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MODEL OF LOGISTICS SERVICE PROVIDERS TRANSITION TO "GREEN" SERVICES

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This paper presents a dynamic model for the transition of logistics service providers from traditional to green transportation services. Driven by regulatory requirements and increasing market demand for sustainable practices, the need for such a model is critical for logistics providers to manage the complexities and cost implications of adopting green technologies. Utilizing real-world data from a leading Baltic logistics provider, the model integrates both micro and macro-level factors, offering a decision-making tool that simulates various scenarios and fore-casts outcomes over a ten-year period. Key findings reveal that while green transportation costs are projected to decrease below traditional costs, demand for traditional services will persist, highlighting the need for a balanced approach in planning. This research contributes a novel framework that aids logistics providers in strategic planning and forecasting the evolution of green logistics, providing valuable insights into future trends in the industry

Keywords: Logistics services, sustainability, system-dynamics model

1. Introduction

In recent years, the logistics sector has faced growing pressure to adopt environmentally sustainable practices, driven by regulatory requirements and increasing consumer demand for green solutions. As key players in global supply chains, logistics service providers (LSPs) play a critical role in reducing the carbon footprint of transportation. However, the transition to green logistics presents challenges due to its complexity and associated costs. This study addresses the gap between the industry's environ-mental goals and the practical implementation of green logistics. While previous re-search has identified motivating factors for LSPs and customers, a comprehensive model to guide LSPs through the transition is still lacking. This research aims to fill that gap by developing a dynamic model that simulates the transition process, considering market demand, green technology costs, and company strategies.

The main objective is to develop an adaptable decision-making framework that enables logistics service providers to evaluate and strategically manage their transition from traditional to green logistics services, addressing the interplay of economic, regulatory, and market factors to forecast sustainable business outcomes. There is following hypothesis introduced: Green transportation service costs will become lower than traditional service costs within a decade due to technological advancements and market adaptation.

By simulating scenarios, the model helps predict outcomes of different strategies, enabling informed decision-making. The study introduces several innovations, including the integration of both micro and macro-level factors and the use of real-world data from a leading logistics provider in the Baltic market.

2. Literature review

In this chapter of the article a summary of conducted empirical literature review is provided. The main objective was to seek answers on two questions that are closely associated with this research and the model that will be further presented: What motivates logistics service providers to switch from traditional to "green" transportation services; What motivates customers to increase demand for "green" transportation services and lower demand for traditional services?

According to (Wehner *et al.*, 2021), logistics service providers (LSPs) are motivated to adopt green logistics practices primarily due to government regulations and the need to comply with stricter environmental laws. Additionally, improving customer relations, saving costs, and enhancing energy efficiency are key drivers. These factors push LSPs towards implementing green logistics to meet regulatory demands and customer expectations while also achieving operational cost savings. The study of (Centobelli *et al.*, 2020) highlights that organizational factor, including company size and financial status, significantly influence the adoption of green logistics. Pressure from customers and internal organizational support are also critical motivators. LSPs are driven by the potential for cost reduction and environmental protection, which are increasingly important for maintaining competitiveness in the logistics sector. Referring to (Lieb *et al.*, 2010), LSPs are motivated by both economic and regulatory pressures to improve energy efficiency. The study emphasizes that compliance with EU directives and the pursuit of competitive advantages, such as cost savings and enhanced customer relations, are significant factors driving the shift to green logistics. (Evangelista *et al.*, 2014) discusses the role of green logistics as a value-added service, where LSPs are motivated by the opportunity to gain a competitive edge. The increasing demand from customers for sustainable practices and the potential for cost reductions through improved energy efficiency are primary motivators for adopting green logistics. Martinsen *et al.* in (2014) identifies environmental sustainability as a critical success factor for LSPs, driven by increasing customer demand for green services and the need to enhance corporate image. The adoption of green logistics is further motivated by the potential for financial benefits, such as access to tax reliefs and subsidies. Isaksson *et al.* in (2013) suggest that LSPs are motivated to shift towards green logistics due to the need to comply with environmental regulations and the growing pressure from stakeholders to adopt sustainable practices. The study also notes that organizational encouragement and the accumulation of green technology expertise are significant internal drivers for this shift. (Browne *et al.*, 2011) reveals that customer pressure and regulatory compliance are major motivators for LSPs to adopt green logistics. Additionally, the desire to improve corporate social responsibility and to meet market demands for sustainability plays a crucial role in driving this transition. McKinnon *et al.* in (2004) suggest that the adoption of green logistics practices among LSPs is primarily motivated by the need to enhance energy efficiency and reduce greenhouse gas emissions. The study underscores those competitive strategies, such as improving customer satisfaction and achieving cost savings, are pivotal in motivating LSPs to shift towards more sustainable logistics operations.

