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Uprating the freight VTT

Report for the UK Department for Transport by Significance and Arup

Final Report | June 2026, revised Aug. 2026

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Project number:
26007

Version control:

Version	Date	Description
Version 1.0	29-5-26	Draft final report
Version 2.0	17-6-26	Final report
Version 3.0	24-8-26	Revised Figures in section 8.3

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Benjamin Franklin (1706-1790):

On making decisions:

“My way is to divide a sheet of paper by line into two columns; writing over the one Pro and the other Con.”

On time:

“Lost time is never found again.”

“Remember that time is money.”

1. Introduction

1.1 Background

In a societal cost-benefit analysis (SCBA), costs and benefits usually refer to different years (most commonly investment costs refer to years before the project starts operation and once the new facility is opened, the benefits accrue year by year). This implies that costs and benefits need to be calculated for every year within a period that may last 50 years or more after the opening of the facility, including discounting of these values.

The transport forecasting models used as an input to the SCBA are often static models based on cross-sectional data. These models are used to predict transport volumes (and changes in transport times, costs and distances) for a single forecast year (e.g. 2050) or just a few future years covering the evaluation period (e.g. 2040, 2050 and 2060). For all other years, the relevant volumes are assumed to be the same as in one of these forecasting years or an interpolation between these year values.

This will get overall costs and benefits for all relevant years in the SCBA. However, after conversion into monetised units, the unit values (e.g. freight VTT and VTTR) need to be corrected for price and real value changes.

All unit values, such as the freight VTT and VTTR in TAG, are in GBP of a certain base year (e.g. 2023), so the price level is constant. For later years, the unit values need to be corrected for real (excluding predicted inflation) changes in the wages and prices that are relevant for the production of transport services and goods over time.

1.2 The current TAG approach and alternative approaches

In 2025, DfT (DfT, 2025) published new road freight values of travel time (VTT) and reliability (VTTR) that are inputs to TAG. This includes proposals (‘uprating assumptions’) for how these values should grow over time, over and above inflation.

For both HGVs and freight LGVs, DfT now proposes (DfT, 2025) to “uprate road freight VTT over time by blending the real wage growth rate for the wage-related component of VTT, with the GDP deflator for the residual component (relating to the wider range of costs reflected in the VTT).” DfT also writes that it believes “this has the benefit of reflecting any premium associated with wage growth, over and above general inflation, while still basing the growth rate on widely used and understood metrics (as opposed to more bespoke freight price indices).”

The use of freight price indices, at least for the transport cost component of the freight VTT, was recommended in the main report on the road freight VTT study (Arup et al., 2023):

“Our recommendation for the growth over time of the VTT is to use the price index numbers for the staff and vehicle time-related transport cost components, and (if possible) specific indices for road freight transport cost such as the wages (otherwise the CPI, so that they remain constant in real terms or GDP as that is TAG’s definition of real). For the change in the cargo component, we suggest the real GDP growth, since the goods values are likely to rise closely to GDP growth.”

DfT in its proposal followed this advice for the wage rate, but not for other transport cost components or the cargo component.

We see two other main approaches (alternatives to the DfT approach) that could be chosen for uprating the freight VTT:

- Make wider use of freight transport cost indices (not just wage costs): distinguish several transport cost components in the freight VTT and relate these to the expected growth of each component over time. For the cargo component one could use real GDP growth or inflation correction only.
- Do all the uprating of the freight VTT on the basis of real GDP per capita growth (possibly with a GDP per capita elasticity), without making any distinctions between components of the freight VTT.

In this report we will investigate the pros and cons of these options looking for theoretical arguments (section 2) and empirical evidence (the other sections).

1.3 Aims, objectives and scope

In its request for proposal, DfT wrote it is open to changing its approach subject to robust evidence. It has requested Significance to submit a proposal that aims to provide a comprehensive review of the available evidence and analytical approaches to inform how the values of road freight travel time and reliability should be assumed grow over time in future years. Significance has teamed up with Arup for this project (where Significance is the main contractor and Arup a subcontractor to Significance).

There are six strands of research in this project, in which we try to find evidence for or against specific uprating approaches (the three approaches listed in section 1.2):

- Using economic theory to determine what we can learn for the development of the freight VTT and VTTR; which factors explain the evolution of the freight VTT over time according to underlying theory and theoretical models;
- Look at repeat freight VTT studies over time and income development to discern a time trend in the freight VTT and GDP (per capita) elasticities of the freight VTT;
- Doing an empirical analysis of historical freight cost indices using data provided by DfT. In this analysis we determine the observed annual real growth rates for different cost components of the time-dependent transport costs for LGV and HGV and compare these to GDP growth. We also develop regression functions to predict future values for these cost components;
- Wider economy and CGE models and how they represent reactions to travel time savings. Here we investigate how in these models the link between freight transport time and GDP is represented and what we can learn from this;
- Looking at what has been assumed about freight VTT growth in other nations' appraisal practice (and international organisations such as Jaspers/EIB);
- Analysing cross-sectional differences in the freight VTT across countries, which can provide a GDP per capita elasticity of the freight VTT.

The outcomes of these are reported in chapters 2-7 of this report.

After that, in chapter 8, we integrate the outcomes to discuss the three potential options for uprating the freight VTT in terms of their pros and cons. In chapter 8 of this report, Significance and Arup will:

- Critically review the assumptions currently proposed;
- Assess alternative approaches to uprating the freight VTT and VTTR;
- Use economic theory and empirical analysis to propose what the approach should be;
- Calculate what rate of growth this implies over a reasonable horizon (at least 2050) using available data sources;
- Provide advice on how freight VTT and VTTR should be maintained and uprated over time.

2. What can we learn from (economic) theory?

2.1 The conceptual background of the freight VTT and implications for uprating

We distinguish two components in the freight VTT, the transport cost component and the cargo component. Within the transport costs we distinguish time-dependent costs and distance-dependent costs:

1. Transport costs:
    a. Time-dependent transport costs (e.g. staff cost, vehicles, overhead);
    b. Distance-dependent transport cost (e.g. fuel);
2. The time costs of the cargo (interest on capital invested in the goods, deterioration, loss of shelf life, requirements of production process).

Both 1a and 2 can be part of the freight VTT and are behind the new freight VTT recommendations of DfT (DfT, 2025).

A visual diagram of the components of the value of freight time is included below split by carrier (costs of moving the goods) and shipper costs (related to the value of the goods being moved).

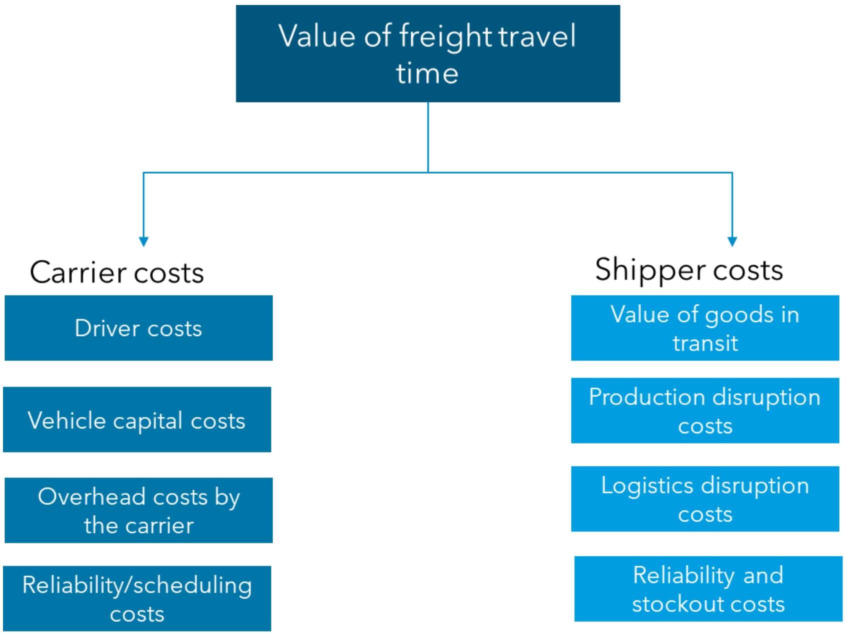

Figure 1: Value of freight time components

2.1.1 Freight VTT and transport cost (the transport cost component of the VTT)

Reductions in transport time in freight can lead to different benefits for different decision-makers in freight transport (Table 1). The transport itself is usually carried out by specialised firms, the carriers, that have their own – sometimes leased – transport vehicles and staff to drive and supervise these vehicles. If the transport times were reduced by, for example, a new road link, the vehicles and drivers would be used for a shorter duration, and the carriers could either perform more transport assignments or perform the same assignment with fewer vehicles and staff. In the short run the options to benefit from this might be limited, but in the long run carriers can reschedule their services and production factors. So, the long-term gain of a time saving could be as high as the sum of the time-related transport costs for the given amount of saved time. These are often taken to be all the transport costs except the purely distance-related costs (such as fuel costs, energy costs and user charges for the use of rail infrastructure). For shippers (the firms that own the goods that need to be shipped: usually the senders, sometimes the receivers) that contract transport out, the benefits related to vehicles and drivers are not directly relevant, but the benefits related to the cargo are. For shippers that carry out the transport on their own account both components of the freight VTT are relevant.

Table 1: Benefits from time savings for different decision makers in freight transport

	Benefits related to the cargo	Benefits related to the vehicles and staff (transport costs)
Carrier	Not relevant	Relevant
Own account shipper	Relevant	Relevant
Shipper that contracts out	Relevant	Not relevant

It can happen in practice that the trade-off ratio for the value of transport time versus time-related transport costs can be smaller than 1, because it may be difficult for firms to convert the time gains fully into cost reductions or additional revenues. The time gain for instance could be too small to use for other transport activities, or additional work for a transport firm can only be realised against high costs (marketing, discounts), taking into account that the volume of transport services is not very price elastic (because the demand for transport largely depends on product markets). Furthermore, there are regulations in the opening times of firms at the origin and destination, on driving and on sailing times and on labour contracts, that prevent full flexibility in using time gains productively for other transports or for reducing costs. In the longer run, which is the proper perspective for SCBA of transport infrastructure, there will be more possibilities for reorganising logistics and therefore to reduce costs or increase output to benefit from time savings.

The imperfect flexibility (or kinked production function or cost function) argument could be more relevant for train, inland waterways and sea transport, since these modes have much larger indivisibilities (large vehicles and vessels that are used for trips that take a long time, possibly also with slot allocation).

Economists of the Netherlands Bureau for Economic Policy Analysis (the main economic advisory in the Netherlands) expect that in the long run the trade-off ratio for road transport will be equal to 1 or not be far below 1. The Netherlands therefore uses the full time-related transport cost (plus the cargo component) as the basis for the freight VTT, for all years after the opening of the project. The trade-off ratios for other modes may be somewhat smaller, but in the long run these too should not be very far from 1. Therefore, the SCBA in The Netherlands uses a ratio of 1 for non-road for the years 10 and later after the opening of a project. For the years 1-9, it uses a linear interpolation between the SP-values and the full time-dependent transport cost (plus the cargo component) as the freight VTT for non-road modes (Significance, 2013, 2023).

This provides an indication that for road freight transport, the transport cost component of the VTT increases with the same rate as the time-dependent freight costs (wage costs, vehicle cost, overheads). This standpoint would imply an uprating of this component of the road freight VTT on the basis of the real cost changes in each of these transport cost sub-components.

Instead of the time-dependent freight factor cost, one could also use the time-dependent factor productivity (the revenues of one hour or freight transport production). In the neoclassical economic model these are equal to the time-dependent factor cost. In practice, most researchers use factor cost instead of factor productivity for reasons of data availability. The time dependent transport costs are the time-marginal transport cost: the derivative of the total transport cost function with respect to transport time. To calculate the transport cost component of the freight VTT by means of the factor cost method, one needs to define which cost are time-dependent (time marginal). In practice, a researcher then needs to make assumptions or use interviews on transport time changes with shippers and carriers. These interviews could take the form of stated preference experiments. One could also take a wider perspective and take the derivative of the total logistics costs, including transport cost and inventory costs (see section 4.3).

2.1.2 The cargo component of the freight VTT

The shipping firms (producers or traders of commodities; could not only be the senders but also the receivers of the goods) want to send their products to their clients, which creates demand for transport services. A part of this demand might be supplied by the shippers themselves (known as own account transport), but in most cases the transport is contracted out to carrier firms or intermediaries, for which the shipper pays an agreed rate. Benefits that a carrier gets when time is reduced may be transferred to the shippers through reductions in the price of transport (depending on the market conditions). Even when no transport cost savings are passed on to the shipper, shippers can benefit from transport time reductions because the fact that the goods themselves are away for a shorter time can:

- reduce the interest costs on the capital invested in the goods during the time that the goods are transported;
- diminish the deterioration in the value of perishable goods during transit; and
- lower the possibility that the production process is disrupted by missing inputs or that customers cannot be supplied due to lack of stock.

In the long run, there can also be benefits arising from opportunities to reorganise the logistics process, which are currently lost because of longer and unreliable transport times. A study into the economic cost of barriers to road transport (Hague Consulting Group, 1998) investigated these effects through interviews with shippers and carriers, a literature review and expert interviews. It concluded that the most important lost reorganisation opportunities of barriers to road transport are related to depot structure and inventory size. These benefits will therefore also mainly be felt by the agents that hold the inventories, usually the senders and receivers of the goods, unless they contract out stock keeping to logistics service providers.

Shippers with own account transport can be expected to see both the vehicle- and staff-related benefits as well as the cargo-related benefits of travel time reductions.

2.1.3 Including both components of the freight VTT in SCBA

The carrier's VTT typically relates to the driver and the transport equipment; drivers are paid wages and the equipment must be depreciated, or their lease paid. A carrier incurs these costs irrespective of the type of goods being carried or even whether the vehicle is loaded – these costs are insensitive to commodity type. However, there are some exceptions to this rule, for instance the transport of hazardous chemicals and refrigerated or heated goods, which increase the cost of transport.

On the other hand, the specific VTT of the shippers relates to the contents of the shipment – the market value of the goods, their depreciation, their tendency to degrade, the risk of theft – and also to the wider logistics system of which the transport operation is a part.

Sometimes, the receivers of the goods – not the senders – are responsible for the transportation and are already considered the owners of the goods during the transportation. In such cases, the cargo-related benefits of time savings may accrue to these receiving firms.

For society, both types of benefits (cargo-related and transport cost related) matter, so in a societal evaluation, like a social cost-benefit analysis (SCBA), both types of benefits should be taken into account. This does not necessarily imply that both should be included in the transport time benefits through the VTT, but this is one possibility.

The distinction between these two components in the freight VTT is a relatively recent insight; it does not appear in reviews before 2008. Before that, researchers could not explain why the freight VTT could vary so much between countries with similar income levels. It later emerged that some countries only used the cargo component for the freight VTT (which led to a relatively low value), whereas other countries used both components (and obtained a much higher value).

There are two distinct schools of thought regarding the use of the freight VTT in SCBA. The first approach (Approach A in Figure 2) defines VTT as the cargo component only and includes impacts of projects on staff and vehicle time saved in the SCBA through the transport cost savings (together with the distance-based cost, including energy and infrastructure use charges, that should not be in the VTT in either approach). The alternative, Approach B, uses a VTT that contains both the cargo and the transport services component; in the SCBA all freight time benefits are expressed through the VTT and transport costs benefits only reflect reductions in the trip lengths (if any).

There is no right or wrong answer in the choice between the two approaches. Both methods are correct and can be carried out in such a way that all benefits are included and no benefits are double counted (mistakes have been made in several countries by combining time gains from one approach with a VTT from the other approach). If VTT is the cargo component only, one should, in evaluating time-saving projects, take care not to forget reducing the time dependent transport costs (as part of the cost savings). If both components are in the VTT, one should take care not to double count the distance-dependent transport cost. Approach A with a low VTT is used in Sweden and Approach B with a high VTT in the Netherlands (see Vierth, 2013). The previous UK approach was a mix of the two: it ignores the cargo component, includes the staff time in the freight time benefits and some vehicle costs savings with the distance costs savings. The new approach in the UK (DfT, 2025) basically follows the philosophy of approach B.

Approach A	**Approach B**
Time savings:	**Time savings:**
Cargo time saved	Cargo time saved Staff time saved Vehicle time saved
VTT	VTT
Transport cost savings:	**Transport cost savings:**
Distance cost saved Staff cost saved Vehicle cost saved	Distance cost saved

Figure 2: Approaches to time/cost benefits in SCBA

2.1.4 The freight VTTR and the two components

For the VTTR, the same two components as for the VTT, can be distinguished: the cargo (shippers) component and the transport cost (carriers) component. However, for the VTTR, studies usually attempt to determine the sum of both components, since no transport time variability is included in the transport cost in SCBAs.

The overall impact of reliability on the carriers has been found by some recent studies to be very limited (not significantly different from zero). On the other hand, a significant impact on the shippers (comparable to the cargo component of the VTT) has been found. In principle, there could be an impact of unreliability on vehicle and staff transport cost. Therefore, it would be good to leave open the possibility of reliability benefits among the carriers as well.

2.2 Choice modelling theory for freight transport

Most freight VTTs in the literature either come from factor cost calculations or discrete choice models. Factor cost calculations by themselves cannot tell us what the freight VTT is and how it changes over time, because they rely on assumptions which components of the transport cost should be included in the freight VTT and to which degree these should be included. Choice models on the other hand can be used to empirically determine the freight VTT. In doing so, choice models can also show which components add up to the freight VTT. Based on this knowledge, there could be room for factor cost calculations for uprating the freight VTT. In this sub-section, we investigate whether discrete choice theory, applied to freight transport, provides any indications for uprating the freight VTT.

Freight VTTs from choice models usually come from (between-)mode choice models on RP or RP/SP data or within-mode choice models on SP data. The decision-maker on mode choice is usually taken to be the shipper (mostly the sender of the goods), but it could also be the receiver or a third-party logistics services provider. Route choice and vehicle type choice are typically the domain of the carrier. Discrete choice models at the disaggregate level have originally been developed in passenger transport, where the dominant choice paradigm and theoretical foundation is that of random utility maximisation. The basic equation of the RUM model is:

$$U_{ik} = Z_{ik} + \varepsilon_{ik} \qquad (1)$$

In which:

U_{ik}: Utility that decision-maker k derives from choice alternative i (k= 1,..K ; i = 1,...,I);

Z_{ik}: observed utility component;

ε_{ik} : random utility component.

Utility maximisation belongs to the economics of consumer behaviour and seems at first sight inappropriate for explaining the behaviour of the firm, where the standard economic paradigm is that of profit maximisation or cost minimisation. However, we can apply the random utility framework to freight transport choices by simply using minus the total generalised transport costs[1] as the observed component of utility and including one or more random cost components to this function:

$$U_{ik} = -G_{ik} - e_{ik} \qquad (2)$$

In which:

G_{ik}: observed component of generalised transport cost;

e_{ik}: random cost component.

In eq. (2) random cost minimisation becomes random utility maximisation. This model can be used for mode choice and transport chain choice, but also for vehicle type or simple route choice. For the standard discrete choice models with an independent error term and without heteroskedasticity, one might just as well write a + sign in front of e_{ik}. The mode choice model for freight transport can then be estimated using the same software as for the RUM model in passenger transport. One only has to take into account that an increase in costs leads to a reduction in utility, but this is also how transport cost

[1] The generalised transport costs here are the direct monetary costs of transporting goods plus the influence of other qualitative characteristics of the modes (transport time, reliability, etc.) expressed in money units.

works in the passenger transport model. If one assumes negative coefficient signs for the cost variables, one can also write + G_{ik} in eq. (2), as we will do below.

