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An Evaluation of Ireland's Sustainable Freight Transport Policy

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Abstract: *Background*: The Irish government has put forth sustainable transport policy measures, yet the emphasis is mainly on the active travel and sustainable mobility for passenger transport. Contrariwise, freight transport has not received equal consideration in policy measures, regulatory frameworks, and support schemes towards the low-carbon transition. This study seeks to address this imbalance. *Methods*: The paper proposes an adaptation of the ASI framework for freight transport and assesses the applicability of a number of international sustainable transport measures based on their potential sustainability impact if adopted in Ireland. The research applied a Policy Delphi Method to a heterogeneous expert panel. *Results*: The findings indicate that the current sustainable freight transport policy measures in Ireland are limited, and the paper suggests 38 measures for supply chains, maritime transport, rail transport and urban freight transport. The analysis further suggests that decarbonisation measures in Ireland should first formulate on the decarbonisation stages 'avoid' and 'shift', and then move to the 'improve' stage, thus leading to a greater impact on decarbonising the freight sector. *Conclusions*: An 'ASI for freight transport' framework is proposed as a taxonomy to systematically compare freight decarbonisation policy measures locally and internationally. This updated framework can serve as a new lens to prioritise sustainable freight policy measures. Recommendations are proposed for developing policy measures for sustainable freight transport in Ireland.

Keywords: logistics; road freight; sustainability; decarbonisation; policy; avoid-shift-improve (ASI) approach; Delphi method; policy Delphi; Ireland

1. Introduction

1.1. A Global Agenda towards Transport Decarbonisation

Approximately a tenth of global carbon emissions derive from logistics activities, freight transport is responsible for around 90% of these emissions [1]. However, unless radical new policies and practices are implemented, global freight transport carbon emissions could more than double by 2050 according to the International Transport Forum (ITF) [2]. Notwithstanding, the sectors of freight transport and logistics appear to have escaped this climate audit thus far [3].

Over the past decade, the top four emitters, which account for more than 55% of the total Greenhouse gas (GHG) emissions are the European Union (EU), China, USA, and India [4]. In December 2019, the European Green Deal of the European Commission was passed following the commitments made by governments and businesses to achieve the goals agreed in the Paris agreement. As outlined in the new environmental package 'Fit-for-55', the main target is to reduce the EU's GHG emissions by 55% by 2030, and become climate-neutral by 2050 [5,6].

1.2. Decarbonising Freight Transport Sector in Ireland

In 2019, Ireland's total GHG emissions were ranked seventh-worst among EU member states; and Ireland's per capita GHG emissions were the second highest at 12.1 tonnes of CO_2 equivalent, which is 53% higher than the EU average of 7.9 tonnes [7].

Ireland's emissions increased significantly, especially in freight transport [8] throughout the "Celtic Tiger" years. Celtic Tiger is a term that refers to Ireland's strong economic growth during the boom period of approximately 1995 to 2007. During this period, due to foreign investment and trade, the Irish economy grew rapidly, averaging over 8% per annum [9]. Ireland's transport sector is the second-largest contributor to carbon emissions (after agriculture). It accounts for 17.7% of the country's greenhouse gas emissions in 2021 [10]. Private cars remain the main mode of transport in Ireland, accounting for 54% of the country's transport carbon emissions in 2020 [10]. Road freight, inclusive of heavy-goods vehicles (19%), and light-goods vehicles (8%), accounts for 27% of total transport emissions [8]. The ageing fleet in Ireland is another key barrier to decarbonisation. Most HGVs in Ireland are diesel-fuelled, and 45% of the national HGVs fleet is over 10 years old [11], which was close to the average age of 11.7 years of trucks in the EU [12].

The Irish Government, considering the growing climatic and environmental disruptions and following the global effort for sustainable development, has committed to a climate resilient and carbon neutral economy by 2050 [13]. Regarding the transport sector, the main goal is to reduce transport-related emissions by 42–50% by 2030 [14]. For the road transport sector in particular, the government focuses on alternative and clean energy fuels for all vehicles, with the ultimate plan to gradually eliminate the sale of Internal Combustion Engine (ICE) HGVs by 2040 [14]. To attune to this new climate reality systemic changes will have to be made including decisions from transport mode, vehicle technology, fuel choice, fuel economy, to route planning, frequency of delivery and infrastructure.

The Irish government has launched sustainable transport policy measures, but the focus is mainly on sustainable mobility for active travel and passenger transport. By contrast, the freight transport specific terms and measures have not received equal consideration for the low-carbon transition. Little prior research has been conducted in Ireland to explore what should be the effective and innovative policy measures for the Irish logistics sector in order to adapt to this global low-carbon transition.

To address this imbalance, this study assesses the applicability of a number of international sustainable transport measures based on their potential sustainability impact if adopted in Ireland. It also proposes a freight transport decarbonisation policy framework to improve policy making. To achieve this aim, two main research questions (RQ) are set:

RQ1: How aligned are Ireland's policies and measures towards climate change and sustainability in the freight transport sector with leading and innovative practices in the EU and the UK?

RQ2: What measures should be adopted in the Irish freight transport sector, and which should be prioritised?

The remainder of the paper is structured as follows: Section 2 reviews sustainable freight transport policies in Ireland and Europe from academic literature, policy reports and regulatory frameworks. Section 3 describes the Delphi research method conducted in this study. Section 4 presents the Delphi survey results and findings. It develops and evaluates policy instruments that have been assessed as having the potential to have a significant impact on decarbonisation in Ireland. Finally, Section 5 discusses the implications and recommendations of this study.

2. Sustainable Freight Transport Policy

2.1. Policy Frameworks Related to Sustainable Freight Transport

Avoid-Shift-Improve (ASI) Framework

Sustainable freight operations pose real challenges with multiple complex technical, operational, and political dimensions. Interdisciplinary and multilateral research approaches

are required to design, test and implement interventions. Such might refer to the introduction of new transport technologies, but they might also refer to changes in policy and legal frameworks for transport, regarding production and logistics processes [15].