All above mentioned studies collectively highlight that regulatory compliance, cost reduction, and customer pressure are the primary motivations driving LSPs towards green logistics, indicating a strong consensus on these factors across the studies. Most authors agree on the importance of energy efficiency and sustainability as competitive advantages that enhance corporate image and meet growing market demands. However, there are differences in emphasis: while some papers focus on external pressures such as regulations and customer demand (e.g., Wehner *et al.*, 2021, Cento-belli *et al.*, 2020), others highlight internal organizational factors, such as management support and innovation (e.g., Isaksson and Huge-Brodin, 2013). Contradictions arise regarding the degree to which customer demand is a driving force; some studies suggest it is secondary to regulatory pressure (e.g., Browne and Allen, 2011), while others argue it is increasingly central (e.g., Evangelista and Santoro, 2014). Overall, the studies converge on the idea that multiple, interrelated factors are pushing LSPs towards green logistics, though they differ on the relative importance of these drivers.

According (Hasanov, 2023) customers are increasingly motivated by regulatory pressure and the growing societal emphasis on environmental responsibility. They are demanding green transportation services as part of their broader corporate social responsibility goals, particularly to reduce their carbon footprints and enhance their brand image. The reduction of CO2 emissions and the alignment with global sustain-ability standards are significant factors driving this shift. (Bilek *et al.*, 2024) suggest that primary motivators for customers include the need to comply with stringent environmental regulations and the desire to maintain a positive corporate image. Additionally, customers are seeking to reduce operational risks associated with climate change by choosing logistics providers who offer green services. Cost savings related to fuel efficiency and long-term sustainability also play a crucial role. According to (Warren, 2012), customers are increasingly demanding green transportation services due to heightened awareness of the environmental impacts of logistics operations. The need to meet regulatory requirements and reduce greenhouse gas emissions is a strong motivator. Moreover, customers perceive green logistics to gain a competitive edge in markets where sustainability is becoming a key differentiator. (Shah *et al.*, 2021) suggest that environmental sustainability is becoming a central concern for customers, particularly in industries heavily scrutinized for their environmental im-pacts. Customers are motivated to demand green logistics to align with their own sustainability goals and to respond to pressure from stakeholders, including consumers and investors. This demand is also driven by the potential for cost savings through more efficient logistics operations. (Evangelista, 2014) reveals that the shift towards green transportation services is largely driven by customers' desire to adhere to environmental regulations and improve their market reputation. Customers are also motivated by the potential for innovation and cost efficiencies associated with green logistics, as well as the growing consumer demand for environmentally responsible practices. Martinsen *et al.* in (2012) suggests that the motivation for customers to demand green logistics services is tied to a broader corporate strategy aimed at reducing environmental impact. This includes minimizing carbon emissions and improving energy efficiency as part of a comprehensive sustainability approach. Customers also recognize the potential for long-term savings and risk mitigation through greener logistics solutions. According (Ellram *et al.*, 2016), customers are motivated by both external pressures, such as government regulations and consumer expectations, and internal corporate goals related to sustainability. The desire to enhance brand value and reputation, along with the need to comply with environmental standards, drives the demand for green logistics services. Additionally, customers see green logistics to innovate and differentiate themselves in competitive markets. (Fabbe-Coste *et al.*, 2016) claims that the demand for green transportation services is increasingly driven by customers' need to comply with environmental laws and to meet the rising expectations of stakeholders for sustainable business practices. The potential for cost savings through fuel efficiency and the ability to offer a lower carbon footprint to end consumers are also significant motivators.

