Doctoral School of Business and Management

THESIS SUMMARY

To the Ph.D. dissertation

Márk Miskolczi

Impacts of highly automated vehicles on urban passenger transport and tourism

Supervisors:

Dr. Melinda Jászberényi

habil. associate professor

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senior researcher

Budapest, 2022

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I Research background and justification of the topic

Our socioeconomic environment has been undergoing a major transformation, fostered by the current industrial revolution (Industry 4.0). Among Industry 4.0 solutions, the most impactful phenomenon is automation, which describes a broad spectrum of technologies that minimize human intervention in different work-related processes (Fagnant and Kockelman 2015). With the development of automation, the use of machines to replace human labour is on the rise and could also fundamentally shape urban passenger transport of the near future.

In passenger transport, the development of autonomous vehicles (AVs) and related infrastructures raises highly multidisciplinary problems, as still many technical, legal, and even social and economic aspects are unanswered or uncertain. With the continuously emerging artificial intelligence (AI) solutions, AVs can move and reach their destination under decreasing human control, since these vehicles are aware of their surroundings by means of various sensors (e.g., optical sensors, laser radar, image analysis) (Tromaras et al. 2018). The prime reason for developing the technology is to increase road safety, i.e., to minimise and then eliminate the number of road accidents caused by human error (Shoettle and Sivak 2014). Furthermore, the diffusion of the technology can contribute greatly to reducing traffic externalities (e.g., congestion, reducing greenhouse gas emissions from passenger transport) (McEvoy 2015; Clements and Kockelman 2017).

However, in addition to the expected positive effects of AVs, non-technological aspects (socio-economic, moral, legal) may hinder its diffusion since many unresolved issues can be still identified around the technology. While the scope of research on the social impact of automated vehicles is growing, detailed sectorial analyses are still limited. Cohen and Hopkins (2019) underline that tourism is one of the tertiary sectors most exposed to technology, as tourism travel is greatly influenced by innovations in the passenger transport system. The spread of self-driving vehicles could fundamentally reshape not only the mobility options for tourists, but also elements of traditional tourism services. Nevertheless, tourism-specific empirical research is currently very limited.

In the light of this, my research question (RQ) is the following: **How does the spread of highly automated (SAE 4-5) vehicles affect the tourism sector, especially the mobility for tourism purposes, and conventional tourism services?**

As part of the Ph.D. program, I wrote an article-based dissertation presenting 4 journal articles. In this thesis summary, I highlight the theoretical background of my research (Chapter I), the methods applied (Chapter II), and the main findings of the publications. The theoretical and business implications of my research outcomes are also presented in Chapter III.

I.I Expected alterations in tourism

Tourism is a remarkable social phenomenon for centuries. Yet, modern tourism developed in the late 18th century, with the industrial revolution laying the foundations for the sector (Towner and Wall 1991). Industry 4.0 could also reshape tourism, the consequences of which are already beginning to be noticed. In light of this, in presenting the basic concepts of tourism, the expected impacts and open issues related to AVs are highlighted (Figure 1).

