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TRILHA PRINCIPAL

Analysis of ICT Investments. Towards a Methodological Guide with Focus on Estimation of Intangible Benefits.

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***Abstract*—Investments in Information and Communication Technologies (ICTs) can provide firms with both tangible and intangible benefits (IBs). However, these investments are generally analyzed and evaluated by means of traditional methods, which focus on the measurement of the tangible to determine, mainly, the amount of profit that has been obtained. In this paper we develop the foundation of a methodological guide with focus on the estimation of IBs. For this, we present evidence that suggests that an analysis of the impact of ICT investments by focusing on the estimation of IBs may be based on the value chain of a business unit; we also provide a list of factors of intangible value of ICTs identified in the literature reviewed and propose stages to fulfill and variables to use so as to contribute for a comprehensive evaluation of said investments.**

***Index Terms*—Estimation of intangible benefits, ICT investments, methodological guide, value chain, value factors.**

I. Introduction

Investments in Information and Communication Technologies (ICTs) are not restricted to providing firms with tangible benefits, easily quantifiable, but can also result in intangible benefits (IBs), difficult to measure [2], [16], [30], [39], as they support and help to improve the performance in their operations in a multidimensional fashion. Hence, IBs may be considered as value sources of intangible gain.

These investments can represent an extremely expensive and time-consuming exercise for firms [7], [11], [23], [34], [38], [43], [45]. Decision makers (DMs) must justify the required big budgets and significant efforts, and they must demonstrate that the desired results are being yielded [11], [12], [38], as their upper managers demand that ICT functions demonstrate value and deliver results that directly impact the success of business strategies [27]. The challenge therefore lies in demonstrating that ICTs are a measurable factor in the productivity statistics of a business unit (BU). On this regard, Robert Solow defined what was later labeled as the productivity paradox: "You can see the computer age everywhere but in the productivity statistics" [40].

Nevertheless, it is important to remark that productivity, understood for our study as the output of a business process in relation to its input, also includes the value created for user beneficiaries (USBENs) [5] that may also be obtained, partly or fully, from intangible factors.

As firms became aware of the potential of ICTs, their investments in these technologies rapidly increased [12], yet there is still a lack of understanding of the impact that processes and practices for the evaluation of these investments may have [23], considering their complexity and the frequent deviations in costs during their lifecycle [3]. The latter suggests a confirmation for [11], [17], [23], [34] in that it is difficult to conduct a detailed evaluation of the contribution of ICTs to firms' operations since it requires multidimensional measurements that must also integrate intangible factors, which are the source of IBs. However, DMs tend to evaluate mainly on subjective judgements such as support to decision-making or ease of use [34].

An intangible benefit is a benefit that cannot be measured directly or quantified easily in terms of money [36], time, or frequency; thus, it cannot be quantified using mathematical equations [44]. Including the analysis of IBs in the evaluation of ICT investments would permit a more detailed and realistic multidimensional measurement of their contribution to firms. However, firms lack a structured methodology or a well-defined framework therefor. Current methods commonly accepted do not provide with procedures to guide DMs in the analysis of intangible benefits, and they focus on quantifiable economic benefits without taking IBs into account [2], [16], [30], [39]. Consequently, the measurement of the impact of intangible benefits remains an unsolved problem [7], [41].

In this paper we develop the foundation of a methodological guide (MG) with focus on the estimation of

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IBs so as to contribute for a comprehensive evaluation of ICT investments. We refer to value chain (VC) models described in [1] and [35] taking into account the following points stated in the literature reviewed that appear to set forth a relationship between "business value" and "technology" through the VC model:

- A firm can be defined as "a machine to create value" [2] and as "a set of activities" that, as such, is "a group of technologies" [35].
- Technology can be represented in any of the activities of the VC from which intangible elements of value can be obtained [32], [35].
- Michael Porter's theory of "Competitive Advantage" can guide the study of how investments in technology allow obtaining business value in a firm [25].

Based on the evidence gathered, we believe that both value chain models described in [1] and [35] may be useful frameworks for analyzing the impact of ICT investments in a BU by focusing on the estimation of intangible benefits in their value activities.

The Oxford's and the Real Academia Española's (RAE) dictionaries define "methodology" as a set or system of methods, that is, a set or system of "procedures followed in science to find the truth and teach it." RAE's dictionary defines "guide" as "that which directs" or a "treatise in which precepts are given to direct in things." Therefore, based on our understanding of these definitions, we will define a "methodological guide" as a written document in which precepts and methods are proposed, in our case, for the estimation of IBs obtained from ICT investments.

The following sections of this paper are organized as follows: in Section II we present the background theory of our study, in Section III we describe the methodology used for this work, in Section IV we present the evidence-based foundation for the presentation of an MG focused on the estimation of IBs obtained from ICT investments, in Section V we set a simple hypothetical scenario to describe the proposed stages to fulfill and variables to use for such estimation, and in Section VI we discuss the results of our work and advances made for a future presentation of the mentioned methodological guide.

II. Background Theory

In this section we define the context of our study by presenting the background theory.

A. Business value of ICTs.

Literature provides definitions of "value" which agree in that this concept involves both tangible and intangible qualities. The perception of what this concept represents can be defined differently by each individual, to the point that "value" is indeed "in the eye of the beholder" and its nature varies for different types of enterprises [16], [35].

This perception of value could be approached by first classifying firms according to what they produce –goods or services– and then defining their value chains based on the models described in [1] and [35]. Thus, the value that ICTs provide to a firm's value generating activities –given that adopting ICTs has proven positive effects in multiple aspects [28], [30]– should turn into business value, that is in "benefits gained by enterprises who invest in the various technologies and in applications that build on the resulting infrastructure" [37].

The business value of ICTs is the contribution of ICTs to the performance of a firm [29], [42] and "the organizational performance impacts of information technology at both the intermediate process level and the organization wide level, and comprising both efficiency impacts and competitive impacts" [26]. Nevertheless, investments in ICTs cannot create business value on their own and therefore depend on several factors such as: management method, organizational structure, and business process [5], [20], [22], [31].

B. Value activities and the value chain.

Every firm is a collection of activities that are performed to design, create, market, deliver, and support its products or services. These activities add value to said products or services and are thus identified as "value activities" which can be represented in a value chain.

