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Roles and Perspectives When Estimating Energy and Environmental Potentials of Urban Consolidation

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Abstract: Urban consolidation centers (UCCs) are presumed to provide more efficient goods distribution in cities and lead to decreased environmental impact and energy usage. There is, however, limited knowledge as to the actual performance of UCCs, and what roles and perspectives the involved actors have in the performance measurement. The overall aim of this paper is to investigate the roles and perspectives of involved actors when estimating and evaluating the performance of UCCs. The article is based on a study of one case that evaluates the performance of a UCC involving several actors. Interviews were triangulated with documents from the case. The results showed that actors have different roles in performance measurements and even if they share a mutual interest in conducting the measurements, they did not share opinions regarding factors such as system limits or performance indicators. The study provides a deeper understanding of the importance of inter-organizational interaction when conducting performance measurements. The study provides additional insights into the roles of the actors and their perspectives in logistics performance measurement that targets energy usage and environmental impact. These aspects are seldom addressed in less complex estimations or mathematical modelling estimations.

Keywords: urban consolidation center; city logistics; freight transport; environmental and social sustainability; collaboration; inter-organizational interaction; performance measurement; assessment; indicators

1. Introduction

Freight transport has a large negative impact on the environment due to excessive energy usage, emissions such as CO₂, as well as social impacts in terms of traffic accidents and noise disturbance [1]. Even if freight transport within urban areas often represents only a small part of the total length of haul, the last mile problem results in inefficiencies with large costs and environmental impact [2]. The problem of energy efficiency has also been singled out as especially relevant in first and last mile distribution, as it comprises a large share of the total delivery's energy consumption [3]. This problem can be targeted by items commonly discussed in sustainable logistics management, such as fuel-efficient vehicles and environmentally friendly transport modes [4], and by enhanced utilization of capacity [5].

The use of urban consolidation centers (UCC) is presumed to provide more efficient distribution in an urban area resulting in decreased energy use and environmental impact [6]. A UCC can be described as a logistics facility located relatively close to the area it serves, e.g., a city center or a shopping center, and from which consolidated deliveries are carried out [7]. UCCs are one of the most frequently implemented and studied city logistics initiatives, according to Lagorio et al. [8].

A trend in Sweden is municipalities' increased use of municipal consolidation centers (here termed MCCs), where the goods from different senders are consolidated before distribution to the municipalities' day care centers, schools, and offices in the region. These centers pick US or UK spelling and use consistently differ from traditional UCCs as they serve a municipality instead of one city, but

the basic idea of increased consolidation for urban distribution, and the potential change of vehicles for the last miles of distribution, is the same (see [9]). Approximately 40 of the 290 municipalities in Sweden have implemented this kind of solution, commonly driven by environmental goals. Several initiatives are managed in a collaboration with up to seven different municipalities.

There is however limited knowledge concerning the actual energy and environmental benefits of UCCs. Behrends, et al. [10] recognized early the need to select a set of indicators to monitor and measure whether the intended results of urban freight initiatives are being achieved. Despite this, the measurements and metrics applied when estimating the benefits from implementing UCCs still vary largely [11]. Besides the variation regarding performance measurements (see e.g., Allen and Browne [12]), there is a widespread usage of different methods to capture raw data and to estimate the impact of transport, and these different methods lead to different results [12,13]. Even if much research has targeted sustainable freight transport performance measurement, the area of urban freight transport is a neglected area [14]. Based on a systematic literature review of research on environmental sustainability in 3PLs, Evangelista, et al. [15] put forward performance measurement as a highly under-researched area and suggested several propositions for further research bridging this gap, such as:

- Better evaluation of the energy efficiency of green measures using alternative environmental performance indicators in the road freight transport sector
- Investigation of outcomes of green actions stimulated by government incentives
- Collaborative measures adopted by road haulers to increase energy efficiency

An effective framework for the development of sustainable performance measurement within (person) transport needs to reflect the stakeholders' different perspectives, as well as the capacities and constraints of involved actors [16], and the same can be argued for freight transport. UCC initiatives are also dependent on cooperation [17] and involve several actors such as logistics service providers (LSPs), receivers, and local authorities [6,18,19]. An MCC initiative could be described in terms of a supply chain with three important actors, the goods supplier, the LSP, and the consumers/receivers (i.e., municipality units), as well as an environmental initiative made in collaboration between the municipality and the LSP. Successful environmental initiatives in buyer-supplier relations can be dependent on the environmental performance metrics collaboratively developed between buyer and supplier firms [20]. However, the findings by Persdotter Isaksson, et al. [21] suggest a very low level of integration between Swedish LSPs and logistics buyers in the environmental logistics performance management (incl. measurement) process. Furthermore, there is a call for research including the consumer's perspective in environmental sustainability and energy efficient supply chain management, due to the customer's crucial role driving the greening of supply chains [22]. In line with this Marchi and Zanoni [23] put forward the need for energy assessment that expands the commonly applied perspective of one organization and points at a research gap regarding supply chain coordination for energy performance improvement. The underlying argument is that collection, management, and report on the performance metrics are dependent on the contributing effort from several supply chain actors, and sometimes also third-party experts. However, the roles and responsibilities of different actors in energy and environmental performance measurement in a UCC context is still an untapped research area.