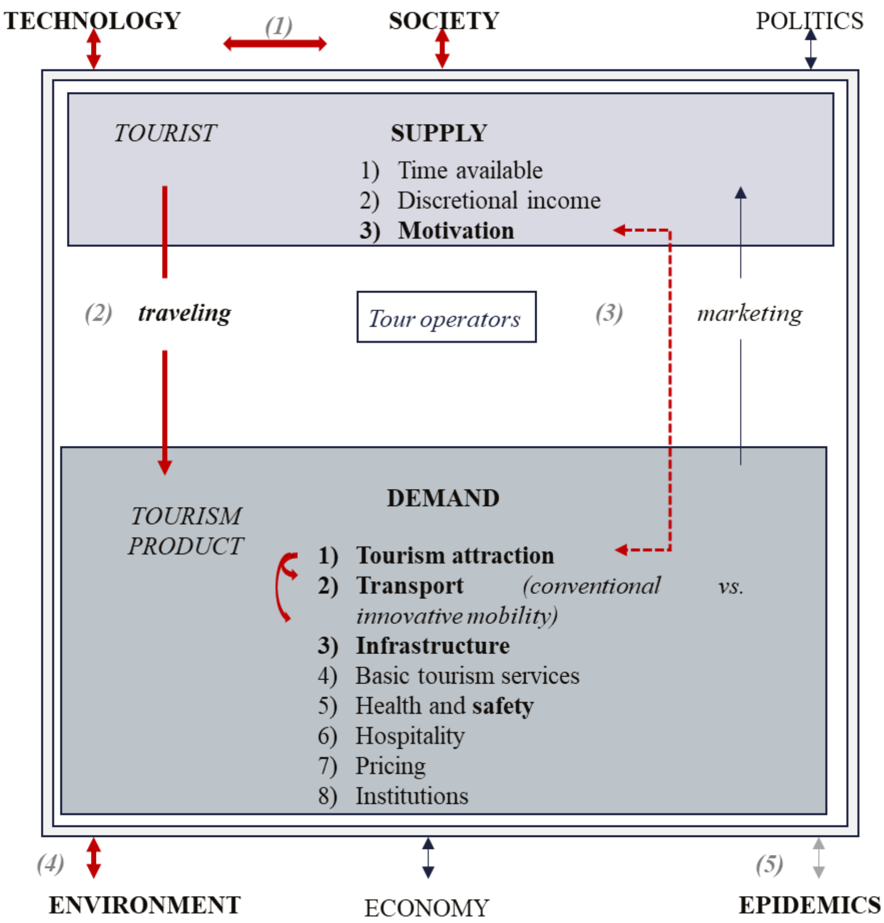

Figure 1. The tourism system based on Lengyel (2005) and Munkácsy (2018) with modifications, own editing

The model describes tourism as an open system, influenced by a wide range of external factors (environmental, social, political, technological, economic and others), which are in strong interaction with each other (Lengyel 2005; Michalkó 2016). Based on the research theme, **five main alterations** can be emphasized in tourism, considering the current leading trends and the expected spread of AVs.

(1) In terms of external elements, the impact of **automation as a leading technological phenomenon** needs to be highlighted, which interacts very closely with the social milieu, as the rapid development of Industry 4.0 technologies might alter our everyday lives (e.g., consumption habits, human-machine interaction). Consequently, automation also could reshape the system of tourism. Stakeholders of the sector experienced how the spread of the internet has influenced the role of traditional travel agencies, or the rise of sharing economy reshaped accommodation services (e.g., Airbnb). Findings (Wicaksono and Maharani 2020; Jung et al. 2021) proved that changes in social openness have played a key role in these transformations. Scholars (Zhang et al. 2019; Du et al. 2021) also highlight the links between the spread of automation and changing social attitudes.

(2) Based on this, major changes in the internal system (supply and demand factors) of tourism might be observed in the upcoming years. Owing to the spread of AVs, the **connection between tourists and tourism products**, i.e., the way of approaching a tourism attraction, might be transformed in several ways (e.g., travel distanced by car, preferred means of transport, consumption during the journey – Cohen and Hopkins 2019). The importance of this issue is further underscored by the long dominant role of car use in tourism. A significant proportion of car usage comes from tourism-related travel, which generates heavy traffic on the road network both seasonally (e.g., at the beginning and end of summer holidays) and spatially (e.g., around coastal resorts) (Munkácsy 2018). Hence, an innovation that affects individual passenger transport can also have an indirect impact on tourism-related travel.

(3) With the spread of AVs, the **motivation of individuals to participate in tourism** may also change. At this point, it is important to clarify that mobility may not only be a means of realising tourism consumption, but that mobility itself, or the use of a particular means of transport (e.g., nostalgia trains, cruise ships), may also appear as a tourism attraction for travelers (Jászberényi and Pálfalvi 2006; Munkácsy 2018). Based on this, the innovative forms of car use enhanced by automation (e.g., sightseeing with AVs) might appear as a tourist attraction in the future (Cohen and Hopkins 2019). Another trip-generating factor could be the ability to see the local (smart) urban infrastructure that will be improved by the spread of AVs (Csiszár and Földes 2017; Csiszár et al. 2019). In addition, high or full

automation (SAE Level 4-5) will lead to a driverless operation which might expand the range of on-board services and thus the passenger experience.