All above mentioned papers collectively highlight that regulatory compliance, environmental sustainability, and corporate social responsibility are key motivators driving customer demand for green transportation services. A consistent theme across the studies is the importance of reducing carbon emissions and enhancing brand reputation as central factors in this shift. However, there are differences in emphasis: some papers focus more on external pressures such as regulations and consumer expectations (e.g., Bilek *et al.*, 2024; Ellram and Golicic, 2016), while others emphasize internal corporate strategies and long-term cost savings (e.g., Martinsen and Björklund, 2012; Evangelista, 2014). Contradictions arise in the weight given to in-novation and cost efficiency as motivators, with some studies viewing them as primary drivers (e.g., Shah *et al.*, 2021), while others see them as secondary to compliance and reputation concerns (e.g., Hasanov, 2023). Overall, the studies agree that a combination of regulatory, market, and strategic factors are pushing customers to-wards green transportation, though they differ on the relative importance of these drivers.

The analysis of the literature reveals that both logistics service providers and customers are motivated to adopt green transportation services due to external pressures such as regulatory requirements and stakeholder expectations, aligning these practices with broader corporate social responsibility goals. Environmental sustainability emerges as a core value for both parties, with cost savings from improved energy efficiency and reduced emissions serving as additional common motivators. However, distinct differences are observed: LSPs are primarily driven by the need to meet customer demands and remain competitive in a market that increasingly values sustainability, whereas customers are more focused on enhancing their corporate image and brand reputation, alongside the imperative to reduce their carbon footprint and comply with environmental regulations. This interplay between regulatory pressures, market demands, and the mutual goal of sustainability underscores the converging yet distinct motivations of LSPs and customers in the adoption of green logistics practices.

3. Research method and data collection

3.1. System dynamics approach and model development

The system dynamics approach effectively models logistics providers' transition to green vehicles, integrating complex factors and capturing feedback loops. It simulates scenarios to guide strategic decisions, assessing long-term sustainability and economic viability. This helps logistics providers adopt environmentally friendly practices, as shown in Figure 1 (causal loop diagram).

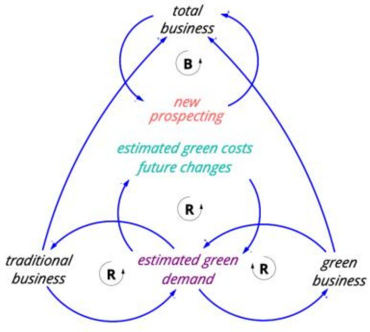

Figure 1. Causal loop diagram

This causal loop diagram demonstrates main indicators that are intended to be forecasted and studied by logistics service providers to support decision-making process related to green service implementation. It demonstrates relations between: Company's offering (red color); Market demand (purple color); Costs of green solutions (green color). By traditional business following is understood - gross revenue of a company generated using vehicles with internal combustion engines (petrol and diesel), including both own and subcontracted vehicles. Green business, however, is gross revenue generated using vehicles powered by alternative energy sources, including Electric vehicles; Hydrogen fuel cell powered vehicles; Compressed gas (CNG) and liquefied gas (LPG) powered vehicles.

Simulation is built around four main pillars which are: businesses (traditional, green and total); new prospecting; estimated green costs future changes; estimated green demand. There is one balancing loop (new prospecting increase total business, while increase of total business cause decrease of new prospecting), and three rein-forcing loops: estimated green demand negatively reinforced by estimated green future costs changes; estimated green demand negatively reinforced by traditional business changes; estimated green demand positively reinforced by green business changes. For practical modelling the authors used Vensim software.

The essence of the developed model is as follows. Model centers on a logistics ser-vice provider operating within a defined region or country. It begins with the prospecting phase, which represents the monthly acquisition of potential new businesses. This is determined by the company's commercial strategy, historical sales data, and marketing activities. Adjustments to prospecting activities depend on the achievement of budget targets, ensuring efficient allocation of resources without overspending. Pro-spected businesses, accumulated over tender durations, can result in losing deals or the addition of either traditional or green businesses. The split between traditional and green business growth is determined by the estimated green demand, which combines current green demand, year-over-year changes, and future green cost forecasts. Traditional and green business stocks grow through both prospecting and organic market growth, with renewals occurring annually based on contract durations and renewal ratios. Green business renewals are straightforward, with businesses either retained or dismissed. Traditional business renewals, however, involve additional complexity, as some renewals shift from traditional to green stocks depending on green demand and green cost dynamics. These costs, forecasted over 10 years, reflect the evolving market attractiveness of green logistics and are influenced by green vehicle market growth, maintenance cost differences, energy cost advantages, vehicle purchase costs, and economies of scale. The model integrates key indicators such as gain ratio (likelihood of winning new business) and renewal ratio (likelihood of retaining existing business) to simulate outcomes. The model's practical application, calibrated with real company data from the Baltic market, allows for scenario analysis to optimize decision-making in transitioning to green logistics solutions.

