Systems & Management 14 (2019), pp 245-256

SYSTEMS & MANAGEMENT
Electronic magazine

NEW TECHNOLOGIES APPLIED IN ECONOMIC AND FINANCIAL FEASIBILITY STUDIES: AN INTEGRATIVE LITERATURE REVIEW

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ABSTRACT

New information and communication technologies (NICT) play a fundamental role within contemporary society and, in this study, an integrative review of the world literature is presented, highlighting its applications for management, more specifically in relation to economic and financial viability studies. For this, an exploratory search was conducted in databases indexed in the Portal of Journals of the Higher Education Personnel Improvement Coordination (*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* – CAPES), in order to search the theoretical framework and an integrative review in the Scopus, Web of Science and IEEE Xplore, for the survey of the NICTs used in economic and financial feasibility studies. In addition to listing them, it can be seen that, in addition to enabling the resolution of problems when used in isolation, they are even more efficient when used together, enhancing their capabilities and employment possibilities in a complementary way.

Keywords: New Information and Communication Technologies; Economic and Financial Feasibility Study; Innovation management; Innovation; Risk Analysis and Financial Sensitivity.

PROPPI / LATEC
DOI: 10.20985/1980-5160.2019.v14n3.1537

Electronic Journal of Management & System
Volume 14, Number 3, 2019, pp. 245-256
DOI: 10.20985/1980-5160.2019.v14n3.1537

1. INTRODUCTION

The digital age proposes a new mental construction in relation to what is meant by management. This is due to the possibility of using new information and communication technologies (NICT) that will be increasingly present in the activities of organizations, with the need to reinvent current business models (Gonzales, 2015).

Technological advancement supported by the continued development of increasingly efficient and smaller computational machines makes it possible for management NICTs to move from link / internet / transport layer solutions, exemplified by Radio Frequency Identification (RFID), used in material control (Glidden et al., 2004), *Vehicle Ad hoc Networks* (VANET), which enable communication between vehicles and the internet (Cunha et al., 2016), LoRaWan (Adelantado et al., 2017), which is a new way to interconnect objects in the Internet of Things concept (IoT) (Al-Fuqaha et al., 2015), Coming to Cloud Applications with Big Data Data Mining for relevant information and forecasting across management areas (Zhong et al., 2015), artificial intelligence used in customer service systems available via mobile devices (Kolbjørnsrud et al., 2016), and many other possibilities that will emerge with this continuous advance, as Gonzales reinforces (2015).

It turns out that before being available in the market, as a rule, these innovations go through processes composed of several phases, in which studies are carried out on the technical, economic, financial, commercial, environmental and social feasibility, that is, when the objective is to minimize the risks of resource loss before manufacturing and marketing, it is important to be aware of innovation capabilities and their possibilities in the market context (Bordeaux-Rego, 2015).

At this point, a paradox is perceived in the "management x technology" relationship, since at the same time it is necessary to manage innovation to implement new emerging technologies (Tidd & Bessant, 2018), and stable new technologies are used to assist this management process (Silva, 2018). The focus of this research is on the second axis of this paradox: NICTs used to aid management, more specifically those used for the study of economic and financial viability (*Estudo de Viabilidade Econômica e Financeira* – EVEF) of innovations, as it is not clear from the literature which NICTs are currently being used in this kind of study.

Thus, the question is: In the context of the continuous advancement of the use of cyber structure for the activities of organizations, which NICT are being used in the EVEF of innovations? To answer this question, the research aims to raise the NICTs used in the EVEF process of innovations.

This survey will allow an overview of the use of NICT for EVEF, which will provide input for future research and to facilitate understanding of the technological tools used in this process. Moreover, with the compilation of the tools used, it will be possible to compare them and support the selection of the ones that best fit future EVEF.

However, in order to identify the NICTs from the perspective of the objective of this research, it is first necessary to discuss the constructs of innovation management in order to understand the stages of their development, from the EVEF, aiming at understanding how this analysis is performed, to an overview on NICTs that support the understanding of current technologies for management, issues that will be addressed in the following section, serving as a basis for transforming findings into research results.

