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A short review of timber truck fuel consumption studies

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Introduction

Transporting woody products by timber trucks is costly due to long travel distances between plantations and mills. Transportation cost accounts for more than 25% of the forestry costs (Svenson and Fjeld, 2016). Higher operating costs may occur due to increased fuel costs. Higher fuel usage will also cause significant emissions to the environment. Transportation is the most fuel consuming element of a wood supply chain in Australia and other countries (Ghaffariyan et al. 2015; Griffin and Brown, 2010). For instance, in Sweden, secondary timber transport consumed about 50% of total fuel usage while harvesting and extraction operations consumed 33-40% (Lindholm, 2006). To reduce the fuel consumption costs, it is important to understand the impact of the different factors such as transport distance, truck weight and payload. This report aimed to review previous studies to achieve the following objectives;

- to create an international data base on truck fuel consumption.
- to examine the relationship between fuel consumption per 100 km and payload

Data collection and analysis

Fuel consumption of timber trucks were collected through a literature review. The studies were carried out in Austria (Kanzian et al. 2006; Fenz and Stampfer, 2007; Kuehmaier et al. 2007; Affenzeller and Stampfer, 2007; Holzleitner et al. 2011; Stampfer et al. 2011), Sweden (Svenson and Fjeld, 2016), Czech Republic (Klvač et al. 2013) and Ireland (Devlin, 2010). The information on truck fuel consumption from each mentioned case study were obtained through the review which formed 20 cases of fuel usage. Then the data were put into an Excel based spreadsheet (Microsoft Excel). For each case study the following information was recorded in the data base; author(s)/reference, country, truck type, transport distance, payload, gross vehicle mass (GVM), fuel consumption (L/100 km). Regression method was applied to examine the relationship between fuel consumption and truck payload.

The former Forest Engineering Research Institute of Canada (FERIC) has developed an empirical model to predict timber truck fuel consumption (with GVM varying from 42 t to 62 t) based on transport distance and road types. The model was developed through the compilation of several field study data sets that measured fuel consumption across a range

of forest transportation operations in Canada supplemented and validated with a truck drive terrain simulator OTTO (Michaelsen, 2000). The road types included paved, gravel, dirt and track. As most of the international studies did not mention the road type to compare the Canadian model versus international studies a weighted average was used to calculate fuel usage for Canadian model. It was assumed that 70% of transport distance was within the paved roads, 10% with gravel road, 10% with dirt and 10% with track. The Canadian model had been designed to calculate fuel consumption based on GVM however in this study it was converted to be based on payload to enable comparisons with Australian model.

As there has been little information available on the timber truck fuel usage in Australia the general truck fuel and cost simulator (http://www.sustainablefreight.com.au/tools-and-programs/emission-calculators/truck-fuel-emissions-and-cost-calculator-and-comparison-tool) was used to predict the fuel usage of various truck configurations versus payload. The data were then put in Excel work sheet to develop a regression model. The Canadian, international and Australian fuel consumption predicting models were graphed against payload to check the relevance of the Canadian model for predicting international fuel consumption.

Results

The important parameter impacting the fuel consumption was payload. A linear regression model was developed to predict the fuel consumption based on payload of the international studies. The model correlation ratio was 0.84 and the model is expressed as follows;

Fuel consumption for international timber trucks (L/100 km) = 1.6619 × Payload (t) + 2.8612
R^2= 0.84, number of observations=20

The Canadian and Australian models were also developed using a linear function as following;

Fuel consumption for Canadian timber trucks (L/100 km) = 1.755 × Payload (t) + 11.284
R^2= 0.99, number of observations=11

Fuel consumption for general Australian trucks (L/100 km) = 0.8601 × Payload (t) + 24.625
R^2= 0.91, number of observations=21

- Three models were developed for the same range of payload (about 20 t to 50 t) to make a reasonable comparison. Based on Figure 1 increasing truck payload will result in higher fuel consumption as a linear function. Canadian model predicts the higher fuel consumption compared with international or Australian model which might be due to relatively old data which used early electronic engines so generally more

efficient in productivity but higher fuel consumer. Assuming the Australian data is based traditional trucks, the bigger trucks will be almost exclusively long-haul highway which drives down that end of the chart as compared to the shorter distance, mixed roads and slower travel speed of the forestry trucks at that weight Higher fuel costs in Europe tend to motivate more efficient driving habits. Although various international data were used in this review, other truck characteristics (such as truck type, brand, engine power, travel speed and tare weight, driver behaviour, tyre types, road standards including vertical and horizontal alignment, etc.) need to be considered in future research. Road surface type can impact rolling resistance which will influence the fuel consumption. In the literature the transport distance varied from 16 km to 435 km however the percentage of paved/gravelled road was not consistently reported and may have an important influence.