The ASI approach was first introduced in Germany in the early 1990s as a framework of systematically structuring transport-related policy measures for climate change mitigation and other environmental issues [16]. It has a three-level hierarchical structure. The ASI framework categorises various policies, regulatory instruments, and best practices into a sequential order (avoid, shift, improve) [16,17]. That is, the 'avoid' transport strategy should be implemented prior to 'shift' measures, and finally 'improve' measures can be implemented [16–18].

The ASI framework is widely used in the transport sector in general, particularly for passenger transport. The Irish government also adopted the ASI approach to present the current and potential measures to decarbonise passenger and freight transport in Ireland (Section 2.2). However, when applying the ASI approach for freight transport, researchers argue that the unique needs of freight transport often are not sufficiently distinguished from passenger transport [3,19].

Particularly, for the 'avoid' approach. Unlike the complete 'avoidance' of car use in passenger transport, 'avoid', in freight transport, is meant to reduce the number of shipments or trip distance [20] and manage freight transport demand growth [3].

For the 'shift' approach, an element of 'consolidation' in supply chain management principles has been stressed by researchers, namely, to combine transport modes smartly [3], as well as to maximise the share and use of fleets and logistics assets [3]. Additionally, in a passenger context, 'shift' refers to the switch to a different transport mode, e.g., use of light urban rail instead of using private cars. In the freight transport context, the shift approach in addition to the switch to a different transport mode, might also indicate a shift to a cleaner fuel option within the same transport mode category.

The 'improve' approach is similar to passenger transport, which is to improve the energy efficiency of logistics assets through technology and cleaner fuels for vehicles [20].

Therefore, it is important to explicitly define the ASI approach in the freight transport context. This study combines and adopts McKinnon's [3] five-step decarbonisation framework and Pfoser's (2022) [20] (p. 32) definition for ASI hierarchy for freight transport (see Table 1). Utilising an augmented and updated *ASI for freight transport* framework will facilitate a systematic approach to categorising and comparing sustainable freight transport policy measures that have been implemented in Ireland and other European countries.

2.2. Sustainable Freight Transport Policy in Ireland

Compared to passenger transport, freight transport in Ireland has received less attention and support from the government to adapt to this emerging climate mandate. Since 2019, the Irish Government has stepped up its commitment to a low-carbon transition in policy making especially for the road freight transport sector. A number of public consultations on policies, supportive funding schemes and incentives were launched, in the areas such as road freight decarbonisation and alternative fuels for HGVs (Appendix A presents the policy documents, reports, and on-going projects that were identified for this research) [11,21–24]. The established and potential policy measures for the freight sector identified in Ireland are summarised using the modified 'Avoid-Shift-Improve' (ASI) framework (see Table 2).

Table 1. Comparison of the Traditional ASI Framework and ASI for Freight Transport.

ASI Category	ASI Approaches for Transport (Including Passenger Transport)	ASI Approaches for Freight Transport
Avoid	Avoid the need to travel [16]	• Reduce the number of shipments or trip distance [20] • Manage freight transport demand growth [3] • Use and combine transport modes smartly [3] • Maximise the share and use of fleets and logistics assets [3]
Example measures	*Improved urban planning, traffic demand management or road pricing, and e-communication options [16]*	*Measures to improve the overall efficiency of the transport system as a whole [20]*
Shift	Shift travel to the most efficient or clean mode [16]	Promote modal shift from the most energy consuming transport mode towards low-carbon transport modes [20]
Example measures	*Use non-motorised or public transport; high-speed rail to replace air travel [16]*	*Promote rail or waterborne freight transport [16]*
Improve	Improve the environmental performance of transport through technological improvements to make vehicles more energy-efficient and fuels less carbon-intensive [16]	Improve the energy efficiency of logistics assets, transport modes and related vehicle technology [3,20]
Example measures	*Adopt low-carbon fuels and increasing fuel efficiency [16]*	*Adopt alternatively-fuelled low-carbon vehicles, such as electric vehicles, compressed natural gas vehicles, etc. [3,20]*

Table 2. Established and Potential Policy Measures for Decarbonisation in Irish Freight Transport Sector.

ASI Approaches	Established Measures in Ireland	Potential Measures in Ireland
Avoid	• Tolls • Heavy goods vehicles cordon	• User charges • Logistics planning support
Shift	None	• Rail freight promotion
Improve	• EU regulations on CO2 • Minimum excise relief for natural gas • Biofuels scheme • Eco-driving • Research projects	• Vehicle registration tax/motor tax reform • Eco-driving supports • Clean vehicle fund

Adapted from: Department of Transport, Tourism and Sport (DTTAS), 2019 [21].

2.3. Sustainable Freight Transport Policy Measures in Europe

To improve the environmental performance of the freight transport sector, Ireland, may adopt international practices. Seeking best practices from other countries, particularly in the EU and UK, we identified a list of policy studies and projects that focussed on freight transport decarbonisation and sustainable freight transport (Table 3).

Table 3. Policy Studies and Projects on Sustainable Freight Measures.

Project/Study	Policy Areas	Geographical Scope	Policy Assessment Method
FREIGHTVISION (2010) [25]	Road transport, rail transport, waterborne transport, supply chain, energy supplier, and vehicle supplier.	EU member states	Survey with more than 100 experts
Transport Climate Action Directory (ITF) [26]	Economic, infrastructure, regulatory, logistics, education & awareness raising, innovation R&D	Global	Based on literature evidence
Sustainable Urban Logistics Plans (SULP) [27]	Urban logistics	EU member states	Stakeholder participatory approach
Letnik et al. (2018) [28]	Urban logistics	129 European cities	Based on literature evidence

The project 'FREIGHTVISION' was conducted between 2008 and 2010, and it was a future-oriented study with a vision to formulate policy actions for Europe to achieve sustainable freight transport by 2050. The policy measures recommended by FREIGHTVISION were based on empirical evidence of an expert continuum with more than 100 experts from academia, governments, governing bodies and associations, and industries [25]. In 2020, the 'Transport Climate Action Directory' launched by the International Transport Forum (ITF) proposed more than 60 different carbon mitigation measures [26]. This directory covers transport policy measures for both public transport and freight transport. Whilst ITF's directory mainly focuses on measures for carbon reduction.

