computation

MDPI

Article

Optimization Algorithm to Sequence the Management Processes in Information Technology Departments

Juan Luis Rubio Sánchez

Escuela de Ciencias e Ingeniería, Universidad a Distancia de Madrid (UDIMA), Ctra A Coruña km38, 5 Vía de Servicio and Collado Villaba, 28400 Madrid, Spain; juanluis.rubio@udima.es

Abstract: The most important standard in technology services management is the Information Technology Infrastructure Library (ITIL). The literature review developed shows that one of the most important questions to answer is finding the sequence of processes to be implemented, mainly in small companies with few resources. The purpose of this paper is to show a methodology that defines an optimal specific sequence of processes for each small company depending on internal and external parameters. The main contribution of this paper is a proven methodology to obtain a particular sequence of ITIL processes specifically adapted to each company, based on a mathematical and statistical model that uses data from a web survey. Its application generates an optimal sequence of ITIL processes. The methodology has been applied with successful results in a real case, and it shows specific benefits over the previous approaches. The main learning objective of this research is a proven method to obtain an optimal sequence of processes for the implementation of ITIL in small companies. Finally, some future works are presented.

Keywords: ITIL; sequence; processes; small company; methodology

Citation: Rubio Sánchez, J.L. Optimization Algorithm to Sequence the Management Processes in Information Technology Departments. *Computation* **2021**, *9*, 60. https://doi.org/10.3390/computation9050060

Academic Editor: Demos T. Tsahalis

Received: 30 April 2021
Accepted: 17 May 2021
Published: 19 May 2021

1. Introduction

One of the effects of the increasing dependency on technology is that the management of IT (information technology) is becoming a key factor in organizations [1], mainly during the current COVID-19 pandemic period. These organizations look for a reduction of costs, an increase of the customer's satisfaction, an increase of the added value of the service and a higher efficiency in the company [2]. In this scenario, the information technology (IT) managers are expected to offer the best service with very few resources (as few as possible) and to achieve the objectives on time, managing the risks with low cost and with the expected quality [3]. All this is possible only by using market standards [4] such as ITIL [5], Capability Maturity Model Improvement (CMMI), Control Objectives for Information and Related Technology (COBIT) [6] and the Committee Of Sponsoring Organizations (COSO) among others [7–9].

ITIL is a well-known standard in the market which aims to offer a set of processes to properly manage IT services. This set of processes includes the strategy, design, transition, operation and improvement processes [10]. They are completely oriented to fulfill the needs of any IT department; that is, they are not planned to be used in any specific business, which make them really valuable for all organizations [11]. These processes are independent of the software, the technology, the programming language and other parameters such as the size of the company, the country and the industry it belongs to. Currently, ITIL describes the set of processes that should be implemented in any IT department, but it does not explain a procedure, nor does it offer a guide on how to implement it or which processes should be selected first for its implementation [12,13].

The increasing interest of companies by the ITIL implementation faces a handicap which is really hard to solve for small companies: the sequence of processes to implement is not explicitly indicated in ITIL. This is something that has been analyzed from years

ago [14] to more recent works [15,16]. The absence of a clear criteria to define the sequence is one of the reasons that most affects implementation projects. Some authors have clearly addressed this problem. One of these authors is [17], who analyzed the reasons why some ITIL projects failed. In this reference, it is clearly shown how many organizations try to implement all or part of the ITIL processes at once without any prioritization. This strategy leads to confusion, staff unrest and no integration between the processes. The recommendation offered by the author is to select the most important processes for the objectives of the organization and, after that, schedule its implementation. A similar analysis can be found in [18], where the importance of basic processes to support the rest of the processes is addressed. For example the process of setting up a database for configuration management should be prioritized over the rest of processes; otherwise, the implementation will fail.

The implementation of ITIL processes has been analyzed from different points of view. The most important ones are as follows:

- The strategy to follow when implementing ITIL [14,19,20];
- The factors that ease the success of ITIL implementation. The authors try to guess the factors that influence the success of an ITIL implementation project. Depending on the authors, different factors are analyzed (e.g., trust in the organization, steering committee involvement and resistance to change). The most relevant references in this area are [21–23];
- The sequence of the processes when implementing ITIL. This a critical issue to success, as is pointed out and analyzed in some references [12,24,25];
- The influence of the characteristics of the company on the result of the implementation project [26], mainly the size of the company, the industry and the country;
- Other specific topics when implementing ITIL.

On the other hand, the management of IT processes is particularly complicated in small companies [27,28]. The main reason for this is the lack of resources to dedicate specifically to ITIL implementation, as explained in [29–31]. That is, small companies do not have the resources to hire or obtain specialists, experts and software, and all of this is needed to fulfill the implementation of ITIL satisfactorily. Considering the difficulties for big companies, all these authors show the harder difficulties of implementing ITIL in small organizations. Some other authors have also focused on ITIL and small companies, such as [24].

The importance of ITIL in small companies is more relevant if the high percentage of these companies in most first world countries is considered [32] as well as the great impact of technology in the small companies' survival [33].

Thus, considering (a) the importance of ITIL standard, (b) the lack of a clear methodology to select the ITIL processes to be implemented and (c) the high percentage of small companies without enough resources, the question to answer in this paper is to define a methodology to determine a sequence of processes to implement ITIL in small companies. The methodology must be stand-alone, meaning no external consultant is required to define the sequence.

The next section presents a literature review about the approaches for the implementation of ITIL and its adaptation for small companies. After that, the methodology is exposed, and an application to a real case is shown. Finally, the results and conclusions are presented.

1.1. State of the Art

A systematic literature review (SLR) was developed to understand the state of the art of the implementation of ITIL and its implications in small companies. The systematic literature review followed a standardized method [34] in the systems engineering discipline. The problem to solve with the review is to find methodologies, sequencing algorithms and any proposal that helps small companies to order the set of ITIL pro-

cesses for its implementation. A summary of the found references is presented in the following paragraphs.

In order to help the understanding of the results, three main strategies were identified:

(I) Critical success factors and examples of implementation: A high number of references about critical success factors were found as well as real examples of implementations to be used as references;

(II) Fixed sequences of processes: A second group of authors establishes a fixed order of ITIL processes with no dependency on the attributes of the company. That is, the size of the company does not matter, nor does the country or its size. It does not matter if it is a big or a small company; in any case, the order of processes for ITIL implementation remains identical;

(III) Adaptive sequences: The more dynamic strategies try to identify sequences considering the specific parameters of the company (i.e., these authors consider different sequences of processes for companies depending on, for example, the size, industry and country).

It is also possible to identify a fourth category regarding specific sequences for small companies.

In the next few paragraphs, the references found for these classifications are commented on.

I. Strategies and critical success factors

The influence of the factors identified as critical in the implementation of ITIL has been one of the most studied research areas. Some authors are very active in this area, as shown in [14,21,31,35,36]. This topic is still being analyzed in recent works [16,37], and it has been a recurrent topic of research, as shown in [38]. The general way to discover the critical factors is to survey the stakeholders or the observation of different ITIL implementations. Although there is not a clear commitment on the set of factors that affect implementation, three of them appear in the majority of the studies: management involvement and the organization's commitment and effectiveness.

Some studies identify factors related to the project of implementation itself: tools, organization of the project, procedures in the project and others. That was the case in [36,39], which demonstrated the importance of using tools to support project implementation as well as the procedures to carry it out under quality considerations. These references stress that even if the commitment of the managers and the organization is important, the use of procedures and tools is also quite important for success.

An alternative approach is shown in [23], where the author shows how important the management of the process change is. The argument is based on the resistance to changing the rules in organizations and why the new processes are not always welcome. It is important to manage the implementation of new ways of doing things, and so the factor of 'management of process change' is important when implementing ITIL.

