Multi-criteria evaluation method for freight logistics innovations

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Antti Permala[1] ✉, Karri Rantasila[1], Markus Porthin[1], Ville Hinkka[1], Jenni Eckhardt[2], Jacques Leonardi[3]

[1]*Technical Research Centre of Finland, Vuorimiehentie 3, 02150 Espoo, Finland*
[2]*Technical Research Centre of Finland, Kaitoväylä 1, 90571 Oulu, Finland*
[3]*University of Westminster, 35 Marylebone Road, London NW1 5LS, United Kingdom*
✉ *E-mail: antti.permala@vtt.fi*

Abstract: The objective of this study is to build up a common approach for the assessment of logistics innovations. Innovations are referred to here as best practices and are considered as existing approaches or solutions providing an answer to a relevant problem or challenge in freight transport. The impact evaluation of logistics innovations takes into account strategic targets, topics covered, transferability and novelty of the best practices. A freight specific multi-criteria analysis approach was designed for the evaluation process.

1 Introduction

The minimisation of inventory and assisting the rapid flow of goods through the supply chain are the key elements in achieving cost efficiency and responsiveness in a volatile business environment [1]. Moreover distribution affects the overall profitability of a firm, because logistics and transport impact directly on both the supply chain cost and the customer experience [2]. The use of technology as an enabler for improved logistics services is increasing remarkably. The importance of environmental issues is also on the rise because of political and image issues.

As a result, sustainable and efficient freight solutions are being pursued and several operators and stakeholders are announcing reports on their innovations and best practices in freight logistics across Europe. Best practice is considered here as an existing approach or solution (industrial business cases, measures, administrative procedures and research results) providing an answer to a relevant problem or challenge in freight transport. However, their comparison and rational assessment pose a number of challenges, as different stakeholders have their own criteria for determining what they consider innovative best practice. There is a lack of standardised assessment methodologies throughout various industrial sectors.

The objective of this paper is to build up a systematic process for the assessment of logistics innovations and their transferability to other operating environments. A comprehensive method is striven for which is transparent and easy to use and understand. The methodology is addressed to European transport policy makers to add an important dimension for understanding the role of freight logistics within European transport policy. Moreover companies can use the approach to assess and compare different innovations and their suitability for their own use.

There are two aspects to the evaluation. The first is innovation case selection; the second is assessment of the impacts of selected cases. In this paper, evaluation criteria and indicators are developed for best practice impact analysis. The approach is based on findings in related literature and previous EU projects on freight transport best practice such as PROMIT, BESTUFS and SUGAR [3, 4]. The wider on-going international debate on evaluation of trials in freight transport and logistics also inspired this paper [5].

The impact analysis should show where the innovation is most usable or appropriate. The assessment should also show the type of problem and the circumstances in which the results are most useful. The assessment methodology should be usable for all types of logistics and freight transport best practice contributions, such as innovative technology trials, industrial systems, case studies and policy schemes.

The remainder of the paper is structured as follows: the main features of different impact assessment methodologies are discussed in Section 2 'Overview of impact assessment methodologies'. Section 3 'Evaluation method for freight logistics innovations' describes the developed multi-criteria evaluation method and example results and the paper closes with the Section 4 'Conclusions'.

2 Overview of impact assessment methodologies

The rigour of evaluation methods applied depends on the user group. Practitioners often use informal evaluation or simplified formal methods. The guidelines approach includes a simplified cost/benefit analysis. Researchers use comprehensive and sophisticated methods including multi-criteria analysis (MCA), which requires more extensive information collection (Fig. 1). An evaluation method cannot unambiguously determine the best solution without input on the preferences of the decision maker. However, it can provide information and aid in the decision-making processes [6].

2.1 Cost-benefit analysis (CBA)

The European Commission (EC) guide to CBA [7] offers to EU officials, external consultants and other parties a common agenda for the evaluation process. CBA of investment projects is explicitly required by the new EU Regulations for structural funds, cohesion fund and instrument for pre-accession countries, for projects with a budget higher than, 50, 10 and 5 Million Euro, respectively. The main limitation for the use of CBA in logistics solutions evaluation is the lack of willingness of many managers to share data on costs of technology trials. Therefore other evaluation methods are needed.

