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A Method for Estimating the Intangible Value Impact of ICT Investments

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***Abstract*— A method for estimating the intangible value (INTVAL) impact of Information and Communication Technologies (ICTs) investments in organizations is presented. The method proposes conducting a comparative analysis of the impact projected by decision makers (DMs) with that perceived by user beneficiaries of the level of contribution of such technologies to the value-generating activities of their business unit. This will allow decision makers to determine: a) how an ICT investment is expected to impact their business unit's value chain, b) how an ICT investment actually impacted their business unit's value chain, and c) whether the INTVAL impact obtained with an ICT investment is aligned with the business' strategic goals in terms of how many value-generating activities intended to be impacted were actually impacted at the predicted extent. A hypothetical example case is presented to illustrate the implementation of the method proposed.**

Keywords—Evaluation, intangible value, ICT investments, method, value chain.

I. INTRODUCTION

Value can reflect the perceived tangible and intangible benefits [22], and the measurement of the impact of intangible benefits (IBs) obtained from investments in Information and Communication Technologies (ICTs) remains an unsolved problem [13], [25], [39]. An intangible benefit is a benefit that cannot be measured directly or quantified easily in terms of money [34], time, or frequency; thus, it cannot be quantified using mathematical equations [42]. IBs are value sources of intangible gain [26], and investments in ICTs can provide firms with both tangible and intangible benefits [4], [18], [31], [33]. Thus, not including the analysis of IBs in the evaluation of ICT investments can be compared to seeing reality with only one eye: you see things, but you cannot totally appreciate their depth.

Whereas analyzing tangible benefits will provide information on what and/or how much a firm has gained with the implementation of ICTs, it will not allow to comprehend the extent of their impact in the business. Decision makers (DMs), however, seem to continue enclosing themselves in this paradigm, which could be changed with a more inclusive approach in order to obtain a more detailed and realistic multidimensional measurement of the contribution of these technologies [26]. If the costs of investing in ICTs are easily countable but the benefits are not accurately assessed (which for this study means assessing benefits of both tangible and intangible nature), ICTs may look like a bad investment [5].

The goal of this paper is to present a method for estimating the intangible value (INTVAL) impact of ICT investments with focus on IBs following stages to fulfill and variables to use as proposed in [26], on which this study is based. Definitions presented in [26] for business unit, factor of intangible value (FIV), intangible benefit, intangible value, and user beneficiaries (USBENs) of ICT investments, are here referred to and a method is presented for estimating the INTVAL impact of said investments in a business unit by means of a comparative analysis of the impact projected by DMs (*ex ante* analysis) with that perceived by USBENs (*ex post* analysis) of the level of contribution of such technologies to their value activities (VAs). *Ex ante* and *ex post* analyses are not competitive alternatives; they complement each other to provide a comprehensive perspective as the former is a prediction of what will happen and the latter is a check of what actually happened [14]. Based on this, the method proposed will allow estimating from a perceptual perspective a "net intangible value" delivered by these investments per value activity. This work is based on the assumption that the Value Chain (VC) models proposed in [1] and [33] may be useful frameworks for analyzing the impact of ICT investments in a business unit by focusing on the estimation of IBs in their VAs [26].

This paper is organized as follows: Section I presents an introduction to the study; Section II presents information gathered from the literature review to provide context for this work; Section III includes a description of the methodology used for this work; Section IV details the stages of the method proposed; Section V presents an example hypothetical case of implementation; Section VI includes a discussion about the

characteristics of the method proposed and results that can be obtained therewith; Section VII presents conclusions and recommendations for future work. Appendix I shows a glossary of terms used in this study.

II. Literature Review

This section presents information gathered from the literature review, which provides context for this work.

A. Definitions of Information Technologies and Communication Technologies

The Oxford's dictionary defines "information" as "data as processed, stored, or transmitted by a computer" and "communication" as "the imparting or exchanging of information by speaking, writing, or using some other medium." Reference [6] proposes the following defnition for ICTs: "*Technological devices (hardware and software) that allow editing, producing, storing, exchanging, and transmitting data between different information systems that have common protocols. These applications, which integrate computer, telecommunications, and networks media, enable both interpersonal (person to person) and multidirectional (one to many or many to many) communication and collaboration. These tools play a substantive role in the generation, exchange, diffusion, management and access to knowledge."* Considering these definitions, one can derive that "Information Technologies" (ITs) are those related to hardware and/or software dedicated to the *storage*, *retrieval*, and *processing* of information, and that "Communication Technologies" (CTs) are those related to hardware and/or software dedicated to the *transmission* and *distribution* of information.

B. The value chain model as a framework for evaluating ICT investments

Literature provides information on techniques and methods proposed for evaluating ICT investments from an approach on intangible elements, and the Value Chain model is considered a useful framework for this end [26]. Importance has also been given to analyzing the level of fulfillment of the goals pursued with the implementation of this type of projects as a critical factor for determining the value delivered [10], [30]. Prior studies present the VC model described in [33] as a helpful concept for the following approaches for the evaluation of ICT investments: .

- Understanding the role of technology within a firm and its function in creating competitive advantage by qualifying it in terms of the degree of impact it will have on the firm's VAs and market [32], [33].
- Understanding how information systems provide support to business functions by integrating the VC model as a representation of the world of business and a layered structure of Information Technology (IT) systems as a representation of the world of ITs [4].
- Assessing the impact of IT on critical business activities within the Value Chain by incorporating corporate goals for IT and management practices as key determinants of realized IT payoffs [40].
- Contributing to the measurement of the level of importance of an ICT investment initiative as part of its assessment process by defining its transversality in terms of alignment with the Value Chain [16].

These approaches agree on the need to analyze the impact of ICT investments on value-generating activities. This study also deals with this assumption.

C. Decision makers' prediction of the intangible value impact of ICT investments

The implementation of investment projects in organizations is a goal-oriented decisional process [8], [37], [43]. No evidence was found in the literature reviewed to believe that the implementation of ICT investment projects (ICT-IPs) does not follow the same orientation.

From a DM perspective in the pre-implementation stage, the implementation of ICT-IPs can be considered as an action that will be taken to provide a practical means to achieve strategic goals previously defined and within a delimited time horizon [3], [8]. An educated prediction of the impact of such action would be the task of decision makers from their special knowledge in their area of expertise, and they should take into account that ICT initiatives may also come from perceptions of needs and wants from business executives, and that these perceptions of want must match business initiatives to ensure alignment and to facilitate prioritization [30], which suggests a confirmation that people and processes play a very important role from an operational point of view [4] in the extent of impact of ICT investments in the business.

The process of predicting the INTVAL impact of ICT investments would constitute the ex ante analysis proposed in [26], and this must have a strong documentation component which enables giving follow up and executing an ex post analysis [44], such as that proposed in [26].

D. User beneficiaries' perception of the intangible value impact of ICT investments

From a USBEN perspective in the post-implementation stage, the implementation of ICT-IPs can be experienced as a service that was provided by their ICT department. As such, their judgments on IBs would tend to be more subjective than objective [20]. This means that their evaluation would be the result of the behavioral responses perception, recognition, and action described in [15]. Following this scheme, they would first perceive effects from such technologies on their performance; then, they would recognize said effects and identify IBs; and, finally, they would execute an action which, in the context of this study, would constitute their personal evaluation of IBs based on the satisfaction they perceived.

