Logistics Research (2018) 11:1
DOI_10.23773/2018_1

BVL International
The Global Supply Chain Network

A framework for classifying sustainable logistics innovations

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Received: 23 March 2017 / Accepted: 17 January 2018 / Published online: 30 January 2018

ABSTRACT

Researchers and practitioners alike need support in the challenges to develop sustainable logistics, and one cannot afford to have a limited view of what constitutes sustainable logistics innovation (SLI). In order to inspire researchers and practitioners to expand their mindset when addressing sustainable logistics, the purpose of this paper is to develop a framework for classifying sustainable logistics innovations, and by classifying some SLIs evaluating the applicability of the framework. The study is based on a literature review within logistics innovation, sustainable innovation, and sustainable logistics innovation, resulting in a framework. It contains three areas: softness, extent of change and scope, which in turn contain nine dimensions. Interviews in three retailers acting in Sweden were conducted. SLIs were illustrated and classified in the framework. By moving outside how research so far has studied SLIs, examples of SLIs in logistics activities other than transport were identified, in forms aside from technological solutions, and in industries outside of logistics service providers. It was found that it was possible to classify SLIs in all dimensions, with some difficulties in extent of change in output, which also shows the applicability of the framework. Using the framework, SLIs can be understood in a more concrete and applicable way, which can inspire practitioners to develop and expand their efforts towards sustainable logistics. Therefore the study has implications for research, practice and society. Several suggestions for future research are presented.

KEYWORDS innovation · corporate social sustainability · sustainable logistics · retailers · framework

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1 INTRODUCTION

Logistics plays an important role in the work towards sustainable development [1]. Present logistics systems are contributors to large environmental and social threats. Research on sustainable logistics has grown steadily during the last decade [26], but despite that, the area is limited when it comes to innovative thinking. As present ways of designing and managing logistics system is far from sustainable, new ways of thinking and acting is a prerequisite for sustainable logistics. The important role of innovations in sustainable logistics was indicated in the literature review by Touboulic and Walker [26], however commonly stressing the environmental dimension. However, few studies have related sustainability to innovation in a logistics context [23]. For example, after reviewing 150 Nordic dissertations within logistics and supply chain management, Rajkumar *et al.* [21] conclude that innovation is one of five under-prioritized areas.

The research streams of logistics and innovation have developed somehow isolated [2]. A large value can be found in relating sustainable logistics to innovation into one concept. Some examples of sustainable logistics innovation (SLI) in practice have been found. Rossi *et al.* [22] studied SLIs and gave some brief descriptions on transport innovations within logistics service providers (LSPs), such as rationalization of routes and the replacement of diesel engines with batteries. Logistics innovations also have a focus on LSPs [5]. Wu and Haasis [28] mention the use of energy-saving technologies as one example of logistics innovations. Technical innovation, e.g.

alternative fuels, was the most widespread sustainable innovation in the literature review by Marchet *et al.* [18].

These examples indicate limitations of how SLIs have been presented in the literature so far: stressing the environmental dimension, focusing on LSPs, on technical and less radical forms of innovations. A focus on technological innovations was also found in the logistics innovation literature, together with a focus on less radical innovations (e.g. [5]). Striving towards sustainable logistics, it is problematic if researchers convey a limited view to practitioners of what constitutes an SLI is or where it can be implemented. On a societal level, no one can afford not to address SLIs outside these limitations. Such an expansion is likely to add important insights regarding potential SLIs to be implemented.

When defining sustainable innovation, Klewitz and Hansen [17] included the triple bottom line and stressed that the innovation should be new to the firm. Accepting these assumptions, SLIs should furthermore include logistics. Academic innovation definitions need to better cover many innovation dimensions, in order to make them more concrete and applicable [2]. In order to fully understand SLIs, the dimensions that have to be taken into account can be illustrated in a framework. Few studies have presented frameworks to illustrate sustainable logistics innovations. Two of them [22, 30] are typical examples of the limited view on SLI, focusing on just environmental innovation in just LSPs. A broader view of potential dimensions can be found in the innovation literature, once again stressing the importance of actually relating sustainable logistics to innovation into one concept. An expanded framework illustrating the multidimensional nature of SLIs, implies that a classification of existing SLIs is provided. It can also create consciousness and be an eye-opener for lacking or potential SLIs in practice. Such a framework can improve the less developed conceptualization of logistics innovation (in line with [2]) and lead to a more systematic and covering development of SLIs.

If it is qualifying that innovations are new to the firm, striving to develop sustainable logistics can include both own and other firms' SLIs. In both situations, a multidimensional framework of SLIs, outside the prevailing limitations, can support and add insights to practitioners. An expanded view on SLIs could offer researchers better understanding and a contribution to how to further study or develop SLIs. In order to inspire researchers and practitioners to expand their mindset when addressing sustainable logistics, the purpose of this paper is to develop a framework for classifying sustainable logistics innovations, and evaluating the applicability of the framework.