2.2 Multi-criteria analysis

MCA is a broad term for different methods for analysing available options taking multiple criteria into account. Dodgson [8] refers to MCA as 'approaches that make the options and their contribution

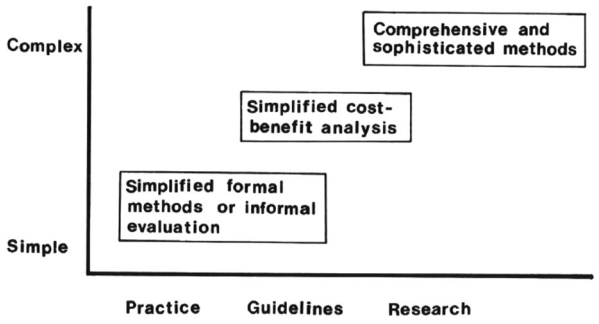

Fig. 1 *Practice, guidelines and research in evaluation [6]*

to the different criteria explicit, and require the exercise of judgement,' noting further that 'they differ in how they combine the data.' MCA techniques can be used to identify the most preferred option, to rank options, to short-list a limited number of options for subsequent detailed appraisal, or simply to distinguish acceptable and unacceptable possibilities.

MCA methods for situations with either an infinite or discrete number of options range from informal ones only listing the characteristics of each option to sophisticated methods such as multi-criteria optimisation, goal programming, outranking methods and multi-attribute value theory (MAVT) [9]. In MAVT [10] each decision alternative is assigned a value $v_i(x_i)$ for each attribute x_i according to the preferences of the decision-maker. The alternatives are given values from 0 for the least desirable to 1 for the most desirable alternative with regard to each attribute. The attribute-specific values are then combined using a value function to represent the overall value of the alternative. MAVT using an additive value function

$$V(x_1, x_2, \ldots, x_n) = \sum_{i=1}^{n} w_i v_i(x_i)$$

$$w_i \in [0, 1], \quad \sum_{i=1}^{n} w_i = 1, \quad v_i(x_i) \in [0, 1] \forall i$$

is referred to as value tree analysis (VTA) [10]. The weights w_i of the attributes x_i indicate a subjective trade-off between attributes, that is, how significant the decision-maker considers a change from the worst to the best level of that attribute relative to a similar change in another attribute. An additive value function exists if, and only if, the attributes are mutually preferentially independent [11], that is, preference statements regarding one attribute are independent of the values of the others. The analytic hierarchy process [12] (AHP) is an application of VTA, where scoring is based on pairwise comparison of alternatives and sub-objectives. While the pairwise comparisons are straightforward and convenient, the number of required comparisons easily become overwhelming in any real case model. AHP suffers also from logical inconsistencies such as rank reversal [13].

One limitation of the VTA method in the context of logistics solution evaluation is that it does not allow an in-depth understanding of causes and effects. Especially when it comes to understanding how a managerial decision led to investments in new technologies, it is necessary to know why this decision was taken. Another limitation is that it does not provide help for quantitative measurements on the scale and magnitude of the impacts. Therefore other methods are also needed.

2.3 Before-after studies

Before-after analysis is also used for impact assessment. The logic of a before-after study is relatively simple: 'before' refers to a measurement being made on the existing logistics activities before an intervention is introduced, and 'after' refers to a measurement being made after its introduction. The before-after design offers evidence about intervention effectiveness and is most useful in demonstrating the immediate impacts of short-term programs. This is because over the longer term, more circumstances can arise that may obscure the effects of an intervention.

Many urban freight cases have been evaluated using the before-after approach. In the case of a last mile logistics business in London, a study was used that describes how urban consolidation centres are effective in reducing freight traffic and its environmental impacts in towns and cities. The results show that the total distance travelled and the CO2 emissions per parcel delivered fell by 20% and 54%, respectively, as a result of this delivery system [14].

One of the limitations of before–after studies is that the original data collection effort of the 'before' situation must be repeated identically in the 'after' phase, which may suffer from bias through managerial decisions and changes in businesses or clients. This method is therefore not appropriate for evaluating any sort of logistics innovation. However, one of the great strengths of this method is that it provides very robust quantitative data on the economic, traffic, environmental and other external impacts of a solution. Some projects close to freight logistics have thus taken up this evaluation approach and integrated it into their framework; one of them is the EC project SMARTFUSION on the evaluation of electric vehicle trials and IT device development and testing for last mile distribution [15].

2.4 Policy impact assessment

The EC has established a thorough approach to monitoring impact assessment and performance indicators attached to the white paper on transport [16]. The assessment criteria and performance indicators reflect the three elements of sustainability: economic, social and environmental impacts. Even more general but comprehensive instructions for policy impact assessment across various sectors can be found in the EC impact assessment guidelines [17].

