The Forecasting Accuracy in the UK Food Logistics-Two System Drivers to Meet the 2050 Net-zero Goal

Yiru Lang
The University of Manchester, Manchester, The United Kingdom;
Email: yirulang@outlook.com

***Abstract*—Recently, the UK government passed legislation that introduces the 2050 net-zero goal, as well as the recent pandemic and net-zero emission targets that call for revolutions in the transportation logistics system. Forecasting dedicates to accurately predict in demand management, production planning, and transportation route optimization to contribute to a better transportation logistics system. Therefore, we must address the importance of forecasting in designing a proper transportation logistic system to achieve a net-zero future, and the food industry is worth discussing in this case. Two system drivers of forecasting accuracy are identified for the 2050 net-zero goal: the end-to-end collaborative logistic system, and the uncertainties addressed by the innovative forecasting tools, respectively document the importance of information flow and the necessity of an innovative subjective forecasting approach to meet the 2050 commitment.**

***Keywords*—2050 net-zero goal, supply chain logistics, forecasting accuracy, food industry, technology applications**

I. Introduction

UK is the first active big economy to strongly support the net-zero target by approving net-zero emission law, which 2050 net-zero emission aims to balance greenhouse emissions according to the environment's tolerance to CO_2 emission and achieve carbon neutrality (GOV.UK, 2022). Department for Transport (Department for Transport, 2020) states that transport keeps ranking as the first largest source of the UK's CO_2 emission in 2018 (28% of total CO_2 emission) and 2019 (27% of the total CO_2 emission). The tone-kilometer (tkm), which stands for the amount of goods transported per tone, has increased by 1% and reached 196 billion tkm since 2018. These statistics score the importance of revolutionizing the transport sectors to reach the net-zero emission target.

According to the recent COVID-19 pandemic, freight travel has been especially pressured to supply food demands, which are essential necessities. However, the travel restrictions and social-distancing regulations have plagued the transportation logistics system and caused a significant loss of fresh goods. Therefore, the pandemic stresses the importance of the transportation logistics system of the food industry.

Manuscript received January 7, 2023; revised February 27, 2023; accepted March 15, 2023.

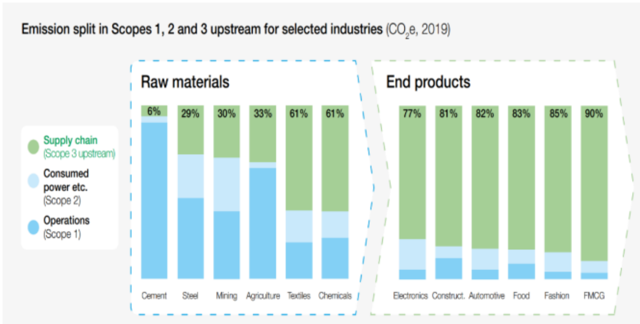

Figure 1. Emissions split in Scopes 1,2, and 3 upstream for selected industries (BCG and World Economic Forum)

Furthermore, as stated by World Economic Forum, the food industry has significant emissions in its supply chain (scope 3), of which most of its upstream suppliers are geographically dispersed. Thus, the greenhouse emission is substantial to notice by its worldwide transportation. Nestlé UK's Nescafe factory based in Derbyshire UK, outsources the Arabica coffee beans from South America for good coffee bean qualities (Nestlé, 2020). Moreover, Mark and Spencer (M&S) have a complex and globalized food supply chain in which M&S sources raw materials from over 70 countries and cooperates with multinational suppliers from 44 countries of more than 800 production sites M&S (2021). These two pieces of evidence of the food supply chain would result in significant transportation across the continents and produce substantial greenhouse emissions.

According to the food industry as an example, the pandemic and greenhouse gas emissions severity call for a reformation of the transportation logistics systems. Indeed, forecasting accuracy is critical to improving the overall capability of the transportation logistics system Hyndman and Athanasopoulos (2013). Forecasting is a series of processes of predicting, planning and balancing the demand and transportation of inventories in every production stage to meet the company's strategic and operational goal. Therefore, forecasting can thoroughly and effectively enhance the transportation logistics system to best optimize and utilize the available resources from multiple processes and achieves the logistic goals at a possible lowest cost of emission.

doi: 10.18178/joams.11.2.44-49

II. Identify the Two System Drivers

As discussed above, forecasting accuracy is beneficial to constructing the transportation logistics system considering the net-zero target. Still, one might ask what things are critical to achieving forecasting accuracy. In this case, two system drivers are identified as end-to-end collaborative thinking and the uncertainties to be addressed in the innovative forecasting tools.