(4) **Climate change** and the increasing frequency of natural disasters all around the world affect tourism both indirectly and in the form of the emerging responsible travel behaviour (Rosselló et al. 2020). Since AVs – based on current forecasts and industry plans (Bagloee et al. 2016) – will be mainly electric or other alternative propulsion vehicles, they could also be a catalyst for more environmentally friendly passenger transport. On the other hand, by increasing the mobility alternatives of individuals, the risk of excessive car use could be increased, which may contribute to the worsening of currently serious traffic problems (e.g., congestion, capacity utilisation of urban spaces and roads) (Bagloee et al. 2016; Bergman et al. 2017; Coppola and Silvestri 2019). Therefore, it is of paramount importance to explore the social openness to a sustainable application of AVs (e.g., the openness to use shared and self-driving vehicles).

(5) In the light of the current crisis, I also indicated the **epidemic** as an external phenomenon of the tourism system, which is currently of particular importance, as the COVID19 outbreak caused by the SARS-COV-2 virus has led to a worldwide recession in tourism (Škare et al. 2021). Based on current predictions (Jia and Yang 2020; Alamo et al. 2021), the frequency of outbreaks of epidemics might increase in the coming decades, which will require the impact of epidemic risk to be considered as a permanent external element of the tourism system.

The spread of AVs raises several questions for the sector – the possible applications of self-driving vehicles for tourism purposes, how these will affect traditional tourism services, and how tourists will relate to the expected changes by the spread of AVs –, therefore, it is reasonable to examine consumer attitudes from a tourism perspective.

I.2 Theoretical background of technology acceptance

For the analysis of consumer attitudes, the theory of technology acceptance has been applied. **Technology acceptance** is a theory that describes how a person relates to the adoption of new technologies (Davis 1986). The emergence of the theory was enhanced by the rapid development of information and communication technology. Technology acceptance allows researchers to appraise adoption during the introduction, highlighting the potential gaps, and identifying the wrong development directions (Venkatesh and Davis 2000).

The first **technology-acceptance model** (TAM1) was developed by F. D. Davis in 1986 (Davis 1986). The original model was improved (TAM2 – Venkatesh and Davis 2000) and new models were created, such as the Unified Theory of Acceptance and Use of Technology (UTAUT1) (Venkatesh et al., 2003), which focuses on technology adoption in workplaces. The latest TAM3 (Venkatesh and Bala 2008) and UTAUT2 (Venkatesh et al. 2012) aim to analyze technology acceptance beyond the workplace environment. In transport sciences, CTAM (Car Technology Acceptance Model) and TPB (Theory of Planned Behaviour) are also frequently applied theories (Osswald et al. 2012; Koul and Eydgahi 2018).

The TAM model has been criticised by scholars over the years. Researchers (Legris et al. 2003; Lee et al. 2019) highlighted that there can be redundancy between exogenous variables of models, which makes it difficult to identify the phenomena that really influence technology acceptance. Researchers (Zhang et al. 2019; Zhu et al. 2020) underline that improved models are less suitable for modelling the acceptance of disruptive technologies without changes due to their complexity and specific variables.

However, several studies (Xu et al. 2018; Buckley et al. 2018; Chen 2019; Yuen et al. 2020; Zhu et al. 2020) have demonstrated the validity of the TAM2 endogenous variables (PEOU, PU, ITU) (Figure 2) for exploring attitudes towards new technologies.