The city-vitality-sustainability or cleaner and better transport in cities (CIVITAS) initiative was launched in 2002 to support cities in introducing transport measures and policies towards sustainable urban mobility. During the several phases of the CIVITAS initiative, numerous research and demonstration projects were carried out in cities across Europe. As part of the research, a transferability algorithm was developed to facilitate a successfully implemented transportation measure or package of measures to be transferred to other cities [18].

2.5 Impact assessment in EC projects

The following EC-funded projects have performed impact evaluations: PROMIT, BESTUFS, SUGAR, NICHES, INNOSUTRA, SUPER GREEN, POSMETRANS and STRAIGHTSOL. The main aspects have been to analyse and compare the solution outcomes with a set of target criteria at business and policy level, impact areas and success and failures. The focus has also been on transferability of best practices and how to make recommendations. Some projects such as SUGAR, NICHES and TURBLOG propose similar approaches to transferability (Table 1).

Previous projects show that the main criteria in impact evaluations have related to the economy, society and the environment and that these criteria have been used for strategic target evaluation in the developed methodology.

3 Evaluation method for freight logistics innovations

3.1 Case selection principles

The logistics innovations considered in this paper are cases provided by different stakeholders. Here, the best practice is defined as an

Table 1 Methodological input from previous best practice projects

Project	Impact evaluation	Transferability
PROMIT	Degree of fulfilment of defined requirements. Benchmark criteria.	N/A
BESTUFS	Considerable and measurable positive effects (qualitative and quantitative) on relevant indicators. Positive and negative impacts.	N/A
SUGAR	Key performance indicators (KPI) at policy level	Good practice sites, transfer sites. Four transfer tools developed. Action plans.
NICHES	Defined impact areas	Move most promising concepts 'niche' position to a 'mainstream' urban transport policy application
TURBLOG	N/A	Worldwide view CIVITAS 10 step transferability algorithm
INNOSUTRA	Commercial innovations and public policy initiatives. Success and failure. Systems analysis framework	N/A
FREIGHTVISION	N/A	N/A
ENABLE	N/A	Analysis of situation and problems in target, mapping challenges and needs
SUPERGREEN	KPIs grouped into five main categories	N/A
POSMETRANS	Criteria for policy schemes, innovative technologies, key players	N/A
STRAIGHTSOL	Multi-criteria decision analysis applied	N/A

innovative and feasible approach beyond the common practice. Innovations include products, processes, services, technologies or ideas that are more effective than previous ones and are accepted by markets, governments and society. To find potential best practice cases in logistics the case study methodology is used. A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-time context, especially when the boundaries between the phenomenon and context are not evident [19]. When the purpose of the case study is to develop a theory, not to test it, the researchers can select the most suitable cases for the study and not worry whether the cases should be a representative of some population [20]. Therefore this paper employs the most developed solutions in Europe as the cases, the selection of which is the result of a comprehensive process.

The focus of the study has been urban freight transport, green logistics, co-modality and e-Freight. These topics were chosen as they represent the most pressing issues in freight transport and logistics in terms of economic, social and environmental sustainability, as well as being closely linked to important innovations and developments in freight service provision to meet the needs of European economies, and finally because they are at the core of the EC freight transport logistics action plan from 2007 [21].

19 institutions in ten European countries searched for and identified a series of cases that fulfilled a minimum specification. The cases should have a positive response to the elementary questions: Is it an innovation? Is it targeting both private benefits and public policy objectives and is the information publicly available? In total 272 cases from the year 2012 were submitted by the project partners. Thus it was necessary to narrow down the selection. This was done by further analysing the identified cases using four pre-assessment criteria [22]

- *Innovative character and feasibility:* The solution should be innovative and include more effective products, processes, services, technologies or ideas that are accepted by markets, governments and society. Both the level of innovation and feasibility of a practice are taken into account.
- *Impact/effects:* The solution should have a positive strategic impact on business and/or policy targets.
- *Accessibility of information:* A minimum of accessible information is needed for consideration. This information has to allow an assessment and evaluation of the case.
- *Transferability of best practice cases:* Transferability of cases to other domains, situations, framework conditions or business structures has to be secured. At least a partial implementation with certain (necessary) adjustments should be possible outside of the originating environment.

