Carbon footprint and packaging logistics within freight transports: a case study

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Abstract

The emissions from the global freight transport sector are continuously growing in a rapid pace. The rise in the transport sector has increased competition and many industries today operate with a just-in-time practise. This has led to a decline in load factor and an increase of empty transports. The global inefficiency within freight transports is directly connected to the low load factors as well as the share of empty driven transports.

The purpose of this study is to examine the carbon footprint of road freight transports and its relation to the cargo capacity and usage as well as the economic impact and opportunities. Through calculating the carbon footprint in a series of scenarios and comparing results from 3 different emissions calculation programs, an overall understanding can be achieved.

Results have shown that the greatest saving potential in CO_2 emissions are seen in vehicles with higher payload capacity as well as vehicles, where the curb weight has the least share in emitted CO_2 of a fully loaded vehicle. By transitioning the load of a fully loaded Light goods vehicle with the engine capacity $\leq$ 1.25t to a heavy goods vehicle with 3.5-7.5t engine capacity, 68.5% less CO_2 emissions are released. In addition to reviewing the economic opportunities, a transporter from a shipping company is interviewed, where the person shares its opinions regarding low load factors and environmental awareness.

Key words: Freight transport, environmental impact, carbon footprint, load factor and packaging logistics.

Abbreviations

CO_2 – Carbon dioxide

COFRET – Carbon Footprint of Freight Transport

DECC – Department for Energy and Climate Change

DEFRA – Department for Environment, Food and Rural Affairs

EN – European standard

EPA – United States Environmental Protection Agency

ETF – Empty trip factor

EUA – Emission Allowance

EU ETS- European Emission Trading System

EURO IV – European emission class 4

EURO V – European emission class 5

GHG – Greenhouse gases

GIS – Geographic Information System

HGV – Heavy goods vehicle

IPCC – Intergovernmental Panel on Climate Change

JIT – Just-in time practice

LF – Load factor

LGV – Light goods vehicle

LSP – Logistics service provider

Many-to-many network – A transport network where shipments are collected in some legs of the total transport.

$M(CO_2)$ – The mass of emitted CO_2 (kg)

$M(CO_{2,\,LF1})$ – The mass of emitted CO_2 at 1% LF

$M(CO_{2,\,LF100})$ – The mass of emitted CO_2 at 100% LF

M(CO_2, tkm) – Emitted tonnes of CO_2 per tkm

SCB – Statistics Sweden

SEK – Swedish kronor

TRAFA – Transport Analysis

WBCSD – World Business Council for Sustainable Development

WRI – World Resources Institute

WTT – Well to tank

WTW – Well to wheel

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Introduction

The quantities of CO_2 emissions, directly tied to global freight transport are increasing rapidly and in 2010 freight and passenger transports were measured to be answerable for 16.6% of global energy emissions (IPCC, 2014). Increasing events of flooding, hotter temperature and higher accident frequencies are all increasing threats to the transport sector because of climate change (Koetse, 2009).

This study investigates the relation between the load factor (LF) and CO_2 emissions in a wide range of heavy goods vehicles (HGV) and light goods vehicles (LGV).

The carbon calculations in this study are done in a certain range of factors, so called scopes. The factors affecting the release of CO_2 is divided into 3 scopes (Ranganathan et al., 2004). The This study is also made possible by the collaboration with Packbud Nordic AB. Packbud is a logistics service provider (LSP), who operates mainly by increasing the LF on pre-arranged transports (Funa, 2016).

Inefficiencies within road freight transports

Some of the leading causes to inefficiency within freight transports are trade imbalances, just-in-time practise (JIT) and fragmentation within the freight transport sector. Levels of empty transports (ETF), and LF were approximately 20% and 56% within Europe in 2010. Transport networks such as JIT, provides low inventory requirements, fast distribution but often with low LFs (Cruijssen, 2012).

LF is the percentage defining the fill rate of a vehicle. One of the main determinants controlling the LF is the price of fuel (Rizet, 2012). The inefficiency in ETF and LF represents a large annual cost on the European union, which was estimated to be around 160 billion € in the year 2010 (Cruijssen, 2012).

Research has shown that by increasing LF, can possibly lead to mitigation in CO_2 emissions without affecting the transport capability (Rizet et al., 2012). Woodrooffe & Ash (2001) investigates the possible reductions in CO_2 emissions by using long combination vehicles. The knowledge, in which this case study aims to bring previous research, is a detailed assessment of CO_2 saving potentials in a range of vehicles. An insight will also be given in to the economic challenges and opportunities, connected to the low efficiency in freight transports.

The inefficiency as earlier mentioned, has a grave impact on the environment. The overall minimum expected cost for not adapting to climate change is expected

to be 250 billion € in the year 2050, within all sectors of the European union (European Commission, 2013). Most of policies within the European Union regarding transport adaption are currently in the planning stages (EEA, 2014). More research is needed on the transport inefficiency and this study aims to contribute in reducing the current knowledge gap.

