The logistics of wood chips in Estonian conditions – a case study

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Abstract

Year by year, the production and transportation of wood chips have increased in Estonia. The maximum gross weight of a road train is 44 tons, hence it is not feasible to use trailers with a capacity of more than 90 m^3 because the moisture content of wood chips varies considerably and it is not recommended to exceed the weight restriction. As the majority of wood chips is cut right by the road side in Estonia, the entire process depends greatly on the weather and affects also the vehicles' fuel consumption, since high precipitation and extremely variable temperatures (-35°C...+35°C) result in changing road conditions.

Consequently the goal of the case-study was defined – to analyse the price formation of wood chips in Estonian conditions. Within one year, all expenses related to a total of 9 vehicles on fuel, manpower and spare parts were examined. The vehicles were divided into 3 groups according to their transport routes. All vehicles were equipped with a GPRS tracking system that provides information on fuel consumption, working hours, driving speed and itinerary in real time and this data were later used to obtain a detailed overview. The fuel consumption varied between vehicles with different transport routes throughout the whole year. As it is very difficult to use the logistic solution of minimising the number of unladen journeys, all costs per each travelled kilometre should be reviewed. The group of vehicles with the lowest fuel consumption included three-axle trucks and the largest item of expenditure was fuel. However, transportation of wood chips with two-axle trucks proved the most inexpensive, because, considering total expenditure, the cost of one travelled kilometre was the lowest.

Key words: wood chips, logistics, production cost

Introduction

Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources is aiming to reach the '20-20-20' goal. The national 25% overall target for the share of energy from renewable sources in the final consumption of energy in 2020 was stated for Estonia. Achieving these goals requires a significant increase in the use of wood as a renewable energy source which may put a strain on the local wood market as the demand for wood fibres of similar quality will increase.

Furthermore, logistics costs gain an important part in the total delivered costs of biomass. [1]

In Estonia up to now the producers of wood fuels have not yet adequately analysed the production and transport costs although it is known that the share of these costs is up to 1/3-1/2 of the final price of wood chips. Consequently the goal of the case-study was defined – to analyse the price formation of wood chips in Estonian conditions.

It may be concluded that the optimal technological solution for the transportation of wood chips in Estonian conditions is a 90 m^3 semi-trailer with a moving floor. A larger capacity of the trailer is not available since the weight restriction on Estonian roads is 44 tons and the weight of a truck loaded with wet chips may exceed the maximum allowable weight. The largest share of transport costs accounts for the expenditure on fuel, manpower and repairs. During the study the average age of observed vehicles was 7 years and this may lead to relatively high costs of repairs. For comparison the data concerning trucks with a maximum age of 2 years was analysed to find out the impact of higher capital costs and lower fuel consumption and maintenance costs on total transport costs.

So far, it has been reported that transport methods for unprocessed raw material are seldom used because of the high unit weight transport costs and high handling costs at the receiving facility [2].

According to the statistical forest inventory, the area of forest land in Estonia is 2.21 million ha. Based on the prepared forestry development plan until 2020, the maximum use of wood arising from the age distribution of Estonian forests could, in short term, reach 22 million m^3 per year; the sustainable long-term goal being 12-15 million m^3 per year. [4]

The main problems occurring in the use of biomass include unstable forest use volume, sporadically insufficient reforestation and low cost-efficiency of used biomass harvesting. Similar studies on the logistics of wood chips have not been conducted in Estonia so far and therefore, no comparative material from earlier studies is unavailable for reference.

The efficiency, productivity and cost of long-distance transportation depend on factors such as the form of the transported material, the solid volume content of the material, the moisture content, the transportation distance and the technical properties of the transport vehicle used. On average, the transportation costs for forest chips and bundles make one-third and for loose residues half of the total supply costs in Finland [6].

By the end of 2012, the nominal power of generating installations operating on renewable energy in Estonia was 363.4 MW. According to the Estonian National Renewable Energy Action Plan until 2020 (NREAP), the target for 2020 is to increase the nominal power of generating installations operating on renewable energy up to 727 MW, which means a growth of 363.6 MW. [3]

In Estonian conditions, only road transport is used internally for transporting wood chips. Rail transport is not used due to problems with ordering suitable transport wagons and increasing costs of repeated loadings, since no larger CHP is located near a railroad. Furthermore, the disadvantage of railways is the relatively dense motorway network in Estonia and since it is a country with a small territory, local distances remain too short for cost-efficient rail transport. Shipping is only used to export wood chips from Estonia, since internal waters are not navigable and there is no proper integrated network of harbours in internal water bodies.