The constant reference to critical success factors is reflected in [40], where a complete systematic literature review is presented. The author shows the different success factors identified by other authors, and the great importance given to the training of the IT staff who will work with ITIL implementation is relevant. The research was developed following the analytical hierarchical process (AHP) to evaluate the factors and eliminate possible inconsistencies and redundancies. Something similar is found in [35], where a vast literature review is presented regarding the critical factors in 160 different organizations which drove the implementation of ITIL.

Some authors have studied the critical factors that have influence on the implementation of ITIL in small companies, such as those in [41]. This approach also makes use of the AHP methodology. The idea is to produce a model which generates the factors that should be considered to succeed. The model considers technical, organizational and behavioral aspects and involves the different stakeholders in the project. One of the main conclusions

is that the small companies need a sequence to implement ITIL; otherwise, the project can fail easily.

A different but interesting approach was developed in [30], in which the author studied the factors which make a project fail. Instead of guessing the factors to increase the possibility of success, the author analyzed the factors which drive failure in ITIL implementation.

Some authors have implemented methodologies to select the critical factors. One of the most mentioned in the literature is in [23]. In this case, the author uses the business process change (BPC) to determine the relevance of the factors.

Finally, it is possible to find some other approaches which define methods or procedures that may ease the implementation of ITIL. A first group of authors who worked on the maturity of the processes to select the initial processes to be implemented was identified [29,40,42], as was a second group of authors who have designed strategies based on the infrastructure, available resources and other issues around the implementation project [11,43].

After reviewing all these references, the summary is that all of them focus on the factors that may affect (positively or negatively) the implementation of ITIL, or they focus on the methods or steps to implement ITIL. None of them give a solution to the order of the processes to be implemented, nor do they make a clear distinction between big and small companies.

II. Adaptive order of processes

Apart from the authors who have worked on methodologies and critical success factors, the problem of the order of processes still remained. Therefore, some authors investigated which order should be used to implement all ITIL processes. There are several ways to define a non-static order for the processes. The first idea is organizing the sequence (or order) of processes attending to the internal parameters of the company or organization [5]. This approach requires hiring some experts to evaluate these parameters and to evaluate the impact they have for the implementation of ITIL. The translation of the opinions of experts into a sequence of processes is supported by fuzzy logic techniques. This idea has two disadvantages: the need of experts and not considering environmental parameters (e.g., competitors, size and country). Something similar occurred in [44,45].

An alternative approach to define the set of processes to implement is to identify the needs of the company by looking at its objectives. The set of processes to implement is defined by considering the objectives of the company. The aim is to get 'quick wins', as the author in [43] recognized. This solution generates an adaptive set of processes, although it has a great disadvantage: the quick wins arise from the surveys given to the clients, and so the strategy is very much oriented by their opinions.

The alternative considered in [46] is based on the technology adoption model (TAM). In this case, the processes proposed depend on the requisites of the company and other issues, such as the industry and size. The sequence defined considers both internal parameters and critical success factors, managing the adoption of the changes with TAM methodology. This idea was shared in [26], where the external parameters (e.g., country and industry) have a great influence on the sequence of ITIL processes to be implemented.

The author in [15] has also worked with adaptive or non-static sequences, which are adapted to each company by taking into consideration the internal issues of the company related to the implementation of ITIL: the distribution of data, flow of information and the tasks required to complete every process.

It is particularly important to consider adaptive sequences in the current changing environment. The different states of the IT department require specific sequences for each one, which means that monolithic and common solutions do not solve the problems in all departments. This idea of conferring flexibility and dynamism to the IT departments is supported in [47], where it clearly states the importance of flexible IT departments and dynamic IT solutions: "under conditions of high environmental heterogeneity [. . .] the impact of IT-enabled dynamic capabilities on competitive performance is amplified". This

is clearly aligned to the adaptive order of processes strategies. However, this is also pointed out in other works, such as in [48], which concluded that some ITIL processes can be managed properly with changing environments if implemented with some prioritization over the rest. One method that is capable of dealing with change, which can make dynamic organizations and respond to change well, is to strategize and apply the concept of continuous service improvement, better known as continual service improvement (CSI). This is also aligned with adaptive sequences, as CSI can be implemented with the correct prioritization once some other ITIL processes (with eventually higher priority) have been implemented. The static order of processes analyzed in the next paragraphs does not confer any importance to CSI, as the methods based on the static order of processes focus mainly on operative processes.

The summary of all these approaches is that different authors have proposed specific sequences considering the internal or external parameters of the company and the implementation itself. Nevertheless, none of the results show that the sequence is optimized for a particular company; that is, there is no evidence that the proposed sequence is optimal for a specific organization.

III. Static order of processes

There is another possibility for establishing a sequence: determining a standard sequence that should be used by all organizations. This approach requires defining a list of ITIL processes to be implemented independently of external considerations, such as the country, the competitors and the industry, and internal considerations, such as organization, flow of information and databases, among others.

Several authors have worked around this approach. Some relevant works include [25], where the sequence is set from the internal relations among every ITIL process. The consideration of every process is measured in terms of the relations and dependencies of this process with the rest of processes of ITIL. The larger the number of dependencies, the greater the importance of the process. The disadvantage of this proposal is that there are so many dependencies among processes that only the first processes of the sequence can be defined. A similar proposal was presented in [49], although it considered only a partial set of ITIL processes to define the sequence.

The idea of a static sequence for all companies has been frequently used in the research history. Another example is in [50], where the author proposes a set of models to define the sequence of processes: A first model with the ITIL processes, as defined in the standard; a second model containing the dependencies among models (something similar to [25]); and a third model that links every process with its capacity level and maturity level in the organization. The result is a model that generates a general sequence (quasi-static, as it slightly differs from one company to another depending on the maturity levels) of ITIL processes.

Another author very active in static sequences is in [21]. This reference is important because it was about the first initiatives to study the most satisfactory sequence for implementations, but it has the disadvantage of proposing a static sequence for all companies. The sequence is based on the observation of real cases. Some other examples in this category are [12,19,24,51], where only the initial processes for the sequence to be implemented are proposed. In some cases, the objective is building a model to help the selection of a static sequence of processes [52].

There are slight differences in the proposed processes from these authors, but a general conclusion is that the operative processes should be initially implemented due to the 'quick wins' returned (incident management, requirement management, access management, event management and problem management).

The publications mentioned previously generally referred to companies of any size. Nevertheless, some of them were specifically oriented to small companies, which will be commented on in the next paragraphs.

IV. Specific approaches for small companies

Small companies have specific handicaps, as they usually do not have enough resources to dedicate to the implementation of standards in their organizations. This affects them in different ways, but the most clear one is the lack of alignment of the different departments and functions to the strategy, objectives and aims of the company. As was stated in [53], "larger firms are more likely to adopt formal processes and use standards, therefore enabling alignment". This happens not only with IT departments but also with other departments, such as with the procurement departments. As was explained in [53], "the size of a firm correlates with its ability to achieve procurement alignment". This study concludes that investing in flexibility in IT solutions and infrastructures will have positive effects in terms of aligning IT, other departments such as procurement and the strategy of the company.

The references to ITIL are mostly oriented to companies both big and small. Nevertheless, there have been authors interested in the implementation of ITIL in small companies in recent years. Initial efforts were developed in [12,24,29,54], where the interest was helping small companies to start the implementation of ITIL, so some specific initial processes are proposed for these organizations to start with.

The interest in the topic grew due to the huge number of small companies in the world and the fact that there was no specific strategy to implement ITIL in small companies. The literature published up to that moment about ITIL and small companies was gathered in [55], which indicates the relevance of the topic. The conclusion of this work is relevant: "there are not many publications of relevance that deal with the topic of ITIL and small companies".