This paper takes its point of departure in the need for increasing the knowledge on estimating the environmental, social, and energy related benefits from implementing UCC solutions. Furthermore, the paper targets the knowledge gap regarding the roles and perspectives of involved actors. The overall aim of this paper is to increase the knowledge regarding estimation of the benefits from implementing UCCs, with a special focus on MCC, initiatives and on the roles and perspectives of the involved actors. Two research questions have been formed targeting the roles and perspectives of involved actors in the process of estimating the benefits from implementing MCC initiatives:

RQ1: What roles can the involved actors have, and why do the roles differ?

RQ2: Which perspectives can the involved actors have, and why do the perspectives differ?

In the next section, which reviews literature on measuring sustainable transport, performance measurement in city logistics and roles and perspectives of the involved actors, the frame of reference is presented. This is followed by a methods section providing insights into the identification of an appropriate case to investigate as well as the design of the case study methodology. A description of the MCC case investigated is then presented, followed by the section titled “Empirical Findings on Roles and perspectives of Involved Actors” presenting the empirical findings made. The article ends with an analyze on the roles and perspectives, and finally the conclusions and future research needs are put forward.

2. Literature Review on Performance Measurement, Roles, and Perspectives

Our literature review starts with ways to estimate the impact in general and more specifically from transport, before elaborating on important aspects to consider in performance measurement for city logistics initiatives. In order to capture the important role of inter-organizational cooperation in performance measuring, the literature review ends by describing the roles and perspectives of the stakeholders involved.

2.1. Measuring Sustainable Transport

Methodologies for assessing transport’s impact on sustainability can be grouped into either bottom-up approaches or top-down approaches [1]. The two methods determine whether to start at an aggregated level and divide a total impact on the desired study object or to aggregate impacts from individual transport segments to form the desired study object [24]. The suitability of the two methods is determined by the purpose of the measurement as well as the available data and its quality [25]. Furthermore, there is a widespread usage of different methods, and that the different methods lead to different results [1].

The energy-based or fuel-based approach takes as point of departure measuring the fuel or energy used. This top-down approach is more commonly applied when the focus is to support (central) government decision, such as designing a new pollution control law, as it provides an understanding of how one can steer systems to achieve intended results [26]. One example of a framework applying this approach in a logistics setting is the analytical framework for green logistics by McKinnon [13], taking as its point of departure the weight of goods produced/consumed/returned via nine key parameters: modal split, average handling factor, average length of haul, average load on laden trips, average empty running, energy efficiency, emissions per unit of energy, monetary evaluation of external costs to the final result: the external cost of logistics operations.

The bottom-up approach commonly takes as point of departure the activities taking place (i.e., it is activity-based) starting with inputs from individual transports, and performance measurements on e.g. goods’ weight, distance travelled, and emission factors per tonne-kilometre, aggregating the individual transport segments to form a study object (such as energy usage or outlets of CO₂) of e.g., a fleet or supply chain [25]. For an external impact to be assessed the activity-based approach requires conversion factors (see e.g., Piecyk, et al. [1]). The European Norm, EN 16258:2012, a European standard for calculating greenhouse gas emissions from transportation, can be used to allocate the outlets of a transport operation to the single shipments [27]. A basic principle in the standard is multiplying quantity of freight by the distance travelled [27]. This is very much in line with how McKinnon and Piecyk [25] describe the activity-based approach where CO₂ is the sum of tonnes transported, average distance travelled, and CO₂ emission factor per tonne-km. Several methods exist that are consistent and compatible with this standard such as the “NTM methodology” applied by e.g., Swedish companies.

2.2. Performance Measurement in a City Logistics Context

Performance measurements and the use of indicators are useful for decision making, estimating progress and improvements as well as enabling comparisons and benchmarking [28], and are of

importance to monitor the sustainability of transport [29]. Furthermore, measurement and evaluation can provide justification for the implementation of green supply chain initiatives [30].

Performance measurements in city logistics have several challenges in terms of e.g., lacking documentation and evaluation methods, as well as lacking performance measurements prior to implementing changes. The city logistics literature has a strong focus on results and the potentials of different initiatives, but a far lesser focus on documentation (see e.g., Allen and Browne [12]). Due to the use of different measurements as well as follow-up analyses, the results from different initiatives are hard to compare [31]. However, it can be questioned if the methodology can be totally standardized as, according to Ljungberg and Gebresenbet [32], this should be adapted to the city in study, taking into consideration site-specific data due to, e.g., the different characteristics of cities. Knowledge and experience are lost due to insufficient measurement systems [33] and lack of a baseline scenario, which makes it hard to estimate the benefits achieved [34].