Possibilities & Challenges

There are countless challenges for LSPs in today's market. The LSP has to have flexibility, fast pace, reliability and a capability to customise transports. The transports today are usually run with a low income marginal. Collaborations between LSPs and shipping companies have been found to give both environmental and economic gain. Incentives such as a rise in productivity, reducing costs and the potential of providing better service are all possible opportunities when collaborations are made. However collaborations such as these are generally limited because of fears and concerns of not finding suitable partners, economic disputes and operational difficulties (Cruijssen, 2012). In this study, a transport company, which is in collaboration with an LSP, is interview.

When it comes to choosing which type of logistics network to use, the cost and reliability are among the main determinants however in networks where a number of transports are collected during the longest leg of the transport, environmental benefits can be attained. In Kellner & Igl (2015) result's, the many-to-many network is the most environmentally friendly with 8.9% GHG emission effect than the average. The packaging efficiency of the cargo space is also an important factor in the overall efficiency (Arvidsson et al., 2013).

Behavioural changes on the individual level such as Eco driving have shown to potentially improve the fuel efficiency by 5-20% (AEA, 2011).

The willingness to pay (WTP), for a greener transports is one of the key factors in order to initiate the adaption of climate change within the transport sector. Research has shown that there is a high intention and positive association on WTP for a greener transport however the awareness of greener transport solutions is generally low (Schniederjans & Starkey, 2014). Because of high fragmentation, the acceptance of responsibility for adaption is often low. There is a series of steps to be taken before one can potentially see companies making own initiatives to lessen their environmental impact. The stakeholders often wait for regulations from authorities; meanwhile authorities are waiting for research by researchers (EEA, 2014).

According to the Intergovernmental Panel on Climate Change (IPCC), there are great opportunities in adapting transport sectors within Organisation for Economic Co-operation and Development countries (OECD), where the development of infrastructures are taking place. Investments in improvements in infrastructure are high with a low economic turnover, which hinders future adaptions

in countries with developed infrastructures. Behavioural change as well as economic instruments, oil and road pricing can be essential in order to mitigate the environmental impact (IPCC, 2014).

Propose and research questions

The purpose of this study is to examine the carbon footprint in HGVs and LGVs as well as its relation the cargo capacity and usage. Through measuring CO_2 emissions of HGV and LGV in relation to LF and ETF, a higher understanding of what environmental and economic gains could be achieved.

This study is based on the assumption: if the LF in global freight transports increase, then the amount of HGV transports will decline.

Research question 1

How much CO_2 emissions could potentially be reduced through optimising the load factor within freight transport?

Research question 2

Can the increase in load factor in the freight transport sector provide a significant economic impact?

Delimitations

External factors such as outside of the 3 calibrated scopes or outside of the well-to-wheels life cycle assessment will not be taken into account. Furthermore scope 2 will be exempt in the calculations of DEFRA's calculation program, in order to calculate in the same range as in the GHG Protocol program.

Placement of the shipment within the cargo space and its effect will not be taken into account in the calculations made in this study. In addition to the vehicles being divided by engine capacity they are also separated by European emission classes EURO IV and EURO V (European commission, 1998 & 2004). The vehicles are thereby under European law and consequently the results are more appropriate within the European union.

The 3 carbon footprint programs, DEFRA greenhouse gas (GHG) conversion factor program, GHG Protocol's GHG emissions from transport and mobile and EcoTransIT are chosen to be different from each other. These databases and tools are not a full representation over the present calculation programs in the world.

Method

To evaluate and determine the relation between CO_2 emissions and the usage of cargo, a series of scenarios have been made with the distance of 1km have been calculated. In this report both calculation programs and scientific reports have been used. The scientific reports have all been searched upon in Web of science's core collection database as well as Lub search. Statistics presented in this study are retrieved from: the Swedish Transport Agency, Transport Analysis (TRAFA), the United Kingdom Department for Transport (DFT) and the United Kingdom Department for Environment, Food and Rural Affairs (DEFRA). The delimitations regarding this study are directly related to the current structure of the 3 chosen calculation programs: EcoTransIT, GHG Protocol and DEFRA emission factors.

The calculation programmes

GHG Protocol is an organisation Co-founded by the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI). GHG Protocol that has created a series of standards, guidelines and calculation tools for a wide variety of industries and purposes (Ranganathan et al., 2004). The calculation tool that is used in this study is called: GHG emissions from transport and mobile sources (GHG Protocol, 2015). Further in this study this program will be referred as GHG protocol.

The carbon calculations created in the GHG Protocol program, were all made according to the Ranganathan et al., (2004) method. The range of GHGs calculated in the GHG protocol program is compatible with the Kyoto protocol (Ranganathan et al., 2004). The emission factors in the program, which are the basis for the calculations, are derived from DEFRA and the Environmental Protection Agency (EPA). The emission factor named "Other" was selected in all of the scenarios and the name "Other" refers to being appropriate for calculation outside of the UK and United states (GHG Protocol, 2015).

