Report on Bachelor / Master Thesis

Institute of Economic Studies, Faculty of Social Sciences, Charles University in Prague

Student: Renáta Wojnarová
Advisor: PhDr. Jiří Kukačka, Ph.D.
Title of the thesis: Agent-Based Analysis of Market Potential for Electric Vehicles in the Czech Republic

OVERALL ASSESSMENT (provided in English, Czech, or Slovak):

Please provide your assessment of each of the following four categories. The minimum length of the report is 300 words.

The thesis of Renata Wojnarova "Agent-Based Analysis of Market Potential for Electric Vehicles in the Czech Republic" elaborates a very challenging research topic of modelling potential market penetration of electric vehicles on the Czech automotive market. This area is not only interesting economically (from various aspects such as the consumer side in terms of financial costs and benefits of purchasing and operating an electric car; business models of automobile factories; macroeconomic aspects as the automotive industry adds a considerable contribution to exports and GDP in many countries, etc.) but also brings considerable contribution to related debates about ecological and technological aspects of the course of recent substantial innovations in the automotive industry. As a supervisor I have to stress here an extensive amount of time and effort Renata devoted to the elaboration of the topic, especially to designing, programming, and testing her own agent-based model of the Czech environment for both standard and electric vehicles. We spent hours and hours discussing various aspects of the model structure and calibration and the model has been redesigned and augmented many times before it reached the functionality of the current version.

Literature

The topic of the thesis was demanding also because not many "standard" academic sources (articles, textbooks) exist. It was not as in many other bachelor or master theses where a student covers a reasonable number of related papers, than a methodology is described based on a specific paper/textbook and one can then to proceed to further analysis. Renata had to search extensively and repeatedly for a large amount of information in academic papers as well as on the internet (e.g. studies of various governmental/EU bodies as well as NGOs, costs by energy companies, or technical details provided by automobil factories), analyse them critically and connect them into a consistent framework on which she was able to base her cost-benefit analysis and the calibration of the agent-based model. The literature review is thus not a "separated" section/chapter of the thesis but naturally pervades several sections and chapters of the work. Regarding the ABM part, Renata gained an important part of her knowledge from a textbook by Railsback and Grimm (which is to the best of my knowledge one of only two textbooks for agent-based modelling in NetLogo) and also cites several most influential papers of the field. To my mind, the agent-based literature overview might have been broader in this section, e.g. some other transportation agent-based models might have been shortly referred.

Methods

In her thesis, Renata in fact combines three methods into an overall analysis of her research hypotheses. First, a static cost-benefit analysis of the purchase, usage and maintenance of an electric vehicle is compared it with the case of a standard car. Ecological and social impact (emissions, batteries manufacturing) is considered first and then a "standard" cost-benefit analysis from a Czech consumer viewpoint follows.

Second, Renata develops her own agent based model calibrated for the Czech environment in which she is able to study various scenarios of potential support for electric vehicles in the Czech Republic and their relative impact. To calibrate the model, either publicly available informations or information from scientific papers (e.g. an empirical daily driven distance distribution) are utilised or a simulation-based method taking the advantage of running the model multiple times with different settings and a combination of parameters' values using the NetLogo Behavior Space tool is used.

To gain full confidence in a realistic function of the model and to learn about its potential nonlinear complex behaviour, Renata elaborates a careful sensitivity analysis based on a procedure suggested

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in the textbook of Railsback and Grimm (2011) and a paper by Delli Gatti and Stiglitz (2010). A local sensitivity analysis of all important parameters is conducted and results are discussed in detail. In fact the model has been updated several times base on a not-completely-satisfactory results of the sensitivity analysis that is a standard process in developing an own agent-based model. A computationally demanding procedure, in which the model runs for 36 000 ticks (30 days) to gain stabilised behaviour and representative results, is repeated multiple times to obtain statistically valid results.

Finally, the calibrated model is used for elaboration of impact of five scenarios of potential (governmental) support of electric vehicles. Renata inspired herself by a strategic study of Czech Ministry of Industry and Trade as well as in Norway and selected five strategies to analyse: three financial (Purchase subsidy and VAT exemption, Electricity supply costs reduction, and Waivers on tolls and parking fees) and two non-financial (Development of charging infrastructure and Access to bus lanes and exclusive zones in the city).