Although European cities strive to address various environmental and social problems that are posed by urban road freight transport, such as air pollution, noise, traffic congestion, and road safety [29], sustainable freight forwarding practices are a matter of interest to European policy makers and the general public. The Sustainable Urban Logistics Plan (SULP) as a guiding framework serves as a policy tool for small sized and medium sized cities in the EU to formulate and implement their policies towards sustainable urban freight transport [29]. Aligning with the Sustainable Urban Mobility Plan (SUMP) concept, SULP is a dedicated planning guideline to urban logistics. SULP and the relevant research projects, which are funded by the European Commission, have captured a set of best sustainable urban logistics practices and policy measures in the EU countries, such as in the Novolog project and ULaaDS project.

Neither SUMP nor SULP practices are yet widespread in Ireland [28], although some sustainable urban freight projects include elements of the SUMP and SULP concept [30,31].

The freight-related sustainable transport policy measures that were identified from these projects and studies are presented in Table 4 below using the ASI for freight transport framework.

Table 4. Identified International Sustainable Freight Transport Measures.

Urban Freight Transport *	Road Transport Measures **	Supply Chain Measures **	Rail Transport Measures **	Waterborne Transport Measures **	Energy Supply Measures **	Vehicle Supplier Measures **
Avoid						
• Off-peak deliveries • Spatial planning for logistics • Freight routes, delivery, and servicing plans • Off-street loading bays • Urban distribution centres	• Modifying the rules for HGV weights and dimensions • Congestion charge • Enforcement of regulations • Progressive distance pricing	• Transport route planning and control				
Shift						
• Cargo bikes • Mobile depots • By boat logistics	• Different pricing with regards to type of freight	• Transport consolidation and cooperation • Intermodal transport • Network optimisation–logistics service provider • Network optimisation–cargo owner • Standardised loading units • CO_2 labels	• Rail Freight prioritisation • Investment in rail infrastructure • Longer trains and heavier trains	• Investment in maritime port infrastructure	• Taxation of fossil fuels	

Table 4. *Cont.*

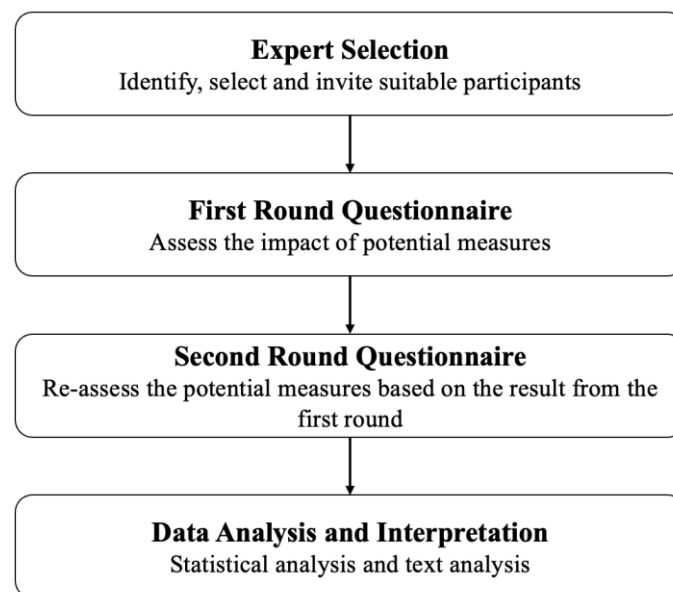| Urban Freight Transport *	Road Transport Measures **	Supply Chain Measures **	Rail Transport Measures **	Waterborne Transport Measures **	Energy Supply Measures **	Vehicle Supplier Measures **
Improve						
	• Investment in Intelligent Transportation Systems • Harmonised speed limits	• Training for eco-driving • E-freight • Automated platooning [32,33]	• Electrification of rail corridors	• Develop new technologies in inland waterways • Investment in inland waterway transport infrastructure	• Improved batteries • Hydrogen infrastructure	• Clean vehicle technologies • Including CO2 standards into HGV regulations • BAT vehicle certification for heavy goods vehicles

Source: * Urban freight measures adapted based on Letnik et al. [28]. ** measures adapted based on [25], one measure from [32,33].

3. Research Methods

3.1. Data Collection—The Delphi Method

The Delphi survey method has been demonstrated as an effective approach to solicit experts' opinions on complex issues, and achieve long-term projections [34,35], particularly when accurate information is scarce or where experts are limited and difficult to identify [36]. This method is suitable when complex and subjective opinions are sought rather than quantitative results [37].

In this study, a two-round Delphi survey following the sequential order was conducted [38,39] (see Figure 1). The questionnaires were furnished to solicit the judgements of freight transport experts who operate in and from Ireland. They also assessed the likely impact of sustainable measures on Ireland's freight transport sector.

Expert Selection
Identify, select and invite suitable participants

First Round Questionnaire
Assess the impact of potential measures

Second Round Questionnaire
Re-assess the potential measures based on the result from the first round

Data Analysis and Interpretation
Statistical analysis and text analysis

Figure 1. Sequential order of the Delphi steps.

3.2. Expert Panel Formation

Based on the guidelines from Okoli and Pawlowski [38], Reefke and Sundaram [39], and Donohoe and Needham [40] expert identification and selection followed a structured approach. It is desirable to include experts from the freight industry, government and academia to capture a broad range of views [40]. Three inclusion criteria were used to select experts and to support the pooling of judgements [39]. Thus, the selected experts must have:

- A proven credentials in academic and/or professional practice in the freight transport and logistics industry;
- A minimum of 3 years of experience in logistics and freight transport in Ireland;
- Demonstrated an interest and or activity in transport decarbonisation and sustainability development.

Literature recommendations on Delphi panel sizes for niche topics are inconsistent. Various studies indicate a range from 10 to 50 experts [34,37,38,41,42]. To gain a well-rounded representation of the Irish freight transport community, 42 freight transport professionals from academia, public sector and private sector in Ireland were nominated for this study. In an attempt to obtain responses from all three groups of stakeholders, survey invitations were sent to all 42 experts via email. Past experience has taught us that it is challenging to engage industry practitioners involved in research studies due to their busy schedule, therefore we initially invited more industry experts (55%) in the survey sample in order to ensure their views were captured (see Table 5).

