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Decarbonisation of the commercial road transport: The role of European Policy

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Abstract

Following the Paris agreement of 2015, the latest reports of the IPCC, exacerbated by the lingering impacts of the Covid crisis and the recent war of aggression of Russia on Ukraine, the European Union is proposing an ambitious set of rules and regulations aimed at making Europe the first climate neutral continent by 2050. As a part of this so-called European Green Deal, the Fit for 55 package was introduced to align the existing and proposed legislature to ensure at least 55% reduction of greenhouse gas emissions by 2030. In this thesis, I analyse selected policy instruments of the Fit for 55 package in combination with secondary material relevant to the sector of commercial road transport. This study's content analysis is centred around topics emergent from literature, namely the market-creating framework for mission-oriented policies, multi-level perspective on the process of change, and geography of sustainability transitions. The results point towards the complexity of the decarbonisation process of the road freight in relation to the number and variety of actors involved, the nature of dominant companies, ambiguities present in the policy instruments and the presence of numerous bottlenecks along the implementation process. Furthermore, despite the unifying goals of the European Union, the results suggested uneven spatial outcomes of the decarbonisation process.

Key words: Commercial road transport, European policy, decarbonisation, multi-level perspective, geography of sustainability transition, mission-oriented policies, policy implementation process

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Table of Contents

List of Figures

1. Introduction

Every day in 2022, more than 750 new, heavy-duty trucks rolled off the production lines in the European Union (EU) alone. Out of the total number of new trucks on the road, exceeding a quarter million of vehicles, almost 97% were powered by diesel and can be expected to remain on the roads for another 14 years, if not longer (ACEA, 2022). Additionally, some 1,3 million light commercial vehicles were also registered in 2022 in the EU, with an average lifespan of 12 years and over 97% being powered by diesel or gasoline. Despite recent incremental advances in alternative powertrains for personal vehicles (i.e., around 5,3% of European passenger vehicles are hybrid, electric or running on alternative fuels), the commercial road transport sector is lagging behind with only about 0,6% of all commercial vehicles within the EU being zero-emissions, heavily concentrated in a handful of progressive countries, such as Germany and the Netherlands, and especially in the lighter segment of the industry, for instance city-delivery light vehicles (ACEA, 2022).

At the same time, the European Union has firmly decided to move towards a fossil-free future and is striving to be the first carbon-neutral continent (European Commission, 2023) by 2050. A plethora of plans and policies has been adopted, or is being considered at the EU, national and local levels, to address a wide range of initiatives aimed at decarbonising the road freight sector. Throughout all scales, those initiatives are set out to tackle the biggest emitters: the energy and industry sectors and above all, transport. Globally, the transport industry is responsible for more than 37% of all GHG emissions (IEA, 2022). Narrowing the sector down, the road transport sector has by far the highest share of transport emissions, accounting for over 77% out of all EU transport modes GHGs (EEA, 2022a). Looking past the passenger transport, the commercial road transport is responsible for more than 40% of all road transport emissions (Axsen et al., 2020), but consistently receives far less policy and research attention compared to the passenger travel sector (Axsen et al., 2020). Despite recent advances and experiments with zero-emission commercial vehicles and research focused on the potential utilisation of accelerated modal shifts (e.g., Carrara and Longden, 2017; Axsen et al., 2020 or Van Grinsven et al., 2021), there is still a considerable gap in understanding the impacts of the recently introduced policies of the *Fit for 55* package, exemplified by explicit calls for a closer analysis of the freight transport industry (i.e., Axsen et al., 2020 or T&E, 2022) or comparable studies conducted in different transport sectors (Bach and Hansen, 2023), pointing towards a need for more research aimed at the road freight industry.

Furthermore, studies looking at the commercial road transport sector and potential pathways to decarbonisation (see for example Van Grinsven et al., 2021 or T&E, 2022) tend to overlook the intricacies of the implementation process of technologies and policies, seemingly still falling into the fallacy once mentioned by Smith (1973) several decades ago, of policy adoption and implementation simply *happening* after its formulation, once, mostly technical, barriers are overcome.

As such, decarbonising the transport industry is set out to be one of the most important and challenging tasks of upcoming decades and rightfully it appears as the focal point of the EUs short- and long-term decarbonisation initiatives, bundled-up in the so-called **Fit for 55 package**. This package, serving as a set of proposals to revise and update the EU legislation, is promised to bring about necessary changes to EU policies, ensuring that they are up-to-date with the climate goals agreed by the Council and European Parliament based on the latest reports of the Intergovernmental Panel on Climate Change (IPCC) and ensures that the policies are *fit* for reducing net greenhouse gas emissions in the EU by at least 55% by 2030, as compared to a 1990 baseline (European Commission, 2023). While the *Fit for 55* package symbolizes the dedication of the highest administrative European levels to decarbonisation of the road freight, national bodies, in cooperation with private institutions, will play a major role in the transition towards a cleaner future of the commercial road transport. However, such a task is no easy one and will require a substantial dedication of financial and human resources, dramatic shifts in public perceptions, the way of doing business and greater cooperation among stakeholders than we have seen to date, at least in the road freight sector (Ragon and Rodríguez, 2022). Furthermore, the situation is exacerbated by the ever-urgent scientific calls for rapid decarbonisation in order to meet the climate targets set out by the Paris agreement, supported by the subsequent IPCC publications (UNFCCC, 2015; IPCC, 2023). As such, an early evaluation of the proposed policies is in place.

1.1 Aim and purpose

The aim of this paper is to analyse the existing and proposed policies at the highest European level aimed at meeting the targets implied by the 2015 Paris Agreement (UNFCCC, 2015) in the sector of commercial road transport. The primary focus is to examine the potential bottlenecks to the policy implementation process, as well as uneven spatial manifestation of intended outcomes of those policies. Taken together, these investigations will serve as an assessment of the fit of the overall approach adopted by the European Union within the framework of sustainability transitions studies.

While most of the recent publications around the road freight sector is focused on the infrastructure for alternative vehicles (Van Grinsven et al., 2021), economic impacts of adopting zero-emission vehicles (Cambridge Econometrics, 2018) or broad financing around new trucks (T&E, 2022), less attention has been paid to the policy implementation process and a broader overview of the policies proposed or updated under the *Fit for 55* package. The fragmented nature of the sector, along with rapidly developing legislature and policy changes poses significant challenges to the whole industry and thus calls for an investigation.

In order to explore the implications of the policy instruments and potential bottlenecks around the policy implementation process, I rely on the method of qualitative document analysis to answer the following research questions:

Research question 1*: What are the key policy instruments set out to decarbonise the commercial road transport within the EU? What are the key actor groups targeted by those instruments? How do those instruments fit within the market-creating framework?*

Research question 2*: What are the key bottlenecks along the policy implementation process potentially hindering the commercial road transport decarbonisation process?*

Research question 3*: What are the risks of uneven spatial outcomes of the policy instruments identified in RQ1?*

The first research question provides an overarching aim for the thesis, as I attempt to synthesise the latest developments and prognosis in the industry. While descriptive in nature, the policy developments are rapid and there is a considerable degree of uncertainty regarding the composition and direction of decarbonisation policies among affected groups, such as shippers and carriers (Van Grinsven et al., 2021). Thus, the identification of the key policies serves as a snapshot of the journey towards decarbonisation and may provide a springboard for further research. Furthermore, the subsequent sub-question allows for identification of the key actors of the road freight, as well as setting the respective instruments within the framework of market-creating policies. The second question is concerned with the intricacies of the policy implementation process, especially with bottlenecks that may hinder any effective policy instrument from the very beginning. Finally, the last question allows for uncovering the nuances of outcomes of policy implementation in different geographical contexts, as while the proposals of the *Fit for 55* package are universally applied, the sector of road freight is by no

means homogenous and thus it can be expected for the transition towards zero-emission road freight to be manifested unevenly.

1.2 Thesis structure

This thesis is structured in the following fashion: After discussing the aim, research motivation and my personal stance, I present a discussion of the relevant theoretical concepts from the contemporary literature, namely the notion of socio-technical systems and sustainability transitions, the role of geography within the process of change in socio-technical systems and the role of policy as a driver of change. I operationalize these key concepts in the subsequent analytical framework section, moving in to providing more background information of the road freight sector, and elaborating upon the methodology of qualitative content analysis that allows me for answering the guiding research questions. Lastly, I present the results, followed by a discussion section and concluding remarks.

1.3 Research motivation and positionality

This research has been greatly motivated by my personal experiences as an intern and later an employee for an industrial support service company in the commercial road transport sector. As a part of my role that started in September 2022, I came across the issues connected to real-life challenges of freight decarbonization, exemplified by the chicken-and-egg dynamic (Mission Possible Partnership, 2022) – the unwillingness of actors to become the first-movers due to unpredictable market direction, legislation, and often unfavourable business cases. Furthermore, working for a company servicing thousands of typical customers in the road freight sector across Europe, I would hear how difficult it was to push any changes in this fragmented industry dominated by very small companies. As a result, I started to realise that if the whole sector wanted to be carbon neutral by 2050, all the policies and initiatives would have to overcome significant obstacles in the policy adoption phase in addition to any number of issues arising throughout the whole policy implementation process. Furthermore, I started to observe the divide between the home country of carriers and destinations of shippers, pointing towards a spatially uneven nature of the road freight sector with a clear separation between richer, more regulated countries contracting cheaper labour. While, after conducting an initial topic research, that was no surprise, I was intrigued by the nature of this divide and whether the bold policies proposed by the EU would lead to either eliminating or increasing it.

Before delving into the research, I would like to also reflect on my own position as a student-researcher, as it may provide insights into my modus operandi.
As a young student in his mid-twenties, I am strongly influenced by the urgency of the latest scientific calls regarding the severity of climate change (IPCC, 2023). Exacerbated by my internship and the current position in the field of sustainability, I feel a deep internal commitment to at least attempt to ameliorate the situation regarding wasteful carbon spending and investment bodies turning a blind eye towards environmental degradation. As such, I intentionally chose a topic that both coincided with my work position and academic interests.

1.4 Philosophical stance

Before moving into other parts of this thesis, I deem it necessary to provide an overview of my philosophical stance regarding the ontology and epistemology of my work. In doing so, positioning myself in the field of philosophy of social science allows for a clear understanding of my motivations, beliefs, and overall tendency to resonate with a certain model of doing research in a particular way.

First things first, this thesis is broadly situated within the stance of critical realism. What it means is that I generally follow the thinking of Bhaskar and Hartwig (2016), perhaps best summarized by Fryer (2022). My ontological stance is thus that of realism, as I believe there is a real world out there worth exploring and studying – the road freight transport is real and has vast implications on the lives of millions of workers and in turn the society as a whole. My epistemological stance, under critical realism, flows naturally as that of subjectivism – I believe that despite the observable capacities of the real world out there, there are barriers to studying it and that the understanding of those capacities is highly theory-dependant. The theory dependency is further elaborated upon in the next section.

Overall, my research is driven by the primacy of ontology, as I strive to uncover and identify the structures (i.e., policies) and blocks (i.e., bottlenecks and enablers in the policy implementation process) and, in general, the causes for the aforementioned in the road transport decarbonisation process (Bhaskar and Hartwig, 2016). Furthermore, my work predominantly aims at highlighting the mechanisms and structures, rather than focusing on a specific case or a single event, allowing for lesser predictive capabilities potentially offered by

a strictly positivist approach, but offering a broader, over-arching view of what is happening in the field of road freight, as related to critical concepts presented in the subsequent chapter.

Furthermore, I believe there is a logical flow from the philosophical stance I adopt into methodology, specific methods and ultimately the sources I utilise for my work, as highlighted by Grix (2002). As such, I apply the appropriate methodology and a connected suitable method – qualitative content analysis – to the specific case of my research, avoiding the pitfalls of a method-led research – as I agree that methods are not value-laden and connected to a specific type of research, for a method is simply a tool used by any type of researcher and it is up to the individual to reflect on values, positions and appropriateness of their work. Ultimately, I take on the liberty of interdisciplinary research, employing a slightly more flexible approach to my work than suggested by Grix (2002) by touching upon concepts from the field of innovation policy studies, system transitions and business management, which is elaborated upon in the subsequent section.

2. Literature review

This section provides an overview of the key theoretical contributions in contemporary literature regarding the topic of this thesis. Starting from the broadest understanding of the movement towards sustainability transitions of socio-technical systems to the notion of multi-level perspective with the focus on the role of state and spatiality of the process of change.

2.1 Socio-technical systems and the sustainability transitions

The notion of socio-technical systems dates back to the 1950s, when in the name of post-war reconstruction efforts, a new approach to coal mining was envisaged, combining both the social element of a company (i.e., people and power dynamics), and technical aspects (i.e., tools and processes) in order to increase productivity. In a new-born field, socio-technical studies were to be carried out in a multi-scalar fashion, covering primary operations within a company, whole organizations as systems and finally so-called macrosocial systems comprising of industrial sectors and institutions operating at a societal level (Trist, 1981). From the very beginning, the concept of socio-technical systems has developed within the open system theory, as individual actors within the system are deeply interdependent on the actions of other actors within that system (Chick, 2004). The understanding of socio-technical systems has evolved since the post-war era; however, the basic principles remain the same. A given

socio-technical system can thus be understood as *a cluster of elements, including technology, regulations, user practices and markets, cultural meanings, infrastructure, maintenance networks and supply networks* (Geels, 2004 p. 3 in), with early examples ranging from media systems or sewer management (Trist, 1981) to more recent elaborations, for instance on the land-based transportation systems (Geels, 2005).

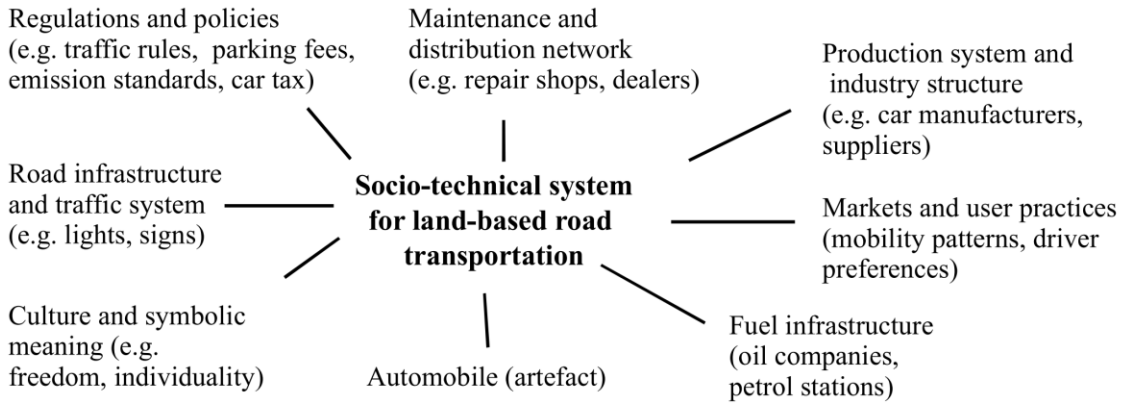

Figure 1: Socio-technical system for modern car-based transportation. Source: Geels, 2005.

Figure 1 represents the complexity of a given socio-technical system; while concerned with land-based passenger road transport, it highlights the complexity of actors involved in such a system. Should the artefact be replaced by a commercial vehicle, the range of actors would likely be increased to accommodate for the dynamic between shippers and carriers, as well as changing some of the specificities of other actors (e.g., market and user practices would be less individual and more business-oriented).

2.1.1 The Multi-Level Perspective

Once a socio-technical system is established, it can remain virtually unchanged for long periods of time (Geels, 2002). However, a technological *niche* challenging the dominant socio-technical system might come about, usually due to either evolution in technology or changes in the social landscape underpinning the socio-technical system itself (Coenen and Truffer, 2012). Such *niches* act as “incubation rooms” for new technologies, typically in a local, micro-level context, but need to be shielded from the dominant system due to their infancy and early inefficiencies (Geels and Kemp, 2007). Some examples include the introduction of steam engines to the shipping industry, the transition from punch cards to computers (Geels, 2004)

or the recent cooperation of Amazon and Rivian in the provision of tailor-made package delivery trucks (Amazon, 2022). Once a substantial number of *niches* is established, it allows for interaction between different *niches* and the emergence of a social and economic community around the specific innovation. Technical problems are slowly solved, users get familiarized with new technology introduced by the *niche* and some guiding rules and regulations are formed. Subsequently, technological *niches* can diffuse into a wider system, once stabilized, and normalized. They gain more visibility and, if successful, economies of scale, further innovation and development and wider adoption may lead to a breakthrough of new technology, ultimately resulting in the creation of new technological *regimes*. While still fragmented, these *regimes* represent a meso-level in a technological transition. Effective or supported *regimes* can build momentum, breaking into a wide range of social and technical institutions, such as mainstream business operations and supportive educational and research institutions. In the last phase, *niches* formalized into *regimes* compete directly with the pre-existing socio-technical system, ultimately forming a new *landscape*, or a new dominant socio-technical system. Such a *landscape* is characterised by a slow level of change (i.e., in order of decades) and is beyond the individual influence of individual actors at *regime* and *niche* level (Geels, 2002, 2004; Geels and Kemp, 2007). This process of change of socio-technical systems, visualised below in Figure 2, is known as the Multi-Level Perspective (MLP).

