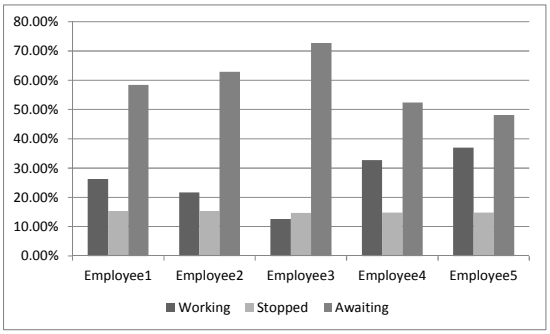


Figure 9: performance of the AS IS system in an example scenario (i.e. Monday, with disturbances) – sharing of the time spent by employees into different categories.

Tables

Table 1: work shifts of the front-office employees.

Working time		Mon					Tue					Wed					Thu					Fri					Sat				
		Employees					*Employees*					*Employees*					*Employees*					*Employees*					*Employees*				
from	to	*1*	*2*	*3*	*4*	*5*	*1*	*2*	*3*	*4*	*5*	*1*	*2*	*3*	*4*	*5*	*1*	*2*	*3*	*4*	*5*	*1*	*2*	*3*	*4*	*5*	*1*	*2*	*3*	*4*	*5*
8	9	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■
9	10	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■
10	11	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■
11	12	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■
12	13	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■		■	■		■	■	■	■
13	14	■					■					■			■		■														
14	15			■	■															■	■										
15	16			■	■	■														■	■	■									
16	17			■	■	■														■	■	■									
17	18			■	■	■														■	■	■									

Table 2: data extracted – distribution of the customers' arrivals as a function of the working hour and month.

Time slot	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	%
7:00:00 - 7:59	2	0	0	0	0	0	0	0	4	0	0	0	*6*	*0.02%*
8:00:00 - 8:59	167	144	285	227	258	302	262	175	330	182	161	116	*2609*	*9.29%*
9:00:00 - 9:59	379	319	480	388	515	600	434	377	470	372	373	231	*4938*	*17.58%*
10:00:00 - 10:59	512	433	617	528	715	658	626	526	629	470	454	299	*6467*	*23.03%*
11:00:00 - 11:59	543	438	587	539	627	614	574	472	653	450	399	269	*6165*	*21.95%*
12:00:00 - 12:59	336	260	295	296	386	375	411	293	370	223	244	200	*3689*	*13.14%*
13:00:00 - 13:59	111	50	99	79	81	109	81	69	61	63	69	36	*908*	*3.23%*
14:00:00 - 14:59	62	38	41	46	50	55	32	42	36	30	45	28	*505*	*1.80%*
15:00:00 - 15:59	108	64	84	83	90	70	66	42	80	57	74	39	*857*	*3.05%*
16:00:00 - 16:59	103	75	124	87	132	127	72	61	125	64	50	62	*1082*	*3.85%*
17:00:00 - 17:59	101	43	114	72	88	97	71	53	61	59	33	33	*825*	*2.94%*
18:00:00 - 18:59	7	0	3	3	4	11	2	2	1	0	0	1	*34*	*0.12%*
Total	*2431*	*1864*	*2729*	*2348*	*2946*	*3018*	*2631*	*2112*	*2820*	*1970*	*1902*	*1314*	*28085*	

Table 3: data extracted – distribution of the customers' arrivals as a function of the working hour and weekday.

