Recenzje spełnia wymogi formalne

Review of Artur Budzyński Thesis

Thesis title : "Forecasting prices for road freight transport services using machine learning".

Silesian University of Technology

Discipline: Civil Engineering, Geodesy and Transport

Przewodniczący Rady Dyscypliny
Inżynieria Lądowa, Geodezja i Transport
Politechniki Śląskiej
prof. dr hab. inż. Piotr Folęga

PhD Supervisor: Professor Aleksander Sładkowski, DSc.

PhD Assistant Supervisor: Associate Professor Marcin Michalak, DSc. Eng.

The Ph-D of MSc Artur Budzyński from Silesian University of Technology is a report of 112 pages and is entitled "Forecasting prices for road freight transport services using machine learning". Two versions of this report were given in Polish and in English. The report is based of an introduction of 5 pages (p.2 - 5), a conclusion of 5 pages (p.103 – 105) and four chapters presented in the table of content p.1. A bibliography of 7 pages is given at the end (p.106 – 112). There is a short and long abstract at the end in the English version.

The Ph-D has a good shape, is very well written, and contents many tables, figures. The reading is easy, the text is well spaced out. Maybe a list of figures, a list of tables, a list of abbreviations could have improved the structures of this report. There is few formal mistakes in the text. P. 91, the table nr. 39 "EU countries GDP" shows "PKB [thousand €]".

The references in the bibliography shows a European open mind linked with this research based on data collection and analysis of price of operation in road freight transport in the European Union within 27 members: the French ECHO survey is mentioned (ref. 29 in the bibliography), data are coming from EUROSTAT. The bibliography is very international (S. Kummer mentioned). Three publications of the author - as co-author - are mentioned:

- Budzyński, P. Malinowski, A. Zaworska, and P. Błaszczyk, "[In Polish: Reduction of empty runs and optimization of cargo space utilization using transport exchanges - case study]," Logistyka, pp. 51–52, 2019.
- Budzyński, "Road transport price : Correlation of rates for road transport services in domestic transport in Poland," Int. Verkehrswesen, vol. 73, no. 3, pp. 65–67.
- A. Budzyński and A. Sładkowski, "Machine Learning in Road Freight Transport Management," in Using Artificial Intelligence to Solve Transportation Problems, vol. 563, A. Sładkowski, Ed., in Studies in Systems, Decision and Control, vol. 563. , Cham: Springer Nature Switzerland, 2024, pp. 485–565. doi: 10.1007/978-3-031-69487-5_9.

In addition, the author presented a research in an international conference:

A. Sładkowski and A. Budzyński, "[In rus. 'Transport exchanges, as one of the promising solutions for the problems of transport logistics']," presented at the Transport bridge Europe-Asia. IV Polish-Georgian scientific and technical conference, Tbilisi, Georgia, 10.10 2018.

Detail review

The main objectives of the thesis is to use machine learning techniques to enhance data analysis in transportation system. A key achievement of this study is that it demonstrates that the model trained using the developed methodology can outperform industry specialists in forecasting accuracy. The model achieved a lower mean absolute percentage error (MAPE) than seasoned professionals. For practitioners, the report shows the average rate of transport costs in Europe of €1.34 per kilometre (given in **Erreur ! Source du renvoi introuvable.**). Similarly, the author observes that "the average price for distances up to 400 km is below the overall dataset average, confirming the hypothesis that higher prices are associated with shorter transport distances" (p. 64).

This study provides a comprehensive analysis of the factors influencing road freight transport pricing and sets a new benchmark in forecasting accuracy. This Ph-D gives a real and accurate contribution in the field of transportation cost forecasting. Maybe, in the introduction, a deeper definition of machine learning – historical foundation, applications in different sectors... - could have helped the reader to understand better and in a wider way the framework of this work.

As we know in the transport sector, distance is a fundamental factor in developing a model to predict the cost of road freight transport services and the research focuses on the distance between the loading and unloading points as a critical determinant of transport costs.

For the models, the Ph-D integrates a lot of complex and large parameters linked with operating of road freight transport : structure of trucks, trailers, form of loading and unloading, vehicules type,... because analyzing the dependency of road freight transport service prices on body type is crucial for understanding the factors influencing pricing in this sector.

The results are clear: as expected, transport distance (KM) has the most significant impact since it directly correlates with operational costs such as fuel consumption, driver working hours, and vehicle wear and tear. The weight of this variable far exceeds that of other factors, underscoring its dominant role in the forecasting model. The report also shows results in terms of seasonality (p.71).

A group of 172 experts was selected to estimate the pricing for five distinct transport scenarios. The report gives us a good analysis of the structure of this expert panel (p. 82-85) : the average error that the experts had was 11.86%, while the model's average was 9.28%, reflecting an improvement of 2.58 percentage points. The analysis reveals that the predictive model outperforms human estimators in all examined transport instances. The reduced error margins of the model suggest higher reliability and precision in forecasting transport outcomes. This performance can be attributed to the model's ability to systematically process and analyze large datasets, reducing the influence of biases and errors inherent in human judgment.

Questions

The thesis shows a very precise knowledge of the parameters determining the activity and operating costs of road haulage.