More specifically, for the choice of mode for a specific shipment by decision-maker k, between three alternatives (road, rail and inland waterways IWW), one might specify the following linear[2] utility functions:[3]

$$U_{road} = \beta_0 + \beta_1 \,.\, COST_{road} + \beta_2 \,.\, TIME_{road} + \beta_3 \,.\, REL_{road} + e_{road} \quad (3a)$$

$$U_{rail} = \beta_4 + \beta_1 \,.\, COST_{rail} + \beta_5 \,.\, TIME_{rail} + \beta_6 \,.\, REL_{rail} + e_{rail} \quad (3b)$$

$$U_{IWW} = \beta_1 \,.\, COST_{IWW} + \beta_7 \,.\, TIME_{IWW} + \beta_8 \,.\, REL_{IWW} + e_{IWW} \quad (3c)$$

In which:

$COST_i$: transport cost of mode i; this could include both the distance-dependent costs $f_i \,.\, DIST_i$ (such as fuel costs), where f is the transport cost per km and DIST the distance in km, and the time-dependent cost $g_i \,.TIME_i$ (such as transport staff and vehicle cost), where g is the costs per hour;

TIME: transport time of mode i in hours;

REL_i: transport time reliability of mode i; this could be measured as the standard deviation of transport time or as the percentage of shipments delivered on time;

$\beta_0, \beta_1, \ldots, \beta_8$: coefficients to be estimated; we expect negative signs for $\beta_1, \ldots \beta_3$ and $\beta_5, \ldots \beta_8$, the sign for β_0 and β_4 can be positive or negative.

In equations (3a) – (3c), the utility that would be obtained when choosing road transport depends on the transport cost and time for that shipment by road transport and its reliability, and likewise for the other two modes. The values for COST, TIME and REL by mode, may come from skimming networks for these modes, but also might be provided by the decision-makers themselves (often they find this hard for non-chosen modes, and there could be perception errors) or have been postulated in a 'what if' fashion by the researcher in a stated preference survey.

The βs are coefficients for which numerical values are determined by estimating the model on data for various decision-makers and corresponding individual shipments (which may vary in terms of origins and destinations, leading to variation in distance and time within modes but over shipments). β_0 and β_4 are so-called 'alternative-specific constants', ASCs. There can only be N-1 ASCs in a model, N being the number of available choice alternatives, because in a utility maximisation model only differences in observed utility matter. In the example above, we have excluded an ASC for the inland waterways alternative, which means that for this alternative, the constant is normalised to 0. For the same reason, we can only include attributes as explanatory variables that differ between alternatives. Attributes of the decision-maker (e.g. the size of the firm) or of the shipment (e.g. containerised or not) can only be included by interacting these variables with characteristics of the modes (for instance by making certain firms less cost-sensitive or including containerisation only for rail, expressing that container transports are more likely to be transported by rail).

Coefficients can be generic, such as β_1 for cost above, or alternative-specific, such as the other coefficients in equations (3a) – (3c). Which is best is largely an empirical matter, which means that various forms should be tested and compared against each other. In the above model specification we have used generic coefficients for costs (but not for the other variables), which has the additional

[2] Non-linear specifications of the utility function, such as functions with logarithmic or quadratic attributes, translog costs functions (e.g. Oum, 1989) or Box-Cox transformations (e.g. Picard and Gaudry, 1998), are also possible.

[3] Strictly speaking there is also a 'scale' parameter, which reflects the variance of the random component of utility and is used for normalising the model. It is called 'scale' parameter, because it scales the β parameters in (3a) – (3c); a higher random variance leads to lower estimated β's.

advantage that one unit of money paid for road transport has the same value as one unit of money paid for rail or inland waterways transport ('a euro is a euro' or 'a pound is a pound')

The decision on mode choice by decision-maker k could be influenced by other variables than the three attributes included above. For instance, the flexibility of a mode, the service frequency and the probability of damage to the goods might also play a role. But the researcher that is constructing the mode choice model may not have any data on these influencing variables, or only data measured with some error. This is a key reason[4] for including the error components e_{road}, e_{rail} and e_{IWW} to the utility functions: they represent variables that affect the utility of the decision-maker but are not observed by the researcher (or observed only with measurement errors).

In order to deal with the error components, the researcher assumes these are random variables (with a mean of zero and some variance). By making different specific assumptions on the probability distribution of the error components, different discrete choice models can be derived. These models are probability models, because they do not generate a certain choice, but probabilities for each of the available alternatives.

In the linear cost function specification of the discrete choice model in equations (3), the road freight VTT is the ratio β_2/β_1, which does not depend on any other variable or coefficient. This cost function specification does not lead to any lessons on influences that would determine how the road freight VTT evolves over time; this model has a fixed real road freight over time. This does not say that the freight VTT in real terms will not change over time: a new estimation in a later year might lead to another VTT. This is studied in the analysis of repeat studies, section 3 of this report.

In the UK road freight VTT study (Arup et al., 2023), the specification of the choice model is somewhat more complex, since it adopted the random valuation model specification with multiplicative error terms for both shippers and carriers and for carriers used mixed logit models using a lognormal density. But without further interaction variables, the mean VTT from these models also is a fixed value. The key model for the final VTT values used is the carrier OGV model. This has no interaction terms (no influence of other characteristics of the trip and the firm). Therefore, the mean VTT that is used from this model is also fixed and offers no lessons for an uprating pattern over time. We conclude that the theory behind the models used to determine the road freight VTT (discrete choice models, based on random cost minimisation) does not offer clues to how the freight VTT might change over time.

2.3 Transport and inventory logistics

It might be that extending the scope of the model to include inventory decisions (especially shipment size choice) together with transport choices can lead to clues on how to uprate the freight VTT, especially the cargo component of the freight VTT. This behaviour is relevant for the sender and/or receiver of the goods, who also decides on the size of the batches (shipment size) that are transported in a single shipment.

The starting point for this analysis is a transport-inventory trade-off model (de Jong and Ben-Akiva, 2007) based on the classic paper of Baumol and Vinod (1970). The total logistics costs G are given by:

$$G = O + T + Y + I \qquad (4)$$

Where:

G: total annual logistics costs;

O: order costs;

[4] There are other reasons in the discrete choice literature for including the error terms.

T: transport costs;

Y: capital cost of goods during transit (also including deterioration of the goods);

I: inventory costs (storage costs) and capital costs of inventory.

Eq. (4) can be further worked out to:

$$G = o \,.\, (Q/q) + T + i.j.g.v.Q + (i.t.v.Q) + w.(q/2) + i.v.(q/2) \qquad (5)$$

Where:

o : the constant unit cost per order;

Q: the annual demand (tonnes per year between two firms);

q : the average shipment size;

i: interest rate per unit of the good per year;

j: the decrease in the value of the goods (in money per tonne-hour);

v: the value of the goods that are transported (in money per tonne);

t: the average transport time (in hours);

w: the storage costs (in NOK per tonne per year).

The transport cost component of the freight VTT (which works through T) has already been discussed in the sections above. Now the cargo freight VTT (per year) can be calculated as the derivative of G (excluding T) with respect to transport time t (here in years):

$$\text{Cargo FVTT} = i.v.Q \qquad (6)$$

The cargo component of the freight VTT in this simple model depends on the (implied) interest rate i, the value of the goods per tonne v and the annual amount of goods transported Q. A dependence on the value of the goods per tonne (value density) also appears in Blauwens and van de Voorde (1988). They derived the following cargo freight VTT from their modal split model in freight:

$$\text{Cargo FVTT} = a_2.v/a_1 \qquad (7)$$

Where:

a_2: the time coefficient of the model;

a_1: the cost coefficient of the model;

v: the value of the good in money units per tonne.

Roberts (1981) defined a slightly different total logistics cost function than equations (4) and (5) and from this the cargo freight VTT can be obtained as follows (again by taking the partial first derivative of this function with respect to transport time; here time is in hours):

$$\text{Cargo FVTT} = (i.v.Q)/(24*365) + (dem.aes)/24 + (ddet.(v/q).shelf.Q)/(24*365) \qquad (8)$$

Where:

dem: dummy for emergency shipping;

aes: special cost (pay day) of emergency shipment;

ddet: dummy for perishable goods;

shelf: special cost for perishable goods due to loss of shelf life.

Again, the interest rate and the value per tonne appear in the cargo freight VTT, now together with terms for emergency shipments and loss of shelf life for perishable goods.

The above simple model of equations (4) – (6) can be extended to include safety stocks, which are kept as a safeguard against running out of stock. In this case, the equation for the cargo component of the freight VTT gets a second component that depends on storage cost w, the probability of running out of stock, the order cost and the transport volume.

Baumol and Vinod (1970) also showed that the freight VTT does not depend on the revenue part of the profit function of the firm, but only on the total logistics cost part.

The standard economic order quantity model yields an optimum shipment size that does not depend on transport cost. This happens because unit transport costs in this model are not differentiated between modes or vehicle type. As soon as one allows for economies of scale in transport cost from moving to modes or vehicle types with a larger capacity, transport cost also enter the equation for the optimal shipment size.

Minken and Johanson (2019) include in their logistics cost function a vehicle costs (per hour) that depends on vehicle size. Other transport cost components are wage cost (per hour) and distance cost (per km). The vehicle cost per hour and the wage cost per hour then also become part of the freight VTT, together with capital and deterioration cost on the inventory in transit (which we already had in the equations above, that again depend on the value of the goods and a perceived interest rate). So, the freight VTT from this model includes both the time-dependent transport cost (wages and vehicle cost) and the interest cost on the capital invested in the goods and their deterioration during transit (as the cargo component).

2.4 Conclusions from the different theoretical backgrounds

Within the freight VTT, a transport cost component (carrier component) and a cargo component (shipper component) can be distinguished. When transport time in freight is reduced, carriers can save on vehicle-related costs (e.g. depreciation), overheads and wage costs of the drivers. In road transport in the long run in competitive markets, it makes sense to consider that these time gains will lead to a full reduction of these transport cost items. This provides an indication that for road freight transport, the transport cost component of the VTT increases with the same rate as the time-dependent freight costs (wage costs, vehicle cost, overheads). This standpoint would imply an uprating of this component of the road freight VTT on the basis of the real cost changes in each of these transport cost sub-components.

The cargo component of the freight VTT has to do with interest on the capital invested in the goods in transit, deterioration of the goods, disruptions of the production process, running out of stock and missed opportunities to optimise depot structure and inventory size.

Discrete choice theory (also when formulated as random cost minimisation) does not lead to any lessons on influences that would determine how the road freight VTT evolves over time; the standard model has a fixed real road freight over time.

Specific formulations of the transport-inventory trade-off theory leads to models in which the cargo VTT is equal to the interest cost on the capital invested in the goods that are in transit, plus terms for deterioration of the goods during transport and loss of shelf life. A theoretical model that also includes transport costs as a determinant of optimal shipment size, has a freight VTT that consists of the vehicle cost per hour and the staff cost per hour (together the transport cost component) and interest and deterioration cost on the value of the goods in transit (together the cargo component).

What the above theoretical background/frameworks suggest for uprating the freight VTT is that the transport cost component of the VTT should be closely related to the expected growth of the transport costs of each of the components of the time-dependent transport costs: wage costs, vehicle costs and overhead costs of the carriers (more detailed distinctions are also possible, depending on data availability). The expected future growth can be based on existing forecasts (e.g. for wages) and on regressions on observed time-series data for these different cost components which are then applied to project into the future. The cargo component of the freight VTT can be expected to grow at the same rate as the interest of the capital invested in the goods in transit. This depends on interest rates (which are likely to grow in line with inflation, not with real GDP) and the value of the goods (which are likely to grow at about the same the rate as real GDP).

In the current TAG approach these insights are used, but only for the wage costs. The approach that is most in line with the theory is using cost indices for several transport cost components. The second approach in section 1.2). The GDP/capita approach is not directly based on the above theory, but in practice it might be compatible with it.

3. Repeat freight VTT studies

3.1 Introduction

There are two countries that have used a similar SP survey and analysis for the freight VTT multiple times in the past decades: Norway and The Netherlands. Significance (staff) participated in all Dutch national freight VTT studies (1990, 2004, 2012 and 2023) and in the most recent Norwegian national freight VTT study (2019). We also have access to the outcomes of the earlier Norwegian national freight VTT study (2010). By comparing these outcomes over time and relating these to income (GDP or GDP per capita) development over the same period, the relation between freight VTT and income will be analysed. In this analysis, we will focus on freight transport by road (The Dutch and Norwegian freight VTT studies looked at several modes, including road transport). This approach was also used for passenger transport VTT in Börjesson et al. (2023). All GDP and GDP per capita figures in this chapter come from the World Bank and currency exchange rates from HMRC.

3.2 Norway

The Norwegian VTT study of 2010 reported a goods component of 0.64 2015 GBP per tonne-hour (reported in the original study as 0.75 euro per tonne-hour). The 2019 Norwegian study reported a goods component of 1.02 2015 GBP per tonne-hour. This implies an increase of 59% between the two studies. Because the later study did not estimate a directly comparable transport component, the comparison here is restricted to the goods component.

Over the same period, real GDP in Norway increased by 14% and real GDP per capita by 5% (Table 2). On that basis, the implied elasticity of the freight VTT (cargo component) is very high: about 4.22 with respect to GDP and 12.02 with respect to GDP per capita.

Table 2: Norway repeat study elasticity

	2010	2018
VTT (goods component) in GBP of 2015	0.64	1.02
Real GDP (billions GBP of 2015)	234.03	266.73
Real GDP per capita (GBP of 2015)	47,866	50,213
Increase VTT	59%	
Increase real GDP	14%	
Increase real GDP per capita	5%	
Elasticity w.r.t. GDP	4.22	
Elasticity w.r.t. GDP per capita	12.02	

3.3 The Netherlands

The Netherlands has conducted four national freight VTT studies: 1990, 2004, 2012 and 2023. However, the resulting values are not all directly comparable. The 2012 study used a different method from the earlier studies, and the 2023 values were derived through uprating rather than from a new survey. For that reason, the only directly comparable observations used here are those from 1990 and 2004.

The Dutch VTT study of 1990 reported a total VTT (transport and goods components together) of 35.52 2023 GBP per tonne-hour. The 2004 study reported a comparable value of 37.51 2023 GBP per tonne-hour. This represents an increase of about 6% between the two studies.

Table 3: The Netherlands repeat study elasticity

	1990	2003
VTT (all components) in GBP of 2023	35.52	37.51
Real GDP (billions GBP of 2023)	320.65	437.17
Real GDP per capita (GBP of 2023)	21,117	26,944
Increase VTT	6%	
Increase real GDP	36%	
Increase real GDP per capita	28%	
Elasticity w.r.t. GDP	0.15	
Elasticity w.r.t. GDP per capita	0.20	

3.4 Conclusions

The implied elasticities from the repeat-study comparisons are shown below:

Table 4: Repeat studies elasticities

Country	Elasticity real GDP	Elasticity real GDP per capita
Norway	4.22	12.02
The Netherlands	0.15	0.20

The implied elasticities vary widely across the two country comparisons. The analysis for Norway suggests a very high elasticity, whereas that for the Netherlands suggests a low elasticity. We have to keep in mind that the results for Norway refer to the cargo component only (a small part of the total) and those for the Netherlands to the transport cost and cargo component together. It might be that the cargo component grows faster with increasing GDP than the total freight VTT, but we have only one observation for each. Given the large spread that we find and given the limited number of comparable repeated studies, we do not consider that we can provide a reliable estimate on how the VTT evolves from repeat studies. We have to look at other sources, such as the meta-regression in chapter 7.

4. Historical freight cost indices

4.1 Introduction

In the original request for tender through the panel, DfT included a file with historical data on freight cost. This data file was provided to us upon the start of the project[5]. We then analysed how the freight cost indices have developed over time and also related this to the development of GDP over time. The relation between transport cost components and the freight VTT was discussed in chapter 2 of this report, where it was concluded that for road transport an equivalence between the time-dependent transport costs (driver wages, vehicle cost, overheads of the carriers) and the transport cost component of the freight VTT can be expected on theoretical grounds.

Historical data on freight cost indices were provided by the DfT at the start of the project. In this chapter 4, we focus on the freight VTT and therefore on the time-dependent transport costs. The analysis of the distance-dependent costs is not presented in this report. For each of the sub-components of the time-based costs, a time-series analysis was performed to understand how their nominal and real (GDP deflator adjusted) values progressed through the years with the observed period being from 2012 to 2024. The progression of these values was also compared with the progression of the real GDP per capita for the UK for the same period. The time-series for the real GDP per capita were accessed from the World Bank and was rebased for 2022, i.e. the year of analysis and are presented in Figure 3.

According to that, the GDP showed a steady increase of 1.5% every year until 2019, when it was significantly impacted by Covid19 decreasing by 10.6% in a single year in 2020. In the following two years it recovered with an increase of 9.3% and 4.7% for 2021 and 2022, respectively, while in the last two years of 2023 and 2024 it showed signs of stagnation.

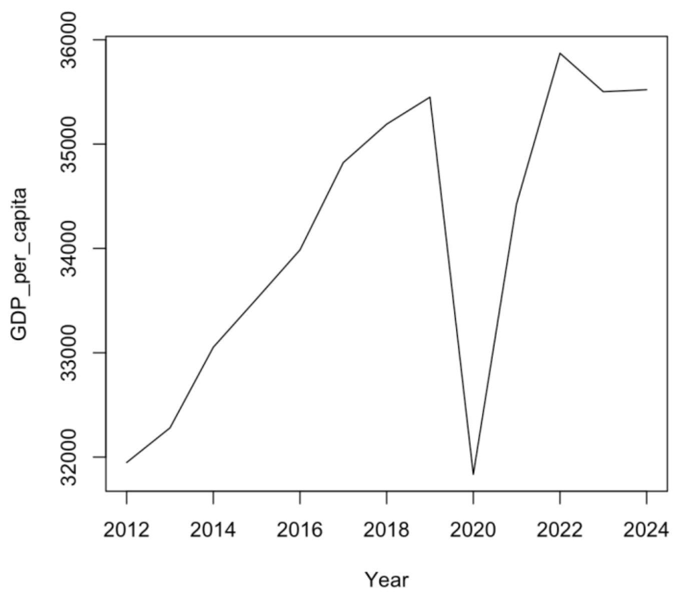

Figure 3: Historical real GDP per capita 2012-2024

[5] The source is: https://motortransport.co.uk/cost-tables.

4.2 Development of vehicle time-related costs

For the time-related costs, the following components have been provided for LGV and HGV from 2012 to 2024:

- Driver wages and National Insurance
- Vehicle insurance
- Establishment/overheads
- Vehicle tax
- Depreciation
- Finance cost (5-year term)

4.2.1 LGV wages and National Insurance

Historical real LGV wages were almost stable for 2012-2017 followed by an increase for years 2018-2019 of 2.5% on average per year. During Covid19, wages decreased by –7.8%, but they quickly recovered and surpassed the previous values in the next two years until 2022 (average increase of 11.3% per year). After that point, wages have continued to increase with a smaller rate of around 1%.

A log-log regression was also performed for the LGV wages (and for the remaining cost indices) against the GDP per capita in order to capture the strength of association between the two variables. The results from these regressions should not be treated as an exact forecast of future LGV wages as a result of GDP per capita increase due to the limited observed years of data used for this analysis. In that case, the log-log regression of LGV wages across all years 2012-2024 against GDP per capita for the same years was able to capture a GDP elasticity of 1.4 (not statistically different fro 1.0) indicating that 1% increase of GDP is associated with a 1.4% increase in the wages of LGV drivers.

