SEI Stockholm Environment Institute

How sustainable is the transformation in road freight?

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IMAGE (ABOVE): Trucks "platooning", Serbia

Key messages

- **Technology and climate mitigation are driving a transformation in road freight. The transformation spans value chains and has implications for business models, social conditions, and regulatory frameworks.**
- **Three key developments are driving the transformation: *automation* of vehicle control, *digitalization* of logistics planning, and coordination and *electrification* of drivetrains. However, the most important changes are likely to come from interactions between these areas.**
- **The changes appear to have substantial benefits, especially for reductions in greenhouse gas emissions, as well as for local air pollution and noise.**
- **At the same time, there are concerns and challenges relating to sustainable supply of battery minerals, equality of opportunity in the transition, and a just transition for transport workers, especially drivers.**
- **The pace of change is increasing, so while it is important to exploit "megatrends" to transform the value-chain, it is also imperative to identify and take measures that meet the challenges arising from the transition.**

Introduction

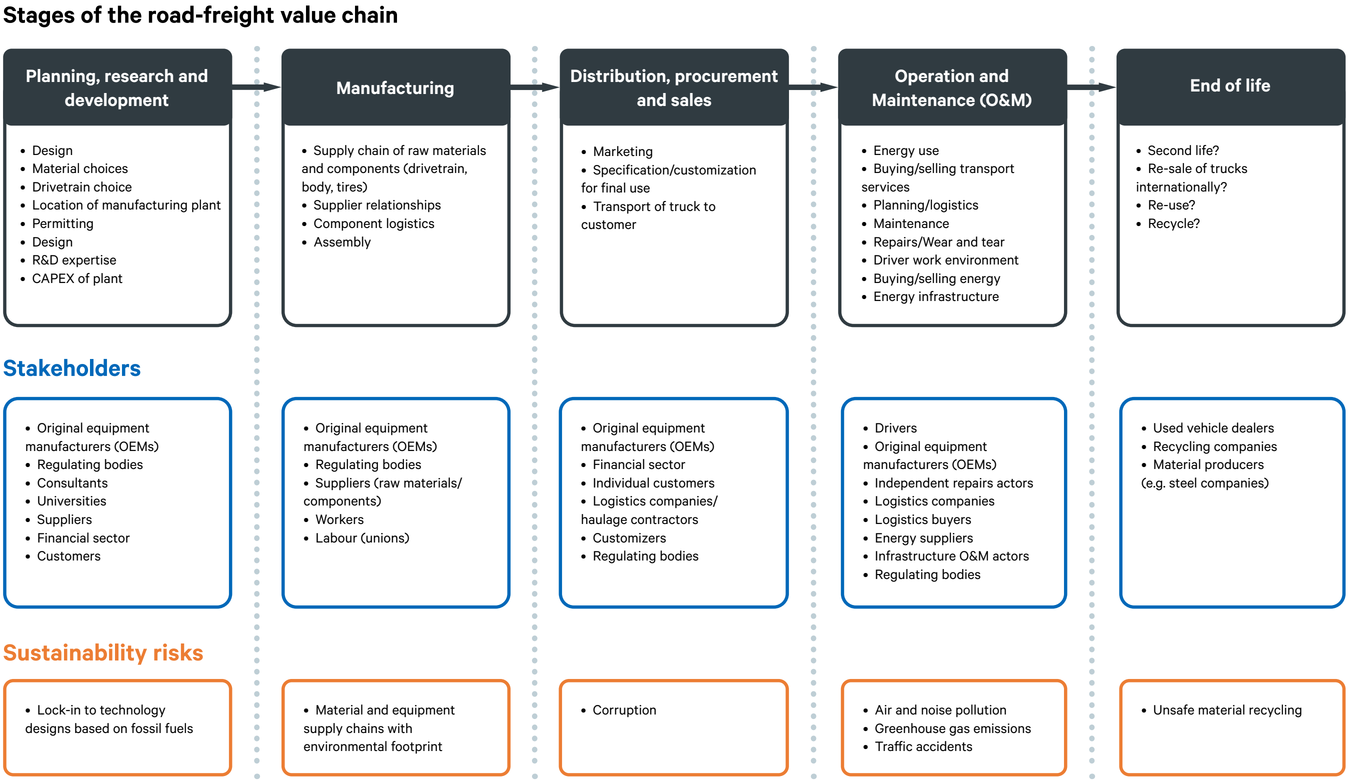
Road freight is one of the most important global economic activities, both in terms of moving goods and products between businesses and consumers worldwide, and as a source of employment. At the same time, the value chain has major sustainability challenges. Road freight makes up around 5% of global CO_2 emissions and is associated with a host of other issues such as local air and noise pollution and traffic accidents.