Table 5. Number of Participants.

Panel Expert	Initial Sample	Round 1	Round 2
Academia	7 (16%)	3	3
Government	12 (28%)	2	2
Industry	23 (55%)	5	5
Total	42	10	10
Response Rate		23.8%	100%

Data collection involved completing two rounds of an online Delphi questionnaire from April 2020 to August 2020. All identified 42 experts were invited to participate in the first-round survey. A total of 10 experts completed the first-round questionnaire, resulting in a 23.8% response rate. Organisational research suggests a benchmark of response rate around 35% to 40%, however, a lower response rate might occur when seeking opinions from industry representatives or executives [43]. Only respondents participating in the first-round of the Delphi survey were invited for the second Delphi round. This allowed us to establish an astute assessment process that is supported by a consistent panel.

The recommendations for Delphi panel sizes were met by the total number of responses. The 10 experts who participated in this Delphi survey were from academia, government (central government or local authority) and industry (road freight transport operations, logistics and supply chain management, air-freight and rail-freight transport).

3.3. Delphi Questionnaire Design

3.3.1. First Round Delphi Questionnaire

The first Delphi questionnaire assessed the potential impact of the sustainable freight transport policies and measures that could be implemented in Ireland. The survey question design was adapted from the '*FREIGHTVISION*' project, and the potential effect of each measure was evaluated according to four sustainability criteria: reduction of GHG emissions, reduction of the share of fossil fuels, reduction of traffic congestion, and reduction of road fatalities [25]. Rather than solely focusing on the decarbonisation aspect, adopting these four sustainability dimensions could allow the panel of experts to assess each proposed policy measure in a more comprehensive manner.

The questionnaire used a 7-point Likert rating scale ranging from '−3' for a strongly negative impact, to '0' for neutral impact, and to '3' for a strongly positive impact. Blank space was also provided below each proposed measure for additional comments.

Members of the research team conducted a pilot test to ensure clarity and further refine the questions. As the Delphi study is future-oriented, this study intends to investigate potential measures, including innovative and future-oriented policies. A list of 38 identified policy measures was presented in the questionnaire to the expert respondents to solicit their reviews on the measures.

3.3.2. Second Round Delphi Questionnaire

The second questionnaire sought to re-examine the impact of proposed policy measures and their prospect of being adopted and implemented in Ireland. The results of the first-round of the Delphi study were analysed and sent anonymously to the 10 experts by email. The experts were invited to review their individual and group ratings, and to revise their responses if necessary. Distributing the results and initial findings is the recommended approach to gain a high-level of consensus among the participants [38] and to generate more insights into the measures which received divergent views [44]. All 10 experts revised their assessments or provided additional comments on the proposed measures.

3.4. Data Analysis Using Policy Delphi Techniques

Policy Delphi, a niche form of the Delphi method, was utilised for data analysis. Apart from capturing the consensus among Delphi panel experts, the policy Delphi also

allows the researchers to explore diverse views towards a certain policy measure [44]. The Policy Delphi is especially practical when studies involve experts with different expertise backgrounds [45,46]. This approach was adopted to identify radical and innovative ideas among experts [46], thus maximising the full potential of the Delphi questionnaire.

In addition, the policy Delphi rating analysis guideline of De Loë [47] was utilised to effectively analyse the consensus level, support, and polarity among experts' opinions (see Table 6).

Table 6. Delphi Rating Analysis Scheme Applied in this Study.

Consensus Level (the degree to which the panel agreed on support.)	High	70% of ratings in 1 category; or 80% in 2 contiguous categories.
	Medium	60% of ratings in 1 category; or 70% in 2 contiguous categories.
	Low	50% of ratings in 1 category; or 60 in 2 contiguous categories.
	None	<60% of ratings in 2 contiguous categories.
Support (where the panel's support lay when consensus achieved)	Strong positive impact	Median ≥ 2
	Medium positive impact	$1 \leq$ Median < 2
	Slight positive impact	$0 \leq$ Median < 1
	Slight negative impact	$-1 \leq$ Median < 0
	Medium negative impact	$-2 <$ Median < -1
	Strong negative impact	Median ≤ -2
	Ambiguous	Consensus is 'none'
Polarity (whether the panel's ratings were polarised)	Strong	SD ≥ 1.5
	Weak	$1.2 \leq$ SD < 1.5
	None	SD < 1.2

Source: Adopted based on guidelines by De Loë (1995) [47].

4. Research Findings

4.1. Evaluation of Proposed Policy Measures

All 38 proposed policy measures received a positive rating regarding their potential impact on sustainability if adopted in Ireland. Figure 2 below shows the ranking of all proposed measures. The rating results for the two Delphi rounds is contained in the Supplementary Material.

An aggregated mean value of each proposed policy measure was calculated for each round for comparative purposes. These were calculated on the four sustainability criteria [25] (see Section 3.3.1). Equal weighting has been assigned to all four criteria when calculating the mean value of each measure. The mean value of the panel ratings was used to convey the potential sustainability impact of the proposed policy measure if adopted in Ireland. Stronger potential positive impact on sustainability is implied by a higher mean value.

4.2. Prioritise Policy Measures Using the ASI Framework

Based on the Delphi survey findings, the proposed 38 measures were presented in sequence of their potential sustainable impact as it was rated by the Delphi panel (see Table 7). The mean values of Round 2 Delphi questionnaire results were used to present the potential sustainability impact of each policy measure.