A firm's value chain and the way it performs individual activities are a reflection of its history, its strategy, its approach to implementing its strategy, and the underlying economics of the activities themselves [35].

The value chain model is the basic tool for understanding the role of technology in creating competitive advantage through the understanding of the impact of technological changes on value activities, as well as for diagnosing competitive advantage and finding ways to create and sustain it [35]. For instance, IT systems used to increase quality of a finished product can be evaluated by Porter's value chain analysis [46].

This model is described in [35] as a disaggregation of a firm into its strategically relevant activities in order to understand the behavior of costs and the existing and potential sources of differentiation. These activities are classified as primary activities and support activities, as shown in Fig. 1.

The VC model described in [35] is reinterpreted in [1] based on the four distinctive characteristics of a service explained in [21] (intangibility, inseparability, heterogeneity, and perishability) and taking into account the elements of a service delivery system identified in [6] (client, physical support, contact personnel, service, internal organization system, and the other clients), making it more suitable for firms in the service industry. The result is a value chain model consisting of ten links, which are classified as primary links –which are subclassified as controllable and non-

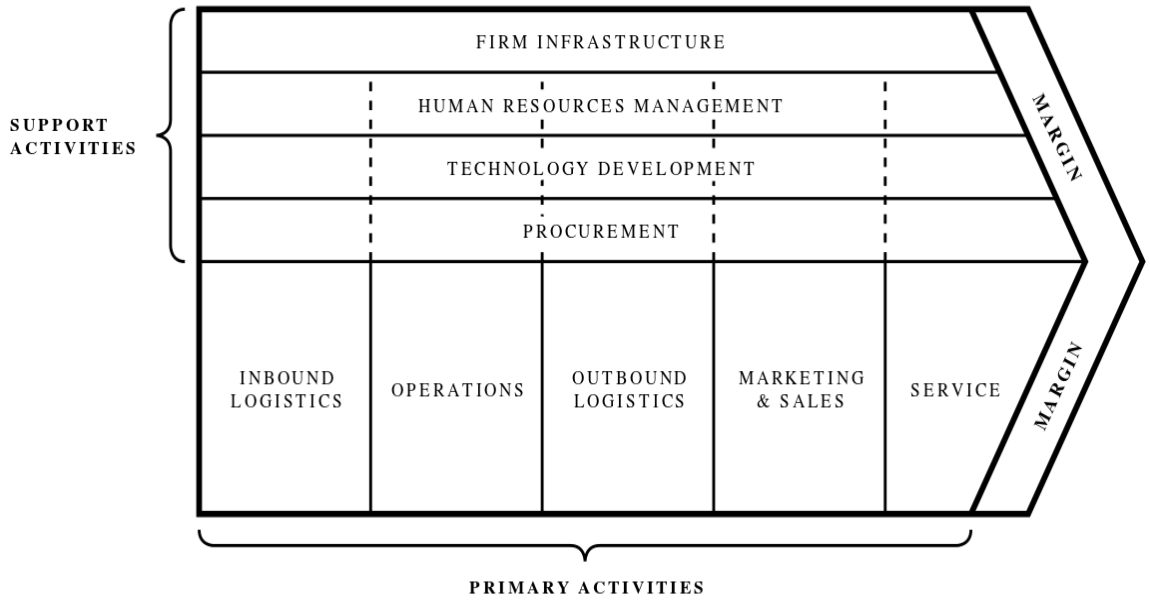

Fig. 1. The Value Chain model proposed by Michael Porter for the identification of competitive advantage. Porter described this model as a disaggregation of a firm into what he named "value activities." Technology can be represented in any of these activities since they all create and use information; therefore, this model may be used as a reference framework for analyzing the impact of ICT investments.

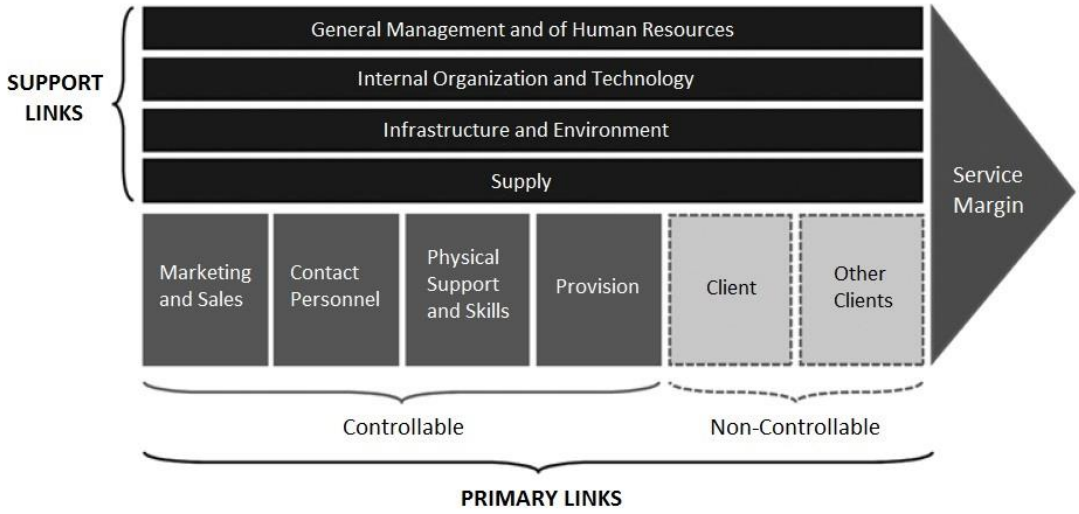

Fig. 2. The Value Chain model proposed by Gustavo Alonso. Alonso reinterpreted Porter's model based on the four distinctive characteristics of a *service* and taking into account the elements of a *service delivery system*. According to Porter, technology can also be represented in any of the activities included in this model since they all create and use information; therefore, this model may also be used as a reference framework for analyzing the impact of ICT investments.

controllable– and support links, as shown in Fig. 2.

Technology can be represented in any of the value activities of a firm, as depicted in Fig. 3, since every value activity creates and uses information [32], [35].

C. The business unit and the value chain.

The best defined value chain is that defined inside a specific company. An industry- or sector-wide value chain is too broad, because it may obscure important sources of competitive advantage [35]. Additionally, firm-level data may enable the estimation of intangible benefits perceived from ICT investments even if these cannot be directly observed [5].