Transferability refers to how applicable the best practice in question is in restructuring transport system and logistics chains in other application areas. This might mean introducing new business models, service concepts and operational principles. Information technology might be used in connecting operations to logistics networks. Moreover the time horizon has an impact on transferability. This approach to transferability is in line with the ten-step transferability algorithm developed as part of CIVITAS to facilitate measures to be transferred to other cities. The hypothesis is that if measures have been successfully implemented within a given geographical, demographic, socio-economic, cultural, technological, institutional and organisational setting, then comparable results in terms of the degree of attainment of the measures' objectives can be achieved in areas characterised by a similar setting [18].

After the analysis, 50 cases were named as best practices or evolving best practices. The selection of urban freight cases are analysed in detail in the paper by Leonardi *et al.* [22].

The next step after the pre-assessment consisted of material and information collection for the selected 50 cases. A standardised collection format was developed. To advance the level of knowledge of all selected cases, a thorough information collection and basic segmentation is necessary within the format. The required information was retrieved through desk research and contact with the developers of a solution.

3.2 Impact evaluation

The guideline for the methodology development has been, while comprehensive, to keep it both relatively easy to understand and transparent. The objective of the evaluation methodology is to show where the case is most usable or appropriate. The analysis should further address the type of problem and the circumstances in which the results are most useful. The advantage of using one common tool for all cases is that it helps to harmonise the results and meets the demand for a simplified approach.

For the impact assessment of the logistics innovations, a common approach based primarily on MCA was developed. Cost-benefit and policy analyses were also employed. Evaluation criteria and indicators were selected and created for the best practice impact analysis. VTA was chosen as the main approach for the case evaluations, as it offers a standardised way to take multiple aspects into account and make their impacts commensurable. For the reasons discussed above, the available case data are not equally well suited to other assessment methodologies. Achievement of strategic targets, topics covered by the best practice and transferability to other domains were selected as the main evaluation criteria as outlined in Fig. 2.

It should be noted that the assumption in VTA of mutually preferential independency may not hold to all extents, for example, the value of transferability of a case may depend on how well the strategic targets are achieved. However, the additive value function used in VTA is still judged to be a reasonable approximation. It could be possible to restructure the value tree to avoid preferential dependencies, but this would make the structure of the model more complex and was thus omitted. In addition, the primary aim of the developed methodology is not to compare the cases with

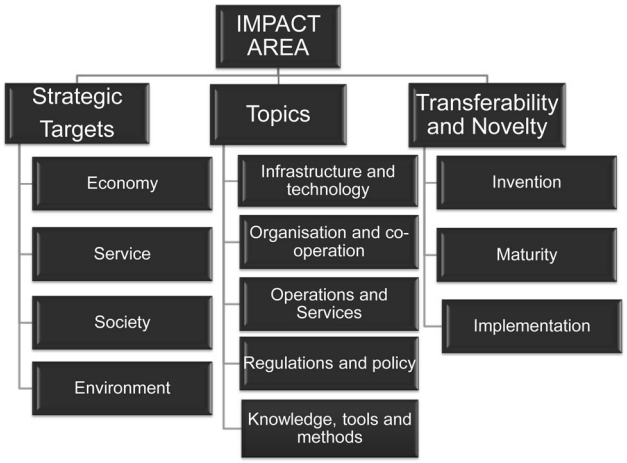

Fig. 2 *Impact evaluation value tree*

each other, but to find cases that support desirable targets, to find covered topics with new innovations and approaches and assess the transferability of each case.

The main evaluation criteria were further defined through an enquiry completed by consultation with a group of experts [23]. The strategic targets were grouped into the sub-categories economy, service, society and environment. The topics covered by a case were grouped into infrastructure and technology, organisation and co-operation, operations and services, regulations and policy and knowledge, tools and methods (Table 2). Transferability and novelty were assessed based on the sub-categories invention, maturity and implementation as outlined in Fig. 2.

For each sub-category a set of attributes, here called impacts, were defined to measure the performance of the case with regard to the sub-category (see Tables 2 and 3). Instead of using the standard 0 to 1 scale for the impacts, as usually done in VTA, a −2 to +2 scale was used to highlight that both positive and unfavourable impacts are taken into account

(2) High positive impact
(1) Slight positive impact
(0) No impact or no available information
(−1) Slight unfavourable impact
(−2) High unfavourable impact

For each impact type belonging to strategic targets and transferability and novelty, evaluation guidelines were developed to standardise the evaluations and minimise the effect of subjective views of the evaluators (see Table 3).

