Effective Mobility Management Policies and the Complexities of P&R Realization in the Brainport Region

A study on the impacts of mobility policies on mode choice by ASML employees and analysis of the implementation process for P&R hubs in the Brainport region

by

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PREFACE

This thesis marks the completion of my academic career in the Master's program for Complex Systems Engineering and Management (CoSEM) at TU Delft. This thesis delves into the influence of ASML's mobility measures on commuting patterns and the complex processes involved in establishing Park & Ride facilities, which are considered critical in addressing the mobility challenges in the Brainport region.

I would like to express my gratitude to my supervisors at TU Delft for their guidance throughout this process. A special thanks to my first supervisor, Eric Molin, whose willingness to engage in regular meetings provided me with the consistent feedback and support necessary to complete this study successfully. Moreover, I am grateful to both Eric Molin and Maarten Kroesen for allowing me to build upon their study for ASML. Accessing their data was instrumental in carrying out this research.

I would also like to extend my appreciation to the interview participants. Your insights were essential in providing a comprehensive perspective on the topics under consideration.

Finally, I want to express my deep gratitude to my family and friends for their unwavering support throughout my academic journey. This achievement is a testament to the collective encouragement and belief you have all invested in me.

Luc van Noesel,
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LIST OF ABBREVIATIONS

- MNL: Multinomial Logit model
- ML: Mixed Logit model
- IIA: Independence of Irrelevant Alternatives
- i.i.d.: independently and identically distribution
- SP: Stated preference
- RP: Revealed preference
- RC: Random component
- P&R: Park&Ride
- MRE: Metropole Region Eindhoven

EXECUTIVE SUMMARY

I. Introduction

As one of the largest innovation hubs in the world, the Brainport Eindhoven region experiences significant economic and population growth. However, with this success comes a challenge: the transportation infrastructure is increasingly strained, with new housing developments and population growth escalating the transport demand. The economic growth includes plans by high-tech giant ASML to roughly double its workforce in Veldhoven to 35,000 by 2030, which poses significant consequences for accessibility, environmental quality, and safety unless effective policy measures are implemented.

This thesis addresses the urgent need for innovative mobility management, exploring the effectiveness of ASML's proposed measures to shift employee commuting behavior towards more sustainable modes. It builds on the work of Molin & Kroesen (2023b), who examined these impacts using a Multinomial Logit (MNL) model. The MNL model, however, is known to exhibit some limitations, potentially leading to biased results. Hence, this research proposes using a Mixed Logit (ML) model, addressing the limitations of the MNL model by capturing the nuanced preferences of commuters and predicting the mode shares under various policies more accurately.

Naturally, the mobility challenges transcend the scope of ASML. The entire Brainport region is actively involved in addressing these issues, underpinned by an ambitious €1.6 billion investment plan to improve accessibility, mobility, and livability in the region. Central to this mobility plan is the development of six regional mobility hubs surrounding Eindhoven, designed to alleviate traffic congestion on the city's arterial roads. Molin & Kroesen's research has underscored the significant potential of Park & Ride (P&R) facilities as regional hubs to effectuate a modal shift under (ASML) employees. Despite the apparent urgency and the acknowledged potential of these P&R hubs, their actualization has been markedly slow. However, the factors interfering with a fluent implementation are mainly unknown to the public.

Accordingly, the objectives of this thesis are twofold: to provide more accurate insights into the effects of mobility measures on ASML employees' commuting mode choice and to clarify the process and complexities regarding the realization of P&R facilities in the Brainport region. The central research questions guiding this thesis are:

1. *"How do ASML mobility measures influence employee commuting mode choices as estimated by an error component ML model relative to an MNL model?"*

2. *"Which factors contribute to the complex and long-term nature of P&R implementation processes in the Brainport region?"*

II. Methodology

This study utilizes a choice modeling framework designed by Molin & Kroesen (2023b) to analyze the commuting mode choices of ASML employees. They conducted a stated choice experiment among 5,642 ASML employees in January 2023, to collect data on their mode choices in various scenarios.

The choice experiment consisted of 5 distinct experiments, which were assigned to respondents based on their commuting distance to ASML and the availability of feasible transportation modes. The conditions and available alternatives for these experiments are outlined in Table I below. The assignment to any of these experiments determined the alternatives presented to respondents in the choice sets.