2. THEORETICAL REFERENCE

2.1 Innovation management

Innovation is not easy to achieve and depends on processes that guarantee its sustainability in the organization (Tidd & Bessant, 2015; Quadros, 2008). For this, the management of innovation, which aims to ensure a culture of continuous innovation within organizations, comes in. Tidd & Bessant (2015) report the need for planning, organization and coordination of the factors that are essential to the development of innovative products, and failing management in these phases is the main cause of failure of organizations.

Quadros (2008) lists six stages of the innovation management process: prospecting, ideation, strategy building, resource mobilization, implementation and evaluation. The prospecting stage comprises activities related to the identification and understanding of market trends to generate innovation. In the ideation stage, proposals and pre-projects are created and they are consistent with the opportunities identified in the prospecting stage, and for this, various techniques are used, such as data analysis, information crossing, and brainstorming. In the next phase, the strategy for the innovation process of the organization is built; this process comprises the analysis step, in order to understand the existing choice strategy alternatives in which it is possible to define the investments and planning, which are the steps for the execution of the innovation project. (Tidd & Bessant, 2015).

Still in the Quadros (2008) model, there is the resource mobilization stage, which defines where each resource will be used. The next step, the implementation, is the main stage of the innovation process, because all the variables analyzed so far come together to create the product. Finally, as a

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DOI: 10.20985/1980-5160.2019.v14n3.1537

last step, there is the evaluation, which aims to monitor the entire innovation management process.

Along with the innovation management process, some challenges emerge to be overcome within the context of organizations so that continuous innovation can be established (Stefanovitz, & Nagano, 2014), such as the difficulty to coordinate the various areas inherent in the project, the lack of information about the market and the new product, the difficulty in dealing with uncertainty and risk, and restricted and / or non-uncertain management processes such as a characteristic of innovation.

However, regarding the fourth stage of innovation management, regarding resource mobilization, it is necessary to have the financial dimension of the project to be invested. In this sense, a good practice to mitigate these risks and uncertainties inherent in innovative processes and products is to conduct studies in the previous phases (prospecting and ideation) to obtain important information about their characteristics and meet them with the minimum requirements set by the market and organizations so that their marketing is viable (Bordeaux-Rego, 2015). In the next item, a review about the EVEF (Gomes et al., 2018) will be addressed to explain its peculiarities.

2.2 Economic and financial feasibility study

Currently, innovation is a fundamental element for organizations to maintain their competitive differential in relation to the market (Quadros, 2008). However, resources need to be invested to make this innovation happen. As opportunities arise, there is also a need to select the best investment options (Ross et al., 2015) so that risks are mitigated with respect to resource use (Abreu, 2015). For this, there are several management tools that can be used as an aid in the investment decision making process (Abreu, 2015), one of which is the EVEF of a project.

In general, EVEFs involve the relationship between money and time and risk and return considerations (Ross et al., 2015). They are performed considering the market uncertainties and variations regarding the possible profitability of the studied product, thus evaluating whether the projections raised can be carried out or not. (Abreu, 2015).

The performance of EVEF involves data collection, estimation of net cash flow, determination, calculation and analysis of economic viability indicators, issuance of conclusive opinion and management decision (Ross et al., 2015; Abreu, 2015; Rasoto et al., 2012).

The data collection stage involves the collection of values related to expenses, costs, initial investment and maintenance; to revenues, which are the expected benefits; cash flows; as well as the identification of those involved in the process, consumers, suppliers and the market (Ross et al., 2015; Abreu, 2015; Rassoto et al., 2012).

The stage of determining viability indicators involves deciding which indicators will be used in the investment analysis process, the most common of which are: net present value (NPV), internal rate of return (IRR), minimum attractiveness rate (MAR) and investment payback. Soon after the determination of indicators, they should be analyzed considering, among many variables, the objectives and structure of the organization that intends to implement or produce this innovation, because the viability must meet the demands of the organization and this involves not only economic value issues, but also the interest in taking the risk of investing in the new product or project (Ross et al., 2015; Abreu, 2015; Rasoto et al., 2012).

From this analysis, an opinion is created on the viability of the product to be appreciated by the management of the organization, giving managers support for decision making (Rassoto et al., 2012).

The following chapter will present the NICT trends for use in management.