In this brief, we present a sustainability analysis of the road freight transport value chain. The analysis builds on the value-chain approach developed by the United Nations Environment Programme (UNEP), which begins by looking at all aspects of the system that enable a particular economic activity, product or service. This approach enables us to not only map potential sustainability concerns, but also identify hotspots (i.e. areas where action is especially needed) and the key actors involved in carrying out mitigation measures.

The road transport sector is currently in the early phase of a potentially disruptive change in terms of both energy use and drivetrains and how vehicles are controlled and coordinated. To include this range of perspectives, our analysis expands the analysis of the UNEP framework and discusses implications from ongoing technological transitions on sustainability across the value chain.

In the following section, we map and briefly discuss the outline and characteristics of the road freight value chain as it is today. We then present key aspects of the ongoing technological transitions in the value chain with a focus on three emerging megatrends: **automation**, **digitalization** and **electrification**, followed by a discussion of how these megatrends influence current sustainability hotspots across the value chain. The brief concludes with recommendations for decision makers on issues that are especially important for sustainable transformation of the road freight value chain.

Figure 1. Overview of the current road freight value chain



The road freight value chain: sustainability considerations now and in the short term

Figure 1 summarizes the configuration of the current value chain for road transport of goods, including its main activities, important stakeholders at each phase, and key sustainability concerns. It is important to note the centrality of the diesel-fuelled internal combustion engine (ICE) in the current value chain, as well as the negative environmental impacts associated with its dependence on fossil fuels. Notably, around 90% of the total life cycle greenhouse gas emissions of a truck typically come from the use of fossil fuels for propulsion. Operating ICEs also leads to local air and noise pollution, which is damaging to the natural environment as well as human health.

Other issues are independent of drivetrain choices, such as particulate emissions that arise from wear and tear on tyres and roads, traffic congestion, and traffic accidents. Accidents are a major concern for freight, because collisions between heavy-duty vehicles and other vehicles are more likely to result in fatalities than those involving other vehicles.

However, most of the environmental footprint of the road freight transport value chain comes from the *operation* of vehicles. The rest of the footprint primarily originates from the production of, and material supply for, the vehicle itself. Iron and steel are particularly important in this regard, making up 60% of the greenhouse gas emissions associated with materials used in a distribution truck.

Turbulent times ahead: three key megatrends

From burning to batteries

It is broadly acknowledged that road freight is in the early phases of disruptive change, not only in the technological realm but also in terms of business models and value chain issues. Battery electrification is emerging as the dominant drivetrain for lighter vehicles and is likely to become the most important drivetrain for medium and heavy-duty vehicles as well. Having said that, there are still – and will likely remain – a set of use cases for which battery electric vehicles (BEVs) may not be the best option and where other alternatives can play a role.

Digital disruptions

For passenger transport, digitalization has enabled new forms of mobility services, such as car-sharing, ride-hailing and peer-to-peer car rentals that reduce the need for actual car ownership. There are now signs of similar developments in freight transport with the rise of platforms such as Uber Freight. In addition to new services, digitalization also enables new levels of route optimization and fleet coordination that combine to reduce energy use, CO_2 emissions and costs.

Welcome our new robot overlords?

Beyond incremental efficiency gains offered by digitalization, the anticipated birth of fully autonomous vehicles would be very disruptive for road freight. One key reason is that by some estimates staff costs make up more than a third of total freight costs. But there are also potential advantages in the form of improved road safety, because most traffic accidents are a result of human error.

Vehicle autonomy functions come in six levels as classified by the Society of Automotive Engineers (SAE), from no autonomy at level 0, via driver assistance functions, to full autonomy at level 5. Substantial uncertainty remains about when full autonomy can be achieved in all real-world conditions. However, well before level 5 autonomy, there are plenty of opportunities for vehicle automation on restricted routes, on private land, in certain environments such as highways and during certain times of the year, or through platooning.

How do automation, digitalization and electrification impact on value chain sustainability?

Battery electrification: environmental hotspots shift from vehicle operation to manufacturing

A shift to BEVs will bring large gains in terms of reduced impacts on the environment and public health. Measures to improve air quality, including vehicle electrification, have helped to reduce premature deaths from air pollution in the EU by 45% between 1990 and 2019. This highlights how so much of the negative environmental impact of road transport comes from the combustion of fossil fuels. While the size of the gains depends on the environmental footprint of the underlying electricity system, research shows that already the current energy mix offers benefits.