Table I: Overview of the five experiments as constructed by Molin & Kroesen (2023b)

	Assignment criteria			Choice set	
Exp	**Distance to ASML**	**Last 10 km on Highway?**	**Is train feasible?**	**Available alternatives**	**P&R distance to ASML**
1	<10 km	NO	NO	Car, carpool, bus, bike	9 km
2	11-15 km	YES	NO	Car, carpool, bike, P&R (with shuttle bus or bike)	9 km
3	>=16 km	YES	YES	Car, carpool, bike, P&R (with shuttle bus or bike), train (with shuttle bus or bike)	9 km
4	>=16 km	YES	NO	Car, carpool, P&R (with shuttle bus or bike)	9 km
5	>=16 km	YES	NO	Car, carpool, P&R (with shuttle bus or bike)	13 km

This study employs discrete choice models to quantify travelers' preferences regarding mode choice. This thesis extends the prior study by applying an ML model, utilizing the Apollo software to account for nesting and panel effects. This approach overcomes the Independence of Irrelevant Alternatives (IIA) constraint inherent to MNL models. The model is used to predict the impact of various ASML policy measures and traffic conditions on the modal split, including:

- Introducing a (daily) reward for not using the car to travel to ASML
- Introducing parking costs at ASML
- Differentiating the travel allowance (up to 20 km) for different modes
- Introducing the requirement to book a parking spot in advance
- Developing P&R locations on route to ASML, with varying levels of service of the mobility
- options from the P&R location to ASML (e-bike /shuttle bus) and the P&R location itself (e.g., parking only or additional facilities like offices)
- Increasing the level of service of the train alternative by offering (first class) NS business cards and by improving the level of service of the mobility options from the Eindhoven train station to ASML (e-bike /shuttle bus)
- Increased congestion, leading to longer average delays

In examining the P&R implementation process in the Brainport region, the study adopted a qualitative approach, conducting semi-structured interviews with key stakeholders to understand the intricacies of the process. This method allowed for in-depth discussions, capturing the varied perspectives and insights on the challenges and dynamics influencing the development of P&R facilities. Data from these interviews were complemented by information from public documents, providing context and background to the P&R projects within the broader mobility strategy of the region.

III. Findings

Choice model estimation

The ML was estimated to address the shortcomings of the MNL model, notably their inability to capture correlations among choices and across individual preferences. Firstly, relevant nests were considered through meticulous statistical analysis to reflect the significant commonalities between travel alternatives. The final configuration included nests for car, shared, multimodal, and bike transport modes. Table II shows the composition of the alternatives within each nest.

Table II: Overview of Nest Compositions

	Car nest	Shared nest	Multimodal nest	Bike nest
Car	X			
Carpool	X	X		
Bus		X		
Bike				X
P&R + shuttle	X	X	X	
P&R + bike	X		X	X
Train + shuttle		X	X	
Train + bike		X	X	X

Simulations for the ML models involved 1000 Halton draws per experiment, revealing a consistent preference for bicycles over cars despite the general favor for cars over other alternatives due to unobserved factors. Notably, Service-related variables largely showed insignificant influence on travel mode choice, except for a slight positive effect of first-class train tickets.

The correlations between the alternatives within the nests over the various experiments are presented in Table III. These are calculated based on the shared components estimated by the ML model. Generally, a correlation coefficient above 0.7 indicates a strong relationship, which is evident in most nests examined. In the second experiment, the correlation within car-related alternatives is notably high at 0.844. This figure should be interpreted with caution due to the smaller sample size in this experiment, which makes the results more sensitive to extreme values, potentially skewing the data.

Through empirical analysis it was indicated that the shared components are significantly influenced by individual preferences for specific alternatives. For example, the high correlation within the car nest is largely due to a strong preference for driving alone rather than a collective preference towards other alternatives which include cars. Despite the pronounced influence of individual random components in some experiments, all nests maintain their statistical significance.

Table III: Estimated correlations between alternatives within the nests across the experiments

Shared components	Experiment 1	Experiment 2	Experiment 3	Experiment 4+5
Cars nest	0.808	0.844	0.759	
Shared nest	0.770	0.746	0.700	0.685
Multimodal nest		0.747	0.709	0.762
Bike nest		0.698	0.773	

Percentage of respondents	42.92%	3.53%	24.30%	29.25%

The ML models demonstrate a superior model fit compared to the MNL models, with higher Rho-squared values indicating a more robust ability to predict choices. This increased fit, detailed in Table IV, validates the more robust predictive capabilities of the ML model in capturing the complexity of commuter decision-making.