Though firms in the same industry may have similar chains, the VC of competitors often differ [35]. Therefore, a business unit can be understood as a firm's segment or division (whether organizational or functional) with specific activities acting on a particular industry. The boundaries for these segments or divisions can be defined by analyzing the relationship between their competitive scope and their value chain [35].

Differences among competitor value chains are a key source of competitive advantage. A firm's value chain in an industry may vary for different items in its product line, or for different buyers, or for geographic areas, or for distribution channels. The value chains for such segments or divisions of

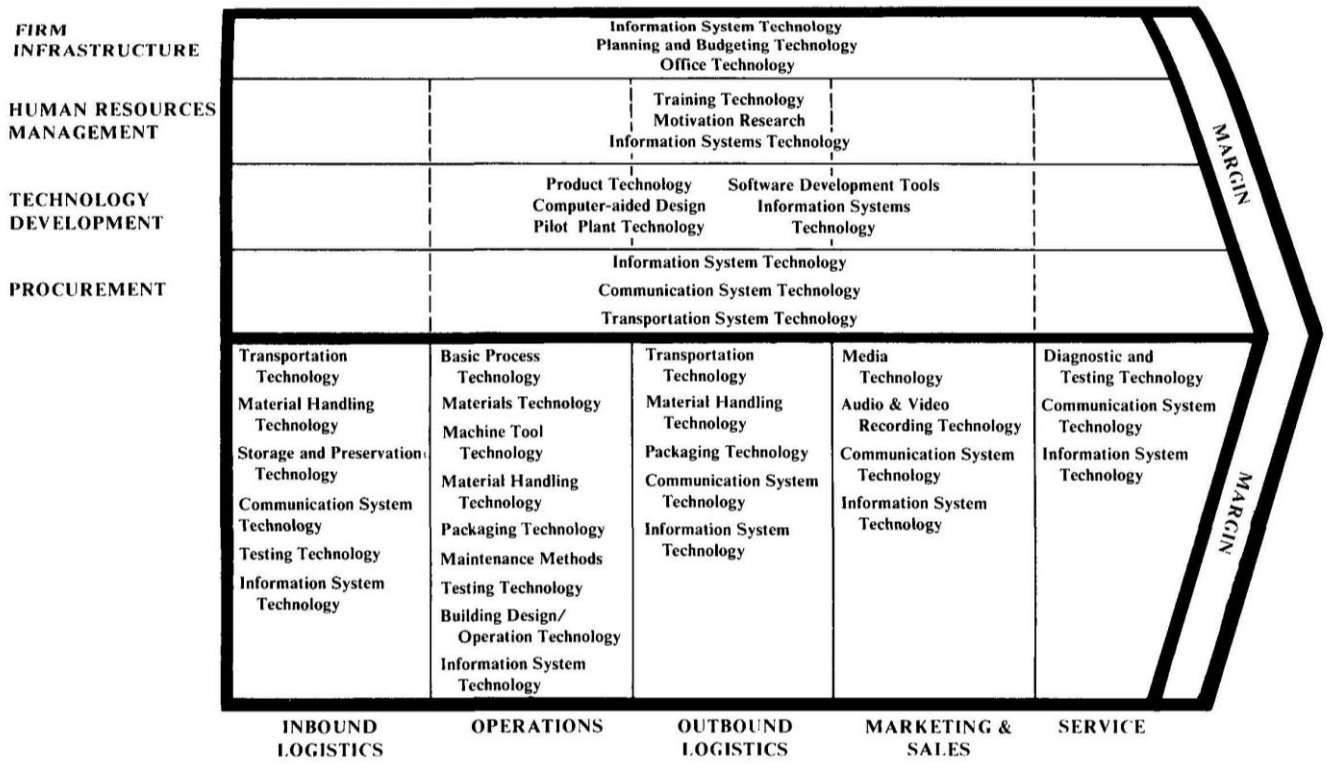

Fig. 3. Representative technologies in a firm's value chain. This diagram depicts how technology can be used in any of the value activities, which means that the value chain models proposed by Porter and Alonso may be used as reference frameworks for analyzing the impact of ICT investments.

a firm are closely related, however, and can only be understood in the context of the business unit's value chain [35]. In view of this, the business unit will be treated in our study as the basic organizational unit in a firm, and therefore the value chain models will be here approached from a business unit perspective rather than from a firm, industry, or sector-wide perspective.

D.Factors of intangible value.

RAE's dictionary defines "factor" as an "element or cause that acts together with others." Oxford's dictionary defines it as a "circumstance, fact, or influence that contributes to a result." For the purposes of this study, "intangible value" will

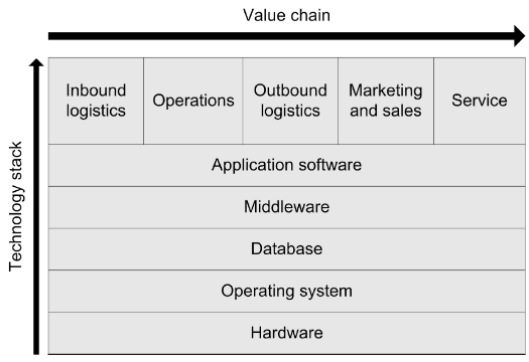

Fig. 4. A representation proposed by Antony Barnes of how the "technology stack" provides support to a firm's value chain. This represents that technological factors may impact the value activities of a firm, or in the case of our study: a business unit.

be understood as the *intangible* business value originated from intangible benefits perceived by user beneficiaries of ICT investments in a firm, that is, the *intangible* contribution of ICTs to their performance.

Hence, we can define an IB as a benefit that cannot be measured directly or quantified easily in terms of money [36], time, or frequency; thus, it cannot be quantified using mathematical equations [44].

An IB may also be defined as "an identifiable benefit of a non-monetary nature and without physical appearance" [24]. In that context, we understand a "factor of intangible value" as an "element or cause of IB."

Some of these elements are: increase in negotiation power with customers and suppliers, prevention of future costs, reduction of competitive risks, improvement of quality of service, increase in employees' satisfaction and commitment, and improvement of quality of decisions [33]. These elements can be associated with technological, organizational, and business factors of value [2], [15], [17], as well as with investors or customers since these can also represent factors of ICT value as their actions may affect the decisions and/or results of the ICT investment [2].