Precise numerical indicators are of large importance in a formal measurement process of any city logistics initiative [17]. Kennedy et al. [35] were early to emphasize the importance of performance measurements that could be used to define sustainability objectives as these are necessary for progress within city logistics. Tipayawong, et al. [36] included the following areas for transportation in green supply chain performance measurement: truck load factor, fuel consumption, and emissions of carbon dioxide as well as other forms of pollution. Based on a review of the literature on measuring sustainable transport, Bandeira, et al. [14] suggested several sustainable transportation indicators that they state could be adapted to urban freight transport, such as: emissions of GHG, emissions of air pollutants (CO, NO_x, PM), noise emissions, fossil energy consumption, loading factors, % alternative and renewable energy used, recycling of tires and end of use vehicles, loading factors, transportation costs, time spent in traffic, traffic accidents, etc. Research studies have been carried out to show the potentials of UCCs expressed in exact measurements (see e.g., [37–39]). The selection of measurements is much in line with the early findings of Browne, et al. [7] stating that the most commonly quantified impacts from implementing UCC are changes in vehicle trips, vehicle km, total fuel consumed, and vehicle emissions. Furthermore, frequent environmental performance indicators in the logistics literature are fill rate, technology (for example age of vehicles and the fuels and engines), air emissions, outlets of CO₂, and energy use (see e.g., [40]). Furthermore, supply chain environmental performance measurements should also include qualitative indicators such as management involvement, green image, and accidents [30].

There is a need for applying more complex performance metrics, combining different performance measurements and result variables. The consideration of integration among variables in the sustainable performance metric of transportation is also put forward by Pei, et al. [16]. Even if the degree of consolidation increases when applying a UCC, the change can result in longer transport distances, sub-optimizations and use of smaller and thereby less efficient vehicles (see e.g., [41,42]). The need for integrated performance measurement metrics including different environmental measurements, as well as economical and service-related measurements were recognized early (see e.g., [43,44]). A holistic approach involving the three central aspects of financial analyses, traffic analyses, and environmental assessment is put forward by several researchers (e.g., [7,17,35]). Lately, more attentions have been drawn towards combining environmental, social and economic measurements when quantifying the potentials of implementing UCCs [11].

The system limitations applied is one important decision in designing measurement approach, and a decision that largely influence the results. Benjelloun, et al. [17] describe five forms of system limitations in city logistics: geographic coverage, transport modes, type of products, type of customers and logistics services. The geographical coverage can for example be the entire city or just a specific area within the city. The limitation to the city center has been criticized in city logistics research as being too narrow (see e.g., [45]). Another limitation is the exclusion of stakeholders and activities in other parts of the supply chain. A more efficient organization of the interface between long distance and last mile freight is needed. The EC [46] and Browne et al. [7] address this aspect from a UCC perspective, stating that to achieve more comprehensive evaluation of implementing UCCs it is desirable to measure

the impact on upstream logistics activities. However, the complete problem of city logistics from the end-consumer to the producer has rarely been tackled [47]. In the general transport measurement literature Piecyk et al. [1] point out the importance of distinguishing the external impacts from e.g., freight transports by classifying them as first-order impacts and second-order impacts. The first-order impacts are those directly associated with usage of e.g., transport systems and warehousing, and therefore more susceptible to being assessed, whilst the second-order impacts originate indirectly from the same activities as first-order impacts, but their form varies. In a similar vein Kalenoja et al. [48] put forward that there is a need to shift the focus to analyze complete supply chains instead of only focus on energy consumption of single shipments. However, expanding the scope could have its challenges regarding performance indicators included. Ahi and Searcy [49], identified 2555 different metrics across 445 articles within the environmental supply chain, with only five indicators used more than 20 times.

2.3. Roles and Perspectives of the Actors Involved

The importance of capturing all relevant stakeholders of the measurement process was early described in the green logistics measurement literature [43]. Based on an literature review on frameworks for sustainable transport indicators, Cornet and Gudmundsson [50] put forward a number of guiding principles on the framing of indicators that relates to the involvement of different actors such as: Connecting the framework to the visions and goals of the agency; Consider the local context via stakeholder input (this also to increase stakeholder awareness and buy in); Consider stakeholders capabilities, mandate constraints, as well as the knowledge and skills required to collect and analyze data.

An ongoing trend within sustainability logistics is to widen the scope from a traditional company internal focus to include upstream and/or downstream actors (see e.g., [51–53]). In line with this, the scope in measuring has also broaden [54,55]. Isaksson et al. [21] put forward the lack of knowledge regarding the integration beyond organizational boundaries in the performance management in general as well as within sustainable supply chain management. Based on a review of the literature they suggest a framework for inter-organizational integration between logistics supplier and logistics buyer in the environmental logistics performance management process consisting of five activities:

- (1) Selecting variables (based on e.g., strategic priorities among involved actors).
- (2) Defining the metrics (e.g., for involved actors to jointly define what to measure and how to measure, thus turning CO₂ into a concrete measurement such as average fleet CO₂ emission per unit driven).
- (3) Setting targets (e.g., formulate specific performance target with a timeframe. However, these could differ between the actors involved).
- (4) Measuring (e.g., data collection and reporting feedback).
- (5) Analysis and action (e.g., performance output in relation to targets and jointly determining corrective actions). Their application of the framework indicated a low level of integration among the three Swedish buyer-LSPs dyads empirically studied.