The overall value of a best practice was calculated following the VTA principles using an additive value function. The weighting of the sub-criteria and impacts was done in a hierarchical manner. Each sub-criterion belonging to same main criterion was given equal weight, as was each impact type under a sub-criterion. However, the selection of weights was seen to be less essential in this application, since the main objective of the analysis was to highlight the favourable and unfavourable impacts of each case.

The assessment of a best practice was done using a three-step process as shown in Fig. 3. In the first step, an expert evaluator reads the full version of the case description and assigns a score (−2 to +2) to each impact type on an evaluation spreadsheet. All numerical judgements are accompanied by a written justification noted down in the evaluation table. The evaluations rely only on the written case description. Impact types for which no information is found receive an impact score of 0. Targets, topics and transferability issues are evaluated. Most cases deal only with some issues listed as evaluation criteria. After the first evaluation, a second evaluator together with the first one goes through all the issues to gain a mutual understanding and change the evaluation if needed. Next, the evaluations are again reviewed by other partners involved in the process, in the framework of a separate working group and a workshop, in order to confirm the results. The second evaluation round caused some considerations of the evaluation results and further corrections; the third round led to only a few more.

Next to the evaluation each innovation was described briefly, showing which gap or need the solution fills and the evaluated impacts on economics, service and the environment (see Table 4).

The results of the evaluation show the main impacts of each current best practice case, its main contribution compared with other cases, strategic targets and topics where the case has beneficial or unfavourable impacts, and its transferability. The analysis further addresses the type of problem and the circumstances in which the results are most useful. The assessment methodology can be applied to different types of best practices, such as case studies and policy schemes.

Table 2 Topics covered

Infrastructure and technology
Access to transport networks, infrastructure and nodes
Freight consolidation and transhipment
Implementation of low emission technologies
IT-technologies and solutions (for management and administration)
Innovative vehicles, vessels and equipment
ICT (e.g. routing and guidance), transport optimisation
Organisation and cooperation
Business to business solutions, cooperation
Competitive aspects: collaboration (cooperation with competitors), prioritisation (priorities on infrastructure and in nodes)
Communication between authorities: cooperation, procedures, legal frameworks
Communication between businesses and authorities: coordination, consultation
Business models: new form of ownership, risk management
Operations and services
Business to customer (B2C) solutions (e.g. e-commerce and last mile delivery)
Innovative operational solutions
Value added services, development (or extension) of services
Service quality and sustainability agreements/certification
Transport management, fleet management
Regulations and policy
Access rules and restrictions of urban areas
Land use and spatial planning: assessment and siting of transport facilities and infrastructure
Infrastructure financing: taxation, user charges, PPP
Environmental standards and policy
Interoperability and standardisation: vehicles, equipment, loading units, infrastructure
Safety and security: measures, regulations, insurance
Knowledge, tools and methods
Modelling and forecasting
Data collection and statistics
Education and training
Working and implementation guidelines
Monitoring and benchmarking of processes

3.3 Example of results – Case TIEKE

The TIEKE (Finnish Information Society Development Centre) Verkottaja Service is an internet based service that assists business and public sector organisations in developing their data communication methods and practices to exchange business documents (messages) electronically with their partners. With the Verkottaja Service guidelines, companies can take the leap from paper based business communication to electronic exchange of documents. The resulting timeliness and precision of communication improves their competitiveness in the market. The innovation of the service is to activate companies in the transport and logistics sector and in other business sectors to implement standard based electronic data exchange as part of their daily business practice. The data exchange standards used are UN/EDIFACT and UBL/XML.

Table 3 Evaluation guidelines for impact types belonging to strategic targets and transferability and novelty