Recently, some authors have published some approaches to the topic of ITIL and small companies in terms of real cases or architectural or theoretical models [4,41,42].

Another approach to the problem which has been taken for ITIL in big companies is to analyze ITIL in small companies by industry [13].

1.2. Research Scope

After all these publications, the conclusion is that the problem still remains: small companies do not have a clear sequence of processes to implement ITIL.

Therefore, the following can be assumed:

- The specific handicaps of small companies regarding the implementation of processes in IT departments;
- The absence of specific tools to define the sequence of ITIL processes for implementation in small companies;
- The great number of small companies all around the world.

The objective of the research is to define a methodology to obtain an adapted ITIL sequence for each small company. The requisites to fulfill the gap in the market should be the following:

1. The sequence must be easy to obtain;
2. The methodology should not oblige hiring experts or consultants;
3. There must be a strong mathematical basis to ensure the quality of the results.

This work is different from the existing ones because (a) it does not require hiring experts or consultants, (b) it generates sequences of ITIL processes specific for each company and (c) every generated sequence is optimal to get close to (some or all of) the rest of the companies.

After presenting the methodology, an example of application in a real small company is shown. Finally, the discussion and conclusions are presented.

2. Materials and Methods

This paper presents a solution to sequencing the ITIL processes based on two main blocks. One of them is the algorithm, and the other one is the database that contains information required by the algorithm, such as the size, age, industry and IT size (among

other data) of each company and the level of implementation of ITIL processes in those companies. The aim of the database is to have available a set of data about other companies, which is the level of implementation of ITIL of these companies. All this information will be used by the algorithm to build an optimal proposal of a sequence.

The second main block is a mathematical model (details of the model can be found in Section 2.4) that calculates the best process to implement. This model calculates the best process by considering the data stored in the database and by considering the characteristics of the company that is implementing ITIL. This results in an optimal sequence. If we calculate the best process to implement in each step, at the end the result is an optimal sequence of processes.

Therefore, the iterative application of the model results in an algorithm that solves the problem of finding the optimal sequence of processes to be implemented.

Figure 1 helps to understand how it works. First of all, it is necessary to have a database (labeled as DB) with data from companies (e.g., size, age, industry, IT size, region and level of implementation of each ITIL process), labeled as SmallComapny1, SmallCompany2, and so on.

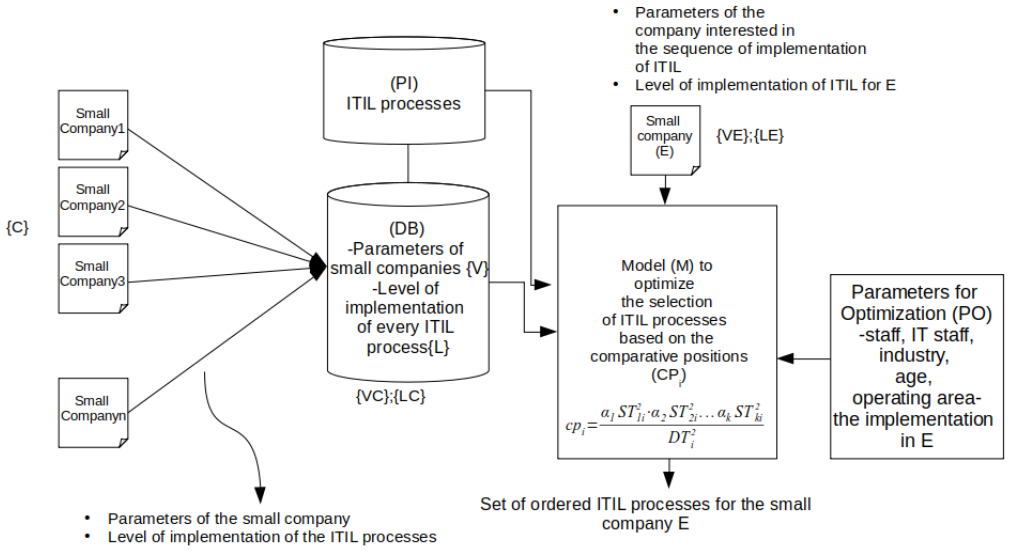

Figure 1. Methodology schema.

The mathematical model also requires information about the small company (E) that is implementing ITIL. The current level of implementation of ITL processes—that is, if there is any ITIL process already implemented and the characteristics of the company E that desires to complete the implementation of ITIL— is required. Moreover, the mathematical model needs the criteria to build the sequence. This means that the optimal sequence can be built to minimize the distance with the companies in the same industry to minimize the distance with the companies with the same age, the same staff or a combination of several criteria. These criteria used in the mathematical model are labeled with PO (parameters for optimization).

The next paragraphs explain in more detail the methodology presented above.

One of the ways to define a methodology to solve a specific problem is though the definition of a set of procedures which operate with data or information. Therefore, it is necessary to clearly set the problem, the procedures and the data:

i. Regarding the problem, this was exposed in Section 1. The aim is to obtain a sequence of ITIL processes that should be implemented in a company.
ii. Regarding the data, let us remember that one of the requisites established was avoiding hiring experts or consultants. The information provided by consultants comes from previous implementation experiences in a set of companies. As such, the proposal is to reach a similar level of information by querying a database with information

about companies, their characteristics and the ITIL processes implemented in them. The simplest way to obtain these data is through sending surveys to companies and storing them in the database. All the details about the survey are explained in Sections 2.1 and 2.2. The database details are included in the Supplementary Material section.

iii. Regarding the procedures, more information is given below.

The procedures are a set of steps that are repeatedly applied on the available data to solve the initial problem. There are commonly two types of approaches: qualitative and quantitative. Due to the availability of the numerical data collected in the survey (see Sections 2.1 and 2.2), the quantitative approach fit better, and so the procedures will be defined on a mathematical basis. The steps are explained in Section 2.4.

It is generally a good practice to have the procedures implemented in a software application when there exists a mathematical basis. This software eases the applicability of the procedures if the computing tasks are heavy. As such, a web application was developed to support the full methodology (see Section 2.3).

The schema in Figure 1 gives an overall view of the methodology. The data collected from the survey (with information about the characteristics (VC) of the companies (C) and the level of implementation (LC) of the ITIL processes) is stored in the database (DB). On the other hand, a model (M) based in a mathematical formulation is the core of the methodology. This model considers the (a) characteristics (VE) and initial level of the ITIL implementation (LE) for the company (E) that wants to generate a complete ordered list of ITIL processes (PI); (b) characteristics (VC) and level of implementation (LC) of a set of companies (C) stored in the database and (c) the criteria or parameters (PO) that should be used by the model (M) to generate an ordered sequence of processes.

Once the model receives these data, the formulae are used to calculate the first process in the sequence. This first process in the sequence is calculated to maximize the closeness to the companies under the criteria defined by the company. To do so, an optimization function to measure the distance to the rest of the companies is defined and evaluated. The iterative evaluation of the optimization function returns the complete sequence of processes. The complete description of the model and some minor settings is given in Section 2.4.

2.1. About the Survey

The steps described in Section 2.4 require a database to work with. This database gathers information about small companies, including the characteristics and the level of implementation of every ITIL process. These data were acquired through a web poll sent to small companies. Table 1 shows the main parameters.

Table 1. Pooling parameters.