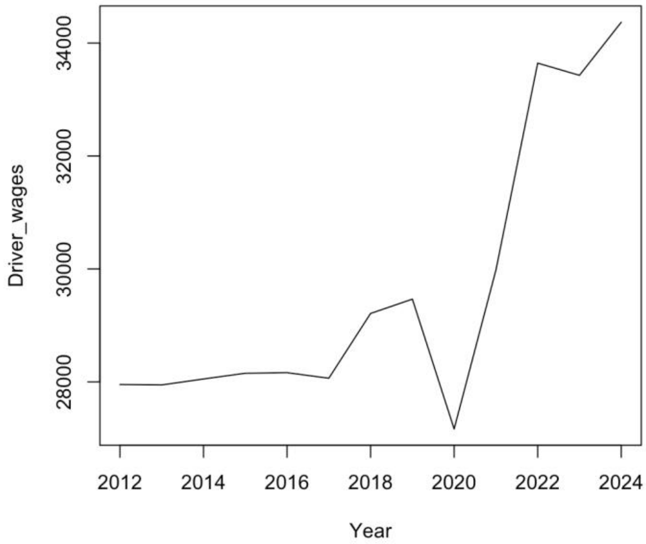

Figure 4: Historical real LGV wages 2012-2024

In the case of wages, a comparison was also performed against the wage increase for All Sectors for the same period of 2012-2024. The wage increases for All Sectors was obtained from the DfT report on [The Value of Road Freight Travel Time]() (Table 12), which were originally accessed from the Office for Budget Responsibility (OBR). These are presented in the following Table 5 and compared against the LGV real wage increase. According to that comparison, the LGV wages increase at a similar rate with the All Sector wages for years before Covid19 (average ratio of LGV / All Sector increase is 1.0). For years beyond

2020, however, the LGV wages increase at a higher rate (average ratio of LGV / All Sector increase is 1.03).

Table 5: Comparison between All Sector and LGV wages growth per year

Year	All Sector wages increase p.a.	LGV wages increase p.a.	LGV wages / All Sector wages
2012	-	-	-
2013	1.0274	1.0000	0.97
2014	0.9937	1.0038	1.01
2015	1.0130	1.0036	0.99
2016	1.0009	1.0004	1.0
2017	1.0158	0.9965	0.98
2018	1.0048	1.0409	1.04
2019	0.9980	1.0087	1.01
2020	0.9517	0.9220	0.97
2021	1.0649	1.1035	1.04
2022	0.9942	1.1223	1.13
2023	1.0095	0.9936	0.98
2024	1.0056	1.0281	1.02
2012-2019	1.0076	1.0076	1.00
2020-2024	1.0052	1.0339	1.03
2012-2024	1.0066	1.0186	1.01

4.2.2 LGV Vehicle insurance

Historical real LGV vehicle insurance costs were almost stable for 2012-2019 followed by a sudden drop of –6.6% in 2020 during Covid19. After Covid19, insurance costs showed an exponential growth of 12.6% on average per year with no observed signs of stabilising in the observed years.

A log-log regression of LGV vehicle insurance across all observed years against GDP per capita for the purpose of capturing association between the two variables was able to capture a GDP elasticity of 1.4 (not statistically different than 1.0) meaning that 1% increase of GDP is associated with a 1.4% increase in the vehicle insurance costs for LGVs, similar to LGV wages and National Insurance. Limiting the regression only to years before 2020, however, the association was weaker resulting in a GDP elasticity of 0.13.

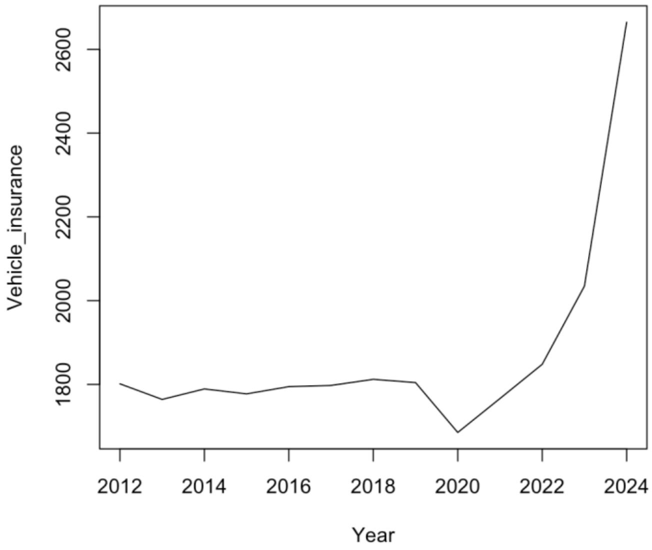

Figure 5: Historical real LGV vehicle insurance costs 2012-2024

4.2.3 LGV establishment/overheads

Historical real LGV establishment and overhead costs increase until 2014 at 2% on average and then they stayed almost stable until 2019. An abrupt decrease in 2020 of –6.6% was followed by an almost equal increase until 2023 of 7.1% on average. In the last two years of 2023 and 2024, there was an overall decreasing trend of -1.2% on average.

A log-log regression of LGV establishment and overhead costs across all years against GDP per capita captured a GDP elasticity of 0.5 meaning that 1% increase of GDP is associated with a 0.5% increase in the establishment/overhead costs capturing a weak association between the two variables.

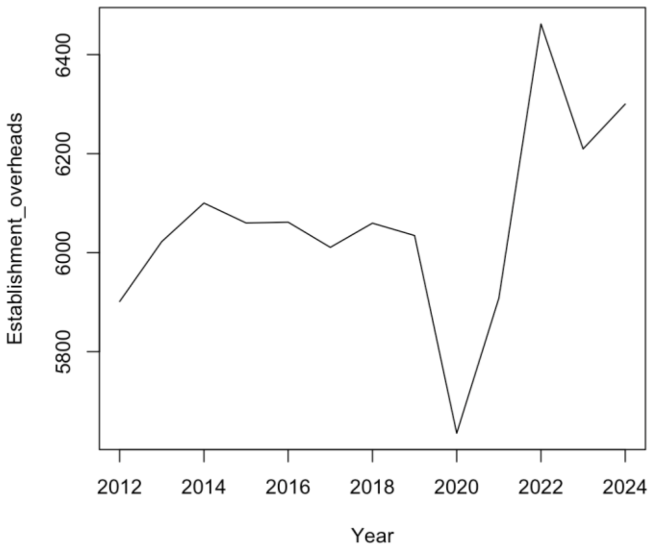

Figure 6: Historical real LGV establishment/overhead costs 2012-2024

4.2.4 LGV Vehicle tax

Historical real LGV vehicle tax costs were stable until 2015 followed by a significant drop of -40% in 2016. After that year there is a continuing decreasing trend until 2024 of –2.9% on average per year.

A log-log regression of LGV vehicle tax costs across all years against GDP per capita captured a strong association between the two variables with a GDP elasticity of –4.4 meaning that 1% increase of GDP is associated with a 4.4% decrease in the vehicle tax costs.

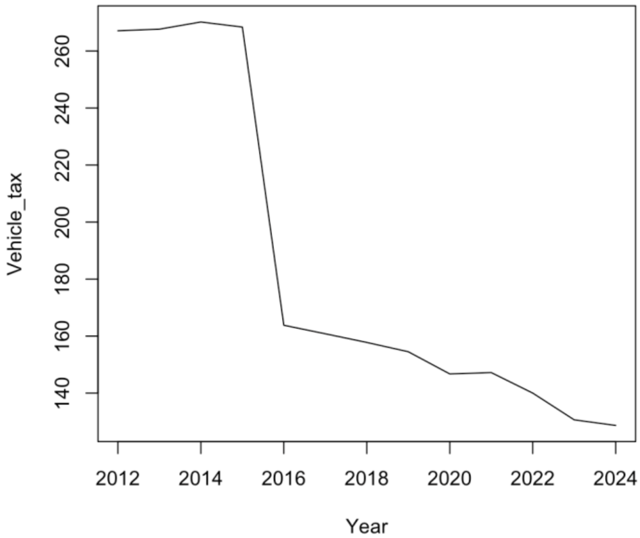

Figure 7: Historical real LGV vehicle tax costs 2012-2024

4.2.5 LGV Depreciation

Historical real LGV depreciation costs show an overall increasing trend during the observed period. More specifically, after an initial average decrease of -3% until 2014, depreciation costs showed a steady increase of 3.4% on average until 2019. During Covid19 there was a decrease of -6.6% followed by s significant average increase 9.1% until 2024.

A log-log regression of LGV depreciation costs across all years against GDP per capita captured a strong association with a GDP elasticity of 2.9 meaning that 1% increase of GDP is associated with a 2.9% increase in the depreciation costs.

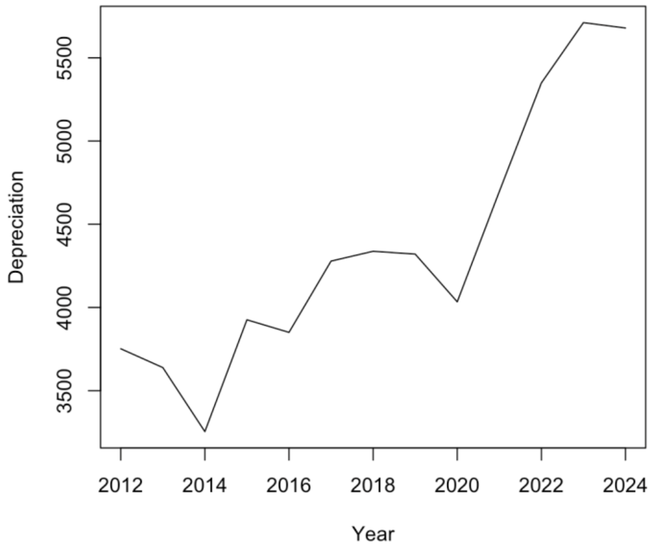

Figure 8: Historical real LGV depreciation costs 2012-2024

4.2.6 LGV finance costs

Historical real LGV finance costs show an overall increasing trend during the observed period, but with significant fluctuations. Years 2012-2014 showed an initial decreasing trend -8.2% per year, which was followed by a sudden increase of 62.8% in 2015. That was again followed by a decreasing trend of –5.4% per year until 2021. In 2022 there was another sudden increase in costs of 66.5% and in the last two years there were some small fluctuations –5.6% and 4% for 2023 and 2024, respectively.

A log-log regression of LGV finance costs across all years against GDP per capita captured a strong association with a GDP elasticity of 3.0 meaning that 1% increase of GDP is associated with a 3.0% increase in the finance costs.

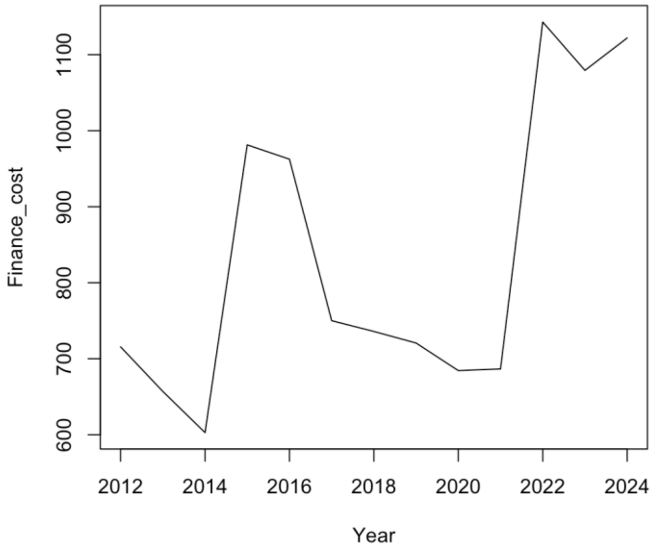

Figure 9: Historical real LGV finance costs 2012-2024

A summary table of the growth of the time-related costs for LGV and the GDP per capita are presented in Table 6 along with the average growth factors for 2012-2019, 2020-2024 and the entire period of 2012-2024.

Table 6: Summary table of real growth per year for the LGV time-related costs and the GDP per capita

Year	GDP per capita increase p.a.	Driver wages and NI growth p.a.	Vehicle insurance growth p.a.	Establishment/overheads growth p.a.	Vehicle tax growth p.a.	Depreciation costs growth p.a.	Finance costs growth p.a.
2012	-	-	-	-	-	-	-
2013	1.0108	0.9997	0.9793	1.0205	1.0021	0.9699	0.9181
2014	1.0267	1.0038	1.0142	1.0129	1.0094	0.8493	0.9175
2015	1.0141	1.0036	0.9934	0.9934	0.9934	1.2064	1.6280
2016	1.0117	1.0004	1.0097	1.0003	0.6102	0.9808	0.9808
2017	1.0214	0.9965	1.0016	0.9916	0.9818	1.1112	0.7793
2018	1.0110	1.0409	1.0081	1.0081	0.9811	1.0138	0.9811
2019	1.0108	1.0087	0.9957	0.9959	0.9793	0.9961	0.9793
2020	0.8941	0.9920	0.9340	0.9338	0.9496	0.9336	0.9496

Year	GDP per capita increase p.a.	Driver wages and NI growth p.a.	Vehicle insurance growth p.a.	Establishment/overheads growth p.a.	Vehicle tax growth p.a.	Depreciation costs growth p.a.	Finance costs growth p.a.
2021	1.0927	1.1035	1.0481	1.0484	1.0032	1.1643	1.0032
2022	1.0472	1.1223	1.0462	1.0938	0.9511	1.1389	1.6648
2023	0.9819	0.9936	1.1010	0.9609	0.9329	1.0677	0.9444
2024	1.0212	1.0281	1.3097	1.0416	0.9850	0.9943	1.0395
2012-2019	1.0152	1.0076	1.0003	0.9989	0.9368	1.0246	1.0263
2020-2024	1.0074	1.0339	1.0878	1.0103	0.9644	1.0598	1.1203
2012-2024	1.0120	1.0186	1.0368	1.0062	0.9483	1.0393	1.0655

In the relatively stable period 2012-2019, real LGV driver wages grew not as fast as real GDP per capita; real vehicle insurance, establishment/overheads and vehicle tax hardly grew at all or went down, whereas real depreciation and finance costs increased more than GDP per capita. In the volatile years 2020-2024, real LGV driver wages grew considerably faster than real GDP per capita, as did real vehicle insurance, depreciation and finance costs. Real establishment/overhead costs grew a bit faster than real GDP/capita in the period 2020-2024 and real vehicle tax went down.

4.2.7 HGV wages and National Insurance

Historical real HGV wages showed a clearer increasing trend of 1.2% on average for years 2012-2017 compared to LGV wages which were almost stable during the same period. They showed a decrease of -5% in 2020 during Covid19 which was followed by a significant increase of 7.4% for years beyond 2020.

Similar to the LGV cost indices, log-log regressions between each HGV cost index and GDP per capita have been estimated in order to capture the strength of association between the two variables. In that case, the log-log regression of HGV wages across all years against GDP per capita captured a strong association with a GDP elasticity of 2.0 meaning that 1% increase of GDP will likely lead to a 2% increase in the wages of HGV drivers. However, if we limit the regression to years before 2020, we get a weaker - but still statistically significant- association with a GDP elasticity of 0.79 (not significantly different from 1.0).

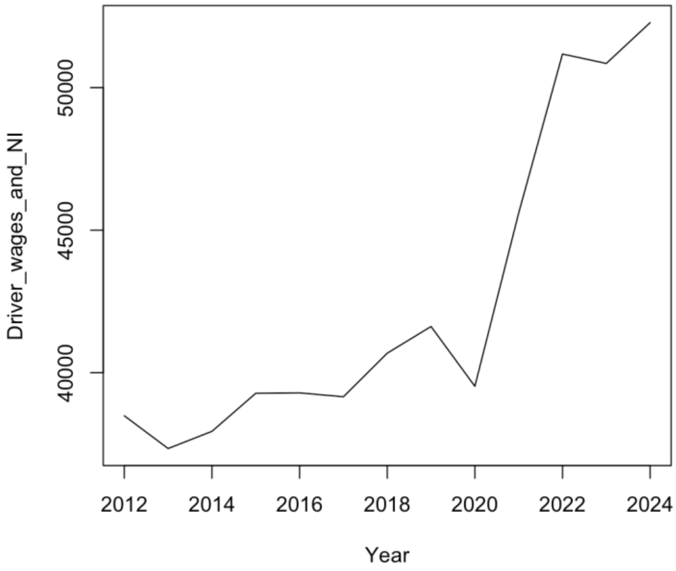

Figure 10: Historical real HGV wages 2012-2024

Similar to the LGV wages, a comparison was also performed against the wage growth for All Sectors for the observed period, which is presented in Table 7. According to that comparison, the HGV wages increase at a similar rate with the All Sector wages for years before Covid19 (average ratio of LGV / All Sector increase is 1.0). For years beyond 2020, however, the HGV wages increase at a higher rate (average ratio of LGV / All Sector increase is 1.04). This finding is almost the same as what is reported for LGV wages in a previous paragraph.

Table 7: Comparison between All Sector and LGV wages growth per year

Year	All Sector wages growth p.a.	HGV wages growth p.a.	HGV wages / All Sector wages
2012	-	-	-
2013	1.0274	0.9702	0.94
2014	0.9937	1.0161	1.02
2015	1.0130	1.0352	1.02
2016	1.0009	1.0004	1.0
2017	1.0158	0.9965	0.98
2018	1.0048	1.0390	1.03
2019	0.9980	1.0230	1.03
2020	0.9517	0.9496	1.0
2021	1.0649	1.1537	1.08
2022	0.9942	1.1223	1.13
2023	1.0095	0.9936	0.98
2024	1.0056	1.0281	1.02

Year	All Sector wages growth p.a.	HGV wages growth p.a.	HGV wages / All Sector wages
2012-2019	1.0076	1.0115	1.00
2020-2024	1.0052	1.0495	1.04
2012-2024	1.0066	1.0273	1.02

4.2.8 HGV Vehicle insurance

Historical real HGV vehicle insurance costs showed some fluctuations for years 2012-2019 – similar to LGV insurance costs – with the exception of a 4.9% drop in 2014. In 2020, there was a similar drop, which was followed by an increase of 4.7% on average until 2022. Finally, in 2024 a significant increase of 31% was observed.

A log-log regression of HGV vehicle insurance costs across all years against GDP per capita captured an association between the two variables with a GDP elasticity of 0.9 (not statistically different than 1.0). meaning that 1% increase of GDP will likely lead to a 0.9% increase in the insurance costs of HGVs.

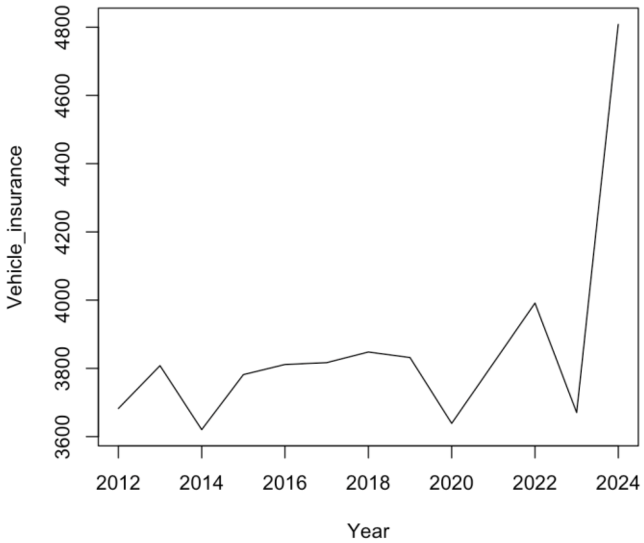

Figure 21: Historical real HGV vehicle insurance costs 2012-2024

4.2.9 HGV establishment/overheads

Historical real HGV establishment and overhead costs showed a stable trend until 2019 besides an 8.8% drop in 2013 and a 13.3% increase the next year. During Convid19 there was another decrease of 5%, which was again followed by a recovery of 3.9% increase on average until 2022. That was again followed by a significant drop of 10.2% in 2023.

A log-log regression of HGV establishment and overhead costs across all years against GDP per capita captured an association with a GDP elasticity of 0.7 meaning that 1% increase of GDP will likely lead to a 0.7% increase in the establishment/overhead costs.