Initiatives within city logistics are also dependent on information support from several stakeholders in the logistics system [31]. It is therefore important to consider the interaction with different actors in measuring [47,56].

Examples of information provided by different stakeholders in performance measurement of a UCC could be measurements regarding:

- load sizes, lead times, time windows, and service levels (from shippers)
- goods flows, origin location, ordering and stockholding arrangements, and the transport flows between e.g. their establishments (from receivers)
- trip details and patterns, loading/unloading activity, location (from LSPs) (see e.g., [12])

The green logistics literature provides several reasons for why not companies in the supply chain contribute with information, such as: unreliable data, lack of environmental data [57], and the

complexity of including customer/supplier input [58]. In the very detailed descriptions of one pilot study including a UCC, the Samlic case, several inaccuracies regarding measuring and transferring information between individuals and organizations were found, such as misunderstandings of terms and not following instructions in data gathering [59].

Murfield and Tate [20] suggest that, for implementation of environmental initiatives between firms, collaborative development of environmental performance metrics between buyers and suppliers both strengthens the metrics as well as increases the importance of the relationship. On the other hand, Hoejmose et al. [60] found that green measurements are more common in a relation based on placing demands, as compared to mutual adjustment and collaborative approaches. Furthermore, energy efficient initiatives can generate few benefits for the actor that invests and implement these, while providing great opportunity for overall supply chain, causing, e.g., return periods of investments to differ depending on supply chain scope and actors involved [23].

The incentives for selecting measurements and measuring are likely different between the stakeholders involved in city logistics due to their different and sometimes contradicting objectives. Shippers (e.g., senders and receivers) target low costs and high delivery service, LSPs also strive to lower costs but focus on achieving a high level of operational transport efficiency (e.g., vehicle utilization, number of vehicles, stops, and driving distance). Authorities' strive for decreased external effects from transport and are held responsible for the development and follow up of regulations and for securing that EC directives are met (see e.g., [17,34]).

3. Case Selection and Data Collection

An empirically based study was selected to target the call for this type of research as the most common approach to quantify the potentials of UCCs is the use of mathematical models and simulations (e.g., [18,38,61]).

First an internet search was performed to identify cases where attempts have been made to quantify the environmental impact and/or energy usage of MCC initiatives. Swedish MCC initiatives were chosen based on convenience [62], since the authors of this study were aware of the initiatives, as well as being able to understand the information provided (in Swedish). This first phase of data collection was furthestmost explorative; however, as the literature review was made beforehand it provided an initial structure for documentation. The internet scan targeted all known Swedish MCC initiatives. The information was gathered from e.g., municipality webpages or available documentation. Initiatives were scanned for descriptions of quantified energy or environmental effects, methods used for measuring performance, and any stated interorganizational interaction.

The most common result was presented as reduced number of transports, deliveries or stops. Few municipalities presented any environmental or energy effects and those who did, lacked a presentation of the approach leading to those results. Instead, many of the municipalities argued that due to reduced traffic, the outcome was also beneficial for e.g. the environment, but did not quantify the effects. This can be illustrated by the following statement on one municipality's homepage: "On a yearly basis, the number of transports is reduced with 11 000 deliveries. The environmental effect is large; the amount of emissions is almost halved compared to previous amount.". However, without providing any information on how this was quantified, or type of emissions addressed. Another MCC initiative which involved several municipalities presented their results as "The first year, the number of stops to 125 functions were reduced from 26,500 to 7000 stops, a 75% reduction." which showed very little connection to environmental or energy effects. Several municipalities presented pre-studies commonly conducted by, or in cooperation with, consultancy firms. The reports were vaguer in their quantification of results, claiming that MCCs can reduce traffic and by doing so, also affecting the environmental impact. Some of the pre-studies went one step further by estimating quantified results but without an approach or methodology as a basis for those results. There were no clear instructions on how the input for these studies was gathered or which actors that were involved in the studies; showing no signs of interorganizational interaction between the actors.

The internet search resulted in the identification of only one initiative with documentation that thoroughly described the methods that were used and that showed signs of inter-organizational interaction. The study was conducted by a research institute and was made on one MCC initiative that includes several municipalities. One important outcome of the performance measurement in the report, besides the results, was a detailed documentation describing e.g., data used, system limitations and conducted analyses. The documentation outlined many environmental, social, and economic measurements quantified, as well as alternative future scenarios and sensitivity analyses. However, neither the report nor other forms of documentation on the initiative found on the Internet provided any deeper insights on the inter-organizational interaction needed and the roles, interactions, and perspectives of different organizations in the measurement.

This initiative was targeted with additional interviews as data collecting method in order to gain deeper insights furthestmost regarding the roles and perspectives of the involved actors. The research institute (i.e., the persons that had conducted the study) was first targeted. Table 1 outlines the respondents in the five conducted interviews.