Satisfaction reflects a person's comparative judgments resulting from a product's perceived performance (or outcome) in relation to their expectations. If the performance falls short of expectations the customer is dissatisfied and disappointed, if it matches the expectations the customer is satisfied, and if it

exceeds expectations, the customer is highly satisfied or delighted [22] – in the context of this study, the term "customers" would refer to user beneficiaries of ICT investments, and their evaluation would be a reflection of their satisfaction for the fulfillment of their expectations of the implementation of an ICT-IP in their VAs. Satisfaction is an attitudinal relative concept [12], [19], meaning that satisfaction is an attitude and as such can be measured using surveys or questionnaires constructed showing attitude scales [38].

E. Methods and techniques for gathering information

Surveys or questionnaires may be used for gathering information for estimating IBs. Questions can be open-ended or closed-ended. In the first case, respondents use their own words to provide information that is more valuable but difficult to code and analyze; in the second case, respondents just select their answer from a list of options. Surveys or questionnaires can be constructed applying attitude scales. The most used are: Likert scales, semantic differential scales, behavior interaction scales, and ordinal scales by range [38]. Likert scales show a neutral option with equal number of agreement or disagreement options on each side; however, the relative weight each item in the scale represents is considered exactly the same, which should not be and normally is not [17]. There is also a possibility of bias due to the respondent's interpretation of a neutral response [2]. A semantic differential scale consists of a series of bipolar adjectives anchored at the ends of an odd or even-numbered continuum [38].

The Delphi method is a systematic, iterative, anonymous, and group consultation process aimed to obtaining opinions and consensus from the experiences and subjective judgements of a group of experts. It was developed in response to the weaknesses of the panel consensus model, for which it creates a heterogeneous group of experts who interactively provide information that is systematically treated by a coordinator in order to finally reach a convergent conclusion [21], [27], [36]. Some characteristics of the Delphi method, such as iteration and anonymity, are applicable to surveys and questionnaires; therefore, they are also applicable to the method proposed in this work since it considers conducting a survey about the expected and perceived intangible value impact on the value-generating activities of a business unit.

For the purposes of this study, decision makers and user beneficiaries will be treated as two separate heterogeneous groups of experts. DMs will be considered as the group of experts for the *ex ante* analysis in view of their knowledge of their area of expertise, the requirements and needs of the business unit where they have decided to implement the ICT-IP, the capabilities of the technology to implement, and the abilities and capabilities of the business unit's personnel. USBENs will be considered as the group of experts for the *ex post* analysis in view of their personal experience with the technology implemented.

F. Alignment of ICT investments with business strategies

ICTs cannot create business value on their own [23]. They depend on several factors and their implementation must be aligned with business initiatives and strategic goals defined by decision makers. Alignment must evolve to a relationship where ICTs and business adapt their strategies together [29]; otherwise, the likelihood that ICTs are not being applied effectively and that valuable opportunities may go unexploited [35] significantly increases, leading DMs to consider their implementation not as an opportunity to potentiate the capabilities of their business unit but as an expense that should be reduced as much as possible. In this scenario, costs would be more evident than benefits and thus ICTs may look as a bad investment [5].

It makes sense to discuss about intangible value obtained only when ICT investments turn out effective, that is when they meet all the requirements defined with the strategic goals. Only if effectiveness is present it is sensible to discuss efficiency [41]. If an ICT-IP is not aligned with the business strategy, it cannot be considered that it will result effective; therefore, its mere implementation would not be efficient, and efficiency is always a desirable benefit.

In this study, alignment is analyzed from an effectiveness perspective, meaning the achievement of the strategic goals pursued in terms of how many value activities intended to be impacted were actually impacted at the extent predicted.

III. METHODOLOGY

This work is based on the process proposed in [26] for the evaluation of ICT investments with focus on the estimation of IBs. Said process is here schematized in four main stages: Pre-implementation, Point of decision, Post-implementation, and Evaluation, and the following stages proposed in [26] are treated as substages: Define and implement ICT-IP, Define BU's VC, Define EFIV, Define IMPEX (*ex ante* analysis), Define AFIV, Define IMPER (*ex post* analysis), Conduct comparative analysis, and Evaluate investment. New stages were added and the first stage was renamed from "Define and implement ICT-IP" to "Defining and categorizing the project." This is shown in Appendix II.. This new scheme was used to propose a course of action for each substage and present an example case of implementation, in which a hypothetical scenario was set for the evaluation of an ICT-IP.

IV. THE METHOD PROPOSED

This section describes the method proposed, instruments to use, and a course of action for each substage.

A. An outline of the method proposed

The method is based on the process proposed in [26], and it consists of the following stages and substages shown in Appendix II and described in section IV.D.:

1) Pre-implementation

a) Defining and categorizing the project

b) Defining the value chain of the business unit

c) Determining value activities intended to be impacted and expected factors of intanigbe value

d) Determining impact expected

2) Point of decision

3) Post-implementation

a) Determining value activities actually impacted, actual factors of intangible value, and impact perceived

4) Evaluation

a) Preparing matrices for comparative analysis

b) Conducting comparative analysis

c) Evaluating ICT investment

B. Information gathering forms

The Project Manager (PM) should prepare two information gathering forms: one for gathering information from decision makers in the *ex ante* analysis (D-IGF) as proposed in Appendix III.a), and another for gathering information from user beneficiaries in the *ex post* analysis (U-IGF) as proposed in Appendix III.b). For the preparation of these forms, the PM may refer to the list of FIVs presented in [26] selecting as a base for the specific analysis those that are pertinent and applicable to the type of project to evaluate.

The D-IGF should be constructed as an *i* x *j* matrix, arranging the VAIIs in rows (*i*) and the expected factors of intangible value (EFIVs) in columns (*j*). In the intersection of a row and a column, decision makers must indicate their prediction of the level of impact of the $EFIV_j$ on the $VAII_i$, here identified as $IMPEX_{i,j}$. The U-IGF should have a similar structure, differing in that: a) *all* the business unit's VAs, and not only VAIIs, are arranged in rows, and b) *all* pertinent and applicable FIVs, and not only EFIVs, are arranged in columns. In the intersection of a row and a column, user beneficiaries must indicate the perceived level of impact of the FIV_j on the VA_i, here identified as $IMPER_{i,j}$.

Decision makers and user beneficiaries must indicate their responses by entering a value from 1 to 6 using a semantic differential scale consisting of the following bipolar adjectives that represent opposite poles of the continuum: "Low impact" corresponding to 1 and "High impact" corresponding to 6. If no impact is predicted by the DM or perceived by the USBEN, the corresponding element must be left blank. Therefore, the IMPEX for each VAII will be denoted by the element $E_{i,j}$, that is $IMPEX_{i,j} = E_{i,j}$, and the IMPER for each VAAI will be denoted by the element $P_{i,j}$, that is $IMPER_{i,j} = P_{i,j}$.