3.2. Format of formulas and figures

Sourcing of trusted information is crucial for reliability of the model. In scope of this research collection of data and information was carried out from multiple sources that can be practically divided into there are three main pillars, as show in Figure 2: market reports; published databases; company data. Under each pillar a list of variables is shown that were estimated based on collected data.

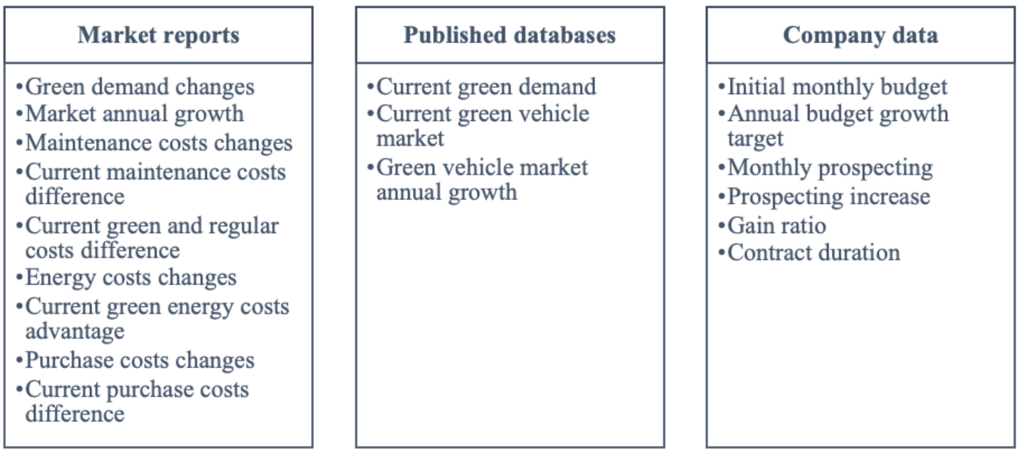

Figure 2. Data sources

Authors relied on several market research, such as GlobeNewswire, 2022; Medium, 2023; Mordor Intelligence, 2024; FN Research, 2024; InsightAce Analytic, 2024; Allied Market Research, 2024. Published databases (Kotlars *et al.*, 2023, Skribans *et al.*, 2024) were used to estimate such crucial indicators as current green demand, green vehicle market size and evolution. Eventually, company's data (global logistics service provider operating in Baltic market) was used to run simulation and conduct application of the model.

Analysing historical purchasing data and consumer behaviour trends through data mining techniques approach was used by authors of this article to define value of current green demand. According to authors, this approach can reveal patterns in demand for eco-friendly logistics. The data was collected from road freight service tender documents issued by various companies (primarily manufacturing) in Europe between 2019 and 2023 and obtained in cooperation with leading European 3PL service provider. There were multiple tender projects studied launched by 184 different companies, as shown in Table 1.

Table 1. Estimation of current green demand

Year	**Number of months**	**Number of analyzed tenders per year**	**Number of tenders with green request per year**	**Number of tenders with green request per month**	**Share of tenders with green request per month**
2019	12	166	33	2.75	19.88%
2020	12	167	36	3.00	21.56%
2021	12	183	41	3.42	22.40%
2022	12	153	31	2.58	20.26%
2023	5	145	25	5.00	17.24%

While analysing projects documentation, particular statements were extracted that describe following elements: the goal of a tender, logistics service provider selection criteria, requirements towards logistics service providers, and expectations concerning green logistics. Expectations concerning green logistics (Number of tenders with green request, as shown in Table 1) is indicator that demonstrates customers' interest in green logistics services. Average value of share of tenders with green request was used to define current green demand.

Another important indicator is green vehicle market and green vehicle market annual growth. Estimations were based on authors calculations (Skribans *et al.*, 2024) database that contains information about petrol, diesel, electricity, gas and hydrogen powered vehicles in Baltic market in 2023. According to simulation results of Carbon-neutral cars adoption simulation model (based on Skribans *et al.*, 2024), a proportion between traditional vehicle market (diesel and petrol) and green vehicle market (electricity, gas and hydrogen powered vehicles) can be estimated, as well as green vehicle market annual growth, from 0.21% in 2024 till 12.44% in 2034.