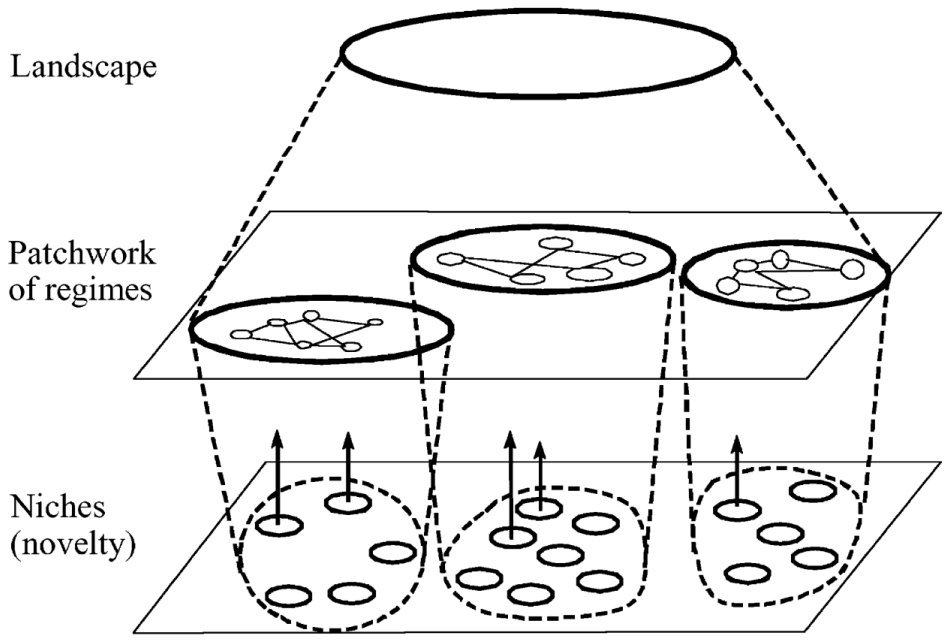

Figure 2: Three levels of the MLP framework. Source: Geels, 2002.

While the process of change might seem rather linear as highlighted above, Geels and Kemp (2007) provide a further discussion of three guiding mechanisms of the process of change, according to the levels involved and roles of actors involved. Firstly, a process of change can be that of *reproduction*, only displaying dynamics at the meso-regime level. It is exemplified by a rather slow, often almost invisible iterative improvements to an existing socio-technical system. While inconspicuous in nature, a reproduction dynamic can still result in significant improvements over time, but will generally not lead to a completely new, radically different socio-technical system. Secondly, *transformation* can happen as a result of interactive dynamics at the regime and landscape level, but still with little to no influence from brand-new niches. The guiding mechanism of a *transformation* is a pressure from the landscape level (i.e., changes in perceptions and agendas, incentive structures or financial costs). Change happens as a result of negotiations, shifting power dynamics and stakeholder cooperation, creating tension that eventually leads to transformation of a system, but usually does not threaten the existence of dominant actors within a respective scenario. As such, a new system may evolve from the old one due to cumulative changes towards a new direction. Lastly, *transition* can occur as a radical shift from one socio-technical system to another. New trajectory is developed because of pressure throughout all levels, typically manifested through successful niche evolvement. Technologies and materials, knowledge and education, infrastructure, user practices, legal regulations and cultural preferences are all shifted towards a new system, often resulting in creative destruction (Bach and Hansen, 2023) of the old system. After a transition is finished, the new system results in a period of stability.

2.1.2 Sustainability transitions within socio-technical systems

Having defined the concept of socio-technical systems and elaborated upon the MLP framework and different mechanism in change process, it is appropriate to shift the attention to the specificities behind sustainability transitions. While the theory of Multi-Level Perspective offers insights into how change comes about, it remains mostly neutral in its form to the prescriptive nature of what kind of transitions ought to happen (Geels, 2002; Jacobsson and Bergek, 2011). In the last two decades, however, the field of sustainability transitions has seen its emergence and a steeply rising popularity across academic and policy fields (Markard et al., 2012). In essence, sustainability transitions are *fundamental shifts in systems that are designed to fulfill societal needs (e.g., the transport system, the food system, the health care system, etc.) caused by profound changes in our dominant – often unsustainable – ways of thinking and doing* (Vandermoere, 2019 p. 1742). As such, they are prescriptive in nature, adding the layer of desired societal outcomes as a goal of transitions within socio-technical

systems. The reasoning behind the need for the specific – sustainability – type of transitions comes from a variety of sources, such as the latest IPCC reports (IPCC, 2023) or explicit calls by scholars (Lawhon and Murphy, 2011; Kattel et al., 2018), exemplified through the growing consensus in the public sphere (Mintrom and Rogers, 2022).

Despite the growing urgency of their goals (IPCC, 2023), sustainability transitions still face the same constraints to change as identified by the MLP approach. As a change needs to occur throughout all levels (see Geels, 2002), it can usually take up to several decades for a shift to happen in a respective system (Vandermoere, 2019). However, the urgency of the so-called grand-challenges (i.e., broad socio-environmental-economic issues affecting virtually the whole planet) does not offer the luxury of time (Coenen et al., 2015) and sustainability transitions thus need to be accelerated beyond the business-as-usual mode of operation (Mintrom and Rogers, 2022).

2.1.3 Geography of sustainability transitions

While the MLP framework serves as useful tools in analysing transitions within socio-technical systems, it has been criticized for a lacking or naïve conceptualisation of space, as the spatial context is too often understood as a passive background, instead of playing the key role (Coenen and Truffer, 2012). It is particularly important to understand the territorial embeddedness, as failure to do so might result in vastly different and uneven policy outcomes in different geographies. Truffer et al. (2015) present three key dimensions of geography of transitions, namely the socio-spatial embedding, multi-scalarity and issues of power, aimed at enhancing the understanding of spatiality within sustainability transitions. Firstly, the socio-spatial embedding refers to a range of conditions within a specific space, such as cultures, institutions, political systems, or networks that allow for change within a respective socio-technical system to happen. While transition study approaches reflect on such embedding (see for instance Geels, 2005), the socio-spatial context needs to be understood in more detail to provide insights into where and how specific transitions may happen. Secondly, while the MLP framework operates with different levels, it lacks a nuanced multi-scalar conceptualization which is necessary in answering the ways in which socio-technical systems are embedded in spatial context and the relationships existing within those contexts. As such, a better geographical understanding of the multi-scalarity within socio-technical transitions can account for the spatial unevenness of outcomes and the direction of change (Murphy, 2015). Lastly, Truffer et al. bring attention to the uneven power dynamics in sustainability transitions. As sustainability transitions gain more traction, there is a need for a better understanding of

who benefits and who may be disadvantaged, as policies may have different impacts on the environmental and socio-economic situation within different contexts (Truffer et al., 2015).

2.2 Policy as a driver for change towards decarbonisation

The description provided above of the transitions within socio-technical systems points towards the sheer complexity of actors, institutions, scales, and timelines that need to be managed and influenced in order to result in a socio-technical transition. If such transitions need to be accelerated, the use of public policy seems to be crucial in steering the transitions towards a more sustainable future through putting pressure on existing socio-technical regimes and encouraging, protecting and nurturing newly-formed niches (Kemp and Rotmans, 2004). The strategy of state interventions, and consecutively international regulatory bodies, such as the European Union, can be characterized either as *market-fixing* or *market-creating* (Mazzucato, 2016).

2.2.1 The market fixing approach

The market fixing approach builds on traditional economic view of the free market, with the role of state intervening only if a given market or sector fails to be successful, in other words, fails to allocate resources efficiently. Frequently, markets would fail to be efficient due to the existence and by-product of negative externalities (i.e., negative impacts on third parties, for instance congestions and greenhouse gas emissions in case of trucking, Gantilo et al., 2022). For negative externalities, there is no market, and they bear a substantial cost to the whole society (Mazzucato, 2016). The market fixing approach thus attempts to regulate such failures of a market through, for instance, carbon pricing or tax breaks for carbon neutral technologies, but offers little insights into the direction a market is headed in the first place. The market fixing approach, while providing useful insights into the regulation of existing and dominant socio-technical systems, offers little value for steering markets towards tackling grand challenges.

2.2.2 The market creating approach

Under the market creating approach, on the contrary to the market fixing approach, the role of state and supra-national bodies is to actively steer the change, as a part of so-called *missions* (Mazzucato, 2016). Such a mission (e.g., decarbonizing the road freight sector) can thus be

understood as a more concrete goal towards which the market is to be proactively directed, usually situated within a broader grand challenge, such as climate change.

Since the responsibility of steering the direction of the market, and, in turn, the society, is put on the policymakers, there are several key questions they need to answer in shaping the transition. Firstly, the directionality of the change needs to be decided with precision and confidence, but transparent enough to include a wide array of actors and to encourage subsequent bottom-up participation. Secondly, the policymakers need to be directly involved within the industry through symbiotic partnerships with the private sector, ideally through a wide portfolio approach to public spending to compensate for inevitably unsuccessful projects. Such an involvement should result in a mobilisation of skills, resources and capabilities needed to achieve the creation of a new market. Thirdly, a new set of metrics needs to be developed to measure the effectiveness of public, mission-oriented policies. The current dominant approach of cost-benefit analysis does not allow for the evaluation of new regimes, as it is backwards-looking and thus can effectively address only already existing regimes. Thus, new metrics and evaluation criteria need to be developed to effectively measure the direction of change with a given socio-technical system. Lastly, in order to create new markets, crucial choices must be made beyond the framework creation for the direction of change, particularly regarding public spending following the transition agenda. Inevitably, some projects will fail, but there is a need for mechanisms to reward the policymakers – the state – for successful investments. In other words, if the state is actively steering the direction of a regime beyond the spending and choice of private companies, it needs to be adequately reflected on the benefits from the wins of these new systems, otherwise securing public funding would be almost unachievable (Mazzucato, 2016).

2.2.3 Successful examples of the past

The role of the state in successful demonstrations of market creation towards sustainability can be exemplified, for instance, in the case of decarbonisation of the Spanish economy, as Cansino et al., (2016) conclude that policy initiatives introduced on the state level, following the calls of international bodies (e.g., the Kyoto protocol and other directives), lead to a positive impact on overall CO_2 emissions of the Spanish economy. Furthermore, Geels (2012) provides evidence for government policies in the UK and Netherlands specifically targeting CO_2 emissions serving as a key catalysator for a change towards sustainability in the road transport sectors in the respective countries.

Similar case studies can be found throughout the scales of the mission for decarbonisation, such as the development of “environmental packages” in Norway for the support of sustainable, low-carbon modes of transport in urban regions (Forbord and Hansen, 2020) or the multi-agent engagement projects to secure sustainable water management practices in Australia (Mintrom and Rogers, 2022).

2.3 The policy implementation process

In the sections above, I highlighted the nature of socio-technical systems, along with theoretical approaches of understanding them, subsequently followed by demonstrations of public policy at steering the change towards sustainability. On the following lines, I elaborate upon the policy implementation process with a particulate emphasis on bottlenecks and enablers that are ever-present throughout the policy process.

The traditional conceptualization of the policy process follows a sequential cyclical model in the form of (1) problem emergence, (2) agenda setting, (3) consideration of policy options, (3) decision-making, (5) implementation, and (6) evaluation (Benson and Jordan, 2015). While this sequence might seem straightforward, scholars repeatedly point out the messiness of the process, due to the number of actors involved, the scale of financial and organisational investment required and uncertainty of outcomes (Cairney, 2018, 2020). Policy implementation represents a distinct stage in the overall policy process, defined as *an iterative process in which ideas, expressed as policy, are transformed into behavior, expressed as social action* (Ottoson and Green, 1987 p. 362 in DeGroff and Cargo, 2009). As such, it serves as the bridge between the policy formulation stages and its real-world impacts, up for evaluation and iterations in later stages.

The European Union policy making has evolved beyond the traditional policy process, mainly due to the complexity of actors and the transparent and participatory nature of the whole process. It has been described as a so-called *mandated participatory planning* (MPP) by Newig and Koontz (2013), as it combines components of participatory (i.e., through the involvement of non-governmental and private actors) and multi-level governance, mandating the implementation of EU policies throughout the levels of national governments, especially prominent in environmental policy directives. While the conceptual understanding of the MPP approach is still developing, it serves as a new way of policy governance, fostering – mandating – the participation of private and non-elected bodies in the decision-making process, as well as calling for enhanced coordination of member states’ administration. While

the over-arching policy is still developed in the higher levels (i.e., the European Commission), it is supposed to be done so through extensive discussion with non-governmental actors. Followingly, the formulation and execution of specific responses to meet the goals of the policy is largely appointed to lower levels of administration in respective member states (Newig and Koontz, 2013).

The success of a policy implementation process is significantly reliant on overcoming bottlenecks and challenges, relating to seven dimensions of policy implementation, as identified by Bhuyan et al. (2010). While these dimensions represent broader categories for consideration, each relates to a specific potential bottleneck in the process, appearing throughout different publications (see Mthethwa, 2012; Rizos et al., 2016; Veale and Borgesius, 2021 or Ragon and Rodríguez, 2022). *(1) Formulation and dissemination*: the policy needs to be clearly formulated and communicated to respective actors, its parameters, such as time horizons and rationale, need to be defined. Unclear, ambiguous or confusing policy objectives may be hindering the successful implementation of a policy from the very beginning, as exmplified by Veale and Borgesius (2021) at the example of the EU Artifical Intelligence Act of 2021 and its poor initial formulation. *(2) Social, political, and economic context:* Policies must be understood in the context of where they take place. Kingdon (1984 p.109 in Mthethwa, 2012) goes as far as defining the political process as *swings in national mood, vagaries of public opinion, election results, changes in administration, shifts in partisan or ideological distributions, and interest group pressure.* As such, the success of policy implementation largely lies within the stability, administrative power, and economic situation of governmental bodies and respective member states. *(3) Leadership for policy implementation:* The level of consensus and cooperation among policy leaders is likely to influence the outcomes of a respective policy. Furthermore, the implementation of policies usually sits within a wide range of different officials, especially in a decentralised process, further stressing out the importance of a successful leadership transfer throughout. Thus, key leadership roles must be explicitly mentioned and accountability for action must be defined to achieve a successful policy implementation. *(4) Stakeholder involvement:* As highlighted above, the EU policy process can be described as a *mandatory participatory planning*. While the involvement of non-public actors leads to improvements in the relevance of policy, it also serves as a bottleneck in the sense of difficulties connected to public-private negotiations and differences in actors' outcomes preferences. Nonetheless, stakeholder involvement takes a crucial step in the formulation and implementation of European policies and closely relates to the leadership for policy implementation, as successful leadership leads to fostering more time effective involvement with key stakeholders and non-governmental organisations. *(5) Resource mobilisation:* Even after policy is formalised, a successful implementation requires

resource planning and mobilisation, as missing budgets, operational directives, and work plans are often the reason for suboptimal policy implementation. Furthermore, connected to point *(3)*, the lack of leadership may result in insufficient human and financial resources, potentially hindering the process. Similarly, different organizations and firms face different challenges and operate with different capacities, thus the degree of successful or timely implementation greatly varies (Cohen and Levinthal, 1990). *(6) Operations and services:* New policies might result in significant delays to operations and services provided by specific actors. Therefore, the implementation process must be tailored to specific local conditions and dynamics, but still often results in uneven outcomes and uncovers new operational barriers. As such, the policy should clearly communicate what are the expected changes to day-to-day operations and services provided by both the official bodies and non-governmental organisations. *(7) Feedback on progress and results:* The long-term success of a policy also relies on the ease and transparency of feedback from individual actors affected by a new policy. While not present in the initial phases of the policy implementation process, continuous evaluation and monitoring of progress are likely to influence the uptake and success of the policy in the long run (Bhuyan et al., 2010).

Figure 3 below represents an overview of the seven key bottlenecks linked to the dimensions of the policy implementation process as highlighted above, as well as relevant previous research elaborating on specific bottlenecks of the policy implementation process.

Potential bottlenecks of the policy implementation process	Potential negative impacts on the policy implementation process	Previous research
The policy, its formulation, and dissemination	Unclear formulation (target groups, rationale, time horizons etc.) might lead to hindrances of the policy process from the very beginning.	**Veale and Borgesius, 2021**: Demystifying the Draft EU Artificial Intelligence Act Analysing the good, the bad, and the unclear elements of the proposed approach
Social, political, and economic context	Unfavourable social, political, and economic factors can negatively influence the policy process.	**Kingdon, 2014**: Agendas, Alternatives, and Public Policies
Leadership for policy implementation	Unclear leadership roles and accountability criteria may slow down the policy implementation process.	**Gilson, 2016**: Everyday Politics and the Leadership of Health Policy Implementation
Stakeholder involvement in policy implementation	Insufficient cooperation with relevant stakeholders may result in slower uptake of new policies and backlash from different groups affected by the policies.	**Challies et al., 2017**: Governance change and governance learning in Europe: stakeholder participation in environmental policy implementation
Implementation planning and resource mobilisation	Improper planning for implementation and insufficient resource mobilization may limit the effectiveness of even a well-formulated policy.	**Leśnodorska, 2011**: Financial Dimension of Resource Mobilization for Environmental Projects in Eastern Europe
Operations and services	New "way of doing things" must be addressed by the policy, otherwise operations and services might be negatively impacted, resulting in delays to day-to-day activities.	**Klein and Knight, 2005**: Innovation Implementation: Overcoming the Challenge

Feedback on progress and results	Unclear feedback and progress monitoring may negatively impact the policy effectiveness in the long run and limit potential improvements in the future.	**Jordan and Matt, 2014**: Designing policies that intentionally stick: policy feedback in a changing climate

Figure 3: Potential bottlenecks to the policy implementation process and relevant previous research. Source: Author's elaboration based on Bhuyan et al., 2010.

3. Conceptual framework

More than twenty years ago, Martin (2001) made a plea for moving towards a new geography of public policy. His essay laid out four fundamental arguments against the fragmented post-structuralist geographies and their disappearing relevance for the formation and ultimately studying of public policies. First, the desire for adoption of latest philosophical or theoretical trends needs to be tempered in order to maintain consistency. Secondly, there needs to be a cohesion of thinking regarding key social issues instead of convoluted epistemological specialism within the discipline. Thirdly, Martin warns against thin empiricism, as a solid methodology and quality of data is paramount. Lastly, any research done by a human geographer is inherently not neutral, thus the purpose of the research must be clearly stated in regard to their political position.