Ranking of Proposed Measures based on Potential Sustainability Impact
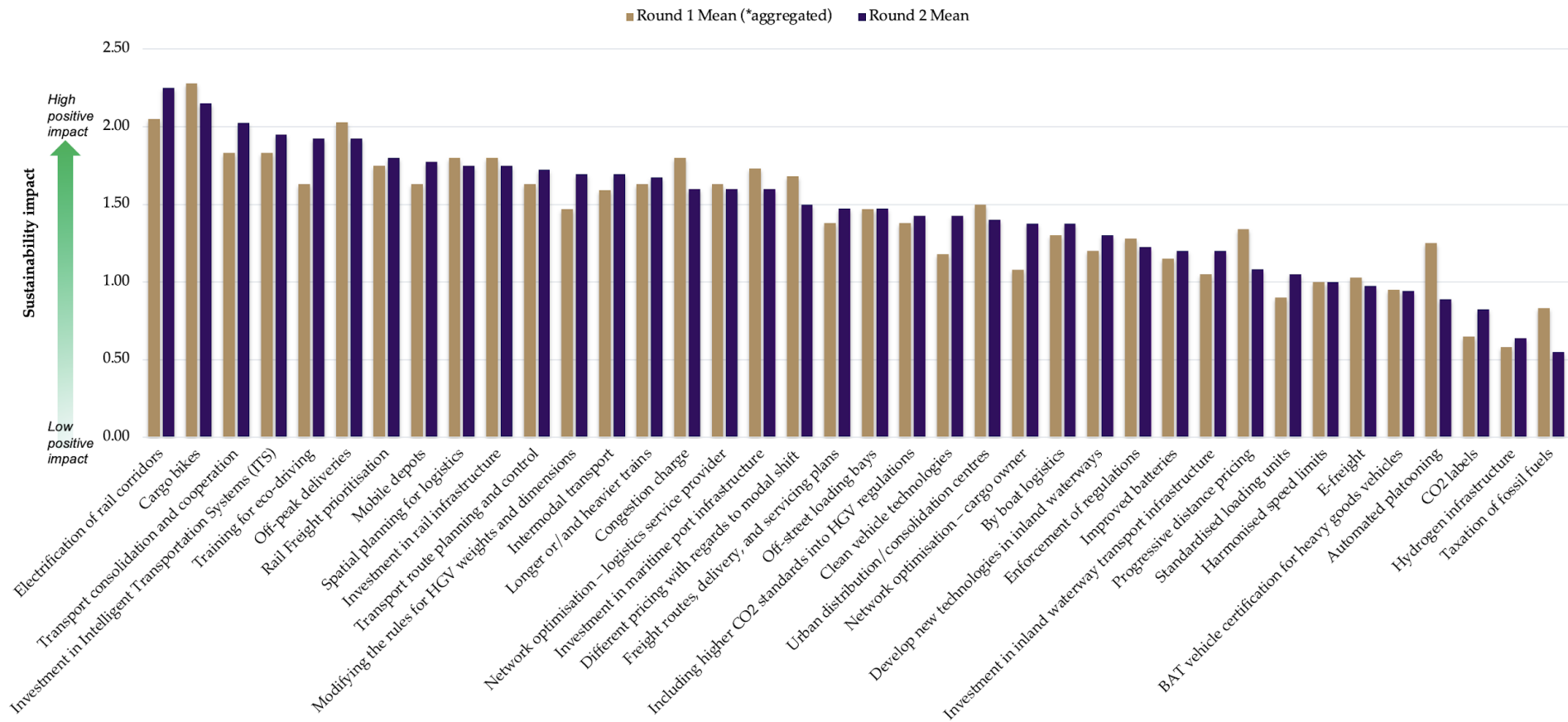
Figure 2. Proposed freight transport policy measures ranked by their potential impact on sustainability (Round 1 and Round 2 results). Note: Rating scheme where '3' = strong positive impact; '−3' = strong negative impact.

Table 7. Comparison of Irish and International Policy Measures for Sustainable Freight Transport.

Urban Freight Transport		Road Transport Measures		Supply Chain Measures		Rail Transport Measures	Waterborne Transport Measures	Energy Supply Measures	Vehicle Supplier Measures
Avoid									
Off-peak deliveries	1.93	Modifying the rules for HGV weights and dimensions	1.69	Transport route planning and control	1.73				
Spatial planning for logistics	1.75	Congestion charge	1.60	Logistics planning support					
Freight routes, delivery, and servicing plans	1.48	Enforcement of regulations	1.23						
Off-street loading bays	1.47	Progressive distance pricing	1.08						
Urban distribution centres	1.40	Tolls HDV cordon							
		User charges							

Table 7. *Cont.*

Urban Freight Transport		Road Transport Measures		Supply Chain Measures		Rail Transport Measures		Waterborne Transport Measures		Energy Supply Measures		Vehicle Supplier Measures
						Shift						
Cargo bikes	2.15	Different pricing with regards to type of freight	1.50	Transport consolidation and cooperation	2.03	Rail Freight prioritisation	1.80	Investment in maritime port infrastructure	1.60	Taxation of fossil fuels	0.55	
Mobile depots	1.78			Intermodal transport	1.69	Investment in rail infrastructure	1.75					
By boat logistics	1.38			Network optimisation logistics service provider	1.60	Longer trains and heavier trains	1.68					
				Network optimisation cargo owner	1.38	Rail freight promotion						
				Standardised loading units	1.05							
				CO2 labels	0.83							

Table 7. *Cont.*

Urban Freight Transport	Road Transport Measures	Supply Chain Measures	Rail Transport Measures	Waterborne Transport Measures	Energy Supply Measures	Vehicle Supplier Measures
			Improve			
	Investment in Intelligent Transportation Systems 1.95	Training for eco-driving 1.93	Electrificatio of rail corridors 2.25	Develop new technologies in inland waterways 1.30	Improved batteries 1.20	Clean vehicle technologies 1.43
	Harmonised speed limits 1.00	E-freight 0.98		Investment in inland waterway transport infrastructure 1.20	Hydrogen infrastructure 0.64	Including CO_2 standards into HGV regulations (EURO VI) 1.43
	Research projects	Automated platooning 0.89			Minimum excise relief for natural gas	BAT vehicle certification for heavy goods vehicles 0.94
	VRT/motor tax reform	Eco-driving			Biofuels scheme	EU regulations on CO_2
		Eco-driving supports				Clean vehicle fund
				Existing Measures in Ireland (2019)	Potential Measures in Ireland (2019)	

Low positive impact   Sustainability impact   High positive impact

Note: Policy measures in Ireland proposed by the Department of Transport, Tourism and Sport (DTTAS) in 2019 have been mapped into the ASI for Freight framework.