For this study, *Investors* and *Customers* can be defined, respectively, as those who contribute with economical resources for ICT investments and those who make use of the technology implemented.

Technological factors are represented in [2] as a

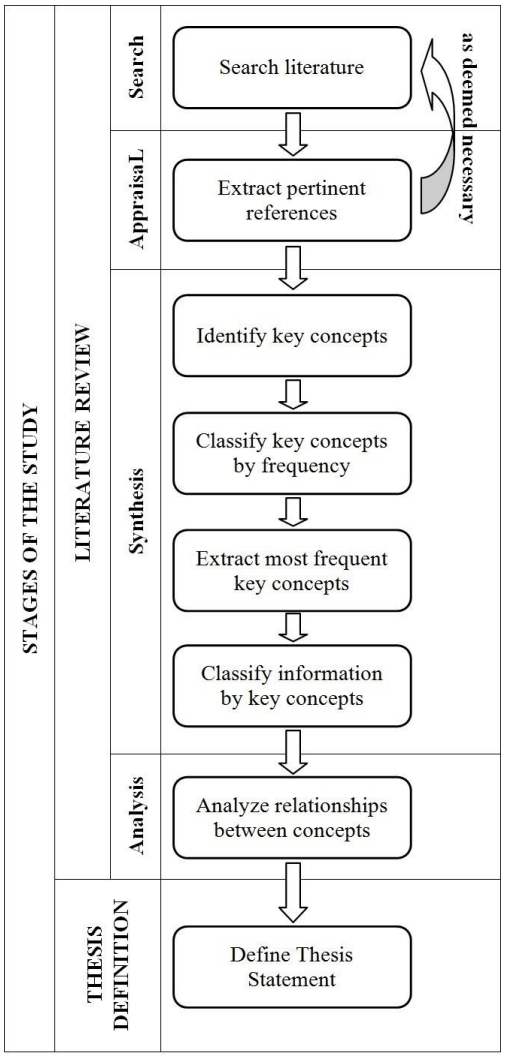

Fig. 5. Stages and sub-stages of the methodology used for this work. The methodology comprised two main stages: Literature review and Thesis statement definition. We subdivided our Literature review using an analytical framework identified with the mnemonic SALSA.

"technology stack," which is described as a layered structure of information technology systems which together support a business application and that, additionally to the value chain model proposed in [35], can be used as a model for decision making in connection with these technologies, taking into account that the value chain represents the world of business, and the "technology stack" represents the world of technology [2]. A representation of how the "technology stack" provides support to a firm's value chain is shown in Fig. 4.

Organizational factors are approached in [2] from an operational point of view, considering of great importance people and processes without subordinating one to the other and reinforcing the vision that all business functions must be reduced to processes which have influence on the structure and systems and thus constitute the central analysis unit for decision making on ICT investments.

Business factors are related to a business unit's business processes –according to [14], a business process is "a set of activities that driven by events and carried out in a certain sequence create value for a customer (internal or external)." These factors are represented in the model described in [2] as the business layer with functions that correspond to the primary activities of a BU's value chain which are directly supported and impacted by information technologies.

Further in this paper we will classify factors of intangible value we identified in the literature reviewed under the categories: Investors, Technological, Organizational, Business, and Customers, which in the context of our study are treated as User Beneficiaries.

III. Research Methodology

We conducted a qualitative study with exploratory and descriptive scope in order to derive a theoretical and descriptive perspective of the current situation regarding the knowledge area of the evaluation of ICT investments.

The methodology used for this work comprised two main stages: Literature review and Thesis statement definition. We subdivided our Literature review in Search, AppraisaL, Synthesis, and Analysis, which constitute the stages of an analytical framework identified in [10] with the mnemonic SALSA. These stages and sub-stages are represented in Fig. 5.

A. Literature review.

We conducted the literature review as part of a research study on the estimation of intangible benefits, exploring value factors, frameworks, standards, procedures, techniques and/or tools that could serve as input for the design of the methodological guide.

The data collection instrument in the qualitative process is the researcher [13]; therefore, for this work we acted as the instrument for the immersion in the field of knowledge using as main sources published books (in printed and electronic formats) and papers (in electronic format) concerning the knowledge area.

1) Search and Appraisal.

We followed the stages of the search process: scoping search, conducting search, bibliography search, verification, and documentation [4]. We extracted and filtered from the collected literature references and evidence that we identified belonged or corresponded to the knowledge field of our interest and had precise or logical relevance to our research, thus being pertinent to our study. In other words, references and evidence were considered pertinent to our study if directly or indirectly contributed to form a theoretical and descriptive perspective of the current situation regarding the knowledge area of the evaluation of ICT investments and/or to build background theory for use in our study.

We repeated this cycle for obtaining references and evidence as deemed necessary, and we stopped when