EcoTransIT is an emission calculation database which functions are based by a geographical information system (GIS). Depending on where the transport is being held, the road gradient parameter in the EcoTransIT model varies. The database is

online and located on the EcoTransIT webpage, where the calculations are easily achieved. This database is in accordance with European standard (EN), 16258. Instead of calculating in scopes, EcoTransIT CO_2 emissions are calculated in a well-to-tank (WTW) life cycle assessment (Knörr et al., 2014). Well-to-wheel is a life cycle assessment where the processes from vehicles and energy is accounted for and is on of the 2 main alternatives in representing CO_2 emissions in the EN 16258 (2012). The calculations are made in the predetermined scenarios and in the method of Knörr et al., (2014). The driven distance in all of the scenarios is consistent with the same coordinates. By using the same set of coordinates, all of the scenarios are driven in same length and with the same topographic gradient. The coordinates are on an actual road and the length between the origin and destination is 1.01km.

Table 1. Coordinates.
Coordinates used in the EcoTransIT calculations

Origin	Latitude 55.477°
	Longitude 13.595°
Destination	Latitude 55.486°
	Longitude 13.593°

The third chosen calculation tool is DEFRA's Greenhouse gas conversion factor program (DEFRA, 2015). The program's purpose is to enable local authorities and companies to calculate their environmental impact. Emission factors are estimated by measurements on the traffic in the United Kingdom (DEFRA, 2015). The methodology for DEFRA's calculation program is made by the Department for Energy and Climate Change (DECC) (DECC, 2015). The activity sheets that are used in the calibrations are named: delivery vehicles, freighting goods and fuels. The equation used in the calculations, equation 1 is shown bellow. *M (CO_2)* stands for the mass of emitted CO_2 in the unit (kg), *D* is the distance with the unit (km) and lastly *Em* stands for emission factor for the selected vehicle. The masses CO_2 emitted from each emission factor is summed up in order to get a total value of emitted CO_2.

$$M(CO_2) = D \times Em_x \qquad (01)$$

In the tables 2 and 3, the structural differences between the 3 programs are illustrated.

Table 2. Structural differences in carbon calculation programs
Presenting the differences between the 3 programmes that are going to be in this study. On the banner are variables that are all active factors in producing CO_2 emissions within freight transports. The boxes give information on availability, what type of units and how many selections there are.

Programme	Distance Unit	Vehicle Types	Fuel	Emission Classes	Derived from
GHG protocol	(Km)	Yes, Several	B20 Diesel, petrol	Non optional	Own standard
EcoTransIT	(Tkm)	Only HGVs	B5 Diesel	Yes, selectable	EN 16258
DEFRA	(Tkm) or (km)	Yes, several	B20 Diesel, petrol.	Non optional	DEFRA, EN 16258

Table 3. Structural differences in carbon calculation programs, continuation.
The table presents the differences between the 3 programmes that are going to be in this study. On the banner are variables that are all active factors in producing CO_2 within freight transports. The boxes give information on availability, what type of units and how many selections there are.

Programme	Weight	LF	ETF	Scopes 1 - 3	WTW	Format	Methodology or guidelines
GHG protocol	Yes, needed	No, options	No	Yes, 1 and 3	No	Excel	No
EcoTransIT	No	Yes	Yes,	No	Yes	Online	Accessible methodology paper
DEFRA	No	Yes, options	No	Yes, 1 to 3	No	Excel	Accessible guidelines

Variables in CO_2 calculations

The vehicles used in the chosen scenarios have all been divided by engine capacity. The maximum weight in the two vehicles, vehicle nr 7 and 11 is 44 tonnes, in accordance with the directive 2015/719 (European Parliament, 2015). Emission classes are assigned to all vehicles in accordance with European laws (European Parliament, 1998 & 2004). The vehicles are calculated with B20 diesel and petrol fuels in the DEFRA and GHG Protocol programmes. B20 diesel stands for a diesel fuel with 20% biofuel component. The vehicles in the ecotransit model are all running on diesel fuels with a 5% biofuel component (Knörr et al., 2014). Average payloads statistics from DEFRA, are used in all of the calculations (DEFRA, 2015). The distance *D,* is 1 km in all of the calculations. During the calculations *M(CO₂)* will

be converted into tonnes. $M(CO_{2,tkm})$ stands for emitted CO_2 tonnes per net tonne km (t/tkm). $M(CO_{2, LF1})$ stands for the emitted kilograms of CO_2 at 1% LF and $(CO_{2, LF100})$ stands for the emitted kilograms of CO_2 at 100% LF. The unit tonne kilometre is distance of a transport multiplied by the weight of the vehicle (DECC, 2015). Measurements on fuel consumption which are used in the DEFRA and GHG Protocol program, are based on the overall consumption in 2014 (DFT, 2014).