SLG Energy OÜ has been operating since 2004 and is one of the largest producers and transporters of wood chips in Estonia. Outside Estonia, the company is also present in

Latvia, Lithuania, Finland, Sweden and Russia. The company's annual output of wood chips in 2013 was 1,114,460 bulk cubic metres produced by drum chippers and 214,279 bulk cubic metres produced by hammer mills.

Materials and methods

Within one year of the survey initial data from SLG Energy OÜ was collected. Three different types of trucks (55 in total) were observed – trucks with a rear driving axle ensembled with a semi-trailer with a moving floor, trucks with double driving axles ensembled with a semi-trailer with a moving floor and multi-lift trucks with a trailer. All trucks were equipped with a GPRS tracking device which records the route and the fuel consumption. During the observation period all costs and revenues related to the concerned machines were accounted. As the machines were monitored throughout the year seasonal variation in fuel costs could be determined and also the impact of the load, volume and moisture content could be observed. On the basis of the results of the study suitable technologies and logistic solutions for Estonian conditions were specified.

The study also reveals the variation in fuel consumption depending on climate conditions. To retrieve this information, the average temperature of each month in Estonia was entered in the databases and later used for evaluating the effects of temperature on fuel consumption.

Multi-lift trucks have Volvo FH500 as the traction unit with the year of production of 2012. These trucks utilise two containers when travelling with a full load, the total capacity reaching 76 m^3. All studied semitrailers are produced by MAN within the period of 2004-2007. Trailers with a moving floor are manufactured by Carnehl and Reich and their capacity is 90 m^3. It would be considerably more effective to use trailers with a larger capacity but they are subject to the weight restriction imposed in Estonia.

In Finland, there are restrictions related to the physical dimensions of the truck-trailer combination regarding total length (25.25 m), width (2.55 m) and height (4.2 m). Weight restrictions limit gross vehicle weight to 60 tonnes for a 7-axle truck-trailer combination and for longer module combinations. This gives a possibility for large variation in the load volume capacity with a practical maximum of 145 m^3 for truck-trailers. [7]

The tracking system used is Navirec. The Navirec system enables to monitor the cars supplied with a GPS (*Global Positioning System*) in real time. Data communication is forwarded by using the GPRS- ***G****eneral* ***P****acket* ***R****adio* ***S****ervice* system which guarantees the constant flow of data, as a result of which the constant monitoring of cars on the location map is possible. Additional information such as speed, coordinates and all other required matters to get an adequate overview of the movement and functioning of the car can always be monitored in the information window. All that is required is a web browser and a small device that is placed inside the vehicle. [5]

To determine fuel consumption, it was checked in each vehicle on a daily basis separately for journeys with a full load and unladen journeys. To the latter, fuel consumption in idle time (waiting time) was added.

Results

The observation period extended from 01.09.2012 to 30.08.2013. During the period, the actual mileages of all vehicles were detected and resulting from this, also the fuel consumption was registered, which is the main item of expenditure in the transportation sector. In addition to fuel consumption, the mileage, costs on manpower, depreciation, repair costs and insurance costs were ascertained for each vehicle. During the observation period, the 9 examined vehicles travelled a total of 460,399 kilometres. The total fuel consumption for travelling the given distance was 189,684 litres, which constitutes the annual average fuel consumption of 0.413 l/km per vehicle.

Rear-driving axle trucks

Among rear-driving axle trucks, two of them were manufactured in 2005 with engine powers of 287 kW and 316 kW. The engine power of the third vehicle was 338 kW and it was produced in 2004. During the observation period, these vehicles travelled a total of 168,668 kilometres and their average fuel consumption was 0.419 l/km. The fuel consumption in laden journeys was 0.476 l/km and in unladen journeys it was 0.362 l/km.

The distribution of costs is shown in Figure 1. Based on the figure, it may be concluded that in the case of two-axle trucks, the major item of expenditure was fuel, which made up 43% of total expenditure. Fuel consumption was followed by costs on manpower, which constituted 29% of total expenditure. Repair and maintenance costs attributed to 13% and depreciation comprised 12% of total expenditure. Costs on insurance were the lowest and only made up 3% of total expenditure.