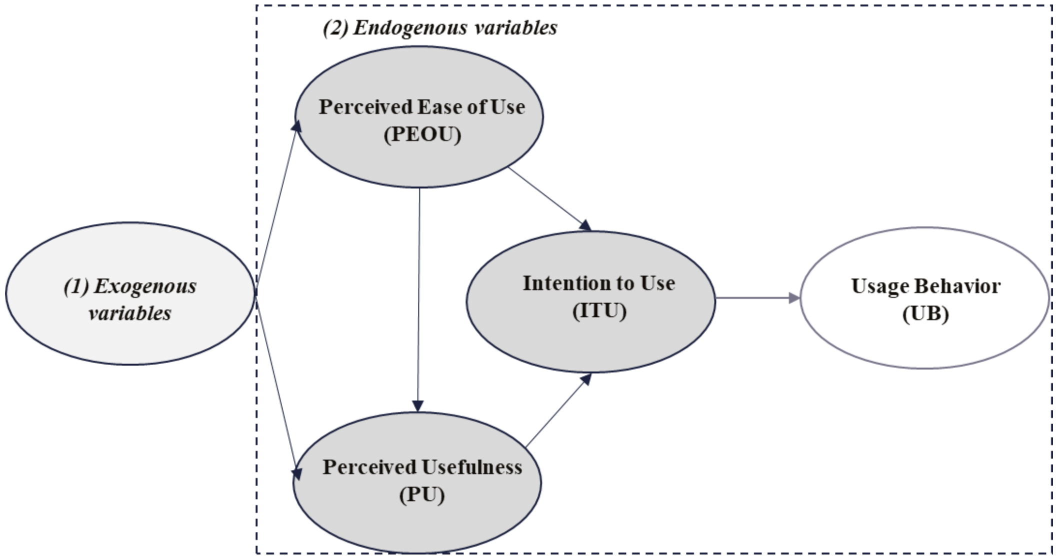

Figure 2. Endogenous variables of TAM2 model, own editing based on Venkatesh and Davis (2000)

The endogenous variables of the TAM2 model:

- *Perceived usefulness (PU):* represents the subject's perception of how their performance is affected (improved or declined) using technology.

- *Perceived ease of use (PEOU):* includes consumer perception of the effort (physical and mental) required to use of technology.
- *Intention to Use (ITU):* defines the consumer’s attitude that characterizes the strength of the consumer's adaptability.
- *Actual Use (AU):* indicates the extent to which the intention to use leads to actual use (Davis, 1986).

Many researchers have successfully modelled the technology acceptance of self-driving vehicles primarily by utilising the variables of the TAM or UTAUT (e.g., Dirsehan and Can 2020; Zhang et al. 2019; Rahman et al. 2019). Since the efficiency of the endogenous variables of **TAM2** has been proven by previous studies, I also adopted these variables (PEOU, PU, ITU) in modelling the technology acceptance of AVs. Researchers (Al-Emran 2018; Sagnier et al. 2020) have suggested that technology acceptance models should be employed only in a specific context. Following this, I focused on the technology-acceptance of AVs and their applicability in the context of tourism-related traveling.

I.3 Research questions

In the light of the expected alterations in tourism by the spread of self-driving vehicles, four research objectives have been set (Table 1).

No.	Research objective statement	Related Qs
1	Identification of the leading socio-economic impacts and dilemmas associated with the diffusion of self-driving vehicles.	Q1
2	Identification of the key innovations affecting passenger transport and their interconnections in the near future (by 2030).	Q2
3	Exploration of the changes expected in the tourism sector associated with the spread of AVs and consumer attitudes towards them.	Q3
4	Exploration of the factors influencing tourists' intention to use AVs, thereby creating a tourism-specific model specialised in the technology acceptance of self-driving vehicles.	Q4

Table 1. Research objectives, own editing

Following the research objectives, a research question (RQ) (*How does the spread of highly automated (SAE 4-5) vehicles affect the tourism sector, especially the mobility for tourism purposes, and conventional tourism services*?) and four sub-questions (Q1, Q2, Q3, Q4) are formulated:

Q$_1$: *With the spread of self-driving vehicles, what socio-economic changes can be expected?*

While exploring the impact of AVs on passenger transport and tourism, it is particularly important to understand the general socio-economic and sectorial impacts arising from Industry 4.0 and the spread of AVs. In this context, before focusing on the tourism-specific analysis, other aspects of the technology (social, moral, industrial) should be discussed, which can both determine the relevance of the RQ and help to formulate a critique of diffusion from a social and economic perspective.