Table 4. Scenarios.
The table displays the arranged scenarios that are going to be the foundation for the calculations in this study.

ID	Vehicle	Fuel	Emission class	Engine capacity (t)	Calculated by program
1	Van LGV	Petrol	4	<1.25	GHG protocol
2	Van LGV	Petrol	4	<1.305	DEFRA
3	Van LGV	B20 Diesel	4	≤ 3.5	DEFRA, GHG protocol,
4	HGV rigid	B20 Diesel	5	3,5-7,5	DEFRA, GHG protocol
5	HGV rigid	Petrol	5	3,5-7,5	DEFRA, GHG protocol
6	HGV rigid	B5 Diesel	5	3,5-7,5	EcoTransIT
7	HGV	B5 Diesel	5	7,5-12	EcoTransIT
8	HGV rigid	B20 Diesel	5	7,5-17	DEFRA, GHG protocol
9	HGV rigid	Petrol	5	7,5-17	DEFRA, GHG protocol
10	HGV	B5 Diesel	5	12-20	EcoTransIT
11	HGV rigid	B20 Diesel	5	> 17	DEFRA, GHG protocol
12	HGV rigid	Petrol	5	> 17	DEFRA, GHG protocol
13	HGV	B5 Diesel	5	20-26	EcoTransIT
14	HGV	B5 Diesel	5	26-40	EcoTransIT
15	HGV articulated	B20 Diesel	5	3,5-33	DEFRA, GHG protocol
16	HGV articulated	Petrol	5	3,5-33	DEFRA, GHG protocol
17	HGV articulated	B20 Diesel	5	> 33	DEFRA, GHG protocol
18	HGV articulated	Petrol	5	> 33	DEFRA, GHG protocol

Empty transports

In order to evaluate the economic and environmental impacts of ETF inefficiency in HGVs, an example will be calculated. Sweden and the year 2014, will serve as an example in this study. Sweden was chosen of the 27 European countries because of the high accessibility in reports and registers.

Statistics on Swedish registered lorries and traffic during the year 2014 was used (TRAFA, 2015a). In TRAFA (2015b), table LB7 was used which views the distribution of lorries per vehicle class. In these calculations 2 assumptions were made: there is an even amount of rigid and articulated HGVs and every vehicle contribute the same mileage.

The active variables in the calculations are: commercial transports without load D_{e1}, company car transports without load D_{e2}, distance of empty transports D_e, percentage of empty transports E_t, Emission factor for the selected vehicle Em_x, Mileage for each vehicle D_m, and amount of HGVs in Sweden H. The approximate carbon emission pricing by European union's Emission Trading System (EU ETS), for October 2014 is € 5,7 per tonne emitted CO_2 (Erbach, 2014). The average exchange rate Euro to Swedish kronor in October 2014 was 9.17 Skr (Riksbank, 2016).

$D_e = D_{e1} + D_{e2}$ (Calculation of total distance of empty transports, (km))

$D_e / D = E_t$ (Percentage of empty trips calculated, (%))

$D_e / H = D_m$ (Calculation of mileage (km))

$CO_2 = D_m \times Em_x$ (CO₂ calibration for each division: rigid 3.5-7.5t, rigid 7.5- 17t, rigid >17t and articulated 3.5-33t)

Interview

An interview with 1 of Packbud's 400 associates has been made. The representative that has been interview has been chosen randomly and been interviewed anonymously. The interview was held via telephone communication and the answers were recorded under the person's consent.

5 questions were asked concerning: incentives, financial opportunities and environmental awareness. After the interview was held, the questions and answers where translated from swedish to english.

Results

The results are presented in 4 sections, which represent the four areas this study has investigated. The first section "CO_2 emissions" will clearly show the results of the calculated CO_2 emissions and calculated comparisons. "Empty load transports within Sweden" is the title of the second section and covers the calculated effects of low ETF in Sweden. Section 3 displays the interview, which was made with the owner of a shipping company. Lastly section 4 is viewing the results of personal communication with Packbud.

CO_2 emissions

In total 29 carbon footprint calculations were made with the 3 programs: DEFRA, GHG Protocol and EcoTransIT. The calculations from DEFRA and GHG Protocol are displayed in table 5. In addition to the information already presented in table 5, information such as average maximum payload, emitted tonnes of CO_2 at 1 and 100% LF as well as the percentage value of $(CO_{2, LF1})/(CO_{2, LF100})$ is shown.

The average maximum payload is calculated and statistics are derived from the DEFRA calculation program. The emitted tonnes of CO_2 at 1%LF range from 0.326 to 0.488 kg in LGVs and 0.145 to 0.582 tonnes in HGVs. The emitted tonnes of CO_2 at 100% LF ranges from 0.187 to 0.117 tonnes in LGVs and 1.67 to 9.82 kg in HGV's. The percentage $(CO_{2, LF1})/(CO_{2, LF100})$ displays how many percent of the emissions emitted from a full transport is derived from the vehicle itself and its 1% LF.