2 METHODOLOGY

The overall methodologies applied build upon a two-step approach; first a literature review is conducted, second a case study is carried out. The literature review was conducted in the data bases Business Source Premier and Google Scholar, using search terms such as sustainab*, logistic*, innovate* and framework in different combinations. The major search was made in 2016, with a complementary search late in 2017. Most of the articles identified were found usable and thereby included in this article. It was important to go outside the limitations in previous research that stress the environmental sustainability dimension, focus on LSPs and transport, and on technical and less radical forms of innovations. The literature presents few frameworks or classifications to illustrate dimensions of innovations. As the literature on SLI dimensions is limited, this review also includes frameworks identified in sustainable innovation and logistics innovation literature. Existing frameworks sometimes include synonyms and different terms for the same dimension. A content analysis of the identified dimensions was made in order to identify e.g. synonyms and overlaps. A consolidation was then made in order to single out nine distinct dimensions, which represent the least common denominator according to extant literature. Along the literature review, it was noted that some dimensions of SLI should be classified along a scale, whereas others have distinct steps or boxes. By a bottom-up approach, it was then possible to identify three areas in which the dimensions were grouped; softness, extent of change and scope. They were supposed to be distinct areas, which represent the least common denominator according to extant literature. Softness (our concept) is a common theme with many names in literature. Extent of change and scope were suggested e.g. in [2]. In order to provide a comprehensive picture, the framework was also illustrated graphically, see further Figure 1.

As it was important to classify SLIs in practice, the empirical study was central. A first plan was to conduct a multiple-case study [31]. Initial company contacts made it clear that SLIs were seldom described in written material (homepages, sustainability reports) from the companies. Neither was it plausible to conduct observations of the SLIs, which in contrast with earlier research preferably should be less technical (and therefore difficult to observe). Interviews were however found to be the core means of data collection, offering enough depth and detail to make it possible to classify SLIs. In order to expand SLIs and dimensions outside earlier research, it was decided to address retailers. Retailers play an important role in sustainability, are logistics-intensive and are often held responsible for the actions of other supply chain actors e.g. suppliers [29]. Three retailers were addressed, selected as they

were known for having taken several innovative actions to increasing the sustainability of their logistics systems. This is in line with an intensity sampling logic and examples of good practice [20]. Furthermore they were partners in an ongoing research project on sustainable logistics innovation, which implied good access. As many SLIs representing all dimensions were found, these three retailers implied that saturation was perceived. The retailers are large actors on the Swedish market. The selection of respondents, including the sequence in which to individually interview them, were decided by each partner company representative, who was well informed about the purpose of the interviews. An overall picture was given by the first respondent, and the following interviews focused more on specific innovations. The respondents were perceived to be experienced in SLI and showed understanding for the questions during the nine interviews. The respondents in each company are shown in Table 1.

Table 1: Interviewed companies and respondents

Retailer	**Brief description**	**Respondents**
1	B2C, daily groceries	Logistics manager, CSR/sustainability manager, Recycling manager
2	B2B, office supply	Environmental/quality manager, Logistics manager, Transport operation manager, Sales director
3	B2C, non-food	Supply chain manager, Logistics and transportation manager

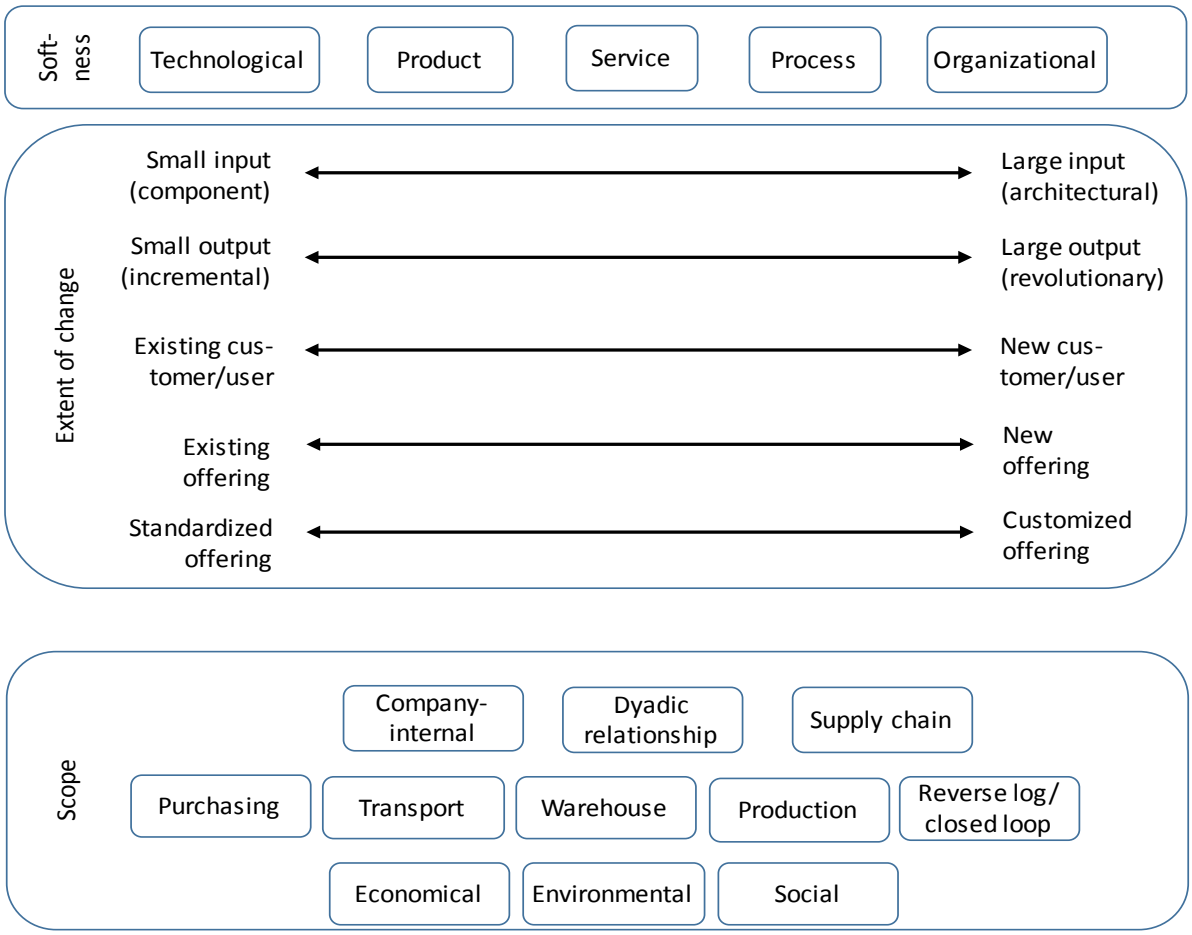
In line with the definition of Arlbjørn *et al.* [2], an innovation is more than a new idea, as it also includes the activities required to commercialize it. It was expected that not all SLIs identified were commercialized, but in order to qualify for this study, they should be implemented at least in a smaller scale. The data collection used an interview guide, based upon the framework to strengthen construct validity [31]. This interview guide was distributed prior to the interview. All interviews were personal, taking place at the premises of each retailer, and lasted between 50 and 90 minutes. They were initiated with each respondent's own description of implemented SLIs. Thereafter each SLI was discussed along the nine dimensions in the framework. Open-ended questions were posed, hence scales or boxes were not mentioned. Thereby empirical input to the framework's scales was expected. By systematically going through the dimensions, respondents could recall more SLIs, which were discussed. Both authors participated in and took notes during the interviews. The two interview note versions were consolidated to ensure inter-rater reliability and sent to each respondent for verification.