Q$_2$: *What major trends shape urban mobility in the tangible future, i.e., until the 2030s and what role will self-driving vehicles have in this alteration?*

The strong interconnection between transport and tourism is evident. Therefore, expected changes in passenger transport needs to be analyzed thoroughly also for a comprehensive, tourism-related analysis. In relation to the spread of AVs and their role in passenger transport, several forecasts have been made, which make it uncertain how strong the penetration of the technology will be. Considering this, it is desirable to analyse research forecasts to get a more accurate picture of the effects of AVs and their role in passenger transport.

Q$_3$: *How might tourism services change with the spread of self-driving vehicles and how do tourists relate to these potential changes?*

After the general impacts and the possible directions of changes are identified, my research concentrates on the expected impacts of AVs in the tourism sector. The identification of tourism impacts is currently very limited, also in the international literature. Following this, there is a need to systematise the already identified expected changes in tourism services by scholars, and to identify tourists' attitudes towards AVs by conducting empirical research.

Q$_4$: *What drives tourists to adopt self-driving vehicles for tourism purposes?*

Following the exploration of tourists' attitudes towards tourism changes induced by AVs, my objective is to identify the factors influencing the intention to use AVs and the interaction between these factors. There is a growing interest among researchers to investigate the technology acceptance of self-driving vehicles (e.g., Rahman et al. 2019; Zhu et al. 2020), though research including tourism aspects is very limited (e.g., Tan and Lin 2020; Ribeiro 2021). In this context, the final phase of the research is the development of a new technology acceptance model which is suitable to determine the tourism-related aspects of the intention to use AVs.

II Methods applied

In my dissertation, I applied both qualitative and quantitative methods and adopted a sequential approach, as qualitative research was followed by quantitative analysis.

II.1 Systematic literature review

As the first step of the research, the findings of previously published papers related to the RQ have been systematized. For this, The **Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA)** was applied, which is a guideline that focuses primarily on the reporting of reviews and thus enhances the validity of systematic reviews and meta-analyses (Page et al. 2021). The PRISMA guideline provides a template, which can be applied and partly adjusted depending on the intention of the SLR or the topic. PRISMA guideline suggests three main phases of SLR:

- *Identification:* this includes criteria for paper selection (e.g., databases, keywords that researchers use). At this stage, duplications can be filtered out.
- *Screening:* the second phase is the systematization of the remaining papers. First, the categorization according to each search criterion created during the identification, and then the exclusion criteria for the papers are clarified.
- *Included papers:* in the third phase, the remaining papers are systematically analyzed and further categorized according to the researcher's criteria (Page et al. 2021).

II.2 Scenario analysing and building

As part of the SLR, the expected role of automation in urban passenger transport has been explored. For this, I collected and analysed journal articles concerning the future of passenger transport. Based on this, scenarios of urban passenger transport have been created.

Scenarios involve imagined, expected, in most cases positive, or in some way contradictory visions of the future (Melander 2018). As the trends in passenger transport are not always defined based on quantitative data, qualitative analysis techniques are also widely accepted. For the analysis, a **new scenario analysis and building method** has been created. The method consists of the following three main:

- *S0 – Synthetisation:* In the first step, the metadata (year of publication, methodology used, geographical scope) of the papers selected for the analysis are categorised, and a similarity analysis is performed to identify co-citation to filter out over-matchings.
- *S1 – Thematic scenario analysis:* In the second step of the qualitative analysis, the themes (e.g., leading social, environmental, trends of the upcoming change) of the scenarios are extracted, and their expected changes are assessed on a 3-point scale (no change, moderate change, significant change) to ensure the comparability of scenarios analyzed.
- *S2 – Scenario building:* In the last phase, key themes are identified (which in most cases determined the future vision), and the scenarios are then grouped into homogeneous groups based on the 3-point evaluation of the themes.

II.3 Uni-and bivariate analysis

During the primary data collection, subjects with tourism experience were asked to participate in an online survey. Furthermore, the proportion of participants by gender (male – 43%; female – 57%) and age group (18-29 – 20%; 30-39 – 21%; 40-49 – 18%; 50-59 – 19%; 60-75 – 22%) was determined in relation to the Hungarian population. However, the final sample slightly differs from the criteria presented above, and the analysis methods applied required data cleansing, so the sample cannot be considered fully representative.