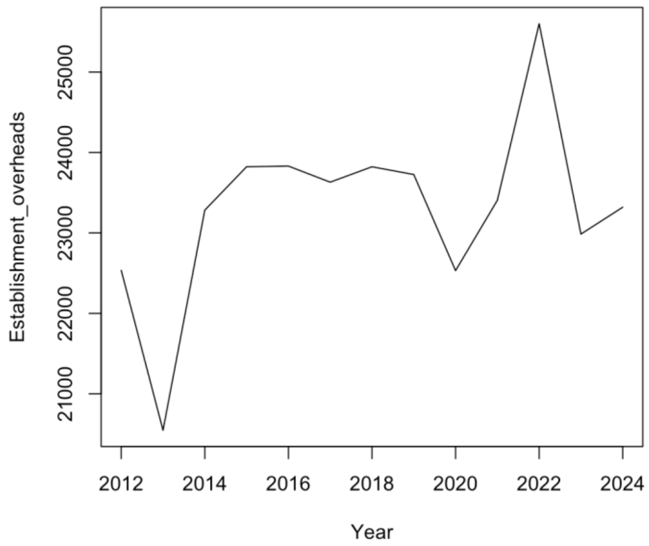

Figure 12: Historical real HGV establishment/overhead costs 2012-2024

4.2.10 HGV Vehicle tax

Historical real HGV vehicle tax costs show a similar trend as the LGV tax costs with values not recovering after Covid19 to the same levels as before 2020. In the case of HGVs there was a significant increase in 2021, but the values started decreasing again each year after that point at 6.3% on average.

A log-log regression of HGV vehicle tax costs across all years against GDP per capita failed to capture any statistically significant GDP elasticity indicating that there is no significant association between the two variables across the observed years at least.

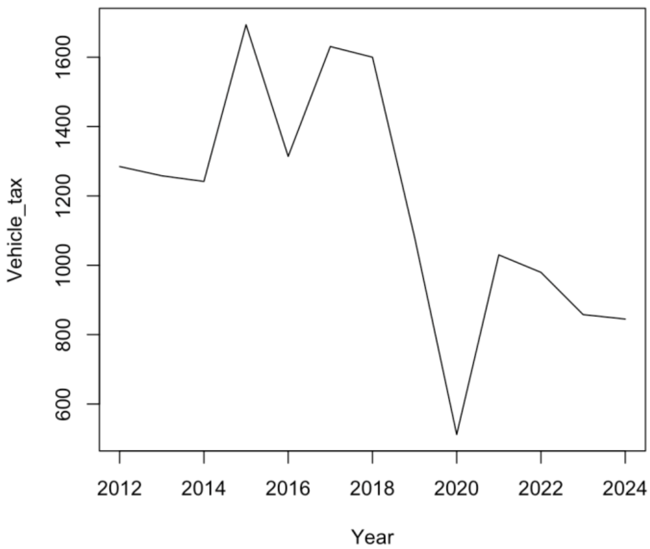

Figure 33: Historical real HGV vehicle tax costs 2012-2024

4.2.11 HGV Depreciation

Historical real HGV depreciation costs show significant fluctuations and an overall decreasing trend until 2020 of around –1.0%. On average, which is followed by a significant increasing trend after that point of around 5.3% on average.

A log-log regression of HGV depreciation costs across all years against GDP per capita captured an association with a GDP elasticity of 0.8 (not statistically different than 1.0 given the standard error of the estimate) meaning that 1% increase of GDP will likely lead to a 0.8% increase in the depreciation costs.

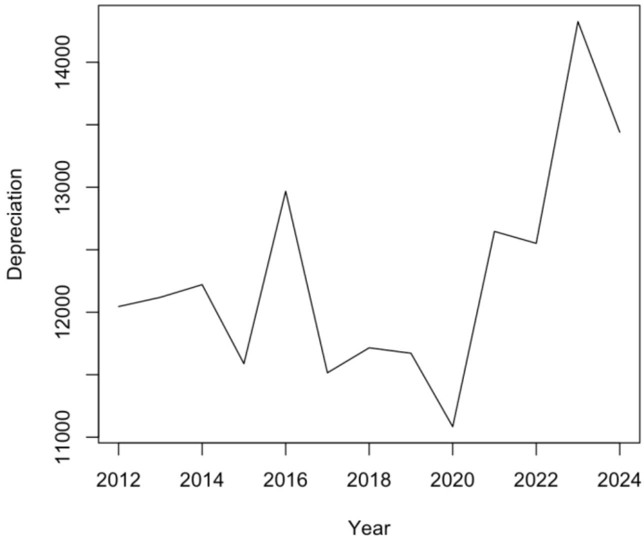

Figure 44: Historical real HGV depreciation costs 2012-2024

4.2.12 HGV finance costs

Historical real HGV finance costs show an overall increasing trend of 6.6% until 2018 followed by a slightly decreasing trend of −1.8% until 2021. There is a significant increase in 2021 of 66.5%, which is again followed by a decrease of −10.1% on average for the next two years.

A log-log regression of HGV finance costs across all years against GDP per capita captured a strong association between the two variables with a GDP elasticity of 4.8 meaning that 1% increase of GDP will likely lead to a 4.8% increase in the finance costs of HGVs.

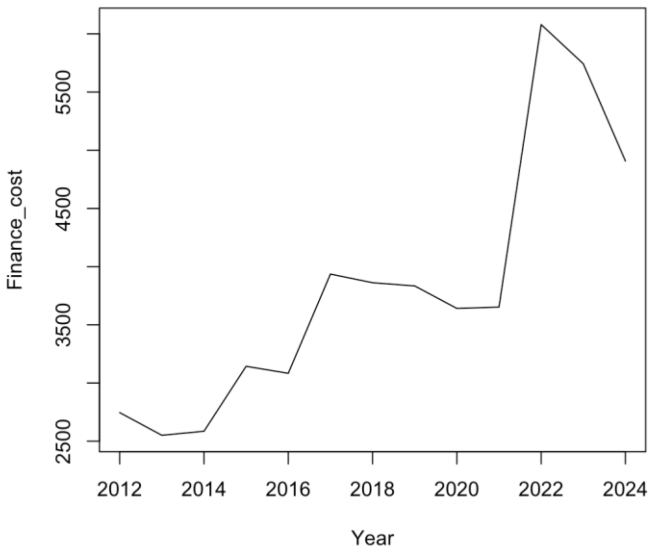

Figure 55: Historical real HGV finance costs 2012-2024

A summary table of the growth of the time-related costs for HGV and the GDP per capita are presented in Table 8. The growth is presented per year as well as average growths the entire period of 2012-2024 and separately for 2012-2019 and 2020-2024 due to the generally different growth trends before and after Covid19.

Table 8: Summary table of growth per year for the HGV time-related costs and the GDP per capita

Year	GDP per capita increase p.a.	Driver wages and NI growth p.a.	Vehicle insurance growth p.a.	Establishment/overheads growth p.a.	Vehicle tax growth p.a.	Depreciation costs growth p.a.	Finance costs growth p.a.
2012	-	-	-	-	-	-	-
2013	1.0108	0.9702	1.0341	0.9118	0.9793	1.0061	0.9290
2014	1.0267	1.0161	0.9507	1.1332	0.9870	1.0084	1.0136
2015	1.0141	1.0352	1.0445	1.0232	1.3639	0.9482	1.2159
2016	1.0117	1.0004	1.0079	1.0003	0.7758	1.1190	0.9808
2017	1.0214	0.9965	1.0014	0.9916	1.2411	0.8880	1.2766
2018	1.0110	1.0390	1.0081	1.0081	0.9811	1.0174	0.9811
2019	1.0108	1.0230	0.9958	0.9960	0.6757	0.9963	0.9928
2020	0.8941	0.9496	0.9496	0.9496	0.4736	0.9496	0.9496
2021	1.0927	1.1537	1.0484	1.0388	2.0118	1.1410	1.0032
2022	1.0472	1.1223	1.0463	1.0938	0.9511	0.9925	1.6645
2023	0.9819	0.9936	0.9196	0.8978	0.8758	1.1413	0.9446
2024	1.0212	1.0281	1.3099	1.0145	0.9850	0.9383	0.8544
2012-2019	1.0152	1.0115	1.0061	1.0092	1.0006	0.9976	1.0557
2020-2024	1.0074	1.0495	1.0548	0.9989	1.0594	1.0325	1.0833
2012-2024	1.0120	1.0273	1.0264	1.0049	1.0251	1.0122	1.0672

In the relatively stable period 2012-2019, real HGV driver wages grew not quite as fast as real GDP per capita; real vehicle insurance and establishment/overheads, vehicle tax and depreciation cost grew slower than the real wages or went down, whereas real finance costs increased more than GDP per capita. In the volatile years 2020-2024, real HGV driver wages grew a lot faster than real GDP per capita, as did real vehicle insurance, vehicle tax, depreciation and finance costs. Real establishment/overhead went down in the period 2020-2024.

4.3 Forecasted values for time-related costs

For the time-related costs, forecasted values were calculated separately for LGV and HGV until 2071. From the previous analysis of historical cost indices, it was clear that there are significant differences in the trends observed before and after 2020, the year where Covid19 started and Brexit was also implemented. Because of that we decided to use only years before 2020 in order to estimate a linear trend from the historic costs between 2012-2019. The decision of using only the period 2012-2019 was further segmented by the fact that, if we took into consideration the entire observed period, we would end up with unrealistic values for LGV and HGV wages in future years beyond 2050, which would be a direct result of picking the volatile trends during 2020-2024 in the regression. Note that any future scenarios where HGVs are autonomous have not been considered as there is no consensus on what that scenario would look like and it was considered out of scope.

We believe that these trends are not likely to continue and that the more stable trends observed during 2012-2019 are more likely to prevail long term. That of course limits our ability to capture any potential future disruptions, which would be possible if we had several decades of observed data for the cost indices. The provided data, however, of 2012-2024 includes two major disruptions for the UK which are very recent meaning that we are still in a period of recovering.

A regression approach was followed for forecasting the cost indices to future years. The forecasting was performed by centering the regression on the starting year of 2012 as cost_j – cost_2012 = b1 * (year_j – 2012) with j=2012, ...2019 and b1 a parameter to be estimated capturing the slope of the linear trend. Following that, we applied the same trend on years from 2024 and beyond until 2071 centering the application of the regression in 2024, therefore matching the forecasted value with the observed one for that year. We have decided to capture a linear trend as that is the simplest assumption given the limited number of years. Furthermore, for 2012-2019 we were not able to observe any other type of trend, such as a geometric one.

4.3.1 LGV forecasted time-related costs

In the following figures 16-21, the estimated trend based on the observed data from 2012-2019 is depicted (green line) together with the projected trend from 2024 to 2071 (red line). For the six time-related cost indices presented in the following, the linear trend was easily captured for years 2012-2019 with the exception of vehicle tax, where we had to use only years 2012-2015 to avoid including the significant drop during 2016 in the linear regression.

In Table 9, the estimated b1 parameter for each cost indicator is presented together with the associated standard errors of the estimated parameters and their respective mean projected growth rate from 2024 to 2071. Besides vehicle insurance costs, the remaining indices show a positive growth in the forecasting period with all of them being below 1% of increase per year on average.

Finally in Table 10, the forecasted values until 2071 per cost indicator are presented. These values (similarly for the other forecasted cost indices) are the result of the regression models previously described, where each estimated value is also accompanied by a standard error. Therefore, these values should not be viewed as exact forecasts, but rather as values with an associated confidence interval around them.

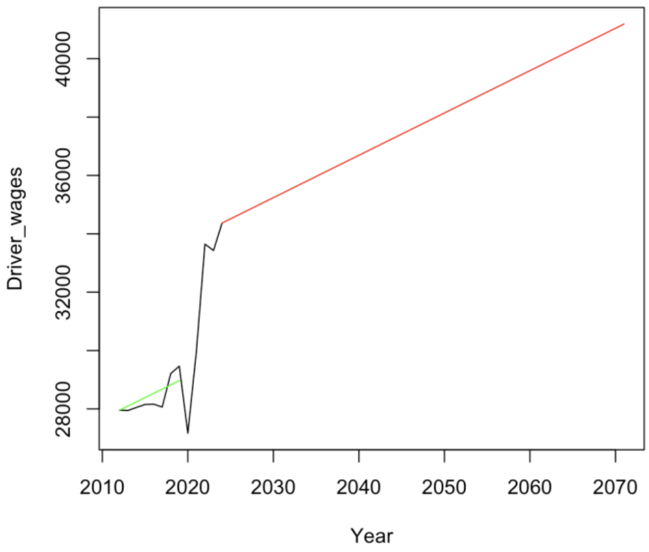

Figure 16: Forecasted real LGV wages 2024-2071

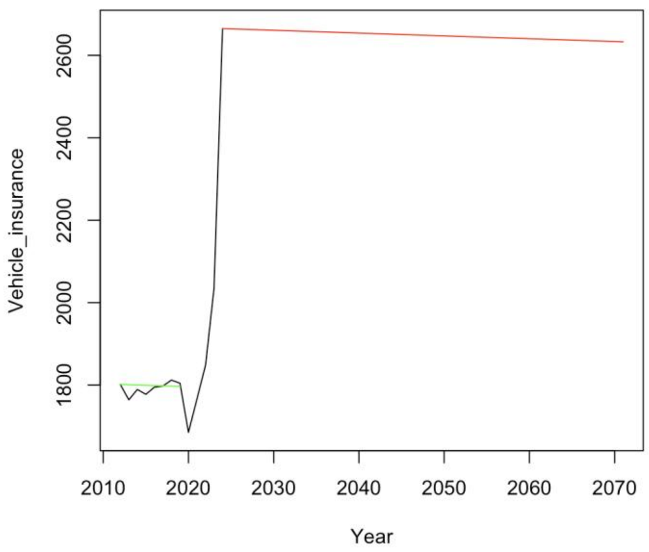

Figure17: Forecasted real LGV insurance costs 2024-2071

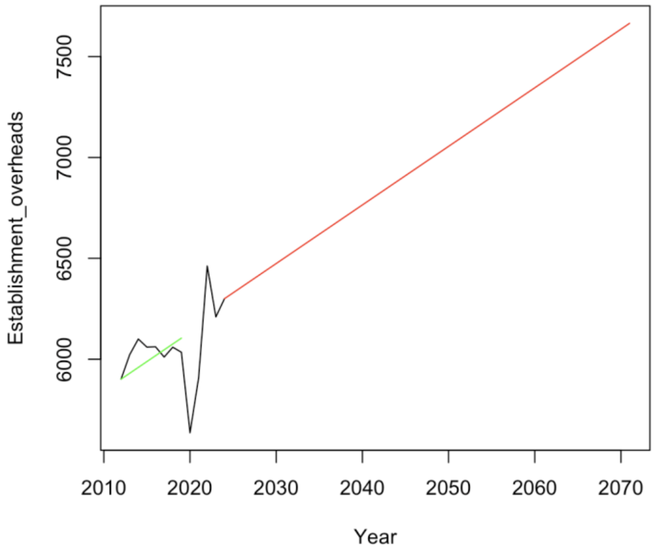

Figure18: Forecasted real LGV establishment/overhead costs 2024-2071

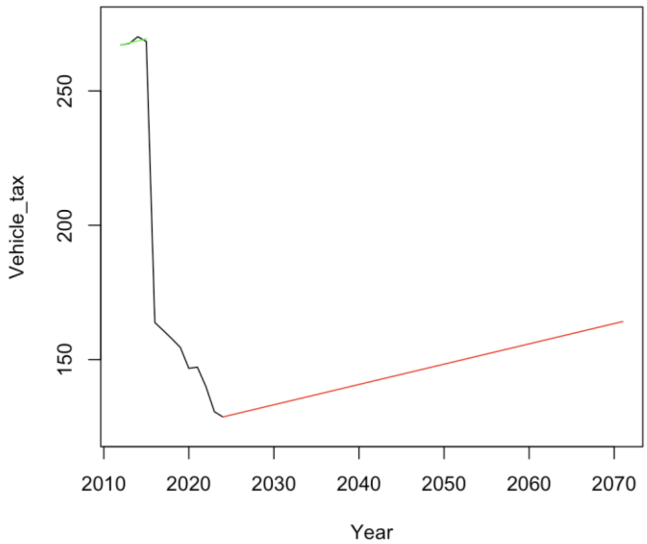

Figure 19: Forecasted real LGV vehicle tax 2024-2071

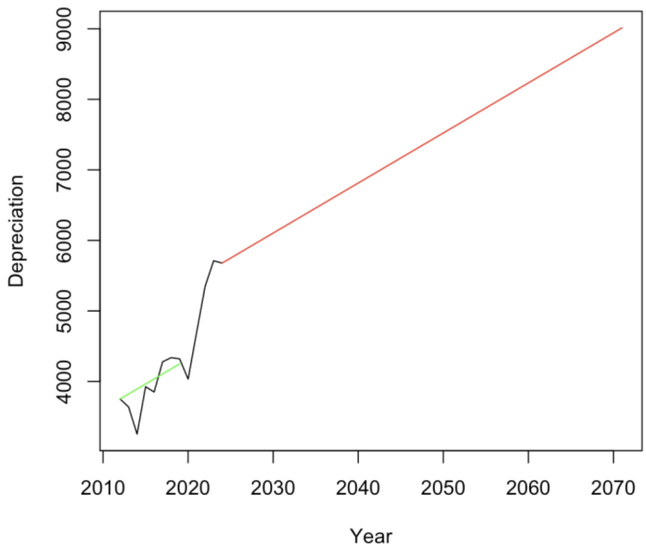

Figure 20: Forecasted real LGV depreciation costs 2024-2071

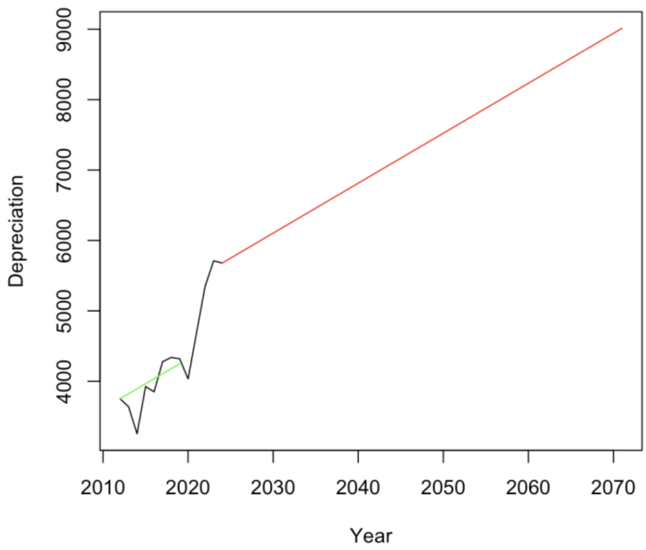

Figure 21: Forecasted real LGV finance costs 2024-2071

Table 9: Estimated parameters, standard errors and mean growth rate per LGV time-related cost index

Cost index	Estimated parameter b1 (standard error in brackets)	Mean growth rate
Driver wages and NI	145.1 (32.38)	1.0039
Vehicle Insurance	-0.6811 (1.511)	0.9997
Establishment/overheads	29.04 (6.531)	1.0042
Vehicle tax	0.7555 (0.2857)	1.0052
Depreciation	70.96 (23.46)	1.0099
Finance cost	13.07 (11.31)	1.0093

