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A Decision-Making Method for Boosting New Digitalization Technologies

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Market acceptance of new digitalization technologies is low. To help to address this shortcoming, the following paper defines a quantitative decision-making methodology for the exante evaluation of the market acceptance of new digitalization solutions in the initial stages of design and development. The proposed decision-making methodology includes a first evaluation, using Volere methodology, for the quantification of how useful the new digitalization solution is for the end users, and a second method, the calculation of the net present value (NPV) based on potential benefits in terms of costs and intangible benefits of the new tool. A new tool for the management of freight transport was used as a case study. The usefulness of a new information technology tool was assessed in six different companies. It was designed to help developers and decision makers in information and communication technology (ICT) product development, and company managers in the evaluation of technical solutions that might better satisfy their needs. Further studies could measure the power of this methodology by comparing the implementation levels of two different prototypes designed for the same function and with different Volere and NPV scorings.

Keywords: Decision-making method; ICT; digitalization; ASSIST; NPV, Volere.

1. Introduction

In 2017, the ICT sector in the EU28 amounted to 630 billion value added, spent 32 billion on R&D, represented 4.1% of the EU28 total value added, and was equivalent to 3.6% of the EU's gross domestic product.[1,2] The ICT sector has experienced a huge expansion over the last years. The development from 1995 until 2017 shows that the EU28 ICT sector multiplied its value added in real terms by a factor of 3.8, while that of the total economy increased by 1.5.[2] However, even with these very good numbers, the introduction of new ICT products into the market always presents challenges and

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many ICT products or services fail. The CHAOS Report of 2018 developed by the Standish Group showed that 36% of the ICT projects are successful, 45% are "challenged" (i.e., the project is completed and operational but over-budget, exceeded the time estimate, and offers fewer features and functions than initially planned), and 19% failed.[3] There are different reasons behind this figure of 64% of ICT projects being unsuccessful. New ICT developments have to contend with company-related, technical, and external barriers during their implementation phase. This leads to uncertainty by company managers in the decision-making process, and to low levels of acceptance by the market. It has been suggested that up to two thirds of corporate change efforts fail, and resistance is the "little-recognized but critically important contributor" to that failure. Therefore, measuring this resistance, prior to implementing a change, is needed in order to avoid unsuccessful efforts. The CHAOS report defines five factors that are required for a successful project: the project needs to be small, the product owner or sponsor must be highly skilled, the process must be agile, the agile team must be highly skilled in both the agile process and the technology, and the organization must be highly skilled at emotional maturity.[3]

Therefore, a lot of money is wasted in ICT tools that will be unsuccessful due to different barriers coming from different stakeholders (internal and external), and of differing natures (operational, psychological, etc.). Decision makers and product managers need tools to help them in the decision-making process of product development. These tools should help them in the assessment of the market potential of the new product or service. They should consider the opinions of the end users in order to identify any possible barrier to implementation, and also to quantify the intangible benefits that it can give to them, as well as considering economic aspects. If a product or service makes you waste money and does not give you any benefit it does not have any potential in the market. There are some different methodologies used to help decision makers in product development (see Sec. 2.2). However, very few of them take into account both quantitative (economic) and qualitative aspects, or translate qualitative aspects into quantitative values that can make the decision-making process easier. This paper contributes to the research area through the definition of a new quantitative decision-making methodology to be used in the initial steps of design and development for the evaluation of the market potential of new digitalization solutions. This methodology combines the quantification of the opinions of the final users using the Volere method and the calculation of the anticipated profitability through the NPV.

The paper is organized as follows. Section 2 covers the different barriers that have been identified in previous works as hindering the implementation of new products, and the different decision-making methodologies that are used in new product development. It is hoped that with these in mind, a product with higher acceptance might be introduced. The methodological framework describing the different steps of the proposed decision-making methodology followed by an exante estimation of the potential market acceptance of innovative products, processes or services is described in Sec. 3. Section 4 includes the results and the discussion. The last section, Sec. 5, concludes the paper and identifies opportunities for future research.

2. Literature Review

2.1. *Barriers to ICT adoption*

Different studies have shown that small and medium enterprises (SME) are more reluctant to adopt IT solutions than large companies, having internal and external barriers influencing their decisions.[4,5] Chouki *et al.* developed a literature review of barriers for the implementation of IT solutions in SMEs and found that the most influential internal barriers in SMEs are as follows: (a) the top management, as they have a central role in the decision-making process, and (b) the employees or end users of the new IT tool, since they will have a direct influence in the success or failure of its adoption. Chouki *et al.* also found the professional skills of external expertise and external assistance received for the adoption of the IT tool[4] as the most important external barrier. Molero *et al.* identified the different barriers and factors influencing the acceptance of ICT tools, and hierarchized them into seven groups: operational, psychological, environmental, technological, corporate social responsibility, maintainable, and economic costs.[5]

One of the main barriers to ICT adoption, identified in several studies, is uncertainty about timely returns on investment, and a lack of methods for the identification and analysis of potential benefits in terms of costs and intangible benefits, due to, for example, additional services.[4,6,7] Perego *et al.*[6] identified a lack of business models to assess the benefits of ICT applications in transportation and logistics companies. Zhicai *et al.*[8] said that the dominant methods for evaluating the socio-economic impact of Intelligent Transport Systems are cost-benefit analysis, cost effective analysis and multi-criteria appraisals. Kengpol and Tuominen[9] evaluated information technologies in logistics firms, considering criteria pertaining to benefits, costs, and risks, using the analytic network process method. On the other hand, Dziallas and Blind[10] did an exhaustive literature review about innovation indicators and highlighted the challenge of measuring newly evolving ideas since it is unclear how, and what, to measure when the necessary conditions tend to change in unexpected and diverse ways. In addition, Carlan *et al.*[11] identified three main reasons behind the investment in emerging digitalization solutions for freight transport and logistics: cost reduction and improvement of the service level, transport process control and monitoring enhancement, and safety and security improvements.

It would be ideal to have quantitative socio-economic data at the beginning of the process of new product development, and during the design stages, so that efforts can be focused on those solutions with market possibilities. What methodologies are currently used in the assessment of the market potential of new products? The following subsections comprise analyses of the methods presently used in developing new projects/products and in assessing their innovativeness and potential market acceptance.

2.2. *New product development (NPD) — How to measure innovation?*

The innovation process of new products includes different steps, these being: strategy, product definition, product concept, validation phase, production phase, and market launch and commercialization.[10,12] New product development theory has evolved, since 1990, with different practices, tools, techniques and management frameworks.[13,14] Appropriate innovation management can only be reached with the appropriate tools and methods. Table 1 shows some of the methods used for product development. For example, Conforto and Amaral[15] analyzed a hybrid project management model which mixed NPD stage-gate models and Agile Project Management, in a qualitative way, using questionnaire and interviews. Results showed that the use of this hybrid framework increased both project and product development performance through the improvement of information accuracy, commitment and leadership. Roeth *et al.*[16] examined the influence of decision makers' states (rationality vs. intuition) in NPD. Their analysis showed that although intuition can lead to agility, it can also lead to unexpected negative outcomes such as increased NPD project costs, while rationality can lessen the commitment to unsuccessful projects; decision makers should be aware of their emotions in situations in which their commitment is likely to escalate, since this might also have negative results.

However, within the product design and development process, the way innovation is measured has always been a challenge and some previous studies can be found in the literature, which try to give an answer.

Banu[17] defined a series of key performance indicators (KPIs) in order to measure innovation in a specific study case. In order to identify these KPIs, the standard modelling language, Business Process Model Notation 2.0, was used. This is a model that gives a graphical representation of the processes or activities needed to develop the innovation, or organize the activities, needed to finally develop and describe the required KPIs, facilitating a more comprehensive understanding of the innovation process. She described four different steps to be followed in order to define the appropriate KPIs, these being: 1. Define and understand objectives, 2. Define and describe results, 3. Design and describe the flow of activities of the new innovation and 4. Develop and describe KPIs based on these activities or processes.

Dziallas and Blind[10] gave a good review of innovation indicators in the different phases of product development. Their review showed that the number of soft (qualitative) indicators exceeds the number of hard (quantitative) indicators, in the early stages of the innovation process, and highlights the fact that actual indicators, to assess the potential of innovation, remain mostly missing. This is probably due to the lack of particular data necessary to evaluate innovations, mainly because, at the beginning of the innovation process, it is very difficult to estimate the future success, or not, of a product since there is not sufficient data and there are many unforeseen

Table 1. Summary of methods used to evaluate new products.