Descriptive statistics have been used to analyse attitudes towards tourism services based on self-driving vehicles. For this, the most important univariate indicators (mean, median, mode, standard deviation) were applied based on (Sajtos – Mitev 2007, Fliszár et al. 2016). The univariate analyses were followed by bivariate analyses to examine attitudes towards the use of different AV-based tourism services. For this purpose, the **Kruskal-Wallis (H)-test** has been applied. The Kruskal-Wallis test or H-test is a non-parametric statistical technique to test whether individual samples can be derived from the same distribution (Spurrier 2003).

II.4 Structural equation modeling

As part of the research, a technology acceptance model has been created, which describes consumer attitudes towards self-driving vehicles in a tourism context. For testing my hypothetical model, I applied a method known as **Structural Equation Modelling (SEM).**

Structural Equation Modelling (SEM) is an advanced statistical technique that aims to confirm hypotheses and validate the correlation between the variables of the model (Hair et al. 2010; Gaskin and Happell 2014). SEM modelling is based on path analysis, which uses regression equations to analyse the relationship between variables (Hair et al. 2010). It is often used to support hypotheses and to model theories (e.g., technology acceptance models) in the social and economic sciences (especially in the field of marketing).

The main advantage of SEM is that factor and regression analysis can be performed simultaneously (Harrington 2009; Brown 2015). SEM thus achieves both the creation of latent variables from indicators (observed variables) and the examination of the correlation between latent variables (Hoyle 2011). SEM modelling can be used for either confirmatory or exploratory purposes, therefore, two types of SEM can be distinguished: **covariance-based structural equation modeling (CB-SEM)** and partial least square equation modeling (PLS-SEM). In my analysis, I have applied CB-SEM modeling. In examining the fit of the structural model, I primarily followed the guidelines of Hair et al. (2010), Byrne (2010), and Gaskin and Happell (2014), and examined the most important fit indices (e.g., RMSEA, GFI, AFFI, NFI, CFI) suggested by the literature.

III Results

In my research, the main socio-economic impacts of automation, the future role of AVs in urban passenger transport, and the implications of their uptake in the tourism sector have been explored. The relevance of my research was supported by the findings of the research conducted, since several previous studies on the socio-economic impacts of automation or the technology acceptance of AVs were identified, but empirical research on tourism impacts is very limited so far. Only the forecasts of Cohen and Hopkins (2019), Cohen et al. (2020) and the empirical findings of Tan and Lin (2020) and Ribeiro (2021) considered some tourism-related factors in connection with AV acceptance in tourism, which served as a basis for identifying research gaps and conducting my empirical research. In the following, I will answer the research questions and highlight the main findings of the research.

III.1 Responses to research questions

Research question*: How does the spread of highly automated (SAE 4-5) vehicles affect the tourism sector, especially the mobility for tourism purposes, and conventional tourism services*?

Response to the research question*:* Based on the research, the spread of AVs could transform the way destinations are approached (e.g., the modal share of cars might increase, fewer resting stops would be enough, and opportunities to observe the environment might be improved while travelling), as well as mobility and tourism consumption patterns within a destination (e.g., new ways to discover the destination – AI tour guide, AutoTour services, etc.). In addition, it has been revealed that the ability to use AVs for tourism purposes and the foreign environment have a positive impact on the intention to use.

As a result of the research, the four sub-questions (Q1, Q2, Q3, Q4) were answered as follows:

Q_1: *With the spread of self-driving vehicles, what socio-economic changes can be expected?*

Response to Q1: Based on the research, four key categories of socio-economic impacts have been identified, namely the changes in the need for human resources (e.g., the changes in the labour market (e.g., some professions are no longer needed), in industrial revenue from traditional vehicle-usage (e.g., insurance market, oil industry, tertiary sector – tourism), in social habits (e.g., growing digital dependence), and in the social and environmental sustainability (e.g., growth of car usage, overtourism).