To further contextualise the proposed international policy measures with existing measures in Ireland, measures were classified under the Avoid–Shift–Improve (ASI) for freight transport framework. Based on this ASI heatmap, it is observed that most of the current Irish decarbonisation measures for the freight sector focus on the 'improve' stage, rather than the first two stages 'avoid' and 'shift'. This ASI for freight transport framework could provide guidance for the policy makers in Ireland to prioritise potential decarbonisation measures, starting from the 'avoid' stage, then moving towards the 'shift' stage, and finally the 'improve' stage.

4.2.1. 'Avoid' Measures

Currently in Ireland, the existing 'avoid' policy measures include pricing measures such as 'tolls', and 'user charges' to reduce the freight traffic, and a regulatory measure such as 'HDV cordon' to limit the HVGs in the city centre. 'Logistics planning support' was proposed by the government as a potential measure to manage the freight transport demand.

Potential measures such as off-peak deliveries, spatial planning for logistics, congestion charge and modifying the rules for HGVs received higher ratings among panel experts. Meanwhile, road transport-related measures such as progressive distance pricing and enforcement of regulations were considered by the panel experts to lower the positive impact to make freight transport more sustainable in Ireland.

4.2.2. 'Shift' Measures

For the 'shift' stage, 'rail freight promotion' was the only measure proposed by the Irish government as a potential measure to implement in the future.

The expert evaluation result suggests that supply chain measures, urban freight measures and rail freight measures were considered with a greater potential positive impact on sustainable transport development if adopted in Ireland. In contrast, energy supplier and vehicle supplier measures were considered with less impact to help current transport to shift to a low-carbon trajectory.

4.2.3. 'Improve' Measures

'Improve' policy measures are mostly focused on freight transport technologies and infrastructure. In general, investment in freight transport infrastructures such as rail, maritime ports and intelligent transport systems were considered with a higher positive impact. Particularly, the rail freight-related measure electrification of rail corridors received one of the highest ratings among experts.

Although all proposed sustainable transport measures received positive ratings in terms of their potential sustainability impact, some measures related to current vehicle technologies such as clean vehicle technologies, improved batteries, hydrogen infrastructure and automated platooning received relatively lower ratings and diverged views from the panel (see Table 8). The standard deviations (SD) value was used to capture the divergence level of opinions [47]. A wider divergence of opinions among panel members is implied by higher SD value.

Table 8. Proposed policy measures with controversial views among the Delphi panel.

Freight Measures	Round 1 Mean	Round 1 SD	Polarity	Round 2 Mean	Round 2 SD	Polarity
Hydrogen infrastructure	0.58	1.44	Weak	0.64	1.84	Strong
Clean vehicle technologies	1.18	0.55	None	1.43	1.41	Weak
Fossil fuels taxation	0.83	0.99	None	0.55	1.39	Weak
Inclusion of higher CO2 standards into HGV regulations	1.38	0.46	None	1.43	1.34	Weak
By boat logistics	1.30	1.14	None	1.38	1.31	Weak
Automated platooning	1.25	1.35	Weak	0.89	1.29	Weak
Inland waterway transport infrastructure investments	1.05	1.16	None	1.20	1.27	Weak
Improved batteries	1.15	0.24	None	1.20	1.21	Weak

5. Discussion

The following sections firstly discuss some policy gaps identified from the Delphi results; and further contextualise the findings with previous research and theory to evaluate their significance.

5.1. Policy Gaps

To examine to what extent the existing policies and measures of Ireland towards climate change and sustainability in the freight transport sector are in line with leading and innovative practices in Europe (RQ1), the study mapped the existing measures in Ireland and proposed 38 policy measures into the ASI for freight transport framework (as shown in Table 7).

The current sustainable transport policy measures for the freight sector in Ireland are limited and require more attention from the government. In terms of policy coverage, the current measures in Ireland mainly focus on road transport, energy and vehicle supply measures. However, policy areas such as supply chain measures, waterborne transport, rail transport and urban freight transport remain absent. The following policy gaps were identified.

5.1.1. Supply Chain Measures

Supply chain measures highlight the role of other crucial supply chain actors, particularly shippers, logistics service providers, transport operators, customs, consumers and vehicle manufacturers. Supply chain measures consist of a number of measures with regard to 'avoid', 'shift', and 'improve' approaches respectively.

In Ireland, 'eco-driving' as an 'improve' approach, with an aim to improve vehicle energy efficiency is the only existing measure identified. While measures with the 'avoid' and 'improve' approach in this supply chain category remain absent.

The Delphi survey findings suggested 'transport route planning and control', 'transport consolidation and cooperation', and 'transport network optimisation' have great potential to achieve carbon emission reductions from the freight transport sector. Most importantly, the policy measures will require collaboration between stakeholders from both public and private sectors, ranging from central governments, and local authorities, to retailers, logistics service providers, and customers.

5.1.2. Waterborne Transport

As an alternative mode of transport to the dominant road transport, waterborne freight transport (including inland waterways and long-distance sea shipping measures) has been considered as a cost-effective and sustainable transport mode [48].

Divergent views have been captured among the panel experts regarding the inland waterway measures, such 'by boat logistics' in the urban areas, and 'investment in inland waterway transport infrastructure'. Whilst experts support 'investment in maritime port infrastructure' as a potential 'shift' measure.

In the EU, approximately 88% of all the transport services performed by inland waterways are carried out in the Netherlands, Germany, Belgium and France [49]. In Ireland, no freight transport has been recorded to be carried on inland waterways as of 2021 [50], given that inland waterways in Ireland are not navigable for commercial freight transport [49,51]. Ireland has over 1000 km of navigable inland waterways comprising lakes, rivers and canals linked into a waterway network [49]. The UK has a similar length of waterways (1050 km) [49], accounting for 5% of the 1.3 billion tonne-kilometres of goods moved in 2020 [52]. The study suggested that Ireland could potentially shift approximately 3% of the country's road freight tonnage to be carried by inland waterways [49].