Method	Qualitative analysis	Quantitative analysis	Advantages	Disadvantages	Ref.
Change formula	√	X	– Describes three factors for change to happen: ○ Level of dissatisfaction with present state ○ Desirability of change ○ Practicality of change – These three factors should be higher than the perceived costs	– Concrete costs not considered	19
Agile methods	√	X	– Flexibility/adaptability to change during the development phase	– Planning/product development strategy – Quantitative analysis/data not considered.	38–40
NPD stage-gate model + agile project management	√ (Questionnaire+ interviews)	X	– High information accuracy – High commitment – Strong leadership	– Costs not considered	15
Definition of KPIs using BPMN 2.0	√ (Graphical representation + definition KPIs)	X	– Information about the flow of activities – Information about expected results	– Costs not considered	17
Volere requirements process	√ (Questionnaire)	(Quantification of qualitative information)	– Quantifies qualitative information	– Costs not considered	18, 27, 28

Table 1. (*Continued*)

Method	Qualitative analysis	Quantitative analysis	Advantages	Disadvantages	Ref.
Sentire (Volere + user experience analytics + simulated personae)	√	X	– Quantifies qualitative information – Uses statistics/simulations for the evaluation of the new ICT product – Greater communication between developers	– Costs not considered	41
Rank + epidemic model (technology diffusion framework)	√ (Questionnaire)	(Quantification of qualitative information)	– Factors considered: ∘ Anticipated benefits of adoption ∘ Barriers to adoption ∘ Absorptive capacity and experience ∘ Information spillovers ∘ Competition ∘ Firm size, firm age and corporate status ∘ Technological opportunities and market prospects	– Evaluation developed based on qualitative data from questionnaires, not real data – Costs not considered	26, 42
ASSIST assessment framework	√ (Scope, context, and stakeholder evaluation)	√ (Quantification of expected benefits using NPV)	– Can be used to measure both financial and intangible factors – Suggests the use of contingencies and Monte Carlo sensitivity analysis to evaluate uncertainties	– Uncertainty; there may be unforeseen factors	43

Table 1. (*Continued*)

Method	Qualitative analysis	Quantitative analysis	Advantages	Disadvantages	Ref.
Cost-benefit analysis	X	√	– Valuable tool to evaluate costs and benefits during a time period. Widely applied to project appraisals of ICT and transport projects	– Nonmonetary costs not considered (e.g., socio-economic impact)	8, 44–46
Multi-criteria decision methodologies: data envelopment analysis	√	√ (Evaluation of quantitative data not related to costs)	– Useful to evaluate the impacts that are difficult to decide in monetary units (e.g., time)	– Concrete costs not considered	8
Multi-criteria decision methodologies (compensatory methods): for instance analytic hierarchy process (AHP), fuzzy AHP	√	(Quantification of qualitative information)	– Useful for evaluating different alternatives from a holistic perspective (i.e., does not just consider economic criteria)	– Concrete costs not considered	5, 30–32, 47, 48
Multi-criteria decision methodologies (out-ranking methods): e.g., ELECTRE, PROMETHEE, TOPSIS, VIKOR	√	(Definition of importance coefficients and thresholds)	– Used to discard unacceptable alternatives to the problem (ELECTRE) – Preference ranking (PROMETHEE, VIKOR, TOPSIS)	– Concrete costs not considered	29, 35, 49–52
Large-scale group decision-making	√	(Quantification of qualitative information)	– Preference ordering. Alternative ranking. Heterogeneous preference formats. – Some use some methods for consensus for large groups (higher than 20)	– Concrete costs not considered	36, 53

factors which can have an influence on its success. One methodology to design and estimate the future success of a new product is the Volere methodology. The Volere Requirements Process is a requirements discovery and specification process whose principles can be applied to almost any kind of application type in almost any kind of development environment.[18] The Volere methodology has been used for the evaluation and quantification of how useful each of the modules of a new ICT solution, based on the opinions of the final users, is.[5,18]

There is a strong need in the NPD process to have quantitative indicators that can give objective appreciations about innovative products. Beckhard and Harris[19] developed the change formula. This change formula captures the process of change by identifying the factors that need to be strongly in place for change to happen. These factors are: level of dissatisfaction with the present state of affairs, desirability of the proposed change or end state, and practicality of the change (minimal risk and disruption). When these three factors are positive, then change will happen, but only if the cost of changing is not too high.[20]

As previously indicated, one important barrier in achieving a good market acceptance of a new product is the uncertainty about timely returns on investment, and a lack of methods for the identification and analysis of potential benefits in terms of costs and intangible benefits.[6,7,21] Financial performance, which is understood as "the earnings of a business through the sale of innovative products in the market",[10] is a key factor when designing a new product. If the product is not financially viable for the market, it will not have a good acceptance. Some examples of indicators of financial innovation are: return on investment of innovations[22] and new to market and new to business sales.[23] Regarding intangible benefits, Carlan *et al.*[24] analyzed the benefits that the Port Community System can give to port stakeholders, and they highlighted that it is very difficult to monetize accurately the full range of benefits of innovation initiatives. In addition, changes in requirements during project development generate additional costs that should be considered at the design stage. Guodong, Yu *et al.*[25] proposed a network-based decision method to analyze change impact. It includes two main criteria for a systematic assessment: a network variation scale and extra network change costs.

Hollenstein[26] analyzed the timing and intensity of a firm's adoption of the Internet and e-selling technologies and specified the anticipated profitability of ICT adoption by considering the presumed benefits as well as costs. They identified, as one of the main group of factors for technology adoption, the anticipated net benefits or anticipated revenue increases due to the use of new technology. Within this group they identified three main variables which have an influence on benefits: anticipated benefits from ICT use due to higher quality, complementary services, better market presence, etc.; cost reductions due to, for example, improving internal communication and decision-making; and anticipated advantages from improving external relationships with suppliers, customers, etc.

After the analysis of the advantages and disadvantages of the different methodologies shown in Table 1, it can be seen that for those methods that include both qualitative and quantitative assessment most of them do not include the quantification of costs or economic benefits. Only the ASSIST assessment framework includes the quantification of costs using NPV but needs to improve the qualitative assessment in order to analyze more deeply the adoption of new ICT tools by the final users. Therefore, there is a research gap on methods that enable combining the results coming from the qualitative and the quantitative assessments. In Table 1 different methods can be seen for a qualitative analysis and evaluation. We propose a new methodology that combines the ASSIST method with the Volere methodology. The Volere method has been selected since its usefulness has been demonstrated in different previous studies[18,27,28]; it is easier to use and understand than other methods[29] such as the AHP,[5,30–32] fuzzy AHP,[32,33] PROMETHEE[34] or ELECTRE[35] (which can also be applied when the number of experts is low). The main aim of this study is to evaluate each module regarding each of the defined criteria but not to compare between different alternatives or hierarchize the different criteria — in this case the use of multicriteria decision methods would be more appropriate. Other studies mention the same issue and have a similar objective than this one, the evaluation of a product or service. Chen *et al.*[36] analyzed passenger demands and evaluated passenger satisfaction with the high-speed rail of China by using a combination of online review analysis and large-scale group decision-making, the interval-valued two-tuple linguistic representation model. These authors also built a multi-perspective multiple-attribute decision-making framework to offer a systematic decision support method for enterprises to select the optimal third-party reverse logistics providers.[37]

2.3. *The VOLERE methodology*

Other studies have used the Volere methodology for the elicitation, categorization and quantification of requirements. Haley *et al.*[27] used the Volere method for the organization and categorization of requirements of a project focused on the creation of a system to support learning using mobile technology. They highlighted the fact that classification and categorization of requirements are not trivial. Within this work, a Volere template was used as a guide for writing requirements and their categorization within 27 categories. However, in some projects this categorization is not helpful and should be further improved. They also highlighted the fact of different perspectives among elicitators; while practitioners only want those requirements that can be implemented, analysts want to gather requirements whether or not they can be implemented with the current technology. Also, Mohammed and Mouhoub[28] used a Volere requirements specification template as guidance for the evaluation of an online shopping system for the evaluation of preferences and constraints. They defined the Volere method as a valuable resource that saves money and time, when developing products, and that guides them to suitable requirements specifications.

The Volere methodology has shown to be a useful tool for the quantification of the usefulness of a new product, and for assessing the potential in the market of a digitalization tool from the perspective of future users. This is in agreement with Maiden,[54] who described Volere as a technique that provides guidance for quantification in the form of content, motivation, examples, and fit criteria. Guidance that is based on a straightforward requirements taxonomy.