Q_2: *What major trends shape urban mobility in the tangible future, i.e., until the 2030s and what role will self-driving vehicles have in this alteration?*

Response to Q2: The urban transport of the future will be shaped by automation, the spread of shared mobility, alternative vehicle propulsion (electrification), and social attitudes. The analysis has led to the creation of four scenarios (Grumpy old transport, At an easy pace, Mine is yours, Tech-eager mobility). Findings suggested that urban passenger transport is expected to undergo a slow transformation by 2030 and this will be driven by the spread of automation and shared mobility services.

Q3: *How might tourism services change with the spread of self-driving vehicles and how do tourists relate to these potential changes?*

Response to Q3: The research indicated that with the spread of AVs in the tourism sector, the impact of technology can be divided into three areas (e.g., handover of driving tasks during tourism-related travel, increasing accessibility of destinations and attractions, new applications of AVs for tourism purposes), in relation to which positive consumer attitudes can be identified. Tourists are willing to give up control to the machine in a foreign environment, would use AVs for sightseeing, and visit more distant destinations with AVs. In the near future, tourists would be open to using a tourist service in which the machine (AI) would be the tour guide (AutoTour), but they are less open to additional leisure activities (e.g., sleeping, reading). during traveling The Kruskal-Wallis test proved, that there is a significant correlation between travel frequency and the attitude towards AV-based tourism services. People who often travel for tourism purposes are more open to the use of self-driving vehicles.

Q4: *What drives tourists to adopt self-driving vehicles for tourism purposes?*

Response to Q4: Based on the empirical research, a new model called Technology Acceptance Model of Autonomous vehicles for Tourism purposes (TAMAT) has been created. Three new, tourism-related variables have been identified that significantly affect the intention to use AVs. Consumers are open to the use of AVs for trips outside their usual environment (positive impact of the Unusual Surrounding variable), and the possibility to use AVs for tourism-related consumption (e.g., sightseeing) can greatly increase the intention to use them (positive impact of the Openness to Tourism Usage variable). It should be stressed, however, that the attachment to traditional vehicle use (the Adherence to Conventional Use variable) negatively affects technology acceptance even in the case of tourism trips.

III.2 Theoretical contributions

Both my secondary and empirical research have led to new theoretical and methodological insights:

- The novelty of the literature review reported in my thesis is the **impact assessment** and the **identification of the socio-economic, sectorial, and moral issues associated with the spread of AVs**. Results also point to the negative externalities connected with the phenomenon, thus, emphasizing some still unanswered questions regarding the technology in different sectors, including tourism.

- **The new qualitative analysis method** I have developed can be considered a new methodological outcome of my research. The scenario analysis method developed can be used for the systematic analysis of scenarios presenting current transport trends and socio-economic phenomena. On the other hand, the method is also suitable for the qualitative analysis of other thematic scenarios, as it consists of steps that can be applied regardless of the topic while offering a transparent analytical framework.
- Applying the scenario analysis and building method; **four scenarios have been created for the future of urban passenger transport by 2030.** The four new scenarios (Grumpy old transport, At an easy pace, Mine is yours, Tech-eager mobility) can serve as a basis for defining urban passenger transport prospects in future studies by 2030.
- I have **typified how the technology could change tourism consumption and thus how tourism services could be altered** (e.g., handover of driving tasks, increasing accessibility, possible applications of vehicles for tourism purposes).
- Empirical results revealed that the **positive attitude is stronger in a different transport environment and among subjects who are more frequently participate in tourism trips**. A particularly positive attitude has also been observed in relation to the idea of sightseeing and test driving with self-driving vehicles.
- A new result is that I have revealed **openness towards AVs based on the Big Five personality types**. In addition to adding a new aspect to attitude research on AVs, the results may provide important inputs for further investigation of the role of psychosocial cues in intention to use.
- A novel **synthetisation of research papers presenting the technology-acceptance** *of AVs* have been created, which is helpful for comparing technology acceptance studies and thus focusing on under-analysed aspects.
- During a structural equation modeling, a **new technology-acceptance (TAMAT) model has been created** which is the first technology acceptance model specialized for AVs that **considers the impact of environmental factors, the tourism applicability of AVs while also considering the distorting effects of the desire for manual control and individual ownership preferences.**

III.3 Practical implications

Overall, my research findings provide an insight into the technological issues that society will face and thus help professionals to react to the expected impacts of the spread of AVs.