Characteristic	Value
Request format	Web
Region	Spain
Universe	Companies (1–249 employees)
Requests sent	250
Answered forms	131
Minimum for significance	64
Confidence level	90%
Selection of companies	Randomized
Phases-pool	1
Type of questionnaire	Questions with multi-option answers
Date	2020

2.2. About Participants and Web Form

The participants were IT managers or general managers in small companies randomly selected out of a database of more than 7000 companies in any industry. The companies were sent a web form with questions about their size, industry, staff, market and other parameters that would be used afterward to optimize the selection of ITIL processes. The companies were also required to answer the level of implementation of every ITIL process.

The type of questions was multi-choice in all cases to simplify the analysis. Each option corresponded to an interval. For example, the parameter age was segmented in four intervals (1: 1–4 years old; 2: 5–9 years old; 3: 10–14 years old; and 4: +14 years old).

There were three possible answers to the level of implementation of ITIL processes (1: not implemented; 2: not implemented but scheduled; and 3: implemented or it will be coming soon).

As indicated in Table 1, the requests were sent by an email containing a hyperlink to a web form where all answers were received.

2.3. Dataset and Application

A database stored the answers to be analyzed and used in conjunction with the steps described in Section 2.4. The application of the methodology required an application due to its mathematical basis. Both the dataset and the link to the application can be accessed in [dataset].

Section 2.4 explains the steps in detail.

2.4. Steps to the Sequence Processes

As pointed out in the introductory paragraph of Section 2, the methodology to obtain the optimal sequence requires a database (DB) with a set of companies {C} and their characteristics. The parameters to consider are usually the size of the company, the number of employees, the number of IT employees, the age of the company and the operating area of the business (international or local), among others. Let us identify by {V} the set of parameters to characterize any company. The database also stores the level of implementation of ITIL in the companies contained in {C}, which corresponds to a matrix {LC}.

The possible values for each parameter in {V} need to be split into intervals. For example, the age parameter might be split into three intervals (1–4 years old; 5–9 years old; and more than 9 years old), assigning the values 1, 2 and 3 to each of them. Therefore, a vector {Pc} is defined for each company, and the matrix {PC} represents the set of {Pc}; that is, it represents all the values for the characteristics in the companies contained in {C}.

In the case of the level of implementation, the criteria might be as follows. A value of 1 means that the ITIL process is not implemented, and it will not be in future; a value of 2 means it is scheduled; and a value of 3 means it has already been implemented or it will be very soon. Thus, a vector {Lc} of the values of implementation is stored for each company. The set of {Lc} values is aggregated in a matrix {LC} for all companies in {C}. The definitions are represented in Figure 1.

Let us assume that E is a company with interest in obtaining an optimal sequence to implement ITIL and {PI} is the set of process candidates to be implemented. Of course, the initial situation is that {PI} consists of all ITIL processes.

Let us identify with {LE} the set of values that indicates the level of implementation of every ITIL process in the company E, and let us identify with {VE} the vector of all the values given to the parameters that define the characteristics of E.

It is possible to build a mean parameter vector {S} with the mean of the level of implementation of every process in {PI} for the companies that satisfy each element of {VE} (i.e., the mean of the organizations with the same value VE_i). In other words, {S} consists of a set of vectors with the mean of the level of implementation for the companies which have the same age, the same industry or any value in {VE} that is the same as E.

The next step is to know how far the implementation of a particular process P_i contained in {PI} is from the maximum value (which is 3, as was indicated previously). This should be done for both the company E and for every vector in {S}, where each column represents the mean of ITIL implementation in companies satisfying each value VE_i. Thus, two vectors of distance to the maximum implementation, called {ST} and {DT}, are obtained. That is, {ST} represents the distance of each process in {PI} (i.e., the values in {LE}) to the value given to an implemented process, and {DT} represents the same distance for the companies satisfying each value VE_i in {VE}.

In this situation, it is possible to define a matrix of values {CP} that identifies the level of implementation of any ITIL process for E compared to the level of implementation of the same process in the companies that satisfy {VE}. This 'comparative position' is defined through Equation (1):

$$cp_i = \frac{\alpha_1 ST_{1i}^2 \cdot \alpha_2 ST_{2i}^2 \ldots \alpha_k ST_{ki}^2}{DT_i^2} \quad (1)$$

where α_i represents the weight of the parameter in the optimization formula (so if all parameters equal 1, all of them have the same influence in the optimization formula). Equation (1) should just contain the selected parameters (PO) for optimization; the parameters which are not needed for optimization should not be present in this expression. This indicator has a great advantage: it allows the company E to decide the criteria that the optimization should use; that is, the organization E decides whether to optimize in terms of the size of the company, in terms of the industry or in terms of any other parameter contained in {V} or a group of parameters.

Finally, the process that should be initially implemented is the one that minimizes Equation (1). Thus, Equation (2) indicates how to select the optimal process:

$$P_{sel} = P_i \mid cp_i \leq cp_k \nabla k \in 1..|\{P_i\} \quad (2)$$

It is clear that if ST_{mi} is close to the minimum value, the competitors are in a better position than company E for the particular process P_i, but also, if DT_i is close to the value representing no implementation (i.e., three) of P_i in E, then cp_i gets larger.

It is possible to prove that P_{sel} is the best process to implement.

Let us assume that the processes p_i are listed by the increasing value of CP. In that case:

$$cp_1 \leq cp_2 \ldots \leq cp_{ITILprocesses} \quad (3)$$

Let us define with $O_n = \{p_1, p_2, \ldots, p_i, \ldots, p_{n-1}, p_n\}$ the optimal sequence of the initial n processes that the company should implement.

Let us define with S = $\{p_1, p_2, \ldots, p_i, \ldots, p_{n-1}, p_{n+k}\}$ any alternative sequence of n ITIL processes, where the p_n element has been substituted by another element p_{n+k} that satisfies the state in which NP_{n+k} is higher than NP_n. In such a case, the set of values for cp is defined by $\{cp_1, cp_2, \ldots, cp_{n-1}, cp_{n+k}\}$.

Let us assume, without losing generality, that the processes from $n + k$ to n_ITIL are included in S in the correct order. In such a case, S = $\{p_1, p_2, \ldots, p_i, \ldots, p_{n-1}, p_{n+k}, p_{n+k+1}, \ldots, p_{n\_ITIL}\}$ is still an optimal sequence, but there still exists a set of processes $\{p_n, p_{n+1}, \ldots, p_{n+k-1}\}$ with $\{cp_n, cp_{n+1}, \ldots, cp_{n+k-1}\}$ which requires selection and inclusion in the sequence.

Let us select the case denoted by p_{n+k-1} with a value NP_{n+k-1} to be added to R. It could have been chosen for any other process, but this one represents the worst case. Therefore, it results in $R = \{p_1, p_2, \ldots, p_i \ldots, p_{n-1}, p_{n+k}, p_{n+k-1}\}$ with $\{cp_1, cp_2, \ldots, cp_{n-1}, cp_{n+k}, cp_{n+k-1}\}$. In the case of S being an optimal sequence, then $p_{n+k-1} < p_n$. As all the processes are ordered by increasing NP values, then $p_{n+k-1} > p_n$. This means that the final R is not an optimal sequence, and so there only exists one optimal sequence O.

Once here, the steps to follow are listed below:

1. Fulfill the database with the data from all possible companies, namely the data of the parameters and data about the level of implementation of ITIL;

2. Require data from the company E about the parameters and the level of implementation of ITIL processes;
3. Eliminate the processes completely implemented in E from the set of candidates {PI};
4. Decide the criteria for optimization and the weights of the parameters in the optimization expression;
5. Evaluate Equation (1) for every candidate process {PI};
6. Select the process P_i in {PI} that minimizes Equation (1) by using Equation (2);
7. Eliminate P_i in {PI};
8. Repeat from step 5 until {PI} is empty or until the maximum number of required processes for the sequence has been reached.