In general, the thesis could have provided a more operational and up-to-date presentation of the road haulage sector in some of the countries considered, in Poland in particular. For example, on p. 30, the various countries of the European Union are presented according to the International Organization for Standardization (ISO) nomenclature, but the work could have presented some indicators of freight transport activity in the countries under consideration. In addition, the work states "In road freight transport, understanding the geographical relationship between loading and unloading locations is

crucial for several reasons" and this report does not offer any maps, for example when studying the relationship between two loading and unloading points. Taking a precise and existing example of the relationship between a point of departure and a destination, with a map, a type of lorry (photo) could have improved the readability of this work. This remark also applies to the price of diesel: the author could have compared this price between different European countries.

The CNR – National Road Freight Transport Observatory (public body) - carries out interesting "Europe" studies and researches that could have been included in this thesis: https://www.cnr.fr/publications?filter_dynamique_publication=&categories%5B28%5D=28&created=2025&created_from=2025&created_to=2025

A more international approach could have facilitated a global understanding of the sector. A general presentation o f the road freight market in Europe would have been a good idea:

Summary:

ALL ROAD FREIGHT TRANSPORT ACTIVITY PER FLAG – 2022:

Poland: 385,089 t.km (million t.km), 19.7% of the EU27 total; growth: 1.4% (2022/2021) and 588 t.km/GPD

France: 173,353 t.km (million t.km), 8.9% EU27 total, 45.0% of Poland; growth: -0.9% (2022/2021) and 66 t.km/GPD

Source: EUROSTAT

In addition, the analysis of the cost of transport could have been improved in the section "Data transformation methods" (p. 46) : with regard to costs (p.47), the thesis identifies other transport costs as an important indicator: "The feature "OTHER_COSTS" is a significant variable in forecasting road freight transport service prices. These costs are not related to the distance between loading and unloading point but still impact the final price of the service. These costs may include tolls for tunnels, bridges, or ferry crossings" (p. 47). It is right: very important costs elements.

Does the author limit himself to these costs: "vignettes" can be introduced. For Germany, is the MAUT included? Some other tolls can have a significant impact on costs. The cost of toll plays now a major role in the cost of freight transport and are expected to increase linked with the environmental policy of the European union toward decarbonization: " For transport from Poland to Germany (DE), the Czech Republic (CZ), and Slovakia (SK), the euro rates per kilometre are relatively high, reflecting long distances or other factors affecting transport costs." Are tolls not an explanation of this increase?

The author then subtracts "other costs" from the cost per km to arrive at a net cost per km. Are there other costs that need to be removed, for example equalizing working times in Europe? France, for instance, differentiates between working time and driving time and includes loading and unloading time in working time, which means that its cost models and competitiveness lag far behind those of other countries, particularly Poland.

The thesis considers (p. 58) the important role of diesel prices in the cost of road haulage. Here again, a presentation of the comparative cost of diesel in Europe might have been of interest for an overall understanding of the road haulage sector. It can be found here: https://www.cnr.fr/en/prix-gazole-europe

Innovation in the road freight transport sector

On the question of innovation, does the thesis include in its analysis the development of heavy goods vehicles running on hydrogen or batteries? Similarly, in Sweden and Germany, the electrification of motorways with catenaries has been developed. The HGV is connected to the electric motorway network by a pantograph. Can these innovations change the results of the model?

Few mentions are available on the technological change linked with the environmental impact of the road freight transport, only mentioned p..58 : « The focus on eco-diesel fuel prices is particularly relevant due to its growing importance in the transportation sector. Eco-diesel, a biodiesel blend, provides a cleaner alternative to traditional diesel fuel by emitting lower levels of pollutants such as sulphur oxides and particulate matter. P. 104, it is written "requirements for alternative fuels such as electricity or hydrogen", but there is no presentation of these developments

It is also regrettable that there is no mention of multimodal transport, combining road haulage and rail transport, for example as part of the European Union's development of major European rail freight corridors. Road freight transport and long distance rail freight transport on corridors can reduce total costs of the relation between loading and unloading points.

Finally, does the Mega-type trailer mentioned on p. 36 or p.74 represent the megatrucks that have been authorized to circulate in Northern Europe (Sweden, Germany)? It offers a total length of up to 25.25 meters, compared with 16.5 to 18.75 meters for standard trucks in Europe, and a total authorized weight of up to 60 tons or more, depending on the country.

Overall evaluation

I consider the thesis in its present form to be suitable for public discussion and, pending the outcome, recommend that the Candidate be awarded the PhD degree. I can accept all three theses of the Candidate as independent scientific results without any changes.

Considering the assessment of the doctoral dissertation, I believe that it is an original solution to a scientific problem and demonstrates the general theoretical knowledge of the PhD student in the conduct of scientific work. It also confirms the ability to conduct scientific work. It thus meets the requirements of the Act of July 20, 2018, Law on Higher Education and Science (Journal of Laws of 2018, item 1668, as amended). I request that it be accepted and allowed for public defense.

Lyon, 24/03/2025

Professor Laurent Guihéry, CY Cergy Paris University, France, laboratory MATRiS