The D-IGF and the U-IGF should be applied in a series of four rounds to each respondent. This should be sufficient to collect the needed information [9], [28].

Unlike Likert-type scales where a category name is given to each number in the response format, the use of bipolar adjectives in a semantic differential-type scale is proposed in this study with the purpose of focusing the respondent's attention on the opposite poles of the continuum and avoid leading them to more specific categories in between. An even-numbered response format is proposed to avoid a visible arithmetic mid-point and thus mitigate the possibility of bias by the respondent's interpretation of a neutral response [2]. A six-point response format is larger than one with four points, providing respondents with more "freedom of choice" to define their response more accurately; but it is not as large as an eight- or ten-point response format, which may bias the results due to the effect of a "psychological mid-point" [45].

C. Iteration monitoring form

For the purpose of keeping track of the application rounds of the D-IGF and the U-IGF, the Project Manager should use an iteration monitoring form (Appendix IV) to keep record of at least the following: a) the name of the business unit where the evaluation is taking place, b) a description of the ICT investment under evaluation, c) the number of respondents, d) the date of each application round, e) the list of respondents, including their names and positions, and f) the application rounds completed by each respondent. Both the D-IGF and the U-IGF should be signed by at least the PM for administrative purposes.

D. Description of the method

1) Pre-implementation

a) Defining and categorizing the project

This stage would include methods and techniques conventionally used for the definition of an investment project, since the implementation of ICT-IPs in a business unit is a goal-oriented decisional process [8], [37], [43] just like any other type of investment project.

However, DMs must also categorize the investment project as Information Technologies-related (IT-IP), Communication Technologies-related (CT-IP), or Information and Communication Technologies-related (ICT-IP) based on their analysis of the specific business unit's requirements and needs. This will result in a clear definition of the object of the future evaluation.

b) Defining the value chain of the business unit

The definition of the business unit's Value Chain will enable both *ex ante* and *ex post* analyses since it encloses the business unit's VAs and thus serves to locate the IMPEX and IMPER. Its definition constitutes a prerequisite for the implementation of the method proposed in this paper for the subsequent comparative analysis.

c) Determining value activities intended to be impacted and expected factors of intangible value

Once the value chain of the business unit has been defined, decision makers must analyze the project's strategic goals and the business unit's processes in order to determine what value activities are intended to be impacted (VAIIs) with the implementation of the project. DMs must jointly review the business unit's Value Chain in order to reach a consensus on what specific VAs should be impacted so that each strategic goal of the project may be fulfilled. This means that each strategic goal must be directly related with at least one business unit's value activity.

Decision makers must define EFIVs based on the project's strategic goals and their individual expert judgement of the capabilities of the technology to implement. This means that

they must refer to each of the VAIIs and determine what FIVs they expect will affect them based on their knowledge of their area of expertise and of the capabilities of the technology to implement. People and processes also play a very important role [4] in the extent of impact of ICT investments in the business; therefore, DMs must also base their definition of EFIVs on their expert judgement of the business unit personnel's capabilities and the business unit processes' suitability, guided by their own experience and their review of any documented information available in their organization on their personnel and processes.

d) Determining impact expected

The Project Manager, who plays a leading role in the life cycle of the project, would be responsible of conducting this task taking into account that DMs would be considered in this substage as "the group of experts" provided their knowledge of: a) their area of expertise, b) the requirements and needs of the business unit where they have decided to implement the ICT-IP, and c) the capabilities of the technology to implement.

The PM should apply a survey to decision makers with the characteristics of iteration and anonymity of the Delphi method [21], [27], [36] by using the D-IGF so as to obtain estimated quantitative data that will allow determining, for each participating decision maker, the impact expected for each VAII. The D-IGF should be applied in a series of four rounds to each DM as shown in Appendix V.a), which should be sufficient to collect the needed information [9], [28].

The arithmetic means for all $IMPEX_{i,j}$ must be calculated for each DM to consolidate their four responses by using (1).

$$AM_{i,j} = (V_1+V_2+V_3+V_4)/4 \quad (1)$$

Where "$AM_{i,j}$" is the arithmetic mean of the values in the intersection of row *i* and column *j*, and "V" is the value in the intersection of row *i* and column *j* per round. The result of this exercise will be a fifth matrix for each DM including the arithmetic mean values of IMPEX of each EFIV on each VAII from their original four matrices. Now there is one consolidated *i* x *j* matrix per DM. This is shown in Appendix V.b). Once all decision makers have been processed, the arithmetic means for all their consolidated $IMPEX_{i,j}$ must be calculated by using (2) in order to obtain a "total IMPEX matrix" as shown in Appendix V.c).

$$TM_{i,j} = (V_1+V_2+\ldots+V_n)/n \quad (2)$$

Where "$TM_{i,j}$" is the total arithmetic mean of the values in the intersection of row *i* and column *j*, "V" is the value in the intersection of row *i* and column *j*, and "n" is the total number of respondents.

2) Point of decision

Decision makers must reach a consensus that the project has been in production for a period of time which is reasonable and sufficient for evaluating results [8], [26]. For this, they must confirm that the following criteria are met in order to proceed with the post-implementation stage of the process: a) all activities programmed to be executed as part of the implementation of the ICT-IP have been completed, b) all USBENs have used the technology acquired according to their functions, and c) all VAIIs have been affected by the use as planned of the technology acquired.

TABLE I
A REFERENCE INTVAL IMPACT CLASSIFICATION PROPOSED IN THIS STUDY FOR IMPEX AND IMPER VALUES BASED ON THE SIX-POINT RESPONSE FORMAT PROPOSED FOR THE D-IGF AND THE U-IGF

IMPER or IMPEX Value (given by X)	INTVAL Impact Classification
X = 0	Inexistent
0 < X < 1	Almost Inexistent
X = 1	Low
X = 3.5[a]	Medium
X = 6	High

[a]X = 3.5 results from the calculation of the arithmetic mean of 1 and 6, which are the lowest and highest values in the six-point response format.

3) Post-implementation

a) Determining value activities actually impacted, actual factors of intangible value, and impact perceived

The first step in the post-implementation stage will be to determine what value activities were actually impacted (VAAIs) with the implementation of the project and what FIVs had actual effect in said impact and to what level. The Project Manager would be responsible of conducting this task by applying a survey to user beneficiaries with the characteristics of iteration and anonymity of the Delphi method [21], [27], [36] by using the U-IGF so as to obtain estimated quantitative data that will allow defining for each participating USBEN the VAAIs, AFIVs, and IMPER for each VA perceived as impacted. The U-IGF should be applied in a series of four rounds to each USBEN as shown in Appendix V.a), which should be sufficient to collect the needed information [9], [28].

The arithmetic means for all $IMPER_{i,j}$ must be calculated for each USBEN in order to consolidate their four responses by using (1). The result of this exercise will be a fifth matrix for each USBEN including the arithmetic mean values of IMPER of each AFIV on each VAAI from their original four matrices. Now there is one consolidated *i* x *j* matrix per USBEN. This is shown in Appendix V.b). Once all USBENs have been processed, the arithmetic means for all their consolidated IMPERi,j must be calculated by using (2) in order to obtain a "total IMPER matrix" as shown in Appendix V.c).