Figure 1

Double driving axle trucks

Among double driving axle trucks two of them were produced in 2005 and their engine power is 316 kW. Another vehicle was manufactured in 2007 with an engine power of 353 kW. During the observation period, all these vehicles travelled a total of 150,419 kilometres and their average fuel consumption was 0.381 l/km. The fuel consumption in laden journeys was 0.441 l/km and in unladen journeys it was 0.322 l/km.

The distribution of costs is shown in Figure 2. Based on the figure, it may be concluded that the major item of expenditure in three-axle trucks was fuel, but its proportion was smaller than in two-axle trucks, forming 39% of total expenditure. Fuel consumption was followed by costs on manpower which constituted 29% of total expenditure, being similar to the cost in the case of two-axle trucks. Repair and maintenance costs attributed to 15% and depreciation 14% of total expenditure. These costs were higher compared to two-axle trucks. Costs on insurance were the lowest and only made up 3% of total expenditure.

Figure 2

Multi-lift trucks

All multi-lift trucks were manufactured in 2012 and their engine power was 375 kW. During the observation period, these vehicles travelled a total of 141,312 kilometres and their average fuel consumption amounted to 0.440 l/km. In laden journeys, the fuel consumption was 0.502 l/km and in unladen journeys it was 0.378 l/km.

The distribution of costs is shown in Figure 3. Based on the figure, it may be concluded that, as with other groups of vehicles, the largest item of expenditure in the case of multi-lift trucks was fuel which constituted 34% of total expenditure. Fuel consumption was followed by, differently from other groups of vehicles, depreciation costs which attributed to 31% of total expenditure. Costs on manpower formed 29% and costs on repair and maintenance comprised 5% of total expenditure. Similarly to the other types of vehicles, insurance costs were the lowest, making up a mere 1% of total expenditure.

Figure 3

Fuel consumption depending on temperature

In using collected data, we added the monthly average temperature to the monthly fuel consumption data. These data are shown in Figure 4.

Figure 4

Figure 4 clearly shows the changes in fuel consumption depending on changes in temperature. Unfortunately, there were no periods with a very low average temperature during the observation period, otherwise the influence of temperature on fuel consumption would have been even more vivid. In order to obtain a comprehensive overview of the changes in the fuel consumption for each group of vehicles in both unladen and laden journeys, we added the results on all vehicles in a joint figure.

Figure 5

Figure 5 depicts the changes in the fuel consumption of all trucks with a different transport route in laden and unladen journeys depending on changes in temperature. It indicates that the vehicles with the highest fuel consumption were multi-lift trucks and that applies for both laden and unladen journeys. In the case of unladen journeys, the fuel consumption of two-axle vehicles was almost as high as in multi-lift trucks when the temperature dropped below 0°C. This kind of a change in fuel consumption was, however, not evident in laden journeys.

By summing up all costs incurred during the observation period on different types of vehicles, we were able to compile a table of expenditure which also shows the vehicles' mileages during the observation period.

Table 1

Costs on manpower were the highest in the case of multi-lift trucks, which can be explained by their higher mileage compared to the other vehicles, as the travelled kilometre is also one of the components of wages. Two-axle and three-axle trucks incurred approximately equal repair costs within a year, although the cost per travelled kilometre was the highest in three-axle trucks. The repair costs of multi-lift trucks are low because the trucks are new and they do not need much repair. Depreciation costs are directly related to a vehicle's accounting value; these costs were the highest in multi-lift trucks.

Discussion and conclusions

Based on the data given above, it may be firmly suggested that the largest item of expenditure in wood chips logistics is fuel, which may, depending on the number of axles in a vehicle, constitute up to 43% of total expenditure. Fuel consumption in multi-lift trucks formed 34% of total expenditure, thus being the lowest, since these trucks are considerably newer than the other studied vehicles, so the result was expected. Costs on manpower accounted for an equal share in total expenditure for all three types of vehicles, amounting to 29%.

If in older vehicles (two-axle and three-axle trucks), costs on manpower ranked second, the second largest item of expenditure in multi-lift trucks was depreciation, which is a highly likely result for new vehicles. In two-axle and three-axle trucks, repair costs were always higher than depreciation costs by 1%, whereas in multi-lift trucks, repair costs made up only 5% of total expenditure, which is expected in new vehicles. The proportion will presumably rise as mileage increases. Insurance costs made up 3% of total expenditure in two-axle and three-axle trucks and was even lower in multi-lift trucks with 1%.