In the analysis phase, the verified interview notes from respondents in the same company built up SLI descriptions. The wish was not to capture the total number of SLIs per company or quantify the existence of certain SLIs, therefore the unit of analysis was the different SLIs, not the companies. Due to many SLIs found, those SLIs that were new to the industry and hence more inspiring, and/or displayed interesting classifications along the dimensions, were selected to be presented in detail. The SLIs were classified into the framework by the researchers, using the scales and boxes from the literature review. The experiences from this built up the analysis in chapter 5, where the applicability to classify each dimension in practice was discussed. The reliability of the study was further ensured by documenting coding, decisions, and questions in a study protocol [inspired by 31]. Earlier versions of this paper were sent to respondents for a second verification, and were thereafter discussed during one research and two practitioners' conferences. This resulted in a few changes regarding the empirical descriptions, but not in the framework.

3 LITERATURE REVIEW: DIMENSIONS OF SUSTAINABLE LOGISTICS INNOVATION

This section is structured around three areas of SLI dimensions; softness, extent of change and scope. The included nine dimensions in each area are *italicized* in the text. This is all visualized in Figure 1.

Figure 1: A framework of dimensions to classify SLIs



3.1 Softness

A large variety of different dimensions of innovation, from hard - such as technology and products - to soft - such as processes and organization, has been identified in the literature. This area is labelled softness. One way of classifying sustainable innovation was applied by Hellström [13], using a combination of "Schumpeterian" innovation forms: new products, new methods of production, new sources of supply, new markets, and new ways of organizing. Another way was provided by Klewitz and Hansen [17], into products (including services), processes (redesigning particularly logistics/ transportation processes into reduced energy and waste) and organizational (reorganization of the supply chain, new forms of management). Grawe *et al.* [11] describe logistics innovation as either product innovation or service innovation. In the review of the logistics innovation literature, Grawe [10] put forward technological product-oriented logistics innovations such as EDI and RFID, and process-oriented logistics innovations such as VMI and cross-docking. Technological innovation often results in new products or services, whereas the softer forms of innovation focus on the process that improves practices and performance [6]. Zailani *et al.* [30] provided a more detailed classification of technological aspects into information and communication (e.g. transport management systems, freight forwarding software), biological (e.g. alternative fuel) and monitoring. Rossi *et al.* [22] mentioned process innovations (minimizing environmental impact) and product/service innovations (more environmental-friendly logistics services). Based on these findings within softness, one can conclude that SLIs can span from *technological*, *product*, *service, process* to *organizational*.

3.2 Extent of change

An innovation implies changes in several dimensions; five dimensions are identified for SLIs. A first dimension for classifying the extent of change is in *input*. Hellström [13] found in his study that environmental innovations range from component innovation, which occurs when small input, a small module or a limited part of the system is changed while the overall system remains, to architectural innovation, which implies so large input changes that the whole system is re-designed. A second dimension to classify extent of change is in *output*, where output is related to improved performance and how many that benefits from the innovation. Hockerts and

Morsing [14] talk about sustainable innovations in terms of sustaining and disruptive innovations; sustaining innovations improve e.g. the performance of established products or services, whereas disruptive innovations consist of e.g. very different products or services that may undermine established ones. Similarly, Tidd *et al.* [25] refer to this from small step continuous innovations (which is common in processes) to erratic transformational innovations (so far-reaching that they change the very functioning of society). Jacoby and Rodriquez [15] suggest more detailed dimensions to classify output and include the customer or other user (could be internal users or suppliers) and the offering. Incremental innovation implies existing offering and existing customer/user; evolutionary innovation consists of new offering and existing customer/user, or of existing offering and new customer/user; and revolutionary innovation involves new offering and customer/user. In line with this, Grawe [10] states that incremental/exploitative innovations are designed to meet the needs of existing customers, while radical/exploratory ones are designed to meet the needs of new customers. Also Arlbjørn et al. [2] distinguished between incremental and radical innovation. Thus, a third dimension is that the *customer/user* could be either *existing or new*. The same literature also indicates a fourth dimension based on the type of offerings: *existing offering* versus *new offering*. A fifth dimension was suggested by da Mota Pedrosa *et al.* [7], distinguishing the extent the innovation is developed based on one customer's needs as *customized* or for all customers' needs as *standardized*.