A. The End-to-end Collaborative Thinking

Forecasting activities in the supply chain are a series of plans and alignment across the procurement, production, distribution, and sales rather than a single factor issue (Mentzer and Scheroeter, 1994). From a supply chain perspective, transportation connects the necessary procedures in the supply chain from the origin of raw materials to the end-users and moves inventories efficiently to the next stage (Tseng *et al.*, 2005). Therefore, end-to-end thinking in the transportation logistics system is essential to increase forecasting accuracy on transportation. Improving forecasting accuracy is a multi-dimensional matter instead of a single factor issue, and end-to-end collaborative planning is proposed to be the first system driver.

1) Information translation into the transportation planning

As the end-to-end supply chain thinking suggests, operational considerations which drive product flows should factor in the forecasting accuracy of the environmental implication. In operational regards, demand forecasts and production forecasts are essential to improve overall forecasting accuracy (Hart *et al.*, 2013). General speaking, the transportation forecast is the next step of the demand and production forecasts that focuses on anticipating how many travelling capacities we need to support the production plan we have in place. Capacity requirements are translated from resource requirements, logistic requirements, and transportation requirements, and it is not straightforward to conduct River Logic (2021). Thus, it is critical to translate the information from demand forecasting effectively and production forecasting to avoid empty running and delayed shipping. From the food carrier's perspective, they work with many shipping companies worldwide. It is difficult to accurately achieve prior forecasting and visibility about their client's transportation requirements in this vast network. The transparency of information flow would improve forecasting accuracy by 25% (Pedersen, 2021). The information is inefficient in translating into a practical format to be readable to the users. Thus, it is hard to match the client's requirement to the carrier's capacity.

However, most companies do not realize the importance of information translation in transportation planning, and this problem is prominently evident in COVID-19. For example, perishable food requires highly efficient transportation capacity management in a temperature-controlled environment, increasing transportation difficulty (Sarıbardak and Security, 2020). Moreover, people especially demand significantly perishable food such as meat, vegetables, and fruit during the pandemic; therefore, it is not easy for cold chain logistics to abate its CO_2 emissions. Hence, perishable food transportation logistics should consider the recent literature's recommendation. The literature documents the difficulty of information sharing and integration mismatch between the shipping requirement and transport capacity within the perishable supply chain logistics and recommends the perishable product industries emphasize information sharing (Davey, 2020). In this case, the perishable food industry should utilize every transportation capacity to minimize its CO_2 emission by adopting end-to-end information sharing.

These conditions allow a collaborative forecasting system to better guard companies from fluctuating demands and transportation restrictions. A forecasting system that successfully translates information from demand and production departments would minimize the loss of unsold perishable food and reduce unnecessary shipments to meet the net-zero emission target. For example, M&S experienced a large amount of food waste in 2019 Christmas with congestions of undelivered food products due to the immature supply chain logistics management (Davey, 2020). Therefore, M&S initiated their Vangarde food supply chain program in York and dedicated it to priorly optimizing transport capacities during seasonality such as Christmas, Black Friday, and Easter. M&S Vangarde food supply chain program enables a collaborative effort in its supply chain to encounter sudden demand growth without increasing the frequency of transportation operations. Instead, information flows to its suppliers, forecasting, logistics, and stores allow M&S to optimize routings with the lowest CO_2 emission.

Capacity planning should react with the new net-zero commitment, suggesting that only the necessary shipments should be made with the proper weight of products on each truck, train, or ship. The weight of each transport contributes directly to the significance of CO_2 emission (Piecyk and McKinnon, 2010; Department for Transport, 2020), so the demand and production departments should only put the necessary amount of products on each shipment instead of putting as much inventory as possible. In a collaborative forecasting system, this is possible to achieve by optimizing the weight of each transport at the most economical cost in coordination with upstream demand and production information. The requirements of the new capacity planning mark the significance of collaborative forecasting thinking with a good ability to translate upstream information into the transportation logistics.

2) Technology

As stated by the collaborative thinking of transportation logistics, key upstream information from demand and production should be effectively validated by translating to the transportation capacity planning to improve forecasting accuracy towards a net-zero future. So one might ask what things should be done to address the problem of information translation.