Surprisingly, three-axle trucks proved the most fuel-efficient, with their annual average fuel consumption per kilometre being 0.381 l/km. This number was the lowest compared to the other vehicles on both laden and unladen journeys. The annual average fuel consumption of two-axle trucks was 0.419 l/km and that of multi-lift trucks was 0.440 l/km. Multi-lift trucks demonstrated the highest annual average fuel consumption also on laden and unladen journeys.

Analysis of gathered data indicated that two-axle trucks had the lowest cost per each travelled kilometre, which was not expected, because the vehicles with the lowest fuel consumption were the three-axle trucks. Although the share of fuel consumption in total expenditure is large, the cost per travelled kilometre cannot be calculated for the vehicles by using only this component, because the final price of a travelled kilometre is determined after all items of expenditure have been taken into account. Although the multi-lift trucks are considerably newer than the other studied vehicles, their cost per kilometre is much higher than that of older trucks. Moreover, the capacity of bulk transported with multi-lift trucks on a single journey is only 76 m^3 compared to the 90 m^3 in other types of trucks, which increases the cost of each bulk cubic metre of transported material by 15%, because the amount transported on a single journey is smaller.

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Extended Summary

Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources is aiming to reach the '20-20-20' goal. The national 25% overall target for the share of energy from renewable sources in the final consumption of energy in 2020 was stated for Estonia. Achieving these goals requires a significant increase in the use of wood as a renewable energy source which may put a strain on the local wood market as the demand for wood fibres of similar quality will increase.

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age of 2 years was analysed to find out the impact of higher capital costs and lower fuel consumption and maintenance costs on total transport costs.

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The observation period lasted from 01.09.2012 until 30.08.2013. During the period, the actual mileages of all vehicles were detected and resulting from this, also the fuel consumption, which is the main item of expenditure in the transportation sector, was determined. In addition to fuel consumption and mileage, costs on manpower, depreciation, repair costs and insurance costs of each vehicle were ascertained.

The largest item of expenditure, as expected, was fuel, which was followed by costs on manpower and then, depending on the type of vehicle, by repair costs or depreciation costs.
During the observation period, the 9 examined vehicles travelled a total of 460,399 kilometres. The total fuel consumption for travelling the given distance was 189,684 litres, which constitutes the annual average fuel consumption of 0.413 l/km per vehicle.

Surprisingly, three-axle trucks proved the most fuel-efficient, with their annual average fuel consumption per kilometre being 0.381 l/km. This number was the lowest compared to the other vehicles on both laden and unladen journeys. The annual average fuel consumption of two-axle trucks was 0.419 l/km and that of multi-lift trucks was 0.440 l/km. Multi-lift trucks demonstrated the highest annual average fuel consumption also on laden and unladen journeys.

Costs on manpower formed 29% of total expenditure in the case of all three groups of vehicles. Insurance costs made up 1-3% of total expenditure depending on the type of vehicle.

Analysis of gathered data indicated that two-axle trucks had the lowest cost per each travelled kilometre, which was not expected, because the vehicles with the lowest fuel consumption were the three-axle trucks. Although the share of fuel consumption in total expenditure is large, the cost per travelled kilometre cannot be calculated for the vehicles by using only this component, because the final price of a travelled kilometre is determined after all items of expenditure have been taken into account.

In the given study, the costs on two-axle trucks were lower compared to the three-axle trucks per each travelled kilometre, resulting in the price of 0.997 euros per kilometre in two-axle trucks and 1.090 EUR/km in three-axle trucks. Although the multi-lift trucks are considerably newer than the other studied vehicles, their cost per kilometre is noticeably higher than in older vehicles, reaching 1.468 EUR/km. Moreover, the capacity of bulk transported with multi-lift trucks on a single journey is only 76 m^3 compared to the 90 m^3 in other types of trucks.