Porter *et al.*[41] used an extended version of Volere called Sentire, which included UX analytics, user behavioral models, and simulated personas, for the development of a national e-service. They defined the Volere method as a rigorous, clear, and simple method that has been perceived positively by policy makers and IT specialists.

2.4. *The ASSIST methodology*

The ASSIST methodology[43] was born in the health sector as a service assessment model to objectively and rigorously evaluate solutions from an evidence-based, multi-stakeholder, perspective. The methodology is based on obtaining benefits, costs, and returns on investment, considering purely financial and intangible factors, and the calculation of the Net Present Value (NPV). NPV is one of the most popular economic valuation techniques and different variations can be found in the literature.[55]–

In addition, success of innovations has been analyzed by assessing different issues regarding technical, economical and other issues, such as the identification of barriers (e.g., legislative, operational, economic, or social barriers).[11,45,46,56–62] The evaluation of new products in the transport sector has shown the need to also evaluate externalities that generate costs such as accidents, environmental costs (e.g., air pollution, congestion) and scarcity costs.[17,63,64]

After analyzing the current state-of-the-art, it can be concluded that innovation change, and the implementation and acceptance of a new product in the market, in this case of emerging digitalization technologies for the management of freight transport and logistics, can only be achieved if (i) there is a strong need in the market and the new solution meets this need, and (ii) if the cost of implementation is feasible. Furthermore, intangible benefits and costs should also be considered in NPD. Analysis of current methodologies highlights the need to propose new decision methods that would help in the design of new solutions and give useful information to potential users about the benefits (economic and noneconomic) of the implementation of the new ICT solution. In light of this, and after the comparison of the methodologies shown in Table 1, we chose the Volere method for the qualitative evaluation of the new tool to discover if the product would meet the needs of the market — since previous work has illustrated its advantages — and the ASSIST method to evaluate what the economic effect would be on companies of the implementation of the new product or tool, since this has been shown to be clear and easy to use, and it allows the evaluation of the presumed benefits and costs of implementing a new product before it is actually developed.

The aim of this paper is to define and evaluate a new quantitative decision-making methodology for the evaluation of the market potential of new digitalization solutions, in the initial steps of design and development, taking into account, firstly, how useful it is for final users, and secondly, to calculate the anticipated profitability of ICT adoption by taking into account the presumed benefits as well as costs. This proposed approach is important for research and practice in the field of new product/process development, because previous methodologies do not usually combine evaluation of the perception of potential users on the possible value of the new tool and an estimation of the economic benefits that it might bring. This study presents a tool that helps developers and decision makers in the process of ICT product development and also company managers in the evaluation of the technical solutions that better satisfies their needs. Section 3 describes the different steps of the methodology. Section 4 applies the methodology to a case study. Section 5 shows the results and discussion after applying the methodology in a case of study, a new ICT solution for the transport of dangerous goods (TDG) called gADGeTs. Some studies have indicated that factors affecting the freight transport sector include delays, poor information, variable demand, delivery constraints and insufficient supply chain integration.[5,65] Furthermore, integration between different modes of transport makes the management and exchange of information more difficult, due to data availability limitations, low quality of the information and coordination problems.[66] The aim of the new digitalization solution is to increase information exchange of the different members of the supply chain and increase safety and security when transporting dangerous goods (DG). Finally, Section 6 introduces the main conclusions of the paper and further developments.

3. Methodology

3.1. *Overall methodology*

Figure 1 shows the decision-making methodology followed by an exante estimation of the potential market acceptance of innovative products, processes or services. This methodology gives a quantitative measurement based on, firstly, the added value that the new product will give to the companies at which the new innovation is targeted, and secondly, the economic benefits that the new digitalization solution will give to the company. Therefore, the methodology includes the following:

- Step 1: Development of the prototype or flow diagram of the new ICT solution (product, process or service).
- Step 2: Analysis of the prototype following the Volere method.[18] It should be noted that if one module of the prototype (M2) cannot work without the presence of another module (M1), they have to be considered as one in the Volere analysis. The Volere method includes the analysis of the solution (product, process, or service) by the quantification — on a scale of 1 to 5 — of different concepts (e.g., customer satisfaction, customer dissatisfaction, priority, and difficulty) of each of

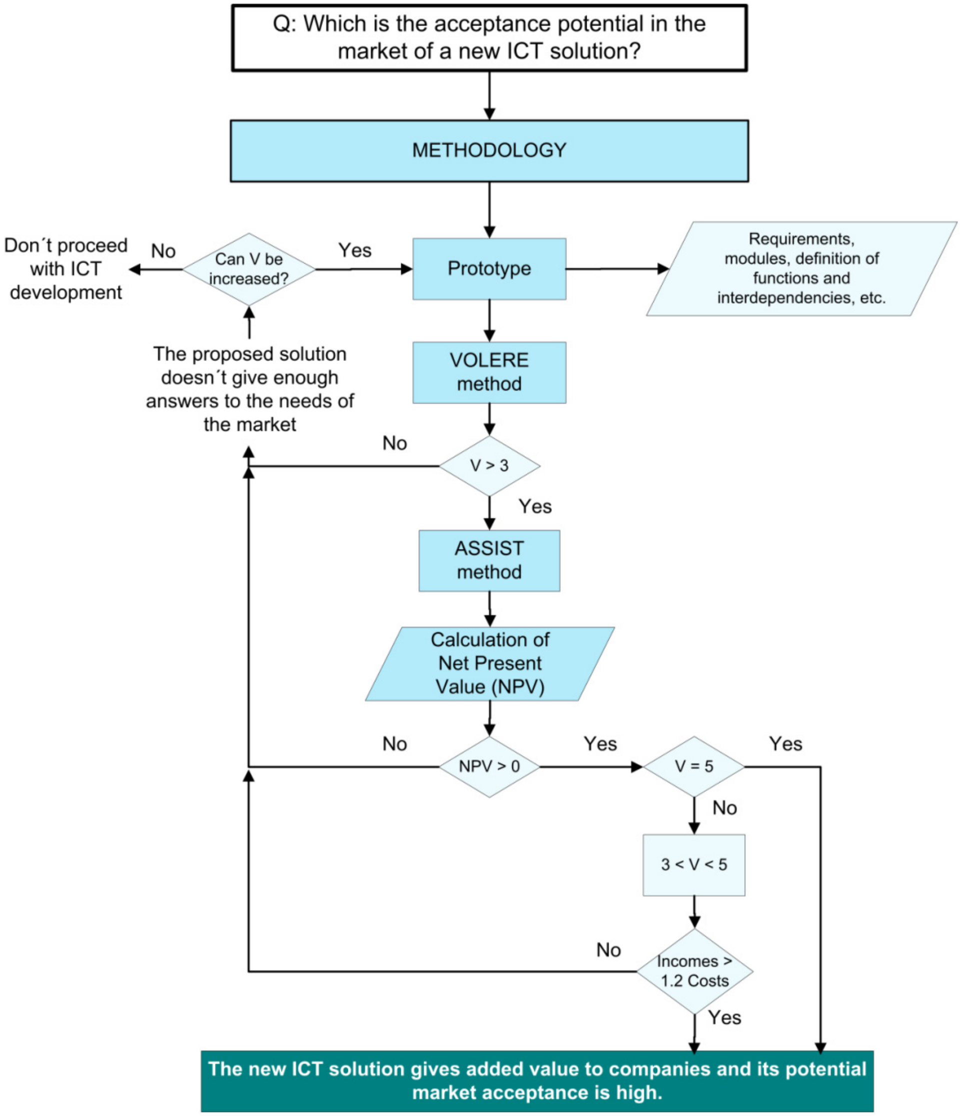

Fig. 1. Scheme of the decision-making methodology followed to analyze, in a quantitative way, the market acceptance of a new ICT solution (process, service or product).

the modules or functions of the new digitalization solution — by end users. In this scale, 3 is the intermediate value, while values higher than 3 (i.e., 4 and 5) are positive values that indicate high user satisfaction, high user dissatisfaction if functionality is not implemented, or a high priority. In the case of evaluation of difficulty, 5 indicates high difficulty in implementation in the market and 1 low difficulty. With the aim of having a single value for the whole solution, the reverse values of the concept of "difficulty" were obtained, namely 1 for high difficulty in implementation and 5 for low difficulty, in order to harmonize the scores between concepts, so that they all indicate that the higher the value, the higher the market acceptance. Since the scores of all the decision makers are considered to have the same importance, the arithmetic average of all the concepts is calculated: (i) per decision maker (see Eq. (1) and Table A.4 as an example), (ii) for each module (see Eq. (2), and Table 3 as an example) and (iii) for the whole solution (see Eq. (3)), this one being the Volere indicator (V) of the whole solution that will be used for decision-making purposes (see Table 2 and Fig. 1). Thus, the development of the new digitalization tool can be continued (if $V > 3$), or redesigned (if $V \leq 3$), according to the Volere methodology that recommends the consideration only of functionalities or solutions that are valuable.[18] Therefore, the arithmetic average of the tool for a decision maker can be calculated using Eq. (1):

$$V_i = \frac{\sum_{j=1}^{M} v_{ji}}{M}. \tag{1}$$

v_{ji} being the value from 1 to 5 assigned by the decision maker i to the the module j of the prototype being analysed, and M being the total number of modules.
The value of the Volere indicator for each of the modules can be calculated using Eq. (2):

$$V_j = \frac{\sum_{i=1}^{N} v_{ji}}{N}. \tag{2}$$

N being the number of decision makers evaluating the module j.