TABLE I
MOST SIGNIFICANT CONTRIBUTIONS TO OUR WORK FROM THE LITERATURE REVIEWED

Year - Author(s)	Title	Type of document	Contribution to our work
1987 – Porter, M.	Ventaja Competitiva. Creación y sostenimiento de un desempeño superior.	Book	Presents the generic VC model and describes it as the basic tool for understanding the role of technology in competitive advantage through the understanding of the impact of technological changes on the value activities of an organization. The author also states that the nature of value differs for different types of enterprises.
1994 – Willcocks, L.	Information Management. The evaluation of information systems investments.	Book	Proposes that the VC model can be used for the analysis of future investments in ICT.
1996 – Mooney, J., Gurbaxani, V. & Kraemer, K.	A Process Oriented Framework for Assessing the Business Value of Information Technology.	Paper	Qualify the VC analysis method proposed by Michael Porter as a framework for considering the role of technology in supporting and creating competitive advantage at the activity level in an organization, and for studying economic (tangible and measurable) and institutional (not necessarily tangible and measurable) outcomes of technology use.
2001 – Van Grembergen, W.	Information Technology Evaluation Methods and Management	Book	Presents a case study to demonstrate how the intangible factor "user satisfaction" can be included in an analysis to justify the implementation of a technology.
2003 – Silva, E.	Evaluating IT Investments. A Business Process Simulation Approach.	Book [a]	Identifies a gap in the evaluation of IT investments as firms lack a structured methodology or a well-defined framework for that purpose, thus using inadequate methods that focus on quantifiable economic benefits without considering IBs. The author also refers to qualitative methods proposed in the literature for the evaluation of IBs obtained from IT investments.
2005 – Marshall, P., McKay, J. & Prananto, A.	Business Value Creation from IT Investments: Towards a process theory of IT Governance	Paper	Refer to Porter as one of the authors of the theory that serves as guide to study how investments in technology allow obtaining business value in an organization.
2005 – Piedrahíta, E.	La evaluación de tecnología, un proceso estratégico y estocástico.	Paper	Comments on the impact of the presence of ICTs in any of the value activities of an organization and their contribution to the achievement of business objectives.
2006 – IT Governance Institute	Enterprise Value: Governance of IT Investments. The Val IT Framework 2.0 Extract.	Book (extract)	States that what the concept "value" represents can be defined differently by each individual, to the point that value is indeed "in the eye of the beholder."
2008 – Alonso, G.	Marketing de Servicios: Reinterpretando la Cadena de Valor.	Paper	Reinterprets the generic VC model proposed by Porter adapting it for companies in the service industry.
2010 – Barnes, A.	A new framework for IT investment decisions. A practical guide to assessing the true value of IT projects in business.	Book	Presents the "technology stack" model and links it to Porter's VC model for assessing the business value of IT investments. The author also provides descriptions of IT value factors and agrees with Silva (2003) in that firms use inadequate methods for the evaluation of their IT projects.
2015 – Tabassum, G. & Yeo, A.	Measurement of Tangible and Intangible Impacts of Telecentres on Rural Communities.	Paper	Indicate that the measurement of the impact of intangible benefits remains an unsolved problem.

[a] Thesis of candidate for the degree of Licentiate of Engineering.

considered that we had reached theoretical saturation [9], which means that no additional information was being found that would significantly further our study.

We selected 169 documents (books and papers in printed or electronic formats) in the first loop of our search based on their titles and/or abstracts. Subsequent loops allowed us filtering our collection to a group of 46 documents more pertinent to our study, of which 11 provide the most significant contributions, as shown in Table I.

Electronic books and papers were retrieved from the Internet by searching indexed databases including Google Scholar, Google Books, ScienceDirect, ACM Digital Library, CiteSeer^X, IEEE Computer Society, Directory of Open Access Journals, as well as the IT Governance Institute and cross-references. We used the broad search terms "evaluation," "ICT investment," "investment project," "intangible benefit," and "value chain" for the first loop of the search. Subsequent loops were based on words and/or concepts derived from the prior loop. Examples of these are: "business value," "competitive advantage," "value factor," "qualitative method," "qualitative technique," etc.

2) Synthesis.

In this sub-stage we synthesized the main ideas of the content of the selected literature that were relevant to our study by marking them with the following terms: "benefits," "business value," "evaluation," "methods/techniques," "organization," "value chain," and "value factors." We then used these terms as key concepts that would serve as the main conceptual support for the structure of our study.

3) Analysis.

We built a concept map beginning with "Implementation of Information and Communication Technologies investment projects (ICT-IPs)" as the main concept and breaking it down into more specific pertinent ones by using the key concepts identified in the previous sub-stage. We included the term "intangible" as a key concept since this represents the specific type of benefits of interest for our study. We connected the concepts using linking phrases and words in order to

TABLE II
EXAMPLES OF FACTORS OF INTANGIBLE VALUE EXTRACTED FROM THE LITERATURE REVIEWED GROUPED UNDER ONE CONCEPT

Factors of intangible value extracted from the literature reviewed	Concept Used
Prevention of future costs Reduction of competitive risks	Identification of risk factors
Product quality Improved product and service quality Improvement of quality of service	Improvement of quality of value activities
Capacity of generating information for management More judgmental executive functions A steady "informatization" of business models Informatization	Informatization in value activities
Organizational performance factors Management quality Improvement of quality of decisions	Organizational performance in value activities
Increase in employees' satisfaction and commitment Improved customer satisfaction	Satisfaction of User Beneficiary [a]
Strategic alignment Alignment	Strategic ICT-Business alignment

[a] For our study, the firm's employees are seen as internal customers, which are treated as user beneficiaries of the investment.

illustrate and examine the relationships between them.

Our concept map is shown in the appendix. The main concept and the key concepts selected in the previous sub-stage appear shadowed. Linking phrases and words illustrate the relationships found between the concepts represented in the map.

We created a list of factors of value as referred to in the literature reviewed. We then narrowed the list to include only those factors of intangible nature and grouped similar factors under one concept. Examples of this are shown in Table II.

We classified each factor in the resulting list based on their pertinence to the technological, organizational, and/or business scopes [2], [15], [17], and/or related to investors and/or user beneficiaries (seen as customers of the ICT department) [2].

B. Thesis statement definition.

We finally defined our thesis statement observing the relationships identified between the concepts as represented in the map shown in the appendix. This concept map depicts, from our evidence-based findings of the first main stage of our study, the conceptual scope of the implementation of an ICT-IP in an organization, more specifically a business unit.

We composed rough draft paragraphs by starting from the main concept and following the "relationship track" that connects the key concepts identified. We refined these draft paragraphs and defined our thesis statement.

IV. PRESENTING A METHODOLOGICAL GUIDE

In this section we present the evidence-based foundation for the presentation of a methodological guide focused on the estimation of IBs obtained from ICT investments.

A. On the problem of evaluating ICT investments.

Prior studies agree in that a comprehensive evaluation of ICT investments is difficult due to the intangible factors that should also be taken into account.

ICT investments are characterized for being critical for firms, and the strategies for their evaluation have evolved from a simple model based on financial ratios towards more complex approaches [18], [34].

Decision makers have the difficult task of demonstrating that ICTs are a measurable factor of productivity, yet they lack methods or techniques for evaluating these investments by integrating tangible and intangible factors. As a consequence, the measurement of intangible factors remains an unsolved problem.

This is exactly the niche in which our work enters. Using the ideas and techniques described, decision makers can better measure these factors that nowadays tend to elude them.