The pseudo code of the algorithm can be found in Appendix B.

3. Results

3.1. Application to a Real Case

In this section, a real case will be deployed. A small company from the leisure industry was selected. This company operates in Spain, although it has had international growth. The company is in the range of small company (less than 250 employees), and the amount of IT staff is 10–14 people. The company is more than 15 years old.

As was pointed out before, one of the main problems of small and medium companies is the difficulty of aligning the operative departments and the strategy of the company. In Section 1, it was presented how IT departments (not only IT, but also other departments such as procurement) have problems offering solutions to the company that help to achieve the objectives. In the case of IT, it is clear that services are mainly focused on offering solutions to other departments and to clients. The main handicap comes from size; due to the lack of resources, it is complicated to find adaptive and dynamic solutions for the specific problem of that small company.

In the example we present here, the aim is to prove the algorithm proposed and to validate its usefulness in a small company. The algorithm is aimed at defining the sequence of ITIL processes that most helps the company to satisfy the objectives; that is, based on the fact that the small company hardly supports a reduced IT department, the algorithm presented avoids hiring external consultants to select the best sequence of implementation of ITIL processes for this particular company.

Once the sequence is obtained, it will be compared to other sequences of other authors. The aim of this comparison is clear: if the sequence obtained is rather similar to the ones proposed by other authors, it will be worthless. However, if it is shown that the sequence obtained is not dependent (meaning it is statistically different) on previous sequences, then we can conclude that the adaptive sequence may help this small company. The second point to show is if the sequence obtained is a valid and implementable sequence of processes. To prove this, the sequence of ITIL processes would be implemented in the company. This project of implementation took about six months, which demonstrates the validity of the sequence. For sure, more trials need to be developed in other companies, but this will be pointed out in the future works section.

The interest of the company was to get an optimal sequence compared with what was commonly done by the rest of the companies, no matter the size, industry, age or other characteristics. As such, the optimization expression was reduced to Equation (4), where the term ST is minimized to the value '1' (i.e., no parameters are more influential than the rest in the optimization), and the index i is extended to every process in {PI}:

$$cp_i = \frac{1}{DT_i} \tag{4}$$

This means that the objective was to optimize the implementation of ITIL processes by minimizing the differences with common companies without caring about its characteristics.

Due to the high amount of calculus required, the application of the described methodology was conducted through a web application that could be accessed in the application

referenced in [56]. This web app just needed to be fulfilled with the characteristics of the company and the desired optimization rules. The application replicated the previously explained model and the algorithm proposed, so the user just needed to introduce the characteristics of the company that wanted to implement ITIL and the parameters to define the optimization function. The application automatically generated the sequence of ITIL processes (the database needed by the algorithm was already fulfilled with data from the survey).

Once the data had been entered and the optimization rules were configured in [dataset], the ordered list of specific ITIL processes for this small company was obtained. The list of ordered processes is presented in Table 2.

Table 2. List of ITIL processes for a real small company.

Sequence Number	Process	Sequence Number	Process
1	Incident management	6	Service catalog management
2	Access management	7	Availability management
3	Improvement process	8	Service portfolio management
4	Information security management	9	Request fulfillment
5	Service validation and testing	10	IT service continuity management

When looking at Table 2 carefully, incident management was the first process to be implemented, which is common in most of the proposals presented in the literature review section. Nevertheless, the improvement process was in the third place, which reveals that the best solution is not always to implement the operative processes, as is supported by many authors. In fact, this aligned with the results in [48], where the continuous improvement process had special relevance.

The importance of this sequence is that the company has a sequence to implement ITIL processes. There is a clear path to follow without hiring experts to define the sequence. This point is particularly important for these small companies with few resources. In the next few paragraphs, two important issues are explained:

- The result of the implementation project: it is necessary to verify the viability of the sequence; otherwise, the algorithm would be producing impossible sequences.
- The comparison to other authors' sequences: it is necessary to verify the independence of this sequence compared with the existing ones; otherwise, the algorithm is producing redundant sequences.

3.2. Results of the Implementation Project with the Sequence Obtained

The implementation project was developed over six months, and these ten processes were satisfactorily implemented. Implication of the full IT staff and of part of the staff of other departments was necessary. Implication of the IT manager directly linked to the steering committee was necessary to fully support the project. Besides that, the internal software tools were used to ease the implementation of some of the processes, such as incidence management, access management and requirement management. Some others additionally required the definition of procedures and implication of the directors to make workers to use them. This is in agreement with the critical factors identified in the systematic literature review.

At the end of the project, a partial implementation of ITIL was achieved, which became a success for this company. Obviously, this implementation pilot allowed implementation

of the first ten processes, which eased the schedule for the next ITIL processes that should have been generated using the model exposed in this paper.

The effectiveness of the process is demonstrated, as the initial restrictions in Section 1.2 are satisfied:

1. The sequence must be easy to obtain: The sequence was obtained by the algorithm just by entering the data into the application [56]. This application is based on the mathematical model presented above and makes use of the database built from data gathered in the survey;
2. The methodology should not oblige hiring experts or consultants: It was not necessary to hire any ITIL experts to build the sequence. This is important because the aim of the paper is to find a solution for small companies that cannot afford to hire experts;
3. There must be a strong mathematical basis to ensure the quality of results: The sequence obtained was based on the mathematical method, so the optimal result was guaranteed.

3.3. Comparison with Other Authors' Sequences

This result was compared to the sequences published in the literature referred to in the Section 2. The objective of this comparison was to know if the list of processes obtained was substantially different from the existing ones (proposed by other authors) or not. It makes sense to follow the optimal generated sequence if it is significantly different from the sequences proposed by other authors; otherwise, it can be assumed that the sequences of the other authors are already optimized. The objective of the comparison was to decide whether the sequence obtained was statistically different. To do so, a Spearman contrast was developed, as this is the typical test to validate the independence of two data series. This test identifies if the sequence obtained was statistically different or not from the published ones. In the case of being statistically different, it is possible to assume that the optimal sequence obtained with the methodology proposed was not previously proposed by other authors' approaches. The test calculated for each reference is as follows:

Hypothesis 1 (H1). *The optimal and reference sequences are independent.*

Hypothesis 2 (H2). *The optimal and reference sequences are not independent.*

The list of commonly referred authors, whose proposals of sequences have been compared with the optimal sequence obtained with the methodology, is shown in Table 3.

Table 3. List of ITIL sequences to compare.

Sequence Number	Sequence Author (Reference)	Sequence Number	Sequence Author (Reference)
1	[51]	4	[25]
2	[26]	5	[5]
3	[15]	6	[52]

The values obtained for the ρ Spearman parameter and the limits of the interval to accept H_1 are presented in Table 4. The significance level is α = 95%.

Table 4. List of ITIL sequences to compare.

Sequence Number	ρ	Interval to Accept H1	Sequence Number	ρ	Interval to Accept H1
1	0.207	±0.46	6	−0.317	±0.7
2	0.086	±0.425	7	−0.371	±0.886
3	0.231	±0.406	8	0.176	±0.648

As can be derived from Table 4, the conclusion is that the proposed calculated sequence in Table 2 was statistically different from the existing ones.

4. Discussion and Future Works

4.1. Discussion

This paper is aimed at presenting a methodology to solve the problem addressed in Section 1: small companies need to implement ITIL, and it is a must to define a sequence of ITIL processes specifically designed for each company.

The methodology presented in Section 3 was based on empirical data obtained from a survey. These data were used in conjunction with a mathematically based model that selected processes one by one in an ordered sequence. The result was an ordered set of processes that was optimized for a specific company, and the optimization parameters were defined by each small company.