Finally, the Volere indicator V of the whole solution can be obtained using Eq. (3):

$$V = \frac{\sum_{j=1}^{M} V_j}{M}. \tag{3}$$

Therefore, if $V > 3$, the user feels that the proposed new digitalization solution has good functionalities and might help them in their business; in other words, based on the information given by the prototype (which gives an overall concept of the proposed digitalization solution), the product has potential and will be useful for the end user. This is mainly a qualitative assessment, and therefore a more in-depth analysis based on costs is needed to assess the opportunity cost of the new digitalization solution for the companies. To this end, a quantitative assessment is made based on the ASSIST method,[43] which is designed to ascertain the benefits, costs and returns on investment considering purely financial and intangible factors and to calculate the NPV. If the NPV is negative, the new digitalization solution will not be successful in the market. The NPV[46] can be calculated using Eq. (4):

$$\mathrm{NPV} = \sum_{t=1}^{n} \frac{I_t - C_t}{(1+i)^t}, \tag{4}$$

where I_t is the incomes of year t, C_t is the costs of year t, n is the number of years considered (five years for this test case), and i is the discount rate, which has been set at 0.1%.[67] It should be noted that the data to be gathered are historical data from the companies to understand the situation of the company (e.g., number of parcels per year, number of people working handling dangerous goods, training hours, etc.), in order to evaluate whether the new solution will have benefits for them and then if it is worthwhile using it. In addition, the selection of the timeline considered to gather data (in this case five years) can be modified, based on the availability of data and relevance to the objective.

In order to calculate the NPV of a new product, economic savings that the company will make if they use the new software tool have been considered as income, and those which the company will incur if they implement the new digitalization tool for the management of freight transport in their facilities have been considered as costs.

- Step 3A: If the digitalization solution is not of extreme importance, i.e., if $3 < V < 5$, then changing the prototype or implementing something new will only be an option if the expected revenues are sufficient. Change management theory indicates that incomes should be $10 - 20\%$ higher than costs for investors to support a specific project.[68] In this paper we take the most restrictive value, i.e., incomes should be 20% higher than costs in order to implement a change or to introduce a new ICT solution in a specific company.
- Step 3B: If $V = 5$, the proposed new ICT solution perfectly matches the user's needs. It can then be implemented, as it meets the essential requirement that the NPV is positive.

To avoid uncertainties by users' respondents, the number of decision makers scoring more than three should be statistically significant with a confidence level α (0.9 or 0.95) in a binomial distribution with a probability = 2/5 and N (number of trials) = number of total decision makers.

This is the first time a combination of the Volere and NPV methods has been used for the evaluation of ICT acceptance at the early stages of product development. It provides decision makers with better tools and further useful information for NPD.

In order to evaluate the new Cloud solution gADGeTs for the management of the TDG, first a prototype or a flow chart was developed showing how the new solution for freight transport will work with the main functions and interrelations (Fig. 2 and Sec. 3.2). Then, the topics analyzed in the Volere assessment and additional specifications are explained in Sec. 3.3. and the algorithms used to calculate costs and intangible benefits that the users would incur can be seen in Sec. 3.4.

3.2. *Step* 1: *Development of the prototype*

A new digitalization solution for the management of the TDG has been used as a case study. The aim of this new ICT solution for transport is to increase the information

Table 2. Volere indicator scores and related decision-making action.

Score volere indicator	Description
$V \leq 3$	The change will never happen.
$3 < V < 5$	The change will happen only if Incomes> 1.2 Costs
$V = 5$	The change will happen if NPV > 0

exchange of the different members of the supply chain and increase the safety and security when transporting dangerous goods. Delays, poor information, variable demand, delivery constraints and insufficient supply chain integration have been defined as some of the main factors affecting an efficient transport supply chain.[65] With the aim of increasing the integration between the different members of the supply chain, as well as facilitating the preparation of transport documentation for the TDG and the compliance with all the safety and security requirements for a safe TDG (e.g., protective equipment, selection of the truck with specific characteristics for a specific type of DG), so reducing errors and increasing the safety in the transport routes, a new ICT solution has been designed, for the TDG, based on Cloud technology. This new ICT solution will have four modules: Info-reading, Tracking & Tracing, Safety & Security, and Low-risk route.

Figure 2 shows the prototype with the structure of the modules of a new digitalization solution for the management of the TDG called gADGeTs, and was evaluated by experts following the Volere method and from which the NPV will be calculated, based on data from different transport and loading/unloading companies.

The initial design of the new digitalization tool for the management of the TDG was formed by four modules:

- The "Info-reading module": The aim of this module is to upload data concerning the DG to be transported to the Cloud, and to provide the geo-location of the freight for the "Tracking & Tracing module," which will allow the monitoring of the freight by the different members of the supply chain. The data is uploaded to the Cloud through the generation of QR (quick response) labels containing all relevant information for the shipment of the DG (i.e., UN number, origin, destination, shipping name, packing group, environmental dangerousness, weight, height and filling degree for tanks/tank containers), and the later scanning of these QR labels by smart phones at the loading site, intermediate points (e.g., warehouses) and the unloading site for input into the "Tracking & Tracing module."
- The "Safety & Security module" is a module for the automatic generation of documentation for each shipment, based on the different regulations and transport codes for each transport mode (ADR (road), IMDG (maritime), RID (rail), AND (inland waterways)) and goods information supplied by the "Info-reading module." The module processes this information and generates all the technical, safety and administrative documentation (e.g., transport documents for the shipment of dangerous goods, stowage procedure, safety equipment, check list,

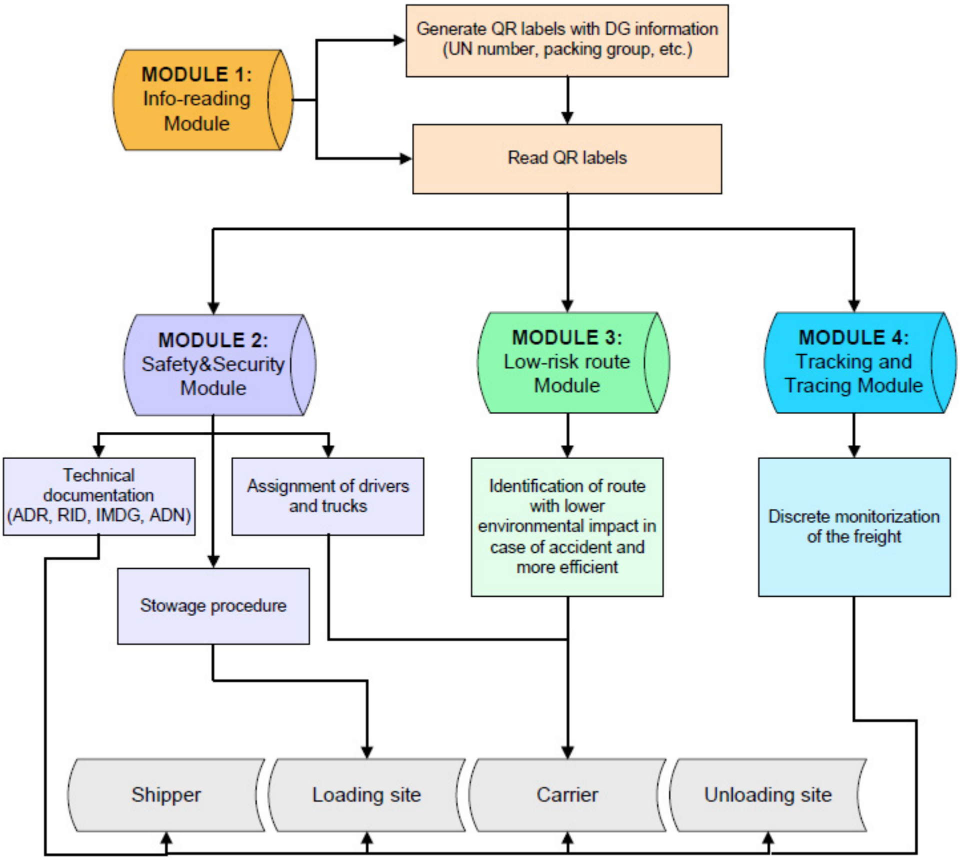

Fig. 2. Prototype of gADGeTs solution with the main modules: Info-reading, Safety & Security, Low risk route and Tracking & Tracing.

special provisions) according to the transport codes, then sends the appropriate documentation to each of the members of the supply chain. In addition, this module also allows the assignment of vehicles and drivers for shipments involving high consequence danger (e.g., the most experienced drivers, those free of criminal records, and the trucks with GPS).