B. On our thesis statement.

The concept map shown in the appendix organizes and structures the knowledge obtained from our literature review. Starting from the main concept and following the "relationship track" that connects the key concepts identified, we may compose the following rough draft paragraphs:

- "The implementation of ICT-IPs should undergo evaluation, which requires multidimensional measures of value factors by means of methodology and frameworks including methods and techniques which can be qualitative."
- "The implementation of ICT-IPs may generate benefits from value factors which may be intangible, measurable with methods and techniques which can be qualitative."
- "The implementation of ICT-IPs may generate benefits for a firm that executes business processes composed of activities of value chain, which creates and sustains business value for a firm."
- "The implementation of ICT-IPs may generate benefits from value factors which are related with management methods, business processes, technologies with roles represented in activities of value chain, investors, organizational structure which considers business processes and user beneficiaries."
- "The implementation of ICT-IPs may generate benefits for a firm which is defined as a machine to create value and a set of activities that use technologies with roles represented in activities of value chain, which creates and sustains business value that involves competitive advantage for a firm."

By refining these draft paragraphs through the merger of their respective main ideas, we may define that the implementation of ICT-IPs in a business unit may generate benefits from value factors related with business processes

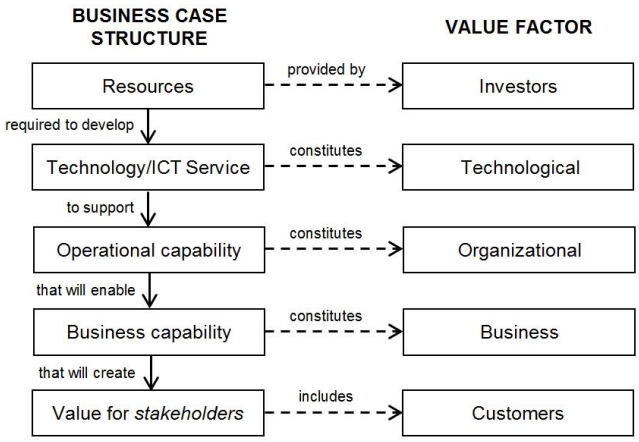

Fig. 6. Graphic representation of value factors based on the business case structure described by ISACA's IT Governance Institute. The graphic represents the relationships between the types of value factors we identified in our literature review and the elements of the business case structure.

and technologies used in the activities of their value chain, which creates and sustains business value for the business unit. Based on our analysis of the evidence provided concerning the relationships between the concepts represented in the map, the value chain models proposed in [1] and [35] may be used as reference frameworks for analyzing the impact of ICT investments in a business unit by focusing on the estimation of intangible benefits in their value activities.

C. On methods and techniques for evaluating ICT investments.

Some methods and techniques proposed in the literature for evaluating ICT investments from an approach on intangible elements include:

- A holistic approach by simulation [8]. The approach consists of a number of steps that aim to transform an ill-defined problem into a set of generic, replicable actions that drive the evaluation effort. Such an approach is needed to codify experience and ideas, and to facilitate structuring, planning, and monitoring of future efforts. This approach is mainly targeted to business change scenarios where IT applications and computer networks play an integral part. It is also suitable for investments that are expected to yield intangible and/or indirect benefits as opposed to hard or strategic ones.
- Multi-criteria analysis [19]. This analysis is mainly directed to assessing the acceptability and the value of IT projects in the public sector, especially when the projects feature the qualitative value along with the monetary one. The approach is based on the possibility of recombining the following three IT projects public value assessing methodologies: the American Value Measuring Methodology, the French MAREVA, and the German WiBe. The analysis features the value acceptability threshold as an indicator of improvements in case of the implementation of a project and as a tool for eliminating projects whose contribution to value is too low.
- Examination of intangible outputs such as innovation [20]. This approach involves further analysis of the impact of information technology on innovation output. This includes an examination of unique time periods, returns to IT capital in IT-using versus IT-producing industries, and the contribution of IT to highly valued, blockbuster innovations.
- Identification of difficulties –which may include intangible aspects– before and after adopting technologies [30]. This method consists of identifying risks and difficulties of adopting technologies in an organization so as to detect opportunities for organizational improvement by developing activities that enable users to obtain better skills in the context of adopting advanced technologies.

Other methods for evaluating ICT investments are described in [39] as follows:

- Multi-objective, Multi-criteria (MOMC): This method attempts to develop a general measure of utility, defined as the satisfaction of an individual's preferences. It is based on the belief that people's behavior is determined to some extent by the feeling that their preferences are recognized. The MOMC method is probably most applicable to complex projects that attempt to meet the needs of many different users and where the benefits are intangible. Using this method enables exploring the value of a set of system proposals in terms of relative preferences for different system features.
- Value Analysis (VA): It emphasizes the value that ICTs provide to a firm, rather than costs. The method is based on the following three assumptions: (1) Innovation is value driven and not cost driven: (2) intangibles can be identified and subjectively assessed but rarely measured accurately, as surrogate measures are often used to satisfy the requirement for most inputs, and (3) individuals driven by cost and those driven by effectiveness will inevitably clash. The analysis begins with the observation that most successful innovations are based on enhancing value added rather than on cost savings. A multi-stage iterative process starts with a prototype system. Rather than developing extensive specifications, the analysis provides simple models that can be expanded and modified until all complex aspects of the problem are included. Users are asked to provide the analyst with feedback on the values and limitations of the solution obtained from the prototype. The main difference between other IT evaluation methods and VA is that the former methods directly aim at a final solution, while the latter uses an evolutionary process to get to a

"satisfiable solution" which may be further improved.

- Critical Success Factors (CSF): This method explores the potential value of information systems involving comprehensive interviews with key managers to obtain their views about the business mission, objectives and current problems. It invites the analyst to explore together with executives the factors that are, in their opinion, critical to the success of the business, in particular the factors important for the functions or activities for which the executives are responsible. The executives can rank issues into levels of importance.

D. On categories of value factors of ICTs.

Value factors defined in [2], [15], [17] are also identifiable in the business case structure described in [15]. According to this structure, resources are required to develop technology/ICT service to support operational capability, and this operational capability will enable business capability that will create value for stakeholders. It is reasonable to believe that resources required to develop technology/ICT service are provided by investors, which means that *investors* represent factors of value for ICT investments; technology/ICT service constitutes *technological* factors of value for an organization; the operational capability constitutes *organizational* factors of value; the business capability constitutes *business* factors of value; and the stakeholders are the parties related with the investment project, including customers who are treated in our study as *user beneficiaries* that can act as factors of value since they make use of the technology implemented. This is represented in Fig. 6.