Following Martin's arguments, I strive for implementing theories in such a way that is aligned with critical realist thinking and human geography in broad terms. In other words, my geography follows the conditions of being transparent and clear, ontologically driven, avoiding thin empiricism through implementing primary policy data sources supported by secondary data coming through expert opinions, white papers, and briefings and, lastly, positioned towards a clear research motivation and objective.

Ultimately, Martin calls for moving beyond specialism within human geography and the need for interdisciplinary collaboration for effective policy research and for the purpose of this work, It is in the light of the arguments above that I turn towards borrowing interdisciplinary models of explanation allowing for a nuanced analysis of relevant policies, bottlenecks and the nature of expected outcomes.

With Martin's guiding principles in mind, I present the operationalization of key theoretical concepts, research questions and data utilised for this thesis below. Figure 4 offers an overview of relationship between the research questions and main theoretical building blocks of the research. As this work represents an interdisciplinary piece of research situated

between policy and geographical studies, I strive for implementing concepts from both fields to achieve a nuanced understanding of the nature of the policy process, potentially hindering bottlenecks and ultimately the spatial variance in outcomes.

More specifically, the first research question allows me to place the current policies of the *Fit for 55* package within the theory of mission-oriented policies, as described by Mazzucato (2016). I aim to do so by exploring to what extent are the four critical dimensions (i.e., the direction of change, the nature of affected organisations, the evaluation of effectiveness and the distribution of risk and rewards) reflected within the policy proposals. Furthermore, as Mazzucato (2016 p. 142) argues, *any framework that focuses on policy only in terms of fixing problems, especially (but not only) market failures, does not embody any explicit justification for the kind of market creation and mission-oriented directionality*. Thus, I add a dimension of evaluation that allows for placing respective policies within either a market-fixing or market-creating approach, enabling for a better understanding of the direction of change. Additionally, I analyse the actors targeted by the specific policy instruments, in accordance with the supply-chain overview, as presented by Ragon and Rodríguez, 2022.

Followingly, to answer the second research question, I borrow from the policy implementation process literature (DeGroff and Cargo, 2009; Benson and Jordan, 2015; Cairney, 2018) in order to assess the key bottlenecks to the success of the implementation process of the specific policy instruments relevant for the road freight sector, relating to the seven dimensions of policy implementation (see chapter 2.3) as outlined by Bhuyan et al. (2010).

In order to address the final research question, I connect the implementation process of the key policy instruments to the MLP framework of Geels (2002, 2004; Geels and Kemp, 2007). This allows me to highlight the potential unevenness of the process, as change is likely to happen at different levels in different contexts. However, to support the MLP framework and following some of its “sympathetic” critique (Coenen and Truffer, 2012) , I bring forward a more nuanced understanding of geography within sustainability transitions, as identified by Truffer et al., 2015. Utilising these dimensions (i.e., of socio-spatial embedding, multi-scalarity and issues of power) allows for a more detailed approach to the explanation of role of space in the transitions of socio-technical system, ultimately providing me with substantial theory to answer the third research question.

The process of change, as highlighted in Chapter 2.1.1, serves as an overarching theme to be explored through the analysis, closely linked to the MLP perspective and last research question.

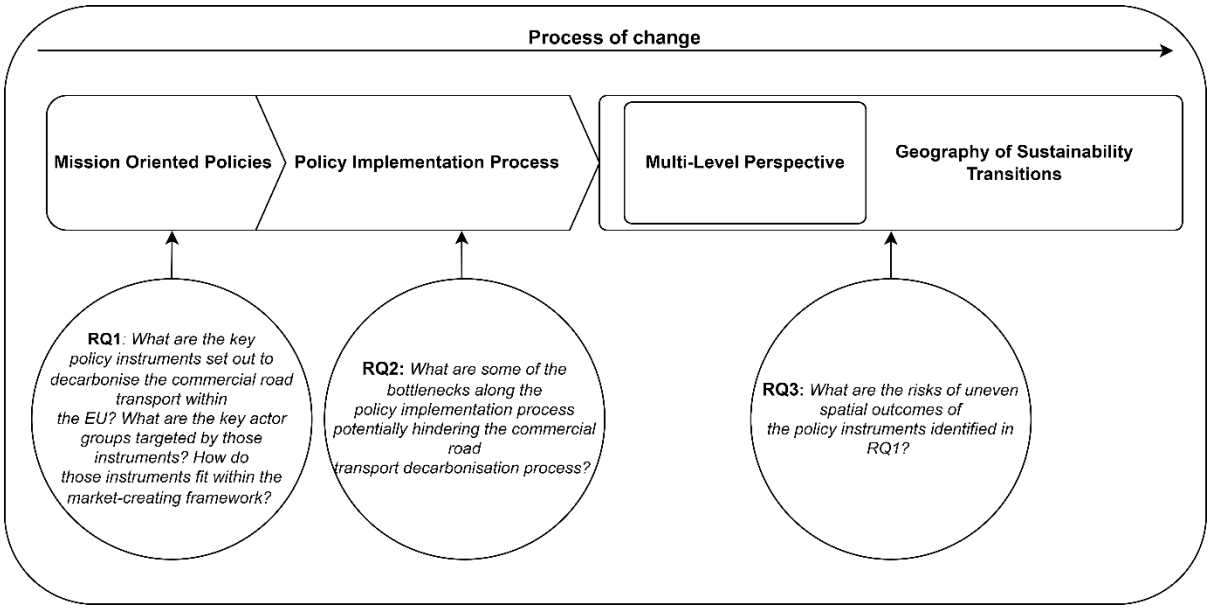

Figure 4: An overview of the analytical process connecting key theoretical concepts and research questions. Author's elaboration.

4. Background and key actors

Sector overview

Road freight transport is a massive industry, employing around 11 million workers in the EU alone (Eurostat, 2021). The commercial road sector, while responsible for only around 15% of total freight activity, emits roughly 44% of all transport CO2 emissions (ITF, 2021). In 2020, the road transport was affected the most out of all sectors by the pandemic, but is recovering to its historical growth levels, both in terms of the amount of goods transported and the number of new commercial vehicles on the roads (Eurostat, 2022a; ACEA, 2022). According to future outlooks, the fleet of commercial cars and thus overall road transport emissions will simply keep rising until a dominant breakthrough in zero-emission truck technologies and policies happens (Beguerie, 2021; ITF, 2021; PwC, 2022). While the growth rate of the freight sector is slowing compared to previous projections, it is expected that the tonne-kilometres activity (i.e. a standard metric understood as the weight of goods transported per amount of kilometres travelled) will more than double by 2050 (ITF, 2021).

Currently, there are around 36 million commercial road vehicles in the European Union (up to almost 50 million including Turkey, the UK and EFTA countries), commonly split into three main categories and 9 use cases (ACEA, 2022; PWC, 2022).

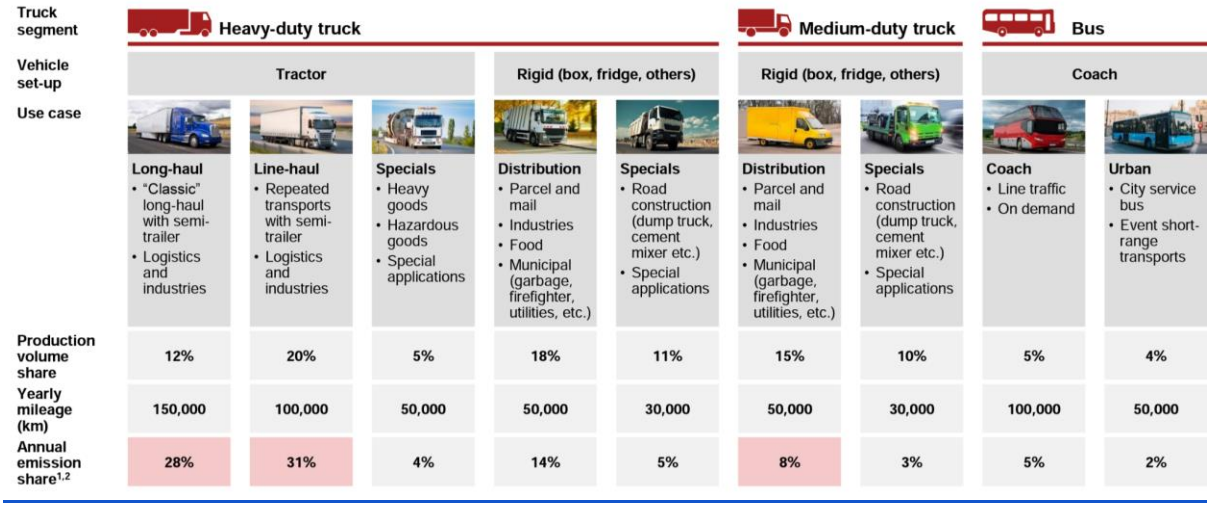

Figure 5: The global truck market segments and use cases. Source: PWC, 2022.

As shown in Figure 5, classic, long-haul trucks and light/medium distribution vehicles have the highest proportion of emissions out of all commercial vehicles. For instance, the urban delivery segment, while covering only about 3% of all freight activity, emits the same amount of emissions annually as the whole maritime transport sector, which is responsible for over 70% of the freight volume, due to its nature of short, frequent trips and small loads (ITF, 2021). Despite the efficiency of heavy goods vehicle in terms of emissions per tonne-kilometre, the overall energy use and related emissions keep rising (T&E, 2020).

Actors, roles, and industry structure

The commercial road transport is a vast industry sector comprised of many actors operating at varied scales (e.g., from shippers active only in a certain region to international governing bodies), with different capacities (e.g., from companies owning a single truck to government-owned logistics giants) and serving unique purposes (e.g., from providing a tax service to manufacturing vehicles) In order to understand the effectiveness of policies aimed at tackling the rising sector's emissions, a correct understanding of the roles and interplays of individual actors is necessary (Behrends et al., 2008). While the final number of actors directly or indirectly involved in a transport system can reach confusing heights (i.e., when counting in academic and research institutions or traffic controllers - see Behrends et al., 2008), a simplified overview (see Figure 6) based on Ragon and Rodríguez, (2022) will facilitate the further debates within this paper.

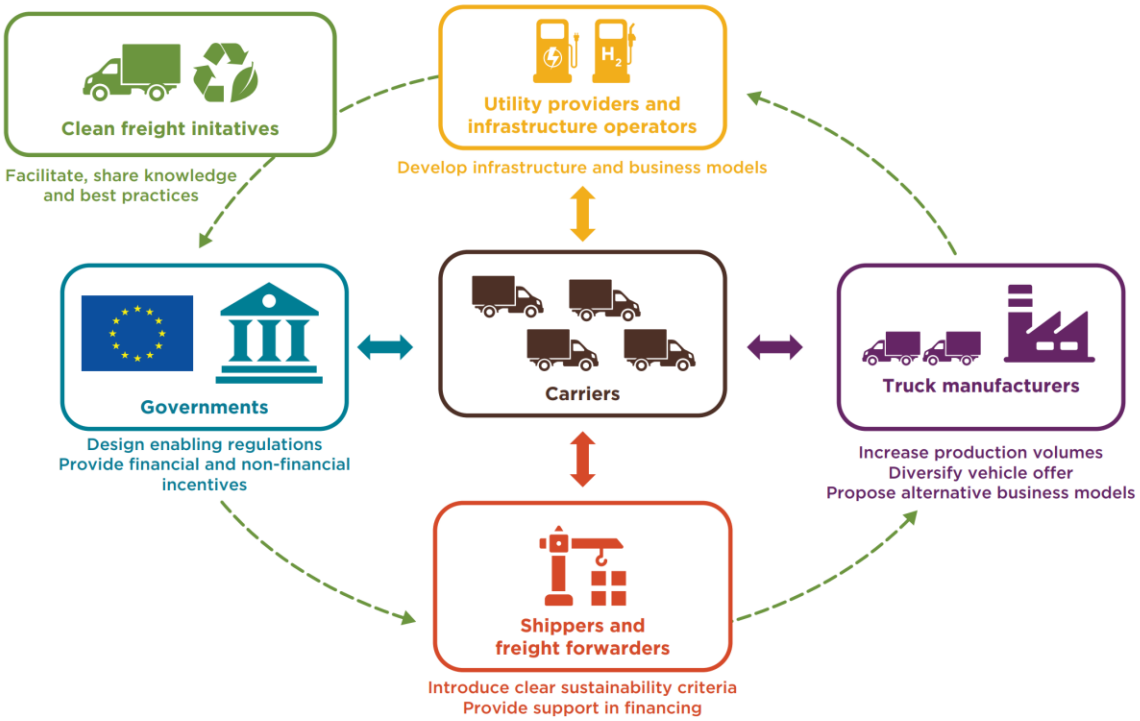

Figure 6: Actors and their role in road freight decarbonisation. Source: Ragon and Rodríguez, 2022.

Carriers

Starting from the operating level, the road freight transport in the EU is dominated by small companies, having fewer than 6 employees on average (see Figure 7, Eurostat, 2023). There are several reasons explaining the size of the carriers and connected implications to sustainability transitions. Firstly, EU carriers are small due to a combination of institutional support for small companies in terms of tax incentives and labour regulations supporting self-employment (Arruñada et al., 2004). While the size of small and medium firms (SMEs) brings advantages of flexible organisation and dynamic leadership (i.e., many EU trucking hauliers are owner-operator, Arruñada et al., 2004), there are also numerous disadvantages, such as dependency on specialised personnel for survival and difficulties of attracting new workers (i.e. there is an estimated shortage of 380 thousand, proportionate to some 10% of all truck driver positions within the EU, IRU, 2022). Furthermore, the personnel situation is likely to worsen due to an aging population of truck drivers, with EU having the highest average driver age of 47 years in comparison with other major markets (IRU, 2022). Moreover, SMEs are also less likely to secure venture capital and bank investments in comparison to large companies. Additionally, SMEs face risk of insolvency in case of failed innovation projects and typically dispose with lower financial capital, hindering the possibilities for start-ups and early adoption of technologies with high up-front cost (Hansen and Klewitz, 2012). As carriers are

ultimately tasked with transporting cargo, they are directly responsible for the majority of greenhouse gas emissions within the road freight industry (Ragon and Rodríguez, 2022).

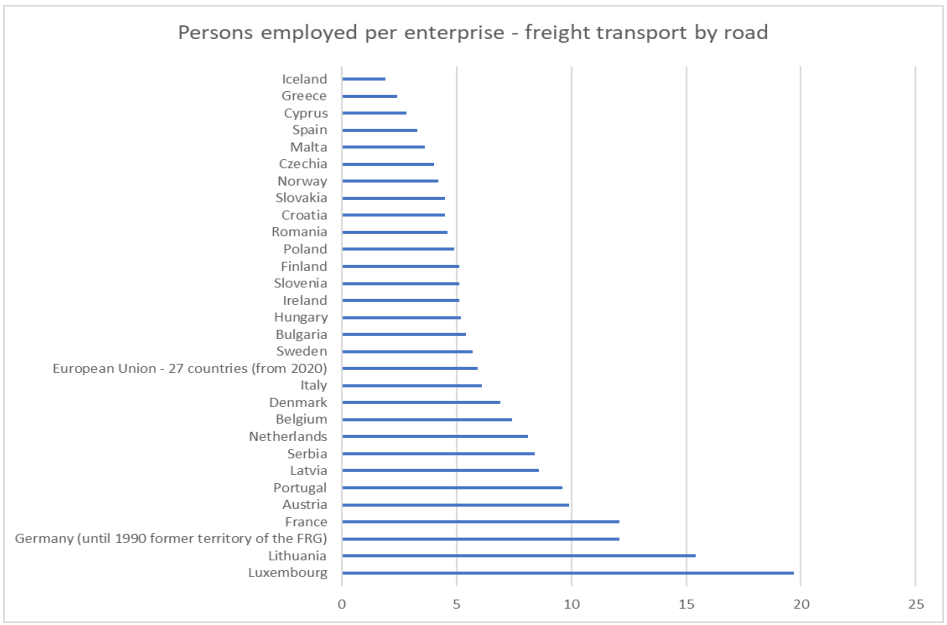

Figure 7: Average number of persons employed per road transport company in the EU in 2019. Source: Eurostat*, 2023.*

Shippers

Inseparable from the hauliers are shippers, or companies that contract hauliers to transport their cargo. Some, usually big shippers (e.g., DB Schenker or DHL), operate their own fleet of vehicles, mostly due to economies of scale. However, most of the EU freight is transported by the aforementioned group of hauliers and not large companies with a direct control over their fleet (Arruñada et al., 2004). While the shippers do not bear the environmental cost of shipping directly, reducing emissions is becoming a focal point in their business practices through the emerging importance of non-financial reporting, as companies are required to report so-called Scope 3 emissions (i.e., emissions resulting from upstream and downstream activities, not directly generated by the company, GHG Protocol, 2013). As such, shippers have a great potential and bargaining power through their choice of carriers in reducing the overall road freight emissions, especially in long-term partnerships allowing for strategic planning and cooperation (Ragon and Rodríguez, 2022).

Manufacturers

Original equipment manufacturers (OEMs) play a critical role in the supply chain through the characteristics of vehicles they deliver to the market. In the case of large shipping companies, there is a possibility for close cooperation with OEMs to manufacture vehicles specifically to

their needs (e.g., the case of Rivian and Amazon in the US producing tailor-made, electric delivery vans, Amazon, 2022, or the Volvo-DHL partnership resulting in a delivery of medium and large electric trucks to the specific needs of DHL, Volvo, 2022). However, most of the carriers in the system do not have the luxury of bargaining power and financial capital to secure similar deals and are left dependent on whatever technology is publicly available (Ragon and Rodríguez, 2022). Manufacturers also play an important role through vehicle financing, as they typically offer several options for customers and can thus accelerate the uptake of low and zero emission trucks through alternative, green financing, similar to those options that can be found in the passenger transport market (GFI, 2021).