Table 10: Estimated LGV time-related cost indices from 2024 to 2071

Year	Driver wages and NI	Vehicle insurance	Establishment/overheads	Vehicle tax	Depreciation costs	Finance costs
2024	34,368.4	2,664.9	6,300.1	128.6	5,678.9	1,122
2025	34,513.5	2,664.2	6,329.1	129.4	5749.9	1,135.1
2026	34,658.5	2,663.5	6,358.2	130.2	5,820.8	1,148.1
2027	34,803.6	2,662.8	6,387.2	130.9	5,891.8	1,161.2
2028	34,948.6	2,662.1	6,416.2	131.7	5,962.7	1,174.3
2029	35,093.7	2,661.5	6,445.3	132.4	6,033.7	1,187.4
2030	35,238.7	2,660.8	6,474.3	133.2	6,104.6	1,200.4
2031	35,383.8	2,660.1	6,503.4	133.9	6,175.6	1,213.5
2032	35,528.9	2,659.4	6,532.4	134.7	6,246.6	1,226.6
2033	35,673.9	2,658.7	6,561.4	135.4	6,317.5	1,239.6
2034	35,819.0	2,658	6,590.5	136.2	6,388.5	1,252.7
2035	35,964.0	2,657.4	6,619.5	137	6,459.4	1,265.8
2036	36,109.1	2,656.7	6,648.5	137.7	6,530.4	1,278.8
2037	36,254.1	2,656	6,677.6	138.5	6,601.3	1,291.9
2038	36,399.2	2,655.3	6,706.6	139.2	6,672.3	1,305
2039	36,544.2	2,654.6	6,735.7	140	6,743.2	1,318.1
2040	36,689.3	2,654	6,764.7	140.7	6,814.2	1,331.1
2041	36,834.3	2,653.3	6,793.7	141.5	6,885.2	1,344.2
2042	36,979.4	2,652.6	6,822.8	142.2	6,956.1	1,357.3
2043	37,124.4	2,651.9	6,851.8	143	7,027.1	1,370.3
2044	37,269.5	2,651.2	6,880.8	143.8	7,098	1,383.4
2045	37,414.5	2,650.6	6,909.9	144.5	7,169	1,396.5
2046	37,559.6	2,649.9	6,938.9	145.3	7,239.9	1,409.5
2047	37,704.7	2,649.2	6,968	146	7,310.9	1,422.6
2048	37,849.7	2,648.5	6,997	146.8	7,381.9	1,435.7
2049	37,994.8	2,647.8	7,026	147.5	7,452.8	1,448.8
2050	38,139.8	2,647.2	7,055.1	148.3	7,523.8	1,461.8
2051	38,284.9	2,646.5	7,084.1	149	7,594.7	1,474.9
2052	38,429.9	2,645.8	7,113.1	149.8	7,665.7	1,488
2053	38,575.0	2,645.1	7,142.2	150.6	7,736.6	1,501
2054	38,720.0	2,644.4	7,171.2	151.3	7,807.6	1,514.1
2055	38,865.1	2,643.7	7,200.3	152.1	7,878.5	1,527.2

Year	Driver wages and NI	Vehicle insurance	Establishment/overheads	Vehicle tax	Depreciation costs	Finance costs
2056	39,010.1	2,643.1	7,229.3	152.8	7,949.5	1,540.3
2057	39,155.2	2,642.4	7,258.3	153.6	8,020.5	1,553.3
2058	39,300.2	2,641.7	7,287.4	154.3	8,091.4	1,566.4
2059	39,445.3	2,641	7,316.4	155.1	8,162.4	1,579.5
2060	39,590.3	2,640.3	7,345.4	155.8	8,233.3	1,592.5
2061	39,735.4	2,639.7	7,374.5	156.6	8,304.3	1,605.6
2062	39,880.5	2,639	7,403.5	157.4	8,375.2	1,618.7
2063	40,025.5	2,638.3	7,432.6	158.1	8,446.2	1,631.7
2064	40,170.6	2,637.6	7,461.6	158.9	8,517.1	1,644.8
2065	40,315.6	2,636.9	7,490.6	159.6	8,588.1	1,657.9
2066	40,460.7	2,636.3	7,519.7	160.4	8,659.1	1,671
2067	40,605.7	2,635.6	7,548.7	161.1	8,730	1,684
2068	40,750.8	2,634.9	7,577.7	161.9	8,801	1,697.1
2069	40,895.8	2,634.2	7,606.8	162.6	8,871.9	1,710.2
2070	41,040.9	2,633.5	7,635.8	163.4	8,942.9	1,723.2
2071	41,185.9	2,632.8	7,664.9	164.2	9,013.8	1,736.3

4.3.2 HGV forecasted time-related costs

A similar analysis was performed for HGVs and presented in the following figures 22-27. All of the estimated linear regressions were fitted on the observed data between 2012-2019. All of them captured a positive growth trend with the exception of depreciation costs, which are forecasted to be decreasing. Table 11 presents the estimated b1 parameters for each cost indicator, their associated standard errors and their respective mean growth rate until 2071. All of the forecasted costs per cost indicator are presented in Table 12.

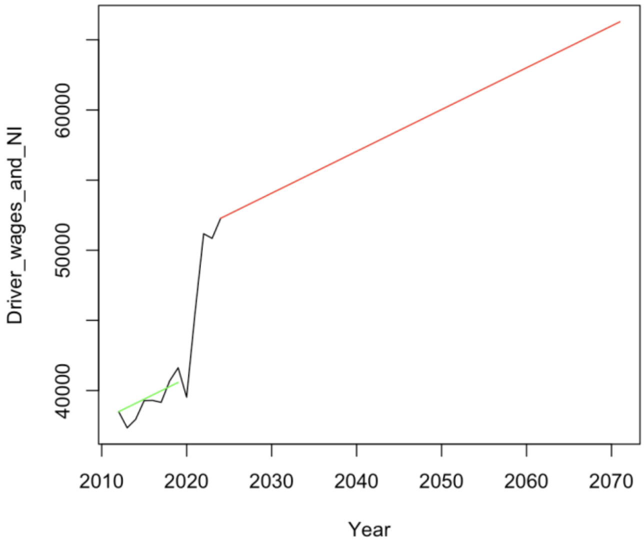

Figure 22: Forecasted real HGV wages 2024-2071

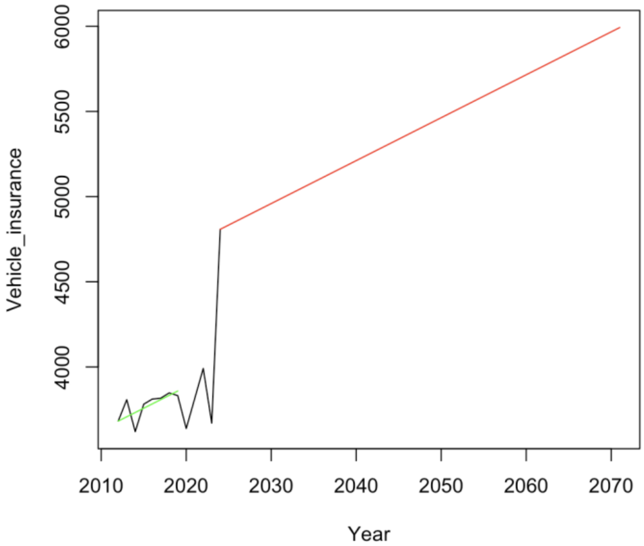

Figure 23: Forecasted real HGV insurance costs 2024-2071

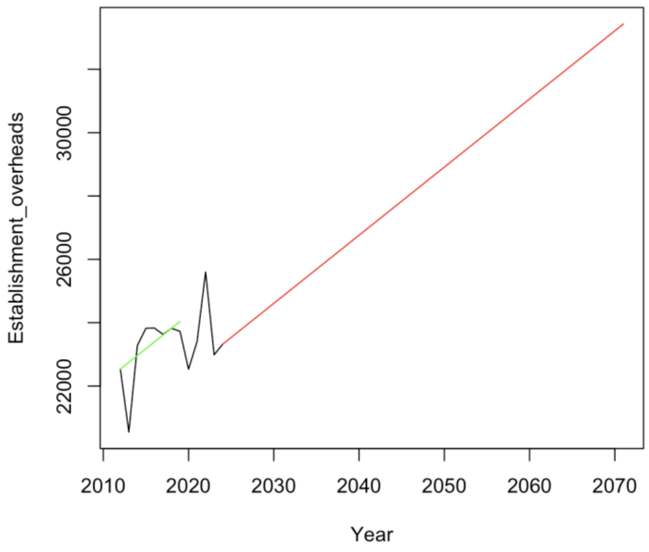

Figure 24: Forecasted real HGV establishment/overhead costs 2024-2071

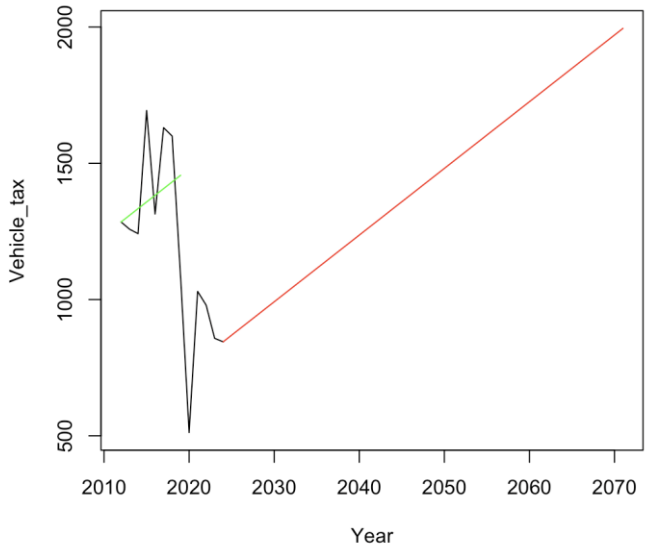

Figure 25: Forecasted real HGV vehicle tax costs 2024-2071

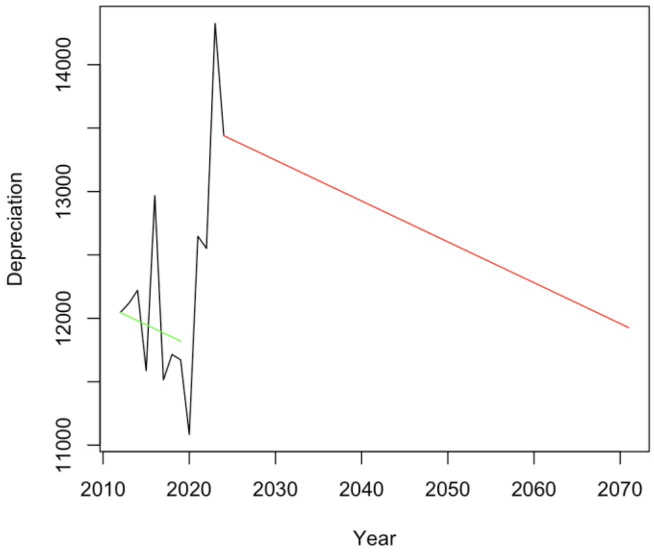

Figure 26 : Forecasted real HGV depreciation costs 2024-2071

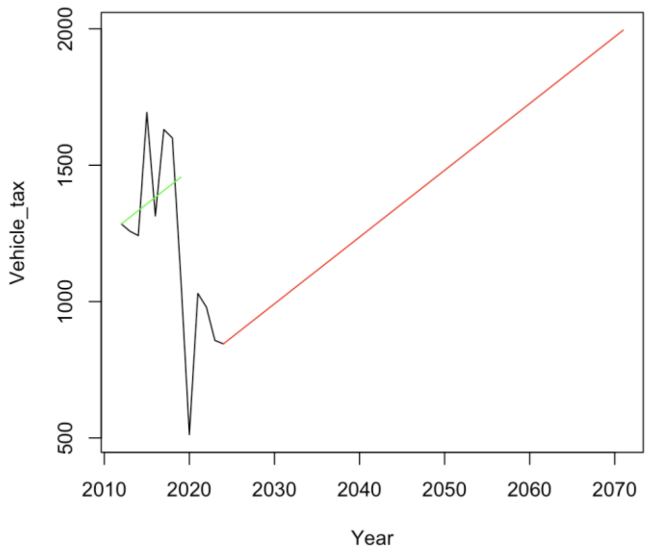

Figure 27: Forecasted real HGV finance costs 2024-2071

Table 11: Estimated parameters, standard errors and mean growth rate per HGV time-related cost index

Cost index	Estimated parameter b1 (standard error in brackets)	Mean growth rate
Driver wages and NI	298.1 (74.89)	1.0051
Vehicle Insurance	25.2 (5.058)	1.0047
Establishment/overheads	215.1 (75.99)	1.0077
Vehicle tax	24.47 (18.83)	1.0185
Depreciation	-32.21 (38.86)	0.9975
Finance cost	159.2 (25.41)	1.0199

Table 12: Estimated HGV time-related cost indices from 2024 to 2071

Year	Driver wages and NI	Vehicle insurance	Establishment/overheads	Vehicle tax	Depreciation costs	Finance costs
2024	52,278	4,808.1	23,319.7	845	13,440.4	4,907.2
2025	52,576.1	4,833.3	23,534.9	869.4	13,408.2	5,066.4
2026	52,874.3	4,858.5	23,750	893.9	13,376	5,225.6
2027	53,172.4	4,883.7	23,965.1	918.4	13,343.8	5,384.9
2028	53,470.5	4,908.9	24,180.2	942.9	13,311.5	5,544.1
2029	53,768.6	4,934.1	24,395.4	967.3	13,279.3	5,703.4
2030	54,066.7	4,959.3	24,610.5	991.8	13,247.1	5,862.6
2031	54,364.8	4,984.5	24,825.6	1,016.3	13,214.9	6,021.8
2032	54,662.9	5,009.7	25,040.7	1,040.7	13,182.7	6,181.1
2033	54,961	5,034.9	25,255.9	1,065.2	13,150.5	6,340.3
2034	55,259.1	5,060.1	25,471	1,089.7	13,118.3	6,499.6
2035	55,557.2	5,085.3	25,686.1	1,114.2	13,086.1	6,658.8
2036	55,855.4	5,110.5	25,901.2	1,138.6	13,053.9	6,818
2037	56,153.5	5,135.7	26,116.4	1,163.1	13,021.7	6,977.3
2038	56,451.6	5,160.9	26,331.5	1,187.6	12,989.5	7,136.5
2039	56,749.7	5,186.1	26,546.6	1,212.1	12,957.3	7,295.8
2040	57,047.8	5,211.3	26,761.7	1,236.5	12,925.1	7,455
2041	57,345.9	5,236.5	26,976.9	1,261	12,892.9	7,614.2
2042	57,644	5,261.7	27,192	1,285.5	12,860.7	7,773.5
2043	57,942.1	5,286.9	27,407.1	1,309.9	12,828.4	7,932.7
2044	58,240.2	5,312.1	27,622.3	1,334.4	12,796.2	8,091.9
2045	58,538.4	5,337.3	27,837.4	1,358.9	12,764	8,251.2
2046	58,836.5	5,362.5	28,052.5	1,383.4	12,731.8	8,410.4
2047	59,134.6	5,387.7	28,267.6	1,407.8	12,699.6	8,569.7
2048	59,432.7	5,412.9	28,482.8	1,432.3	12,667.4	8,728.9
2049	59,730.8	5,438.1	28,697.9	1,456.8	12,635.2	8,888.1
2050	60,028.9	5,463.3	28,913	1,481.3	12,603	9,047.4
2051	60,327	5,488.5	29,128.1	1,505.7	12,570.8	9,206.6
2052	60,625.1	5,513.7	29,343.3	1,530.2	12,538.6	9,365.9
2053	60,923.2	5,538.9	29,558.4	1,554.7	12,506.4	9,525.1
2054	61,221.4	5,564.1	29,773.5	1,579.1	12,474.2	9,684.3

Year	Driver wages and NI	Vehicle insurance	Establishment/overheads	Vehicle tax	Depreciation costs	Finance costs
2055	61,519.5	5,589.3	29,988.6	1,603.6	12,442	9,843.6
2056	61,817.6	5,614.5	30,203.8	1,628.1	12,409.8	10,002.8
2057	62,115.7	5,639.7	30,418.9	1,652.6	12,377.6	10,162
2058	62,413.8	5,664.9	30,634	1,677	12,345.3	10,321.3
2059	62,711.9	5,690	30,849.1	1,701.5	12,313.1	10,480.5
2060	63,010	5,715.2	31,064.3	1,726	12,280.9	10,639.8
2061	63,308.1	5,740.4	31,279.4	1,750.5	12,248.7	10,799
2062	63,606.2	5,765.6	31,494.5	1,774.9	12,216.5	10,958.2
2063	63,904.4	5,790.8	31,709.6	1,799.4	12,184.3	11,117.5
2064	64,202.5	5,816	31,924.8	1,823.9	12,152.1	11,276.7
2065	64,500.6	5,841.2	32,139.9	1,848.3	12,119.9	11,436
2066	64,798.7	5,866.4	32,355	1,872.8	12,087.7	11,595.2
2067	65,096.8	5,891.6	32,570.2	1,897.3	12,055.5	11,754.4
2068	65,394.9	5,916.8	32,785.3	1,921.8	12,023.3	11,913.7
2069	65,693	5,942	33,000.4	1,946.2	11,991.1	12,072.9
2070	65,991.1	5,967.2	33,215.5	1,970.7	11,958.9	12,232.2
2071	66,289.2	5,992.4	33,430.7	1,995.2	11,926.7	12,391.4

4.4 Conclusions

We analysed annual freight cost indices per sub-component of the time-dependent transport cost from Motor Transport provided to us by DfT for the period 2012-2024. In the relatively stable period 2012-2019, real LGV driver wages grew not as fast as real GDP per capita. On the other hand, real vehicle insurance, establishment/overheads and vehicle tax hardly grew at all or went down. Real depreciation and finance costs increased more than GDP per capita in this period. In the volatile period 2020-2024, real LGV driver wages grew considerably faster than real GDP per capita, as did real vehicle insurance. depreciation and finance costs. Real establishment/overhead costs grew a bit faster than real GDP/capita in the years 2020-2024 and real vehicle tax went down.

In the relatively stable period 2012-2019, real HGV driver wages grew not quite as fast as real GDP per capita. Real vehicle insurance and establishment/overheads, vehicle tax and depreciation cost grew slower than the real wages or went down, whereas real finance costs increased more than GDP per capita. In the volatile years 2020-2024, real HGV driver wages grew a lot faster than real GDP per capita, as did real vehicle insurance, vehicle tax, depreciation and finance costs. Real establishment/overhead went down in the period 2020-2024.

Linear regression functions were estimated for these time-dependent transport cost components on the data for the relatively stable period 2012-2019 and applied for the period 2024-2071. This gives future growth rates for these cost indices that are considerably smaller than for the growth of GDP per capita in the 2012-2019 period. In chapter 2 we have seen that on the basis of theory the growth of the time-related transport costs over time is likely to coincide with the growth of the transport cost component of the freight VTT.

5. Wider economy and CGE models

5.1 Overview of Computable General Equilibrium Model (CGE)

The main objective of this chapter is to assess, using existing CGE models and evidence, whether freight time savings generate proportionally larger wider economic welfare impacts over time within a Computable General Equilibrium (CGE) framework.

A CGE model is a large-scale numerical framework that simulates interactions between key economic agents households, firms, government, factors of production, and the rest of the world. It is calibrated using a comprehensive representation of the economy, typically a Social Accounting Matrix (SAM), constructed from input-output tables, national accounts, household survey data, trade statistics, and labour market data. The SAM provides a consistent snapshot of the economy in a base year and serves as the benchmark against which policy scenarios are assessed.

These data are linked through a system of equations grounded in general equilibrium theory, ensuring that supply and demand balance across goods, services, and factor markets. The framework captures how agents respond to changes in incentives, allowing the model to trace the economy-wide effects of policy interventions and external shocks over time.

Model parameters and behavioural relationships are informed by economic theory and empirical evidence, although some parameters remain subject to uncertainty where the literature does not provide clear consensus. Figure 28 provides an overview of the linkages between sectors and the different agents in the economy.