4) Evaluation

a) Preparing matrices for comparative analysis

At this point, the Project Manager has obtained two consolidated matrices: the "total IMPEX matrix," from the ex ante analysis, and the "total IMPER matrix," from the ex post analysis.

The U-IGF includes all the business unit's VAs and all pertinent and applicable FIVs, unlike the D-IGF; therefore, the "total IMPER matrix" may be larger than the "total IMPEX matrix." In such case, the "total IMPEX matrix" must be "expanded" to also include elements for the rest of VAs and

TABLE II
DESCRIPTIONS USED IN THIS STUDY FOR POSSIBLE SCENARIOS IN THE ANALYSIS OF RELATIONSHIPS VAIIs↔VAAIs AND EFIVs↔AFIVs

Condition	Set notation	Description
Only all VAIIs were impacted.	VAAIs = VAIIs	The investment generates INTVAL at the extent of impact expected.
None of the VAIIs was impacted.	VAAIs = ADDVAs - VAIIs	The investment does not generate INTVAL at a significant extent.[a]
All VAIIs were impacted and additional VAs were also impacted.	VAAIs = VAIIs ∪ ADDVAs	The investment generates INTVAL at an extent of impact greater than expected.
Only some VAIIs were impacted and additional VAs were also impacted.	VAAIs = (ADDVAs ∩ VAIIs) ∪ ADDVAs	The investment generates INTVAL impact.[b]
Only some VAIIs were impacted and no additional VA was impacted.	VAAIs = ADDVAs ∩ VAIIs	The investment generates INTVAL at a medium extent of impact.
Only all EFIVs produced impact	AFIVs = EFIVs	There are sufficient causes to obtain INTVAL at the expected extent of impact.
None of the EFIVs produced impact	AFIVs = ADDFIVs - EFIVs	There are no causes to obtain INTVAL at the expected extent of impact.
All EFIVs produced impact and additional FIVs also produced impact	AFIVs = EFIVs ∪ ADDFIVs	There are sufficient causes to obtain INTVAL not only at the expected extent of impact, but at an additional extent of impact.
Only some EFIVs produced impact and additional FIVs also produced impact	AFIVs = (ADDFIVs ∩ EFIVs) ∪ ADDFIVs	There are no sufficient causes to obtain INTVAL at the expected extent of impact, but an additional extent of INTVAL impact may be obtained.
Only some EFIVs produced impact and no additional FIV impacted	AFIVs = ADDFIVs ∩ EFIVs	There are no sufficient causes to obtain INTVAL at the expected extent of impact, and no additional INTVAL impact can be obtained.

[a] While the investment may generate some value, it does not generate it as expected; therefore, it does not satisfy all the strategic goals.
[b] However, it does not fully satisfy the expected results.

FIVs and thus prepare the scenario for the comparative analysis of two "total" matrices of the same size. For this end, all blank elements must be assigned a value of zero for calculation purposes as proposed in Appendix VI.a). After all, it is reasonable to assume that DMs agreed that they did not expect any impact in such elements, and therefore: $AM_{i,j} = 0$.

The next step is to calculate arithmetic means for all AM_j per VA in both matrices (now that they are of the same size) as proposed in Appendix VI.b). This will result in the "net" IMPEXs and IMPERs per VA. A proposed intangible value impact classification for IMPEX and IMPER values is shown in Table I based on the six-point response format proposed for the D-IGF and the U-IGF.

b) Conducting comparative analysis

The comparative analysis of the "total" matrices may now be conducted on the following points with the following formulas:

- Relationship between VAIIs and VAAIs:
  X = total of VAAIs / total of VAIIs
- Relationship between AFIVs and EFIVs:
  X = total of AFIVs / total of EFIVs
- Relationship between the "total" IMPERs and IMPEXs per VA:
  X = total $IMPER_i$ / total $IMPEX_i$
- Relationship between the "net" IMPEXs and IMPERs per VA:
  X = net $IMPER_i$ / net $IMPEX_i$

The analysis of relationship between VAIIs and VAAIs consists of determining whether all VAIIs became value activities actually impacted and whether the group of VAAIs includes additional value activities (ADDVAs), so that the following scenarios are possible:

- *Only all* VAIIs were impacted.
- *None* of the VAIIs was impacted.
- *All* VAIIs were impacted and additional VAs were also impacted.
- *Only some* VAIIs were impacted and additional VAs were also impacted.
- *Only some* VAIIs were impacted and no additional VA was impacted.

Considering VAIIs, ADDVAs, and VAAIs as sets [11] of value activities, these scenarios can be described as in Table II.

The analysis of relationship between EFIVs and AFIVs consists of determining whether all EFIVs became AFIVs and whether the group of AFIVs includes additional FIVs (ADDFIVs), so that the following scenarios are possible:

- *Only all* EFIVs produced impact.
- *None* of the EFIVs produced impact.
- *All* EFIVs produced impact and additional FIVs also produced impact.
- *Only some* EFIVs produced impact and additional FIVs also produced impact.
- *Only some* EFIVs produced impact and no additional FIV impacted.

TABLE III
DESCRIPTIONS PROPOSED IN THIS STUDY FOR LEVELS OF ACHIEVEMENT OF INTVAL IMPACT REGARDING RELATIONSHIPS TOTAL IMPEXS↔TOTAL IMPERS PER VA AND NET IMPEXS↔NET IMPERS PER VA

Condition	Level of Achievement
Impact index[a] < 1	Expected INTVAL impact not achieved.
Impact index = 1	Expected INTVAL impact achieved.
Impact index > 1	Expected INTVAL impact overachieved.

[a]Impact index = IMPER / IMPEX

Considering EFIVs, ADDFIVs, and AFIVs as sets [11] of factors of intangible value, these scenarios can be described as in Table II.

A factor of intangible value is an element or cause of intangible benefit [26]. Thus, it is reasonable to believe that the more FIVs there exist, the more elements or causes of intangible benefit there will exist, and therefore the more likely it will be to obtain INTVAL. On this regard, additional FIVs (defined as factors of intangible value resulting from the implementation of an ICT investment that are additional to those expected) should be considered as cause of significant intangible value impact only if they contribute to the achievement of the strategic goals.

The analysis of relationship between the "total" IMPEXs and IMPERs per VA consists on determining whether each VA was impacted by each FIV as predicted, and the analysis of relationship between the "net" IMPEXs and IMPERs per VA consists on determining whether each VA was generally impacted as predicted. These analyses would enable decision makers to identify: a) opportunities to take better advantage of FIVs and/or b) important causes of INTVAL impact.

The levels of achievement of intangible value impact regarding relationships Net IMPEXs↔Net IMPERs per VA can be described as proposed in Table III.

c) Evaluating ICT investment

The most appropriate criteria for success are the project goals 10]. In the context of this study, this success will be estimated based on decision makers' predictions and user beneficiaries' perceptions of the INTVAL impact of ICT investments on the value activities of a business unit, which should respectively derive and be approached from the strategic goals defined for the ICT investment project. For this end, qualitative indicators can be analyzed as qualitative variables by means of statistical tools, or they can be transformed into quantitative variables and interpreted as such [7].