Value factors related to *Investors* and *Customers* are described in [2] as external to the business strategy; however, from an analysis approach on IBs perceived from ICT investments, we will consider for our study that these can also contribute to value perceived and, therefore, may serve as references for the analysis of intangible benefits.

Whereas the term *consumers* may refer to external buyers of goods or services (external clients), for this study it will be understood as referring to internal users of a business unit who consume the services delivered by the ICT department (and are therefore *internal consumers* for such department) and make use of the product of the implementation of ICT-IPs for the execution of their value activities. Therefore, for this study, the *Customers* will be understood and treated as *User Beneficiaries* of ICT investments.

Technological factors will be defined for our study as including all related with information and communication technologies, that is, all related with ICTs.

Organizational factors will be defined for our study as including all related to elements of the organizational environment between people and processes that can contribute to value perceived and, therefore, may serve as references for the analysis of intangible benefits.

Business factors will include all related to a BU's business processes and their requirements [15].

E. On factors of intangible value of ICTs.

Table III shows the list of factors identified in the literature reviewed which are of intangible nature. We have classified these factors as technological, organizational, business, investors, and/or user beneficiaries-related based on the nature of their possible output and/or effect on the business unit's value activities; that is, whether their output and/or effect may have an impact of intangible nature on the BU's value activities regarding technological, organizational, business, investors, and/or user beneficiaries-related aspects.

F. On value chain models.

The value chain models described in [1] and [35] classify value activities in two hierarchical categories. They are classified in [35] as "primary activities" if involved in the physical creation of a product, its marketing, distribution to the consumer, and after-sales assistance, and as "support activities" if they support primary activities.

The concepts provided in [1] for "primary links" and "secondary links" are not much different. The most relevant differences are found in the organization of the primary links and their classification regarding their susceptibility to control by the business unit. Secondary links also differ but maintain their role in contributing to providing a service.

The value chain models analyzed agree in that these categories support each other –regardless of their hierarchy– by offering input, technology, human resources, and diverse global functions. Evidence suggests that these models may be used as reference frameworks for analyzing the impact of ICT investments made in a business unit by focusing on the estimation of IBs in their value activities.

V. HYPOTHETICAL SCENARIO

In this section we propose stages to fulfill and variables to use for the evaluation of ICT investments with focus on the estimation of intangible benefits. For this end, we set a simple hypothetical scenario assuming that the following conditions are met in a business unit within a time frame comprising from the definition of an ICT-IP (pre-implementation) through a point in time defined by decision makers when results should and can be evaluated (post-implementation):

- An ICT-IP has been defined and implemented in a BU. The definition and implementation of an ICT investment project is a key factor for obtaining complete information for the evaluation of the investment made.
- The Head of the BU affected by the project has clearly defined their VC. The definition of the business unit's value chain is a key factor for the application of the evaluation method proposed, as it shows the set of activities that add value to the products or services

TABLE III
CLASSIFICATION OF FACTORS OF INTANGIBLE VALUE OF ICTS IDENTIFIED IN THE LITERATURE REVIEWED BASED ON THE NATURE OF THEIR OUTPUT AND/OR EFFECT IN THE VALUE ACTIVITIES OF A BUSINESS UNIT

Factor [a]	Categories of Value Factors				
	Investors	Technological	Organizational	Business	User Beneficiary
Accuracy of results		X			
Automation in value activities		X			
Availability to User Beneficiary		X			
Capacity coverage		X			
Comprehensibility of results		X			
Coordination in value activities			X		
Effectiveness perceived by User Beneficiary					X
Efficiency in value activities				X	
Flexibility of use		X			
Goods/services customizing				X	
Human Resource	X	X	X	X	X
Identification of risk factors				X	
Identification of success factors				X	
Improvement of quality of value activities				X	
Improvement of value system			X		
Informatization in value activities		X			
Infrastructure	X	X	X	X	X
Innovation in value activities		X			
Installability		X			
Integrability with existent and future ICTs		X			
Integrity of processes/results		X			
Interactability with existent and future ICTs		X			
Learnability					X
Maintainability		X			
Manageability		X			
Management control			X		
Operability		X			
Optimization in value activities				X	
Organizational performance in value activities			X		
Portability		X			
Productivity in value activities				X	
Receptiveness		X			
Reliability		X			
Repairability		X			
Responsiveness to external clients				X	
Reusability		X			
Robustness		X			
Satisfaction of User Beneficiary					X
Security		X			
Strategic ICT-Business alignment			X		
Supportiveness				X	
Testability of results		X			
User Beneficiary-friendliness		X			

[a] Alphabetical order.

provided by the business unit.

- DMs have defined expected factors of intangible value (EFIV). This activity defines what factors of intangible value are expected to impact the business unit's value activities according to the strategic objectives followed with the implementation of the investment project.
- DMs have defined the impact expected (IMPEX) in their VC from the implementation of the project (ex ante analysis). This activity defines the impact extent expected to be obtained from the ICT investment in terms of intangible value.
- DMs agree that the project has been in production for a period of time which is sufficient for evaluating results. This event will be a milestone in the process, marking that it is time to collect information of the results obtained from the ICT investment.
- DMs have identified and defined actual factors of intangible value (AFIV). This activity defines what factors of intangible value actually impacted the business unit's value activities; these will be compared with EFIVs previously defined.
- DMs have evaluated the impact perceived (IMPER) in their VC from the implementation of the project (ex post analysis). This activity helps defining the actual extent of the impact obtained from the ICT investment in terms of intangible value; these will be compared with the IMPEX previously defined.