- The "Low-risk route module" is a module designed for the calculation of routes that have a lower environmental impact in the event of an accident and offer security for transport; e.g., roads that are considered to provide secure parking,[69] and are established in national regulations for the TDG (e.g., the RIMP map in Spain).[70] The module contains information about the origin and destination of the shipment from the "Info-reading module," and uses it to calculate the best route, based not only on costs and time but also on environmental, safety and security criteria (e.g., avoidance of protected areas and highly populated zones).

- The "Tracking & Tracing module" receives information about the location of the freight each time the shipment QR label is scanned by the "Info-reading module." It processes this information and sends it to all members of the supply chain.

Due to the interrelation in the functions of the Info-reading and the Tracking and Tracing module (one cannot work without the other), these two modules have been considered as one in the Volere analysis.

3.3. *Step* 2: *Application of Volere method to the case study*

The Volere Requirement Process is a methodology used for obtaining and analyzing the requirements in iterative development processes. The Volere methodology introduces a general template for presenting the layout and structure of the requirements specification document, and defines a series of the concepts that can be included in the Volere assessment, which have to be selected based on the needs and specifications of each project.[18] The concepts that have been included, to evaluate each of the modules of the new ICT tool for the TDG, are: customer satisfaction, customer dissatisfaction, priority, and difficulty (see Tables A.1–A.3 in Appendix A).

Therefore, through the Volere method it is possible to quantify, from 1 to 5, each of the selected concepts for each module of the new management solution for the TDG (see Table A.4). Six potential final users ($N = 6$) completed the three tables ($M = 3$) with their opinions in a workshop session where they could ask any question regarding the functionalities shown in the prototype scheme. The profiles of these six final users were: the manager of a road transport company, a commercial manager and an informatics technician of a technology services company specializing in port logistics, the technical manager of a petroleum company, the project manager of a chemical company, a member of a railway company, and a member of a forwarder involved in the maritime and air transport of goods. Afterwards, the arithmetic average of all concepts, per each decision maker, module, and the overall value (see Eqs. (1)–(3) respectively), were obtained, the latter being the Volere indicator (V) which will be used for decision-making purposes in order to continue with the development of the new digitalization tool (if $V > 3$) or to redesign it or not proceed with it at all (if $V \leq 3$), see Table 2 and Fig. 1.

3.4. *Step* 3: *Calculation of the case study's NPV*

The NPV of the ICT prototype was calculated for six companies who provided quarterly data from the period 2012 to 2016 and were assessed during one full working day after the testing of an alpha version of the prototype. The companies comprised one large company focused on the production of chemicals, especially polymers and coatings, one SME (small and medium-sized enterprise) logistics company specializing in the storage and transport of different chemical products, an SME that manufactures and distributes sanitary products, and three logistics operators in the phytosanitary and agrochemical sectors.

Equation (4) shows the formula of the NPV. Incomes and costs for this new tool are evaluated as shown in Secs. 3.4.1 and 3.4.2.

3.4.1. *Incomes* (I_t)

The incomes or cost savings that the company will have in the year t of usage of the tool are

$$I_t = S_{FC_t} + S_{ShP_t} + S_{SD_t} + S_{AI_t} + S_{\mathrm{Comm}_t}, \tag{5}$$

where

S_{FC_t}: savings due to fine compensations in year t, i.e., since the ICT tool automatically treats safety and security documentation, and also gives the safety and security information for safe transportation, automatically, compliance with transport regulations is assured and there will not be any fines due to improper documentation or unsafe transport of the dangerous goods. S_{FC_t} can be calculated using Eq. (6), where c_{F_t} is the cost in year t of the costs incurred in fines by the company.

$$S_{FC_t} = c_{F_t}. \tag{6}$$

S_{ShP_t}: savings coming from the reduction in shipment time preparation. S_{ShP_t} can be calculated using Eq. (7), where n_{Sh_t} is the number of shipments in year t, $\overline{\Delta t_{ShP}}$ is the decrease in time needed for the preparation of a shipment, i.e., the difference between the average time needed for the preparation of a shipment before using the new tool ($\overline{t_b}$) and the average time that will be needed after the implementation of the new tool ($\overline{t_a}$), and $\overline{c_P}\,t$ is the average cost of the people involved in the preparation of the dangerous goods (DG) shipment in €/h in year t.

$$S_{ShP_t} = n_{Sh_t} \cdot \overline{\Delta t_{ShP}} \cdot \overline{c_{P_t}} = n_{Sh_t} \cdot (\overline{t_b} - \overline{t_a}) \cdot \overline{c_{P_t}}. \tag{7}$$

S_{SD_t}: savings due to the avoidance of returned deliveries due to incorrect documentation or the lack of the required safety equipment in the transport vehicle. S_{SD_t} can be calculated using Eq. (8), where n_{BD_t} is the number of "bad deliveries" including delivery problems due to accidents per year, incidents, and returns due to transport mistakes, in year t, and $\overline{t_{Sh_t}}$ is the average time used for a shipment in year t.

$$S_{SD_t} = n_{BD_t} \cdot \overline{t_{Sh_t}} \cdot \overline{c_{P_t}}. \tag{8}$$

S_{AI_t}: savings in accident insurance due to a reduction in the number of accidents (i.e., transport in compliance with safety and security regulations and avoiding protected natural zones). S_{AI_t} can be calculated using Eq. (9), where n_{A_t} is the number of accidents in year t, and c_{A_t} is the cost produced per accident due to repairs, etc. in year t.

$$S_{AI_t} = n_{A_t} \cdot c_{A_t}. \tag{9}$$

S_{Comm_t}: savings due to a reduction of the time spent in communication with other members of the supply chain (e.g., shipper, driver). S_{Comm_t} can be calculated using Eq. (10), where r_{Comm} is the ratio of shipments where communication between members of the supply chain is needed (which goes from 0 to 1), and $\overline{t_{\text{Comm}}}$ is the average time spent in communication with the other members of the supply chain, to check the state of the shipment.

$$S_{\text{Comm}_t} = n_{Sh_t} \cdot r_{\text{Comm}} \cdot \overline{t_{\text{Comm}}} \cdot \overline{c_{P_t}}. \tag{10}$$

3.4.2. *Costs (C_t)*

The costs that the company will have to incur in the year t for the implementation of the tool are

$$C_t = C_{Li_t} + C_{T_t} + C_{I_t} + C_{La_t} + C_{D_t}, \tag{11}$$

where

C_{Li_t}: cost of the license per year (c_{Li}).
C_{T_t}: cost of training those involved, in the shipment of DG, in the use of the new tool in the year t. C_{T_t} can be calculated using Eq. (12), where n_{PT_t} is the number of people trained in the year t, and t_{T_t} the duration of the training, in hours per year in the year t.

$$C_{T_t} = n_{PT_t} \cdot t_{T_t} \cdot \overline{c_{P_t}}. \tag{12}$$

C_{It}: cost of installation of the new freight transport digitalization tool in the facilities of the company, understood as the time that ICT personnel have to spend for the installation of the tool on the computers of the company that will use it. It can be calculated using Eq. (13), where n_{Comp} is the number of computers where the tool will be working, t_I is the time needed for the installation of the tool and/or for making it work in each of the computers (e.g., permissions of execution in the computer, antivirus program, etc.) in hours, and $\overline{c_{P\_ICT_t}}$ is the average cost of ICT personnel of the company in €/h in year t. This cost is only produced during the first year.