The evaluation stage of the method proposed includes the analysis of qualitative indicators as qualitative variables regarding relationships VAIIs↔VAAIs and EFIVs↔AFIVs (Table II), as well as the interpretation of qualitative indicators as quantitative variables regarding relationships Total IMPEXs↔Total IMPERs per VA and Net IMPEXs↔Net IMPERs per VA.

V. A HYPOTHETICAL EXAMPLE CASE OF IMPLEMENTATION

This section presents an example case of implementation of the method proposed, in which a hypothetical scenario is set for the evaluation of an ICT-IP.

Hypothetical scenario: Decision makers of a firm's auto parts sales department have decided to implement an ICT-IP to improve their sales management. The project consists of the acquisition, installation, and implementation of a new sales management computerized system and related hardware to manage purchase orders, sales data, inventory, clients' data, and contacts with clients to request their feedback and/or solve their inquiries.

a) Defining and categorizing the project

The project involves technologies related to hardware and software dedicated to the *storage, retrieval, and processing* of information, and it does not involve any technology related to hardware and/or software dedicated to the *transmission and distribution* of information. Therefore, the ICT-IP can be categorized as Information Technologies-related (IT-IP).

b) Defining the value chain of the business unit

Decision makers have defined the business unit's Value Chain shown in Appendix VII [24].

c) Determining value activities intended to be impacted and expected factors of intangible value

Based on the project's strategic goals and the business unit's processes, DMs determined that the following VAs should be impacted with the investment:

- Electronic recording of transactions ($VAII_1$).
- Follow-up and resolution of claims ($VAII_2$).
- Processing of purchase orders ($VAII_3$).

Based on the project's strategic goals and their individual expert judgement of the capabilities of the technology to implement and the business unit's personnel's capabilities and processes' suitability, DMs defined that the following FIVs should affect the VAIIs:

- Effectiveness perceived by User Beneficiary ($EFIV_1$).
- Identification of success factors ($EFIV_2$).
- Optimization in value activities ($EFIV_3$).
- Responsiveness to external clients ($EFIV_4$).

d) Determining impact expected

The Project Manager applied 4 rounds of a survey to decision makers by using the D-IGF. For the purpose of this example case, let us assume that the following data was obtained from one DM in all 4 rounds:

- Round 1:

	$EFIV_1$	**$EFIV_2$**	**$EFIV_3$**	**$EFIV_4$**
$VAII_1$	2	5	2	5
$VAII_2$	4	2	2	4
$VAII_3$	2	3	2	5

- Round 2:

	$EFIV_1$	**$EFIV_2$**	**$EFIV_3$**	**$EFIV_4$**
$VAII_1$	1	3	3	4
$VAII_2$	5	2	3	3
$VAII_3$	2	2	3	6

- Round 3:

	$EFIV_1$	**$EFIV_2$**	**$EFIV_3$**	**$EFIV_4$**
$VAII_1$	1	2	4	2
$VAII_2$	3	5	1	6
$VAII_3$	3	2	4	5

- Round 4:

	$EFIV_1$	**$EFIV_2$**	**$EFIV_3$**	**$EFIV_4$**
$VAII_1$	2	4	3	4
$VAII_2$	4	4	6	3
$VAII_3$	3	1	4	1

The consolidated matrix for this DM including the arithmetic means for all IMPEXi,j would be:

- Consolidated matrix:

	$EFIV_1$	**$EFIV_2$**	**$EFIV_3$**	**$EFIV_4$**
$VAII_1$	1.5	3.5	3	3.7
$VAII_2$	4	3.2	3	4
$VAII_3$	2.5	2	3.2	4.2

For the purpose of this example case, let us assume that the following Total IMPEX Matrix is the result of processing the responses of a total of 4 decision makers:

- Total IMPEX Matrix:

	$EFIV_1$	**$EFIV_2$**	**$EFIV_3$**	**$EFIV_4$**
$VAII_1$	1.7	2.2	2.5	2.7
$VAII_2$	3.5	4.2	4	4.2
$VAII_3$	2.7	2.2	3.7	3.2

e) Determining impact perceived and conducting the comparative analysis.

Let us also assume that the following Total IMPER Matrix is the result of processing the responses of a total of 7 user beneficiaries:

- Total IMPER Matrix:

	$AFIV_1$	**$AFIV_2$**	**$AFIV_3$**	**$AFIV_4$**
$VAAI_1$	2.2	3.2	3.5	3
$VAAI_2$	2.5	3.2	3.7	4
$VAAI_3$	3.2	4	3	4.2

The Net IMPEX and IMPER matrices per VA will be the following:

Net IMPEX		
	AM	*INTVAL Impact Classification (as per Table I)*
$VAII_1$	2.3	Medium-Low
$VAII_2$	4	Medium
$VAII_3$	3	Medium

Net IMPER		
	AM	*INTVAL Impact Classification (as per Table I)*
$VAAI_1$	3	Medium
$VAAI_2$	3.4	Medium
$VAAI_3$	3.6	Medium

The comparative analysis may now be conducted between the Net IMPEX and Net IMPER matrices. In order to simplify this example case, the ICT investment under evaluation impacted a total of VAs as expected (Total of VAAIs / total of VAIIs = 1), which corresponds to the scenario "*Only all* VAIIs were impacted," and generated a total of FIVs as expected (Total of AFIVs / total of EFIVs = 1), which corresponds to the scenario "*Only all* EFIVs produced impact." The aforesaid leads to conclude that this investment is aligned to the strategic goals pursued.

The analysis of relationships Net IMPEXs↔Net IMPERs per VA can be summarized as follows:

	Impact index = IMPER / IMPEX	**Level of achievement of expected INTVAL impact (as per Table III)**
VA_1	1.3	Overachieved
VA_2	0.8	Not achieved
VA_3	1.2	Overachieved

VI. DISCUSSION

A method for estimating the intangible value impact of ICT investments with focus on IBs has been presented in this paper based on the process proposed in [26], which has been developed to detail the activities to perform. New stages have been added and the first stage has been renamed from "Define and implement ICT-IP" to "Defining and categorizing the project." The reason for this change is that the method is intended to be applied in parallel with the life of the project and not only after it has been implemented. This may be considered as an improvement in the definition of the method since it better conceptualizes ts intended use and purpose, which is to be used along with the life of the project in order to provide DMs with important information on the INTVAL impact expected and perceived that will assist them in managerial decision making.

In the *ex ante* analysis decision makers should determine VAIIs and EFIVs in consensus, considering the strategic goals. Once these have been so determined, the educated prediction of the impact of EFIVs may be subject to the DMs' individual expert judgment. In the ex post analysis, even though user beneficiaries may have their own expectations from an ICT investment, the method here presented proposes to focus on the DMs' expectations, which means that its approach is from the perspective of decision makers. This is coherent with the purpose of the method since USBENs are not involved in managerial decisions.