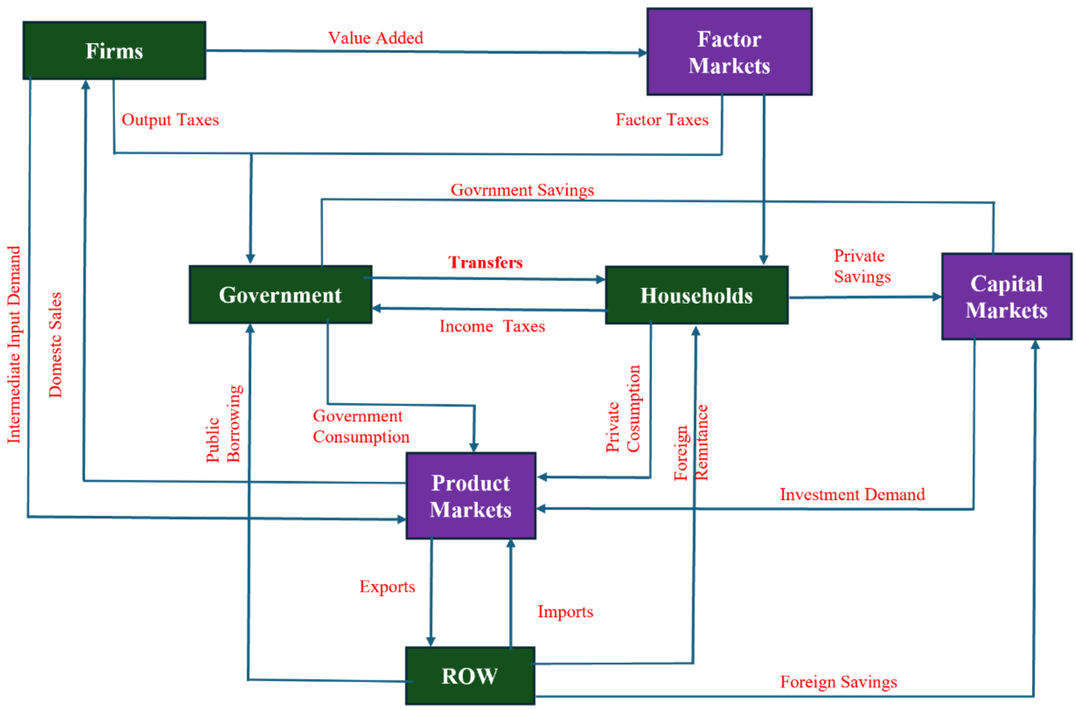

Figure 28: Structure of a CGE Model

In most cases, CGE models will capture how reductions in road freight travel time costs propagate through inter-sectoral supply chains and interactions between firms, households and government, allowing wider economic impacts to be assessed consistently across sectors and agents in general equilibrium. While CGE models robustly capture how reductions in freight travel time costs propagate through the wider economy via supply chains, prices, and factor markets, they do not directly model the reverse effect, i.e. how wider economic impacts feed back into the valuation of freight time savings themselves. Instead, any feedback captured in a CGE framework operates indirectly through changes in economic activity, sectoral composition, and demand for freight transport. This can increase the scale of freight movements and hence the aggregate benefits realised, but it does not alter the underlying unit valuation of time savings as defined in transport appraisal.

As such, CGE models are not used to inform recommendations on FVoT uprating, as they do not adjust or re-estimate time savings in a manner consistent with standard user benefit frameworks. However, they are considered to provide complementary insights into how changes in transport costs can affect wider economic outcomes such as GDP variation, trade patterns, consumption and productivity through endogenous responses within the economy.

5.2 UK CGE model and the production function structure

Within the UK academic and policy landscape, several CGE-type models have been developed for specific purposes. We focus on the HM Revenue & Custom (HMRC) CGE model developed in 2013, and on CGE-based trade modelling approaches used in the Department for Business and Trade. These two are appropriate because they jointly capture domestic general equilibrium mechanisms (HMRC) and trade-related transmission channels (DBT-type models), which are the two main pathways through which freight time savings affect the economy.

5.2.1 HMRC CGE model

HMRC's CGE model is a recursive dynamic, micro-founded representation of the UK economy linking households, firms, government and the foreign sector to assess economy-wide impacts of tax and fiscal policy changes. In practice, this means that the model simulates how each economic agent responds to changes in prices, incomes and policy incentives, while ensuring market clearing across goods, labour and capital markets in each period. The recursive dynamic structure allows the model to track the economy's adjustment path over time, with investment, capital accumulation and labour supply determining how shocks propagate beyond the initial period.

The model is built around a fully balanced SAM, which provides a complete accounting of flows between production sectors, households, government, investment and the rest of the world. The SAM ensures consistency between income, expenditure and production accounts, and serves as the calibration baseline for the model. By combining ONS National Accounts, survey data and HMRC administrative data, the SAM provides a detailed representation of the UK economy at a given point in time, from which counterfactual scenarios can be simulated.

Production in the model is represented through nested functional forms grounded in general equilibrium theory. Typically, firms combine intermediate inputs and value added using fixed-proportion (Leontief-type) structures at the top level, while allowing substitution between labour, capital and, in some implementations, different labour skill types through Constant Elasticity of Substitution (CES) functions. This structure enables firms to adjust their input mix in response to relative price changes, while also capturing rigidities in input use where substitution is limited. As a result, shocks such as changes in input costs or productivity can propagate through supply chains, affecting both production costs and output levels across sectors.

The model incorporates a foreign sector consistent with a small open economy framework. Imports and exports are modelled explicitly, allowing domestic production to respond to changes in relative prices between domestic and international goods. However, world prices are treated as exogenous, and the UK is assumed not to influence global market conditions. Trade therefore acts primarily as a transmission channel through which domestic cost changes affect competitiveness, export demand and import substitution, rather than as a source of endogenous global price adjustments.

While the model does not explicitly represent transport networks, spatial interactions or journey times, transport services are treated as standard production sectors within the SAM and production structure. Consequently, freight time savings cannot be modelled directly as reductions in generalised travel time or network performance. Instead, they must be introduced indirectly through equivalent economic shocks, most commonly:

- **Productivity shocks**, where reduced travel times increase the effective productivity of firms (e.g. through improved logistics efficiency or reduced delivery times); or
- **Cost-reduction shocks**, where transport inputs enter production functions at lower effective prices, reducing unit costs of production or trade margins.

These shocks then propagate through the model via input-output linkages, affecting production costs, prices, wages, consumption, investment and trade flows. Importantly, the model captures how these effects interact in general equilibrium for example, how lower costs increase demand and output, which in turn raises demand for labour and capital, potentially offsetting some initial cost advantages. However, the model does not re-estimate the underlying value of freight time savings itself. Rather, it translates these savings into economy-wide outcomes through the assumed productivity or cost channels embedded in the model structure.

5.2.2 DBT trade-focused CGE model

Global Trade Analysis Project (GTAP)-based CGE models used by the Department for Business and Trade (DBT) are designed to assess the long-run, economy-wide impacts of trade policy changes such as free trade agreements (FTAs), tariff reductions and non-tariff measure reforms. These models combine nested Constant Elasticity of Substitution (CES) production structures with an Armington trade specification, in which goods are differentiated by country of origin, and are solved under assumptions of profit-maximising firms, utility-maximising households and full market clearing under perfect competition. As a result, reductions in trade or transport costs lower effective input prices, improve allocative efficiency and increase output, trade flows and welfare.

The model is calibrated on the GTAP global database, which provides a fully consistent Social Accounting Matrix linking production, consumption, bilateral trade flows, tariffs, trade costs and factor endowments across countries and sectors. This database captures the full circular flow of income and expenditure in the global economy and ensures accounting consistency across all regions and markets.

Within this framework, transport is not modelled as an explicit network or infrastructure system. Instead, it is represented through international transport margins and transport services sectors that account for the costs of moving goods between countries (e.g. sea, air and other shipping services). These margins drive the difference between export (Free on Board, FOB) and import (Cost, Insurance and Freight, CIF) prices and are embedded within trade flows and production costs.

Consequently, transport enters the model as a component of trade and production costs, rather than through explicit representations of congestion, routing or journey time. Freight time savings, therefore, cannot be directly modelled as reductions in travel time, but must instead be introduced as reductions in trade costs or as productivity shocks that alter the effective price or efficiency of production and trade.

5.3 Freight time savings and the wider economic impact: How it works in theory

There is an extensive literature assessing the wider economic impacts of transport policy using a range of approaches, including Land Use-Transport Interaction (LUTI) models, Quantitative Spatial Models (QSM), and Computable General Equilibrium (CGE and SCGE) frameworks. This subsection therefore focuses on CGE-based approaches developed to evaluate the economy-wide effects of freight time savings.

Koike et al. (2021) develop a spatial computable general equilibrium (SCGE) model to quantify freight travel time savings (FTTS) and their wider economic impacts within a theoretically consistent general equilibrium framework. The model represents the economy across 8 regions and 21 industries, capturing interregional production, consumption, and trade linkages. Demand is specified using an Armington aggregation structure, such that composite consumption of good g in destination region r, denoted C_{gr}, is given by

$$C_{gr} = \left[\sum_{s} \delta_{(g,sr)} \, Z_{(g,sr)}^{\frac{\theta_g - 1}{\theta_g}}\right]^{\frac{\theta_g}{\theta_g - 1}} \tag{9}$$

where $Z_{(g,sr)}$ represents the delivered quantity of good g from origin region s to destination region r, inclusive of transport costs, θ_g is the elasticity of substitution across regional varieties, and $\delta_{(g,sr)}$ is the Armington share parameter. This specification implies that trade flows respond endogenously to relative delivered prices, allowing substitution between sources of supply as transport costs change.

Freight travel time enters the model through an iceberg transport cost formulation, whereby transport frictions increase the effective quantity of goods required to satisfy final demand:

$$Z_{(g,sr)} = M_{(g,sr)} \left(1 + \tau_{(g,sr)}\right) \tag{10}$$

$$\tau_{(g,sr)} = \lambda_g \cdot T_{sr} \tag{11}$$

Here, $M_{(g,sr)}$ denotes the physical shipment of goods (net of losses), T_{sr} is freight travel time between regions s and r, λ_g is a time-to-cost conversion parameter, and $\tau_{(g,sr)}$ captures the proportional increase in required shipments due to transport frictions. This formulation implies that longer travel times act as an implicit "tax" on trade, raising unit delivery costs and widening the gap between producer and consumer prices. Reductions in freight travel time therefore enter the model as decreases in $\tau_{(g,sr)}$, lowering effective trade costs and improving interregional connectivity.

Within the general equilibrium system, these cost reductions propagate through multiple transmission channels. At the micro level, lower delivered input costs reduce firms' unit costs, leading to adjustments in production, input demand, and trade patterns under cost-minimising behaviour. At the macro level, the model enforces market clearing across goods and factor markets, so that lower trade costs induce reallocations of labour and capital towards more productive sectors and regions. This generates changes in relative prices, wages, and returns to capital, thereby altering both production structure and income distribution.

Welfare effects are measured using standard CGE accounting, typically via equivalent variation (EV), which captures the monetary value of the change in household utility associated with a given reduction in freight travel time. In this framework, reductions in $\tau_{(g,sr)}$ increase real household income by lowering consumption prices and expanding the set of accessible goods (i.e. gains from trade). The welfare decomposition can be expressed as the sum of:

- Allocative efficiency gains, arising from improved resource allocation across sectors and regions;
- Terms-of-trade effects, reflecting changes in relative export and import prices;
- transport cost savings, captured through reductions in trade margins; and

- Market access effects, whereby lower trade costs increase effective demand and supply opportunities across regions.

These welfare gains are closely linked to changes in aggregate output (GDP) through both demand- and supply-side channels. On the supply side, reductions in transport costs act analogously to a productivity shock, increasing effective Total Factor Productivity (TFP) by lowering the composite price of intermediate inputs and enabling more efficient production. On the demand side, lower prices increase real consumption and trade volumes, expanding economic activity. As a result, GDP changes reflect a combination of increased factor utilisation, sectoral reallocation, and expanded trade flows.

Importantly, the model distinguishes between level effects (a one-off increase in GDP due to improved efficiency) and reallocation effects (shifts in production across regions and industries). While the iceberg formulation (equations 10 and 11) does not explicitly model transport infrastructure or congestion, it captures the essential mechanism through which freight travel time influences the economy namely, by altering trade costs and thereby affecting prices, production decisions, and welfare in equilibrium. Longer travel times increase $\tau_{(g,sr)}$, raising trade costs and reducing welfare, whereas reductions in travel time generate welfare gains that can be consistently decomposed and interpreted within the CGE accounting framework.

5.4 Selected Results on the Wider Economic Impacts of Freight Time Savings

This subsection presents key findings from the literature on the wider economic impacts of freight time savings, highlighting their magnitude and transmission channels.

Robson and Dixit (2017) demonstrate that reductions in freight travel time play a central role in transmitting transport improvements to the wider economy within an integrated network–general equilibrium framework. In their model, transport interventions affect freight costs through congestion and user-equilibrium traffic assignment, which determine travel times endogenously. Changes in freight travel time directly influence firms' production costs via freight margins embedded in intermediate inputs, thereby altering the cost structure across industries. As freight travel times decrease, effective transport costs fall, reducing unit production costs and improving the efficiency of interregional and intersectoral supply chains. This affects firms' output decisions and relative prices, leading to reallocations of production and trade flows across sectors and regions. At the same time, lower transport costs reduce the prices of goods faced by households, increasing real income and affecting consumption, labour supply, and leisure decisions.

These effects interact through general equilibrium feedbacks, whereby increased economic activity generates additional travel demand that feeds back into congestion and travel times, closing the system. The study reports annual welfare gains in the range of AU$118 million to AU$831 million, alongside increases in production (0.005%-0.060%), consumption (0.031%-0.251%), and leisure (0.007%-0.069%). These results are consistent with CGE modelling theory, where reductions in transport costs generate welfare gains-typically measured as equivalent variation through improvements in allocative efficiency, changes in relative prices, and the reallocation of resources across sectors and regions.

Robson and Dixit (2017) develop an integrated spatial computable general equilibrium (CGE) and transport network model to overcome the limitations of conventional appraisal frameworks that treat transport costs as exogenous and ignore economy-wide feedbacks. The objective is to provide a unified modelling framework in which transport network performance and economic activity are jointly determined, allowing transport interventions to affect household behaviour, firm production, and welfare within a consistent general equilibrium setting. The model is applied to the Sydney metropolitan area, disaggregated into 14 regions and two industries (a transport sector and a composite non-transport sector), with firms defined by region-industry pairs and households defined by residence-workplace combinations. The economic structure is calibrated using a multi-regional input-output framework (effectively a spatial social accounting matrix) constructed from IELab data, combined with transport and trip data to ensure consistency between economic flows and observed origin-destination travel patterns.

Methodologically, the model integrates a spatial CGE system with a traffic assignment model formulated as a nonlinear complementarity problem. Households maximise utility over consumption and leisure subject to both monetary and time constraints, where travel time enters explicitly through commuting, shopping, and leisure trips. Firms minimise costs subject to constant returns to scale technologies, using labour, capital, and intermediate goods sourced across regions. Crucially, freight is modelled explicitly via transport margins that are proportional to interregional travel times, rather than using an iceberg formulation. The transport model assigns trips according to user equilibrium with congestion (BPR functions), and resulting interregional travel times feed back into both household time costs and firms' sourcing decisions, closing the model system. Policy shocks are introduced by directly modifying network characteristics: (i) increasing link capacity by 50%, (ii) reducing free-flow travel times by 25% on key links, and (iii) adding new high-capacity express links.

The results show that these transport interventions generate significant welfare gains (equivalence variation), but of varying magnitude: approximately $118 million, $324 million, and $831 million per year across the three scenarios, respectively. These welfare impacts are accompanied by small but positive changes in production (up to +0.06%), consumption (up to +0.25%), and leisure, alongside reductions in overall travel time of up to 1.78%. However, the distribution of impacts is heterogeneous, with some regions experiencing welfare losses despite travel time savings, reflecting general equilibrium adjustments in wages, prices, and competitiveness.

The study by Avetisyan et al. (2014) examines the macroeconomic and trade impacts of reducing freight wait times at U.S. land border crossings, treating inspection delays as a non-tariff barrier to trade. The primary objective is to quantify how reductions in border wait times achieved through additional inspection staffing affect trade competitiveness, production costs, and macroeconomic outcomes across the U.S., Canada, and Mexico. A key motivation is the increasing importance of cross-border supply chains, where intermediate goods frequently cross borders multiple times, implying that reductions in transport delays can have amplified economy-wide effects beyond direct user benefits.

Methodologically, the analysis uses a multi-country CGE framework based on the GTAP model, calibrated to global trade flows and underpinned by a social accounting matrix. The model is aggregated to four regions (U.S., Canada, Mexico, Rest of World) and 57 commodity sectors, capturing intermediate and final goods linkages. Freight transport is modelled via trade margins ("transport services") bridging FOB and CIF prices and linked to bilateral trade flows.

The policy intervention adding one customs officer at each of the 12 major U.S. land freight crossings—increases inspection capacity during peak periods, reducing wait times (by approximately 38% to 100% depending on congestion). These reductions are estimated using a deterministic queueing model and translated into transport cost savings through a logistics cost model, yielding cost reductions of around -0.05% to -0.25% per crossing (approximately $11.67m annually). These changes are then introduced into the CGE model by exogenously reducing transport margins, representing a productivity improvement in transport services.

The macroeconomic results show small but positive impacts, consistent with the relatively modest magnitude of the transport cost shock. On average, adding one inspection officer per crossing increases U.S. GDP by about $0.25 million and generates approximately 2.55 additional jobs per crossing. Aggregated across all crossings, this corresponds to roughly $3.0 million in U.S. GDP gains and about 30 additional jobs, while Canada experiences larger gains (around $8.6 million), reflecting stronger trade linkages and greater responsiveness to cost reductions. At the individual crossing level, impacts are very small in percentage terms (e.g. U.S. GDP increases of the order of 0.000005% for a single crossing such as Blaine), but consistent in direction. Trade results show increases in both imports and exports, with imports typically rising more than exports, leading to slight trade balance deteriorations for the U.S. and Canada in some cases.

Freight time savings enter the model explicitly and play a central role in transmission mechanisms. Wait time reductions reduce border-related truck transport costs, which are a function of delay time through driver wages, fuel use, and vehicle operating costs. These cost reductions are then mapped into the CGE model as reductions in transport margins (trade costs), effectively lowering the delivered price of imports (CIF prices). Because a large share of imports consists of intermediate goods, lower import costs reduce production costs in the U.S., thereby increasing export competitiveness—a key general equilibrium feedback effect. This mechanism highlights that freight time savings primarily operate through supply chain cost reductions and improved competitiveness, rather than direct user benefits. However, the study also finds that part of the initial benefit accrues to trading partners (especially Canada), since reduced border costs directly enhance their export competitiveness into the U.S. market before second-round effects materialise.

Overall, the paper demonstrates that even relatively small reductions in freight delays can generate positive macroeconomic impacts through trade and production linkages, although the magnitude of these effects remains modest in aggregate terms. It also emphasises that the economic benefits of freight time savings are critically linked to the structure of cross-border supply chains and the role of intermediate goods in production.

5.5 Conclusions/main takeaway

CGE models are widely used to evaluate the impact of policy interventions on key macroeconomic indicators, including GDP, consumption, investment, welfare and trade. By modelling the interactions between sectors, households and firms, they provide a consistent framework for assessing how policy or economic shocks propagate across the whole economy.

These models are also applied in transport interventions, where they capture the economic effects of changes such as reductions in journey times, accessibility, investment and freight time reduction. In this context, CGE frameworks allow analysts to move beyond direct user benefits and assess how transport improvements influence productivity, market interactions and overall economic performance taking into consideration market failures. Evidence from both CGE and spatial CGE (SCGE) models shows that freight time savings generate positive impacts on the wider economy including welfare, GDP consumption, labour and investment. In particular, reductions in freight costs can improve supply chain efficiency, enhance competitiveness, and support increased economic activity across regions and sectors. This finding is aligned to the conclusions in a recent study by DfT on the wider economic impacts of road freight, although this study noted that some of these impacts may now be captured in the updated value of freight time in the most recent TAG update. However, given that SCBA usually distinguishes between direct effects (effects on the transport market) and indirect effects (effects on other markets), it would make more sense not to extend the scope of the freight VTT, but to include the above non-transport market effects (being indirect effects) in the separate category of the wider benefits.

Within CGE models, the monetary value of freight time savings typically enters the production function as an input affecting production and propagates to the wider economy. As such, general equilibrium frameworks are particularly well suited to capturing the spillover effects of freight time savings across the economy, rather than analysing the reverse relationship. However, complementary approaches including meta-analysis and econometric techniques such as time series models can be used to identify the determinants of freight time savings, allowing the effects of macroeconomic variables such as GDP, investment and consumption to be analysed.