 4 of the calculated scenarios shown in table 5 are compared to each other in 2 comparisons, shown in table 6. The first comparison I made between a van and a rigid HGV. In the comparison, both vehicles are loaded with the same amount of weight. Next to the loaded weight in the table, LF is shown. In addition to showing emitted CO_2 (t), emitted CO_2 t/tkm is also shown. In table 6 higher values of emitted CO_2 can be seen in the 2 larger vehicles. The emitted CO_2 in ton per net tonne kilometre is lower in the 2 heavier vehicles.

Table 5. CO$_2$ emissions
Table nr. 6. Shows the calculated carbon emissions form the 3 chosen calculation programs: GHG Protocol, EcoTransIT and DEFRA emission conversion factors.

Program	Vehicle type	Engine capacity (t)	Average Maximum Payload (t)	Fuel	CO$_{2,LF1}$ (Kg)	CO$_{2,LF100}$ (Kg)	(CO$_{2,LF1}$) / (CO$_{2,LF100}$) (%)
GHG Protocol	Van LGV	≤ 1.25	0.540	Petrol	0.326	0.420	78
	Van LGV	≤ 3.5	1.18	B20 diesel	1.39	1.87	74
	HGV rigid	3.5 – 7.5	2.20	B20 diesel	1.45	2.45	59
	HGV rigid	3.5 – 7.5	2.20	Petrol	1.47	2.47	60
	HGV rigid	7.5 – 17	7.10	B20 diesel	2.62	3.62	72
	HGV rigid	7.5 – 17	7.10	Petrol	2.65	3.65	73
	HGV rigid	> 17	9.41	B20 diesel	3.99	5.99	67
	HGV rigid	> 17	9.41	Petrol	3.99	5.99	66
	HGV articulated	3.5 – 33	12.5	B20 diesel	4.66	7.66	61
	HGV articulated	3.5 – 33	12.5	Petrol	4.70	7.70	61
	HGV articulated	> 33	19.0	B20 diesel	5.82	9.82	59
	HGV articulated	> 33	19.0	Petrol	5.82	9.82	59
DEFRA	Van LGV	≤ 1.305	0.540	Petrol	0.414	0.814	51
	Van LGV	≤ 3.5	1.18	B20 diesel	0.448	0.696	64
	HGV rigid	3.5 – 7.5	2.20	B20 diesel	1.57	1.75	90
	HGV rigid	3.5 – 7.5	2.20	Petrol	1.50	1.67	90
	HGV rigid	7.5 – 17	7.10	B20 diesel	1.97	2.32	85
	HGV rigid	7.5 – 17	7.10	Petrol	1.87	2.22	84
	HGV rigid	> 17	9.41	B20 diesel	2.68	3.36	80
	HGV rigid	> 17	9.41	Petrol	2.52	3.40	74
	HGV articulated	3.5 – 33	12.5	B20 diesel	2.29	2.96	77
	HGV articulated	3.5 – 33	12.5	Petrol	2.03	2.70	75
	HGV articulated	> 33	19.0	B20 diesel	2.30	3.20	72
	HGV articulated	> 33	19.0	Petrol	2.17	3.07	70

The relation between the different vehicle types and the value of (CO$_{2,LF1}$/CO$_{2,LF100}$) shown in table 6, are displayed in chart 1. The range of vehicles shown in chart 1, are displayed by their ID number is presented in table 4. In the chart, one can see both the measurements from DEFRA and GHG Protocol. A trend line is drawn across chart, showing the average percentage value of (CO$_{2,LF1}$/CO$_{2,LF100}$).
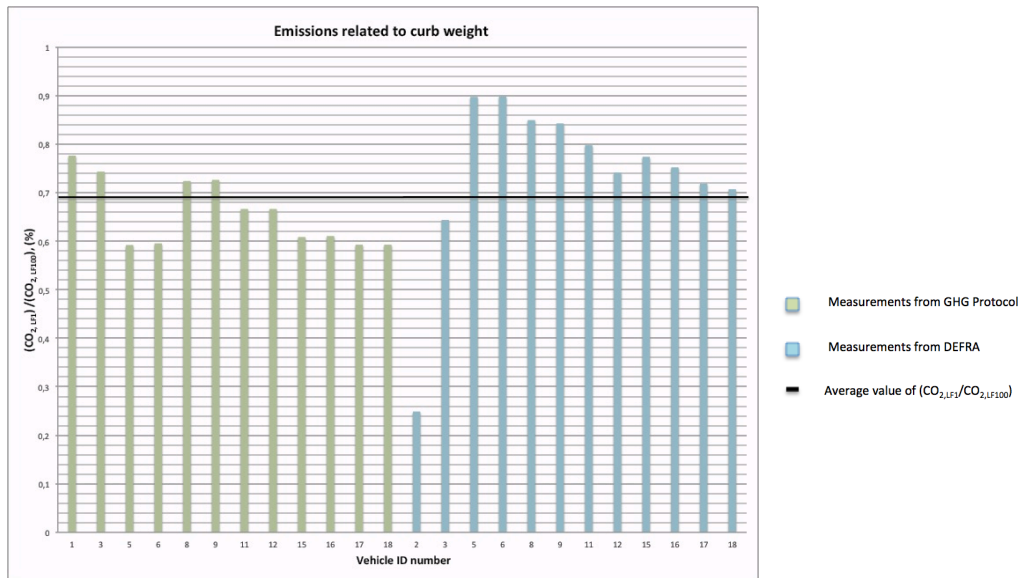
Chart 1.