Infrastructure and services providers

While the infrastructure supporting traditional internal combustion trucks is well-developed, standardized and available across the continent, infrastructure connected to charging of electric vehicles or refuelling of other alternative powertrains is virtually absent (Van Grinsven et al., 2021). While most electric trucks are expected to be charged in private depos, long-haul, zero-emission trucks will require substantial improvements of availability of the alternative infrastructure, and thus the infrastructure and service providers will serve as a key link in the decarbonisation efforts of the road transport (Ragon and Rodríguez, 2022).

Governments and regulatory bodies

Early intervention of governments and regulatory bodies are a necessary step in socio-technical transitions (Kemp and Rotmans, 2004) and the decarbonisation efforts within the road freight industry are no exception. Regulatory bodies, such as the European Union through its administrative units devising directives (i.e., common goals to be transposed into national law of member states) and regulations (i.e., universally applicable binding legislature), and member states' governments support and shape the whole transition through several distinct categories, related to other main actors within the industry. Firstly, there are already emission standards in place to support more efficient vehicles, though some of them require no penetration of zero-emission trucks. Secondly, some governments support the transition through direct financial or tax benefits for carriers, should they buy a zero-emission truck. However, financial benefits are highly varied throughout the member states and dramatically insufficient to motivate a large-scale switch at the moment (T&E, 2022). Thirdly, regulators play a key role in supporting the development of infrastructure necessary for zero-emission trucks, as under current market conditions (i.e., very low number of alternative vehicles on the roads) infrastructure and service providers simply do not have a business case to invest in such projects. Lastly, sub-national governments are increasingly adopting low- and zero-emission zones within urban areas, effectively acting as a strong incentive for both shippers

and carriers to switch to alternative powertrains, should they continue to operate withing those areas (Ragon and Rodríguez, 2022).

Clean freight initiatives

The last major category directly influencing the road freight sector are think-tanks, research institutes and other initiatives. For instance, the World Economic Forum has proposed a roadmap to achieve road freight decarbonisation, The Greenhouse Gas Protocol has defined standards for non-financial reporting regarding emissions, pushing for greater accountability throughout the supply chain. Generally, these initiatives are facilitating a role that allows for greater knowledge sharing, education and establishment of best business practices (Ragon and Rodríguez, 2022).

Germany and Poland – an exemplary dynamic

While virtually all actors are present in all markets across the continent in road freight, I bring attention to the case of Germany and Poland, as the two countries represent a special case and feature particularly interesting dynamics. Germany is by far the biggest market with almost a quarter of all road freight tonnage transported within its borders in 2021. On the other hand, Poland is the largest home country of carriers, covering over 33% of international haulage in Europe in 2021 (Eurostat, 2022b). Naturally, neither market exists separated from the rest of the EU, but the dynamic is an illustration of general trends in road freight, where lower-income countries, such as Poland and Lithuania, dominate the supply of road transport in higher-income countries (Suproń, 2020). Furthermore, the nature of the size of the carriers is vastly different, with Polish trucking firms being on average less than 5 people and German counting upwards of 12 (Eurostat, 2023). As such, Polish firms tend to be more sensitive to even incremental changes in operating costs and changing macroeconomic environment (OECD, 1997), as discussed in the “Carriers” section above. This sensitivity has been manifested through the recent implementation of the so-called *Mobility Package* (European Commission, 2022), aiming at harmonizing the regulations and conditions for workers across EU member states, but ultimately criticised for breaching the free market structure and resulting in overall higher labour and operating costs, thus reducing the competitiveness and potentially diminishing the market position of hauliers from Central and Eastern Europe (Suproń, 2020).

5. Methodology

This thesis presents a qualitative study of the policy environment and difficulties related to the policy implementation process exemplified at the sector of road freight transport utilising policy documents, reports and expert opinions gathered through secondary data sources. More specifically, I am to utilise the policy proposals of the *Fit for 55* package relevant to the commercial road transport sector, identify bottlenecks along the implementation process and shed light on potentially uneven outcomes. Most research focused on policy analysis has been called derivative in nature (Bardach, 2012), since the researcher's job is typically to analyse and synthesize information that is already present in policy documents. As such, final results typically come through the interplay of theory, ideas and meanings based on pre-existing data, rather than from a generation of completely new policy proposals or theories (Bardach, 2012).

5.1 Method

All data for the purpose of this thesis comes through publicly available online sources, consisting of primary data sources in the form of European policy material and secondary sources from research institutes and non-governmental organisation, as per understanding of primary and secondary sources of information, presented by Hox and Boeije (2005) . As this piece of work is concerned with studying the public policy and its implications, the collection process is predominantly steered by the selection of relevant publications, inspired by similar studies (for instance Suproń, 2020 or Creutzig et al., 2011). As previously mentioned by Bardach (2012), the majority of policy research work relies on readily available data in form of documents of different forms, therefore the collection process should be guided by clear delineation of the selection criteria utilised to choose certain material over other, as for practical reasons it may be impossible to analyse or even access all available documents.

5.1.1 Selection criteria

The material for this thesis was selected through on-line, publicly available means. However, despite the ease of accessing the material, I followed the Scott's (Scott, 1990 in Bryman, 2012) criteria for accessing data in the form of documents. Firstly, any material is to be judged based on *authenticity*. This proved to be rather straightforward, as most of my material consists of official policy documents published by the European Union and coming directly from the official EUR-Lex website. For non-policy documents, I only sourced material from established institutes, such as the Transport and Environment or the International Road Transport Union,

backing up the authenticity criteria to a sufficient level. Secondly, the *credibility* of the material needs to be assessed, meaning to what extent is it sincere and accurate. As my material represents either policy documents from original sources or white paper-type documents, it is safe to assume that it is credible, and the publisher would stand behind it. Thirdly, *representativeness* needs to be judged in the sense of whether a document is typical for its kind and fitting into a broader context. In my case, neither source is unique in its form, and each represents a common approach to policy or document publication, thus can be classified as representative. The last criterion is concerned with the nature of meaning, and arguably the hardest to assess. While under Scott's definition it includes, among other things, whether a document clear and comprehensible, the final meaning of each data document needs to be set within a context and cross-referring to other documents, especially in the case of European policy material. Nonetheless, all data sources utilised for my work can be considered meaningful (Scott, 1990 in Bryman, 2012).

With the criteria outlined above in mind, I gathered materials relevant to the commercial road transport from three sources. The primary source consists of policy proposals in forms of regulations and directives of the European Union's *Fit for 55* package, as summarized by EEA (2022b) and updated for current changes and developments in legislature (e.g., Regulation (EU) 2023/857 was published on the 26th of April, 2023, serving as a an example of the fast pace of developments of the relevant EU policies). I selected the most recent material that reflects the latest developments in the legislature in relation to the commercial road transport. The data from secondary sources consist of white paper-type documents of several research institutes and clean freight initiatives, such as the World Economic Forum, the International Road Transport Union, CE Delft, or the International Council on Clean Transportation. Together, the document basis provides a solid foundation for the research, centred around the policy material, and supplemented by non-policy documents to form a comprehensive view of the overlying policy structure, the implementation process, and the nature of outcomes of the policies.

In total, I gathered 10 main policy documents, representing the latest iterations of the European Union policy on decarbonisation with a relevance for the commercial road transport. Subsequently, 6 studies or briefings were collected to supplement the primary policy documents. While this material is by no means exhaustive, it represents a substantial body of 685 pages to facilitate the analysis towards answering the research questions and is consistent with similarly positioned research, such as of EEA (2022b). Figure 8 below presents an overview of the analysed material with reference to document type, publisher, relevance of the material for the road freight sector and other information.

ID	Document name	Document Type	Publisher	Publication date	Length (pages)	Relevance for road transport
1	Directive 98/70/EC	Directive	European Commission	2018	41	Regulates the quality of petrol and diesel fuels.
2	Regulation (EU) 2018/842	Regulation	European Commission	2018	17	Sets binding annual greenhouse gas emission reductions by Member States from 2021 to 2030, of which road transport is a specific subsection.
3	IRU vision for decarbonising commercial road transport leading up to 2050	Briefing	International Road Transport Union	2018	6	Position briefing by the International Road Transport Union, proposing its vision for decarbonisation of the road freight.
4	Directive 2014/94/ EU	Directive	European Union	2021	17	Establishes a framework of measures for the deployment of alternative fuels infrastructure, sets out minimum requirements for the building-up of alternative fuels infrastructure, including recharging points for electric vehicles and refuelling points for natural gas (LNG and CNG) and hydrogen.
5	Regulation (EU) 2018/1999	Regulation	European Union	2021	86	Aims to ensure that the EU's Energy Union Strategy on energy security, internal energy market, energy efficiency, decarbonisation and research, innovation and competitiveness is implemented and coordinated coherently. Transport is one of key subsections.
6	Regulation (EU) 2021/1119	Regulation	European Union	2021	17	Establishes a framework for the irreversible and gradual reduction of GHG emissions. Transport is one of key subsections.
7	Alternative fuel infrastructures for heavy-duty vehicles	Study / White paper	CE Delft / TRAN Committee	2021	59	Outlines the current situation, prospects, barriers and enablers and policy recommendations for the deployment of infrastructure supporting zero-emission heavy duty vehicles.
9	Directive (EU) 2018/2001	Directive	European Union	2022	149	Establishes a common framework for the promotion of renewable energy. Transport is one of key subsection.
10	How to buy an electric truck	Briefing	Transport and Environment	2022	31	Provides an analysis of the financial mechanisms and incentives surrounding the uptake of alternative heavy-duty vehicles.
11	Making Zero-Emission Trucking Possible	Study / White paper	Mission Possible Partnership	2022	60	A synthesis report informing public and private actors about the nature, timing, cost, and scale of actions necessary to achieve net zero within the sector by 2050.

12	Road freight decarbonization in Europe	Study / white paper	The International Council on Clean Transportation	2022	32	Overview paper suggesting all necessary steps, enablers, and barriers in order to decarbonise the commercial road transport.
13	Regulation (EU) 2023/857	Regulation	European Union	2023	14	Establishes obligations to member states as regards their minimum contributions to the fulfilment of the EU's commitments on reducing its GHG emissions. Transport is indirectly a subsection.
14	Regulation (EU) 2023/435	Regulation	European Union	2023	27	Supports coordinated planning and financing of cross-border and national infrastructure as well as energy projects and reforms towards energy independence and decarbonisation. Transport is a key subsection.
15	Procedure 2023/0042/COD	Proposal for a regulation	European Union	2023	52	Sets out stricter CO2 standards for new heavy-duty vehicles.
16	Directive 2003/87/EC	Directive	European Commission	2023	68	Establishes a GHG emission trading scheme. Transport is a key subsection.
17	Road Freight Zero: Towards a Holistic Regulatory Framework for Reducing Road Freight Emissions in Europe	Briefing	Road Freight Zero / World Economic Forum	2023	9	Suggests regulatory framework for decarbonisation of the road freight. Transport is a key subsection.

Figure 8: Overview of the selected material. Author's elaboration.

5.1.2 Trustworthiness criteria

After outlining the selection criteria for the material, I would like to touch upon the notion of trustworthiness within research employing the method of qualitative content analysis. As highlighted by Elo et al. (2014), a large portion of a research utilising qualitative content analysis depends on the insights and intuitive actions of the researcher, which may be particularly challenging to describe and explain to outside readers of the work. Nonetheless, clear articulation regarding the following three categories of trustworthiness helps to validate the research. Firstly, *credibility* refers to the confidence between the focus of the research and the level of confidence of addressing the focus through data selection and analysis (Graneheim and Lundman, 2004). I highlight the criteria for material selection in Chapter 5.1.1, providing a substantial reasoning behind choosing certain material over other. Furthermore, I discuss the appropriateness of employing the method of qualitative content strategy and my approach to analysing the data, providing additional information behind the credibility criteria

for this study. As I chose documents as my unit of analysis and this thesis represents an individual piece of work, there were no opportunities for participants consultation or cross-researcher credibility validation, respectively. In this section of results reporting, I follow a systematic approach referring to the codebook and providing evidence in form of exerts and examples of operationalisation of individual codes, relating to the theoretical foundation of the study. Secondly, *dependability* needs to be discussed regarding the evaluation of trustworthiness. Generally, dependability refers to the research process being logical, well-documented and traceable. There are no measurable criteria regarding dependability, but I aimed for a clear, logically flowing articulation of my research to meet this criterion. Furthermore, dependability refers to the stability of data over time (Elo et al., 2014). However, as this thesis was conducted over one semester and data comes through documents rather than through interviews or other methods, stability of data was not a big concern. That being said, it is important to bear in mind that this study serves as a snapshot of the current developments in decarbonisation policies, and it can be expected that some of official European policies will be changed, as they are either not formalised yet or will come under revision in the upcoming future. Lastly, *transferability* is concerned with the potentials for extrapolation. While it is mostly up to the reader to assess whether the findings of this study can be transferred to another context (Elo et al., 2014), I strive to enhance it through clear, detailed description of the whole research process, from the theoretical underpinning of selected codes to the material selection and analysis strategy. However, this study serves as a snapshot of the development in the field of European road freight decarbonisation policies, which are likely to change along with increasing pressures from the public and technological developments. Thus, transferability of the results is limited to similarly positioned and timed analyses.

5.1.3 Analysis strategy

For the purpose of this thesis, I utilise the method of qualitative content analysis of policy and other documents. This method is widely utilised by social scientists and can be considered the leading method in document analysis studies (Clark et al., 2022). As I intend to provide an overview of developments in relevant policies, as well as discuss the bottlenecks along and beyond the implementation process, this method is highly appropriate for several reasons. Firstly, it allows for a pre-defined construction of themes and categories to be looked for in the data, based on existing literature and previous research, as outlined in the analytical framework section. This deductive approach enables the building of a coding protocol which brings consistency and transparency to the process of data analysis, clearly showing how

each document links to the pre-determined dimensions of inquiry. Secondly, content analysis can be classified as a non-reactive method due to the data used coming from already existing sources, thus conducting the research does not impact the data. Therefore, much of the potential bias introduced through some other qualitative methods, such as the interviewer effect (i.e., a phenomenon of the characteristics of the interviewer subconsciously influencing the answers of the interviewees, Bryman, 2012) is avoided. Lastly, utilising the method of content analysis of existing material allows for the reduction and understanding of large documents, which themselves would be beyond the production capacity of a student-researcher when it comes to the amount of data collected or produced (Clark et al., 2022).

The generation of codes for the analysis followed the model for a deductive qualitative content analysis as highlighted by Mayring (2000), portrayed in Figure 9. This process has also been called the template-style of coding, as a template – or a codebook – is developed *a priori* to the data analysis (Fereday and Muir-Cochrane, 2006). While most of the specific codes and categories were formed deductively based on the framework that emerged from the literature review, there was a possibility for revisions after the initial analysis of a portion of the data (Fereday and Muir-Cochrane, 2006). The unit of analysis (Graneheim and Lundman, 2004; Elo et al., 2014) has been chosen as the individual documents selected for this study. The meaning units were deductively derived from theory and formulated as respective codes.

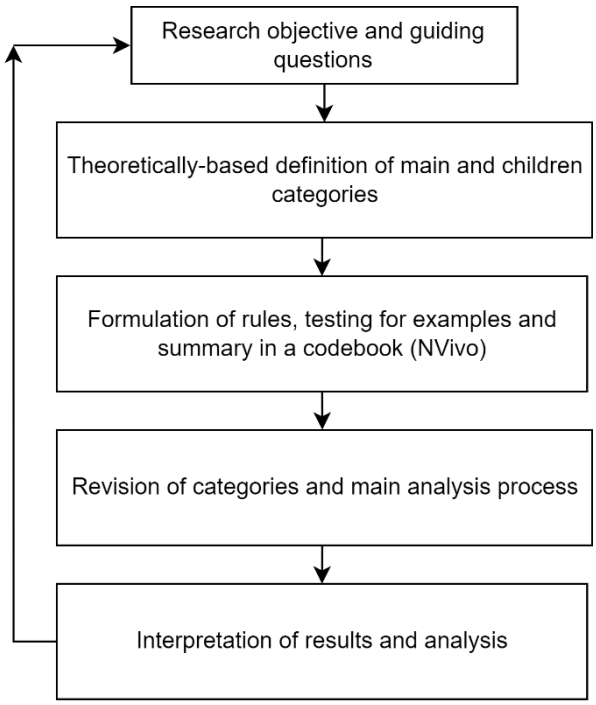

Figure 9: Deductive coding procedure for content analysis. Author's elaboration based on Mayring, 2000.

As highlighted above in Figure 9, the first part of the deductive coding procedure is to re-state the main research objective and research question. The research objective can be summarized as follows: This aim of this paper is to analyse existing and proposed policies aimed at meeting the targets implied by the 2015 Paris Agreement (UNFCCC, 2015), summarized in the *Fit for 55* package (European Council, 2023) in the sector of commercial road transport with the focus on discussing potential constraints to the policy implementation process, as well as uneven spatial manifestation of intended outcomes of those policies.
To do so, I rely on three main research questions:

Research question 1*: What are the key policy instruments set out to decarbonise the commercial road transport within the EU? What are the key actor groups targeted by those instruments? How do those instruments fit within the market-creating framework?*

Research question 2*: What are the key bottlenecks along the policy implementation process potentially hindering the commercial road transport decarbonisation process?*

Research question 3*: What are the risks of uneven spatial outcomes of the policy instruments identified in RQ1?*

Building on the objective and supporting research questions, I define the main and sub-categories in relation to key theoretical concepts presented in Chapter 2 and summarized in Chapter 3. In the next step, rules for coding were developed in order to effectively identify the relevant pieces of information throughout the material. The final codebook is presented below.