Artificial Intelligence (AI): Over the years, potential forecasting tools are progressing with evolving technologies to remedy and improve transportation logistics systems by inputting valuable data from the very start (Speranza, 2018). AI is popular nowadays, and the supply chain logistics sector looks forward to its promising application to address different problems. AI functions to exchange information to ensure continuous flow in supply chain management (Japtap *et al.*, 2020). In this respect, AI can recognize, match, and align incompatible data across the supply chain departments. Specifically, predictive AI finds the cause-and-effect relationships within the demand and production forecasts and translates this information into a single and consolidated form for the transportation department (Japtap *et al.*, 2020). With AI implemented in the forecasting processes, information translation is achieved and improved to information unification (Traasdahl, 2020).

Internet of Things (IoT): Food logistics 4.0, according to Jagtap *et al.*, (2020), suggests multi-dimensional management of the food supply chain logistics supported by cyber-physical systems. They further indicate that reducing carbon emissions is a highly possible bonus from the collaborative and high-technological feature of food logistics 4.0. For instance, the internet of things is critical to addressing real-time information sharing, allowing end-to-end objects to interact to pass information to the transportation logistics system and jointly produce less carbon emission in the transport channels. As Fig. 2 shows, IoT in the truck allows real-time information gathering and monitoring of the food status, thereby providing sufficient data to the forecasting processes and reducing overall circulation time. Furthermore, with IoT and AI implemented in food logistics, smart technologies can calculate the weight of each transportation from the tire pressure sensor and brake sensor for addressing the net-zero emission target, thereby adding a bonus to the high-tech implementations.

It is not the far future that smart technologies will help transportation logistics with innovative digital solutions to address the net-zero emission commitment (World Economic Forum, 2021). Smart technologies like AI and IoT facilitate real-time information exchange in a readable form to all departments, thereby allowing end-to-end collaborative forecasting along with the transportation logistics system.

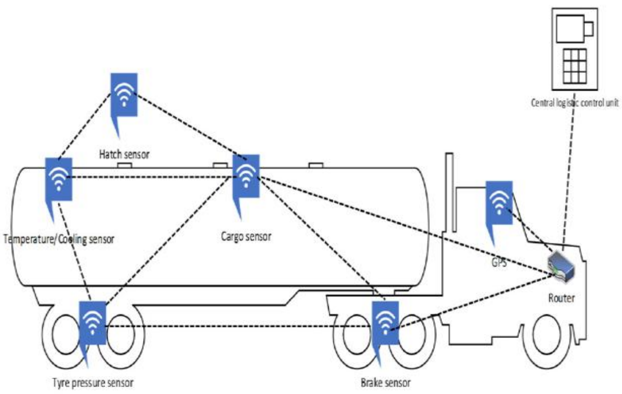

Figure 2. IoT powered food haulage truck (Japtap *et al.*, 2020)

B. Uncertainties in the Innovative Forecasting Tools and Methods

Information flow in an end-to-end collaborative transportation logistics system is critical to determining the forecasting accuracy under the net-zero emission commitment. Smart technologies are expected to tackle the problems of information translation, thereby facilitating the construction of the collaborative system. However, the details of forecasting tools and methods are neglected to address the net-zero emission target. In this case, forecasting tools should be able to cope with the emerging uncertainties and changes over time; therefore, the second system driver of uncertainty in innovative forecasting tools and methods is identified.

1) Limitations of time-series analysis

The problem with a traditional transportation forecasting system is that it follows the orders from the ERP system to coordinate the overall supply chain planning and generate shipments sequentially, lacking the flexibility to deal with changes and uncertainties (Gonzalez, 2013). In general, the food industry uses traditional transportation logistics methods, continually adopting time-series analysis based on historical information and relationships. However, this forecasting method ignores changes and uncertainties over time, thereby only accounting for the outdated information which does not fit in the current context.

Forecasting varies in short-term, medium-term, and long-term forecasting, focusing on different strategic purposes with different lengths of time horizons. The food industry usually starts with weekly demand forecasting to plan the raw material purchase and align the following production and transport operations (Paták and Vlckova, 2012). However, it was found that the weekly demand forecasting only takes the previous week's sales data into account, which lacks the consideration of changes and uncertainties. Therefore, more advancing forecasting tools and methods are called to address the current net-zero emission target.