$$C_{I_t} = n_{\text{Comp}} \cdot t_I \cdot \overline{c_{P\_ICT_t}}. \tag{13}$$

C_{La_t}: cost of labelling packages, and over packs, for the use of the Info-reading module in the year t. This cost can be calculated using Eq. (14), where n_{La_t} is the number of labels in year t, c_{La} is the cost of one label, and $\overline{n_{Par_t}}$ is the average number of parcels per shipment in year t.

$$C_{La_t} = n_{La_t} \cdot c_{La} = [(n_{Sh_t} \cdot \overline{n_{Par_t}}) + n_{Sh_t}] \cdot c_{La}. \tag{14}$$

C_{D_t}: cost of the purchase of devices (e.g., mobile phones), if needed, in order to scan the QR labels for the info-reading and track and tracing modules in the year t. C_{D_t} can be calculated as defined in Eq. (15), where n_D is the number of devices to buy, and c_{Dev} is the cost of each device. This cost will be included as a cost for the first year of implementation of the tool.

$$C_{D_t} = n_D \cdot c_{\text{Dev}}. \tag{15}$$

Calculations of the NPV have been made considering a period of time of five years. Regarding costs, the first year will include all types of costs, while for years 2 to 5, there will not be costs regarding cost of devices and cost of installation of the tool in the company facilities. Replacing in Eqs. (2) and (8) the expression for the calculation incomes and costs for each year can be seen in the following Eqs. (16)–(18):

$$I_t = c_{F_t} + (n_{A_t} \cdot c_{A_t}) + [n_{Sh_t} \cdot (\overline{\Delta t_{Sh_P}} + (r_{\text{Comm}} \cdot \overline{t_{\text{Comm}}})) + (n_{BD_t} \cdot \overline{t_{Sh_t}})] \cdot \overline{c_P}_t \quad t = 1, \ldots, 5. \tag{16}$$

$$C_1 = c_{Li} + (n_{PT_1} \cdot t_{T_1} \cdot \overline{c_P}_1) + (n_{\text{Comp}} \cdot t_I \cdot \overline{c_{P\_ICT_1}}) + [(n_{Sh_1} \cdot \overline{n_{Par_1}}) + n_{Sh_1}] \cdot c_{La} + (n_D \cdot c_{Dev}). \tag{17}$$

$$C_t = c_{Li} + [(n_{Sh_t} \cdot \overline{n_{Par_t}}) + n_{Sh_t}] \cdot c_{La} \quad t = 2, \ldots, 5, \tag{18}$$

and replacing in Eq. (1) it can be obtained the NPV value for each company.

4. Results and Discussion

Then the barriers, costs, and intangible benefits that the users would incur, as well as how valuable the developed prototype will be for final users, are shown in sections 4.1 (Volere assessment) and 4.2 (NPV analysis).

4.1. *Volere assessment*

The function of each of the modules and how the whole ICT solution will work was explained to the experts in a workshop session where the experts could ask questions and clarify the functions of the new product that we were asking them to evaluate using the Volere method. The scores given to the gADGeTs tool by each of the experts after completing the tables for each of the tool modules can be seen in Appendix A (see Tables A1–A3). Table 3 shows a summary of the experts' evaluation of each of the modules regarding (1) their satisfaction, i.e., how happy they would be if the module is successfully implemented, (2) their dissatisfaction if the module is not implemented, (3) their priorities and (4) how difficult its

Table 3. Statistics on the evaluation of each Volere concept for each gADGeTs module by the experts.

	Module info-reading + tracking & tracing		Module safety & security		Module low risk route	
	Average	SD	Average	SD	Average	SD
Customer satisfaction	3.83	0.98	4.5	0.55	3.67	1.03
Customer dissatisfaction	3.17	1.33	3.83	0.98	3.17	1.17
Priority	3.17	1.33	3.83	0.98	3.00	0.63
Difficulty[a]	2.00	0.89	4.67	0.52	1.83	0.41
Total	3.04	1.27	4.21	0.83	2.92	1.06

Notes: [a]Reverse values for difficulty of implementation are considered in this table, indicating that the higher the value the more easy it will be to implement the module.

implementation would be within their company, considering supply chain issues, such as interconnectivity and the exchange of data between members of the supply chain, multimodal transports, etc. The results show that the Safety and Security module was the one considered to have the highest priority for potential users as well as being the module with which they will be most satisfied and for which failure to implement will dissatisfy them most. Furthermore, they consider that the implementation of this module will be extremely easy. Final users considered that this module would be very helpful for the preparation of their expeditions and to exchange TDG safety and administrative information between the members of the supply chain, reducing noncompliances with the transport codes and making the transport of the dangerous goods safer and easier.

The next most valued module was the tandem Info-reading and Tracking and Tracing modules, although closely followed by the low risk route module (see Fig. 3). Info-reading and Tracking and Tracing modules had an intermediate Volere score of 3.04. The experts assessed this module as very useful, scoring 3.83 in user satisfaction for the module, however its priority is medium and its implementation not easy. Some experts highlighted the difficulty of the Tracking and Tracing module and its usage among all the members of the supply chain. SMEs experience particular difficulty with this since they do not have enough power to influence the other members of the supply chain to make them use the track and tracing solution. Marchet *et al.* also identified this issue; they said that smaller haulage operators remain dependent on traditional communication and process systems, while the larger logistics companies are the ones developing new ways of working supported by ICT adoption.

Customer satisfaction with the low risk route module was also medium, although its priority was assessed lower than the other two modules. They also consider this module with the highest difficulty of implementation. The aim of this module is to

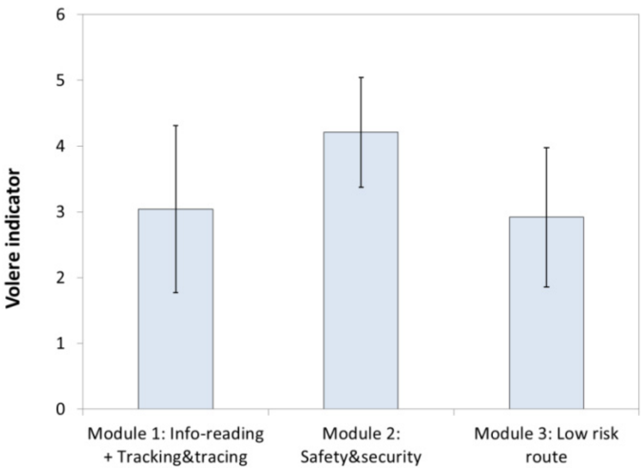

Fig. 3. Volere indicator of the gADGeTs modules: Info-reading and Tracking and Tracing; Safety and Security; and Low risk route.

establish a transport route avoiding protected environmental areas or highly populated zones, and looking for safe parking. One of the main drawbacks or difficulties of this module is the prioritization by companies of time and economic benefits, and seeking a higher profit; and also the fact that changes to the route can be produced at any time during the transport of a shipment in order to carry an additional shipment or if there is any problem or noncompliance with the requirements of the customer and the goods delivered are returned, which can cause changes to the routes.

The analysis of the results (see Table A.4) shows that the average Volere scores for all the modules range from 2.92 to 3.67, making the average score for the whole solution (the Volere indicator) 3.4. Five of the six experts evaluated the gADGeTs prototype with a Volere score higher than three. According to the binomial distribution B $(P = 2/5,\ N = 6)$ the significance level of this result was of 0.99. This indicates that the new digitalization tool could achieve good acceptance in the market if the incomes are 1.2 times the costs (see Table 2). The use of the Volere template and categories has been demonstrated to be useful in defining each ICT module and evaluating them from different perspectives. It should be noted that the results obtained have some limitations or threads; results are based on the opinions of six final users, based on the explanation given to them about the prototype and how it is expected to work. If the concepts given to them are not entirely clear this can lead to some uncertainties in their responses. Also, any small modification in the prototype could change the results obtained, and iterations should be developed when any change is produced. The use of fuzzy theory could be considered to deal with uncertainties, however, the decision maker should consider that sometimes results obtained could be much more restrictive and more data may be needed. In this study we selected the standard Volere since it has been shown to be an easy tool to use with good results in many studies.

4.2. *Net present value*

Communication and external relationships with other members of the transport supply chain are not included in current assessment methods.[26] They have been incorporated into the proposed NPV formula.

Table 4 shows common values for the six companies, because they were shown common during the assessment of the prototype in companies along one full working day, or because they are linked to the ICT solution and consequently company independent data. Table A.5 shows, as an example, the data obtained for those variables specific to each of the companies for the implementation of the new digitalization tool for TDG. With this data, and Eqs. (4), (16)–(18), the NPV of the new tool for each company was calculated and can be seen in Table 5.