Table 1. Respondents in the Interview Study.

Organization/Actors	Respondents' Titles
Research institute	Researcher and responsible for this investigation
County administrative board	Climate and energy strategist
Municipalities	Environmental investigator at one municipality; Two MCC coordinators and developers at the coordination unit (for all municipalities)
Logistics company	Strategical responsible

This second phase of the study was mostly deductive in character, i.e., the interview guide was designed with reference to the literature review, see example in Table 2.

Table 2. Examples of Interview Questions.

Aspect	Interview Aspects Covered	Reference
Aim of the study	Why was the performance of the initiative measured? How has the results been used?	[25]
System limitations	Which system limitations were applied? Why? Which actors decided on the limitations?	[17,45,46]
Indicators selected	Which performance measurements were used? Who decided on the indicators used? How were different indicators combined?	[38,39]
Approaches	Which was the measurement approach applied? Who decided and/or designed the measurement approach applied? (collaborative development) What was the goal and interest of different actors in the investigation, did it influence the selection of approach?	[20,24,63]
Data gathering	What data gathering methodologies were applied? Was information provided from different actors? (which actors/type of info.)	[12,58]
Data quality	How were unreliable and/or lacking data handled? Trustworthiness of the data from different actors? Were sensitivity analyses made?	[57–59]
Documentation	How has the performance measurement approach been documented? Availability of this documentation?	[12]

The organizations and respondents were identified based on the information found in the internet scan and by asking respondents for suggestion on other potential respondents. The respondents were selected based on their active role and responsibilities during the performance measurement study. Method triangulation was made for the information available on internet using multiple homepages, and respondent triangulation as several organizations were targeted (see Table 1), in line with Yin [64]. The respondents' descriptions of the performance measurement initiative were confirmatory or complementary, as no differentiations in their descriptions was found. This strengthen the study's validity and reliability. Two researchers participated during each interview.

Section 4 below presents basic information of the case studied. The information is based on furthestmost the homepage of the initiative, complemented and validated with information provided from the interviews with the municipalities. This is followed by Section 5, providing the empirical findings regarding the roles and perspectives of the involved actors.

4. Description of the Case Studied

The need for a performance measurement study of the MCC initiative was identified when several municipalities raised the question whether consolidation of goods could reduce their negative sustainable impact. Based on the amount of purchases, they realized that the goods also generated an excessive amount of transport. A consolidation center was used to consolidate the goods. After an initial project phase, the MCC became a permanent solution.

After a while, local politicians started to question whether the MCC initiative improved the municipalities' sustainable performance and put pressure on the initiators to present the actual environmental and economic benefits. No other initiatives in Sweden had presented any documented performance calculations on these benefits. As a response to the politicians, the county administrative board applied for, and received, funding from the Swedish energy council to determine the benefits from the MCC initiative. A research institute was approached to design and perform the evaluation.

Goods from product suppliers are delivered to the municipalities' service functions (e.g., schools and offices) via the MCC. A local LSP was given the assignment of operating the MCC and its outbound transports in the municipalities. During the time of the research institute's investigation, only food was distributed through the MCC. The three largest food suppliers were included in the measurement study. Other forms of product groups and suppliers have later been added. The MCC is coordinated by a mutual management organization that represents all of the involved municipalities.

The measurement approach was based on emission factors from the Handbook Emissions Factors for Road Transport (HBEFA, a bottom-up methodology) and data was captured from suppliers and the LSP. The inclusion of suppliers provided a uniqueness since other up-to-date estimations had failed to include the suppliers. However, the data from the suppliers was not estimated by the research institute but instead provided directly from the suppliers. This data included estimations of their deliveries before the MCC was implemented. Data from the LSP were captured directly with the use of measurement tools (e.g., fuel consumption, distance, speed, position and fill rates).

Besides direct costs connected to fuel usage, handling costs etc., external costs for the MCC were captured. This included costs for environmental impact, safety, and work environment. The external costs also required additional data regarding work environment at the receivers (i.e., the service functions). The results of the investigation presented a wide range of output variables:

- Regional and global aspects targeted energy usage, CO₂e (73% reduction), and NO_x (approximately a 70% reduction).
- Local aspects targeted outlets of particles (approximately a 70% reduction), traffic safety, and changed work environment.

In terms of quantifiable results, the investigation showed that the usage of fossil fuel dropped with over 70% whilst the vehicle-km dropped with 4%. It was suggested that reduction of fossil fuel was an effect of change to HVO-fuel (a 100% fossil free diesel) rather than a more efficient transport

system. However, this change was enabled due to the fact that the aggregated municipalities had better possibilities to procure sustainable transports. Notable is that the operating costs of the MCC greatly exceed the external costs.

5. Empirical Findings on Roles and Perspectives of Involved Actors

The structure of this empirical chapter is inspired by the activities in the environmental logistics performance management process (see Isaksson et al. [21]), adding aspects regarding the design of an overall measurement approach (e.g., [63]) and system limitations (e.g., [17]) to the activities relating to selecting variables and defining the metrics.