Table IV: Comparison of model fit between MNL and ML models

	Exp 1	Exp 2	Exp 3	Exp 4+5
MNL model				
# of parameters	11	17	23	18
Rho^2 (ρ^2)	**0.42**	**0.27**	**0.13**	**0.17**
ML model				
# of parameters	13	21	27	20
Rho^2 (ρ^2)	**0.72**	**0.67**	**0.54**	**0.51**

Scenario analysis

After the estimation of the model parameters, these were implemented to predict the choice probabilities in particular scenarios. These mode shares were assessed to compare the effects of policy interventions on commuting behaviors. Figure I shows that financial (dis)incentives are most influential in reducing car use, according to both models. Through the employment of €3.00 parking fees and commuting rewards for alternative options, an 8.9% reduction in car share can be realized according to the ML model. Remarkably, the effects of service-related policy measures for alternative travel modes, such as providing first-class train cards or full-service and meeting rooms at P&R facilities, appeared mostly insignificant.

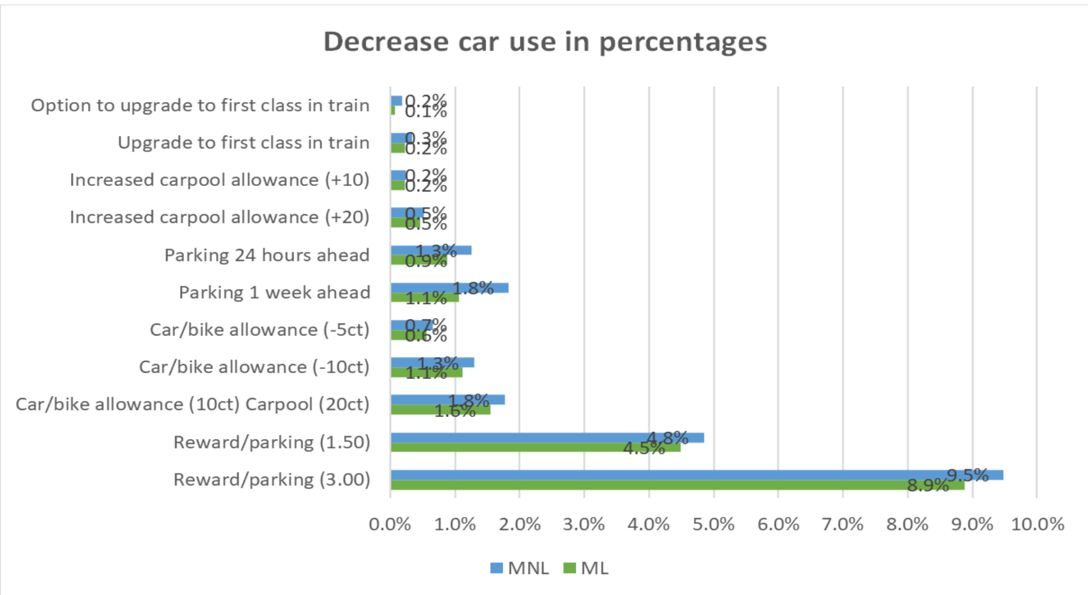

Figure I: Decrease in car use through implementation of single policy measures as estimated by the MNL and ML

In the assessment of potential policy interventions, two scenarios stood out for their impactful outcomes and policy relevance, highlighted in this summary. For both scenarios, mode share predictions are compared with the base scenario reflecting the current conditions, estimated by both the ML and the MNL models, as can be observed by the different colors in the graphs below.

In scenario 1, the 'Monetary Package,' encompassing €3.00 daily rewards for not using a car and equivalent parking fees, coupled with differentiated travel allowances to favor cycling and carpooling, emerged as a highly effective strategy. Figure II shows that this policy intervention results in a notable shift of 10.2% from car usage to more sustainable commuting options. Particularly, the ML model predicts a significant rise in carpooling from 2.8% to 4.3%.