While these data sources are reliable and relevant to the study's objectives, certain limitations must be acknowledged. The geographic focus on the Baltic market may limit generalizability to other regions with different regulatory environments or market conditions. The sample size of 184 tenders, though robust for the European con-text, may not fully represent global logistics trends. Additionally, the green vehicle cost data relies on forecasts that may not account for unanticipated market disruptions. To address these limitations, sensitivity analyses were conducted to assess the model's robustness under varying assumptions. Furthermore, integrating multiple data sources reduced biases inherent in individual datasets. Future research could expand the geographic scope and incorporate additional data sources to further validate the findings.

4. Simulation results

After conducting calibration of the model and applying necessary parameters obtained from market reports and calculated by using data from published databases (described in Chapter 3.2 of this article), simulation of scenario was made by integrating data obtained from global logistics service provider operating in Baltic market. The indicators analysed by the authors as a result of the simulation are: Amount of traditional business and amount of green business (and proportion of these indica-tors); Estimated green costs future changes; Estimated green demand; New prospecting. Furthermore, sensitivity analysis of estimated green costs future changes and estimated green demand was conducted to assess total impact of influencing factors foreseen in the model. Figure 3 demonstrates amount of green and traditional businesses forecasted for 120 months (10 years), from 2024 until 2034.

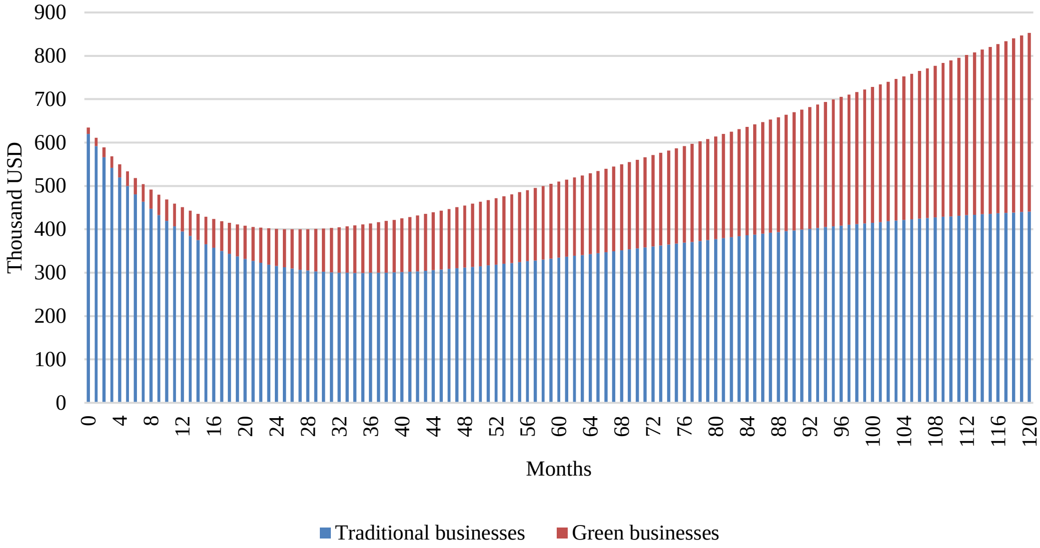

Figure 3. Simulation results of business volumes

According to data shown in Figure 3, in starting point amount of traditional business is equal to 620 thousand USD and green business – 15 thousand USD. There is a decline of total business visible until month 27, particularly due to significant drop of traditional businesses and low increase of green businesses. As it is shown in Table 2, there is negative impact of high green costs (estimated green costs future changes) that starts from 0.240 (it means that green transport services are estimated by be in average by 24% more expensive than traditional services) and is sustained at high level until end of year 3. After year 3 due to several factors (explained by green part of the model), there is decrease of estimated green costs forecasted that also make an impact of increase of green business share. Starting from month 28 there is positive trend of total business growth, particularly due to increased share of green businesses. By month 60 share of green business is forecasted to be at level of 34%, and by month 120 it is forecasted to reach 48.3%.