Category	Subcategory	Definition	Rule
1: **Key actors addressed in the material**		Based on Ragon and Rodríguez (2022), highlighting the key actor groups playing a major role in the socio-technical system of road freight addressed by the policy or mentioned in the material.	Code any occurrence of a reference to the key actor group in the material. If there is an overlap, code to all relevant actor groups (e.g., shipper operating their own fleet to be classified both as a "shippers" and "carrier")
	1.1 Carriers	Actor operating commercial vehicles.	
	1.2 Shippers	Actors contracting carriers to transport goods, can operate their own fleet.	
	1.3 Manufacturers	Original equipment manufacturers (OEMs) of commercial road vehicles.	
	1.4 Infrastructure and service providers	Actors providing and servicing infrastructure, payment solutions, tax services, repairs, other related services to commercial road transport.	
	1.5 Government and regulatory bodies	Public bodies responsible for regulations of the sector.	
	1.6 Clean freight initiatives	Non-governmental organisations focused around sharing best-practices, knowledge, facilitating discussions among other actors.	
2: **Fit within the framework for innovation policy**		Assessment of the criteria as highlighted by Mazzucato (2016) necessary for a successful market-creating policy to take place.	Code any occurrence of a reference to one of the key dimensions of market-creating policies.
	2.1 Direction of change	Clearly expressed direction towards a specific mission (road freight decarbonisation).	

	2.2 Nature of affected organisations	Clear delineation of the skills, resources, capabilities, and structures within affected organisations.	
	2.3 Evaluation of effectiveness	Clear mention of dynamic metrics of assessment instead of static one; new measurement criteria for the policy. Such metrics should be able to evaluate the direction towards new system rather than re-evaluating the old one.	
	2.4 Evenness of distribution	Clear mention of the mechanisms of distribution of potential rewards and risks.	
3: **Bottlenecks and enablers of the policy implementation process**		The success of a policy implementation process is reliant on overcoming challenges related to seven dimensions of policy implementation, as identified by Bhuyan et al. (2010).	Code any occurrence of a reference to one of the key dimensions of policy implementation, according to its definition.
	3.1 The policy, its formulation, and dissemination	Clear mention of problem, goals and objectives, target population to benefit, clear strategy. Furthermore, clear mention of time horizon, rationale and language. Explicitly mentioned cooperation strategies.	
	3.2 Social, political, and economic context	Mention of the political process, social and economic factors within the document.	
	3.3 Leadership for policy implementation	Clear delineation of the role of leadership, clarity of leadership engagement with relevant stakeholders.	
	3.4 Stakeholder involvement in policy implementation	Engagement of various stakeholders, direct mention of involvement of groups affected by the policy.	
	3.5 Implementation planning and resource mobilisation	Clear mention of resources mobilisation (monetary, personnel, equipment, infrastructure), mentions of new roles and responsibilities.	
	3.6 Operations and services	Changes to the current modes of operation and service provisions under the new policy, clear mention of challenges and changes, flexibility criteria.	
	3.7 Feedback on progress and results	Clear mention of measurement and feedback mechanisms, roles and responsibilities, feedback distribution.	
4: **Levels of the MLP**		Based on Geels (2002) relating to the three main levels of the MLP perspective.	Code any occurrence in text relating to one of the MLP levels.
	4.1 Niche	Lowest level, specialised technology, sheltered from competition, local scale.	
	4.2 Regime	Meso-level of more connected, dominant niches, bigger momentum, early institutionalization.	
	4.3 Landscape	Macro-level of a new, dominant socio-technical arrangement, competing directly with old landscapes.	
5: **Characteristics of the process of change**		Three characteristics based on Geels and Kemp (2007); system can either undergo *reproduction* (dynamics only at regime level, iterative change, improvements), *transformation* (dynamics at regime and landscape, not niches, slower process of change, evolutionary character) or *transition* (radical shift to a new trajectory, dynamics at all levels, creative destruction of the old system).	Code any occurrence in text relating to one of the types of process of change.
	5.1 Reproduction	Regime-level dynamic, iterative change.	
	5.2 Transformation	Regime and landscape dynamic, evolutionary shift to a new system.	
	5.3 Transition	Radical, enforced and encouraged shift through creative destruction towards a new system.	
6: **Core conceptual dimensions of the geography of transitions**		Building on Truffer and Coenen (2012) and Truffer et al. (2015), identifying core dimensions of geography of transitions aids in understanding space beyond the naive conceptualization within the MLP framework.	Code any occurrence in text to the subcategories of dimensions of geography within sustainability transitions.
	6.1 Socio-spatial embedding	Clear reference to spatial and institutional embeddedness.	
	6.2 Multi-scalarity	Reference to different scales of change within transitions beyond levels of the MLP.	
	6.3 Issues of power	Clear reference to power dynamics or uneven outcomes resulting from varied contexts.	

Figure 10: Final codebook utilised in the coding process. Author's elaboration.

5.1.4 Limitations

As any other research technique, qualitative content analysis is not free from certain limitations. Firstly, a content analysis can only be as good as the material that is examined. (Clark et al., 2022). To overcome this limitation, I followed the Scott's (1990) recommendations for assessing the quality of documents, as presented in Chapter 5.1.1. Secondly, there is an inevitable degree of personal interpretation in the creation of the coding manual. While I attempted to provide sufficient level of detail in connecting the specific codes to relevant literature, some potential for misinterpretation still might be present. Lastly, content analysis has been accused of being *atheoretical* (Clark et al., 2022). However, I believe that through employing a deductive approach to devising my coding manual and closely relying on the existing theory for selecting my codes in the first place, I mitigate the potential of my method being *atheoretical*.

6. Results

Within this section, I present the results, with selected representative exerts from the material, of the qualitative content analysis centred around the key coding themes identified in Chapter 5.1.3.

Understanding the key policy instruments and actors addressed by those instruments

The decarbonisation of the road freight is targeted by various policy instruments in the form of directives and regulations. They are centred around setting environmental standards for fuels and vehicles (Documents 1 and 15), promotion of renewable energy and energy security (Documents 5, 9 and 14), general emissions reduction targets and trading (Documents 2, 6,13 and 16), and promotion of alternative infrastructure supporting the deployment of zero- and low-emissions vehicles (Document 14). The actors addressed by the respective instruments fall within the categories as identified in Chapter 4. Overall, government and regulatory bodies, most frequently referred to as "member states" or in the form of European administrative bodies as "commission", "parliament" or "council", represent the vast majority of actors directly referenced in the instruments:

(…) ***Member States*** *shall prohibit the marketing of leaded petrol within their territory (…).*

(Document 1)

The Commission *(…) may authorise higher limit values (…) for one or more fuel components for a period not exceeding six months.* (Document 1)

The roles are clearly communicated, as well as specific dynamics between actors, especially regarding the responsibilities spread between the EU bodies and member states:

The Commission *shall* ***assess*** *the application of the requirements (…) taking into account the development of the market for electric vehicles, in order to ensure that an additional number of recharging points accessible to the public are put in place in each* ***Member State*** *by 31 December 2025 (…).* (Document 4)

Member States *and* ***manufacturers*** *annually report the CO2 emissions and fuel consumption of newly registered heavy-duty vehicles to the* ***Commission****.* (Document 16)

Member States *shall lay down the rules on penalties applicable to infringements of the national provisions adopted pursuant to this Directive.* (Document 16)

Generally, there is an unrepresentativeness of direct reference to other actors besides member states and EU bodies, with exceptions including various stakeholders mentioned either specifically (see exert from Document 15) or reduced to generic statements about stakeholders and public-private cooperations (see exert from Document 5):

(…) specific objective is to provide benefits for ***European transport operators and users****, most of which are SMEs, resulting from a wider deployment of more energy-efficient vehicles. The HDV CO2 emission performance standards trigger* ***manufacturers*** *to increase the supply of zero-emission vehicles.* (Document 15)

In line with the ***Commission's*** *strong* ***commitment*** *to better* ***regulation*** *and consistent with a policy that promotes research, innovation and investment, the governance mechanism should result in a significant reduction of administrative burden and complexity for the* ***Member States*** *and* ***relevant stakeholders.*** (Document 5)

In sum, most analysed policy instruments stress out clearly the role of national and European legislative bodies in the process of decarbonisation, with limited or vague references to other stakeholders, noting the exception of instruments of Documents 4 and 15. As such, the

specific roles and responsibilities of other key actors are to be transposed into national laws and regulations, making the overall contribution of individual actors beyond the roles of governmental and regulatory bodies somewhat unclear.

Fit within mission-oriented policies

Policy instruments adopted by the European Union as a part of the *Fit for 55* package represent very bold goals and are supposed to be one of the first steps in delivering the promised climate neutrality (COM /2021) 550, 2021). However, to achieve such objectives, policies ought to be market-creating rather than fixing, as elaborated upon in Chapter 2.2.2.

Direction of change

Setting the direction of change is a critical step for policies that are a part of a mission-oriented package, such as the *Fit for 55*. Instead of incremental changes and fixing the existing system, in order to "fit" within the framework of innovation policy, respective instruments need to show a clear direction towards the mission their supposed to be addressing. The degree of clear articulation of the direction of change is varied throughout the material. Some documents display very clear articulation of the direction of change, with specific goals and explicit mentions of the mission. For example, regulations taking force after 2019 explicitly mention the European Green Deal as a common goal towards which the EU is headed (exerts from Document 6 and 15). Given the publication date of the EU Green Deal of 2019 (European Commission, 2019), it is understandable, but older instruments lack such a unifying common goal, even if they were revised after 2019 (e.g., Document 15). As such, the direction of older policy instruments can be understood as more market-fixing, as demonstrated with the exerts from Document 1 and 4 below:

The Commission has (as a part of achieving the European Green Deal*) set out a* ***new growth strategy*** *that aims to* ***transform*** *the Union into a fair and prosperous society, with a modern, resource-efficient and competitive economy, where there are* ***no net emissions of greenhouse gases in 2050*** *and where economic growth is decoupled from resource use.*
(Document 6)

The Green Deal (…) will enhance the competitiveness of Europe's ***net-zero industry*** *and support the fast* ***transition*** *to climate neutrality. Such plan aims to provide a more supportive environment for the scaling up of the EU's manufacturing capacity for the* ***net-zero technologies*** *and products required to meet Europe's* ***ambitious climate targets****.*
(Document 15)

*Member States shall require suppliers to **reduce as gradually** as possible life cycle greenhouse gas emissions per unit of energy from fuel and energy supplied **by up to 10 %** by 31 December 2020 (…).* (Document 1)

*(…) establishes a common framework of measures for the deployment of alternative fuels infrastructure in the Union **in order to minimise dependence on oil** and to mitigate the environmental impact of transport.* (Document 4)

Nature of affected organisations

Evaluating the nature of affected organisations is the second dimension of fit within mission-oriented policies. The policy instruments should display clear concern for establishing new skills, capabilities, and structures in order to enhance the effectiveness of affected actors, symbolized through public-private partnerships (Mazzucato, 2016). Unfortunately, this dimension was seldomly expressed throughout the policy instruments, with the notable exception of Document 15:

*(…) the Commission is **engaging together** with public authorities, stakeholders and social partners in a **co-creation process** to identify the green and digital transition pathways that will support the **scale-up** of the manufacturing of zero-emission vehicles, the rapid deployment of alternative fuels infrastructure and the associated **up- and re-skilling of workers** (…).* (Document 15)

However, mentions of public-private cooperation can be found in non-policy documents, such as Document 10 both calling for and providing an example of an already deployed project:

*Many of the national **ZET funding programs do not include** support for charging or refuelling stations. (…) But **countries should back** the expansion of (semi-)public infrastructure, in particular depot charging. **Public-private partnerships** such as the megawatt charging project **HoLa in Germany** guarantee a **shared** shouldering of the **costs** for **all involved parties**.* (Document 10)

Evaluation of effectiveness

The third dimension of fit within the mission-oriented policies is concerned with new sets of metrics for the evaluation of effectiveness of the policy instruments, moving beyond the dominant approach of cost-benefit analysis, as such a measurement does not allow for

forward-looking assessment of new regimes. Some policy instruments display measurement and evaluation criteria beyond cost-effectiveness, such as the overall success of the instrument is to be measured in greenhouse gas emissions savings or similar measures:

*The greenhouse gas **emissions savings** from the use of renewable liquid and gaseous transport fuels of non-biological origin **shall be at least 70 %** from 1 January 2021.* (Document 9)

*The proposal will **ensure that CO2 emissions** from heavy-duty vehicles are **reduced**, will provide benefits for transport operators and users in terms of **air quality and reduction of energy consumption** (…)*. (Document 15)

*(…) indicators for monitoring progress and achievements (…) The **number and share** of newly registered **zero- and low-emission** vehicles will be monitored through the annual monitoring data submitted by Member States; The **level of innovation** will be measured in terms of **new patents** by European automotive manufacturers **related to zero-emission** technologies through publicly available patents databases (…).* (Document 15)

However, the most dominant evaluation criteria remain to be the cost-effectiveness of respective policy instruments:

*Member States shall require electricity distribution system operators to **assess** (…) whether the use of the identified potential would be more **resource- and cost-efficient** than alternative solutions*. (Document 9)

*In its conclusions of 11 December 2020, the European Council stated that the new 2030 greenhouse gas emission reduction **target will be delivered** collectively by the Union in the **most cost-effective manner possible** (…).* (Document 13)

*This Directive establishes system for greenhouse gas emission allowance trading within the Union in order to promote reductions of greenhouse gas emissions **in a cost-effective and economically efficient manner**.* (Document 16)

Evenness of distribution

The last dimension of fit within mission-oriented policies covers the need for risk and rewards to be spread among public and private actors in order to facilitate an active role of the policy makers in supporting the market-creating role. Mazzucato (2016) mentions a need for a direct

monetary return to the policy makers to fund higher-risk investments. However, only few instruments directly cover the returns of funds and subsequent utilisation, such as:

The Modernisation Fund ***shall be financed through the auctioning of allowances*** *as set out in Article 10*. (Document 16)

As an ***extraordinary and one-time measure****, until 31 August 2026, the* ***allowances*** *(…) shall be* ***auctioned*** *until the total amount of revenue obtained from such auctioning has reached EUR 20 billion.* ***That revenue shall be made available*** *to the Recovery and Resilience Facility*. (Document 16)

Revenue from the ***excess emission premiums*** *should therefore continue to be considered as revenue* ***for the general budget of the Union*** *in accordance with Article 8(4) of Regulation (EU) 2019/1242.* (Document 15)

Figure 11 below represents a generalised fit of the respective policy instruments within the framework for innovation policy based on combining the analytical categories of inquiry. Instruments of Documents 14 and 15 can be considered both market fixing and creating, as they display characteristics of both approaches, especially in their directionality. For instance, Document 15 clearly mentions *fixing* the market of heavy-duty vehicles through the introduction of stricter CO2 emission standards for existing vehicles, but also *creating* a new market thanks to channelling resources into development and uptake of zero-emission technologies.

ID	Instrument	Market Fixing (F) or Creating (C)
1	Directive 98/70/EC	F
2	Regulation (EU) 2018/842	C
4	Directive 2014/94/EU	F
5	Regulation (EU) 2018/1999	C
6	Regulation (EU) 2021/1119	C
9	Directive (EU) 2018/2001	F
13	Regulation (EU) 2023/857	C
14	Regulation (EU) 2023/435	F / C
15	Procedure 2023/0042/COD	F / C
16	Directive 2003/87/EC	F

Figure 11: General fit of policy instruments to the framework for innovation policy. Author's elaboration.

Key bottlenecks of the policy implementation process

The success of a specific policy instrument largely depends on successfully dealing with the seven dimensions of policy implementation, as highlighted in Chapter 2.3. Each of the dimensions represents a potential bottleneck in the policy process.

The policy, its formulation, and dissemination

The European Union has a rather standardised format of presenting policy, whether in the form of regulations or directives, as analysed for this study. Clear rationale is presented in the beginning of the instrument, time-horizons and specific targets are included in alignment with the policy objective. Definitions are present in all instruments to leave no room for ambiguity regarding key terms and concepts. However, as directives represent instruments stating a common goal of the EU, but individual member states have the freedom in formulating country-specific policies, several instances of lacking clarity in the instrument have been identified, exemplified in Document 4 regarding the deployment of alternative fuels infrastructure and related Document 7:

*Each **Member State** shall adopt a **national policy framework** for the **development** of the market as regards alternative fuels in the transport sector and the **deployment** of the relevant infrastructure.* (Document 4)

*Developments on recharging and refuelling infrastructure are currently **hampered** by limited investment security and the **lack of a stable long-term policy framework, including binding targets**.* (Document 7)

***Transposition** of these EU directives* (regarding, among others, Document 4) *into national law has resulted in **differences in procedures** between Member States.* (Document 7)

While Document 4 clearly states the direction the EU is taking regarding the alternative fuels infrastructure, there is a lack of targets and benchmarks within that instrument, directly referenced to in Document 7, as member states are given freedom in devising their own strategy.