2.3 New information and communication technologies and their possibilities

The NICTs are being widely used to perform the various activities of the digital society. The evolution of information and communication technology (ICT) hardware components, with ever smaller dimensions and increasing processing capacity, along with new forms of protocols and communication, enables the emergence of NICT.

The constant evolution of NICTs makes it possible to connect conventionally non-computational “things” to the internet. (Marcelino et al., 2018; Altoe et al., 2013). These “things” make use of hardware and applications to connect to the global network, opening up a wide spectrum of usability, from home automation and control to improved public safety operational and administrative services, by means of smart cameras, fire prevention systems and biometric offender registration (Oliveira, 2017); or precision agriculture, with sensors that enable better management of planting resources (Marcelino et al., 2018).

In addition to Internet-connected objects for research and innovation, NICTs come in many forms, whether in experimentation / automation / remote control or the use of data mining algorithms in Data Science, Big Data and also software that help several tasks, such as the management of theoreti-

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cal references, the case of Online mechanism to References (*Mecanismo Online para Referências* – MORE) of the Federal University of Santa Catarina (De Negri & Squeff, 2016).

This multidisciplinarity in the use of ICT assists in the search for solutions to contemporary problems, such as resource management efficiency (Marcelino et al., 2018), social issues in relation to digital breaches (Gomez, 2018) and renewable energy (Sônego et al., 2018).

Next, the methodology will present the path taken to identify the NICTs that are being used for EVEF.

3. METHODOLOGY

To achieve the objective of the study, an integrative review was performed, based on the revision model proposed by Botelho et al. (2011), which foresees six stages.

In the first stage, the research theme was defined as "NICTs applied to EVEF", based on the problem identified in relation to the need to investigate them, which also supported the formulation of the research question: Which NICTs are being applied to EVEF?

As a descriptor for the search, the economic feasibility study was defined, in quotation marks, aiming only at the return of feasibility studies and avoiding the return of articles that contain the words separately, which could be misaligned with the theme and with the purpose of the research. At the end of the first stage, the research databases were also defined, namely IEEE Xplore, Scopus and Web of Science, as they are multidisciplinary and indexed databases. The search was performed on December 6, 2018.

In the second stage, the inclusion (*critérios de inclusão* – CI) and exclusion (*critérios de exclusão* – CEx) criteria of contents were defined. This study included only articles with free access (open access); and excluded duplicates, those whose theme was different from the scope of the article, using as reading resource the reading of titles and abstract and those which did not have full text available.

With the inclusion and exclusion criteria defined, previously researched articles were analyzed, selecting those that fit the proposed research.

Thus, the research followed the script described in the previous paragraph, and the process of applying the inclusion and exclusion criteria, as well as the evolution of the balances of publications selected after each criterion are described in Table 1, where "X" represents the number of publications excluded and "S" the balance of publications after the criterion has been applied.

Table 1. Selection of articles according to inclusion and exclusion criteria

Criteria	IEEE Xplore		Scopus		Web of Science	
	X	B	X	B	X	B
Initial Search	-	1082	-	555	-	293
Inclusion: open access	1061	21	541	41	249	44
Exclusion 1: Duplicates	1	20	18	22	4	40
Exclusion 2: Divergent Theme	10	10	3	19	2	38
Exclusion 3: Does not provide full text	0	10	1	18	0	37
Selected	65 publications					

Source: From the authors. X: represents the number of publications excluded; B: Represents balance of publications after applying criteria.

To assist in the management of publications, EndNote X9 software was used. Then, the 65 selected publications were numbered from 1 to 65, to facilitate the representation of the findings in tables and figures, as shown in Table 1.

Chart 1. Reference Numbering

Reference	Numeral
Alnifro et al., 2017	1
Altoe et al., 2013	2
Anastasopoulou et al., 2016	3
Arzola de la Peña, 2006	4
Cao et al., 2016	5
Chae et al., 2015	6
Chaiklahan et al., 2018	7
Chatterjee & Rayudu, 2017	8
Chermat et al., 2018	9
Lima et al., 2016	10
Debastiani et al., 2014	11
Duvergel Cobas & Argota Vega, 2017	12
El-Galad et al., 2015	13
El Zanati & Elnahas, 2018	14
Fletcher et al., 2017	15
Galevsky et al, 2016	16
Gamou et al., 2002	17
Garcia Garnica et al., 2018	18
Hailu Kebede & Bekele Beyene, 2018	19
Hameed et al., 2011	20
Han & Han, 2013	21
Ke et al., 2008	22
Kim, 2015	23
Lage et al., 2016	24