2) CPFR

As the first system driver suggested, a collaborative effort from all critical supply chain departments contributes to forecasting accuracy. Therefore, the Collaborative Planning, Forecasting and Replenishment (CPFR) strategy seems to fit the concept of end-to-end forecasting. CPFR can be validated by the technology implementation discussed above and can integrate the forecasts of transportation logistics systems by jointly planning forecasting activities from demand and production actors and therefore improving the forecasting accuracy (Lusiantoro *et al.*, 2018).

However, even though CPFR takes collaborative forecasting into account and facilitates information flows along with the supply chain enterprises, it still poses several challenges to serve the current global disruption by the recent turbulence of uncertainties. First, CPFR has limited adaptivity to uncertainties because any amendments to CPFR require executive sponsorship (Kluwer, 2019). Second, CPFR is built upon several enterprises and manifests complex relationships in the logistics network. Hence, any changes made to the CPFR would trade off the interests within the network.

3) Scenario planning

Furthermore, scenario planning is one of the subjective forecasting approaches which can account for the uncertainties regarding the current situations, and this forecasting tool also engages multifaceted users by facilitating their communication and collaboration (Önkal *et al.*, 2013). This helps companies to prepare various plans to encounter different uncertainties in different scenarios. Especially under the joint pressure of COVID-19 and the net-zero target, scenario planning can help the food industry prepare for the challenging management of the transportation logistics system by producing what-if planning.

The future of food: The food industry is driven by multifaceted factors around environmental, economic, and societal externalities and is highly dependent on the vivid transportation logistics system (Benton, 2019). The recent pandemic has weakened the food industry because of transportation restrictions, and the food industry saw unprecedented challenges in the transportation logistics system. Besides, the net-zero emission target casts other constraints and uncertainties on the food industry. In this aspect, scenario planning is helpful to give several possible scenarios for these megatrends, and also qualitatively account in the food industry's most updated contextual uncertainties in the forecasting, thereby increasing the forecasting accuracy (World Economic Forum, 2017).

Bringing in the driver-driven forecasting: As discussed above, traditional forecasting tool such as time-series analysis and CPFR has limited implications nowadays. Therefore, the subjective approach of scenario planning is more effective in examining the rising uncertainties given the recent pandemic and environmental concerns. Given the current data availability and smart technologies, Bartman *et al.* (2020) suggest that combining scenario planning with driver-based forecasting can make forecasts more robust in response to emerging uncertainties. They also propose that the recent pandemic has a much longer recovery period than the previous disruptions and hence has invalidated many complex forecasting models as more errors occur due to the unprecedented and overwhelming uncertainties.

Sub-driver 1: The electric freight vehicles (EFVs): Indeed, more uncertainties about the transportation logistics system's restructuring towards net-zero emission arise and expect to be addressed by the ideal forecasting tools. Alternatives of transportation equipment such as electric freight vehicles are promising to address the environmental problems arising from freight transportation. However, there are many uncertainties regarding this new vehicle type that is hard to predict. The uncertainties of the EFVs should be considered in the forecasting process and therefore increase the forecasting accuracy. In detail, EFV's uncertainties include weather and road conditions, and most predominantly, the unstable new energy consumptions (the rolling friction, the travel speed, the temperature, air drag, and air density (Pelletier *et al.*, 2019).

For example, Piecyk and Mckinnon (2010) document three scenarios to assess CO_2 energy consumption: business-as-usual (BAU), optimistic, and pessimistic. This subjective forecast is handy to display the likelihoods made by the new energy; however, it neglects driver analysis. In this case, Bartman *et al.* (2020)'s method can address this issue by forecasting with the identification of uncertain drivers and what-if scenarios. Assessing EFVs and justifying their validations are a "must" while forecasting the scenarios for net-zero emission. This would accelerate the EFVs application in the transportation logistics system, thereby achieving environmentally-friendly freight transport as soon as possible.

Sub-driver 2: Total cost of ownership (TCO): The other significant uncertainty regarding the 2050 transportation logistics system is the initiation cost and the subsequent costs. As documented by much literature, EFVs and new energy are expensive, and we doubt whether investing in these novel vehicles consumes new energy (Juan *et al.*, 2020); Piecyk and Mckinnon, 2010). Hence, the TCO method should be included in the forecasting tool to justify the value of EFVs and identify the worthiest investment that accelerates the transportation logistics system's adaptation to the 2050 net-zero emission target (Degraeve *et al.*, 2000). With help from scenario planning, TCO acts as a driver to serve Bartman *et al.* (2020)'s forecasting method to improve accuracy in forecasts. TCO is also available to identify the effectiveness of the first system driver–end-to-end collaborative logistics forecasting. Building a well collaborative logistics forecasting system requires technology investment, and therefore, TCO can assess the cost of building collaborative logistics forecasting and justify its worthiness as well.