Social, political, and economic context

Unfavourable contextual conditions might negatively impact the success of a policy instrument. Thus, considering the social, political, and economic situation surrounding the respective police represents an important step of its formulation and potential success. For

example, Document 7 mentions repeatedly the issues of insufficient political coordination in developments of unified alternative fuels infrastructure:

*To date, however, **policymakers** and other stakeholders have focused mainly on creating fuelling infrastructure for passenger **cars rather than trucks.*** (Document 7)

*A **coordinated approach** is **lacking**, however, with individual OEMs focussing on **different** types of solution.* (Document 7)

In other policy instruments, references are made to wider socio-political conditions, influencing the decisions of the EU, most notably the recent Russian war of aggression on Ukraine and the COVID crisis:

*In the context of the Union **emergency** intervention to address high energy prices resulting from the **impact of Russia's war of aggression** against Ukraine (…) through a flexible use of resources (…) should **help small and medium enterprises** (SMEs) particularly affected by energy price increases (…).* (Document 14)

*In light of the **economic and social impact** of the current energy crisis, where persistently **high and volatile** energy prices are aggravating the impact of the COVID-19 crisis by further increasing the **financial burden for consumers**, in particular (…) **vulnerable companies** including micro-, small and medium enterprises (…).* (Document 14)

*The **crisis** linked to the **invasion** of Ukraine by Russia makes the case to reduce EU **dependency on fossil fuel** even stronger, as highlighted in the REPowerEU plan, setting out **actions to save energy, diversify supply, substitute fossil fuels** and carry out smart investments and **reforms** in all economic sectors.* (Document 15)

In a similar fashion, economic contexts are referenced throughout the material, pointing towards various characteristics hindering the decarbonisation process:

*Fleet operators, too, will have difficulty making a **positive business case** for alternative fuels. Besides **higher vehicle purchasing costs** and the risk of **reduced residual value**, **operating costs** may also be **higher** owing to limited refuelling infrastructure, although fuel **prices may be lower** for some fuels.* (Document 7)

*Demand for ZETs is highly dependent on ZET **pricing**. Production at small scale leads to **high prices**, which leads **to lowered demand** for ZETs, **slowing purchases** and inhibiting the **development of economies of scale**. Similar chicken-and-egg dynamics exist with the **deployment of grid infrastructure** to enable ZET charging.* (Document 11)

Leadership for policy implementation

Delineating specific leadership roles and responsibilities is a crucial step in successful policy implementation (Bhuyan et al., 2010). The level of consensus among different leaders' groups and key stakeholders is likely to impact the roll-out and timing of respective instruments, especially if cross-nation cooperation is required. Generally, the leadership roles are explicitly directed towards the bodies of the EU and member states:

***Member States** shall **cooperate** with each other, taking account of all existing and potential forms of **regional cooperation**, to meet the objectives, targets and contributions set out in their integrated national energy and climate plan **effectively**.* (Document 5)

*The **Commission** is **empowered** to adopt delegated acts (…) for the purpose of adapting them to amendments to the Union Energy and Climate policy framework that are directly and specifically related to the Union's contributions under the UNFCCC and the Paris Agreement.* (Document 5)

*In the two countries with the **largest heavy duty vehicle fleets** in Europe, Poland and Italy, it **is unclear** whether the ZET funds are **already available** as the respective portals and application forms **are not accessible**.* (Document 10)

Stakeholder involvement in policy implementation

Policy instruments should not be separated from a discussion with relevant stakeholders that are to be affected by the respective policy. However, stakeholder involvement may result in hindrances to the process, as different actor groups might have varied outcome preferences. For instance, the need for greater cooperation for the deployment of alternative fuels infrastructure and vehicles is expressed by Document 7, but such calls are not reflected in the relevant policy instrument of Document 4, which vaguely offloads the role of engaging stakeholders to member states.

(…) ***stakeholders*** *often operate quite independently, while* ***cooperation*** *could be* ***beneficial*** *for* ***knowledge exchange*** *and could* ***accelerate*** *harmonisation and standardisation.* (Document 7)

Bringing ***stakeholders*** *together in a* ***coordinated approach*** *in which small and medium-sized enterprises can also benefit from* ***scale advantages*** *(…)* (Document 7)

National policy *frameworks shall take into account, as appropriate, the interests of regional and local authorities, as well as those of the* ***stakeholders*** *concerned*. (Document 4)

Nonetheless, public-private cooperation is encouraged by other instruments:

Two or more Member States *may* ***cooperate*** *on all types of joint projects with regard to the production of electricity, heating or cooling from renewable sources. Such* ***cooperation*** *may involve* ***private operators****.* (Document 1)

Member States *should be able to* ***encourage*** *the establishment of* ***public-private partnerships*** *(…).* (Document 2)

In order to enhance ***involvement*** *of all economic actors, the* ***Commission*** *should facilitate sector-specific climate dialogues and* ***partnerships*** *by bringing together* ***key stakeholders*** *in an inclusive and representative manner, so as to encourage sectors themselves to draw up indicative voluntary roadmaps and to plan their transition towards achieving the Union's climate-neutrality objective by 2050.* (Document 6)

Implementation planning and resource mobilisation

Arguably one of the most common bottlenecks hindering the successful implementation of even well-formulated policy instrument is the insufficient or miscalculated resource mobilisation and planning (EEA, 2022b). Fortunately, both the need for and specific mobilisation of resources in monetary and other forms is clearly demonstrated throughout the material:

EUR 20 000 000 000 *in current prices (…) shall be made available as additional* ***non-repayable financial support*** *(…) to increase the resilience of the Union's energy system through a* ***decrease of dependence*** *on fossil fuels and* ***diversifying*** *energy supplies at Union level.* (Document 14)

*At least **50 % of the revenues** generated (…) should be used for one or more of the following: (…) to develop **renewable** energies (…) to encourage a **shift** to low-emission (…) forms of transport (…) to finance **research and development** in energy efficiency and clean technologies (…) to promote **skill formation and reallocation** of labour.* (Document 16)

***325 million** allowances (…) and **75 million** allowances (…) shall be made available to support innovation in low-carbon technologies and processes (…).* (Document 16)

*The **concrete** aim is to build, by 2025, half the 1,000 hydrogen stations and one million out of three million public recharging points needed in 2030. With a total **of 672.5 billion euro** allocated (…).* (Document 7)

*In Germany, **advancing charging infrastructure** is a key measure of the federal government, with fast charging receiving two-thirds of the budget (**300 million euro**) (…)* (Document 7)

*In France and **Germany**, the **launch** of the calls were **delayed** or **closed earlier**, **running out of budget** quicker than expected. This causes additional **unpredictability**.* (Document 10)

Operations and services

Implementation of new policy instruments will inevitably alter the provision of day-to-day services and affect operations, especially if a one-size-fit-all approach is adopted, which is a risk of European instruments. Thus, clear articulation of new modes of operation and flexibility criteria to account for specific contexts is a vital part of successful policy instruments. For example, the intricacies of adjusting to new powertrains are discussed in Document 11 or different possibilities for vehicle operation models in Document 12:

*The **economics** of trucking are **more complex** in a zero-emissions world. Historically, trucking drivetrains were "one size fits all". Trucks mostly used **diesel** fuel, and **range** had **little impact** on vehicle costs. Diesel prices are **volatile**, but unlike with electricity, diesel's costs do not vary on an **hourly basis** or by the **speed** at which the **fuel** is **dispensed**. The world of zero emissions trucking requires **new** purchasing and fuelling planning and **practices**.* (Document 11)

Solutions *such as trucking-as-a-service and charging-as-a-service are widely perceived (…) to* ***facilitate*** *the transition to zero-emission trucking for fleet owners, as they are less capital-intensive solutions that provide support throughout the truck's lifetime. Trucking service providers can also help to* ***aggregate*** *demand from small fleets and catalyze development of the market in early stages.* (Document 12)

Feedback on progress and results

Feedback mechanisms are important to ensure a policy instrument reaches its full potential. While it is generally not possible to predict the effectiveness of a new policy, continuous evaluation and monitoring of progress are likely to influence the uptake and success of the respective policy instrument in the long run. References to specific frequency and monitoring criteria are present throughout the analysed material, both relating to the role of member states' governments and the EU:

The Commission *should* ***monitor*** *the implementation of the reforms and investments (…) and provide information (…) through* ***reporting*** *in the recovery and resilience scoreboard, and through a* ***dedicated section*** *in the annual report to be submitted to the European Parliament and to the Council.* (Document 14)

A well-established ***system*** *is already in place* ***for monitoring*** *the* ***implementation*** *of Regulation (EU) 2019/1242. Member States and manufacturers annually report the CO2 emissions and fuel consumption of newly registered heavy-duty vehicles to the Commission. The Commission, supported by the EEA, publishes* ***every year*** *the final monitoring data of the preceding reporting period, including the manufacturer-specific performance against the CO2 targets or trajectory. The legislation* ***will continue to rely*** *on this well-established monitoring and compliance framework.* (Document 15)

The Commission *shall submit by 31 December 2012, and every three years thereafter, a* ***report to the European Parliament and the Council*** *(…)* ***That report*** *shall in particular take account of the* ***following****: the use and evolution of automotive technology and, in particular, the feasibility of increasing the maximum permitted biofuel content of petrol and diesel (…) CO2 emissions from road transport vehicles (…) the consequences of the greenhouse gas reduction target (…).* (Document 9)

Large-scale decarbonisation of the road freight will require substantial investments into new technologies, rollouts of infrastructure projects, shifts in customers' habits and models of operation, as well as intensive cooperation of individual member states and other actors in the sector. Due to the infancy of the sector, potential bottlenecks can be found along the whole spectrum of dimensions as identified in Chapter 2.3, however, the most substantial bottlenecks are likely to be centred around the deployment of resources and leadership roles for successfully managing those resources, as well as formulating long-term, clear and binding Union targets regarding the direction the sector should be headed. While in the current form, the EU's targets are theoretically ambitious, several documents still highlight the ambiguity surrounding the specific measures in order to achieve the targets (Documents 7, 10 and 12) and potentially exploitable loopholes in maintaining investments into internal-combustion technologies (Document 10). The role of leadership is also likely to play a critical role, as Document 15 highlights the risk of market fragmentation as a result of a lack of coordination at the European level – if progressive states and first-mover organisations in respective contexts move ahead of other member states, it may pose significant challenges to a sector that is inherently dependant on international dynamics (Document 7).

Multi-level perspective and the process of change

The multi-level perspective offers an approach to analyses of the process of change in the levels of *niche, regime,* and *landscape*. Identifying dynamics at those different levels points towards a respective process of change in the form of either *reproduction, transformation,* or *transition* (see Chapter 2.1.1). The dynamics within the material can mostly be found on the *niche* and early *regime* levels:

Apart from infrastructure for trucks running on gaseous fuels, ***other types of alternative infrastructure*** *are still virtually* ***absent****. There is a* ***paucity*** *of data on its* ***accessibility*** *for trucks. The number of* ***1042*** *(hybrid) BETs currently on the road will be served by* ***private (depot) charging infrastructure*** *where vehicles can be recharged for short- and medium-haul trips.* (Document 7)

Pilots and first-mover initiatives *on BET and fuel cell electric trucks (FCET) and electric road systems (ERS) are taking place mainly in Western European countries.* (Document 7)

Zero-emissions trucks (ZETs) are in ***early-stage production*** *by manufacturers (…).* (Document 11)

*(…) the fleet of zero-emission trucks in Europe is still **limited** to a **few pilot models** showcased by **progressive** fleets* (…). (Document 12)

*The **German** postal services group (…) currently owns a **fleet of around 20,000 electric vehicles** from the manufacturer StreetScooter, which they **formerly owned** (…).* (Document 12)

Beyond small, *niche* levels of experimental change, some dynamic has been documented on the *regime* levels as well, particularly in the form of first-mover initiatives of several member states. However, the direct competition with the existing system is likely to pose significant challenges (Document 7):

*(…) several **Member States** (Netherlands, Portugal, **Germany**, France, Spain, Italy) have announced a **hydrogen strategy**, all containing specific **targets for** (mainly heavy-duty) **transport**, including hydrogen refuelling stations (…).* (Document 7)

*The main economic barriers for alternative fuels in general and the related infrastructure is the **competition with a well-established transport system** that has been operated and **optimised** for over a century and offers stakeholders a predictable income. The **infrastructure** for **alternative** fuels is still **to be built**, at both higher cost and higher risk, creating **less predictable** business cases for investors.* (Document 7)

Regarding the process of change, the material points towards reproductive characteristics, as elaborated upon in Chapter 2.1.1. For instance, Document 7 presents arguments for the need of shift beyond internal combustion engines, but also stress out the possibility of drop-in fuels adoption within the sector. While drop-in fuels request only minor changes to the actual technology of vehicles, the emissions savings potential is still debated (Document 7) and as such the process of change would be only incrementally adjusting the existing system – *reproduction.* Similarly, Document 15 points towards reproductive characteristics of the process of change with only limited uptake of zero-emission vehicles in the near future. Furthermore, Document 10 points towards the potential of further lock-ins to gas-powered vehicles and infrastructure as a result of either direct encouragement or loopholes in current incentive funds in different member states, also pointing towards reproduction of the current system.

***Drop-in** fuels (liquid biofuels, gaseous biofuels and e-fuels) can be used **in existing vehicles and infrastructure**.* (Document 7)

The ambition of the EU Green Deal is ***bound to affect fuel mix and vehicle fleet composition****. In the long term, especially, the* ***aim is essentially zero-emission*** *mobility, implying the need for a* ***major shift from internal combustion engines (ICE) to alternative power trains****.* (Document 7)

This proposal revises the ***existing CO2 emission*** *standards for heavy-duty vehicles (…) The proposal (…)* ***does not go beyond what is necessary*** *in order to achieve the Union's objectives of* ***reducing greenhouse gas emissions*** *in a* ***cost-effective manner****.* (Document 15)

Concerning the heavy-duty vehicles, with the ***target levels proposed*** *in Article 3a for the year 2030 the* ***share of zero emission*** *vehicles in the* ***total fleet of vehicles*** *circulating on the road as well as the* ***electricity consumption*** *in the sector will* ***remain limited****.* (Document 15)

The EU's sustainable transport funds (the AFIF and CEF), its taxonomy and some member states' vehicle purchase incentives schemes (Italy, Croatia, Sweden and Finland) ***encourage or create loopholes for the deployment of gas powered vehicles and infrastructure****. This creates* ***dangerous lock-ins*** *and* ***compromises*** *Europe's* ***path*** *towards* ***energy independence****.* (Document 10)

Socio-spatial embedding

As new socio-technical arrangements (*niche)* occur in specific places, they are intrinsically interlinked with existing agents and structures. If successful aligned, these *niches* are legitimised through interactions with pre-existing conditions of the dominant *regime*. As such, the socio-spatial embedding refers to the specific conditions of emergent changes within a system. For instance, Document 11 points toward a link between regional contexts and capabilities and the ability to shift to new technologies. Similarly, Documents 7 and 15 highlight the spatial embedding and the need for social considerations of the process of change.

Some geographies are well positioned to move quickly; others are more likely to move later. The main drivers will ***be local policies, differing economics, infrastructure availability****, and truck* ***travel patterns*** *that will influence drivetrain selection.* (Document 11)

*Most **pilots and first-mover** initiatives on these technologies are taking place in **Western European** countries, **parallel** to initial uptake of the **associated vehicles**.* (Document 7)

*A **socially acceptable** and just transition to a sustainable low-carbon economy requires changes in investment behaviour, as regards both public and private investment, and incentives across the entire policy spectrum, **taking into consideration citizens** on whom and **regions** on which the transition to a low-carbon economy **could have adverse impacts**.* (Document 15)

Multi-scalarity

Adding a layer of spatial conceptualisation on the levels of MLP allows for an understanding of the ways in which different actors in different contexts come together in the process of change within socio-technical systems. While to goals of the EU might be well-articulated and universally applicable, specific conditions at different scales might hamper the results of the policy instruments:

*In certain **Member States** successful **roll-out*** (of the Alternative Fuels Infrastructure, as per Document 4) *was **hampered** to varying degrees by a range of issues, including **lack of national coordination and low initial investments**.* (Document 7)

*BET recharging **infrastructure is dependent** on the **physical** presence and **capacity** of the **local** energy grid.* (Document 7)

*As of 2021, there are **144 hydrogen refuelling stations** (HRS) in **operation** in the EU, the majority in **Germany** (…).* (Document 7)

***Member States** may also consider establishing mechanisms to ensure the **regional diversification** in the deployment of renewable electricity, in particular to ensure cost-efficient system integration.* (Document 9)

*As **citizens and communities** have a powerful role to play in driving the transformation towards climate neutrality forward, strong **public and social engagement** on climate action should be both **encouraged** and **facilitated** at **all levels**, including at **national, regional** and **local** level in an inclusive and accessible process.* (Document 6)

*(…) initiatives at the **national**, **regional** and **local** levels can create synergies, alone they will **not be sufficient**, also considering the inherent **international dimension** of **road freight** transport. A lack of coordinated EU action would translate into a risk of **internal market fragmentation** due to the **diversity** of national schemes, **differing ambition levels** and design parameters.* (Document 15)

Issues of power

The collective outcome of respective policy instruments is likely to be influenced by the power relations present throughout different scales. As a result of uneven power dynamics between individual actors, there is a risk of unbalanced distribution of risks and benefits in different contexts. For example, Document 7 provides arguments regarding the company size and its bargaining power both in attracting capital investments for the purpose of uptake of new technologies, as well as in incentives from the state concerning the tax level on energy.