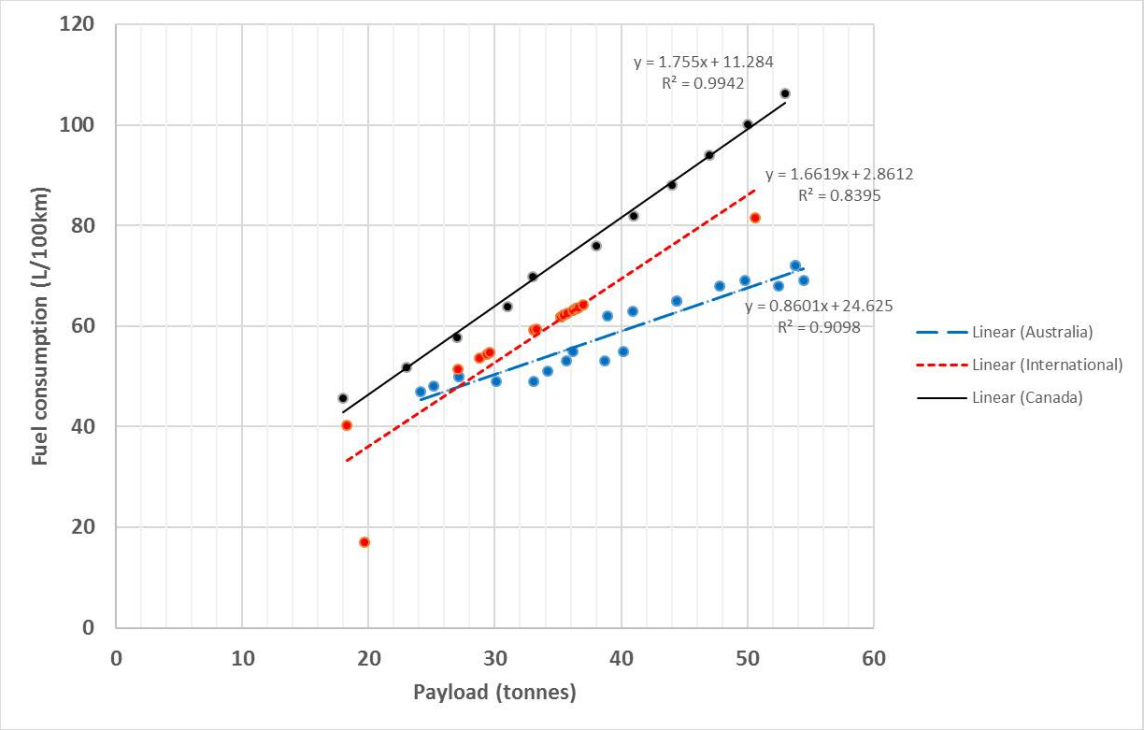

Figure 1. Impact of payload on fuel consumption for international model (dash red line), Canadian model (solid black line) and Australian model (dash blue line)

Table 1 presents the predicted fuel consumption (L/100km) for three models for five payload categories. For any payload less than 27.25 t the international model predicts lower fuel consumption than Australian model (and Canadian one). For payloads larger than 27.25 Australian model predicts lower rates than other models (reasons mentioned earlier).

Table 1. Predicted fuel consumptions for three models based on payload

Payload (t)	Canadian model	International model	Australian model
20	46.4	36.1	41.8
27.25	59.1	48.1	48.1
30	63.9	52.7	50.4
40	81.5	69.3	59.0
50	99.0	86.0	67.6

Take-home messages

- Payload significantly impacts the fuel consumption of timber trucks.
- Canadian truck fuel consumption model over predicts the fuel consumption compared with international model.
- The Australian fuel consumption model for general trucks might be a guide for the forest industry. To get an accurate estimate of fuel usage future study can develop a fuel usage predicating model for Australian timber trucks with the current operations and road infrastructure.

More information

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