Table 2. Simulation results of parameters based on reference scenario

Year	**Month**	**Estimated green costs future changes**	**Estimated green demand**	**New prospecting (thousand USD)**
0	0	0.240	0.204	500
1	12	0.241	0.205	506
2	24	0.240	0.212	549
3	36	0.215	0.222	614
4	48	0.168	0.235	686
5	60	0.108	0.250	760
6	72	0.035	0.268	834
7	84	-0.050	0.288	909
8	96	-0.149	0.313	984
9	108	-0.267	0.341	1059
10	120	-0.405	0.376	1134

Based on forecasted data from Table 2, considering reference scenario values, estimated green costs future changes are forecasted to sustain at level above 20% until end of year 3. Starting from year 4 there is significant decrease forecasted, and after year 7 it is assumed that logistics service providers costs for securing green transportation services would be lower than costs of traditional service (negative indicator represents more beneficial conditions for green services). At the same time, estimated green demand shows that customer's interest in green services would demonstrate steady grow over 10 years, but demand for traditional services will be still sustained. According to authors, this indicator shall not be treated as mandatory substitution or replacement of traditional services. It shall be associated with other factors that are not included in this model, such as customers' awareness. Forecasted values of new prospecting suggest logistics service provider to strengthen sales and marketing activities to reach budget growth target. The simulation results also reveal significant trends and actionable insights for logistics providers navigating the transition to green logistics. While the cost of green services remains higher in the short term, the forecasted decline by 2030 suggests that early investments in green technologies could yield long-term cost advantages. Providers should consider leveraging these insights to design phased adoption strategies that align with both cost dynamics and market demand. The persistence of traditional business demand underscores the need for a balanced approach, where providers maintain competitive offerings in traditional logistics while progressively increasing their green service capabilities. For instance, the estimated green demand can serve as a strategic guide for sales and marketing teams to prioritize tenders with higher green logistics requirements. Additionally, the findings on tender success rates and renewal processes suggest that enhancing service quality and customer engagement will be critical in retaining and growing green business volumes.

Figure 4 demonstrates results of sensitivity analysis of new prospecting, estimated green costs future changes and estimated green demand. In takes into consideration cumulative impact of such input factors, as changes of company's initial monthly budget (between 300 and 800 thousand USD), annual budget growth target rates (between 0.05 and 0.20), and prospecting increase rate (between 0.05 and 0.35).