III. Conclusion

The UK's net-zero emission commitment would revolutionize the way the transportation logistics system operates. As a result, forecasting plays an integral role in achieving this environmentally friendly goal. Two system drivers were identified based on examples from the food industry: end-to-end collaborative thinking in transportation logistics uncertainties in innovative forecasting tools. These two system drivers affect forecasting accuracy in different aspects. In the first place, collaborative thinking suggests that all parties involved in the supply chain contribute to the transportation logistics system through effective information exchange, particularly demand and production. This will enable us to achieve both efficiency and environmental impacts. Second, subjective scenario forecasting is necessary to consider the significant uncertainties in light of two major megatrends: the pandemic and the net-zero emission target, and the sub-drivers of EFV and TCO are discussed in Bartmen *et al.* (2020)'s study.

However, this study does not provide any practical implications for forecasting food logistics in the UK.

Rather, it contributes to identifying critical trends in research. As Sodhi *et al.* (2022) suggest, real-world technology implementations do not perform according to expectations. In the case of practical applications, vendors can worsen the situation if they insist on fixed goals, affordances, and constraints when selling novel technologies. Despite theoretically addressing the two system drivers, future studies should consider practical factors such as policy, network design, and supply chain collaborations to improve forecasting accuracy in UK food logistics.

Conflict of Interest

The author declares no conflict of interest.

Author Contributions

Yiru Lang individually conducted all of the research tasks in this paper; Yiru Lang had approved the final version.

References

Bartman, T. *et al.* 2020. *Approach to logistics forecasting | McKinsey*. Available at: https://www.mckinsey.com/industries/travel-logistics-and-infrastructure/our-insights/a-fresh-approach-to-logistics-forecasting-in-2021 (Accessed: 28 May 2022).

Benton, T. G. 2019. Using scenario analyses to address the future of food, ***EFSA Journal***, 17(S1): e170703. doi: https://doi.org/10.2903/j.efsa.2019.e170703.

Davey, J. 2020. *Haunted by Christmas past, Britain's M&S tackles food waste | Reuters*. Available at: https://www.reuters.com/article/us-m-s-food-waste-idUSKBN26W085 (Accessed: 29 May 2022).

Degraeve, Z., Labro, E. and Roodhooft, F. 2000. An evaluation of vendor selection models from a total cost of ownership perspective', ***European Journal of Operational Research***, 125(1): pp. 34–58. doi: 10.1016/S0377-2217(99)00199-X.

Department for Transport. 2020. Transport Statistics Great Britain 2020, p. 6.

Gonzalez, A. 2013. Revisiting Transportation Forecasting, ***Talking Logistics with Adrian Gonzalez***, 21 May. Available at: https://talkinglogistics.com/2013/05/21/revisiting-transportation-forecasting/ (Accessed: 28 May 2022).

GOV.UK (n.d.) ***UK Becomes First Major Economy to Pass Net Zero Emissions Law***, *GOV.UK*. Available at: https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law (Accessed: 26 May 2022).

Hart, M., Lukoszová, X. and Kubíková, J. 2013. ***Logistics Management Based on Demand Forecasting***, p. 10.

Hyndman, R. J. and Athanasopoulos, G. 2013. ***Forecasting: Principles and Practice***, p. 504.

Jagtap, S. *et al.* 2020. Food Logistics 4.0: opportunities and challenges, ***Logistics***, 5(1): 2. doi: 10.3390/logistics5010002.

Juan, A. *et al.* 2016. Electric vehicles in logistics and transportation: A Survey on emerging environmental, strategic, and operational challenges, ***Energies***, 9(2): 86. doi: 10.3390/en9020086.

Kluwer, W. 2019. *Collaborative Planning Forecasting and Replenishment (CPFR) 101*, *Vanguard Software*. Available at: https://www.vanguardsw.com/resources/blog-newsletter/collaborative-planning-forecasting-and-replenishment/ (Accessed: 30 May 2022).

Lusiantoro, L. *et al.* 2018. A refined framework of information sharing in perishable product supply chains, ***International Journal of Physical Distribution and Logistics Management***. doi: 10.1108/IJPDLM-08-2017-0250.