The methodology was tested in a small company that finally implemented a subset of the ITIL processes (due to limitations of time and economical resources). It was a great advantage to start the ITIL implementation with a clear path to follow.

Some considerations can be made regarding the methodology and its application:

1. The aim of this paper was to define a stand-alone methodology for small companies, as indicated in Section 1. The methodology was presented and tested in a real case.
2. There is an important advantage in this methodology: it is not required to hire external consultants or experts for its application. The knowledge is stored in the database, and the methodology avoids needing external advisers. This was one of the hypotheses established in Section 1. The steps explained in Section 3 and the mathematical formulation make hiring external resources unnecessary.

Apart from these issues, there exist some other positive arguments in the exposed methodology:

1. The methodology has a mathematical basis, which makes it reliable. The optimization model allows for finding the set of processes to implement and the order to perform them in. This optimization model permits a small company to identify and introduce its main interests in the calculations. This generates an optimal result for the specific company that is using this methodology.
2. Another advantage is that the model operates over a real database with data gathered in a survey. This is useful for small companies to know what other companies are doing. It also allows for configuring the optimization and emphasizing which aspect should be more important in the result; that is, this methodology allows for emphasizing the staff, IT staff, market, age or any other characteristic of the company. This is important because small companies can align the implementation of ITIL with the objectives of the company. For example, if a company desires to minimize the difference with the situation of the competitors (in terms of ITIL implementation), it just needs to configure the optimization parameters, or in the case that the small company desires to maximize the effort of the IT staff, it is possible to obtain a sequence of processes referring to companies with similar IT staff.
3. It is also important to indicate that this was not just a theoretical study, as there is an app and a database supporting the research.
4. The application to a real case exhibited success, although not all of the ITIL processes were implemented in the end. A partial implementation of ITIL processes is better than nothing, and it represents a great advance for the small company where the methodology was applied.

However, there are still some issues to point out and consider for further studies:

1. As was pointed out in Table 1, the survey was developed with Spanish companies. This implies that there could be some limitations in the application of the methodology if the characteristics of the companies are very different in other countries. It is well known that small companies in most European countries and other First

World countries have similar characteristics, but it would be necessary to confirm the application of these results.
2. The results obtained were statistically significant. Nevertheless, it is important to extent the study to more organizations in other industries that are moving into the massive use of technology.
3. There is an issue to evaluate regarding ITIL processes. It is assumed that all the processes included in ITIL are valid for these small organizations. This study was extended to the whole set of processes. It is needed to analyze whether all of the proposed processes are really needed in small centers. This limitation requires new research.

4.2. Future Works

Considering the mentioned elements, there are some possibilities for future work to develop around this research:

1. A future immediate work is to extend the application of the methodology to other real cases and generate a set of real cases so that a satisfaction analysis can be obtained. Even if a real case of application has been shown, it is necessary to implement the specific sequences of processes in different companies and evaluate the results.
2. In second place, the prioritization of processes can be improved by including the importance of the processes; that is, some ITIL processes are more relevant for the business than others. For example, in the current version of ITIL, all security topics have the same importance as other non-critical processes (for example, provider management). It could be interesting to analyze how to improve the model presented by weighting these issues.
3. The extension of the data to more countries would be useful, and it would generate adapted results to small centers in different locations. The utility of the model still remains, and the benefits for more and more companies could be increased. This work implies generating new surveys in different countries to build a big database so the methodology can operate with it.
4. Another improvement is represented by the inclusion of critical success factors in the optimization functions. For example, this could be considered the confidence on the team, the involvement of the steering committee or the management of the resistance to change.
5. Finally, the database can be improved by updating the processes that may appear in new ITIL versions.

5. Conclusions

The aim of this paper was to present a methodology to help small centers to sequence IT processes. The model has a mathematical basis to optimize the selection of processes while it uses real data to make a decision about the sequence that best fits the needs of the organization. The optimization can be oriented to satisfy the needs of the small company thorough different parameters. The methodology does not require hiring resources or consultants.

After presenting the model, a real application case was shown. The success of the implementation was a key point in the small company selected for the validation project.

The methodology was proven to be efficient and a good alternative for those companies that decide to implement ITIL and require some help to start sequencing the set of processes. The methodology allows these companies to select how to optimize the sequence by configuring the parameters in the optimization function.

Despite the optimal behavior of the methodology, some improvements and future works were addressed to enhance its benefits and applicability.

Supplementary Materials: The following are available online at https://zenodo.org/record/4481865#.YKRz8aERWUk.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Available on https://zenodo.org/record/4481865#.YKRz8aERWUk.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

The questions and the possible answers in the survey are presented in Table A1.

Table A1. Questions and possible answers in the survey.

Questions about the Company	**Possible Answers**
Company name	[open]
Staff	1–9 10–49 50–249
Staff in IT	0–4 5–9 10–14 15–
Age of company	0–4 5–14 +15
Operating area	Local National International
Industry	IT Health and social services Taxes—legal Real state Telecomm. Energy, water, electricity, gas Marketing, image, communication Commerce—eComm Electronics—semiconductors Delivery, logistics, transport Construction, maintenance Metal industry Education, sports Finance, insurance, bank Food, chemical, pharma Other
Questions: Level of Process Implementation	**Possibilities for Answers**
P1. Service strategy management	Not implemented/Not planned Ongoing/Planned Implemented
P2. Service portfolio management	Not implemented/Not planned Ongoing/Planned Implemented
P3. Finance management	Not implemented/Not planned Ongoing/Planned Implemented

Table A1. *Cont.*

P4. Demand management	Not implemented/Not planned Ongoing/Planned Implemented
P5. Business relation management	Not implemented/Not planned Ongoing/Planned Implemented
P6. Design management	Not implemented/Not planned Ongoing/Planned Implemented
P7. Service catalog management	Not implemented/Not planned Ongoing/Planned Implemented
P8. Availability management	Not implemented/Not planned Ongoing/Planned Implemented
P9. Service level management	Not implemented/Not planned Ongoing/Planned Implemented
P10. Continuity management	Not implemented/Not planned Ongoing/Planned Implemented
P11. Security management	Not implemented/Not planned Ongoing/Planned Implemented
P12. Provider management	Not implemented/Not planned Ongoing/Planned Implemented
P13. Capacity management	Not implemented/Not planned Ongoing/Planned Implemented
P14. Transition schd. management	Not implemented/Not planned Ongoing/Planned Implemented
P15. Change management	Not implemented/Not planned Ongoing/Planned Implemented
P16. Deployment and version management	Not implemented/Not planned Ongoing/Planned Implemented
P17. Validation and test management	Not implemented/Not planned Ongoing/Planned Implemented
P18. Configuration management	Not implemented/Not planned Ongoing/Planned Implemented
P19. Change evaluation management	Not implemented/Not planned Ongoing/Planned Implemented
P20. Knowledge management	Not implemented/Not planned Ongoing/Planned Implemented

Table A1. *Cont.*

P21. Incidence management	Not implemented/Not planned Ongoing/Planned Implemented
P22. Problem management	Not implemented/Not planned Ongoing/Planned Implemented
P23. Access management	Not implemented/Not planned Ongoing/Planned Implemented
P24. Event management	Not implemented/Not planned Ongoing/Planned Implemented
P25. Request management	Not implemented/Not planned Ongoing/Planned Implemented
P26. Improvement management	Not implemented/Not planned Ongoing/Planned Implemented