High level criteria/sub-criteria/impact attributes/assessment values in scale +2–−2 Strategic Targets			
Economic issues		Distribution impacts	2: Smooths the distribution of total output, income or wealth among individuals or among the factors of production (such as labour, land and capital). 1: Smooths the distribution on at least in one subcategory
Efficiency and productivity in logistic processes, transport service (incl. costs)	2: Significant e improvement in efficiency regarding time and resources, for example, accelerates the movement of goods, shortens lead times, enables better planning of vehicles/other assets and personnel, automation 1: Minor improvement, for example, optimisation of routes and processes, IT system for tracking and tracing, avoids highway congestion, fast transhipment, reduction of 'empty kilometres', simplified processes	Employment level and conditions	2: Significant creation of new permanent jobs 1: Some new jobs created
New business	2: Has created (and will create) new business activities and opportunities 1: May open new business opportunities or enables new markets to be developed	Environmental issues	
Availability of funding/Reduced financial risks	2: Investors commercial money available for investments or operation 1: R&D funding available, subsidies/loans for investments or operation	Green technology	2: Introduction of technology with significantly less emissions and noise (e.g. eVehicles) 1: Introduction of technology with slightly less emissions and noise
Economic growth/Transport activity	2: Expandable business opportunities with measurable indicators 1: Growth of existing business or on project level	Emissions (Incl noise)	2: Zero emissions and/or noise locally and on system level in addition to technology, for example, full modal shift to environmental friendly mode 1: Clearly less emissions and/or noise
Modal shift	2: Total modal shift to rail or waterways 1: Partial sustained shift to rail or waterways, from diesel vans to electric vehicles, from cars to bikes	Use of resources (energy)	2: Use of renewable energy only or significant load factor improvement 1: Use of electricity instead of fuel, energy-efficient transport mode, load factor improvement
Reduction of administrative burden	2: Reduction in administration/reduced administrative tasks and steps, for example, facilitation in authority authorisation or reporting, improved processes and IT/electronic messaging supporting 1: Reduction in administration; at least in one of the topics above	Climate change (GHG)	2: Greenhouse gas (CO_2e) significant decrease 1: Greenhouse gas (CO_2e) partial decrease
Service issues		Transferability and novelty	
Competitiveness	2: Price and quality/service level success against rivals or not offered by the competition 1: Price or quality/service level success against rivals	Invention	
Quality (Incl strikes, weather)	2: Two or more factors improving quality, for example, improved reliability (data or transportation), increased punctuality, improved booking or other IT system, electronically transferred information (less mistakes), improved data quality, improved access to data 1: One factor improving quality	The case has an innovative character	2: Use of new technology or existing technology used for a new purpose/ new application or new service concept; more effective products, processes, services, for example, new horizontal collaboration 1: Utilisation of technology that has been introduced relatively recently, new application: for example, new horizontal transhipment system, first dual fuel vessel in Europe, diverse intermodal corridor development, combining different actors to the same system.
Image	2: Two or more factors improving image, for example, sustainability, modern, innovative, development oriented 1: One factor improving image	The case is feasible (economic, political)	2: The case has several characteristics supporting strongly success (e.g. efficient, low cost, easily transferrable, environmentally friendly) and no remarkable constraints 1: The case has some characteristics supporting strongly success and no remarkable constraints Note: feasibility is only evaluated for cases that have not yet been implemented in real life
Safety (e.g. to avoid damages)	2: Decreases accidents or damages, for example, LPG solution, computer-assisted safety risk assessment (port, terminal, vehicle etc). Enables faster and easier reaction to unusual events including disruption, pre-notes and better information regarding dangerous goods 1: May prevent accidents or damages or inform about them, for example, improves the following of working time regulation on road, incident and exceptions are identified and reported, more fluid traffic (less stops)	The case contributes standardisation	2: Contribution to official or de facto standards such as ISO, CEN, UBL 1: Contribution to harmonised practice where appropriate
Security (e.g. to avoid thefts)	2: High level surveillance, track and trace available, computer-assisted security risk assessment, fast reaction on unusual/suspicious events 1: Access to guarded parking places, monitoring of some processes, risk assessment procedures in place, reaction to unusual/suspicious events	Maturity	
Access to services	2: Several / alternative /open services available including SMEs 1: Limited number of services available	The case provides clear and measurable positive effects	2: When there are clear and measurable benefits, 1: When benefits are clear but are based on estimates, or model or only some part of benefits are measurable