Weekday	Monday - Thursday		Tuesday - Wednesday		Friday - Saturday	
Time slot	Number of customers	%	Number of customers	%	Number of customers	%
7:00 - 7:59	2	0.02%	4	0.05%	0	0.00%
8:00- 8:59	944	7.72%	906	10.76%	759	10.20%
9:00- 9:59	1802	14.74%	1672	19.86%	1464	19.67%
10:00 - 10:59	2266	18.54%	2124	25.23%	2077	27.91%
11:00- 11:59	2216	18.13%	1981	23.53%	1968	26.44%
12:00 - 12:59	1326	10.85%	1264	15.01%	1099	14.77%
13:00 - 13:59	436	3.57%	402	4.77%	70	0.94%
14:00 - 14:59	444	3.63%	57	0.68%	4	0.05%
15:00- 15:59	849	6.95%	7	0.08%	1	0.01%
16:00 - 16:59	1080	8.84%	2	0.02%	0	0.00%
17:00 - 17:59	825	6.75%	0	0.00%	0	0.00%
18:00 - 18:59	34	0.28%	0	0.00%	0	0.00%
19:00 - 19:59	0	0.00%	0	0.00%	0	0.00%
Total	**12224**	**100%**	**8419**	**100%**	**7442**	**100%**

Table 4: data extracted – mean and standard deviation of the customers' service time as a function of the service requested and employee.

		Registry	Certificates	Marital status	Other
Employee 1	mean	00:07:49	00:06:22		00:05:04
	standard deviation	*00:03:10*	*00:00:39*		*00:01:36*
Employee 2	mean	00:10:06	00:08:48		00:08:05
	standard deviation	*00:03:58*	*00:03:06*		*00:03:23*
Employee 3	mean			00:07:21	
	standard deviation			*00:02:03*	
Employee 4	mean	00:06:00	00:04:32		00:03:26
	standard deviation	*00:02:50*	*00:00:47*		*00:01:00*
Employee 5	mean	00:11:13	00:07:46	00:05:30	00:06:30
	standard deviation	*00:06:01*	*00:04:09*	*00:01:58*	*00:02:20*
Overall average		00:08:47	00:06:52	00:06:26	00:05:46

Table 5: performance of the AS IS configuration of the municipality.

Operating condition	KPI	Mon	Tue	Wed	Thu	Fri	Sat
with disturbances	Maximum number of users in queue	4	4	4	4	5	4
	Average waiting time	00:00:05	00:00:09	00:00:26	00:00:54	00:01:21	00:00:41
	Average employee saturation	41.07%	47.83%	49.79%	44.76%	45.66%	53.02%
without disturbances	Maximum number of users in queue	4	4	4	4	5	4
	Average waiting time	00:00:14	00:00:00	00:00:23	00:00:09	00:01:21	00:00:27
	Average employee saturation	30.68%	28.36%	34.17%	31.35%	27.18%	42.54%

Table 6: TO BE configurations for employees mix.

Configurations	1	2	3	4	5	6	7	8
Employees working	2, 3, 4 and 5	1, 3, 4 and 5	1, 2, 4 and 5	1, 2, 3 and 5	1, 2, 3 and 4	1, 2 and 5	1, 4 and 5	1 and 5
Employees moved to other offices	1	2	3	4	5	3 and 4	2 and 3	2, 3 and 4
Applicable on	Wednesday, Friday, Saturday	Monday, Tuesday, Wednesday, Thursday, Friday, Saturday	Tuesday, Wednesday, Thursday, Friday, Saturday	Tuesday, Wednesday, Thursday, Friday, Saturday	Monday, Tuesday, Wednesday, Saturday	Tuesday, Wednesday, Thursday, Friday, Saturday	Tuesday, Wednesday, Thursday, Friday, Saturday	Tuesday, Wednesday, Thursday, Friday, Saturday

Table 7: summary of the results for the TO BE scenarios with increase in the customers' arrivals.