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Lavander et al., 2013	25
Lee, 2017	26
Lopes Silva et al., 2014	27
Lorenz et al., 2014	28
Mohan et al., 2018	29
Molinos-Senante et al., 2011	30
Moratilla Soria & Villar Lejarreta, 2013	31
Mustafa et al., 2017	32
Naty et al., 2016	33
Niu et al., 2014	34
Nugraha et al., 2016	35
Omer et al., 2015	36
Gularte et al., 2017	37
Park et al., 2017	38
Park et al., 2005	39
Paul & Prabu, 2016	40
Poilvet & Barreau, 2012	41
Price & Schmidt, 1998	42
Renda et al., 2016	43
Silva et al., 2016	44
Rodrigues et al., 2017	45
Romallosa & Kraft, 2017	46
Rospi et al., 2017	47
Shah et al., 2018	48
Sheng & Zhang, 2017	49
Shoeb & Shafiullah, 2018	50
Simonic & Pintaric, 2005	51
Sixt & Strube, 2018	52
Spriet & Hendrick, 2017	53
Tartaglia & Cerati, 2016	54
Thomas & Costa, 2017	55
Torres Fernández et al., 2015	56
Umemiya & Sato, 1989	57
Vorpagel et al., 2017	58
Wang et al., 2015	59
Yambot et al., 2016	60
Yao et al., 2018	61
Zaied, 2017	62
Zgheib et al., 2018	63
Zhang et al., 2017	64
Zhao et al., 2014	65

Source: Authors' elaboration.

Following the integrative review process, the articles were categorized into two groups: those that use technological tools directly for EVEF calculations and for other phases, which will be identified as "C1"; and those which did not present tools for the calculation itself, but provided solutions for support activities, such as data collection, representation of results, and relevant information, such as images, figures, and tables, identifying these articles as "C2". This facilitates the analysis of the results of the integrative review, as can be seen in Table 2.

Chart 2. Categorization of articles

References	Categorization
[1]; [2]; [3]; [6]; [8]; [9]; [10]; [14]; [15]; [18]; [19]; [22]; [24]; [35]; [36]; [37]; [50]	C1 - EVEF calculation
[4]; [5]; [7]; [11]; [12]; [13]; [16]; [17]; [20]; [21]; [23]; [25]-[34]; [38]-[49]; [51]-[65];	C2 - EVEF support activities

Source: Authors' elaboration.

After categorizing the articles, it was possible to analyze and interpret the data obtained from the complete reading of all selected articles, in order to identify the technologies found in each research, considering two aspects: report of the use of technology by the author, and use expressed in technology publications even if the author does not address its use in the text.

For this, a qualitative analysis of the data was performed and the results will be presented visually with the aid of Tableau software, which discusses what was obtained from the research, allowing a better understanding of the data. In addition to the integrative review, an exploratory search was needed to better clarify issues related to innovation management, EVEF and new technologies.

4. RESULTS

This chapter covers the results of the study, consisting of three parts. The first presents a general review of the studies; the second presents the NICTs found for EVEF; Finally, the NICTs used by the authors for support activities are presented.

4.1 General Review of Articles

Initially, it can be seen that the EVEF permeates several areas of knowledge, as well as the NICT, further emphasizing the importance of this activity for the evaluation of innovative projects and products, regardless of the area of study.

Within the range of selected research, studies focusing on energy, agribusiness, automation, engineering, ecology,

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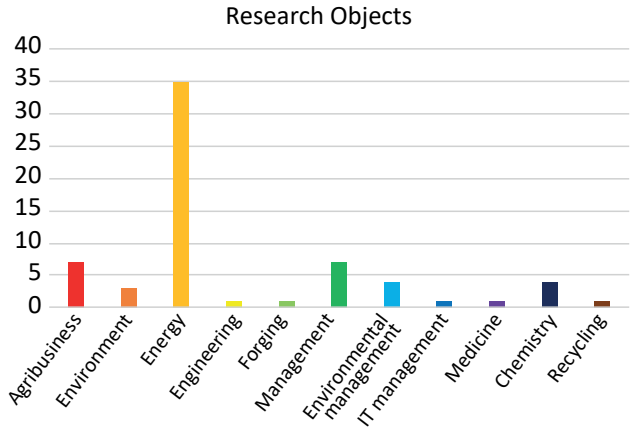
chemical processes, management and finance were observed, which can best be seen in Chart 3.

