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The long haul towards decarbonising road freight – A global assessment to 2050

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HIGHLIGHTS

- Global historic road freight activity data is analysed and projected to 2050.
- The IEA's Mobility Model is used to calculate future energy and emissions.
- Current INDCs relate to a 56% increase in road freight GHGs between 2015 and 2050.
- The maximum potential reduction over the same time-frame was found to be 60%.
- Energy efficiency, improvements in operation logistics, and alternative fuels contribute to this reduction.

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ABSTRACT

Road freight transportation is a key enabler of global economic activity while also a central consumer of fossil fuels, which presents a challenge in realising a low-carbon future. To identify feasible decarbonisation solutions, we first assess significant drivers of activity in the road freight sector. We then use these drivers to project road freight service demand, vehicle stock, mileage, sales, final energy demand, and well-to-wheel GHG emissions using the IEA's Mobility Model (MoMo) under two scenarios – the first incorporating the policy ambition of the Nationally Determined Contributions pledged at COP21, and the second extending ambitions to emission reductions that are in line with limiting global temperature rise to 1.75 degrees. In the former scenario, road freight well-to-wheel GHG emissions increase by 56% between 2015 and 2050, while in the latter, sectoral emissions are reduced by 60% over the same period, reflecting our assessment of the threshold of emission reductions potential. This reduction is catalysed by policy efforts including fuel economy regulations, carbon taxes on transport fuels, differentiated distance-based pricing, widespread data-sharing and collaboration across the supply chain as enabled by digital technologies, and sustained investment in ultra-low and zero-carbon infrastructure and research development and deployment.

1. Introduction

The road freight network acts as the arteries for global economic activity. As such, it is strongly linked to globalisation and economic development within nations – as a country's economy develops, so does its level of infrastructure, freight logistics, and demand for goods, all of which tends towards an increase in freight demand. This trend has become most prominently apparent in developing countries in recent decades. For example, according to national statistics, road freight activity in India – measured in tonne-kilometres[2] (tkm) – increased by more than 9-fold over the period 1975–2015, [1,2] while road freight activity in China grew by more than 30-fold over this same period [3]. Road freight activity in developed regions has not been as extreme, but is still significant: in the United States, for example, road freight tonne-kilometres increased by 2.5-fold [4] over the same forty year period (see Fig. 1).

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[2] A common method of reporting freight activity is in tonne-kilometres, which is the product of the gross mass of the goods carried by the truck and the distance carried.

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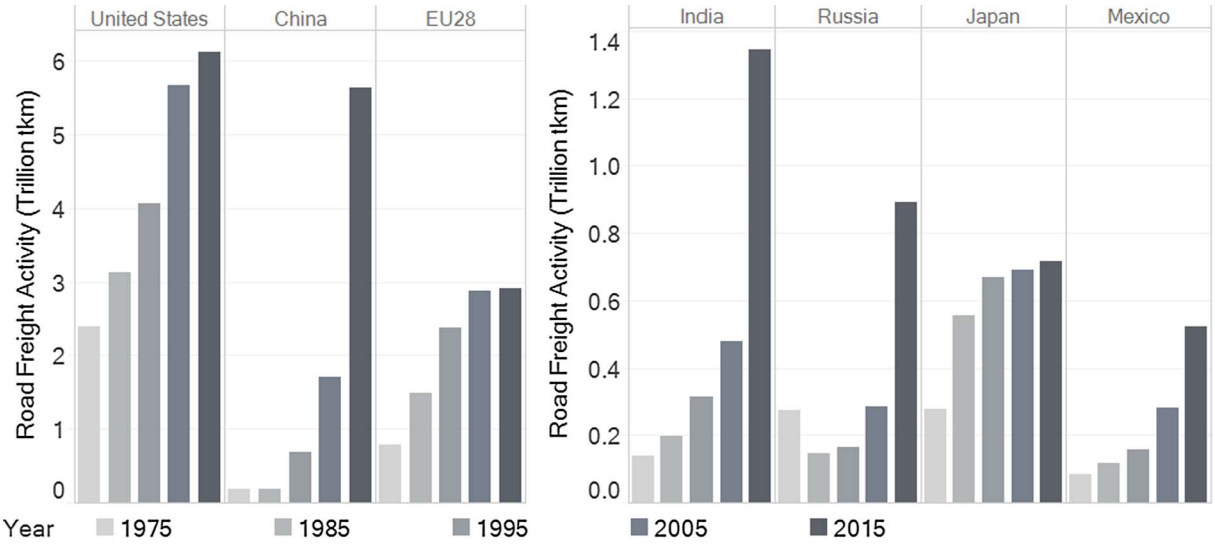

Fig. 1. Road Freight Activity in Major Economies (Road freight activity shown in this graph is extrapolated based on national and regional data sources and calibrated using the IEA Mobility Model. The calibration is based primarily using data on vehicle sales, stocks, mileage, energy use per vkm and total energy demand, complemented by information on loads (including empty runs and laden trips with partial capacity utilisation). Vehicle mileages and load factors are the parameters with the greatest uncertainty in terms of data availability and reliability. This bottom-up approach, mainly focused on vehicles and energy, leads to estimations of total tkm that differ substantially from official statistics, especially in China, where official statistics report higher tkm values, and in the European Union, where Eurostat data provide lower tkm estimates.) (see Appendix for sources).