Appendix B

The pseudocode for the algorithm is briefly described below.

```
fun generate_optimal_sequence ()
{
for each characteristic of company E
input (ch[j])
#For company E, the implementation level for each process is set
for each ITIL process p_i
{
input (d[pr_i]);
V[pr_i] ← MAX_IMPL – d[pr_i];
}
#Generate vector of candidates
candidates= {}
for each ITIL process pr_i
{
if d[pr_i] <> MAX_IMPL
candidates= candidates U {process pr_i}
}
#Initialize selected processes
sel ← {}
#Generate vectors m and M
{
for each characteristic ch[j]
{
for each possible value of ch[j]
{
calculate m[i][j][k]; #optimization expression
M[i][j][k]← MAX_IMPL-m[i][j][k];
}
}
}
#Initialize the criteria for optimization formula:
```

```
# alpha[j] weights every characteristic
for every characteristic j in optimization formulae
{
input (int alpha[j]);
}
while sel<> {}
{
CP_min = CP[candidates[1]];
pr_sel ← 1; #Process with NP_min
for i ← 2 until processes in candidates
{
calculate CP[candidates[i]]; #optimization formula
if CP[candidates[i]] < CP_min
CP_min ← CP[candidates[i]] #new minimum
pr_sel← i; # New process min
}
#Select the process pr_sel
sel ← sel U {candidates[pr_sel]} #include in sel list
candidates←candidates- {candidates[pr_sel]}
}
#The optimal sequence is sel.
display sel
}
```

References

1. Mykytyn, P. COVID-19 and Its Impacts on Managing Information Systems. *Inf. Syst. Manag.* **2020**, *37*, 267–271. [CrossRef]
2. Mitev, Y.; Kirilov, L. Using IT Management Processes for Achieving Better Efficiency in the IT Service. In Proceedings of the ICEST 2014, Niš, Serbia, 25–27 June 2014; Volume 1, pp. 247–250, ISBN 978-86-6125-108-5. Available online: http://www.icestconf.org/ (accessed on 2 January 2021).
3. Gelles, M.G. How to Handle the Risk of Insider Threats Post-COVID-19. Available online: https://searchcio.techtarget.com/feature/How-to-handle-the-risk-of-insider-threats-post-COVID-19? (accessed on 20 August 2020).
4. Silva, H.; Silveira, D.; Dornelas, J.; Ferreira, H. Information Technology Governance in Small and medium enterprises: A systematic mapping. *J. Inf. Syst. Technol. Manag.* **2020**, *17*, e202017001. [CrossRef]
5. Zare, A.; Mansouri, T.; Mehrabioun, M. Supporting the module sequencing decision in ITIL solution implementation: An application of the fuzzy TOPSIS approach. *Int. J. Inf. Technol. Syst. Approach* **2014**, *7*, 41–60. [CrossRef]
6. Hesch, J. COBIT in relation to other international standars. *Inf. Syst. Control J.* **2004**, *4*, 37–40.
7. HP IT Service Management (ITSM). Transforming IT Organizations into Service Providers. 2003. Available online: ftp://ftp.hp.com/pub/services/itsm/info/itsm_businesswp.pdf (accessed on 31 May 2018).
8. Bahsani, S.; Himi, A.; Moubtakir, H.; Semma, A. Towards a poolimg of ITIL v3 and COBIT. *Int. J. Comput. Sci. Issues* **2011**, *8*, 185.
9. Pérez, D.H. De la Administración al Gobierno de TI. 2008. Available online: http://52.0.140.184/typo43/fileadmin/Revista_97/7_-_tres.pdf (accessed on 31 May 2018).
10. Van Bon, J.; de Jong, A.; Kolthof, A.; Pieper, M.; Tjassing, R.; van der Veen, A.; Verheijen, T. *Gestión de Servicios Basados en ITIL*; Haren, V., Ed.; Van Haren Publishing: 's-Hertogenbosch, The Netherlands, 2016.
11. Fry, M. *ITIL Lite: A Road Map to Full or Partial ITIL Implementation*; The Stationery Office: Norwich, UK, 2010; ISBN1 0113312121. ISBN2 9780113312122.
12. Lema, L.; Calvo, J.A.; Colomo, R.; Arcilla, M. ITIL in small to medium sized enterprises software companies: Towards an implementarion sequence. *J. Softw. Evol. Process* **2015**, *27*, 528–538. [CrossRef]
13. Rubio Sánchez, J.L. Methodology to Improve Services in Small IT Centers: Application to Educational Centers. *Computers* **2021**, *10*, 8. [CrossRef]
14. Pollard, C.; Cater-Steel, A. Justifications, strategies and critical success factors in successful ITIL implementations in USA and Australian companies: An exploratory study. *Inf. Syst. Manag.* **2009**, *26*, 164–175. [CrossRef]
15. Miller, A.C. Implementation Priority of the ITIL Framework Based on a Process Sequencing Model. Ph.D. Thesis, The George Washington University, Washington, DC, USA, 2017.
16. Shaw, K. Prioritizing Information Technology Infrastructure Library (ITIL) Implementations and Identifying Critical Success Factors to Improve the Probability of Success. Ph.D. Thesis, Capella University, Minneapolis, MN, USA, 2020.
17. Sharifi, M.; Ayat, M.; Rahman, A.; Sahibuddin, S. Lessons Learned in ITIL Implementation Failure. In Proceedings of the 2008 International Symposium on Information Technology, Kuala Lumpur, Malaysia, 26–28 August 2008; Volume 1, pp. 1–4.