6. What can we learn from uprating approaches used by other nations and international organisations?

6.1 Overview of this chapter

In this analysis we will include both countries (and periods) using a wage-based/CSA type approach, and especially those using SP with some consideration of wider values beyond factor costs (e.g. shipper values), such as Norway and The Netherlands. The question here is what have other countries used for uprating the (road) freight VTT.

We looked for material that describes how other countries and international organisations have dealt with uprating the freight VTT. Below, we discuss the European investment bank (EIB), the European Commission (EC), The Netherlands, JASPERS, France and Australia. We also looked at project appraisal frameworks of Denmark and Germany but could not find recommendations on uprating the freight VTT.

6.2 RAND Europe and CE Delft (2004) for EIB

Some countries/organisations use an escalation factor, based on real GDP per capita growth here (on top of the general price increase). For the values of travel time (passengers and freight) and safety that RAND Europe and CE Delft (2004) recommended for the European Investment Bank (EIB), a GDP per capita elasticity of the VTT of 1 should be used.

6.3 European Commission (HEATCO, 2006; CSIL, 2014)

The HEATCO (2006) project on Harmonised European Approaches for Transport Costing and Project Assessment for the European Commission recommended a GDP per capita elasticity of 0.7 here (HEATCO, 2006). This elasticity was based on research in passenger transport and then the same elasticity was used in passenger and freight transport for consistency. As an alternative for freight transport, HEATCO (2006) mentions that the escalating factor for freight transport could also be based on the growth in the time-dependent transport costs (which would be the dominant component of the freight VTT) over time.

CSIL (2014), in later guidance for the European Commission, recommends including driver wages, vehicle operating costs and a goods component in the SCBA. For uprating of all these components, GDP per capita is recommended, using an elasticity of 0.5 or 0.7.

6.4 The Netherlands (HCG et al., 1992; RAND Europe et al., 2004; Koopmans and de Jong, 2004; Significance, 2013, 2023)

In the first and second national value of time study for freight transport in The Netherlands (HCG et al., 1992; RAND Europe et al., 2004), the freight VTT was determined on the basis of a trade-off ratio between transport time and transport cost from a model in relative changes to a base level. The trade-off ratio for the value of transport time versus time-related transport costs, that comes directly from the SP models, in both studies turned out to be close to 1 for road transport.

In the subsequent third and fourth national VTT studies, different types of models were used for road transport, but since economists of the Netherlands Bureau for Economic Policy Analysis expect that in the medium to longer run the trade-off ratio for road transport will be equal to 1 or not be far below 1, the Netherlands decided to use the full time-related transport cost (plus the cargo component) as the basis for the road freight VTT, for all years after the opening of the project (Significance, 2013, 2023).

The uprating of the freight VTT in the Netherlands is described in Koopmans and de Jong (2004). The following is a translation from this guidance manual.

"It is evident that extra time taken up by transports, for example due to congestion, leads to extra labour costs.... In the longer term, the capital costs also depend on the duration of transports (for example, more trucks are needed if the duration of transports is longer). In principle, the change in all cost items must be included. However, in future scenarios, various cost items, such as depreciation and interest, tend to be almost constant in real terms (i.e. they roughly follow general inflation). However, this does not apply to wage costs. It is therefore reasonable to increase the valuation of travel time in proportion to the share of wage costs. Table 13 shows the development of labour costs in the transport sector in the most recent long-term scenarios[6] of the CPB (1997). The table shows that labour costs are rising faster than the general price level.

Table 13: Increase in wage cost in the transport sector in three scenarios (1995-2020)

Cost component/scenario	Divided Europe (DE)	European Coordination (EC)	Global Competition (GC)
		% per year	
Labour (wage cost per hour)	4.71	3.66	3.15
Price index (consumers)	3.34	1.95	1.39
Real wage cost	1.33	1.68	1.74

Source: Information from W. Groot (CPB)

The estimated share of labour costs for hauliers is shown per mode of transport in the first line of Table 14. It shows that labour costs have a high share of the total costs per hour of transport companies, especially in road transport. This share is lower for other modes of transport than road transport. However, there are still several uncertainties that may be investigated further[7]. For the time being, therefore, it is recommended to increase the travel time valuation for non-road transport by a quarter of the real increase in labour costs.

Table 14: Share of wage cost in the transport cost per hour

	Road	Rail	Inland waterways	Sea	Air
Calculated share of transporters	64%	10%	50%	26%	28%
Recommended share in total cost	50%	25%	25%	25%	25%

Source: Estimation on the basis of NEA, Factorkosten van het goederenvervoer: een analyse van de ontwikkeling in de tijd, Rijswijk, March 2003.

[6] See CPB, Economy and Physical Environment, Sdu., 1997; CPB, Environmental Scenarios Long-Term Exploration 1995-2020, Working Paper 89, 1996.

[7] The uncertainties include the impact of shippers' time valuations, productivity increases and the shares of different types of vehicles within each modality.

Table 15: Increase in real cost per mode in three scenarios (% per year, 1995-2020)

	Road	Other modes
Divided Europe (DE)	0.66	0.33
European Cordination (EC)	0.84	0.42
Global Competition (GC)	0.87	0.43

Source: Calculated from Tables 13 and 14.

If we weigh the real increase in labour costs with the recommended share of labour in total costs, we arrive at an estimate of the real increase in total costs (Table 15). It turns out that the estimated real costs increase by an average of 0.33% to 0.87% per year. The cost increase is highest in road transport, due to the high share of labour costs."

6.5 JASPERS (2017)

JASPERS is a joint venture of the European Investment Bank, the European Bank for Reconstruction and Development and the European Commission. The JASPERS appraisal guidance (JASPERS, 2017) for rail freight transport bases the time escalation factor for transport time and operating costs on the real changes over time in the transport costs (instead of GDP/capita), since the transport costs are the key driver of the changes of the values over time. This method for escalation is also used for freight transport value of time and reliability, in The Netherlands for example.

The amount of change in the transport costs depends on the changes in the various components of transport costs (originally in the guidance rail transport cost, but revised now in this report to apply to road transport):

- Crew cost (time-dependent costs);
- Depreciation and time-dependent maintenance cost of HGVs and LGVs (time-dependent costs);
- Energy costs (electric, diesel), distance-dependent maintenance costs and tolls, which are distance-dependent costs;
- Overhead costs (time-dependent costs).

The preferred method for escalation, according to JASPERS, is to make bottom-up assumptions on the evaluation over time of these cost items. This then needs to be combined with the share of total transport costs of these cost items. Together this will yield the growth in nominal terms of transport costs, but also of VTT and VTTR.

The above nominal growth in the transport costs can be compared to the general price increase to reflect how much the transport costs increase more (or less) than the expected general price level (inflation). Real % increases can then be applied to the benefits in the SCBA for each of the relevant years. Unit labour cost increases may well be fully offset by efficiency increases (e.g. with more use of machines for maintenance).

For the cargo element of VTT, JASPERS recommends no real increase of unit costs, as there is no evidence to suppose that such prices will increase systematically with GDP. This assumption can also be applied for distance-based costs in the absence of a comparative data set between countries at different economic level.

When no forecasts for the non-wage cost components can be obtained/made, JASPERS suggests increasing the crew cost with the wage increase and the other components only with the general price increase. This in spite of the fact the overhead has a large labour component (because overheads in JASPERS countries, such as Eastern Europe, can be expected to decrease in general).

6.6 France

The use of VTTs for both shippers and carriers is recommended for France in Direction générale des Infrastructures, des Transports et de la Mer (2019). The values to use can be found on the website of the Ministère de la Transition écologique et solidaire (www.ecologique-solidaire.gouv.fr) under '.Valeurs recommandées pour le calcul socio-économique'. The carrier value for road transport is 39 euro per hour per vehicle in euros of 2015. The shipper or cargo component, varies by commodity type, as can be seen in the following table.

Table 16: Recommended unit values for the cargo component in the value of time for Fance (in 2015 euro/tonne/hour)

Commodity	Value in euro per tonne per hour
freight with low added value: < 6000 euro/tonne, e.g. bulk/aggregates	0.01
ordinary freight: 6000-35000 euro/tonne, e.g. other rail, sea and river transport	0.21
freight with high added value: > 35000 euro/tonne, e.g. combined, parcels, refrigerated, roro	0.64

This document also includes guidelines for uprating these values:

- Keep the value of the carrier component constant in real terms (only correct for general inflation);
- Use the growth over time of GDP per capita with an elasticity of 2/3 for the shipper component.

6.7 Australia

Australia uses for the appraisal of transport projects for the freight VTT the wages of the drivers, as the UK used to do (Australian Government, 2023). These values are uprated using the Producer Price Index (PPI) for freight transport, which is a more specific index than CPI or the GDP deflator.

6.8 Conclusions from uprating practice used by other nations and organisations

The findings in this chapter 6 are summarised in the following table.

Table 17: Uprating assumptions used for freight VTT by other nations and international organisations

Country/organisation	Year	Recommendation on uprating the freight VTT
European Investment Bank	2004	GDP per capita elasticity of 1
European Commission	2006	GDP per capita elasticity of 0.7
European Commission	2014	GDP per capita elasticity of 0.5 or 0.7
The Netherlands	Since 2004	Real wage growth for wage sub-component (=50% for road); Only inflation correction for other components
JASPERS	2017	Bottom-up assumptions on the evolution of transport time-dependent cost; Only inflation correction for cargo component
France	2019	Only inflation correction for carrier component GDP per capita elasticity of 2/3 for shipper component
Australia	2023	Apply producer price index for freight transport to uprate wage-cost-based values

The European Investment Bank (EIB) and the European Commission (EC) have used an uprating of the real freight VTT in one step based on the real increase in GDP per capita. The Netherlands and JASPERS start from a philosophy to base the uprating of the transport cost component of the real freight VTT on the real change over time of the underlying transport cost components. In practice, the Netherlands only applies this for the wage cost component of the VTT and uses an inflation only correction for all other transport cost components and the cargo component. This means that the wage cost component is likely to grow faster than inflation, whereas all other components of the freight VTT will increase with inflation. This basically is the same approach as suggested now in TAG but derived independently. JASPERS does not work out the growth of the transport cost components any further but recommends using inflation correction only for the carrier component (in line with the advice for this component in The Netherlands and the UK).

France distinguishes the same two components as the UK, The Netherlands and JASPERS (the carrier and the shipper component), but its uprating guidance is almost completely opposite: let the transport cost component grow on the basis of inflation only and the cargo component will have a growth rate over and above inflation based on real per GDP per capita growth and an elasticity that is reasonably in line with that of EIB and EC. Australia uses a specific producer price index (not general real wage growth, but values specific to the freight sector) and applies this for the wage cost.

7. Cross-sectional differences in freight VTT across countries

7.1 Meta analysis and meta-regression

In this chapter, we will discuss several meta-analyses of the freight VTT, or more precisely several meta-regressions. A meta-analysis is a statistical analysis of the outcomes of studies on the same topic that can be found in the existing literature. This can be done to find the direction that the bulk of the available evidence is pointing to. In case of a meta-regression, the statistical analysis method used is that of the regression: function is estimated that explains the outcomes of primary studies from characteristics of these studies, their study area and their study period. In this report, our focus is on results for the GDP per capita elasticity of the freight VTT.

7.2 Zamparini and Reggiani (2007)

Zamparini and Reggiani (2007) assembled 46 observations on the VTT in freight transport for 22 countries in Europe and North America. Their regression function explained the natural logarithm of the VTT from GDP per capita, region and mode. Their GDP per capita elasticity of the VTT was 0.68.

7.3 Binsuwadan et al. (2022)

The freight VTT meta-analysis of Binsuwadan et al. (2022) included 106 monetary valuations collected from 56 studies from different countries about the valuations of freight travel time from the period 1988–2018. These studies consist of journal papers, government reports, PhD theses, conference papers and academic reports, both published and unpublished. While these 56 studies cover 25 countries across the world, the majority were conducted in Europe. Different search engines, such as Google and Google Scholar, were used to identify and select the studies. Searches were also conducted of specialist databases in transport studies, such as the Transport Database and EconLit. For 'grey' literature, conference websites were searched, and libraries were searched for pertinent theses and national studies related to VFTTS.

Binsuwadan et al. (2022) first estimated a regression equation using the ordinary least squares estimation method on all 106 observations. This gave a GDP per capita elasticity of 0.68. Then, a weighted least squares model was estimated that only used studies for which the number of observations in the primary survey was known. This reduced the dataset for meta-analysis to 87 studies and produced a GDP per capita elasticity of 0.77. Finally, to correct for the panel nature of the data (several values for the same country), fixed effects and random effects models were estimated on all data This gave GDP per capita elasticities of the freight VTT of 1.49 for the fixed effects model and 0.80 for the random effects model. The latter model was the preferred model according to a Hausman test.

7.4 New extension of Binsuwadan et al. (2022)

For this project we updated Binsuwadan et al. (2022). The update uses the same search methods, key search terms (notably the combination of 'value of (travel/transport) time' and 'freight/goods'), and sources. A regression function is estimated that explains the VTT from income and other (control) variables. One of the outputs will then be an income elasticity of the freight VTT (by mode).

We added eight studies to the dataset of Binsuwadan et al. (2022), contributing ten additional values. Some studies contribute more than one observation, for example because they report results for different model types (such as MNL, NL and ML), for different modes, or separately for carriers and shippers. To reduce unnecessary noise in the estimation, we excluded observations with ambiguous classifications, specifically where the mode was unclear or where it could not be determined whether the valuation referred to a carrier or a shipper.

As in Binsuwadan et al. (2022), we assume that VTT and GDP per capita are related through a multiplicative specification:

$$VTT_i = e^{(beta_0)} * (GDPpc_i)^{(beta_1)} * e^{(beta_2 isCarrier_i)} *\dots* e^{(u_i)} \tag{12}$$

Which is equivalent to (and easier to estimate as):

$$ln(VTT_i) = beta_0 + beta_1 * ln(GDPpc_i) + beta_2 * isCarrier_i + \dots + ui \tag{13}$$

The parameters can be interpreted as follows:

- For continuous variables, such as *GDP per capita*:
  - The beta corresponds to the elasticity of the parameter. This value is general for all the dataset, independent of which the reference categories for the dummy variables are.
- For dummy variables, such as *carrier*:
  - if the coefficient is positive, the VTT is higher than in the reference category by a factor of e^{β};
  - if the coefficient is negative, the VTT is lower than in the reference category by a factor of e^{β}.

We tested three models, all using road transport and shipper values as the reference category:

- Ordinary least squares (OLS).
- A specification that, when a study reported more than one model type, retained only the most advanced model. The ranking criterion was:
  1. Mixed logit
  2. Latent Class
  3. Nested logit
  4. Ordered logit
  5. Multinomial logit
  6. Aggregate logit
- A random-effects model with study-level effects (RE).

The estimation results are in Table 18.

Table 18: Meta-model results

	OLS		Advanced		RE	
Observations	63		52		63	
R2	0.64		0.71			
LL	-59.7				-39.8	
	Estimate	t value	Estimate	t value	Estimate	t value
(Intercept)	-3.04	-3.28	-3.31	-3.53	-3.48	-2.59
logGDP	**0.66**	3.22	**0.75**	3.63	**0.82**	2.77
carrier	0.96	5.24	0.89	4.90	0.63	3.14
IWW	-1.96	-5.29	-2.08	-6.06	-1.70	-7.19
rail	-0.51	-2.70	-0.64	-3.32	-0.95	-8.81
air	2.14	4.74	2.01	4.80	1.75	9.10
RE					0.64	

All three models fit the data reasonably well. The estimated income elasticity ranges from 0.66 to 0.82, which is broadly in line with the earlier findings of Binsuwadan et al. (2022) and with the international evidence reviewed in Chapter **Error! Reference source not found.**. The positive coefficient on *carrier* implies that carrier values are higher than shipper values in all three specifications.

The *advanced* and RE models cannot be compared directly on the basis of a single fit statistic, because they are estimated on different samples and use different modelling structures. On balance, we consider the RE model the most suitable for interpretation here because it uses more observations, accounts for correlation between values drawn from the same study and produces plausible coefficient estimates.

7.5 Conclusion

The preferred specifications of meta-regressions on the freight VTT using data from various countries at different moments in time give a GDP per capita elasticity of the freight VTT (all components together) of 0.66 to 0.82. These elasticities can be used in conjunction with the GDP/capita approach to uprating the freight VTT.

8. Synthesis, conclusions and recommendations

8.1 Synthesis: three main options with their pros and cons

In this chapter we synthesise the findings from the previous six chapters to distinguish three basic options for uprating the freight VTT and compare these in terms of their pros and cons. In this discussion we are assuming that all money values are in prices of the same year (2022 or 2023), so that nominal differences don't matter: all values have already been corrected for inflation (e.g. applying the GDP deflator, as used in TAG), as is commonly done in SCBA.

The three main options for uprating the freight VTT that we see are:

1. The current TAG approach: uprating the real freight VTT by means of the real economy-wide wage cost growth (for the wage cost share in the freight VTT) of 1.5% per year and letting the other components (other time-dependent costs and the cargo component; for the remaining share in the freight VTT) grow by inflation only, leading to an overall growth of 0.35% per year (HGV) and 1.10% (LGV) for the real freight VTT.
2. Uprate using different freight transport cost indices for each transport cost component of the VTT (leading to an average uprating factor from taking the weighted average of the components); for the cargo component of the freight VTT use inflation only;
3. Use real GDP per capita (and some elasticity) to uprate the freight VTT as a whole.

The three approaches and their results are summarised in the table below.

Table 19: Key mechanism, key inputs and key outcomes of the three options to uprating the freight VTT

Option	Mechanism	Key Inputs	Outcome
1. Current TAG approach	Split VTT into wage and non-wage components	Wage growth (~1.5%/yr) + inflation for other components	Real VTT growth: ~0.35% (HGV) ~1.10% (LGV)
2. Component cost indices	Apply index to each component and weight	Freight cost indices + inflation (cargo)	Weighted average uprating factor
3. GDP per capita	Treat VTT as a whole	Real GDP per capita (~1.5%/yr) + elasticity (between 0.66 and 0.82)	Single growth factor for VTT*elasticity -> between ~0.99%/yr for elasticity of 0.66 and ~1.23%/yr for 0.82 (refers to both HGV & LGV)

The pros and cons of each of these three main options are listed in the three tables below.

Table 20: Pros and cons of the current TAG approach to uprating the freight VTT

Pros	Cons
The economic theory behind the freight VTT makes a real growth of the road freight VTT by the same percentage as the real growth in the time-dependent transport costs likely. In this approach this is used for the wage cost.	If the non-wage cost within the time-dependent transport cost (e.g. vehicle depreciation, overhead costs of the carriers) would increase at another rate than inflation, this is not accounted for.
Real vehicle depreciation costs can be expected not to grow faster than inflation.	The real money value of the goods to be transported can be expected to grow at about the same rate as real GDP (faster than inflation).
The theory on the transport-inventory trade-off implies that the cargo component will grow with the real growth of interest cost on the value of the goods in transit (plus depreciation cost and loss of shelf-life cost). Interest rates are likely to change at a rate similar to that of inflation (not as fast as real GDP).	In the period 2012-2019, vehicle and overhead costs (as measured by Motor Transport) grew faster than inflation (measured by the GDP deflator) and LGV vehicle depreciation cost and LGV and HGV finance cost grew even faster than wage costs.
In the period 2012-2019, LGV and HGV driver wage costs (as measured by Motor Transport) grew faster than inflation (measured by the GDP deflator) and at a rate similar to the general (all-sector) wage increase	The approach is not in line with the guidance for uprating in France.
Predicted long-term general wage cost growth in TAG (based on productivity forecasts) exceeds inflation (measured by the GDP deflator).	This approach is not in line with that of the EIB and EC.
The Netherlands has been using a similar approach in practice since 2004.	Australia uses more specific producer price indices for freight transport.
For the wage costs and the cargo component the approach is in line with the JASPERS guidance.	There is evidence for an overall GDP/capita elasticity of around 0.7-0.8 from various meta-regressions on studies from multiple countries (largely cross-sectional data).
Projections for future years for real wage cost growth (based on long-term productivity forecasts) are available and already used in TAG.	