Chart 3. Research Object Rating

Studies focus	Articles
Agribusiness	[24][25][58][9][10][11][4]
Environment	[30][39][62]
Energy	[1][13][14][15][17][18][19][2][21][27][28] [3][31][32][33][34][35][36][38][40][43] [45][46][47][48][49][50][56][57][59][6] [61][64][65][8]
Engineering	[60]
Forging	[16]
Management	[12][17][22][26][44][54][55]
Environmental management	[41][42][51][53]
IT management	[23]
Medicine	[52]
Chemistry	[5][7][29][63]
Recycling	[37]

Source: Authors' elaboration.

It can be verified that most studies have the viability of innovations and projects for the area of energies as object of analysis. This will also be repeated in the next chapter dealing with NICTs for EVEF. Another aspect raised refers to the date of publications: 51 of the 65 studies were published in the last five years, indicating the increase of these studies from the year 2014.



Graph 1. Publications by research object (quantitative)
Source: Authors' elaboration.

Regarding the EVEF procedures, it was found that, in general, the works follow the line of what is presented in the theoretical framework of this study, i.e. they focus mainly on three viability indicators: IRR, NPV and payback. However, some studies use more complex feasibility analysis techniques, such as the multi-index methodology and the advanced multi-index methodology (Cao et al., 2016; Fletcher et al., 2017; Hailu Kebede & Bekele Beyene, 2018; Lavander et al., 2013; Moratilla Soria, & Villar Lejarreta, 2013), such as the multi-index methodology and the advanced multi-index methodology which, in addition to verifying economic and financial viability, also verify investment risk and sensitivity analysis, thus indicating the level of stability of the product variables, that is, the viability response of the product, if a given input cannot be purchased as planned, because the more stable the lower the risk.

In the next topic, the tools raised in the review, used for EVEF, will be presented.

4.2 New information and communication technologies for the calculation of economic and financial viability

As seen in the previous item, most of the studies were conducted in the area of energies, and the survey of the tools for EVEF was done. The software for these studies has been found to be very robust and allows both technical data collection and productivity simulations, as well as automated EVEF, such as the Hybrid Optimization Model for Multiple Energy Resources (Homer) software (Adelantado et al., 2017; Anastasopoulou et al., 2016; Bordeaux--Rego, 2015; Botelho et al., 2011; Cunha et al., 2016; Duvergel Cobas & Argota Vega, 2017; Lage et al., 2016; Omer et al., 2015).

Other non-energy focused software such as CU$TO DIETAS (agribusiness) (Gamou et al., 2002), Monte Carlo (general use) (Fletcher et al., 2017; Kolbjørnsrud et al., 2016) and AspenHysys (general use) (Alnifro et al., 2017; Chermat et al., 2018), enable simulations to be performed in various financial scenarios, as well as options for project improvement. Regarding the complexity of the calculations, $AVE (Cao et al., 2016) presents the possibility of performing the EVEF based on the multiple index method, proving to be a good tool when the objective is a detailed risk study and sensitivity analysis. Still on the technologies employed, there is the spreadsheet "Excel", cited in the review (Lavander et al., 2013), and a viability web application (Lavander et al., 2013) that enables study sharing and calculations through the web. Regarding these spreadsheets, despite not being new due to their popularization and use by society, it is clear that more users and programmers are improving these tools to get results faster, clearer and automated. A summary of these tools can be seen in Table 4 and Graph 2.