*Investors are also looking for **large potential user groups** to ensure sufficiently **high utilisation rates**, **benefiting larger companies** seeking cooperation and putting **small** and **medium-sized enterpris**es at a **disadvantage**.* (Document 7)

***Larger companies** can also **benefit more** from economies of scale and lower scale-related tax tariffs. For example, in the Netherlands **energy taxes** per kWh are **lower** for **larger** grid connections.* (Document 7)

Member States** shall have the right (…) to decide **to which extent they support** electricity from renewable sources which is **produced in another Member State. (Document 9)

*(…) **small businesses** typically have **much less** access to **capital** than their **larger competitors** and often have less ability to maintain and repair new technologies such as ZETs.* (Document 11)

*Given their **early adopter status**, those organization **benefit** from **first-rate support** from truck manufacturers and infrastructure providers to incorporate zero-emission trucks in their fleets, and **early feedback** enables them to build expertise and develop best practices for zero-emission trucking. Moreover, **early adopters** can plan for the transition of their fleet at the desired pace, **without imminent pressure** from **policies** like the implementation of **zero-emission zones**.* (Document 12)

Combining the evidence gathered through the analysis of the levels of the MLP and the core conceptual dimensions of geography of sustainability transitions, there are strong suggestions of dynamics at the *niche* level, especially concentrated in a handful of first-mover countries, such as Germany or the Netherlands, and progressive companies either manufacturing or operating new technologies. Furthermore, these first-movers are leading the way of transition towards zero-emission road freight through early uptakes of nation-wide initiatives, such as the hydrogen strategy, as mentioned in Document 7. Such moves could be characterised as *regime* level dynamic, starting to directly compete with the dominant *landscape*, also mentioned in Document 7. In a similar fashion, the process of change is starting to depart from *reproduction* – the normal state of incremental adjustments to the system, such as in forms of stricter regulation for emission standards of new vehicles (Document 15) or the regulation tightening up the quality of diesel and petrol fuels (Document 1) – to *transformation* and ultimately *transition* of the system, as the policy frameworks are starting to address all aspects of the road freight either directly, such as in the provision and general targets for alternative fuels infrastructure (Document 4), or indirectly in the form of general greenhouse gas emission standards steering the overall economies and systems of individual member states towards carbon neutrality (Documents 2, 5, and 6). While the transformation of the dominant system is still in its infancy, the arguments above provide evidence for early changes of the socio-technical systems. In many cases though, as Document 15 states, it is too early to assess the success of the policy instruments:

> *an evaluation of the effective application of these provisions* (regarding strengthening of the CO2 emission performance standards for new heavy-duty vehicles) *is not possible at this stage*. (Document 15)

Furthermore, different conceptual dimensions of geography of transitions will likely play a role in the process of decarbonisation of the road freight in specific contexts; as practices and actors are socio-spatially embedded, the degree of successful alignment between emerging *niche* and the dominant regime will be varied. Similarly, there are already power imbalances being manifested, either due to the size of individual actors and their bargaining power and legislative benefits to the potential of member states cooperation towards decarbonisation and subsequent exclusion of other member states. Additionally, differences throughout scales can be observed, such as the presence or lack of physical infrastructure being able to support new technologies, the localised implementation of new infrastructure or regionalised deployment of renewable energy projects, in turn leading to differences in the uptake of zero-emission vehicle.

7. Discussion

The departure points for this discussion are manifested through the three guiding research questions. The first question asked for *What are the key policy instruments set out to decarbonise the commercial road transport within the EU? What are the key actor groups targeted by those instruments? How do those instruments fit within the market-creating framework?* The first two sub questions, while rather descriptive in nature, allow for an analysis of the policy instruments guiding the decarbonization of the road freight in the European context. As the whole *Fit for 55* package addressing the sector is still evolving, it is important to keep in mind the snapshot characteristic of the analysis, at least regarding the specific policy instruments, which are likely to be amended in the future. While the selected policy instruments do not represent an exhaustive list of all policies directly or indirectly relevant to the sector of road freight, they are aligned with previous studies and policy suggestions, such as that of EEA (2022b) concerned with the most relevant policy instruments shaping the sector and the holistic regulatory framework as proposed by the World Economic Forum (2023). Regarding the actors addressed by the policy instruments, I relied on the supply-chain overview as presented by Ragon and Rodríguez, 2022. However, with a notable exception of Document 15, the policy instruments delegate roles and responsibilities almost exclusively to member states or the administrative bodies of the European Union. While that is understandable in case of directives that need to be transposed into nation-specific laws, exclusion of a wider range of actors leaves gaps in the comprehensiveness of the policy proposals and specific roles to be decided by member states, potentially leading to discrepancies and nonuniformities between member states, hindering the collective effort for decarbonisation in the long run. Subsequently, I attempted to analyse the proposed policy instruments in connection to the market creating framework for mission-oriented policies. While the *Fit for 55* package covers all aspects of regulating the road freight in terms of gradually reducing the environmental impacts of heavy-duty vehicles, it by no means represents a coherent set of proposals, unified in their directionality or targeted actors. Firstly, missions imply a clear direction of change to be set (Mazzucato, 2016). While some of the analysed instruments display a clear directionality towards a specific mission, such as in Documents 6 and 15, symbolized through their pledge in contributing to the European Green Deal (European Commission, 2019), other instruments can be characterised by broader, market-fixing directionality of setting general targets for the promotion of renewable energy (Document 6) or establishing an emissions trading scheme (Document 16). Although such instruments are arguable contributing to the overall mission through incremental adjustments to the system, they lack the nuance of clearly articulated direction, characteristic for market-

creating policies. Secondly, a mission-oriented policy framework requires public actors to rethink the degree of risk they are willing to take and asks for their active role in creating public-private partnerships. However, such discussions are virtually absent in the analysed policy instruments, with the notable exception of Document 15 directly addressing the need for a public-private cooperation towards upscaling of production of zero-emissions vehicles and connected up- and re-skilling of workforce. Thirdly, the market-creating approach calls for the implementation of dynamic metrics of evaluation to even allow for the assessment of policies promoting new landscapes. While some evidence points towards new metrics of success of the individual instruments, such as savings of greenhouse gas emissions (e.g., Documents 9), innovative outcomes measured in patents of zero-emission technologies (e.g., Document 15), the prevailing criteria remains to be cost-effective delivery (e.g., Documents 13 and 16) aligned with the market fixing approach. Lastly, there needs to be a symbiotic private-public partnership facilitating sharing of the risks and rewards connected to the creation of new markets. While it is difficult to assess this dimension for most of the instruments, as they offload the responsibility to the individual member states and are generally in early stages of long-term goals, some mechanisms of fund re-distributing and channelling towards further investments are present, especially in Documents 15 and 16. Overall, the combination of individual dimensions points towards a somewhat mixed *fit* within the mission-oriented nature of market-creating policies as proposed by Mazzucato (2016).

As a part of the second question, I embarked on answering the following: *What are the key bottlenecks along the policy implementation process potentially hindering the commercial road transport decarbonisation process?* The policy implementation process signifies the transposition of formulated policy instruments into real-world action (DeGroff and Cargo, 2009), but its success closely interlinked to a range of dimensions, most concisely described by Bhuyan et al., 2010. The first step of a successful policy instrument lies in a proper *formulation and dissemination*. While seemingly issues related to policy formulation should be alien to an institution such as the European Union, previous instances highlight that is not always the case. For instance, poorly formulated draft regulating the use of artificial intelligence was criticised by Veale and Borgesius, 2021. In the case of the analysed instruments, the formulation is generally clear with dimensions such as the rationale, timeframes, and objectives explicitly stated. However, some instruments, notably of Document 4, leave too much interpretation to specific member states despite a proposed unifying common goal and have been directly criticized for the lack of clear, binding targets, necessary for the long-term success of the instrument, by Document 7. Regarding the second bottleneck, *social, political and economic context* is undoubtedly playing a role in the policy implementation process for decarbonisation of the road freight. Firstly, the ongoing Russian

war of aggression on Ukraine have sparked an upsurge of interest into providing energy security for the Union. Volatile energy prices seem to be the motivating factor, as well as the degree of dependence on imported fuels from third countries, as repeatedly mentioned in the material. While Kingdon (1984 in Mthethwa, 2012) warned about the swings in political mood and election results, the actions from the European administrative levels point towards a long-lasting pursuit of energy security, which could lead to a more stable environment for the deployment of alternatively powered commercial vehicles, as mentioned in Documents 11 and 14. Secondly, and closely related to the political aspect, economic and social factors can be expected to pose problems, especially due to high upfront costs of new technologies, such as vehicles and infrastructure. Most transport companies are already operating at very low margins and dispose with limited capital available for upfront investments (Hansen and Klewitz, 2012), a situation further exacerbated by the Covid crisis and the recent energy crisis linked to the war in Ukraine. As such, a coordinated approach of financing the transition, especially focused on support to small- to medium-sized companies will necessary, though there is evidence of such approach lacking at the moment (Document 7). The potential impacts of the bottlenecks relating to the *leadership for implementation, stakeholder involvement and resource planning and implementation* can be bundled together, as they are intrinsically interlinked. After the policy formulation, reflecting the contemporary socio-political pressures, a clear delegation of leadership roles is necessary to ensure accountability in the policy implementation. However, the role of the European Union, while clear in setting the overall targets and goals, is somewhat undermined by the degree of freedom that is provided to individual member states in terms of cooperation and formulations of nation-specific laws. For instance, in Poland, the country with the largest truck fleet in Europe, the leadership is not effectively translated into actions, as the nation's portal for the support of zero-emission commercial vehicles has not been running since its introduction (Document 10). Similarly, leaders of the policy process are responsible for effective stakeholder engagement. This is encouraged by the European Union but in many cases leaves the degree of cooperation and involvement to the respective member states (Documents 1, 2 and 4). While it is unclear at the moment to what degree individual member states will involve various stakeholders due to the infancy of the specific proposals, the socio-spatial embedding of certain actors of the industry, such as the close interlink between the German state and the biggest European logistics company, the DHL, points toward a varied stakeholder involvement in different contexts. Additionally, leaders responsible for the policy process are also in charge of mobilising resources and their effective distribution. While the Union is dedicating significant budgets to the transition towards zero-emission freight, serving as an external source of resources for respective member states (Leśnodorska, 2011), the resources are not always managed in the most efficient manner, as mentioned in Document 10. Improper management,

especially in early phases of policy implementation, may result in significant delays and further build-up of distrust of involved actors and unpredictability connected to the provision of resources (Document 7). The last two analysed bottlenecks relate to the changes in *operations and services* and *feedback on progress and results.* As new technologies are implemented and mandated through policy instruments, changes to day-to-day services are inevitably going to affect different actors of the road freight sector. For instance, as presented in Documents 11 and 12, the deployment zero-emission commercial vehicles will require shifts in the consumption practices regarding charging times and even the increased price volatility of electricity for battery-powered vehicles. Similarly, new ways of operating vehicles are being proposed, potentially altering the ownership and operation structures of heavy-duty vehicles. Trucking-as-a-service and charging-as-a-service are just two suggested solutions altering the operational structure, potentially catalysing the process of change in its early phase (Document 12). However, the degree to which the changes might affect daily operations and services are mostly speculative at this point, as the share of zero emission vehicles and strain on the grid systems is expected to be limited as far as 2030 (Document 15). Regarding the last bottleneck of *feedback on progress and results*, it is unclear at the moment to what extent will the leaders of the process be successful in measuring and communicating the impacts of the policy instruments due to the infancy of the whole system, which is clearly stated in Document 15. However, the European Union does have numerous processes in place to monitor the implementation of regulations (Documents 14 and 15), and thus the feedback structures can be expected to effectively monitor the shift towards zero-emission freight, at least in case of EU-wide regulations.

The last research question called for an understanding of *What are the risks of uneven spatial outcomes of the policy instruments identified in RQ1?* To do so, I utilised a combination of the MLP framework (Geels, 2002) in addition to the conceptual dimensions of geography of sustainability transitions (Truffer et al., 2015). Firstly, there is significant evidence pointing towards dynamics happening at the *niche* level – actors are experimenting with different technologies (i.e., electric or hydrogen powered trucks), collaborating with manufacturers towards single-purpose, tailored solutions (e.g., such as the cases of DHL and Volvo, Volvo, 2022 or Rivian and Amazon, Amazon, 2022). These *niches* in their early form are heavily concentrated in specific contexts, socio-spatially embedded as a result of the location of actors and supporting infrastructure, especially in Western European countries (Document 7). In a similar fashion, wider dynamics are starting to appear in the form of government-supported rollouts of infrastructure and national support for the uptake of zero-emission vehicles. While the evidence is limited, the material points towards some first-mover initiatives (e.g., a state-led hydrogen initiative), again in Western European countries like Germany (Document 10).

As a result, despite the unifying goals of the European Union, there is a risk that decarbonisation will happen in a fragmented fashion, further exacerbated by the uneven power dynamics of different actors. For instance, the most dominant country in terms of the provision of carrier companies in road freight, Poland, has been marked by an unsuccessful deployment of its zero-emission incentive scheme (Document 10) and Polish carriers are, on average, very small companies employing less than five people. As such, local carriers in Poland are hampered by lower operating capital and are less likely to absorb new technologies (Arruñada et al., 2004), mainly due to significant up-front investments needed (Document 11). Polish carriers are already pushed to the limit in terms of profitability (Suproń, 2020), and will likely struggle significantly to adjust to the market shifts under the proposed regulations. Larger companies, situated in spatial contexts with better conditions to adopt new technologies, and benefiting from greater bargaining power, are thus more likely to enjoy the first-mover advantage, plan the transition at their desired pace and avoid the imminent pressure created by progressively more stringent international regulations (Document 12).

8. Conclusion

The aim of this thesis was to provide a snapshot analysis of the contemporary policy instruments of the European Union targeted at decarbonisation of the commercial road freight, particularly centred around the bottlenecks inherent to the policy implementation process. To do so, I employed a qualitative content document analysis method and explored various policy instruments, either directly or indirectly targeting the sector of freight. Through the analysis, it became apparent that reducing the emissions of the sector will pose significant challenges at all fronts, due to a variety of reasons. Firstly, despite the ambitious goals of the European Union and its Green Deal proposal (European Commission, 2019), there was mixed evidence for the fit within mission-oriented policies of the respective instruments. While that may be changed in upcoming iterations of the instruments, the ambiguity of their directionality and respective contribution to the mission is likely to pose challenges to actors attempting to navigate space of those policy instruments. Secondly, bottlenecks to the implementation process of individual instruments were observed in a variety of dimensions. While the severity of those bottlenecks is difficult to assess, especially for very recent proposals, they need to be addressed to deliver the process of implementation in a timely, efficient and equal fashion, something which seems to be at the forefront of priorities of the EU. Lastly, while the current infrastructure supporting commercial vehicles is rather homogenous throughout the continent, deployment of new technologies for vehicles and charging is unlikely to be harmonised in different geographies and contexts. As it became apparent through the analysis, the socio-spatial embedding of the multitude of actors, in combination with uneven power dynamics and the multi-scalarity of the process, may, despite the best intentions of the European Union, result in a new, but fragmented socio-technical system. While the increasingly stringent standards for greenhouse gas emissions reductions, for the proportion of renewable energy and quotas for zero-emission commercial vehicle manufacturing may eventually even out the playing field, the upcoming years might be marked by clear “winners” and “losers” of the process of decarbonisation.

While this research may serve as an overview snapshot of *what is happening*, further research could elaborate and contribute to related topics on several levels. In my first question, I attempted to analyse the policy instruments in accordance to affected actors and the fit of those instruments with the framework of market-creating policies. However, following the call of Axsen et al. (2020), a more in-depth elaboration on the proposed instruments from the policy mix perspective would be beneficial. In my second question, I focused on the bottlenecks to the policy implementation process, but I adopted a broad, overview perspective, covering all

the dimensions. While I deem that important, a more focused, in-depth analysis of the most critical bottlenecks, such as effective leadership and deployment of resources in the road freight sector, could provide further insights into the optimal adjustment of the policy instruments. In my third research question, I touched upon the spatial differences that might arise from uneven implementation of the instruments, but a case study approach could further elaborate on regional and national differences in capacities and potentials for implementing the variety of technical solutions necessary for decarbonisation of the road freight.

Ultimately, decarbonisation of the road freight will be a long, costly, and difficult process. The current dominant socio-technical system has been operating for over a century and the upcoming alternative technologies are not yet unified to a degree that would challenge the system as a whole. Hopefully, through its powerful role, the European Union shall unify its policy instruments and will ensure a timely, just and efficient transition towards a new system of zero-emission commercial road freight. However, only time will tell whether the proposed solutions of the Fit for 55 package are enough to achieve so.

9. References

***ACEA* (2022**) *VEHICLES IN USE EUROPE 2022*. Available at: https://www.acea.auto/publication/report-vehicles-in-use-europe-2022/ (Accessed: 22 May 2023).

Amazon (2022) *Amazon's electric delivery vehicles from Rivian roll out across the U.S.* Available at: https://www.aboutamazon.com/news/transportation/amazons-electric-delivery-vehicles-from-rivian-roll-out-across-the-u-s (Accessed: 22 May 2023).

Arrunada, B., González-Díaz, M. and Fernández, A. (2004) 'Determinants of Organizational Form: Transaction Costs and Institutions in the European Trucking Industry', *Industrial and Corporate Change*, 13(6), pp. 867–882. doi:10.1093/icc/dth033.

Axsen, J., Plötz, P. and Wolinetz, M. (2020) 'Crafting Strong, integrated policy mixes for Deep CO2 mitigation in Road Transport', *Nature Climate Change*, 10(9), pp. 809–818. doi:10.1038/s41558-020-0877-y.

Bach, H. and Hansen, T. (2023) 'Imo off course for decarbonisation of shipping? Three challenges for stricter policy', *Marine Policy*, 147, p. 105379. doi:10.1016/j.marpol.2022.105379.

Béguerie, W. (2021) *2021 review of Road Transport in Europe*, *Market Insights*. Available at: https://market-insights.upply.com/en/2021-review-of-road-transport-in-europe (Accessed: 23 May 2023).

Behrends, S., Lindholm, M. and Woxenius, J. (2008) 'The impact of urban freight transport: A definition of sustainability from an actor's perspective', *Transportation Planning and Technology*, 31(6), pp. 693–713. doi:10.1080/03081060802493247.