In terms of sea shipping, Ireland has a number of long-distance sea routes. However, policy support such as 'investment in maritime port infrastructure' is still vital as a shift measure. It could potentially shift freight transport from road to sea, and therefore reduce road freight traffic through the UK Landbridge to the Europe continent. Developing alternative ports in Ireland (such as Rosslare Europort) could also reduce the congestion and air pollution around the Dublin Port and the M50 motorway in the Greater Dublin Area.

5.1.3. Rail Transport Measures

Rail freight in Ireland accounted for 0.6% of total inland freight transport volume in 2019 [50] falling to one of the lowest modal share levels among EU countries. Iarnród Éireann (Irish Rail) is Ireland's only rail freight carrier. The relatively small freight volumes have declined sharply in recent decades. The latest strategy update of Iarnród Éireann was published in its 2030 Rail Network Strategy Review in 2011 [53]. The report did not elaborate on rail freight and there is no other updated strategy for rail freight.

Promoting rail freight as a potential means of tackling climate change was put forward by the Irish Transport Department in its Sustainable Mobility Policy Review [21]. Notwithstanding, modal shift within the Irish context remains a matter of debate in terms of cost-efficiency. Delphi study panel members argued for upfront investment in infrastructure, limited numbers of large bulk movements, the relatively compact size of Ireland, and low density of freight related economic activity. All these factors could limit the economic viability of road freight alternatives.

The role of rail freight in Ireland needs further research and assessment for its potential implications for policy decisions. Areas worth further investigation include general awareness and perceptions of key stakeholders, the development of the Western Rail Corridor, the development of rail freight hubs by major ports, and the introduction of incentives to attract additional rail freight operators. Implementing these measures in Ireland will require detailed cost analysis and feasibility assessments.

5.1.4. Urban Freight Transport Measures

Regarding urban freight measures, no policy measures have been introduced from the national level. However, there is growing interest at the city level, especially in central Dublin where local authorities are leading. For example, the EU-funded SENATOR project launched in Dublin in 2020, aims to create new urban logistics models to make cities more sustainable [24,54]. Initiatives such as cargo bikes, urban depots, smart loading bays, and urban consolidation centres were being implemented on a pilot test basis.

The Delphi research findings resonate with these new initiatives currently being carried out, which indicates measures such as cargo bikes, off-peak deliveries and spatial planning for logistics are of great potential to make freight transport more sustainable if adopted in Ireland.

5.2. ASI for Freight Framework: A New Lens to Prioritise Freight Decarbonisation Policies

The prioritisation of policies is not a simple process, particularly under constrained resources and time. To explore what measures should be adopted in the Irish freight transport sector and which should be prioritised (RQ2), we proposed the ASI for Freight framework as a new lens to prioritise sustainable freight policy measures.

This study augmented the conventional ASI framework into the proposed 'ASI for Freight transport' framework with two key main features. Firstly, each 'Avoid-Shift-Improve' level is re-defined explicitly for the freight transport context based on McKinnon's five-step decarbonisation framework [3] and Pfoser's definition for ASI [20]. Secondly, the study provided an additional dimension to the ASI framework by adding the freight-related constructs to categorise policy instruments based on international categorisation (such as in the Freightvision project [25] and ITF Transport Climate Action Directory [26]) of various policy measures. Thus, the 'ASI for Freight transport' framework as a taxonomy for policy measures, could allow both policy makers and industry stakeholders to systematically capture and compare the various decarbonisation measures in Ireland and abroad.

Based on the policy gaps identified (Section 5.1), some recommendations for adopting potential policy measures to decarbonisation Irish road freight sector are proposed as follows.

Firstly, the freight decarbonisation measures should have a wide coverage of all freight-related areas. For Ireland, current measures are mainly road transport focussed. Other areas such as supply chain measures, urban freight transport, rail transport and waterborne transport are in need of more attention.

Secondly, the freight decarbonisation measures should work in sequence, starting from the 'avoid' stage and then moving to 'shift' and 'improve' stages. The freight transport demand should be managed in the first place, with relevant supply chain, road transport and urban freight measures; then apply 'shift' measures to optimise the efficiency of logistics fleets and other assets (such as urban mobile depots), as well as to 'shift' to more sustainable transport modes such as rail freight and inland waterway transport. The 'improve' stage at the last measures for technology improvement, with regard to intelligent transport systems, clean vehicle and fuel technologies, and eco-driving training.

However, certain policy measures could fit into more than one freight category, or arguably, fit into different A-S-I stages depending on their specific purposes in a specific context. Therefore, it is up to the user of the '*ASI for Freight transport*' framework to decide which is the best way to categorise the policy measures based on their purpose.

Another limitation of the ASI framework is that it solely focuses on the carbon emission environmental perspective, which could easily lead to the so-called 'carbon tunnel vision' [55]. When it comes to sustainable development for the freight transport section, aspects such as congestion and road safety issues [25] are also important in policy decision-making. Thus, this study adopted four sustainability criteria to evaluate each proposed measure.

6. Conclusions

This study aimed to evaluate Ireland's stance on climate change for the freight transport and logistics sectors. By proposing the 'Avoid-Shift-Improve' (ASI) for freight transport framework, this study assesses the applicability of a number of international sustainable transport measures based on their potential sustainability impact if adopted in Ireland. A policy Delphi survey analysis with a special focus on the Irish context has been used to identify the policy gaps from a multi-stakeholder perspective. The research findings confirm that the current sustainable transport policy measures for the freight sector in Ireland are limited compared to other EU countries. Our finding suggests that Ireland requires more measures in areas such as supply chains, maritime transport, rail transport and urban freight transport. The analysis further suggests that most of the current Irish decarbonisation measures for the freight sector focus on the 'improve' stage. Potential

future measures should focus on the first two stages 'avoid' and 'shift', which could lead to a greater impact on decarbonisation.

6.1. Research Contributions

The research contribution of this paper can be concluded in terms of the framework proposed, the niche form of policy Delphi method used, and the research context investigated.