This paper does not attempt to analyze the problem whether the decision makers' and/or user beneficiaries' expectations from an ICT investment are realistic. DMs and USBENs are treated in this study as two separate heterogeneous groups of experts; therefore, it is assumed that their individual judgement has an experience-based component and a realistic point of view. A future study may explore the influence of this factor on the quality of information gathered from decision makers and user beneficiaries and its impact on the results of the method here proposed.

The method proposes calculating arithmetic means to consolidate the responses obtained from DMs and USBENs in connection with each value-generating activity in their business unit. In view that decision makers may agree that some VAs might not get impacted with the implementation of an ICT investment or that some FIVs should not be expected, and that user beneficiaries may in the end perceive an impact on said VAs or from said FIVs (or *vice versa*), the calculation of a weighted average could be deemed to be suitable for consolidating their responses based on the quantities of EFIVs and AFIVs per each VA. However, such calculation was discarded in this study since it was considered that VAs that were not expected to be impacted or not perceived as impacted, as well as FIVs that were not expected to impact or not perceived as having an impact, should not be ignored and instead should be taken into account with a value of zero. The aforementioned could be explained with an example of a value-generating activity that was expected by DMs to be impacted with the implementation of an ICT investment but in the end was not perceived as such by USBENs. In said case it should not be ignored that a VAII did not become a VAAI, and therefore the implementation of the ICT investment project might not had the extent of INTVAL impact expected, and/or it was not totally aligned with the strategic goals pursued.

A hypothetical case has been presented in this paper only to illustrate the implementation of the method proposed. It does not elaborate on real situations and is set on a simple scenario so as to avoid any complexity in view that its purpose is to serve as an illustrative representation of the activities to perform and not to validate the accuracy of the results in a specific scenario. A future study could apply this method in a specific scenario for validation, taking into account that some important factors for the success of the application of this method include, without limitation, the clear categorization of the ICT-IP to evaluate, the clear definition of the business unit (and the pertinent actors) where the evaluation is to take place, and the selection by decision makers of factors of intangible value which are suitable to the type of ICT investment to analyze. Other success factors may have "a role in this game;" however, they would be determined by the characteristics of the specific scenario where the method is to be implemented.

This method proposes conducting a simple-flow process as shown in Appendix II, which integrates *ex ante* and *ex post* analyses that are subject to specific conditions of the current situation. This means that its application should be periodical and not a one-time exercise, in view that both decision makers' predictions and user beneficiaries' perception of INTVAL impact may vary in time.

Finally, although the method mathematically allows continuing the calculation of arithmetic means for Net IMPEX and Net IMPER and subsequently obtaining a single numerical value resulting from the calculation of a final arithmetic mean of the average Net IMPEX and the average Net IMPER, such exercise might not have any practical importance/utility for the purposes of the method proposed, as this covers various analyses for estimating the intangible value impact obtained per each value activity related with the strategic goals. Claiming that one single numerical value could enclose the extent of INTVAL impact obtained from an ICT investment would not be congruent with the purpose of the method.

VII. Conclusion

A new method was developed for estimating the intangible value impact of ICT investments. The decision makers' predictions of the intangible value impact expected before the implementation of an ICT-IP may be compared with the user beneficiaries' perceptions of such impact after the project has been implemented and in production for a period of time which is reasonable and sufficient for evaluating results, allowing to estimate a "net intangible value" delivered by these investments per value activity. This may reveal important information for managerial decision making. A future study could analyze whether the level of reality in decision makers' and/or user beneficiaries' expectations from an ICT investment has any influence on the method's results.

This paper contributes to both theory and practice since it presents background theory to support why the method proposed is based on decision makers' predictions and user benficiaries' perceptions, as well as a hypothetical case which serves as an example to illustrate the implementation of the method proposed. It does not include, however, an application of the method in a real scenario, and therefore it does not provide evidence on the level of accuracy of its results. A future study could apply the method in a specific scenario in order to validate it and evaluate its effectiveness.

The information gathered from the literature review and the hypothetical example case presented indicate the probable applicability of the method in a real case scenario, where important factors such as those indicated in this study for the success of its application should be taken into account.

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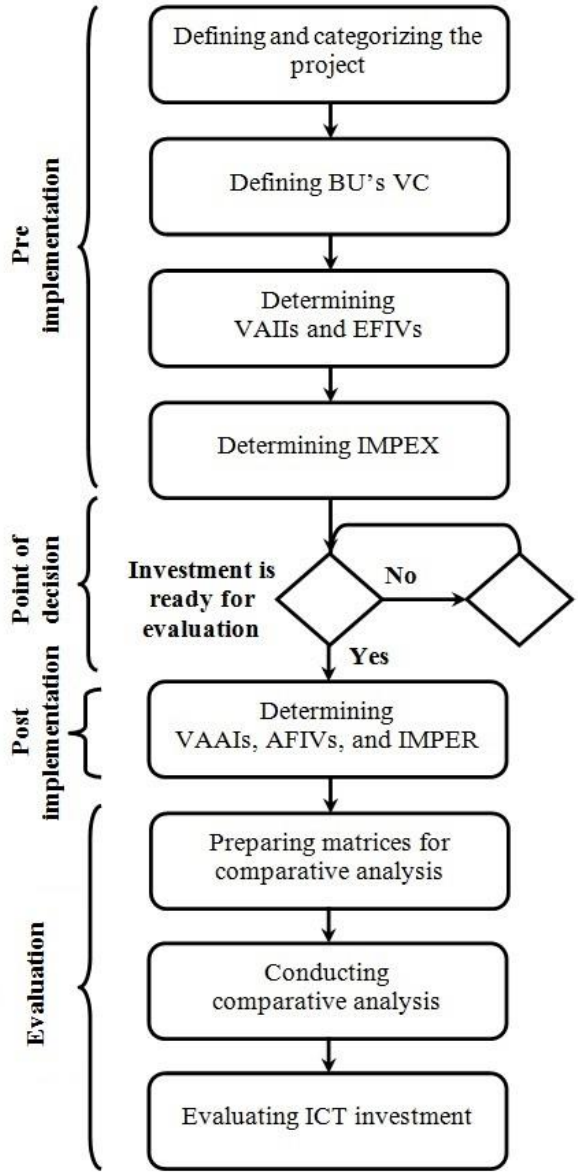
APPENDIX I

Glossary of terms used in this study.