The main driver of this recent growth, particularly in emerging countries, has been the robust economic development which has accelerated growth in on-road freight activity due to increased demand for consumer and industrial goods. Logistics, as well as intra- and intermodal infrastructure tends to improve in tandem with economic development, thereby facilitating the more efficient movement of a greater volume of goods. In China, for example, the increase in freight activity over the past four decades is strongly driven by the globalisation of production activities, rapid industrialisation, and urbanisation coupled with the uneven geographic allocation of raw materials [5]. However, this growth in road freight activity is not universal – in some developed nations aggregate road freight activity in tkm has slackened (in Japan) or even declined (in the UK). In the case of Japan, this can be related to a stagnating economy during the mid-90s following the economic collapse and to improvements in domestic logistics and operations [6], while the reduction in road freight activity in the UK can be attributed to a structural shift in the economy as well as infrastructure improvements [7].

Despite the few cases of slackening growth or declining activity, which is a phenomenon limited to very rich countries over recent decades, overall global road freight activity is still largely on the rise. As a result, the road freight sector has played a growing role in global oil demand, accounting for 18% of global oil primary energy consumption in 2015, and about one-third of global transport final energy demand and well-to-wheel (WTW) global transport related greenhouse gas (GHG) emissions [8]. The sector's significant share in energy demand and GHG emissions, considered in light of the ambitious commitments of the world's major economies to decarbonisation, as laid out at the 21st meeting of the Conference of Parties (COP21), presents a challenge for road freight in transitioning from its current state, which is largely dominated by fossil fuels, towards low-carbon alternatives.

Despite the necessity of this transition if national commitments are to be achieved, there has been a lack of focus set on the road freight sector relative to others. For example, of the 133 submitted Intended Nationally Determined Contributions (INDCs), which represent national mitigation and adaption plans of 160 countries intended to comply with the ambitions set by COP21, only 13% mention freight while 61% mention passenger transport [9]. In a further comparison against passenger cars, standards mandating minimum fuel economy of new sales of heavy-duty road freight vehicles in 2015 covered about 50% of heavy-duty truck sales, while fuel economy standards for light-duty vehicles covered more than 80% of sales, [10,11]. Also considering that long-term growth of road freight transport activity and oil demand has been faster than that of passenger vehicles, and that this trend is expected to continue [12–14], the lower level of focus given to road freight sector is likely to become increasing problematic as countries strive to adhere to their climate commitments.

A plethora of factors contribute to recent changes in road freight activity. While the link between economic development and road freight activity has been strongly evident in the past [13,15], there are many other factors - such as fuel prices, the distribution of natural resources, availability and quality of infrastructure, and population density - that influence shifting patterns of goods transport. The first aim of this study is to identify the key parameters, from a wide range of variables such as these, which are most consistently and highly correlated with road freight activity. Based upon comparison of various regressions, we adopt a log-log multivariate linear regression model to project future national trends in road freight activity. These are integrated into the International Energy Agency's (IEA) Mobility Model (MoMo) to provide the basis for activity demand-driven and policy-dependent scenarios of road freight vehicle fleet and sales, mileage, technology shares, energy demand, and GHG emissions. These projections are carried out under a Reference Technology Scenario (RTS), which considers all relevant policies and measures that are already adopted today or have been announced, including those of the INDCs pledged at COP21, and a Modern Truck Scenario (MTS), which focuses on the maximum policy commitments to (i) transition to more fuel-efficient road freight vehicles, (ii) improve logistics and operational efficiency (thereby reducing vehicle activity), and (iii) shift to ultra-low and zero-emission vehicle and fuel technologies. The resulting impact on energy demand and emissions in the MTS would be sufficient to bring the sector in line with ambitions stated in the COP 21 agreement to take efforts to limit global temperature rise to 1.75 °C, with a probability of achievement of 50%.

This paper is outlined as follows: first, the structure and functionality of the model used in this study, MoMo [16,17], are presented. Second, the key drivers of global freight activity and the methods adopted for projecting future activity are discussed. Third, the options available for decoupling GHG emissions from the goods movement services delivered by the road freight sector are introduced, including