Firstly, this study contributes to knowledge by proposing the *ASI for freight transport* framework, which was built on the established ASI decarbonisation approach for the transport sector in general. The paper enriches the definition of ASI hierarchy for the freight transport sector by integrating current literature [3,20] in logistics and supply chain discipline. The ASI for freight transport framework provides a taxonomy that could allow researchers, policy makers, and industry practitioners to systematically map out and compare relevant decarbonisation policy measures.

Secondly, by utilising the policy Delphi survey method, this study demonstrates an effective way to assess policy measures from a multi-stakeholder perspective. The inclusion of both private and public sectors stakeholders allows us to gauge a more balanced view on certain policy issues. A number of policy measures with controversial views were identified (see Section 4.2). The findings from the Delphi study allow us to contrast and analyse the policy-implementation gaps with current policies.

Thirdly, this study is the first policy study in Ireland to focus on the freight transport and logistics sector. Previous research on Irish transport decarbonisation policy did not distinguish freight from general public and passenger transport.

While the Irish Government has indicated that it is stepping up its efforts to develop transport sector specific policies for a low-carbon transition, this study finds that existing policies and measures appear to prioritise passenger transport, and that freight transport specific terms and measures have not received equal consideration for the low-carbon transition. The research findings of this study show that sustainable freight policy measures in Ireland still remain largely absent compared to measures for the public transport sector. Based on the Delphi analysis results, measures with the potential to make a strong impact are identified and a list of recommended policy measures and instruments on sustainable freight transport is put forward.

6.2. Policy and Practical Implications

This study also points towards areas in need of further exploration for developing policy measures for sustainable freight transport.

On a managerial level, cross-sectoral collaboration among government, local authorities, industry, research institutes, and public and private stakeholders is required to support policy decisions. Freight transport by its very nature, consists of various actors and stakeholders along the value chain. Stakeholder engagement is also part of the key principles of the EU's SUMP and SULP guidelines [27,29]. Currently there are trials and pilot projects in sustainable logistics being carried out by Dublin City Council and cooperating partners under the 'Smart Dublin' initiative [56] and the EU Horizon 2020 research project 'SENATOR' [53]. Yet, an inclusive freight partnership programme [57] engaging the wider communities rather than just the 'project partners' should be put forward at the long-term and national level to facilitate policy making.

On a practical level, the freight transport industry needs more supporting policy measures and initiatives to raise the awareness, readiness and engagement of industry for the low-carbon transition. Policy efforts towards adoption of low-carbon, alternative-fuel vehicle technologies, and sustainability education need greater audience participation, thereby driving positive behavioural change and empowering stakeholders' collaboration along supply chains. To put Ireland on a long-term low-carbon trajectory it is a necessity to raise awareness about the reality of climate change within the transport sector and the wider society.

6.3. Research Limitations and Future Research Directions

Reflecting on the research process and findings in this study, some research limitations have to be remarked.

First, this paper reviewed the existing freight decarbonisation policy measures in Ireland and evaluated international policies and measures that could be potentially implemented in Ireland. This study only focused on two dimensions of the policy measures using the *ASI for Freight* framework—the avoid, shift, improve hieratical approaches and various freight transport policy constructs. Other important attributes that contribute to policy measures could be added, for example policy measure types, such as pricing [58], regulatory [26,58], technological [26,58], infrastructure [26], education & awareness raising [26] and behavioural measures [58] and policy timeframe (such as short-term, mid-term, and long-term).

Second, each measure assessed in this study was administered individually, the effects of combining multiple measures were not examined in this study. Effective impact on energy consumption levels and carbon footprint savings can be also achieved by soft measures. Such measures might come with low costs and low investments [28]. For example, a single measure can reduce energy consumption and carbon emissions by about 20% to 30% on average, while optimal combinations of measures can result in reductions of up to 60% to 70% [28]. Additionally, beyond single policy measures the desired outcomes can be achieved by a combination of complementary measures [58]. For instance, strong carbon pricing measures should be put in place along with incentives for renewable energy and clean vehicles.

Finally, transport policies should be future-focused, effective and efficient, and must be based on objective analysis and practical experience. The evaluation of policy measures using the Delphi survey in this study was carried out in 2020, given the dynamic nature of the green vehicle and fuel technologies and initiatives, the study needs to be replicated every two years to allow for comparison and to measure progress and change of attitudes.

More questions were also generated during this research. Such as what contributions are needed from policy makers, industry, research institutes, wider communities for the transition to low carbon freight transport? What organisational and behavioural changes are needed, and how they can be managed to a low-carbon trajectory? What should we do to strengthen the engagement and collaboration among stakeholders in Ireland?

By carrying out this study, we aspire to raise awareness of this perpetual sustainability agenda for the policy makers, industry practitioners and the general public. Therefore, to foster closer collaboration among various stakeholders to move towards a sustainable pathway for the freight transport sector in Ireland.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Sustainable Freight Transport-Related Policies and Projects in Ireland

Table A1. Summary of sustainable freight transport-related policies and projects in Ireland.

Organisation	Policy Area	Publications
Policy documents		
Government of Ireland	National plan	• The National Planning Framework • 'Project Ireland 2040'—Sustainable Mobility as one of the key priorities (2017)
Department of Transport, Tourism and Sport (DTTAS)	Transport; Climate change; Spatial planning	• Sustainable Mobility Policy Review (2019) • Planning Land Use and Transport Outlook 2040 (2018) • Developing Resilience to Climate Change in the Irish Transport Sector (2017) • Smarter Travel Plan 2009–2020—the Framework Policy for Sustainable Transport (2009) • The National Cycle Policy Framework (2009)
Freight transport related projects		
Department of Transport, Ireland	Road freight	Public Consultation on Ten-year Strategy for the Haulage Sector (2022)
Dublin City Council & partners	Urban planning; Urban mobility	• 'Smart Dublin' initiative • 'Senator' project (on-going)
Transport Infrastructure Ireland (TII) & ARUP	Freight and logistics	'Decarbonisation in HGV' research project (2020)

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