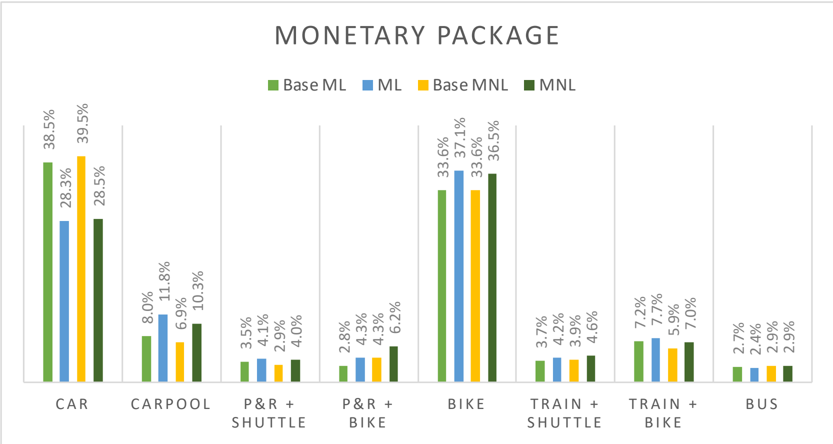

Figure II: Estimated effects of monetary package on the modal split

Scenario 5B presents a future scenario in which car commuters experience an average 40-minute delay resulting from increased congestion, and shuttles from P&R locations can bypass traffic over emergency lanes without delay. As presented in Figure III, this scenario is predicted to result in a substantial decrease in the use of cars to 26.4%. Notably, the option of P&R combined with a shuttle service experiences a surge in popularity, its share escalating by 7.9 percentage points. The option of P&R with a bicycle also sees an uplift, increasing its share to 7%. Together, these shifts denote a pivotal trend: an impressive 18.4% of ASML employees are projected to opt for P&R alternatives, signifying the potential of direct shuttle services in the future.

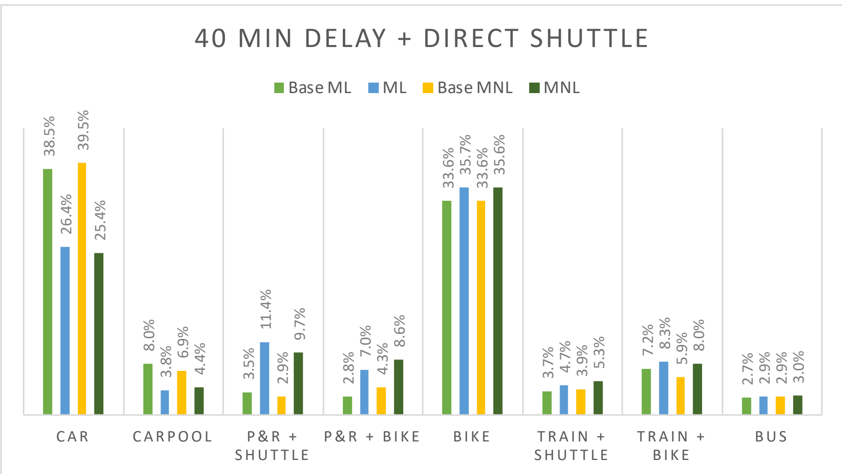

Figure III: Estimated effects of scenario with an average car delay of 40 minutes and direct shuttle

Implementation analysis of P&R facilities in Brainport

The establishment of P&R facilities emerges as a central measure within the Brainport region's mobility plan. The initiative is part of a strategy for the increasing mobility demands driven by the region's economic growth and urban expansion. However, the realization of such infrastructure projects is a complex venture involving a broad spectrum of stakeholders and facing multifaceted challenges. The key stakeholders include SmartwayZ.NL, Brainport Bereikbaar, Eindhoven and the surrounding municipalities, the MRE, provincial and national authorities, regional companies, consultancy firms, and residents.

Through the interviews with various stakeholders, five main challenges were identified:

- **Location and Infrastructure constraints**: The strategic placement of the P&R location is essential to their success. These procedures require extensive research in which multiple parties are involved. These processes have largely been completed for the four prioritized hubs, but only for the hub in Maarheze, the exact location is yet known; for the others, 2 or 3 potential destinations remain.
- **Inter-municipal stakeholder dynamics**: Harmonizing the interests of numerous stakeholders, including the municipalities, the province, companies, and local communities, is challenging in Brainport. The absence of a central authority leads to delays as consensus is needed across the board. Different levels of engagement from companies add complexity to the dynamics.
- **Governance and financial planning**: Governance structures and financial planning are critical obstacles. There is ambiguity over ownership, management, and financial risk after development. The lack of a centralized authority is felt since municipalities are not interested in ownership or investment. These are key issues that must be solved before transitioning into the next phase.
- **Legal and Environmental Regulations**: The rigid legal and environmental regulatory framework underlying the complexity of the decision-making process. Restrictions regarding nitrogen emissions are challenging since regulations have stopped construction permits for projects all across North Brabant.
- **Integration with Overall Mobility Strategy**: Effective integration with the overall mobility plans is critical for P&R success. The development of transport services like the HOV line and cycling infrastructure must be timely and well-coordinated. Incentives to encourage P&R use over direct car travel are crucial, requiring policy support and alignment with commuter behavior.