Benson, D. and Jordan, A. (2015) 'Environmental policy: Protection and regulation', *International Encyclopedia of the Social & Behavioral Sciences*, pp. 778–783. doi:10.1016/b978-0-08-097086-8.91014-6.

Bhaskar, R. and Hartwig, M. (2016) *Enlightened common sense: The philosophy of critical realism*. London: Routledge.

Bhuyan, A., A. Jorgensen, and S. Sharma. (2010) Taking the Pulse of Policy: The Policy Implementation Assessment Tool. Washington, DC: Futures Group, Health Policy Initiative, Task Order 1.

Bryman, A. (2012) *Social Research Methods*. Oxford: Oxford University Press.

Cairney, P. (2018) 'Three habits of successful policy entrepreneurs', *Policy & Politics*, 46(2), pp. 199–215. doi:10.1332/030557318x15230056771696.

Cairney, P. (2020) *Understanding public policy: Theories and issues*. London: Bloomsbury Academic.

Cambridge Econometrics (2018) *Trucking into a Greener Future: the economic impact of decarbonizing goods vehicles in Europe.* Available at: https://europeanclimate.org/wp-content/uploads/2019/11/6-09-2019-trucking-into-a-greener-future-technical-report.pdf (Accessed: 22 May 2023).

Cansino, J.M., Román, R. and Ordóñez, M. (2016) 'Main drivers of changes in CO2 emissions in the Spanish Economy: A Structural Decomposition Analysis', *Energy Policy*, 89, pp. 150–159. doi:10.1016/j.enpol.2015.11.020.

Cantillo, V. *et al.* (2022) 'Influencing factors of trucking nu willingness to shift to alternative fuel vehicles', *Transportation Research Part E: Logistics and Transportation Review*, 163, p. 102753. doi:10.1016/j.tre.2022.102753.

Carrara, S. and Longden, T. (2017) 'Freight futures: The potential impact of road freight on climate policy', *Transportation Research Part D: Transport and Environment*, 55, pp. 359–372. doi:10.1016/j.trd.2016.10.007.

Challies, E. *et al.* (2017) 'Governance change and governance learning in Europe: Stakeholder participation in environmental policy implementation', *Policy and Society*, 36(2), pp. 288–303. doi:10.1080/14494035.2017.1320854.

Chick, V. (2004) 'On open systems', *Brazilian Journal of Political Economy*, 24(1), pp. 3–17. doi:10.1590/0101-31572004-1638.

Clark, T. *et al.* (2022) *Bryman's Social Research Methods*. Oxford: Oxford University Press.

***IPCC* (2023)** *AR6 Synthesis Report*. Available at: https://www.ipcc.ch/report/ar6/syr/ (Accessed: 22 May 2023).

Coenen, L. and Truffer, B. (2012) 'Places and spaces of sustainability transitions: Geographical contributions to an emerging research and Policy Field', *European Planning Studies*, 20(3), pp. 367–374. doi:10.1080/09654313.2012.651802.

Coenen, L., Hansen, T. and Rekers, J.V. (2015) 'Innovation policy for grand challenges. an economic geography perspective', *Geography Compass*, 9(9), pp. 483–496. doi:10.1111/gec3.12231.

Cohen, W.M. and Levinthal, D.A. (1990) 'Absorptive capacity: A new perspective on learning and innovation', *Administrative Science Quarterly*, 35(1), p. 128. doi:10.2307/2393553.

Creutzig, F. *et al.* (2011) 'Climate policies for road transport revisited (I): Evaluation of the current framework', *Energy Policy*, 39(5), pp. 2396–2406. doi:10.1016/j.enpol.2011.01.062.

DeGroff, A. and Cargo, M. (2009) 'Policy implementation: Implications for evaluation', *New Directions for Evaluation*, 2009(124), pp. 47–60. doi:10.1002/ev.313.

EEA (2022a) *Greenhouse gas emissions from transport in Europe.* Available at: https://www.eea.europa.eu/ims/greenhouse-gas-emissions-from-transport (Accessed: 22 May 2023).

EEA (2022b) *Decarbonising road transport — the role of vehicles, fuels and transport demand*. Available at: https://www.eea.europa.eu/publications/transport-and-environment-report-2021 (Accessed: 23 May 2023).

Elo, S. *et al.* (2014) 'Qualitative content analysis', *SAGE Open*, 4(1), p. 215824401452263. doi:10.1177/2158244014522633.

Elzen, B., Geels, F.W. and Green, K. (2004) 'System innovation and transitions to sustainability', in *System innovation and the transition to sustainability theory, evidence and policy*. Cheltenham: E. Elgar, pp. 1–19.

European Commission (2023) *A European green deal.* Available at: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en (Accessed: 22 May 2023).

European Commission (2022) *Implementing Mobility Package 1: European Commission harmonises enforcement of road transport rules*. Available at: https://transport.ec.europa.eu/news-events/news/implementing-mobility-package-1-european-commission-harmonises-enforcement-road-transport-rules-2022-05-02_en (Accessed: 23 May 2023).

European Commission (2021, July 7) COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS: 'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality (COM(2021) 550 final). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0550

European Commission (2023, February 2) Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Regulation (EU) 2019/1242 as regards strengthening the CO_2 emission performance standards for new heavy-duty vehicles and integrating reporting obligations, and repealing Regulation (EU) 2018/956 (2023/0042 (COD)). Available at: https://eur-lex.europa.eu/resource.html?uri=cellar:4a3b2136-ad3e-11ed-8912-01aa75ed71a1.0001.02/DOC_1&format=PDF

European Council (2023) *Fit for 55 - the EU's plan for a green transition*. Available at: https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/ (Accessed: 22 May 2023).

European Parliament (1998, October 13) Directive 98/70/EC of the European Parliament and of the Council of 13 October 1998 relating to the quality of petrol and diesel fuels and amending Council Directive 93/12/EEC. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:01998L0070-20181224

European Parliament (2003, October 10) DIRECTIVE 2003/87/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32003L0087

European Parliament (2014, October 22) Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0094

European Parliament (2018, December 11) Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001

European Parliament (2018, May 30) REGULATION (EU) 2018/842 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 30 May 2018
on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R0842

European Parliament (2021, July 29) Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of

the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1999

European Parliament (2021, June 30) EGULATION (EU) 2021/1119 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law'). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R1119

European Parliament (2023, April 19) REGULATION (EU) 2023/857 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 April 2023 amending Regulation (EU) 2018/842 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement, and Regulation (EU) 2018/1999. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R0857&qid=1684796713193

European Parliament (2023, February 27) REGULATION (EU) 2023/435 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 February 2023 amending Regulation (EU) 2021/241 as regards REPowerEU chapters in recovery and resilience plans and amending Regulations (EU) No 1303/2013, (EU) 2021/1060 and (EU) 2021/1755, and Directive 2003/87/EC. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R0435

Eurostat (2021) *Transport Workers in the EU*. Available at: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20210923-2 (Accessed: 23 May 2023).

Eurostat (2022a) *Road freight transport by journey characteristics*, *Statistics Explained*. Available at: https://www.ec.europa.eu/eurostat/statistics-explained/index.php/Road_freight_transport_by_journey_characteristics (Accessed: 23 May 2023).

Eurostat *(2022b)* *Road freight transport statistics*. Available at: https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Road_freight_transport_statistcs#E2.80.98Food_products.2C_beverages_and_tobacco.E2.80.99_was_the_main_group_of_goods_transported_in_terms_of_tonne-kilometres_in_2021 (Accessed: 23 May 2023).

Eurostat (2023) *Employment in goods road transport enterprises*. Available at: https://ec.europa.eu/eurostat/databrowser/view/ROAD_EC_EMPL/default/table?lang=en (Accessed: 23 May 2023).

Fereday, J. and Muir-Cochrane, E. (2006) 'Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development', *International Journal of Qualitative Methods*, 5(1), pp. 80–92. doi:10.1177/160940690600500107.

Forbord, M. and Hansen, L. (2020) 'Enacting Sustainable Transitions: A case of biogas production and public transport in Trøndelag, Norway', *Journal of Cleaner Production*, 254, p. 120156. doi:10.1016/j.jclepro.2020.120156.

Fryer, T. (2022) *A short guide to ontology and epistemology: Why everyone should be a critical realist*. Available at: https://tfryer.com/ontology-guide/ (Accessed: 22 May 2023).

Geels, F. (2002) 'Technological transitions as Evolutionary Reconfiguration Processes: A multi-level perspective and a case-study', *Research Policy*, 31(8–9), pp. 1257–1274. doi:10.1016/s0048-7333(02)00062-8.

Geels, F. (2005) 'Co-evolution of Technology and society: The transition in water supply and personal hygiene in the Netherlands (1850–1930)—a case study in multi-level perspective', *Technology in Society*, 27(3), pp. 363–397. doi:10.1016/j.techsoc.2005.04.008.

Geels, F.W. and Kemp, R. (2007) 'Dynamics in socio-technical systems: Typology of change processes and contrasting case studies', *Technology in Society*, 29(4), pp. 441–455. doi:10.1016/j.techsoc.2007.08.009.

GFI (2021) *Road to Zero: Unlocking public and private capital to decarbonise road transport*. Available at: https://www.greenfinanceinstitute.co.uk/news-and-insights/cdrt-report-road-to-zero-unlocking-public-and-private-capital-to-decarbonise-road-transport/ (Accessed: 23 May 2023).

GHG Protocol (2013) *Technical Guidance for Calculating Scope 3 Emissions*. Available at: https://ghgprotocol.org/sites/default/files/ghgp/standards/Scope3_Calculation_Guidance_0.pdf (Accessed: 22 May 2023).

Gilson, L. (2016) 'Everyday politics and the leadership of health policy implementation', *Health Systems & Reform*, 2(3), pp. 187–193. doi:10.1080/23288604.2016.1217367.

Graneheim, U.H. and Lundman, B. (2004) 'Qualitative content analysis in nursing research: Concepts, procedures and measures to achieve trustworthiness', *Nurse Education Today*, 24(2), pp. 105–112. doi:10.1016/j.nedt.2003.10.001.

Grix, J. (2002) 'Introducing students to the generic terminology of Social Research', *Politics*, 22(3), pp. 175–186. doi:10.1111/1467-9256.00173.

Hansen, E. and Klewitz, J. (2012) 'Publicly Mediated Inter-Organizational Networks: A Solution for Sustainability-Oriented Innovation in SMEs?', in *Entrepreneurship, Innovation and Sustainability*. Greenleaf, pp. 254–278.

Hox, J.J. and Boeije, H.R. (2005) 'Data collection, primary vs. secondary', *Encyclopedia of Social Measurement*, pp. 593–599. doi:10.1016/b0-12-369398-5/00041-4.

IEA (2023) *Improving the sustainability of passenger and freight transport*, *IEA*. Available at: https://www.iea.org/topics/transport (Accessed: 22 May 2023).

IRU (2022) *Driver Shortage Global Report 2022*. Available at: https://www.iru.org/system/files/IRU%20Global%20Driver%20Shortage%20Report%202022%20-%20Summary.pdf (Accessed: 22 May 2023).

ITF (2021) *ITF Transport Outlook 2021*. Paris: OECD Publishing.

Jacobsson, S. and Bergek, A. (2011) 'Innovation system analyses and sustainability transitions: Contributions and suggestions for research', *Environmental Innovation and Societal Transitions*, 1(1), pp. 41–57. doi:10.1016/j.eist.2011.04.006.

Kattel, R. *et al.* (2018) *The economics of change: Policy and appraisal for missions, market shaping and public purpose*. Available at: https://www.ucl.ac.uk/bartlett/public-purpose/sites/public-purpose/files/iipp-wp-2018-06.pdf (Accessed: 22 May 2023).

Kemp, R. and Rotmans, J. (2004) 'Managing the transition to sustainable mobility', in B. Elzen, F. Geels, and K. Green (eds.) *System innovation and the transition to sustainability theory, evidence and policy*. Cheltenham: E. Elgar, pp. 137–168.

Kingdon, J.W. (2014) *Agendas, alternatives, and public policies*. Harlow: Pearson Education Limited.

Klein, K.J. and Knight, A.P. (2005) 'Innovation implementation', *Current Directions in Psychological Science*, 14(5), pp. 243–246. doi:10.1111/j.0963-7214.2005.00373.x.

Lawhon, M. and Murphy, J.T. (2011) 'Socio-technical regimes and Sustainability Transitions', *Progress in Human Geography*, 36(3), pp. 354–378. doi:10.1177/0309132511427960.

Leśnodorska, A. (2011) 'Financial Dimension of Resource Mobilization for Environmental Projects in Eastern Europe', in T. Nałe¸cz (ed.) *Groundwater management in the east of the European Union Transboundary Strategies for Sustainable use and protection of resources*. Dordrecht: Springer, pp. 181–186.

Markard, J., Raven, R. and Truffer, B. (2012) 'Sustainability Transitions: An emerging field of research and its prospects', *Research Policy*, 41(6), pp. 955–967. doi:10.1016/j.respol.2012.02.013.

Martin, R. (2001) 'Geography and public policy: The case of the missing agenda', *Progress in Human Geography*, 25(2), pp. 189–210. doi:10.1191/030913201678580476.

Mayring, P. (2000) 'Qualitative Content Analysis', *FORUM: QUALITATIVESOCIAL RESEARCHSOZIALFORSCHUNG*, 1(2).

Mazzucato, M. (2016) 'From market fixing to market-creating: A new framework for innovation policy', *Industry and Innovation*, 23(2), pp. 140–156. doi:10.1080/13662716.2016.1146124.

Mintrom, M. and Rogers, B.C. (2022) 'How can we drive sustainability transitions?', *Policy Design and Practice*, 5(3), pp. 294–306. doi:10.1080/25741292.2022.2057835.

Mission Possible Partnership (2022) *Making Zero-emissions trucking possible*. Available at: https://missionpossiblepartnership.org/wp-content/uploads/2022/11/Making-Zero-Emissions-Trucking-Possible.pdf?trk=public_post_comment-text (Accessed: 22 May 2023).

Mthethwa, R. (2012) 'Critical dimensions for policy implementation', *African Journal of Public Affairs*, 5(2), pp. 36–47.

Murphy, J.T. (2015) 'Human geography and socio-technical transition studies: Promising intersections', *Environmental Innovation and Societal Transitions*, 17, pp. 73–91. doi:10.1016/j.eist.2015.03.002.

Newig, J. and Koontz, T.M. (2013) 'Multi-level governance, policy implementation and participation: The EU's mandated participatory planning approach to implementing environmental policy', *Journal of European Public Policy*, 21(2), pp. 248–267. doi:10.1080/13501763.2013.834070.

OECD (1997) *SMALL BUSINESSES, JOB CREATION AND GROWTH: FACTS, OBSTACLES AND BEST PRACTICES*. Available at: https://www.oecd.org/cfe/smes/2090740.pdf (Accessed: 22 May 2023).

PwC (2022) *The dawn of electrified trucking*, *Strategy&*. Available at: https://www.strategyand.pwc.com/de/en/industries/transport/the-dawn-of-electrified-trucking.html (Accessed: 23 May 2023).

Ragon, P.-L. and Rodríguez, F. (2022) *Road freight decarbonization in Europe: Readiness of the European Fleets for Zero-emission Trucking*, *International Council on Clean Transportation*. Available at: https://theicct.org/publication/road-freight-decarbonization-europe-sep22/ (Accessed: 23 May 2023).

Rizos, V. *et al.* (2016) 'Implementation of circular economy business models by small and medium-sized enterprises (smes): Barriers and enablers', *Sustainability*, 8(11), p. 1212. doi:10.3390/su8111212.

Smith, T.B. (1973) 'The policy implementation process', *Policy Sciences*, 4(2), pp. 197–209. doi:10.1007/bf01405732.

Suproń, B. (2020) 'Influence of the mobility package on the functioning of the Polish road transport of goods sector', *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, 64(3), pp. 92–106. doi:10.15611/pn.2020.3.08.

Transport & Environment (2022) *How to buy an Electric Truck.* Available at: https://www.transportenvironment.org/discover/how-to-buy-an-electric-truck/ (Accessed: 22 May 2023).

Trist, E. (1981) *The evolution of socio-technical systems*. Available at: http://sistemas-humano-computacionais.wdfiles.com/local--files/capitulo%3Aredes-socio-tecnicas/Contribution%20of%20complexity%20theory1.pdf (Accessed: 22 May 2023).

Truffer, B., Murphy, J.T. and Raven, R. (2015) 'The geography of sustainability transitions: Contours of an emerging theme', *Environmental Innovation and Societal Transitions*, 17, pp. 63–72. doi:10.1016/j.eist.2015.07.004.

UNFCCC (2015) *Paris Agreement*. Available at: https://unfccc.int/sites/default/files/english_paris_agreement.pdf (Accessed: 22 May 2023).

Van Grinsven, A. *et al.* (2021) *Research for Tran Committee - Alternative Fuel Infrastructures for heavy-duty vehicles: Think tank: European parliament*, *CE Delft*. Available at: https://www.europarl.europa.eu/thinktank/en/document/IPOL_STU(2021)690901 (Accessed: 22 May 2023).

Vandermoere, F. (2019) 'Sustainability Transitions', in W. Leal Filho (ed.) *Encyclopedia of Sustainability in Higher Education*. Cham, Switzerland: Springer, pp. 11742–1746.

Veale, M. and Zuiderveen Borgesius, F. (2021) 'Demystifying the draft EU artificial intelligence act — analysing the good, the bad, and the unclear elements of the proposed approach', *Computer Law Review International*, 22(4), pp. 97–112. doi:10.9785/cri-2021-220402.

Volvo (2022) *DHL and Volvo Trucks Kick-off New Zero emission cooperation with order for up to 44 electric trucks*. Available at: https://www.volvogroup.com/en/news-and-media/news/2022/may/news-4263474.html (Accessed: 23 May 2023).