For cities and local governments, the results of my research are worth considering. As I have described the main social drivers of technology diffusion, my results can provide important input for determining the feasibility of urban development projects related to automation. Results are particularly relevant in the case of large cities with high tourist flows (e.g., capitals with a rich built heritage and cultural experiences).

For the automotive industry, results can be useful in developing urban and transport strategies along with the key trends identified. The scenarios for 2030 can be used for urban mobility planning as categories into which municipalities can be classified according to their readiness for innovative transport solutions (e.g., shared mobility, self-driving vehicles). The empirical results on the social acceptance of autonomous vehicles can have a direct impact on the ongoing development of self-driving vehicles and the infrastructure, as well as on the development of related policy, regulatory and official frameworks. Considering the key findings of my research may be critical to attracting future consumers. Personality traits can be used to better target marketing campaigns to increase the intention to use AVs and AV-related tourism services.

For the tourism sector, the results suggest that self-driving vehicles could become an important means of transport for tourism travel in the near future and indicate that the industry needs to consider the externalities (e.g., changing consumer preferences - demand for accommodation, travel leisure, etc.) and benefits (e.g., new tourism services based on AVs) resulting from this future trend. Based on the consumer attitudes revealed, there will be soon a demand for AV use for tourism purposes, especially in the field of urban tourism (e.g., sightseeing by self-driving vehicle) and the sector must prepare for the expected penetration of the technology. It is of particular importance to developing in the near future tourism development strategies that also analyse the impacts of automation, for which the main conclusions of my research can serve as a good basis.

III.4 Limitations and future research directions

There are limitations to my research. In the empirical research, subjects reported their attitudes based on the pre-pandemic period. Therefore, the distorting impacts of COVID19 on travel habits and tourism-related consumption should be considered in future research. The persistence of the effects of the pandemic is also an open question, and it would be worthwhile to examine the effects of COVID19 in the context of technology acceptance. Furthermore, the pandemic has also influenced the development of technology, raising the question of whether changes in the development paths presented in the scenarios will be affected by the pandemic. It is also important to continuously monitor the development of automation and artificial intelligence and, in this context, to track changes in consumer attitudes and the identified tourism-related impacts on technology acceptance.

All this justifies further exploration of the topic, for which the research results, methods presented in my thesis can provide a useful background. Although the research focused primarily on socio-economic aspects, my results can also be a starting point for technical developments outside my research area. As several vehicle development priorities have been identified, my research results offer ideas for vehicle engineers to consider. For transport engineers, the expansion of self-driving vehicles in tourism could also offer exciting research opportunities, as my results suggest that the development of infrastructure for accessing attractions with AVs could become a priority in the near future.

Besides, I also intend to continue working on the following research topics related to my doctoral research in the near future:

- Investigating the applicability of self-driving vehicles for Hungarian destinations. The research would focus on the analysis of the cooperation between shared mobility service providers and tourism operators (e.g., self-driving vehicles for tourists, included in sightseeing packages).
- Explore opportunities for cooperation between tour companies (e.g., Hop-on Hop-off) and automotive companies to develop the details of an AutoTour service based on self-driving vehicles.
- A consumer attitude analysis based on real experiences (e.g.: participation in living lab surveys) to verify the validity of the variables I have identified that influence the technology acceptance of self-driving vehicles.
- My aim is also to broaden the scope of my current research area and analyse the societal impact of other AI-based solutions in tourism. In my future research, I would

like to focus on the consumer perception of different levels of AI, and the thematization of the effects of AI-based devices on consumption patterns and machine-human interaction.

For a thorough exploration of these research topics, it is advisable to involve experts from different subfields of transport and tourism (e.g., traffic engineers, companies developing self-driving vehicles, tour operators, tour guides). It is also important to further investigate consumer preferences on a representative sample of the Hungarian population by gender, age, and place of residence to get a more detailed picture of the possible future applications of AVs.

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V List of publications

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