5.1. Selecting Approach, Limitations, and Variables

The selection and design of the overall approach was made by the research institute. Both the municipalities' respondents and the respondent from the county administrative board did refer to the research institute's special competence within this area and relied on them for selecting the best approach. The research institute had experiences based on similar estimations of other types of transport system and relied on this knowledge. No inspiration was found in the previous estimations of other MCC-initiatives, as these estimations were not based on real data (a statement in line with the findings of the initial internet search).

System limitations were suggested by the research institute and presented to the municipalities and the county administrative board who, after some discussions, accepted these. There was a discussion between the research institute and the municipalities in group meetings with the other actors. The scope of the discussions targeted different variables of the investigation and varied based on the phase of the investigation, as previously exemplified. The municipality only wanted an investigation of a system that laid within their own control. However, the wider perspective was finally accepted by the municipalities. The municipalities do not indicate a changed mindset when it comes to consider the consequences of implementing MCCs from a larger system perspective. They are interested in how the municipality can reduce their impact and create values for their employees and inhabitants, not how changes impact other actors, such as suppliers. This is seen as being outside their control and mission.

The broader investigation elicited different reactions once finished. Retailers and producers, being product suppliers to the municipalities' facilities, welcomed the investigation. One of the retailers had already carried out a pre-study as they were skeptical about the very positive outcomes that the municipalities presumed that MCC initiatives have. The criticism mainly concerned the too narrow system limitations applied, focusing only on the goods consumed by the municipalities and thereby sub-optimizing their logistics system causing the product suppliers to lose some of the large-scale advantages in their systems.

The type of input-variables in the measurement of the performance were also selected by the research institute based on what was needed, given the selected approach. The decision to carry out an estimation of the external costs was mutual as the municipalities, the research institute, and the county administrative board had an interest in gaining this information. The aspects to be investigate were decided by the municipalities to secure that these were aligned with the overall goal of the initiative. The research institute decided on the methodology. Furthermore, the need for sensitivity analyses were identified by the research institute who also decided on the parameters to test. It targeted the total quota between external costs and monetary costs for the MCC and altered the variables climate benefits, traffic safety benefits, and administrative cost for the MCC.

No other organization contributed or objected to the design during the measurement process. The explanation to this was that the research institute had, in the application to the Swedish energy council, been given the responsibility for the development and design of the approach.

5.2. Setting Targets

The municipalities decided on the overall outcome (result) variables of the investigation, which were in line with their overall aims when implementing the initiative. The research institute decided to

add energy use as one output to be estimated as they wanted to include an indicator for the efficiency of the system and thereby capture the impact from e.g., changed vehicle types and increased fill rates. Estimating the energy usage gives the actors a mutual understanding of the efficiency and the effect each actor contributes with to the system. Towards the end of the investigation, when the research institute presented their preliminary results, it became evident that the actors had somewhat different opinions as to whether the right outcome variables had been selected. While the research institute had focused on furthestmost regional and global aspects (e.g., energy usage, CO₂e, NO_x), the municipality called for additional results targeting more local aspects regarding the transport situation and the work environment as well as the positive results of increased information quality due to improved order and structure. Some of the municipalities did not get the evaluation expected as some result variables were not considered. They pointed at the need for further development of measurements to apply in the estimation of external costs as the initiative do not give full recognition to the benefits made. Raising the question: "How can the positive value of order and structure be estimated". Explanation to the late awareness of different targets that were addressed could be explained by the unclear communication of the type of output expected, and since responsible persons at the research institute changed over time.

The dialogue with the municipalities provided inspiration to some of the scenarios by sharing information regarding potential development strategies for the initiative. The results from the scenario studies have given the municipalities increased local acceptance among the politicians to further develop the initiative.

5.3. Measuring

The research institute collected the data from the different actors. The respondent at the research institute describes this as "being less problematic than we first thought it would be". The respondents at the county administrative board do however put forward that this was no easy task. While the logistics firm shared much of their information, the product suppliers were not as cooperative in providing data. This view is also expressed by the respondents at the municipalities. The researchers at the research institute were aware of the interests and situation of the different actors, which was an important point of departure when approaching the different actors with the question to contribute with data. This awareness was also taken into consideration when validating the trustworthiness of the input data from different actors. However, the research institute found no reason to question the data, as it was in line with their previous experiences from similar traffic situations and actors.

The respondent from the research institute put forward that the top-management at the logistics company played a very important role in order to gain acceptance for this crucial information. Using confidentiality agreements also facilitated the possibility to access data. However, one consequence of these agreements was that important input was to be excluded from the public report as well as the empirical investigation targeting roles and responsibilities.

The research institute stated that the data from the suppliers was hard to capture and therefore likely the one with the largest impact on the quality of the overall result. One reason to this was that the suppliers did not measure their performance for this limited system in isolation. The respondents at the municipalities are more skeptical to the accuracy of this data, as it was based on the product suppliers own estimated and aggregated data. Confidentiality agreements were also used to gain access to information from the suppliers, resulting in the inability to share any other form of underlying data, except from the information provided in their public report.