18. Top 10 Reasons Why Do ITSM Implementation Fails. Available online: https://www.novelvista.com/blogs/it-service-management/why-itsm-tools-implemenation-fail (accessed on 15 January 2020).
19. Masarat, A.; Mohammad, S.; Shamsul, S.; Sulaimi, I. Adoption Factors and Implementation Steps of ITSM in the Target. In Proceedings of the 2009 Third Asia International Conference on Modelling & Simulation, Bali, Indonesia, 25–29 May 2009; pp. 369–374.
20. Ahmad, N.; Shamsudin, Z.M. Systematic Approach to Successful Implementation of ITIL. In Proceedings of the 1st International Conference on Information Technology and Quantitative Management (ITQM), Suzhou, China, 16 May 2013.
21. Cater-Steel, A.; Tan, W.G. Implementation of IT Infrastructure Library (ITIL) in Australia: Progress and Success Factors. In Proceedings of the IT Governance International Conference, Auckland, New Zealand, 14–16 November 2005.
22. Khosravi, H.; Wang, J. *How to Implement ITIL Successfully?: What Steps are Necessary to Implement ITIL What Factors are Critical within Implementation Process*; LAP Lambert Academic Publishing: Saarbrucken, Germany, 24 October 2011; ISBN 978-3-8454-7646-9.
23. Pedersen, K.; Kræmmergaard, P.; Lynge, B.C.; Schou, C.D. ITIL implementation: Critical success factors a comparative case study using the BPC framework. *J. Inf. Technol. Case Appl. Res.* **2010**, *12*, 11–35. [CrossRef]
24. Calvo, J.A.; Lema, L.; Arcilla, M.; Rubio, J.L. How small and medium enterprises can begin their implementation of ITIL? *Rev. Fac. Ing. Univ. Antioq.* **2015**, *77*, 127–136.
25. Arcilla, M.; Calvo, J.; Cuevas, G.; Gómez, G.; Ruiz, E.; San Feliu, T. A Solution for Establishing the Information Technology Service Management Processes Implementation Sequence. In *Software Process Improvement, 15th European Conference, EuroSPI 2008*; O'Connor, R.V., Baddoo, N., Smolander, K., Messnarz, R., Eds.; Springer: Berlin/Heidelberg, Germany, 2008; Volume 16.
26. Marrone, M.; Gacenga, F.; Cater-Steel, A.; Kolbe, L. IT Service Management: A Cross-national Study of ITIL Adoption. *Commun. Assoc. Inf. Syst.* **2014**, *34*, 49. [CrossRef]
27. Lehner, F.; Sundby, M.W. IT Capabilities for SMEs: An Analysis at the Organisational Level. In *The Impact of Digitalization in the Workplace Professional and Practice-Based Learning*; Harteis, C., Ed.; Springer: Cham, Switzerland, 2018; Volume 21. [CrossRef]
28. Holt, K. *The Influence of an ITIL Based Service Desk on Users' Perceptions of the ITIL Service and Their Use of ICT from the Perspective of the IT Team*; Charles Sturt University: Bathurst, Australia, 2017.
29. Binders, Z.; Romanovs, A. ITIL Self-assessment approach for small and medium digital agencies. *Inf. Technol. Manag. Sci.* **2014**, *17*, 138–143.
30. Shang, S.S.C.; Lin, S.F. Barriers to implementing ITIL—A multi-case study on the service-based industry. *Contemp. Manag. Res.* **2010**, *6*, 53–70. [CrossRef]
31. Cater-Steel, A.; Pollard, C. Conflicting views on ITIL implementation: Managed as a project–or business as usual. In Proceedings of the 2008 International Conference on Information Resources Management, Niagara Falls, ON, Canada, 18–20 May 2008.
32. Oricchio, G.; Lugaresi, S.; Crovetto, A.; Fontana, S. SMEs in Europe: An Overview. In *SME Funding*; Palgrave Macmillan: London, UK, 2017.
33. Papadopoulos, T.; Baltas, K.N.; Balta, M.E. The use of digital technologies by small and medium enterprises during COVID-19: Implications for theory and practice. *Int. J. Inf. Manag.* **2020**, *55*, 102192. [CrossRef] [PubMed]
34. Stapic, S.; López, E.G.; Cabot, A.G.; Ortega, M.; Strahonja, L.V. Performing Systematic Literature Review in Software Engineering. In Proceedings of the Central European Conference Information and Intelligent Systems (CECIIS' 12), Varazdin, Croatia, 19–21 September 2012; pp. 441–447.
35. Iden, J.; Eikebrokk, T.R. The impact of senior management involvement, organisational commitment and group efficacy on ITIL implementation benefits. *Inf. Syst. e-Bus. Manag.* **2015**, *13*, 527–552. [CrossRef]
36. Roar, T.; Iden, J. ITIL Implementation: The Role of ITIL Software and Project Quality. In Proceedings of the 2012 23rd International Workshop on Database and Expert Systems Applications, Vienna, Austria, 3–7 September 2012; IEEE Computer Society: Washington, DC, USA, 2012; pp. 60–64.
37. Sebaaoui, S.; Lamrini, M.; Bouayad, A.; el Abbadi, L. Challenges of ITIL Implementation Approaches. In Proceedings of the 4th International Conference on Business Intelligence (CBI'18), Beni Mellal, Morocco, 25–27 April 2018.
38. Iden, J.; Eikebrokk, T.R. Implementing IT Service Management: A systematic literature review. *Int. J. Inf. Manag.* **2013**, *33*, 512–523. [CrossRef]
39. Mahy, Y.; Ouzzif, M.; Bouragba, K. Supporting ITIL Processes Implementation Using Business Process Management Systems. In Proceedings of the Third International Conference on Systems of Collaboration (SysCo), Casablanca, Morocco, 28–29 November 2016; pp. 1–4.
40. Ahmad, N.; Noha, T.A.; Qutaifan, F.; Alhilali, A. Technology adoption model and a road map to successful implementation of ITIL. *J. Enterp. Inf. Manag.* **2013**, *26*, 553–576. [CrossRef]
41. El Yamami, A.; Yamami, A.; Ahriz, S.; Mansouri, K.; Qbadou, M.; Illoussamen, E. Developing an Assessment Tool of ITIL Implementation in Small Scale. *Environ. Int. J. Adv. Comput. Sci. Appl.* **2017**, *8*, 183–190.
42. El Yamami, A.; Mansouri, K.; Qbadou, M. Toward a New Multi-Agents Architecture for the Adoption of ITIL Framework by Small and Medium-Sized Enterprises. In Proceedings of the 4th IEEE International Colloquium on Information Science and Technology (CiSt), Tangier, Morocco, 24–26 October 2016.
43. Menken, I. *ITIL V3 Implementation Quick Guide–The Art of Stress-Free IT Service Management*; Emereo Pty Ltd.: London, UK, 2009.
44. Shojafar, M.; Zarrazvand, H. The Use of Fuzzy Cognitive Maps in Analyzing and Implementation of ITIL Processes. *arXiv* **2012**, arXiv:1206.2297.

45. Kate, E. The Beguinners Guide to ITIL. Available online: https://www.smartsheet.com/itil-processes-guide (accessed on 1 February 2021).
46. Mehravani, S.; Haghighinasan, M.; Hajjiheydari, N. ITIL adoption model based on TAM. In Proceedings of the 2011 International Conference on Social Science and Humanity, Singapore, 26–28 February 2011.
47. Mikalef, P.; Pateli, A.; van de Wetering, R. IT architecture flexibility and IT governance decentralisation as drivers of IT-enabled dynamic capabilities and competitive performance: The moderating effect of the external environment. *Eur. J. Inf. Syst.* **2020**, 1–29. [CrossRef]
48. Ranggadara, I.; Prastiawan, H. Strategy Implementing Continual Service Improvement with ITIL Framework at PT. Anabatic Technologies Tbk. *Int. Res. J. Comput. Sci.* **2018**, *5*, 70–76.
49. Ruiz, E.; Arcilla, M.; Cerrada, C.; Gómez, G.; Calvo-Manzano, J.A.; San Feliu, T.; Sánchez, A. Una propuesta organizativa de los procesos de SD y SS en ITIL. *Rev. Española Innovación Calid. Ing. Softw.* **2007**, *3*, 6–20.
50. Lucio, T.; Colomo, R.; Soto, P.; Popa, S.; Amescua, A. Implementing an IT service information management framework: The case of COTEMAR. *Int. J. Inf. Manag.* **2012**, *32*, 589–594. [CrossRef]
51. Lema, L. ITIL in Small to Medium-Sized Enterprises: Toward a Proposal Based on an ITIL Processes Implementation Sequence and a Profile Scheme Strategy for Implementing the First Process in the Sequence. Master's Thesis, Universidad Politécnica deMadrid, Lenguajes y Sistemas Informáticos e Ingeniería del Software, Madrid, Spain. Available online: http://oa.upm.es/36237/ (accessed on 18 May 2021).
52. Pastuszak, J.; Czarnecki, A.; Orlowski, C. Ontologically Aided Rule Model for the Implementation of ITIL Processes. In *Advances in Knowledge-Based and Intelligent Information and Engineering Systems*; IOS Press: Amsterdam, The Netherlands, 2012.
53. Mikalef, P.; Pateli, A.; Batenburg, R.; van de Wetering, R. Business alignment in the procurement domain: A study of antecedents and determinants of supply chain performance. *Int. J. Inf. Syst. Proj. Manag.* **2014**, *2*, 43–59.
54. Albero, F.; Calvo, J.A.; Arcilla, M. A case study related to the control of it services in a small enterprise. In Proceedings of the 5th Iberian Conference on Information Systems and Technologies, Santiago de Compostela, Spain, 16–19 June 2010.
55. Cruz-Hinojosa, N.J.; Gutiérrez-De-Mesa, J.A. Literature review of the situation research faces in the application of ITIL in Small and Medium Enterprises. *Comput. Stand. Interfaces* **2016**, *48*, 124–138. [CrossRef]
56. Rubio Sánchez, J.L. Small Companies ITIL. Available online: https://doi.org/10.5281/zenodo.4481865 (accessed on 18 May 2021).