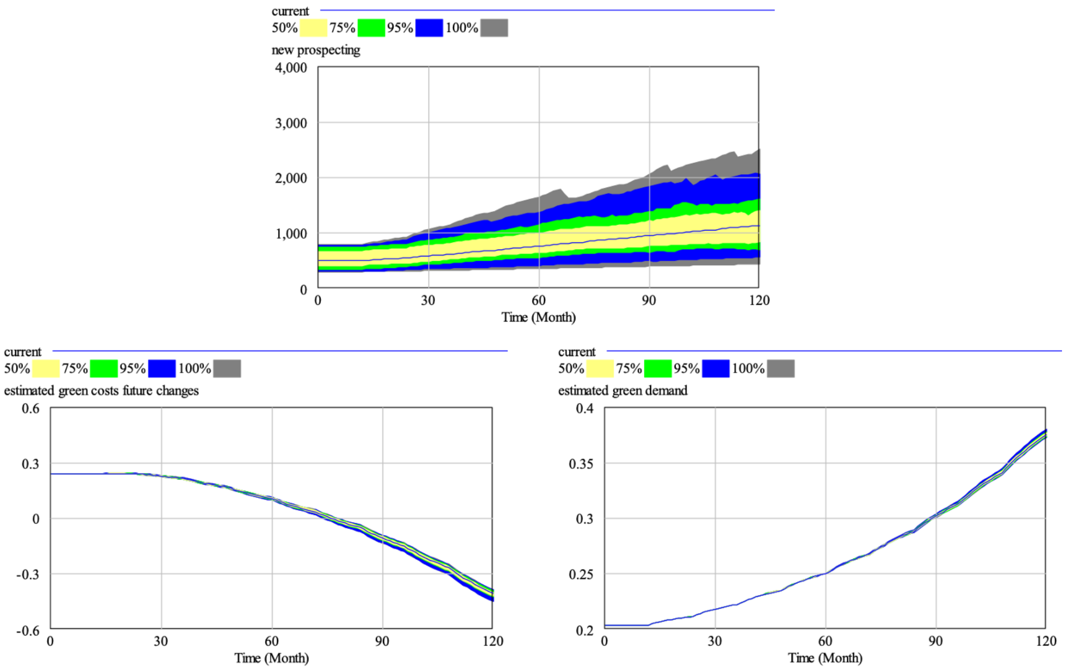

Figure 4. Sensitivity analysis

New prospecting over a 120-month period, showing a steady growth trend with in-creasing uncertainty over time. Initially, the projections demonstrate narrow variability, with confidence bands (50%, 75%, 95%, and 100%) closely aligned, reflecting high confidence in short-term outcomes. However, as time progresses, the bands widen significantly, indicating greater uncertainty in long-term projections. This suggests that while median projections show consistent growth in prospecting efforts, logistics service providers should account for a broad range of possible outcomes and maintain flexibility in their sales and marketing strategies to adapt to changing conditions and mitigate risks associated with this variability. Estimated green costs future changes decline steadily over time, with the median following a smooth downward trend. The variation or spread between upper and lower borders of the interval in-creases over time, which may indicate increasing uncertainty in the model as the projection period extends. The sensitivity bands (especially the 95% and 100%) indicate a wider range of potential outcomes toward the end of the simulation. Looking at estimated green demand, there is a steady increase visible in green demand over time, with the median following a clear upward trend. The variability or uncertainty represented by the sensitivity bounds remains relatively small but slightly widens as time progresses. This suggests a consistent increase in green demand, with some uncertainty introduced later in the time horizon (closer to 120 months).

5. Conclusions

Based on the empirical literature review, both logistics service providers and customers are motivated to adopt green transportation services due to such factors, as regulatory requirements and stakeholder expectations. However, there are also several differences in motivations observed, for example, logistics service providers are initially driven by the need to meet customers' demands and remain competitive in a market, while customers are more focused on enhancing their corporate image and brand reputation.

Model of logistics service providers transition to "green" services proposed by authors aims to support management of logistics service providers and was developed considering logistics providers market knowledge and experience and supported by industry data.

By integrating company's actual data, this model can support logistics service providers in planning of customer prospecting activities, and forecasting market prices changes and customers' "green" demand evolution.

It must be considered that this model cannot predict exact level of "green" transport service costs, exact customer's demand for "green" services, however, what is important, that it can provide overall trend and development direction of above-mentioned aspects, if model is provided with the data of particular logistics service provider's commercial and operational activity.

As a result of simulation based on data from global logistics service provider operating in Baltic market, while share of green vehicles in the Baltic market is estimated to reach 12.44% by 2034, share of green businesses of particularly considered logistics service provider could reach 48.3%, assuming current market forecasts, such as cost difference between "green" and traditional services, maintenance cost difference, and purchase cost difference.

Based on results of simulation, "green" transportation service costs will eventually become less than traditional costs in the Baltic market after year 2030 and this trend is likely to be continued in future.

Regardless cost advantage of "green" transport services over traditional services, based on the model's estimations, demand for traditional services will remain at high level by 2034, therefore, it requires more in-depth study to consider other aspects that influence customers' demand apart from transportation costs.

Recommendation for logistics service providers is the following.

One key recommendation for logistics companies is to adopt a phased approach to green logistics. The model's projections of decreasing green costs over the next decade suggest that companies should begin with a hybrid strategy, maintaining a balance between traditional and green logistics services. As green costs become competitive with traditional options, companies can progressively increase the share of green services, ensuring a smooth and cost-effective transition.

Targeting high-demand segments is another actionable strategy. The model identifies trends in estimated green demand, enabling logistics companies to focus their prospecting efforts on customers and tenders with a higher likelihood of requiring green services. Tailoring marketing campaigns to emphasize the environmental and cost-saving benefits of green logistics can further enhance tender success rates and strengthen customer relationships.

The model's insights into cost trends, including energy, maintenance, and vehicle purchase costs, provide a basis for strategic decision-making. Logistics companies should monitor these forecasts closely to identify the optimal timing for fleet up-grades and green technology adoption. Leveraging cost advantages as they emerge can enhance competitiveness and profitability.

Further studies are needed to better understand customers' motivation and future trends of "green" demand evolution. In this model "green" demand was forecasted using report from the study based on analysis of procurement documentation that reflects current stage of the market; however, authors believe that wider scope of aspects must be studies to define future "green" demand trend.

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