All the companies analyzed received an NPV > 0 and an incomes-cost rating (I/C) higher than 1.2 with the exception of Company 4, whose NPV was lower than 0; it would therefore not gain by the implementation of gADGeTs. Comparing company 4 with the others, the fact that the NPV is negative could be because (i)

Table 4. Variables with common values for the 6 companies assessed in the study.

Variables NPV	Symbol	Units	Estimated value
Decrease in time needed for the preparation of a shipment after the implementation of the prototype[a]	$\overline{\Delta t_{ShP}}$	h/shipment	0.15
Ratio of shipments where communication between members of the supply chain is needed[a]	r_{Comm}	—	0.5
Average time spent in communication with the other members of the supply chain to check the state of the shipment[a]	$\overline{t_{\mathrm{Comm}}}$	h/shipment	0.15
Cost of the license per year[b]	c_{Li}	€	1000
Time needed for the installation of the tool and/or for making it work in each of the computers (e.g., permissions of execution in the computer, antivirus program, etc.)[b]	t_{I}	h	0.25
Cost of one label[b]	c_{La}	€/label	0.01
Number of devices to buy[b]	n_{D}	–	2
Cost of each device[b]	c_{Dev}	€/device	237

Notes: [a]These values were shown common for the 6 companies during the *in situ* assessment.
[b]These values are linked to the ICT solution and, consequently, they are equal to the 6 assessed companies.

this is the company with the lowest number of shipments, (ii) they have the lowest rate of bad deliveries, (iii) the average cost of the people involved in the preparation of the DG shipment is the lowest, and (iv) it has the highest number of parcels per shipment, which will need a high amount of labels and consequently, higher costs. Therefore, the results show that the use of a high number of labels and the

Table 5. NPV, incomes, costs and I/C ratio that would produce the implementation of gADGeTs in the six companies.

		2012	2013	2014	2015	2016	NPV
Company 1	Incomes	14087.97 €	10783.29 €	13769.13 €	14574.09 €	12302.71 €	38247.61 €
	Costs	4059.17 €	4025.71 €	5146.34 €	7549.57 €	7311.5 €	
	I/C	**3.47**	**2.68**	**2.67**	**1.93**	**1.68**	
Company 2	Incomes	7319.69 €	6554.1 €	5455.91 €	5596.01 €	4970.51 €	20694.29 €
	Costs	2469.90 €	1935.87 €	1738.48 €	1671.96 €	1733.80 €	
	I/C	**2.96**	**3.38**	**3.14**	**3.35**	**2.87**	
Company 3	Incomes	4367.81 €	4797.99 €	4245.27 €	4022.41 €	4547.18 €	12227.82 €
	Costs	2726.26 €	2120.65 €	1934.89 €	1703.95 €	1662.65 €	
	I/C	**1.60**	**2.26**	**2.19**	**2.36**	**2.73**	
Company 4	Incomes	4103.04 €	1103.04 €	1103.04 €	1103.04 €	1853.04 €	−729.80 €
	Costs	2790.00 €	2016.00 €	2016.00 €	2016.00 €	2016.00 €	
	I/C	**1.47**	0.55	0.55	0.55	0.92	
Company 5	Incomes	5243.72 €	26570.09 €	19663.10 €	29490.11 €	22885.77 €	97629.18 €
	Costs	1847.88 €	1071.94 €	10711.72 €	1090.68 €	1081.78 €	
	I/C	**2.84**	**24.79**	**18.35**	**27.04**	**21.15**	
Company 6	Incomes	2076.28 €	2235.88 €	3508.56 €	3264.96 €	3694.67 €	7935.46 €
	Costs	1996.25 €	1198.37 €	1300.67 €	1268.21 €	1342.82 €	
	I/C	1.04	**1.86**	**2.70**	**2.57**	**2.75**	

Note: In bold ratios of I/C higher than 1.2.

complexity of the logistics procedures can be an issue when implementing the whole digitalization solution; complexity that is mainly related to the Info-reading and Tracking & Tracing modules when handling many packages or many shipments in one transport unit.

To sum up, in the majority of cases, the implementation of the new digitalization tool in transport loading and unloading companies, handling dangerous goods, will provide benefits in terms of economic revenues and added value services, so the solution has a very good potential and would have a good acceptance in the market.

It should be noted that results obtained have some conditions or limitations, the main issues being (i) the fact that for the analysis of the adoption of a new theoretical tool by the market, historical data is gathered, which could change in the future, (ii) the expected quantitative advantages of using the new tool are estimations (see Table 4), and (iii) the calculation of the NPV has some limitations which introduces some imprecise information and therefore uncertainty. Some authors have analyzed NPV calculation limitations. Žižlavský[46] reviewed the advantages and weak points of the NPV. It was highlighted in the study, as one of the advantages of the NPV, that it allows the association of cash to each opportunity. On the other hand, some of the most important limitations, highlighted by different scholars, refer to the calculation of the discount rate and the difficulty to define cash flows in the long term. This is an issue that we have also experienced when calculating the NPV. Some authors have indicated that the discount rate of innovative projects should have two components, a risk free rate, which is mainly referred to as a short-term interest rate, and a risk-premium rate that considers financial, technical and commercial perceived risks of the new project or product.[46,71] To solve this, some modifications to the NPV have been developed, such as the risk-adjusted net present value (rNPV) variant and the certainty equivalent NPV, or the stochastic NPV.[72,73] The rNPV tries to assess the value of a technology when revenue, risk, cost, and time are all considered. It is based on the assumption that the discount rate should be adjusted to consider, explicitly, the aforementioned two basic elements: the risk-free rate and the project specific risk premium.[72,74] The certainty equivalent NPV adjusts future cash flows generated by the project, taking into account their risk, through introducing a coefficient α, ranging from 0 to 1.[72,74] On the other hand, the stochastic NPV goes further in considering each component of cash flow as a stochastic variable, with a given distribution of probability (usually a normal distribution), a mean value, and a variance.[75] In addition, when there are uncertainties in the costs and benefits of the assessed project (but not stochastic), some authors have elaborated different algorithms that include fuzzy numbers, this being called fuzzy NPV.[76–79]

The aim of the proposed methodology is to keep calculations as simple as possible so that it can be easily understood by both ICT developers and final users, such that they can easily see the benefits, for their company, of the implementation of innovations. It is not possible to eliminate uncertainties at the initial stages of product development, but they can be reduced to the minimum if efforts are made to obtain as much accurate information as possible and if the presence of some uncertainties are recognized when our assessments are being developed. The NPV calculation could be further adjusted to include risks and probabilities (e.g., using rNPV, stochastic NPV, fuzzy NPV, or certainty equivalent NPV). However, factors such as project-specific risk are difficult to estimate. A safety coefficient for unforeseen risks could be considered. We would also suggest performing iterations and recalculating the values obtained during the development process, and gathering as much precise information as possible from the prospective of the future users so that more accurate results can be obtained and uncertainties reduced.

5. Conclusions and Further Developments

The overall level of market acceptance of new digitalization solutions is low. There are different factors or barriers that make companies not implement them. Several studies have shown that important barriers in achieving a good market acceptance of a new product are on the one hand, uncertainty about timely returns on investment, and on the other hand, a lack of methods for the identification and analysis of potential benefits in terms of costs and intangible benefits.[6,7,21] It is clear that, if the benefits of a new digitalization technology, and its service or processes, are not sure for a company, then it is not worthwhile making the change.

ICT design and development methodologies do not usually consider financial factors as a return on investment or cost opportunity of the new digitalization solution when it is launched in the market. Innovation change, and then the implementation and good acceptance of a new product in the market, can only be achieved if there is a strong market need and the new solution or technology gives an answer to that need, and if the cost of implementation is feasible.

Within this paper, a new quantitative decision-making methodology for the *ex-ante* estimation of the market potential of new digitalization solutions has been introduced. This new methodology includes an initial step, using the Volere methodology and if this evaluation is positive, then the financial feasibility is evaluated, calculating the anticipated profitability of the ICT adoption. An incomes and costs ratio has been considered as the minimum value for change to occur. A safety margin could be included when evaluating the incomes and costs ratio to allow for issues that cannot be taken into account when the development process is in its early stages.