In this hypothetical scenario, decision makers would have gathered information for the following variables: EFIV, AFIV, IMPEX, and IMPER. They would then be able to

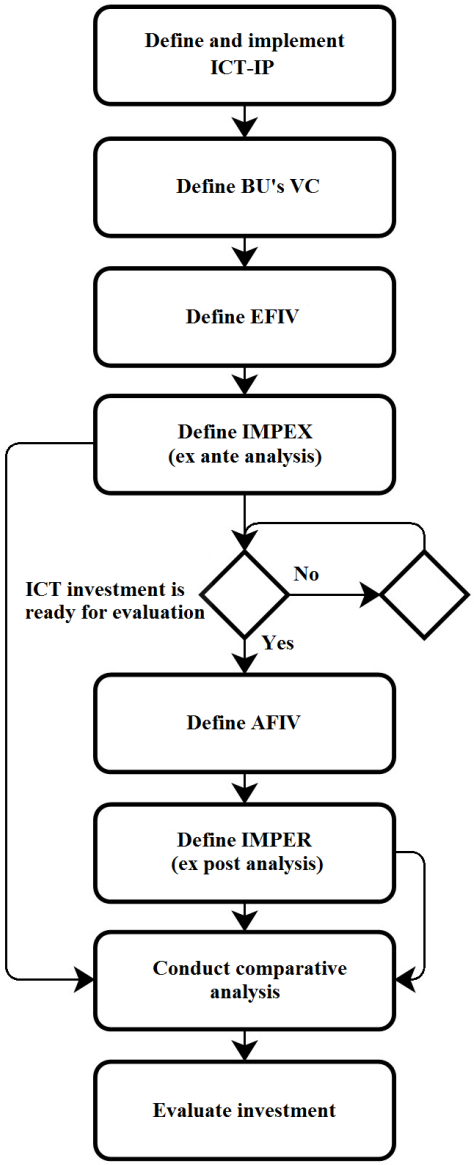

Fig. 7. The proposed process for the evaluation of ICT investments with focus on the estimation of IBs. The diagram represents the sequence of the stages based on the hypothetical scenario described.

compare these variables and identify the degree of alignment with the strategic objectives pursued with the implementation of the project. They would also be able to detect what value activities were actually affected with IBs and to what extent. Thus, the results of the evaluation of the implementation of the project would be based on a comparative analysis of the estimated extent of impact of intangible benefits expected and intangible benefits perceived, which we here conceptualize as IMPEX and IMPER, respectively. The value chain models studied would be used to diagram the value activities of a specific business unit where a specific ICT-IP would have been implemented and locate the IMPEX and IMPER, thus constituting the base model for a subsequent comparative analysis for the evaluation of the examined project.

Fig. 7 depicts the proposed process for the evaluation of ICT investments with focus on the estimation of IBs based on this hypothetical scenario.

VI. Discussion

The widely accepted paradigm that the total value obtained from ICT investments can be determined by measuring only tangible benefits could be changed with a more inclusive approach, taking intangible benefits also into account.

Firm and comprehensive identification and verification of both tangible and intangible benefits obtained from ICT investments would enable DMs to justify the amounts allocated to these projects with a more solid base before the upper managers. However, even though intangible benefits cannot be quantified easily in terms of money, time, or frequency, or by using mathematical equations, they may be considered as value sources of intangible gain, and value can be defined differently by each individual to the point that it is indeed "in the eye of the beholder." Taking this into consideration, we believe that an approach for estimating intangible benefits could be based on DMs' predictions and user beneficiaries' perceptions of the contribution of ICTs to the value activities of their business unit. Such approach would help revealing the "intangible side" of the value obtained from ICT investments made in a business unit.

We have built a list of factors identified in the literature reviewed which are of intangible nature, and we have classified these factors as technological, organizational, business, investors, and/or user beneficiaries-related based on the nature of their output and/or effect, as shown in Table III. However, we consider that it will also be necessary to categorize these factors by type of ICT-IP, that is, as Information Technologies-related and/or Communications Technologies-related, as said technologies differ in characteristics such as structure, processes, and purpose.

Decision makers should also verify the applicability of each factor to the specific ICT investment in both *ex ante* and *ex post* analyses. For the ex ante analysis, the definition of these factors would determine the approach for the evaluation, and for the ex post analysis it would reveal the reach of the impact of the ICT investment analyzed. For example, if DMs determine in their *ex ante* analysis that the factors "accuracy of results" and "automation in value activities" (see Table III) are applicable to the specific ICT investment, they would likely conduct the *ex post* analysis focused on the technological impact of the investment results on the value activities of the business unit. On the other hand, if the *ex post* analysis reveals that not only factors "accuracy of results" and "automation in value activities" were perceived but also factor "optimization in value activities", this would mean that the impact of the investment results reached further than expected.

The value chain models described in [1] and [35] group the value activities carried out in a business unit, whether it is a producer of goods or a provider of services. These models can

be contextualized and redefined to respond to the specific characteristics of the business unit to analyze and thus can serve as basic tools to identify the role of technology in the creation of competitive advantage through the understanding of the impact of technological changes on their value activities [35].

Taking into account that the adoption of ICTs has had a positive effect in multiple aspects, that the value activities that compose a BU's value chain can differentiate technologically to create competitive advantage, and that technology can be represented in any value activity of a business unit's value chain from which intangible elements of value can be obtained, we believe that the value chain models proposed in [1] and [35] would serve as useful frameworks for analyzing the impact of ICT investments in a business unit by focusing on the estimation of intangible benefits in their value activities. This would then be the basis for presenting a methodological guide focusing on the estimation of intangible benefits that would facilitate the process of decision making in the evaluation of ICT investments.

Developing a comprehensive methodology for evaluating ICT investments is an ambitious task. Hence the presentation of a methodological guide to describe steps to follow to estimate IBs should contribute to improving the process of decision-making in the evaluation of these projects. For this end, a methodological guide should consider value factors, standards, tools, and stages to fulfill for the estimation of IBs.

A future study presenting an MG could be guided by the research question "What stages must be fulfilled in order to estimate intangible benefits perceived from ICT investments made in a business unit?" This research question should be answered by: a) evaluating factors of intangible nature proposed in the specialized literature, which are pertinent for the estimation of intangible benefits obtained from ICT investments, b) performing a critical analysis of the specialized literature assessing frameworks, standards, procedures, techniques, and/or tools that include in their scope the analysis of intangible benefits, c) identifying elements from the frameworks, standards, procedures, techniques, and/or tools analyzed that may serve as input for the design of an MG, and d) analyzing how generic value chain models proposed in the literature may be used as bases for estimating intangible benefits perceived from ICT investments made in a business unit.

In order to contribute to find an answer to this research question, we have proposed stages to fulfill and variables to use for the evaluation of ICT investments with focus on the estimation of intangible benefits. A future study should further the analysis of the specialized literature to confirm these stages and variables and to identify instruments for gathering and analyzing data on IBs (expected and perceived) of ICT investments made in a business unit, in order to design a methodological guide by using procedures and standards for the analysis of said benefits.

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APPENDIX

Concept map of implementation of ICT-IPs.