Abbreviation /Acronym	Meaning	Definition
ADDFIV	Additional factor of intangible value	A factor of intangible value that was not expected but was identified in the ex post analysis.
ADDVA	Additional value activity	A value activity that was not expected to be impacted with the implementation of an ICT investment project but was found in the ex post analysis to have been impacted.
AFIV	Actual factor of intangible value	An expected factor of intangible value that was found in the ex post analysis to have indeed caused intangible value upon the implementation of an ICT investment project.
CT	Communication technology	Technology related to hardware and/or software dedicated to the transmission and distribution of information.
CT-IP	Communication technology - Investment project	An investment project involving communication technology.
D-IGF	Information gathering form for decision makers	A tool designed to be used by the Project Manager in the ex ante analysis to gather from Decision Makers information on their expectations of intangible value to be obtained with the implementation of an ICT investment project.
DM	Decision maker	A person involved in decision making regarding ICT investment projects.
EFIV	Expected factor of intangible value	A factor identified in the ex ante analysis that is expected to cause intangible value upon the implementation of an ICT investment project.
FIV	Factor of intangible value	An element or cause of intangible benefit and, subsequently, intangible value.
IB	Intangible benefit	A benefit that cannot be measured directly or quantified easily in terms of money, time, or frequency.
ICT	Information and communication technology	Technology related to hardware and/or software dedicated to the storage, retrieval, processing, transmission, and distribution of information.
ICT-IP	Information and communication technology investment project	An investment project involving information and communication technology.
IMPER	Impact perceived	The level of impact of intangible value perceived by a User Beneficiary on a specific value activity upon the implementation of an ICT investment project.
IMPEX	Impact expected	The level of impact of intangible value expected by a Decision Maker on a specific value activity upon the implementation of an ICT investment project.
INTVAL	Intangible value	The intangible business value originated from intangible benefits perceived by User Beneficiaries upon the implementation of an ICT investment project.
IT	Information technology	Technology related to hardware and/or software dedicated to the storage, retrieval, and processing of information.
IT-IP	Information technology investment project	An investment project involving information technology.
PM	Project manager	A person responsible for leading an ICT investment project from inception to implementation.
U-IGF	Information gathering form for user beneficiaries	A tool designed to be used by the Project Manager in the ex post analysis to gather from User Beneficiaries information on their perception of intangible value obtained with the implementation of an ICT investment project.
USBEN	User beneficiary	A person who benefits from the use of the technology implemented in their business unit with an ICT investment project.
VA	Value activity; value-generating activity	An activity performed in a business unit that is physically, technologically, and strategically distinct and generates value to final consumers.
VAAI	Value activity actually impacted	A value activity that was identified in the ex post analysis as impacted by the implementation of an ICT investment project.
VAII	Value activity intended to be impacted	A value activity identified in the ex ante analysis that the implementation of an ICT investment project intends to impact.
VC	Value Chain	Models proposed in [1] and [33] that represent a chain of value activities performed in a business unit to create competitive advantage.

APPENDIX II

Outline of the method proposed.



APPENDIX III

Iteration Gathering Forms.

a) Information Gathering Form for Decision Makers (D-IGF)

INFORMATION GATHERING FORM
(DECISION MAKERS)

Company name: _____
Business unit: _____

Description of the investment:	**Round ___ of 4**
Position of the respondent:	**Date of application:**

[Here the Project Manager should insert an introductory paragraph explaining the purpose of the form and how to use the six-point response format]

EXPECTED FACTORS OF INTANGIBLE VALUE / **VALUE ACTIVITIES INTENDED TO BE IMPACTED**	$EFIV_1$	$EFIV_2$	$EFIV_3$	…	$EFIV_n$
$VAII_1$	*[In these cells respondents must indicate the expected INTVAL impact by entering a value from 1 to 6, being 1: "Low impact" and 6: "High impact"]*				
$VAII_2$					
$VAII_3$					
$VAII_4$					
…					
$VAII_n$					

b) Information Gathering Form for User Beneficiaries (U-IGF)

INFORMATION GATHERING FORM
(USER BENEFICIARIES)

Company name: _____
Business unit: _____

Description of the investment:	**Round ___ of 4**
Position of the respondent:	**Date of application:**

[Here the Project Manager should insert an introductory paragraph explaining the purpose of the form and how to use the six-point response format]

ACTUAL FACTORS OF INTANGIBLE VALUE / **VALUE ACTIVITIES ACTUALLY IMPACTED**	$AFIV_1$	$AFIV_2$	$AFIV_3$	…	$AFIV_n$
$VAAI_1$	*[In these cells respondents must indicate the perceived INTVAL impact by entering a value from 1 to 6, being 1: "Low impact" and 6: "High impact"]*				
$VAAI_2$					
$VAAI_3$					
$VAAI_4$					
…					
$VAAI_n$					

APPENDIX IV

Iteration Monitoring Form for use by the Project Manager.

ITERATION MONITORING FORM

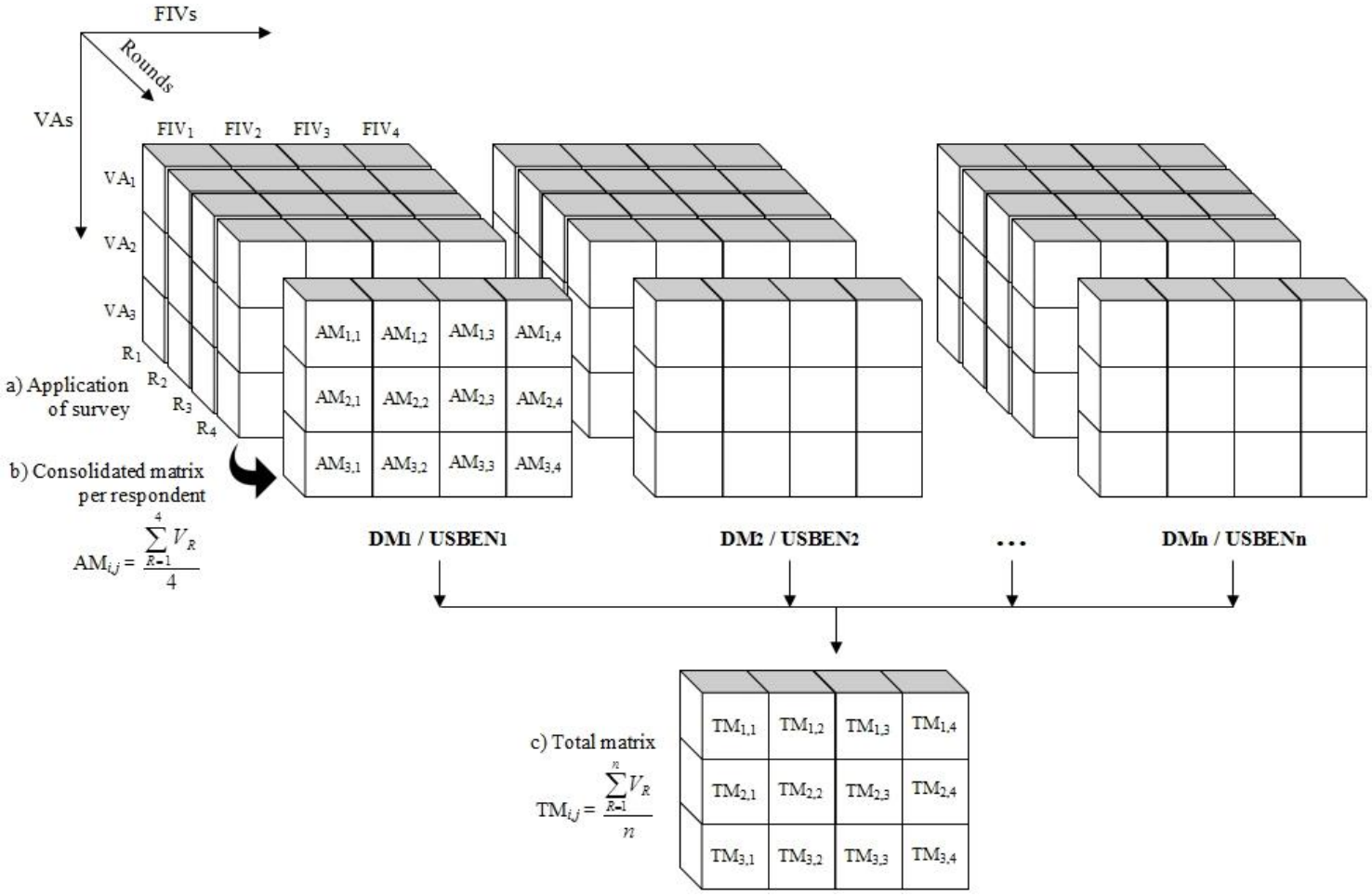
Company name: _____
Business unit: _____