Relevance to SMEs	2: Service providers or users in growing business 1: Start-up of SME involvement	The case has clear and reliable information and which is widely available and accessible	2: A lot of reliable information can be found (in English), 1: Some information is available in English or other languages
Society issues		The case has been implemented in real life (not a pilot)	2: Implemented in full scale 1: Implemented at least in pilot
Acceptance and influence	2: General business (customer and service provider) and political (EU, nation, local) consensus 1: Acceptance at least of one interest group	The case is scalable	2: Scalable in all aspects including business model, solutions, hard technology, IT 1: Scalable in some aspects
Balanced provision of goods and services	2: No monopoly situation, several providers available including SMEs 1: Only limited number available	Implementation	
Increased amenity value	2: Physical qualities and characteristics of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence and cultural and recreational attributes 1: At least one 'pleasant' aspect available	The case is transferrable to other geographical areas	2: Without any restrictions, 1: Including some restrictions (e.g. weather, type of freight)
Wealth generation (Incl. SMEs)	2: Increases monetary measures (natural, human and physical assets), wellbeing 1: Increases at least one of the assets	The case is transferrable to other industries	2: To several other industries to specific industries
Highest safety and security	2: For example reduces the number of vehicles, lower speed, modal shift from road to rail, less illegal truck parking on lanes, improved security 1: Less mileage because of optimisation, minor reduction in vehicles used, pre-notes and better information regarding dangerous goods, incidents and expectations are informed, more fluid traffic	Case is transferrable to other regulatory systems	2: Can be widely transferred to other regulatory systems 1: Can be transferred to another specific regulatory system (e.g. to Low Emission Zones or systems using specific international standards)

Guidelines are listed only for positive impacts, unfavourable ones are assessed in an analogous manner.

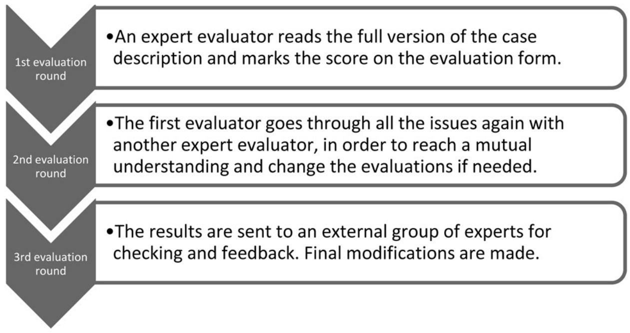

Fig. 3 *Impact assessment process*

Table 4 gives a qualitative evaluation of TIEKE and illustrates the different aspects of the evaluation. Specific gaps in the e-Freight area are partly addressed by this Best Practice solution. Impacts are described and recommendations are derived from the findings on the benefits obtained, such as time savings and high transferability.

Fig. 4 shows the scoring results for TIEKE and other e-freight cases. It is a series of mean impact values obtained from the impact assessment of strategic targets (blue 0.13), topics covered (red 0.19) and transferability and novelty criteria (0.94). The values obtained for targets and topics are quite low, because the area of e-Freight is narrow, compared with all criteria, resulting in many zero impacts in the model. The TIEKE service is available globally and the guidelines are free of charge on the Internet, which explains the high value for transferability.

3.4 Reliability of the proposed method

The proposed method is designed to be fully reproducible and transparent. Evaluation guidelines and peer review procedures are defined in order to minimise the impact of individual subjective views. The sources of the evaluation judgements are traceable because of documented justifications. However, as the evaluations are based solely on case descriptions they are strongly dependent on how in-depth the information is, and on how positive and unfavourable impacts are described. The information collection guidelines require the evaluator to answer all the questions on the form. As cases tend to emphasize positive impacts, the researchers must approach the given information critically. The cases are also at different stages of development; some have been operating over a longer period of time while others are in the pilot phase. Furthermore, some cases are based on highly detailed and very

Table 4 Evaluation results, case TIEKE

Cluster 3 Case ID 3: TIEKE Verkottaja Service
Gap Communication between businesses and also business and administration. Standardised e-documents are needed, also standardised data exchange (EDIFACT and UBL/XML). *Best Practice Solution (In-depth)* The service provides guidelines in Finnish and in a limited extent in English on international standards (UNCEFACT) and their implementation, and recommendations for different business branches. *Impacts/Ex ante evaluation* *Economic*: Standardised information exchange smoothens processes. Significantly reduces paper work and time used for information processing. Administrative processes become more efficient. *Service*: Fewer mistakes as information is transferred electronically. Gives the image of a modern & sustainable organisation. *Environment*: Less use of paper. *Transferability and novelty*: Messaging/standards are international/global, thus the solution is transferable. *Recommendations* *Business*: The implementation of standardised EDI is recommended. Moreover the use of branch-specific standards is recommended. *Policy*: EU should provide guidelines for the use of EDI and work on global interoperability/interfaces of different standards. The e-Freight project provides good basis for this.