Operating condition	KPI	Customers increase	Mon	Tue	Wed	Thu	Fri	Sat
with disturbances	Maximum number of users in queue	20%	5	4	4	7	5	6
		40%	9	4	5	6	5	18
		60%	16	12	22	16	5	35
	Average waiting time	20%	00:00:54	00:00:00	00:00:44	00:01:21	00:02:15	00:00:45
		40%	00:01:12	00:00:27	00:01:03	00:00:27	00:01:39	00:06:04
		60%	00:02:15	00:01:52	00:04:39	00:05:42	00:02:33	00:15:00
	Average employee saturation	20%	48.14%	49.57%	53.57%	50.38%	55.49%	66.38%
		40%	51.65%	62.33%	60.87%	52.30%	59.19%	60.82%
		60%	51.44%	66.74%	65.03%	59.79%	65.27%	74.62%
without disturbances	Maximum number of users in queue	20%	4	4	4	5	5	4
		40%	4	4	5	5	5	7
		60%	10	6	9	11	5	31
	Average waiting time	20%	00:00:32	00:00:00	00:00:27	00:01:12	00:01:30	00:00:36
		40%	00:01:30	00:00:05	00:00:27	00:01:16	00:01:44	00:01:35
		60%	00:00:45	00:00:59	00:00:36	00:01:16	00:01:35	00:14:30
	Average employee saturation	20%	32.31%	32.80%	42.36%	34.02%	40.68%	50.87%
		40%	35.79%	42.48%	49.05%	37.13%	47.40%	61.75%
		60%	42.67%	50.32%	59.63%	44.09%	48.93%	62.61%

Table 8: summary of the results for the TO BE scenarios with modifications of the employees' mix.

Operating conditions	KPI	Configuration	Mon	Tue	Wed	Thu	Fri	Sat
with disturbances	Maximum number of users in queue	1			4		5	4
		2	6	6	4	4	5	9
		3		4	5	4	5	5
		4		4	4	18	5	14
		5	9	4	4			18
		6		4	4	21	5	19
		7		6	4	4	5	22
		8		10	15	25	9	46
	Average waiting time	1			00:00:32		00:01:48	00:00:41
		2	00:00:54	00:00:59	00:00:32	00:00:41	00:00:23	00:04:21
		3		00:00:27	00:00:59	00:01:03	00:01:30	00:01:48
		4		00:00:36	00:00:49	00:02:33	00:01:57	00:15:29
		5	00:01:26	00:00:41	00:00:59			00:17:42
		6		00:01:16	00:01:03	00:04:39	00:02:06	00:25:48
		7		00:02:42	00:00:49	00:00:59	00:01:52	00:23:15
		8		00:07:30	00:15:00	00:19:07	00:07:03	00:21:00
	Average employee saturation	1			54.94%		56.10%	53.02%
		2	49.73%	50.57%	51.95%	47.56%	41.86%	62.64%
		3		53.51%	57.64%	49.80%	51.75%	61.89%
		4		50.42%	56.06%	51.18%	54.55%	74.00%
		5	46.29%	49.16%	51.98%			73.09%
		6		63.99%	64.63%	60.42%	67.98%	92.25%
		7		65.46%	61.07%	57.69%	58.07%	86.54%
		8		79.65%	87.46%	75.87%	83.14%	84.59%
without disturbances	Maximum number of users in queue	1			4		5	4
		2	4	4	4	4	5	4
		3		4	4	4	5	5
		4		4	4	16	5	12
		5	6	4	4			17
		6		4	4	19	5	15
		7		4	4	4	5	19
		8		4	4	19	5	44
	Average waiting	1			00:00:32		00:01:44	00:00:27

	time	2	00:00:09	00:00:05	00:00:09	00:00:18	00:01:26	00:00:36
		3		00:00:09	00:00:14	00:00:23	00:01:21	00:01:39
		4		00:00:18	00:00:27	00:01:16	00:01:39	00:07:12
		5	00:01:21	00:00:05	00:00:36			00:14:15
		6		00:00:27	00:01:12	00:02:03	00:01:39	00:05:39
		7		00:00:14	00:00:27	00:01:12	00:01:30	00:20:24
		8		00:00:54	00:01:12	00:06:36	00:01:39	00:19:59
	Average employee saturation	1			41.55%		41.39%	42.54%
		2	30.66%	32.06%	36.36%	35.84%	36.82%	45.62%
		3		33.23%	43.24%	36.45%	33.61%	48.19%
		4		39.38%	44.80%	37.57%	40.04%	63.99%
		5	31.44%	34.74%	38.30%			63.25%
		6		48.80%	53.98%	57.09%	52.91%	90.34%
		7		39.44%	44.21%	46.71%	49.56%	81.03%
		8		65.41%	73.15%	64.72%	69.91%	80.77%