Lyu, J., Ding, J. H. and Chen, P. S. 2010. Coordinating replenishment mechanisms in supply chain: From the collaborative supplier and store-level retailer perspective, ***International Journal of Production Economics***, 123(1): 221–234. doi: 10.1016/j.ijpe.2009.07.017.

Mentzer, J. T. and Scheroeter, J. 1994. *Integrating logistics forecasting techniques, systems, and administration: The multiple forecasting system-ProQuest*. Available at: https://www-proquest-com.manchester.idm.oclc.org/docview/212589367/fulltextPDF/7A8E0FC702CB4B14PQ/1?accountid=12253 (Accessed: 31 May 2022).

M&S. 2021. *Supplier Management*, ***Supplier Management***. Available at: http://corporate.marksandspencer.com/sustainability/food-and-household/supplier-management (Accessed: 28 May 2022).

Nestlé 2020. ***Nestlé supply chain disclosure: Coffee***. Nestlé

Önkal, D., Sayım, K. Z. and Gönül, M. S. 2013. Scenarios as channels of forecast advice, ***Technological Forecasting and Social Change***, 80(4): 772–788. doi: 10.1016/j.techfore.2012.08.015.

Paták, M. and Vlckova, V. 2012. ***Demand Planning Specifics in Food Industry Enterprises***, p. 1175. doi: 10.3846/bm.2012.150.

Pedersen, J. T. 2021. *How to Achieve Transparency and Traceability in Logistics*. Available at: https://www.mixmove.io/blog/how-to-achieve-transparency-and-traceability-in-logistics (Accessed: 25 May 2022).

Pelletier, S., Jabali, O. and Laporte, G. 2019. The electric vehicle routing problem with energy consumption uncertainty, ***Transportation Research Part B: Methodological***, 126: 225–255. doi: 10.1016/j.trb.2019.06.006.

Piecyk, M. I. and McKinnon, A. C. 2010. Forecasting the carbon footprint of road freight transport in 2020, ***International Journal of Production Economics***, 128(1): 31–42. doi: 10.1016/j.ijpe.2009.08.027.

River Logic. 2021. *9 Supply Chain Planning Software Capabilities to Consider for 2022*, *Supply Chain Brief*. Available at: http://www.supplychainbrief.com/?open-article-id=16156970&article-title=9-supply-chain-planning-software-capabilities-to-consider-for-2022&blog-domain=riverlogic.com&blog-title=river-logic (Accessed: 28 May 2022).

Sarıbardak, E. and Security, R. 2020. *How to Transport Perishable Goods with Cold Chain Management Systems*, ***Food Logistics***. Available at: https://www.foodlogistics.com/transportation/cold-chain/article/21197731/rewire-security-how-to-transport-perishable-goods-with-cold-chain-management-systems (Accessed: 29 May 2022).

Sodhi, M. S., Seyedghorban, Z., Tahernejad, H., Samson, D., 2022. Why emerging supply chain technologies initially disappoint: Blockchain, IoT, and AI. ***Prod. Oper. Manag.*** 31, 2517–2537. https://doi.org/10.1111/poms.13694

Speranza, M. G. 2018. Trends in transportation and logistics, ***European Journal of Operational Research***, 264(3): 830–836. doi: 10.1016/j.ejor.2016.08.032.

Traasdahl, A. 2020. *How A.I. and Analytics are Changing Fresh and Perishable Food Forecasting | SupplyChainBrain*. Available at: https://www.supplychainbrain.com/blogs/1-think-tank/post/31411-how-ai-and-analytics-are-changing-fresh-and-perishable-food-forecasting (Accessed: 29 May 2022).

Tseng, Y. Y., Yue, W. and Taylor, M. 2005. The role of transportation in logistics chain, ***Proceedings of the Eastern Asia Society for Transportation Studies***, 5: 1657–1672.

World Economic Forum. 2017. *Shaping the Future of Global Food Systems: A Scenarios Analysis*, *World Economic Forum*. Available at: https://www.weforum.org/whitepapers/shaping-the-future-of-global-food-systems-a-scenarios-analysis/.

World Economic Forum. 2021. Net-Zero Challenge: The supply chain opportunity. Available at: http://www3.weforum.org/docs/WEF_Net_Zero_Challenge_The_Supply_Chain_Opportunity_2021.pdf.