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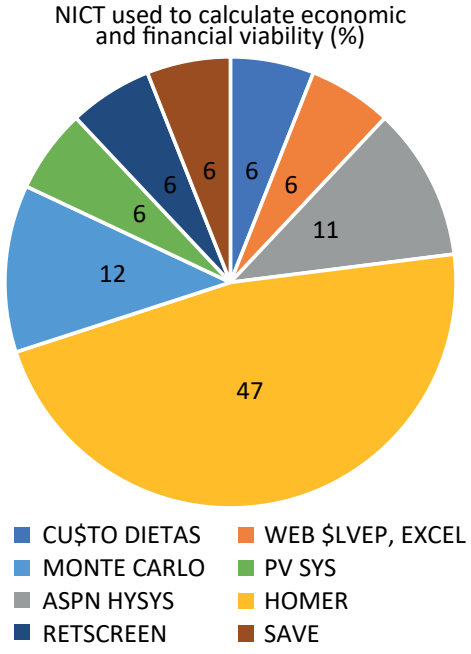
Chart 4. New information and communication technologies used to calculate economic and financial viability

Software	Reference
CU$TO DIETAS	[24]
WEB $LVEP, EXCEL	[37]
ASPN HYSYS	[1][14]
HOMER	[3][6][8][9][15][19] [36]50]
MONTE CARLO	[22][35]
PV SYS	[18]
RETSCREEN	[2]
SAVE (SISTEMA DE ANÁLISE DE VIA-BILIDADE ECONOMICA – ECONOMIC FEASIBILITY ANALYSIS SYSTEM)	[10]

Fonte: Elaboração dos autores.



Graph 2. New information and communication technologies used to support economic and financial viability

Source: Authors' elaboration.

4.3 New information and communication technologies to support economic and financial feasibility study activities

From the analysis of the publications it was also possible to gather information regarding the NICT used for EVEF support activities, in the preliminary and complementary phases.

Regarding the preliminary stages to the calculation of EVEF, that is, data collection and estimation of net cash flow in general, the studies presented tools for the acquisition of technical data that are relevant to the feasibility study, as they measure the innovation capacity and their potential revenues. Regarding the acquisition of accounting and financial data, the use of specific tools for this activity can be verified. Chart 5 shows a summary of the NICTs for these activities and the purpose of their use.

Chart 5. New information and communication technologies used to support economic and financial feasibility study activities

Supporting Software	Reference	Goal
Agricultural Technical Risk Application (Aplicativo de Risco Técnico Agrícola - RTA)	[58]	Data acquisition
Aspen HYSYS	[34] [63]	Data acquisition
ASPEN Plus Software	[3]	Data acquisition
bba (binary bat algorithm); Generic and Swarm Algorithm	[49]	Mathematical calculations
GAMS General Algebraic Modeling System	[1][30]	Mathematical calculations
Google Maps	[48] [50]	Data acquisition
Google Earth	[40]	Data acquisition
MATLAB	[16] [20]	Mathematical calculations
Monte Carlo	[53]	Statistical simulator
SPARTAN	[24]	Chemical simulator
TRNSYS, Design-Builder software eEnergyPlus	[47]	Data acquisition
TRNSYS, SolDesigner, SolarPro e T*SOL	[2]	Data acquisition
Windows MovieMaker	[62]	Video editor
WPLSoft	[60]	Logic programming

Source: Authors' elaboration.

It should be highlighted the diversified use of tools, such as: mathematical calculation modeling tools, such as MATLAB (Cunha et al., 2016; El Zanati & Elnahas, 2018); General Algebraic Modeling System (GAMS) (Alnifro et al., 2017; Hailu Kebede & Bekele Beyene, 2018); simulation tools and financial risk – agricultural technical risk (*risco técnico agrícola* – RTA) (Rasoto et al., 2012); Monte Carlo (Park