3.3 Scope

The scope of an SLI can imply three different dimensions. First, it is related to how many actors are involved in implementing the SLI [2]. It can then span from company-internal operations, but as companies may not have all necessary resources to innovate, they need to find innovation capabilities outside their own organization e.g. at suppliers [9]. Therefore dyadic relationships (including the innovating company and its supplier or customer) can be needed, or even supply chains (three or more organizations involved [3, 8, 22]). The scope of an innovation could therefore range from *company-internal*, via *dyadic relationships* to *supply chains*. A second dimension to classify scope is in which logistics activities SLIs can exist; in *purchasing, transportation, warehouse, production,* and *reverse logistics* [4, 27]. Often the focus is on transport; however, Jensen *et al.* [16] exemplify green supply chain innovations in reverse logistics. In a food supply chain, waste from the retailer, instead of being destructed, was transformed to a value by introducing a biogas manufacturer that used the reverse flow from the bakery as input to manufacturing. This was done after the bakery took this initiative and involved other supply chain actors. Thus, reverse logistics was expanded to a *closed-loop supply chain*. A third intuitive dimension of describing the scope of sustainable logistics innovations would be to distinguish between the sustainability dimensions: *economical, environmental,* and *social.* Several studies [23, 26] noticed a focus on the environmental dimension in sustainability logistics research. By adding this dimension the need for addressing SLIs outside common limitations, hereby emphasizing social sustainability, is further addressed.

4 ILLUSTRATING AND CLASSIFYING SLIS

It was interesting to find different SLIs, which verified that companies with good practices had been selected. Five SLIs were selected to be presented in detail and classified in the framework.

4.1 Proactive/forced transport planning

Proactive and forced transport planning is used by one retailer. As one important KPI is high fill rate in the trucks, innovative practices and actions had to be taken to improve fill rates. The centralized transport planning works proactively with levelling out and moving delivered volumes to the stores between weekdays, resulting in a significantly improved fill rate. This implied that the store may have to wait an extra day for the goods, or receive them one day earlier. Forced methods are also used, through which the transport planning fill up available space in the trucks with products with high turnover rates (e,g. toilet paper, mineral water), even if those products were not ordered, or ordered in smaller volumes by the store.

This SLI can be classified in terms of softness as having a strong focus on improved processes. It is also an organizational change, as the decisions to determine when certain goods should be delivered, are moved from the stores to the central transport planning function. The change in terms of input is small, as some new decision rules are added as a component to the planning process for the central planner, whereas the change in output, in terms of reduced environmental emissions from the transport operations, is fairly large as fewer vehicles with high fill rate are operating. Furthermore output is assessed by classifying customer and offering. Existing customers are addressed and the existing offering – the delivery to the store – is changed in terms of volume and timing. This is connected with incremental to evolutionary output according to Jacoby and Rodriguez [14]. Furthermore, the SLI is standardized, addressing all customers or stores. This SLI affects the dyadic relation between the central transport planning function which implemented the innovation, and the stores that receive its consequences. The scope of this SLI lies in the

transportation activity. It is strongly driven by economic gains, but has also indicated large improvements environmentally in terms of reduced emissions. The classification of this SLI, along the framework dimensions, is shown with a (blue) square in Figure 2.

4.2 Small order calculator

Customers of one retailer are given the possibility to make more aware decisions that affect their sustainable purchasing behaviour. The small order calculator is a pedagogical tool developed to assist customers' purchasing behavior towards not buying too small, frequent volumes. During purchasing, it schematically shows the different types of costs both for the customer, such as administrative and invoice handling costs, and for the retailer, such as picking and transportation costs. It also shows the sustainability consequences for both partners. This tool has a "hard stop", implying that too small orders are denied and must be paused until additional orders come from that customer, and a "soft stop", which gives information about the costs and environmental effects and recommends the customer to refrain that purchase. It has "opened the eyes" of customers. Based upon guidance from the retailer, customers (who often are large organizations with many possible purchasing units) can, on a central level, decide the limits for and hence customize their own soft and hard stops. This SLI implies a development in the opposite direction than the remaining office supply industry, in which free over-night delivery of extremely small orders is praxis.

The softness of this SLI is a service to the customers. It is implemented as a component in the existing order systems, therefore is input is small. For its extent of change in output it has a large potential to consolidate many small orders into larger dispatches and reduce the need for transportation, but the possibilities lie first within the use and behavior of customers. Second, there are possibilities for the retailer to learn what triggers different customers' behavior, which in turn could affect the way the tool is developed and improved. It is directed towards all existing customers, but has a potential to attract new customers as it deviates from the remaining industry. It is a standardized solution, but its details can be customized to the customer's own limits for soft and hard stops. For this SLI to function, it is implemented in a dyadic relationship; the customer is dependent on the information from the retailer, and the retailer is dependent on the customer's actions. Also, in the development of the tool, competency and experiences from both customers and retailer were needed to decide on involved parameters and schematic values for those parameters. This SLI is classified as a purchasing tool, taking place in the purchasing activity of the retailer's customers. The ambition is to both save costs and to save the environment (with decreased transportation), hence it affects both economic and environmental sustainability. The classification of this SLI, along the framework dimensions, is shown with a (red) circle in Figure 2.