Description of the investment:	
Number of respondents:	**Date of implementation of the project:**

Name of respondent	**Position**	**Rounds completed**			
		1	**2**	**3**	**4**
		Date:	Date:	Date:	Date:
		Date:	Date:	Date:	Date:
		Date:	Date:	Date:	Date:
		Date:	Date:	Date:	Date:
		Date:	Date:	Date:	Date:

APPENDIX V

Sequence of activities of the method proposed: a) application of survey, b) obtainment of consolidated matrix per respondent, and c) obtainment of total matrix.



APPENDIX VI

Processing of total matrices: a) assigning zeros to blank elements in total IMPEX matrix, and b) calculating arithmetic means per VA in total IMPEX/IMPER matrices.

a) Assigning zeros to blank elements in total IMPEX matrix

	$EFIV_2$	$EFIV_3$	$EFIV_4$
$VAII_1$	1	2	3
$VAII_3$	4	5	6
$VAII_4$	1	2	3

➡

	$EFIV_1$	$EFIV_2$	$EFIV_3$	$EFIV_4$
$VAII_1$	0	1	2	3
$VAII_2$	0	0	0	0
$VAII_3$	0	4	5	6
$VAII_4$	0	1	2	3

b) Calculation of arithmetic means per value activity in total IMPEX matrix and total IMPER matrix

Total IMPEX Matrix					
	$EFIV_1$	$EFIV_2$	$EFIV_3$	$EFIV_4$	AM
$VAII_1$	0	1	2	3	1.5
$VAII_2$	0	0	0	0	0
$VAII_3$	0	4	5	6	3.75
$VAII_4$	0	1	2	3	1.5

Net IMPEX Matrix per VA

Total IMPER Matrix					
	$AFIV_1$	$AFIV_2$	$AFIV_3$	$AFIV_4$	AM
$VAAI_1$	1	2	3	2	2
$VAAI_2$	5	6	2	3	4
$VAAI_3$	4	5	6	4	4.75
$VAAI_4$	1	2	3	3	2.25

Net IMPER Matrix per VA

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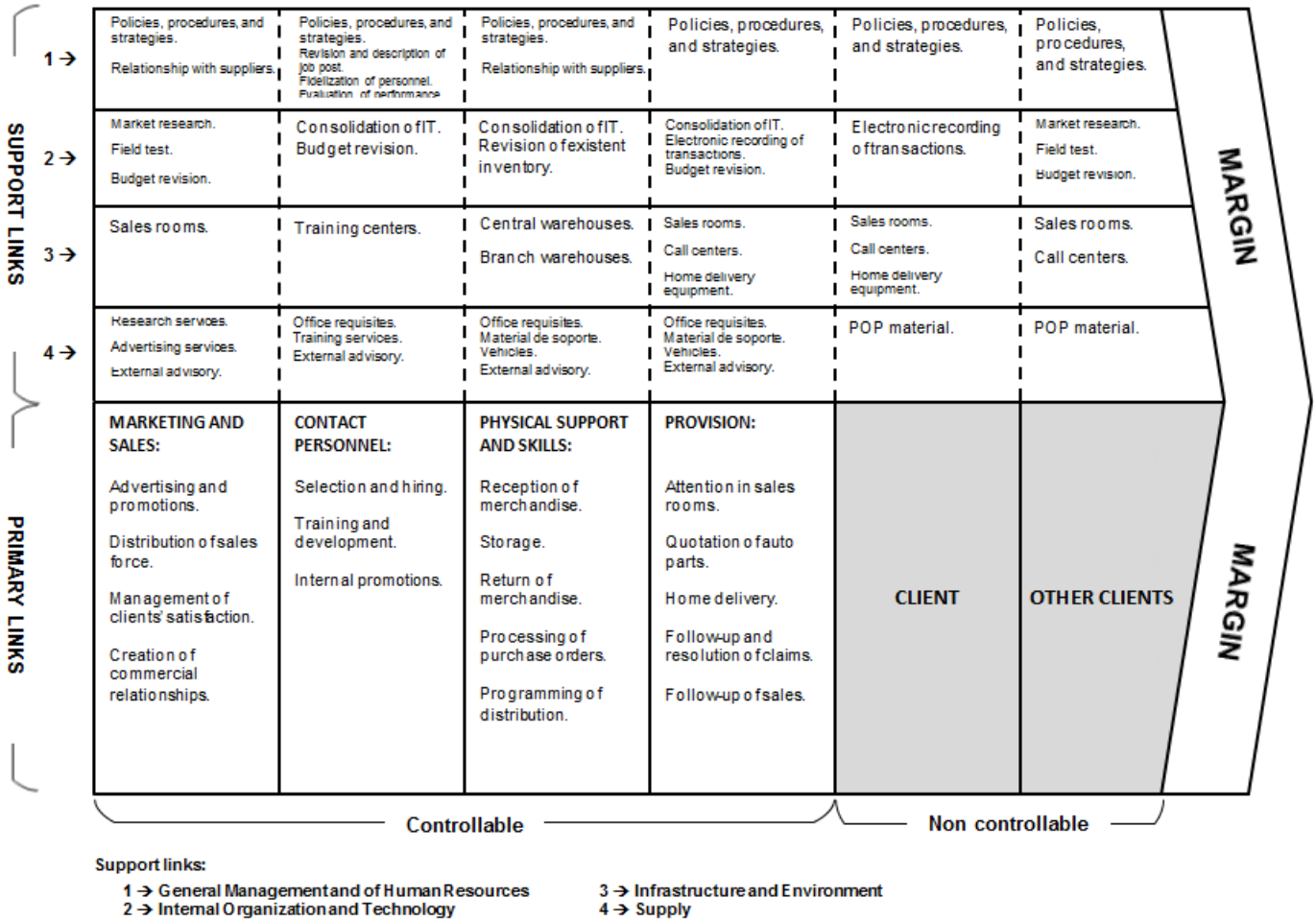
APPENDIX VII

Value chain of the business unit of the hypothetical case.



Support links:

1 → General Management and of Human Resources
2 → Internal Organization and Technology
3 → Infrastructure and Environment
4 → Supply