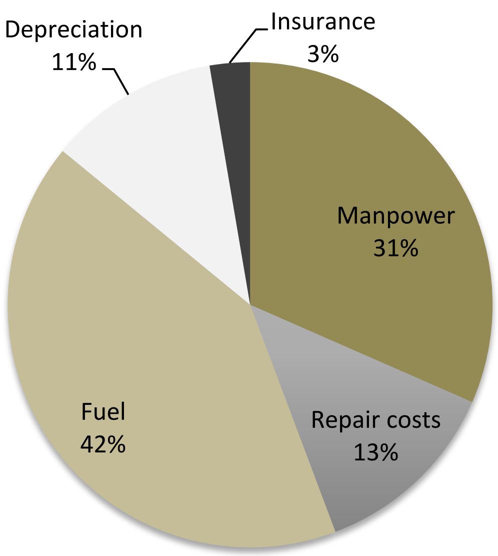

Figure 1. Rear driving axle trucks

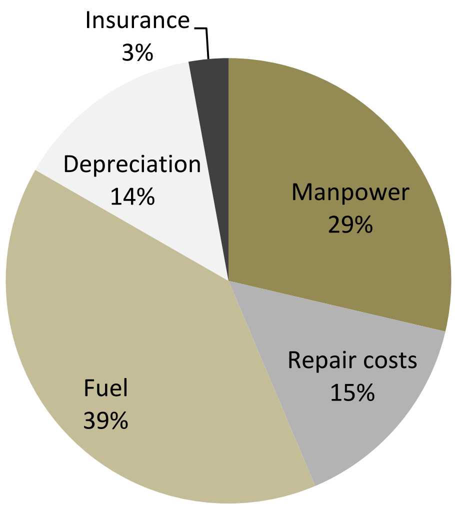

Figure 2. Double driving axle trucks

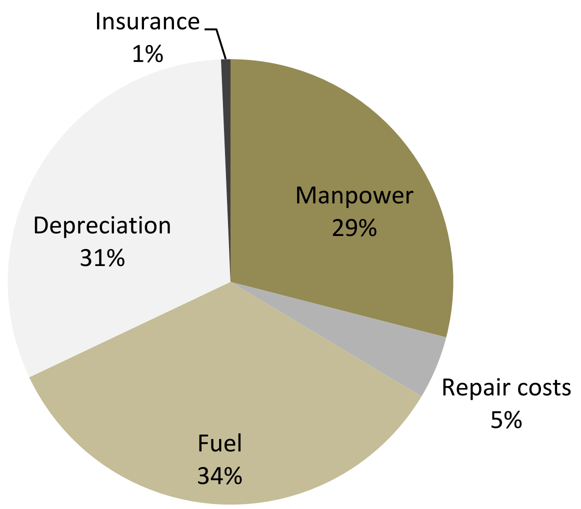

Figure 3. Multi-lift trucks

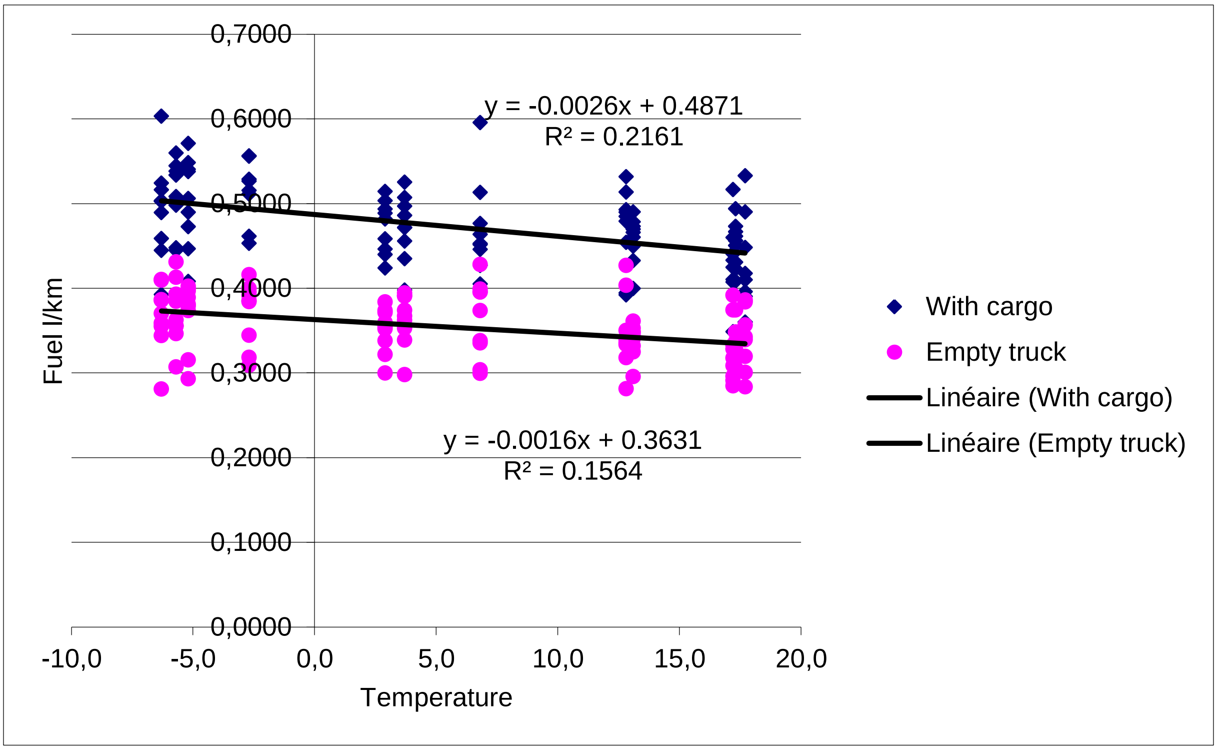

Figure 4. Differences in fuel consumption depending on temperature

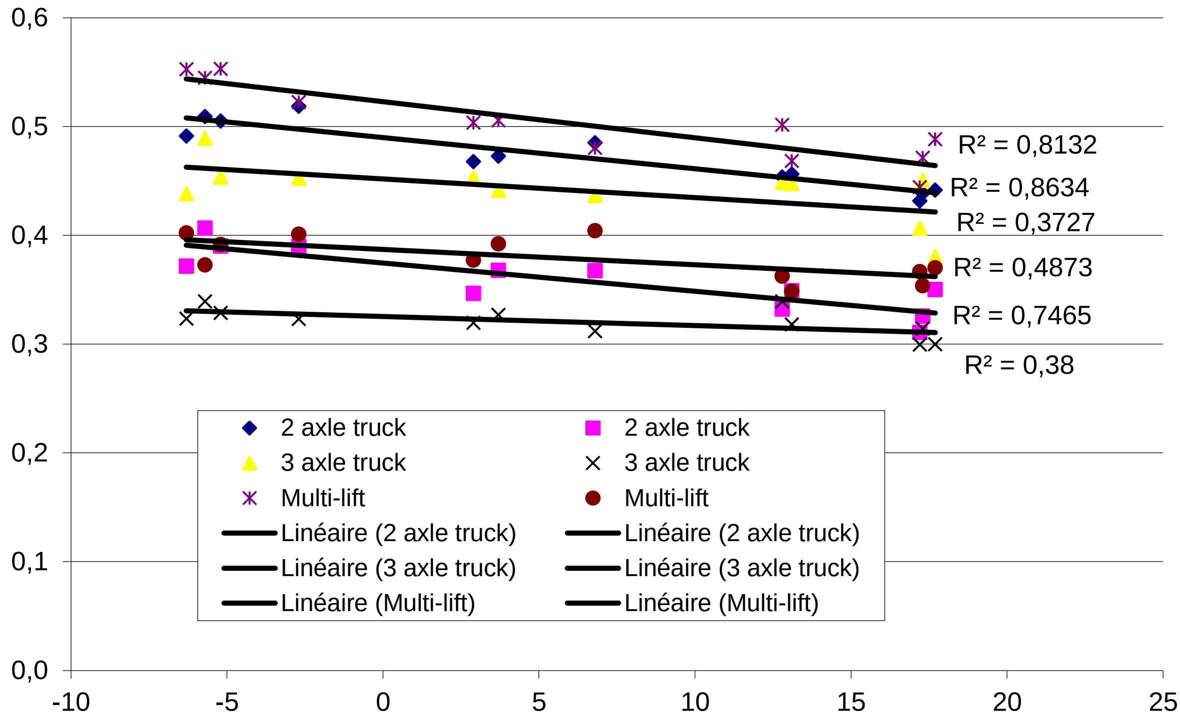

Figure 5. Changes in fuel consumption in vehicles with a different number of axles depending on temperature

Table 1. Total expenditure and mileage

	2-axle trucks	3-axle trucks	Multi-lifts
Manpower (EUR)	53078	46991	60192
Repair costs (EUR)	21366	24567	9540
Fuel (EUR)	70027	65026	71278
Depreciation (EUR)	19150	22673	65088
Insurance (EUR)	4509	4716	1413
Total cost (EUR)	168130	163973	207511
Haul distance, km	168668	150419	141312
EUR/km	0.997	1.090	1.468