4.3 Height adjustment of primary packaging

This retailer has a very large range of products, with product sizes that differ significantly. Customers' orders of different products vary, and as this retailer had just two standardized sizes (different bottom areas) of primary packaging, the fill rate in the package varied significantly. Now, the innovative, highly automatized packaging equipment used, finishes each picked order by automatically measuring the height of the goods in each package. Then it adjusts the height of the package, cuts is off and folds it close to the height of the goods. This ensures a very high fill rate in the primary package, which in turn, results in a higher fill rate on the pallet, in the dispatch area and in the trucks.

This SLI is in terms of softness a technical innovation that is starting to spread over the world, and this retailer is among the first to use it in Sweden. A part/component of the input is changed i.e., adding one, although very complex, packaging machine as the final stage in the order picking process. As this has resulted in an output change with as much as 40% reductions in the charged transportation volumes, output is classified as evolutionary. It is applied for existing customers, close to the existing offering however with a smaller packaging. The SLI is standardized and the same for all customers, even if each customer gets a customized packaging. Therefore it is classified between standardized and customized. This SLI is implemented on company-internal basis. The change occurs in the warehouse activity, but the effects appear mainly in transport. Short-term, under the current contract and charging model with the LSP, this SLI has implied a lot of economic gains for the retailer; the pay-back time for this SLI was short. Long-term economic gains will be related to coming LSP contracts, as the LSP becomes aware about the new structure of the goods from the retailer. The potential environmental gains are large, but dependent on whether the LSPs manage to fill up the reduced volumes with goods from other customers. Furthermore, social gains, such as more compact packages and easier handling, exist in terms of improved work environment and decreased risk of injuries. The classification of this SLI, along the framework dimensions, is shown with a (green) triangle in Figure 2.

4.4 Silent night delivery

For stores in large city centres, there are difficulties regarding delivering on time during the day due to congestions. One retailer has participated in the development of an SLI designed to handling this issue. They have tested electric hybrid trucks in

extensive collaboration with a university, the community, and the truck manufacturer, in order to enable silent night deliveries in cities. The truck recognizes by GPS if it is in a quiet zone or not, then it turns the radio off and minimizes the beeping noise when reversing. This retailer has actively participated in developing, adapting, and testing handling equipment to fit with the quiet vehicles, such as quiet forklifts and ramps. The driver can lock up the store's warehouse and unload in the accurate temperature zones, so the goods are available to sell the next morning. A unique aspect of this SLI is the holistic concept of identifying all components with disturbing noises. It is directed towards safer city transportation, and less congestion, which is of relevance in a larger city (where night activity is more likely to be accepted).

In terms of softness, there is a strong focus on technology in this SLI. It is also an organizational SLI as it affects the organization with dispatch and goods reception at other times. As nightly transportation is often prohibited, new temporary contracts have to be negotiated with the community to test the SLI, after which it may become permanent. The extent of change in input is large; it has required the design of a totally new delivery system. The extent of change in output, measured as higher average driving speed and lower emissions is promising, however difficult to classify as it yet is implemented in a small scale. This retailer has operations in many countries with large cities, where legislation may be more allowing. This SLI is directed towards existing customers or stores. At the same time it is a new offering for the stores. Using the typology of Jacoby and Rodriguez [14], existing customers and a new offering imply evolutionary output. It is a customized offering, customized for those customers/stores that are located in congested city centres. The scope of this SLI is supply chain; it is implemented by the retailer, one LSP and several stores. The scope is also classified as affecting transport and warehousing of the stores. It affects the entire triple bottom line, including economic effects from improved service and reduced driving time and cost, reduced emissions, and undisturbed local inhabitants. The classification of this SLI is shown with a (yellow) star in Figure 2.