The chart displays the relation between vehicles and the percentage of emissions connected to the curb weight as well as the 1% LF, in transports where the vehicle is fully loaded.

Table 6. Comparisons of CO_2 emissions

Comparisons in t CO_2 have been created with different vehicles and payloads. The values are retrieved from table nr. 6.

Comparison (Nr)	Vehicle	Engine capacity (t)	Fuel	Load weight (t)	Average LF (%)	CO_2 (Kg)	$CO_{2, tkm}$ (t/tkm)
1	Van LGV	≤ 1.25	Petrol	0.540	100	0.982	0.000787
	HGV Rigid	3.5 − 7.5	B20 Diesel	0.540	24.0	1.45	0.000248
2	HGV Rigid	3.5 − 7.5	B20 Diesel	2.20	100	2.45	0.000339
	HGV Articulated	3.5 − 33t	B20 Diesel	2.20	11.6	54.1	0.000238

In table 7, the calibrations from the EcoTransIT database are shown. The results of emitted CO_2 are presented at 1% and 100% LF. The carbon calculations are calculated in the unit t/tkm. In al of the scenarios, higher values of CO_2 t/tkm are shown at 1% LF.

Table 7. EcoTransIT calibrations
The table displays the $CO_{2,tkm}$ values calibrated with EcoTransIT.

Vehicle	Engine capacity (t)	$CO_{2,tkm}$ at 1% LF, (t)	$CO_{2,tkm}$ at 100% LF, (t)
HGV	3.5 – 7.5	0.0223	0.000300
HGV	7.5 – 12	0.0345	0.000400
HGV	12 – 20	0.0500	0.000600
HGV	20 – 26	0.0500	0.000700
HGV	26 – 40	0.0500	0.000700

Empty load transports within Sweden

The calculations regarding the empty transports in Sweden are displayed in table 9. The percentage of empty driven freight transport is 25.5%, which is equivalent to about 459 million kilometres. The equal driven distance per transporting vehicle is 5774.55 km. The dispersion of HGV is clearly shown in table 8. The total amount of emitted CO_2 from freight transports are 32×10^5 tonnes, which can be seen in table 8. The emitted CO_2 economic value in accordance with EU ETS carbon price for October 2014 is calculated to be about 1 844000 € or 17000000 Skr.

Table 8. Values regarding Sweden's transports.
Table nr. 9. Displays the calculated values of empty transports environmental and economic effects in Sweden.

Empty HGV freight transports in Sweden 2014	
ETF in Sweden, (%).	25.5
Empty freight transports distance, (km)	46×10^6
Portion of empty driven km's, (%).	15.2
Driven distance per HGV, (km).	5775
Amount of rigid HGVs (>3.5-7.5t).	2784
Amount of rigid HGVs (7.5-17t).	7391
Amount of rigid HGVs (>17t).	30×10^3
Amount of articulated HGVs (3,5-33t).	40×10^3
CO_2 emitted from empty HGV transports (kg).	32×10^5
Emitted CO_2 economic value in accordance with EU ETS carbon price, Oct 2014, (€).	18×10^5

Emitted CO_2 economic value in accordance with EU ETS carbon price, Oct 2014, (Skr).	17×10^6

Interview with transporter

Anna-Karin Andersson held an interview on the 11th of May 2016. The shipper in question is interview anonymously and chosen randomly of the 400 shippers that are in cooperation with Packbud Nordic AB. The questions and answers have been translated to English from the original Swedish version.

1. What are the benefits for you as an entrepreneur to work with companies, which work on optimising the load factor?

   The only reason is that it improves the fill rate of my transports.

2. Has the cooperation with Packbud benefited you financially?

   Yes it has.

3. Does your strive to run your transports with full loads? If, and if so, how

   Yes we do, you basically search for work wherever you can. We put bids and offers on the available transports that we can offer.

4. Do you have any idea of how often you run with full loads?

   No, I don't.

5. Are you aware of the environmental impact of transportation with low fill rate have on the environment?

   No, I have No idea.

Business opportunities

In this section business opportunities regarding LF in road freight transports are addressed. The results derive from personal communications Packbud. Packbud performs as an example in this study and is not meant to be an overall perception on business opportunities within this sector.