On the other hand, there are indications that air pollution caused by wear and tear on tyres and roads could actually increase with the shift to BEVs, because of the higher weight of BEVs compared to corresponding vehicles with ICEs. It is also important to note that the shift to BEVs is a shift to a new kind of *system*, where it will be of crucial importance to consider charging infrastructure and how this interacts with the power grid at large.

Battery electrification of transport will mean that environmental hotspots in the road freight value chain will shift away from vehicle operation and arise more from the extraction and processing of materials used in the vehicles, as well as from the increased material requirements of batteries. Battery production will require large volumes of minerals, the extraction and processing of which can be associated with substantial risks for environmental and social sustainability.

However, an increased share of emissions from material supply chains compared with those from operations can also catalyse improvements in supply chain sustainability. Recently, large European vehicle manufacturers have been partnering with steel companies on offtake agreements to purchase low-emission steel. This is driven by growing ambitions to lower emissions across the entire value chain and provides steel companies with the certainty of early demand. There are similar partnerships in development for reverse supply chains for end-of-life vehicles.

Digitalization: improving efficiency, disrupting job security?

Large efficiency gains could be made from using digital platforms to improve fleet management. This is currently especially valuable for BEVs, which are limited in range compared to ICE vehicles. Key enablers of the transition include monitoring vehicle charge and charger availability, as well as optimized planning.

On the other hand, digitalization is likely to have significant impacts on those employed in the road freight sector and on drivers in particular, of which there are about three million in the EU alone. While the rise of digital "gig economy" platforms has enabled new forms of employment that can offer workers independence and flexibility (e.g. the choice to work for several different employers) there are also clear concerns about employment agreements that fall into regulatory grey areas and put workers at risk of being exploited.

Automation: costs down, accidents down, work for drivers …?

The emergence of vehicle autonomy comes with advantages as well as potential risks. Traffic safety is already improving from the introduction of low-level (SAE levels 1 to 3) automation features in the form of driver assistance systems, such as traction control systems and driver monitoring. Further advancements will likely allow the vehicle to operate without a driver in some (SAE level 4) or all (SAE level 5) circumstances, which has the potential to be very disruptive for the road freight value chain. Some analysts have predicted massive job losses among drivers, but these are likely to be exaggerated because level 5 autonomy is not expected to be available in the near-term. Furthermore, there is currently a shortage of drivers in both the US and the EU, and automation could alleviate this problem. However, there are still uncertainties over how and in what time frame this would affect the driver workforce.

Automation, especially in combination with battery electrification and digitalization, will lead to substantially lower operational costs for the road freight industry. While this will have many benefits, such as lower costs for consumers, it also comes with risks in terms of potentially increased pressure on the use of roads and other public spaces where the capacity of the road network could become a bottleneck.

Conclusions and policy recommendations

Road freight is in an early phase of disruptive change, manifested through three megatrends – automation, digitalization, and electrification. Together, these can unlock new value in road freight transport, including new business models and new stakeholders throughout the value chain. The transition is likely to entail a substantial reduction in total life-cycle greenhouse gas emissions across the road freight value chain because of the reduction in use-phase emissions from fossil fuel combustion.

With the use of low-carbon electricity as input for BEVs, operational emissions will decrease substantially to the point where the environmental sustainability hotspot will shift from the operational phase to the vehicle manufacturing phase. Further, electrification, automation and digitalization are together likely to increase efficiency and reduce costs of road freight. This is in many ways a positive development but could have unintended consequences in terms of increased congestion and road wear and tear.

It is important that decision makers in policy and business alike not only identify the broader impacts of the transition, but also focus on the detail in specific contexts, as in our research project on Just Swedish Transport Industry Transitions (JUSTIT).

While it is important to capitalize on the megatrends that are enabling decarbonization, it is also imperative to quickly identify and mitigate the new challenges they will bring. One opportunity is to build on the momentum of decarbonizing the use-phase to also address upstream supply chain environmental impacts. This could be done through off-take agreements for low emission materials, through standards and certification for more sustainable minerals supply chains to help de-risk investments in supply, and by developing public procurement to help drive demand for more sustainable products.

In terms of needs for further analysis, much of the academic research on the three megatrends highlighted above is carried out in silos, analysed one at a time. But there is a need to better understand how the megatrends converge and interact and what they imply for transitions to a more sustainable road freight value chain.

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