4.5 Closed loop waste management

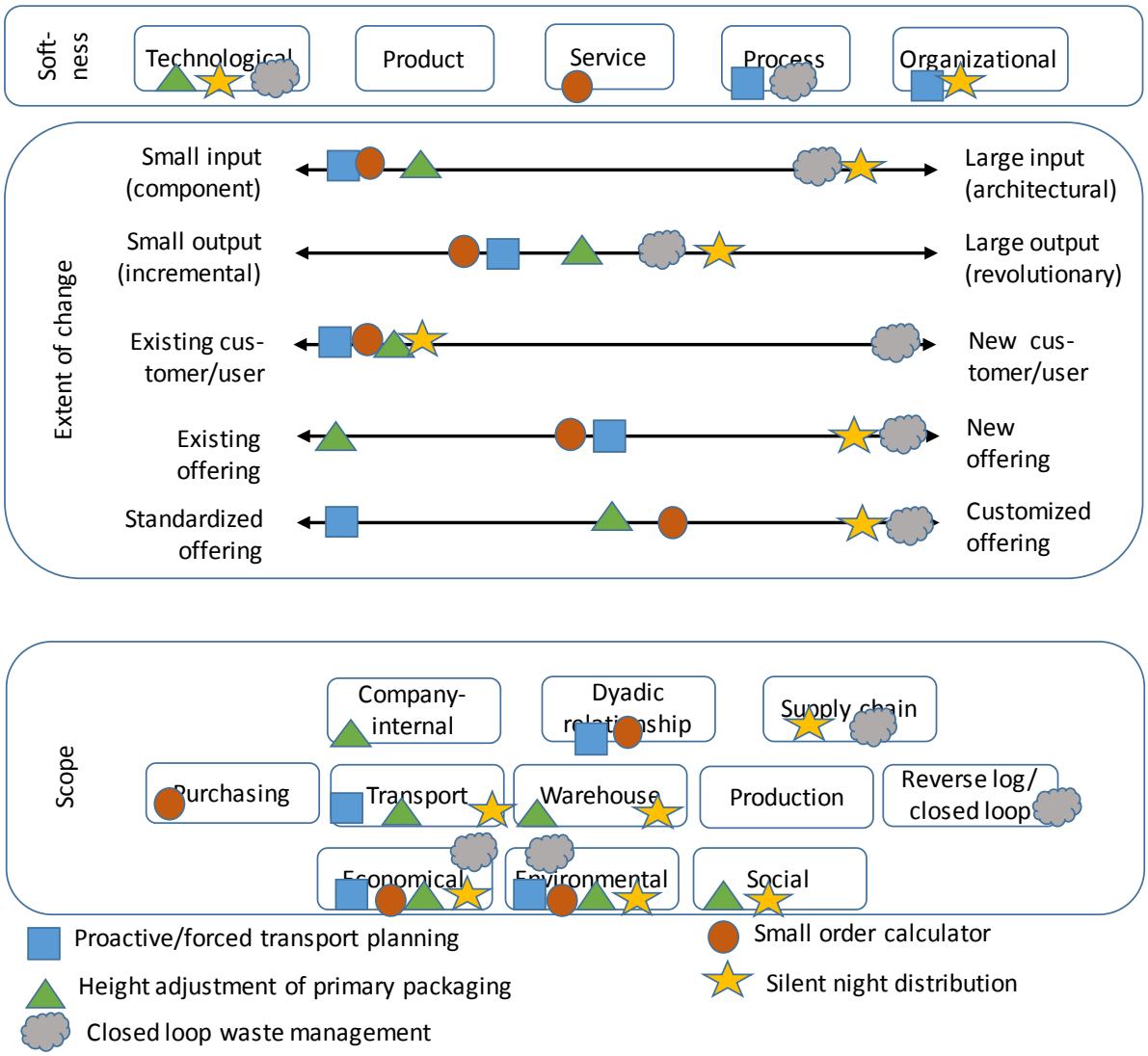
One retailer has developed a new waste management system for their left-over bake-off bread from stores. Instead of sending away the outdated bread locally in each store for disposal/destruction, the bread is taken back to the distribution center, in a reverse logistics flow with the emptied distribution vehicles. The bread is then sold to a new customer, an ethanol manufacturer, which uses organic material as raw material for production. This implies that waste has gone from a cost to become a revenue-generating asset. The ethanol producer complements the retailer's supply chain as a new actor and closes the supply chain into a loop. In order to close the supply chain into a loop, the retailer has had to acquire certain types of bags to handle the bread, and develop new routines and processes for handling the bread during transport.

Softness-wise, this SLI builds upon a technological innovation that makes it possible to use organic material as an input in ethanol production. In order to become closed loop waste management, it has also required developed processes in the stores as well as during transport. The extent of change in input is seen as large and architectural, as this SLI has required designing a new waste management system. Output should be related to how many can benefit from improved sustainability performance. This is again more difficult to classify; it has a large potential in reducing waste and emissions. However output is a bit de-graded as bake-off bread is a small share of the assortment. It introduces a completely new customer, and therefore, the offering is highly customized. According to the Jacoby and Rodriguez [14] typology, this SLI therefore has the potential to imply revolutionary output. This SLI is taking place with a supply chain scope and impacts reverse logistics/closed loop supply chain. It has good economic effects, as new revenues are generated from the ethanol manufacturer and costs for disposal/destruction of bread are not needed anymore. Furthermore the empty return transports imply no additional cost. Environmental sustainability is generated by not disposing food and instead recycling it as a renewable fuel. The classification of this SLI, along the framework dimensions, is shown with a (grey) cloud in Figure 2.

4.6 The SLIs classified in the framework

Figure 2 illustrates suggestions how to classify the five SLIs.

Figure 2: Five SLIs classified in the framework



5 EVALUATING THE APPLICABILITY OF THE SLI FRAMEWORK

This chapter evaluates the applicability of the framework to classify SLIs in three areas.

5.1 Classifying softness

Softness was about classifying each SLI into boxes as technological, product, service, process or organizational, which was possible to do. It is also noted that some SLIs tick two boxes within the same dimension; closed loop waste management was both technological and process, and proactive/forced transport planning was both process and organizational. One lesson learned is therefore that even if boxes are identified, more than one box may be needed to classify the softness of a certain SLI.

Even if many SLIs identified are technological, in line with the statements of Busse and Wallenburg [5] and Rossi *et al.* [22], a number of complementing SLIs were found along the dimensions. Several interesting SLIs put forward in the empirical findings were found; in terms of softness they relate to processes (such as closed loop waste management), as well as organization (silent night distribution). No product-related SLIs are found, which should be a sign of the service/processual character of logistics, and completely in line with Chapman *et al.* [6]. It is worth mentioning that during the interviews, all retailers brought up the fact that their innovation efforts outside logistics, are largely directed towards product innovation.

5.2 Classifying extent of change

Extent of change is a complex area consisting of five dimensions: input, output, customer, existing/new offerings, and standardized/customized offering. The SLIs described often build upon small, component

input changes, which concur with the findings on logistics innovation by Busse and Wallenburg [5]. However both silent night delivery and closed loop waste management build upon input changes more in line with what Hellström [13] calls architectural input. Classifying the input to an SLI was straight-forward to do, as the respondents were able to describe input well. In the use of silent night delivery and closed loop waste management, large change in outputs are noted in line with what Jacoby and Rodriguez [15] call evolutionary innovations. Output builds upon knowledge or measurements of sustainability performance. This was seldom known by the respondents. This calls for a stronger routine in following up sustainability performance, related to certain SLIs. Output is also a very relative dimension to classify. A large improvement of sustainability performance can occur in a very limited area, such as in a pilot project (silent night delivery) or in a part of an assortment (closed loop waste management). Related to the notion that SLIs can be just new to the firm [17] and that logistics innovation often are not commercialized, SLIs can be internal and local and therefore imply a smaller extent of change in output. Furthermore output should be linked to a time dimension, where output may increase over time as the SLI is up-scaled. For these reasons, extent of change in output was a difficult dimension to classify. It is also obvious from the literature review that many studies have tried to capture extent of change in output, indicating that it is challenging.