Table 21: Pros and cons of using different freight transport cost indices for uprating the freight VTT

Pros	Cons
The economic theory behind the freight VTT makes a real growth of the road freight VTT by the same percentage as the real growth in the time-dependent transport costs likely. In this approach this is used for all sub-components of the transport cost component of the freight VTT (not only for wage costs, but also for vehicle costs and overhead costs of the carriers).	Real vehicle depreciation costs can be expected not to grow faster than inflation.
The theory on the transport-inventory trade-off implies that the cargo component will grow with the real growth of interest cost on the value of the goods in transit (plus depreciation cost and loss of shelf-life cost). Interest rates are likely to change at a rate similar to that of inflation (not as fast as real GDP).	The real money value of the goods to be transported can be expected to grow at about the same rate as real GDP (faster than inflation).
In the period 2012-2019, driver wage cost, vehicle cost and overhead costs (as measured by Motor Transport) grew faster than inflation (measured by the GDP deflator) and LGV vehicle depreciation cost and LGV and HGV finance cost grew even faster than wage costs.	The approach is not in line with the guidance for uprating in France.
The philosophy behind this approach is also used in the Netherlands and by JASPERS.	The Netherlands uses a different approach in practice.
Australia also uses more specific producer price indices for freight transport.	This approach is not in line with that of the EIB and EC.
Outcomes of regressions on freight transport cost data from Motor Transport might be used to predict future years.	There is evidence for an overall GDP/capita elasticity of around 0.7-0.8 from various meta-regressions on studies from multiple countries (largely cross-sectional data).
	It is difficult to decompose the full freight VTT into its transport cost sub-components and the cargo component.
	Projections for future years for real driver wage cost, vehicle costs and overhead cost of carriers are not readily available and are not used in TAG. The approach makes no reference to external forecasts used in TAG.

Table 22: Pros and cons of using a GDP per capita elasticity approach to uprating the freight VTT

Pros	Cons
If the wage or non-wage cost within the time-dependent transport cost (e.g. vehicle depreciation, overhead costs of the carriers) would increase at the rate of real GDP/capita instead of inflation, this is accounted for.	The economic theory behind the freight VTT makes a real growth of the road freight VTT by the same percentage as the real growth in the time-dependent transport costs likely. In this approach this is not directly used.
The real money value of the goods to be transported can be expected to grow at about the same rate as real GDP (faster than inflation).	Real vehicle depreciation costs can be expected not to grow faster than inflation.
In the period 2012-2019, driver wage costs, vehicle costs and overhead costs (as measured by Motor Transport) grew faster than inflation (measured by the GDP deflator).	In the period 2012-2019, most sub-components of driver wage costs, vehicle costs and overhead costs (as measured by Motor Transport) grew not quite as fast as real GDP.
This approach is in line with that of the EIB and the EC.	The theory on the transport-inventory trade-off implies that the cargo component will grow with the real growth of interest cost on the value of the goods in transit (plus depreciation cost and loss of shelf-life cost). Interest rates are likely to change at a rate similar to that of inflation (not as fast as real GDP).
Predicted long-term general wage cost growth in TAG (based on productivity forecasts) exceeds inflation (measured by the GDP deflator).	This approach is not in line with that of the Netherlands and JASPERS.
Projections for future years for GDP/capita growth are available and already used in TAG.	The approach is not in line with the guidance for uprating in France or that in Australia.
There is evidence for an overall GDP/capita elasticity of around 0.7-0.8 from various meta-regressions on studies from multiple countries (largely cross-sectional data).	
This method is simple, also in the sense that it does not rely on wage forecasts or on the share of wages in transport costs or VTT.	
The uprating for the VTT in passenger transport (work and non-work time) also uses GDP/capita (with an elasticity of 1)	

The treatment of the wages in the TAG approach has theoretical underpinnings and can be carried out easily in practice for future years, since TAG already uses the OBR general wage growth. Its treatment of the other components (only inflation correction) is not well supported by theory and empirical observations. The cargo component is probably determined to a large extent by the interest cost of the capital invested in the goods for the time that the transport takes. Besides travel time, this is determined by the interest rate and the value of the goods. The interest rate will probably grow more in line with inflation than with real GDP, but the value of the goods is likely to increase at a rate similar to real GDP. A growth of the cargo component at the rate of real GDP (or GDP/capita) growth seems more appropriate than at the rate of inflation.

For the second approach, the argument that long term projections (almost 50 years ahead) for the driver wage costs, vehicle costs and overhead costs of the carriers are not available and that this method is not connected to external forecasts used in TAG seems quite important. This method can be used for predicting the future freight VTT by applying the regression coefficients for the model in real prices from chapter 4. However, this would lead to growth rates that are not in line with other growth rates in TAG. Another important drawback is that a full decomposition of the freight VTT into the sub-components of the transport cost component and the cargo component is difficult to make. The second method needs such a decomposition to weight the growth rates of each (sub-)component. These drawbacks make the second approach unattractive in practice, in spite of its theoretical advantages. A more practical variant of the second approach would be to use the regression outcome for the driver wages only (and the share of wages in the time-dependent cost) and inflation correction for the other (sub-)components. This variant resembles the current TAG approach and does not use the projected general wage cost increase but a prediction for the HGV and LGV drivers' wage cost growth.

The third method (grow all components by real GDP growth) is not so strongly tied to theory on transport cost components as the first two but might be more realistic for the non-wage components than the first approach. It is also easy to apply in practice and ties the freight VTT growth to GDP/capita growth, as is also used in TAG. It is also in line with the uprating method TAG uses for travel time of persons (with a GDP/capita elasticity of 1.0). One might use a GDP/capita elasticity of 1.0 here for freight as well, but the meta-regression evidence in chapter 7 and the experience in other countries suggests that a value between 0.66 and 0.82 would be more appropriate for the freight VTT.

In the next subsection, we will look at results for the freight VTT for the period 2022-2071 for all three main methods.

8.2 Predictions of the evolution over time (2022-2071) of the freight VTT

The graph below shows what the freight VTT would be like over time for HGV when using each of the tree main methods. The TAG uprating uses an overall freight VTT growth per year of 0.35% for HGV. The second method uses the regression for the driver wages from chapter 4 and applies the resulting growth of 0.50% per year for all components of the freight VTT. It uprates the freight VTT just a bit more than the TAG method. The GDP/capita method uses a growth of around 1.5% per year (projected real GDP per capita growth from OBR, which happens to be more or less equal to the productivity growth from OBR), combined with a GDP/capita elasticity of 0.82 (best results from chapter 7). This leads in the long run to much higher values than the other two methods.

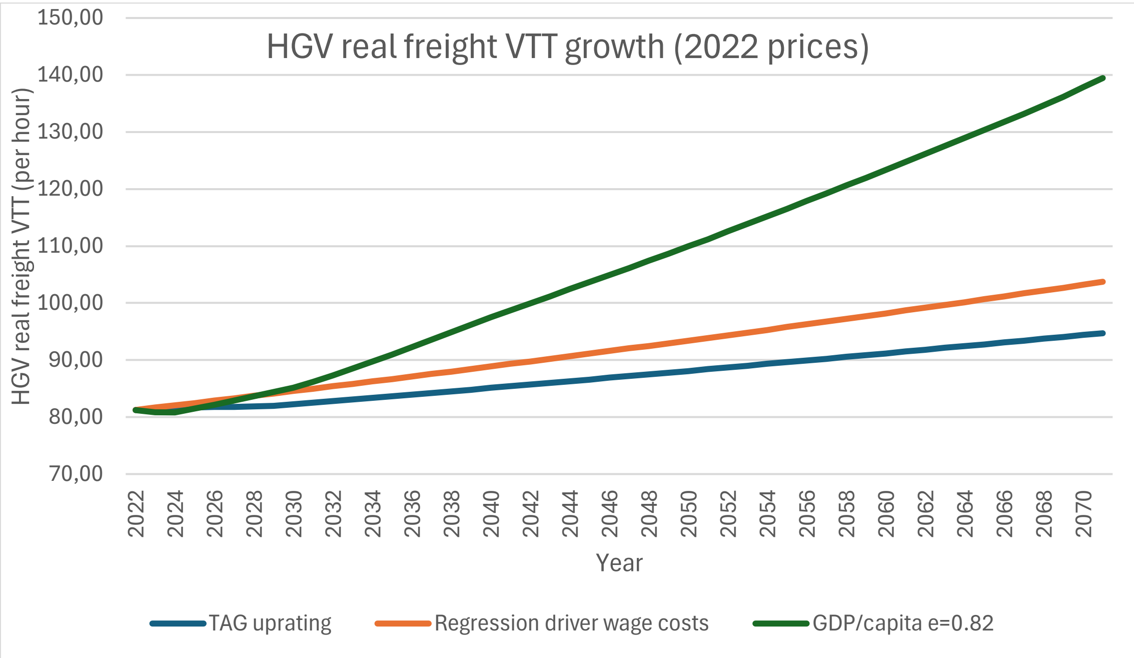

Figure 29: Three methods for uprating the freight VTT until 2071 for HGV

Figure 30 shows the freight VTT over time for LGV for the tree main methods. The TAG uprating again uses an overall freight VTT growth per year of 1.10% for LGV. This exceeds the TAG growth rate for HGVs, because wages are more important for LGVs than for HGVs. The second method uses the regression for the driver wages from chapter 4 and applies the resulting growth of 0.38% per year for all components of the freight VTT. It uprates the freight VTT clearly slower than the TAG method. The GDP/capita method uses a growth of around 1.5% per year (projections from OBR) with the elasticity of 0.82 (from chapter 7) and leads in the long run to higher values than the other two methods.

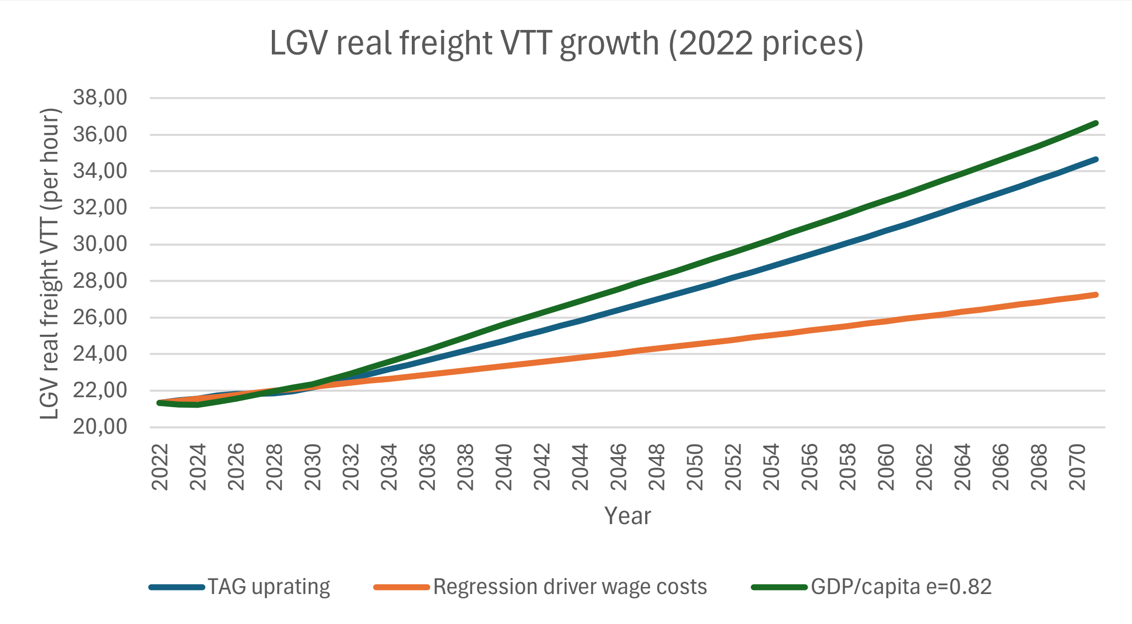

Figure 30: Three methods for uprating the freight VTT until 2071 for LGV

In the figures below, for HGV and LGV, we tried out different elasticities (0.66, 0.82 and 1) for the GDP/capita approach and compare the uprating results against those of the TAG approach.

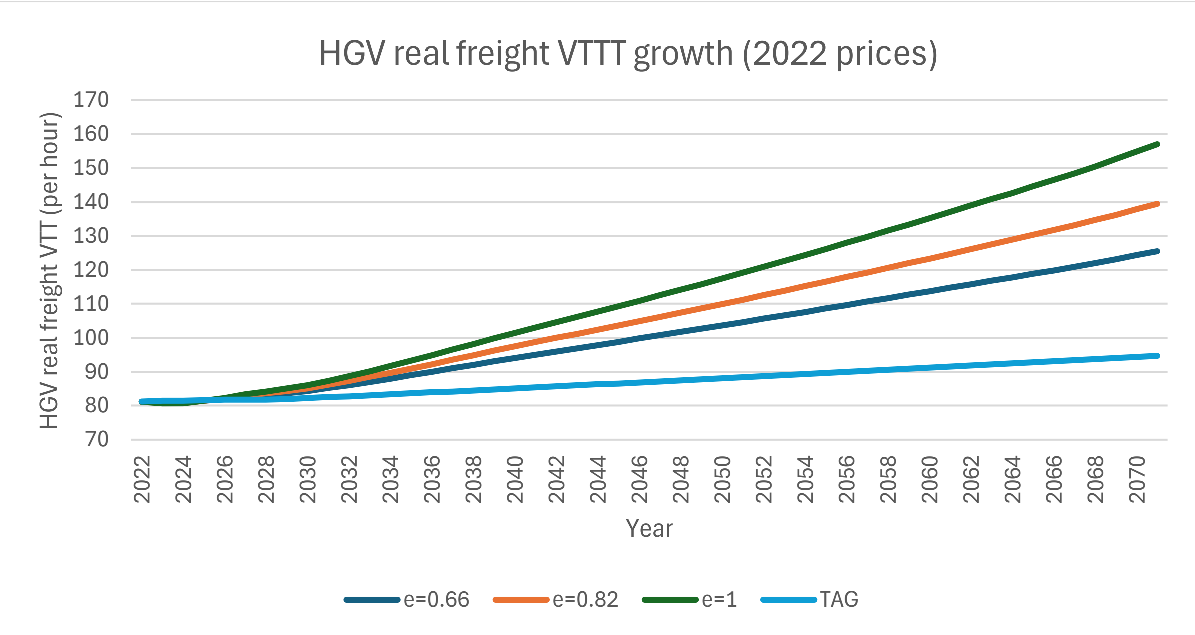

Figure 31: GDP/capita at various elasticities and TAG method for uprating the freight VTT until 2071 for HGV

For HGV, the TAG approach is always below the GDP/capita approach at plausible values of the elasticity. For LGV, the elasticity of 0.66 produces lower uprated freight VTTs than the TAG approach, whereas elasticities of 0.82 and 1 yield higher uprated freight VTTs.

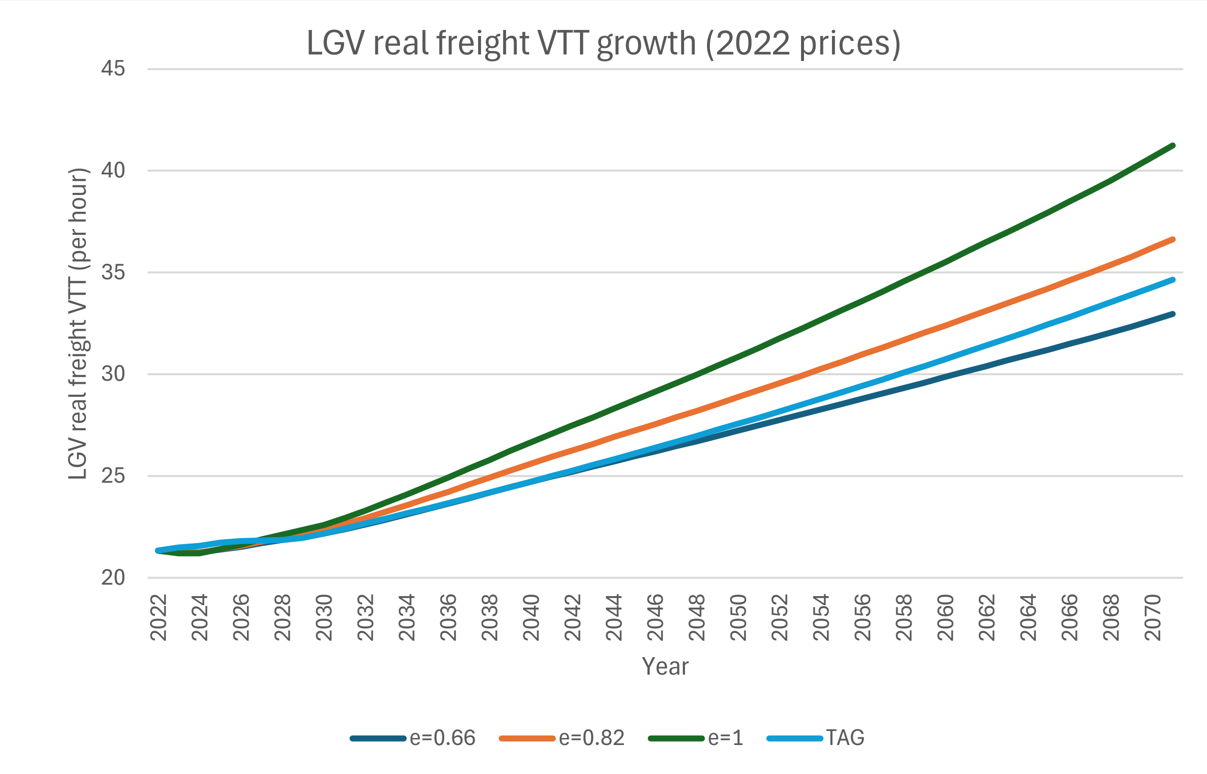

Figure 32: GDP/capita at various elasticities and TAG method for uprating the freight VTT until 2071 for LGV

8.3 Uprating the freight VTTR

The freight value of travel time reliability (VTTV) can be defined as:

VTTR = RR . VTT (14)

In which:

VTTR: value of travel time reliability in money, per hour standard deviation of travel time;

RR: reliability ratio of travel time;

VTT: value of travel time in money, per hour.

This relation provides a practical method for uprating the freight VTTR that is consistent with the uprating for the freight VTT: first calculate the uprated VTT for some future year and then apply the (fixed) RR to calculate the VTTR for that year. The RRs for HGV (0.58) and LGV (0.70) can be found in Department for Transport (2025).

8.4 Conclusions and recommendations on the preferred approach

For uprating the freight VTT, we see two good candidates:

- The current TAG approach that uses the general wage cost growth for the wage cost part and only inflation correction for all other components;
- The GDP/capita approach that uses real GDP per capita growth and an elasticity (candidates are 0.82 from the best model on the largest number of studies or 0.74 as the average of the likely range).

The regression-based approach is not an appropriate candidate because as inputs it does not use projections that are available in TAG and because it requires a full decomposition of the freight VTT into its components (which is difficult to make).

The main difference between the two remaining approaches is that in the GDP/capita approach other components than the wage cost also grow more than inflation. This seems plausible/realistic. The GDP/capita approach gives clearly higher values for HGVs than the current TAG approach and similar to somewhat higher values for LGVs. The current TAG approach therefore has the benefit (if this is a benefit) of being more conservative. The GDP/capita approach has the benefits of greater simplicity and of greater consistency with the uprating for the passenger VTT in TAG. Furthermore, it leads to the same growth for HGV and LGV, whereas the current TAG approach leads to much higher growth over time for the LGV values.

Considering the pros and cons mentioned in the tables above and the differences just mentioned, we think both the current TAG approach and the GDP/capita approach can be justified, but we have a slight preference for the GDP/capita method. The most appropriate elasticity for this method in our view would be 0.82.

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