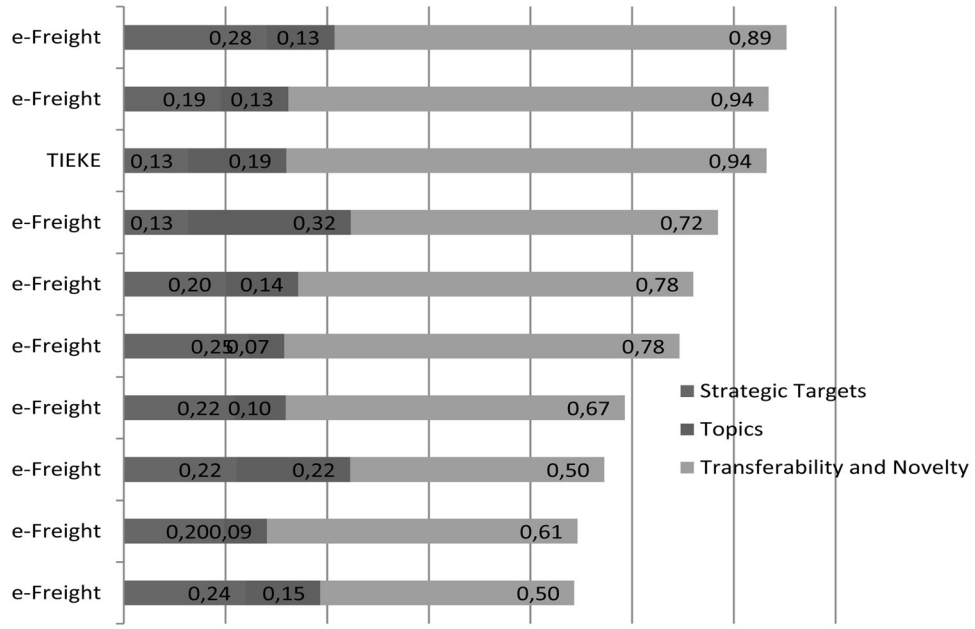

Fig. 4 *Quantitative evaluation results in the e-freight area*
Cases other than TIEKE are shown anonymously

informative in-depth studies, while others may offer only a brief description, complicating the evaluation task. Should the evaluator reach a conclusion that is not directly indicated in the best practice case description, this could easily lead to wrong interpretations. Thus only the issues indicated in the best practice case descriptions are included in the evaluation, even when the descriptions are not complete. Hence the evaluation is mostly indicative and points out the areas that the cases affect. Comparison between different cases based only on the numerical evaluation may be misleading for the reasons described above.

4 Conclusions

This paper presented a generic evaluation method for the impact assessment of logistics innovations and their transferability to other operating environments. The method includes a VTA-based multi-criteria structure and a defined process for information retrieval and assessment of the cases. The main evaluation criteria are strategic targets fulfilled by the innovation, the logistics topics covered, as well as its novelty and transferability to other operating environments. Literature studies and expert panels showed that the main strategic targets of logistics innovations are economy, service and society and environmental issues. The employed VTA approach enabled a balanced consideration of a vast number of specific impact types, accounting for both positive and negative effects, as well as comparison of initiatives with similar focus. The methodology is not limited solely to evaluation of logistics best practise solutions. However, it should be noted that different domains may require customisation of the evaluation criteria.

In this study, 272 potential innovation cases were identified, from which 50 best practices were chosen based on pre-selection criteria. These best practices representing urban freight, green logistics, co-modality and e-freight were evaluated using the developed method revealing their main positive and unfavourable impacts. The results showed that the positive effects were clearly dominating for all the selected best practices. The most promising cases from each cluster were also identified. The impact of the evaluators' individual subjective views on the results was minimised because of the structured evaluation method, evaluation guidelines and peer review procedures. However, the evaluations were based solely on the information available and documented in the case descriptions, which should be remembered when analysing the results.

The method fulfils the current need for an objective evaluation method of logistics best practices. It is applicable for making both business and policy recommendations and can also be used for before-after evaluations and self-assessment by companies. Unlike previous models, this model allows the identification of innovations where good impacts exceed unfavourable ones, lists any unfavourable impacts and pinpoints the targets fulfilled and topics covered by a best practice as well as its transferability.

The evaluation model enables alternative weightings of different sub-criteria in order to emphasise, for example, environmental or economic impacts. This makes it possible to model the views of different decision makers or highlight certain types of cases. However, these possibilities have not yet been taken advantage of in this study, but will be further examined in coming research.

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