A third dimension is which customer or user to address. Flint *et al.* [8] emphasize the importance of involving customers, but do not distinguish between existing and new customers. The studied retailers indicate that it is most common to have SLIs towards existing customers and users, which is interesting to discuss further. One explanation to this tendency could be that logistics has an internal approach, in line with Chapman *et al.* [6], and therefore is aimed for existing users. Another explanation could be that a limited amount of customers are interested in sustainable logistics services, and thus, might be an up-and-coming customer segment. A third explanation is that companies have not yet noticed the support these customers can bring to the development process of innovations. The exception to the rule is closed loop waste management, which required a completely new type of customer, an ethanol producer. Enabled by this new customer, this SLI differs from most other SLIs in terms of other dimensions. This indicates the large potential in addressing new customers. This is a straight-forward dimension to classify. The dimension of offering is found along a scale from existing to new. With existing customers, evolutionary innovations are most common, per Jacoby and Rodriguez [15], and it is not possible to achieve revolutionary innovations. It seems that it takes a SLI with a new customer, closed loop waste management, to create revolutionary innovations. This is in line with Grawe [10], as incremental changes, like the small input changes often are designed to meet the needs of existing customers and users. The difficulty to classify output may be a reason why Jacoby and Rodriguez [15] suggested capturing output as the newness of the customer combined with the newness of the offering, both of which were easier to classify. Finally, in the dimension of standardized to customized offerings, the SLIs are distributed along a scale, as suggested by da Mota Pedrosa *et al.* [7]. The existence of customized SLIs gives hope that also new customers will be addressed in the future, enabling revolutionary SLIs. Also offering was possible to classify, based upon information from the respondents.

5.3 Classifying scope

Classifying scope in boxes from internal to supply chain, in line with Björklund and Forslund [3], was another straight-forward dimension to classify and all scopes were found in the SLIs studied. It is interesting to note that many SLIs require at least a dyadic scope. Here examples of retailers involving LSPs as suppliers in the development of SLIs are found (e.g. in silent night delivery), in line with the suggestions by Fossas-Olalla *et al.* [9]. Closed loop waste management is an SLI that has a supply chain scope. Such SLIs contribute to a higher level of integration in supply chains, encouraged by general supply chain management literature. The common belief that SLIs activity-wise occur in transportation [18] is somehow contradicted as examples in other logistics activities, such as purchasing (small order calculator), warehousing (height adjustment of primary packaging), and reverse logistics (closed loop waste management) are found. As expected, no production-related SLIs were found among the retailers. Height adjustment of primary packaging affected both transport and warehousing, indicating that more than one box is needed to fully classify scope. Additionally, in transportation, new innovative practices such as silent night deliveries and proactive/forced transport planning are seen. Furthermore, the development towards closed loop supply chains, as discussed by Jensen *et al.* [16], shows a lot of promise. This is a type of SLI that brings large improvements both to logistics and sustainability and can be expected to increase in the future.

Scope can also be addressed in terms of the triple bottom line [26]. Almost all SLIs are ticking the economic and environmental boxes, but it is more difficult to find examples of social ones. The respondents had a hard time trying to identify the social dimension, and even more so when trying to measure and evaluate the extent of change in this dimension. A smaller aptitude to realize the social dimension is observed, as there is a lack of knowledge

or examples regarding what constitute socially sustainable logistics innovations. This is an important area for development. One explanation is that research has provided fewer guiding examples [26]. Good examples of SLIs covering the complete triple bottom line are silent night delivery and height adjustment of primary packaging. There may, however, be SLIs that affect the social dimension, even if they were not mentioned by the respondents. As good examples are few in this field, some SLIs with potential social implications not identified by the respondents are presented. For example, the proactive/forced transport planning could also imply social sustainability in the shape of work environment, as the store knows that full trucks will arrive each time, making it easier to estimate and plan the goods reception and the staff needed. Using food waste has social aspects, and one can question the use of food as fuel.

5.4 The applicability of the framework to classify and expand SLIs

The framework was applicable in illustrating the various SLI dimensions, and all dimensions, with the exception for extent of change in output, were possible to classify based upon qualitative interviews. Extent of change in output either required complementing quantitative measurement information, or could be handled as a combination of the newness of customer and offering. The empirical study did not add new dimensions to classify SLIs, nor any new suggestions for scales or boxes to classify the dimensions. Therefore the framework seems to fulfil its purpose in its current design.

The framework provided an overview of the location of SLIs, such as that most SLIs are directed towards existing customers. It has also an important property in highlighting gaps where very few SLIs exist. That can pose important why-questions. Hence it can also be used to develop and expand new SLIs that differ in several dimensions from other SLIs. The framework does not only offer practitioners and researchers an understanding of the multidimensional nature of SLIs, but it can also challenge the further expansion of SLIs by adding new dimensions and raising new questions to address: How could this innovation be designed to be even more revolutionary? Can it be designed in the form of new offerings? How can it be designed to also attract new customers? The logistics focus implies that commercializing [2] the SLIs is less common, but that could be a possibility. Furthermore, by considering the triple bottom line, companies can gain inspiration and insights to also consider their SLI in the light of the social dimension, often lacking in both research and practice. These aspects could guide companies and the framework can, thereby, be an important tool for companies that wish to expand SLIs in order to improve their sustainable logistics.