5.4. Results and Action

The result has played an important role within the municipalities to gain a continued support from the local politicians to carry on and develop the initiative. The county administrative board highlights the municipalities surprised reaction towards decreased emissions. The research institute state that the implementation of the MCC played an important role as it accelerated the update of the fuel applied, a change that otherwise would have taken approximately five more years. The respondents at

the coordination division agrees “Municipalities, as compared to most companies, do place higher demands on the logistics system and therefore accelerates the exchange to more renewable fuels”.

6. Analysis

Several municipalities provide information on e.g., their homepages regarding the benefits from implementing MCCs. The result variables are very similar between the initiatives studied (e.g., decrease in number of stops), indicating a different tendency compared to what e.g., Ahi and Searcy [49] found, regarding the variation in performance metrics applied in green supply chains. However, only one public document on the applied performance measurement approach was found. This is in line with earlier findings (see e.g., [12,34]) indicating the lacking documentation is still an important aspect to address when it comes to performance measurement within city logistics.

The exception is the studied case, with a report outlining the performance measurement process. However, this report provides limited input regarding the perspective and roles of the involved actors. One finding when empirically investigating the roles and perspectives more focused was that the research institute to a large extent had solely been designing the measurement approach, even if the approach was anchored and presented to the involved actors. One could question if not more actors ought to be involved, in line with suggestions from the green logistics measurement literature.

The full interests of the municipalities were not considered as some result variables were not addressed. To connect the measurement matrix with the goals of the different actors was put forward as one guiding principle in the framing of indicators by Cornet and Gudmundsson [50]. The more active inclusion of other organizations in the design phase of the measurement approach is also in line with the suggestion by Murfield and Tate [20], stating that successful environmental initiatives that spans over buyer-supplier relations, are dependent on the collaborative development of performance metrics. However, as the pre-results were not covering aspect put forward as important by the municipalities, the approach had to be adjusted and expanded in order to include this. Several parties have contributed with input data as well as the involvement of third-party expert, something put forward by the same authors as increasing the chances for successful initiatives. Furthermore, considerations have been taken to the stakeholders' different capabilities, mandates and constraints in the requirement and analyze of data, for example by applying available data-based technique to measure the transport distances, speed and routes, and giving the research institute the overall responsibility in designing the measurement framework as this was within their area of competence.

The involvement of several actors with different interests, resulted in a larger number of performance indicators and a more complex performance metrics covering several both local and global interests. However, the measurements selected and used in the evaluation are very much in line with those put forward in present literature (see e.g., [7,14,36,40]). However, the municipality's call for additional measurements targeting more local aspects regarding the transport situation, work environment as well as the positive results of increased information quality due to improved order and structure, do point at the need for also including more qualitative aspects to the equation, in line with Tundys and Wiśniewski [30] stating that sustainable performance measurement in supply chain should include qualitative indicators. Besides this, by considering energy usage, the efficiency of the system was targeted, adding the economic dimension to variables furthestmost aiming to capture the environmental and social consequences of the initiative. A holistic approach involving the three central aspects of financial analyses, traffic analyses, and environmental assessment is put forward by several researchers (e.g., [7,17,35]), but more seldomly applied in practice. This complex analyze shows that the system has furthestmost positive environmental consequences on local to global level. However, the efficiency of the system was not that improved, illustrated by e.g., the result that vehicle-km only dropped with 4%. This provides further support for the claims made by e.g., Browne, et al. [41] and Lin, et al. [42], that the implementation of UCCs is not always positive as the total distance travelled might increase. The evaluation of this initiative also added a clear strive to combine environmental, social, and economic measures, not only by addressing these dimensions in separation, but by calculating the external costs

of the environmental and social impact integrating these. In previous performance measurement of the benefits of UCCs, the use of external costs to capture these potentials are very seldomly applied [11]. Furthermore, the results gained from this evaluation did also provide the municipality the justification needed to further support develop the initiative, in line with the many reasons for measuring the sustainability of transport (see e.g., [29,30]).

This case shows that complexity is not only a matter of the number of performance indicators included but also system limitation and thereby inclusion of more actors delivering input data for the analysis. This study answers a call regarding the involvement of different actors in measuring (see e.g., [23,56]). The system limitation drawn can be described as a combination of two of the five potential limitations suggested by Benjelloun et al. [17]: the type of product and type of geographical coverage, as the consideration of development towards inclusion of more products and suppliers was included in the scenarios investigated. This also shows a larger inclusion of the city logistics from end-consumer to the producer, a problem seldom addressed in city logistics according to Russo and Comi [47]. Furthermore, including the suppliers in the measurement shows several similarities with including the third order external impact (see e.g., [63]) something very seldomly applied in the estimation on external impact of any city logistics initiative.