During the 3 years that Packbud has been active more than 10000 transport inquiries have been made by individuals have been made. With every mediated transport administered by Packbud, Packbud takes an administrative charge of

75SEK (8.15€ (Riksbank, 2016a) of the buyer. Packbud also takes a 10% commission of the transport fee of the shipping company (Funa, 2016).

Discussion

In this study, 3 calculation programs where used. The motivation for choosing the 3 programs is simply to see the potential differences between them. There are several carbon footprint programs in the world and al of them differs in a certain way. The 3 programs require different types of input data from the user. Of the 3 programs, DEFRA and GHG Protocol is the most similar to each other. Both of them are based in Excel where the user does the calculations. In EcoTransIT the calculations are made by the webpage after typing in the certain scenario. All of the 3 programs offer a certain portion customisation in your calculations. DEFRA offers a high customisation within fuel consumption and fuel types but only has 3 options of LFs. GHG Protocol can customise both fuels and LF however the user has to know the certain payload and curb weight of the vehicle and only scopes 1 and 3 are available. Finally EcoTransIT offers a high customisation in LF and ETF but not in fuel consumption or fuel type. Depending on what information the user has on the transport, 1 of the 3 programs is more suitable.

Calibrations

In 83.3 % of the 24 calculations with GHG Protocol and DEFRA, GHG protocol showed higher values than DEFRA. The average differences between the 2 programs are 3.07kg/km at 100% LF and 1,76kg/km at 1%LF. The difference between the 2 programs may be due to a number of reasons. The emission factors used in the DEFRA program derives from measured road statistics from the DFT (DECC, 2015). As earlier mentioned, GHG Protocol's emission factors originates from DEFRA and EPA, however the program does not disclose what areas in the program are derived from each source. Because of this, we cannot by certain know that the same emission factors where used. Future studies are needed in order to get a full evaluation.

The results show that vehicles with diesel engines emit approximately 10% more CO2 than petrol engines. This was slightly expected because the emission factors in fuel use, used in the DEFRA program is higher for B20 diesel than petrol. Because the source of GHG protocol's emission factors is unknown, the differences in the fuel use emissions factors are also unknown.

By calibrating (t CO_2, $_{LF1}$)/(t CO_2, $_{LF100}$), the percentage of emissions emitted because of the curb weight and it's 1% LF is shown. With a lower percentage more emissions stems from the weight of the load. If a bigger share of the emitted CO_2 from the load, then a higher CO_2 reducing potential could be achieved. The vehicles with lower percentages are found among the larger vehicles, such as the articulated HGVs.

In table 7, 2 comparisons were made in order to see what saving potentials could be achieved by changing vehicles when transporting a specific weight. In the first comparison between a small van and a rigid truck, using the rigid HGV will emit approximately 69 % less CO2 per tkm. In the second comparison, using the articulated HGV emits 30 % less CO_2, which is close to Woodrooffe & Ash's (2001) findings.

As assumed EcoTransIT showed higher values of CO_2 emissions because of the wider range of factors accounted for in the calculations. As earlier mentioned in the method section, EcoTransIT operates by calculating with a WTW assessment instead of scopes (Knörr et al., 2014). Since not all 3 scopes are calculated in GHG Protocol and DEFRA, one could only expect that there would be higher values shown by EcoTransIT. In table 8, the scenarios calculated by the EcoTransIT database are shown. In all of the calculated vehicles, less CO_2 (t/tkm) is emitted at 100% LF. Greater differences in CO_2 (t/tkm) are seen among vehicles with higher engine capacities. Table 8 also shows, that as the LF increases the emitted CO_2 per (tkm) decreases. By calibrating the CO_2 emissions in (t/tkm), one can more easily see the relation between CO_2 saving possibilities and LF.

By stating these facts one can state that, by increasing the LF of a vehicle or by changing vehicle to one with a higher engine capacity, savings in CO_2 emissions can be made. This conclusion is in agreement with Rizet et al., (2012), McKinnon et al., (2010) and Woodrooffe & Ash 2001 founding's.

The importance using a vehicle with a higher carrying possibility is also stressed. The CO_2 saving possibilities are significantly greater in both rigid and articulated HGVs, however an effective coordination is needed. If coordinating shipments in a particular transport is deemed too difficult to implement then a smaller LGV is recommended. By using a smaller LGV less CO_2 is emitted. Once eco-driving is taken into consideration even a greater reducing effect in CO_2 emissions can be achieved. One can also clearly state that the results of carbon calculation are highly influenced by what program is used.

Empty transports

The ETF of national transports in Sweden in 2014 was calibrated to be 25,5 %, which is within the European average and in line with McKinnon et al., (2010)

results. The calculated ETF for 2014, is a 2.1% rise from the average 23.4% registered in the years 2001 to 2009 registered in the Swedish transport agency's (2011) report. Sweden's carbon taxation is one of the highest within the European union and was once implemented; the earlier energy tax was unchanged. As the EU ETS got into place, countries where high carbon taxation already existed, exclusions in taxations where gradually implemented (World Bank, 2014).