In a practical situation, it is possible to use the framework to systematically expand SLIs along the dimensions of the framework. An SLI should have a certain type of softness. Its extent of change could be captured along five dimensions. The scope is especially important and adds to the special character of SLIs. It highlights how many actors that are involved and in which logistics activities it can occur. If a qualifier for a SLI would be to cover the triple bottom line, many of the retailers' SLIs would be excluded. As every step towards sustainability is important, it is suggested that SLIs that address environmental *or* social together with economical sustainability are included. When this research area evolves, which should be in line with the suggestions of Rajkumar *et al.* [21], it might be more suitable to limit the definition to only include innovations that cover the triple bottom line. Overall the suggestion that SLIs should be new to the firm [17] implied that a large number of SLIs were possible to illustrate. This is important in terms of not discouraging retailers to have too high demands on their innovativeness (such as if SLIs had to be new to the industry). In practice and on a societal level, every step in every company towards improved sustainability is important. The definition aspect, if SLIs should be new to the industry or to the firm (even if it can be seen as less innovative and continuous improvement of sustainable logistics by a mature company), must not be hindering. Overall, SLI is an area of concern for companies, confirming the studies by Abbasi and Nilsson [1] and Russo Spena and de Chiara [23].

6 CONCLUSIONS, IMPLICATIONS AND FURTHER RESEARCH

In order to inspire researchers and practitioners to expand their mindset when addressing sustainable logistics, the purpose of this paper is to develop a framework for classifying sustainable logistics innovations, and by classifying some SLIs evaluating the applicability of the framework. A framework expanding the limitations from earlier research, consisting of three areas and nine dimensions, was built up from literature. By studying three retailers, a number of SLIs were identified, and thereafter classified by the authors applying the developed framework. It was found that the SLIs identified were possible to classify along all dimensions, with some difficulties in extent of change in output based upon qualitative interviews. The framework with its scales and classifications are contributions to literature, not only on SLIs but also on sustainable logistics in general as the qualifying newness of an SLI varies. The study has implications for research, as it has bridged the research streams of logistics and innovation in accordance with the suggestions of Arlbjørn *et al.* [2], areas with large research needs. It has challenged the researchers to see social

implications. Practical implications are related to the interviews: by pushing the respondents and suggesting all nine dimensions, they were made conscious, and were able to reflect and see their work in a new light. Practical implications occur also for other practitioners who can become aware of the multidimensional nature of SLIs. Applying the framework (shown in Figure 1), SLIs can be understood in a more concrete and applicable way, which can inspire managers to expand their efforts towards sustainable logistics. For practitioners who already have implemented SLIs, one recommendation is to apply the framework in order to achieve a holistic overview of existing SLIs, and an understanding of the gaps in dimensions not covered, which signals development potentials. This results in an overview similar to the one illustrated in Figure 2, but made from one company's perspective instead. This structured mapping can also facilitate benchmarking between similar companies within, for example, the same group of companies. Another recommendation is to apply the framework to expand and further develop an existing SLI, for example towards customized offerings for standardized SLIs or towards new customers for SLIs targeting existing customers, In this paper, classification is carried out applying the framework "from top to bottom", starting with softness and ending with scope. However, practitioners are recommended to start with the dimension that is the easiest to map with regard to that specific SLI. Not either is it necessary to classify all dimensions of an SLI, thus it is possible to only use parts of the framework. However, the more dimensions included, the more covering understanding will be gained.

As practitioners have not yet tested to classify SLIs in the framework, the validation of its practical applicability is a first suggestion for further research. This could possibly be done as case studies or as a Delphi study. This study was designed to encompass retailers. As LSPs have been addressed previously, manufacturers could be a logical next step to address, which may lead to additional dimensions in the framework and more inspiring examples of SLIs. The possibility to classify the dimension extent of change in output could also need additional research using deeper qualitative methodology. This study was designed to focus on implemented innovations. Therefore, the possible dimension "rate of adoption" was excluded. Schleper and Busse [24] describe five innovation-related qualities that determine the rate of adoption: relative advantage (if potential adopters perceive the innovation to be superior to its present alternatives); compatibility (if potential adopters find the innovation to fit well, considering the present context in terms of values, coexisting technologies, and past experiences); trialability (if potential adopters have the opportunity to test the innovation, learn its particular advantages, and build confidence for the new technology or process); observability (the transparency and accessibility of the effects of the innovation); and complexity (the ease of potential adopters to understand and use the innovation). If a company would like to apply the framework towards innovation customers, these qualities could form an additional area including one dimension (with five boxes) to classify rate of adoption. During the interviews, some examples of less successful tests or not yet implemented ideas were mentioned, and were consequently excluded from this paper. However, further research analyzing these kinds of tests and ideas in the light of the framework provided by Schleper and Busse [24] could provide understanding about the largest hindering factors in adopting SLIs. A last suggestion for continued research, is a larger scale survey study with the purpose to assess the existence of various SLIs in different companies and along different dimensions.

COMPLIANCE WITH ETHICAL STANDARDS

The authors declare that they have no conflict of interest.

FUNDING

This study was funded by Vinnova, the Swedish Innovation Agency (grant number 2014-03363).

ACKNOWLEDGEMENTS

The authors wish to thank VINNOVA, Sweden's Innovation Agency, for funding the project "Transport-related CSR for profitability and innovation", in which this paper is a part.

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