The study addresses the research gap regarding supply chain coordination for energy performance improvement [23], as well as providing new concrete examples of the struggles of including supplier and customer input (see e.g., [58]). This was made by putting forward aspects such as the need to understand the mindset and operations of different actors and demands regarding secrets. By using different methods to gain data and to adapt the methodologies to the different cultures of organizations and data types (such as surveys and follow up interviews to gain information from transport company) shows that there are ways to tackle misunderstandings and lacking data. Another interesting aspect with this case is that it uses a bottom-up approach even if the underlying purpose is to steer governmental decisions, indicating that this approach could be applied also from other actors' perspectives than e.g., companies and for other purposes.

7. Conclusions

This paper contributes insights to several areas where more research and knowledge is called for, such as performance measurement in the urban freight transport sector [14], as well as studying an initiative stimulated by the pressure put forward by governmental incentives [15], here in the form of a municipality, but also the Swedish energy agency and the county administrative board.

In order to carry out a deep evaluation of the external effects of implementing MCCs, the study indicates that more actors ought to be involved. These actors play different roles regarding e.g., the contribution of crucial information, and in facilitating the evaluation, see Table 3.

Existing MCC initiatives provide very little guidance regarding how the external impact can be estimated as well as the roles and perspectives of different actors. One exception is this case indicating the important and varying roles of actors to facilitate an estimation of the impact. This case study contributes to both practitioners and the research community by showing the importance of understanding the perspectives of involved actors. Some factors are identified that are key for this deep evaluation: clear demands from the local politicians, a clear interest and support from the county administrative board that also took lead in securing financing, a financier that saw the importance of developing proper measurement tool for real empirical data and the important guiding role of result variables from an MCC initiative, an independent research institute with researchers with a deep knowledge in measuring external impact from transport as well as an understanding of the involved organizations operations and contexts, municipalities able to anchor and provide incitement for e.g., their units to contribute with information regarding the experienced changes, a logistics company willing to share sensitive information on their routes, fuel consumption etc., and finally, the product suppliers, providing the information needed to gain a holistic understanding of the consequences for other actors when implementing MCC initiatives.

Table 3. Roles and Perspectives of the Involved Actors: A Summary.

Organization	Roles	Perspectives
Swedish Energy Council	Finance the cost for carrying out the performance measurement	The “customer” of the performance measurement study
County Administrative Board	Indicate the need for municipalities to carry out a deep evaluation on their initiative; Indicate the need for the development of a measurement approach	The need for increased awareness of the consequences of these initiatives on a more general level (i.e., less importance what city/region)
Local Authorities	Place demands on the performance indications and demonstration of results based on real empirical data	The efficiency of the MCC imitative in comparison with other potential initiatives they can implement in their cities
Municipalities	Inform receiving units about the initiative to gain acceptance; Decide on result parameters to be used in communication with e.g., local politicians in the argumentation of the future existence and development of the initiative; Secure that local interest of the municipality is taken under consideration; Communicate results to local politicians, provide a basis for future decisions regarding the MCC	Clear focus on local environment and social impact; Focus on actions and performance of which the municipality has mandate to control; Inclusion of qualitative measurements
Research Institute	Develop measurement designing including e.g., measurement indicators, scenarios, sensitivity analyses, system limitations etc.; Anchoring and gaining acceptance for the measurement design; Data collection and analyses; Documentation	Focuses local, regional, and global environmental impact; Focuses on quantitative performance indicators
LSP	Provide data by e.g., letting the research institute using their measuring equipment in the vehicles	A large strive to satisfy their customer (the municipality) and thereby contribute with necessary information
Product Suppliers	Provide data on their transport need before and after the initiative	How the implementation of the MCC system positively or negatively influenced the impact and efficiency of their operation

This do not only show the importance of accepting that performance measurement of this type of initiatives is not a “one actor show”, but dependent on the collaboration between several organizations. This study also shows the large dependence between actors, as the will to carry out the evaluation and participating with data as well as in the investigating gathering new data vary between actors.

Some more crucial factors have also been identified such as the important role of communication and the need to understand each other. Even if the municipalities had a clear vision of the kind of results they aimed for, this was not fully delivered by the research institute. Several tentative reasons to this mismatch could be found such as the municipalities being unclear in communicating their aim, the research institutes unwillingness to, in a very late stage of the process, develop and complement existing estimation approaches or the lack of data etc. Other struggles are the varying quality of the data from different actors as well as different methodologies used in the before and after analyses. Despite the varying quality of input data, exact output data are asked for, an equation that do not always end up nicely.

There is a need for more studies, furthermost empirically based estimations of the effects of these initiatives in order to increase the understanding of the underlying factors, such as the actors involved in the measurement process, influencing the sometimes positive and sometimes negative results when implementing this type of solutions.

Large improvement potentials regarding environmental impact as well as energy usage of UCCs are most likely to be found targeting aspects such as packing and loading of vehicles, inventory management, and modal split/change. Despite that mathematical modelling (e.g., optimization and simulation) is the most common method applied in journal articles focusing UCCs [11], these issues are likely of large interest for further research applying both qualitative and quantitative methodologies (see e.g., [65,66]).

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