The cost of empty transport in Sweden in 2014 was worth approximately 184 000€ or 17 000 000 SEK, which is a considerable amount of money. This realisation of potential waste, could maybe serve as an additional incentive for decreasing the share of ETF.

The interview

The questions in the interview were about intentions, financial situation and environmental awareness. The interviewed transporter is currently in collaboration with an LSP. The answers given from the person was quite short and straight to the point. In question 1, the person fully declared that the reason for the co-operation is in order to increase profit.

Kellner & Igl (2015) discusses what determines the choice of logistics networks. Here just as in the interview, the potential profit is undoubtedly what determines the choice, however choosing an option that is more environmentally friendly has several possible benefits. Choosing a more environmentally sustainable logistics network can be an opportunity to stand out among competitors with effective marketing. Even though the general awareness is quite low, Schniederjans & Starkey (2014) recommends governments and organisations to encourage greener transports solutions.

In question 2, the person acknowledges that the collaboration has benefitted the company financially. The economic gain that is related to the cooperation with Packbud is directly linked to the amount of completed transports. In order to get possession of a transport, which is proposed by an individual, the company has to offer the lowest price among its rivals (Funa, 2016). The rivalries between the competitors' presses down the price of the transport. Even though the price is potentially low, it will possibly make costumer to return.

Question 3, involves what goals are made concerning the LF in the transports made by the company. The answer is given in a strictly financial perspective, with no environmental awareness shared. The lack of environmental point of view is not surprising, since the public awareness is low but maybe also because of the slow adaption to climate change within the transport sector.

The questions 4 and 5 are closely related to each other. Since overall awareness of sustainable transports is low, the answers given are slightly expected. Once the

interviewed person was told about the actual inefficiencies of freight transport in Sweden, the person had never thought of the environmental effects connected to low LFs. Since the transport companies in Sweden have no obligations in registering the LF in transports, fewer incentives learning about the effects of low LF and ETF are expected.

Economic potentials

During the 3 year of Packbud operating as an LSP more than 10 000 proposing transports from individuals have been made (Funa, 2016). This is a great testament to WTP and to the positive association to sustainable solutions in transport, as discussed in (Schniederjans & Starkey, 2014).

By having a low cost in mediating transports, as an LSP and having it shared both by the individual proposing the transport and the transport company hypothetically could raise the incentives from both areas to stay and continue using the LSP.

The many-to-many logistics network was found by Kellner & Igl (2015) to be the most environmentally friendly network, with 8.9% less GHG emitted than average. More than half of the transport mediated by Packbud goes into filling already planned transport (Funa, 2016). This strengthens the many-to-many network usage and the benefits of this are worth marketing.

The Swedish Transport Agency (2011), argues that changes in infrastructure and informative instruments would have a low effect in increasing the LF in Sweden. There is a knowledge gap regarding LFs in the Swedish transport sector and because of this further studies in LF in Sweden are recommended (Swedish transport agency, 2011).

Even thought the need for rising awareness is stressed by Schniederjans & Starkey (2014) as well as from Cruijssen (2012), the awareness is rising gradually. The cost of inefficiency as earlier mentioned in the introduction, is a vast amount of money. Once the adaption of climate change is under way in the transport sector, on can expect a decrease in the amount of transports driven in relation the overall expected rise within the global freight sector. One possible outcome is seeing a rise in green transportation companies as well as environmentally oriented jobs in the transport sector.

Conclusion

In conclusion we can clearly state that increasing LF and ETF is an effective way in decreasing CO_2 emissions. The greatest saving potential in CO_2 emissions are seen in vehicles with higher payload capacities and where the curb weight is responsible for the least share of emitted CO_2, in a fully loaded vehicle.

By transitioning the load of a fully loaded LGV with the engine capacity $\leq 1.25t$ to a HGV with 3.5- 7.5t engine capacity, 70 % less CO_2 emissions are released. A similar comparison between a rigid and articulated HGV shows a CO_2 emissions saving potential of 30%, which is close to Woodrooffe & Ash's (2001) findings.

The ETF accumulated in Sweden's freight transport was calculated to be 25.5% of all transport, which is a 2.1% increase since the latest official report was made. The current inefficiencies within freight transports in the European union can possibly give away for a wide range of opportunities. The present main challenge for governmental bodies are organisations, is raising the awareness of more sustainable solutions within freight transports. Further research is needed on packaging logistics and willingness-to-pay in order to push the European adaption policies forward.

A fair share of negative perspectives has been shared in this study regarding the transport sector and its low LFs however the expanding transport sector has brought many positive things, including bringing the economy forward and thereby raising the prosperity of societies.

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