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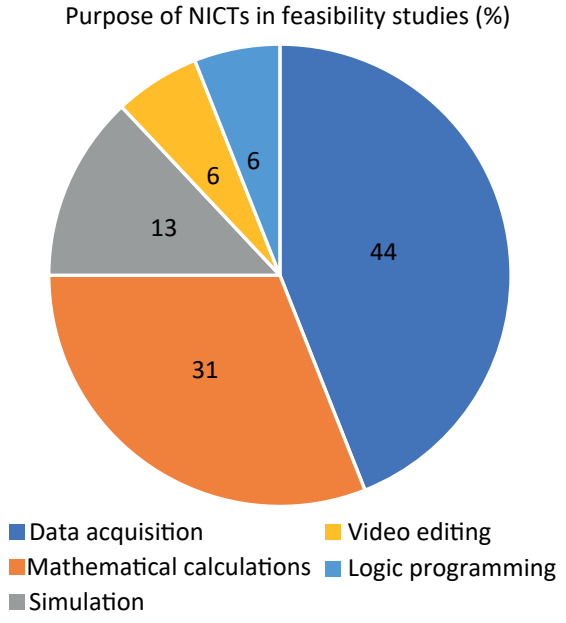
et al., 2005); technical data collection tools such as ASPEN Hysys (Park et al., 2017; Rospi et al., 2017); EnergyPlus (Niu et al., 2014); WPLsoft (Silva et al., 2016); T*sol, Solar Pro and TRNSYS (Abreu, 2015; Niu et al., 2014); tools for geographic data collection such as Google Maps (Nugraha et al., 2016; Omer et al., 2015); and Google Earth (Lorenz et al., 2014). It can be seen that software technologies have hegemony in EVEF, as can be seen in Graph 3.



Graph 3. Use of economic and financial feasibility study software
Source: Authors' elaboration.

In the complementary phases of the EVEF, in which it is necessary to represent the information through graphs, tables, images and other resources, the authors using these tools were raised. It is known that today there are several editors and modelers of images and visual representation, but as the articles studied did not present the means by which they made visual representations, Table 6 presents the presentation of information on EVEF.

Still on Chart 6, digital images, 3D project modeling, infrastructure images, process flows, innovations, and places where they would be allocated are within the scope of the images cited.

Representing information at the concluding opinion stage is very important to facilitate project financiers' understanding, given that the project or innovation must pass on feelings of confidence, stability, low risk and considerable gains, and enhancing the visual representation of information facilitates this activity.

Chart 6. Forms of information representation

Form of Representation	References
Tables and Figures	[1][2][3][4][5][6][7][8][9][10][11][12][13][14] [15][17][18][19][21] [22][23][24][25][26][27] [28][29][30][31][32][33][35][36][37][38][40] [41][42][43][45][46][47][48][49][50][51][52] [53][54][56][57] [58][59][60][62][63][64][65]
Photographic innovation, infrastructure or project images	[1][2][3][6][8][9][13][18][20][25][29][33][35] [36][38][40][46][47] [53][54][60][62]

Source: Authors' elaboration.

An indispensable area for NICT is communication, and in this review it was also surveyed, along with selected articles, the communication technologies used in the process of EVEF, from the prospecting phase, with market research (innovation management), until the presentation of the project's EVEF results. Thus, a widely used technology was the Internet, either to search for technical data, component prices, download applications and software essential to perform the EVEF or even remotely monitor the sensors of power systems and control innovations via satellite. The authors who reported using this technology were: Alnifro et al., 2017; Abreu, 2015; Adelantado et al., 2017; Anastasopoulou et al., 2016; Bordeaux-Rego, 2015; Botelho et al., 2011; Chaiklahan et al., 2018; Duvergel Cobas & Argota Vega, 2017; El Zanati & Elnahas, 2018; Cao et al., 2016; Lavander et al., 2013; Lorenz et al., 2014; Omer et al., 2015; and Paul & Prabu, 2016. It was possible to assemble a cloud with the words most commented by these authors regarding Internet use, see Figure 1.

Figure 1. Internet usage word cloud
Source: Authors' elaboration.

It can be seen that the internet has many uses, whether in remote device control, automation, communication between systems, web applications and climate data, and access to financial information databases.

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This word cloud concludes the item of the results, showing that the internet has a fundamental role for the communication and interconnection of various devices and areas, including management, and is used for EVEF.

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Received: May 19, 2019

Approved: Aug 21, 2019

DOI: 10.20985/1980-5160.2019.v14n3.1537

How to cite: Gomes, N. N. S.; Lavina, M. E.; Gruber, V., et al. (2019), "New Technologies Applied in Economic and Financial Feasibility Studies: an Integrative Literature Review", Sistemas & Gestão, Vol. 14, No. 3, pp. 245-256, available from: http://www.revistasg.uff.br/index.php/sg/article/view/1537 (access day month year).