The proposed decision-making methodology was applied to a new digitalization solution for the management of the transport of dangerous goods. Evaluation using Volere showed that the proposed solution will be useful for the end users, giving added value and additional services to potential users. In addition, the financial feasibility, estimated by the NPV calculation, indicated that the implementation of the new digitalization tool in transport, and loading and unloading companies, handling dangerous goods, will give economic benefits. Therefore, since the solution has been evaluated positively by the final users, and the NPV gives enough benefits (incomes is 1.2 times higher than the costs), then the solution has very good potential and would have a good appeal in the market. As a further step after Volere and NPV analysis, the tool was designed through two co-creation sessions with a small and a big company, which helped in the further definition of each of the modules and the identification of improvements. For example, one of the companies was quite interested in facilitating the introduction of data into the system by getting the information directly from the ERP (Enterprise Resource Planning) system of the company.

It must be acknowledged that this methodology has some limitations. (1) A poor presentation of the new product to stakeholders could produce deviations in the Volere assessment and therefore lead to an erroneous assessment. (2) the calculation of the NPV includes some uncertainties: the assumption of a discount rate and unforeseen variables in the costs algorithm would lead to errors (e.g., to the development of an ICT tool that will not be economically beneficial, or to not developing a tool that will be beneficial), and the data used to evaluate the future, the acceptance of a new tool, is based on the historical data of the companies, which can change from one company to another and also over the time. And (3) if there is any modification in the prototype it should be done an iteration and repeat the whole process. To reduce the uncertainties and possible errors it is very important to be rigorous in the definition of the modules and the financial variables to consider and evaluate the tool.

Further studies should measure the power of this methodology by comparing the implementation level of two different prototypes designed for the same function and with different Volere and NPV scorings. In addition, this model can be further improved by including fuzziness in Volere and NPV calculations. A comparison between the methodology defined here with other methods for the development of the same tool could help in the identification of weaknesses and strengths. In addition, expertise or importance of some experts in the decision-making process may be different, considering a factor to give higher relevance or importance to those experts with a higher influence on the decision-making process (e.g., manager and/or a CEO) would be a further improvement of the proposed methodology. Other aspects to refine the method is the inclusion of interest rate uncertainty. Finally, this methodology can be complementary to other methods used in ICT development such as co-creation.

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Appendix A

Table A.1. Volere template for the Info-reading and tracking and tracing module.

Name	Info-reading + tracking & tracing module
Description	It consists in the use of codes or labels that could be scanned through informatics apps developed for mobile devices. T&T allows the geolocation of dangerous goods and their monitoring.
Customer satisfaction	Degree of happiness if this requirement is successfully implemented (Scale from 1 = uninterested to 5 = extremely pleased)
Customer dissatisfaction	Degree of unhappiness if this requirement is not implemented (Scale from 1 = hardly matters to 5 = extremely displeased)
Priority	The requirement is ranked according to the customer value (Scale from 1 = low priority to 5 = high priority)
Difficulty	Level of difficulty for requirement implementation (estimation) (Scale from 1 = low difficulty to 5 = high difficulty)

Table A.2. Volere template for the safety & security module.

Name	Safety & security module
Description	It provides all the agents involved in the supply chain with all technical, regulatory and specific legal information for the transport of dangerous goods.
Customer satisfaction	Degree of happiness if this requirement is successfully implemented (Scale from 1 = uninterested to 5 = extremely pleased)
Customer dissatisfaction	Degree of unhappiness if this requirement is not implemented (Scale from 1 = hardly matters to 5 = extremely displeased)
Priority	The requirement is ranked according to the customer value (Scale from 1 = low priority to 5 = high priority)
Difficulty	Level of difficulty for requirement implementation (estimation) (Scale from 1 = low difficulty to 5 = high difficulty)

Table A.3. Volere template for the Low-risk module.

Name	Low risk route module
Description	It allows the calculation of the most secure routes for the transport of dangerous goods depending on their type. Re-routing could also be considered
Customer satisfaction	Degree of happiness if this requirement is successfully implemented (Scale from 1 = uninterested to 5 = extremely pleased)
Customer dissatisfaction	Degree of unhappiness if this requirement is not implemented (Scale from 1 = hardly matters to 5 = extremely displeased)
Priority	The requirement is ranked according to the customer value (Scale from 1 = low priority to 5 = high priority)
Difficulty	Level of difficulty for requirement implementation (estimation) (Scale from 1 = low difficulty to 5 = high difficulty)

Table A.4. Results of Volere methodology: scores of the experts and overall score for the gADGeTs tool for each expert.

Volere concept	Description	Expert 1 Score	Expert 2 Score	Expert 3 Score	Expert 4 Score	Expert 5 Score	Expert 6 Score
Module 1: Info-reading + tracking & tracing							
Customer satisfaction	Degree of happiness if this requirement is successfully implemented	4	3	5	3	3	5
Customer dissatisfaction	Degree of unhappiness if this requirement is not implemented	3	3	5	1	3	4
Priority	The requirement is ranked according to the customer value	3	3	5	3	1	4
Difficulty	Level of difficulty of the implementation	3	2	1	1	3	2
Module 2: Safety & security							
Customer satisfaction	Degree of happiness if this requirement is successfully implemented	5	4	4	5	5	4
Customer dissatisfaction	Degree of unhappiness if this requirement is not implemented	5	3	4	3	5	3
Priority	The requirement is ranked according to the customer value	4	4	4	4	5	2
Difficulty	Level of difficulty of the implementation	5	5	4	5	4	5
Module 3: Low risk route							
Customer satisfaction	Degree of happiness if this requirement is successfully implemented	3	5	3	3	5	3
Customer dissatisfaction	Degree of unhappiness if this requirement is not implemented	3	4	2	2	5	3
Priority	The requirement is ranked according to the customer value	3	4	2	3	3	3
Difficulty	Level of difficulty of the implementation	2	2	2	2	2	1
Average (SD)		3.58 (0.99)	3.5 (1.00)	3.42 (1.38)	2.92 (1.31)	3.67 (1.37)	3.25 (1.21)

Note: Reverse values of the "Difficulty" concept of tables A1 to A3 are indicated, i.e., 1 for a high difficulty of implementation and 5 for a low difficulty, in order to calculate the Volere indicator V

Table A.5. Trimestral data of company 1 from 2012 to 2016.

Variables NPV, unit	2012				2013				2014				2015				2016			
	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
Cost of the costs incurred in fines by the company (c_{F_t}), €	0	0	300	0	100	0	0	0	1302	0	0	0	300	200	0	0	100	250	0	100
Number of accidents (n_{A_t})	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Average cost produced per accident due to repairs, etc. (c_{A_t}), *€/accident*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of shipments (n_{Sh_t})	1331	2035	1119	1107	1137	1431	940	815	1123	1672	1190	1048	1349	2059	1241	1010	1432	1677	947	668
Number of "bad deliveries" (e.g., due to accidents, incidents and returns due to transport mistakes) (n_{BD_t})	1,60	2,44	1,34	1,33	1,36	1,72	1,13	0,98	1,35	2,01	1,43	1,26	1,62	2,47	1,49	1,21	1,72	2,01	1,14	0,80
Average time used for a shipment ($\overline{t_{Sh_t}}$), *h/shipment*	0,42	0,42	0,42	0,42	0,42	0,44	0,44	0,44	0,44	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,46	0,46	0,46	0,46

Table A.5. (*Continued*)

Variables NPV, unit	2012				2013				2014				2015				2016			
	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
Average cost of the people involved in the preparation of the DG shipment ($\overline{c_P}_t$€/h	10,93	10,93	10,93	10,93	10,96	10,96	10,96	10,96	10,98	10,98	10,98	10,98	11,03	11,03	11,03	11,03	11,13	11,13	11,12	11,12
Number of people trained = number of people working with DG (n_{PT_t})	4,18	4,2	4,1	4,2	4,2	4,1	4,2	4,3	4,1	4,2	4,1	4,1	4,2	4,2	4,3	4,2	4,2	4,1	4,2	4,2
Duration of the training (t_{T_t}), h	5,00	35	144	0	0	54	136	0	16	35	160	0	0	70	168	27	54	24	176	0
Number of computers where the tool will be working (n_{Comp})	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Average cost of ICT personal of the company ($\overline{c_{P\_ICT_t}}$), €/h	7,75	7,75	7,75	7,75	7,85	7,85	7,85	7,85	7,85	7,85	7,85	7,85	7,92	7,92	7,92	7,92	8,02	8,02	8,02	8,02
Average number of parcels per shipment ($\overline{n_{Par_t}}$)	55	42	53	72	59	59	71	117	73	75	90	81	119	122	123	161	135	121	71	115

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