Contribution

The contribution of the thesis is threefold. **First**, Renata collected and interlinked a complete set of economic information describing the current Czech environment for electric vehicles resulting interesting findings in a cost-benefit analysis. **Second**, an original and advanced agent-based model was designed to study conditions for electric vehicles in the Czech Republic. As amount of time devoted to the development of the model might not be directly seen in the thesis itself, I feel obliged to stress the works hidden beyond the main text of the thesis here. The model starts from a basic spatial frameworks of a traffic grid in which an emergence of congestion is studied, but it is augmented by Renata by many additional features such as commercial charging stations, home-charging, various goals to travel to, highway to commute to another city, etc. The model is well calibrated to actual Czech conditions, we can in fact imagine it as a stylised map of the Czech Republic where cars commute to various goals in various cities and a researcher can elaborate the dynamic development of studied variables for both the electric as well as standard vehicles. An extensive and carefully elaborated sensitivity analysis adds to a confidence that the model behaviour is reasonably realistic and the impacts of individual variables are as we would expect them to be. **Third**, although I could imagine even a more elaborate assessment of the scenarios, the analysis already brings important results and specific numbers: purchase subsidies appear the most effective financial incentives to support electric vehicles; waivers on tolls and parking fees are the most effective policies in terms of the variable operational costs. A better charging infrastructure policy does not bring any considerable advantage - the charging networks seem to be already dense enough as majority of drivers charge their vehicles at home.

Manuscript form

The aim of the work, working hypotheses, and the design of the model and its further analyses are clearly stated and carefully elaborated. The work is well structured and meets academic standards also in terms of academic English and text-editing quality in the LaTeX environment. Citing is well elaborated both in the main text as well in References. This is especially important as citing of non-standard items such as webpages or various studies downloaded from internet might be tricky. Graphics is done in R and adds to the overall quality of the work.

Suggested question for the defense:
- What are the main advantages of your agent-based model and what are potential drawbacks. In what kind of analysis does the model provide credible results and when do we need to interpret results with caution?
- What are potential upgrades of the model in case the research is about to be expanded?
- Can you imagine other scenarios that could be implemented into your model?

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Summary

All in all, I do find this bachelor thesis **meeting academic standards in all aspects for a quality theses written at IES**. Personally considered, the amount of materials and pieces of information Renata had to consider, development of an own original agent based model and a very careful and thus time consuming sensitivity analysis of the model are the most distinctive qualities of the work.

I am very pleased **I can with no doubt recommend the thesis of Renata Wojnarova to defense at the IES FSV UK. I suggest the grade "1", i.e. "excellent"**.

SUMMARY OF POINTS AWARDED (for details, see below):

CATEGORY		POINTS
Contribution	*(max. 30 points)*	26
Methods	*(max. 30 points)*	28
Literature	*(max. 20 points)*	16
Manuscript Form	*(max. 20 points)*	18
TOTAL POINTS	*(max. 100 points)*	**88**
GRADE	**(1 – 2 – 3 – 4)**	**1**

NAME OF THE REFEREE: Jiri Kukacka

DATE OF EVALUATION: 31. 8. 2017

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Referee Signature

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EXPLANATION OF CATEGORIES AND SCALE:

LITERATURE REVIEW: The thesis demonstrates author's full understanding and command of recent literature. The author quotes relevant literature in a proper way.

Strong	*Average*	*Weak*
20	*10*	*0*

METHODS: The tools used are relevant to the research question being investigated, and adequate to the author's level of studies. The thesis topic is comprehensively analyzed.

Strong	*Average*	*Weak*
30	*15*	*0*

CONTRIBUTION: The author presents original ideas on the topic demonstrating critical thinking and ability to draw conclusions based on the knowledge of relevant theory and empirics. There is a distinct value added of the thesis.

Strong	*Average*	*Weak*
30	*15*	*0*

MANUSCRIPT FORM: The thesis is well structured. The student uses appropriate language and style, including academic format for graphs and tables. The text effectively refers to graphs and tables and disposes with a complete bibliography.

Strong	*Average*	*Weak*
20	*10*	*0*

Overall grading:

TOTAL POINTS	GRADE		
81 – 100	**1**	= excellent	= výborně
61 – 80	**2**	= good	= velmi dobře
41 – 60	**3**	= satisfactory	= dobře
0 – 40	**4**	= fail	= nedoporučuji k obhajobě