IV. Conclusion

Impact of ASML's mobility measures

An error component ML model has been established accounting for shared heterogeneity within nests for car, shared, multimodal and bike alternatives. The ML model demonstrated superior predictive power over the MNL model, as evidenced by a notable improvement in model fit. Financial incentives emerge as the most effective measures for altering people's commuting mode choices, similar to the MNL model. Specifically, the introduction of parking fees and rewards for non-car alternatives are anticipated to significantly reduce reliance on private cars, favoring a shift towards carpooling and cycling. In contrast, service improvements, such as first-class train cards, are beneficial but less impactful, according to the model. The model predicts that a 20-minute average delay due to congestion (instead of 10 minutes) will slightly decrease car usage, while a 40-minute delay could lead to a 10% reduction in car share. The implementation of a direct P&R shuttle service, able to bypass congestion, is projected to further decrease car usage, potentially achieving an 18.4% P&R share.

These insights advocate for ASML to prioritize financial disincentives for car use and to enhance the attractiveness of alternative modes. The establishment of additional P&R facilities is crucial for accommodating smart and sustainable transport for commuters from various locations. This requires extensive planning and a concerted effort between ASML and government authorities.

Implementation challenges for P&R facilities in Brainport

Interviews with stakeholders from multiple organizations revealed the complex nature of P&R implementation in the Brainport region. The effort to establish P&R facilities in the Brainport region brings together a diverse array of stakeholders, including governmental organizations such as SmartwayZ.NL and Brainport Bereikbaar, local municipalities, regional authorities, private companies like ASML, and the public. Each stakeholder has their own objectives and concerns, making the coordination of the project complex. In addition, various other challenges were identified, including the strategic selection of locations and navigating intricate governance and legal processes while aligning the multiple facets of the Brainport Mobility plan. The primary barriers involve nitrogen emissions restrictions and financial uncertainties over ownership and operation.

The current governance structure requires inter-municipal consensus on decisions, leading to delays in the process. Financial planning presents another considerable challenge since municipalities are reluctant to take ownership and bear the associated financial risks. Without a clear governance structure and financial model to ensure long-term sustainability, the project is unable to progress into further stages of development. The need for a more centralized governance model is implied to streamline the decision-making process and allocate resources efficiently. Following the advancements in the site selection process for four key hubs, the actual initiation of construction is pending due to the mandatory zoning and environmental procedures. These legal steps are crucial but can extend timelines even further if faced with appeals or objections.

V. Limitations & reflections

The reliance on stated preference experiments can introduce uncertainties, as it is not guaranteed that the decisions simulated in such experiments will mirror actual commuting behaviors. While these experiments are invaluable for evaluating potential policy impacts, they lack real-life choice data. The assumption that the survey data represent all ASML employees is challenged by indications of a potential underrepresentation of car drivers and an overrepresentation of cyclists, as addressed by Molin & Kroesen (2023b). Additionally, not all alternatives were uniformly presented to all respondents due to variations in individual travel-related conditions, such as distance to work. For instance, employees living further than 15 kilometers from ASML were not presented with the option of cycling as the share was expected to be negligible.

While the estimated ML model accounted for preference dispersion for nests of alternatives, the heterogeneity for specific alternatives is inherited to the relatively high sigma's for the random components, potentially leading to overestimations of the nesting effects.

This study's analysis of P&R implementation in Brainport focuses on inputs from major stakeholders, primarily assessing strategic and policy aspects. Localized challenges and individual perspectives of smaller entities were less explored. The research highlights stakeholder roles and broad challenges without an in-depth procedural analysis or comparative case studies. Consequently, while providing strategic insights, the study lacks detailed management or broader scenario implications.

VI. Recommendations

For future research, a thorough cost-benefit analysis considering both economic and societal impacts of mobility measures is recommended. Additional studies could assess the environmental footprint of various policy measures, alongside their social and economic effects on local communities and regional development.

Detailed case studies on stakeholder engagement and the use of project management theories could further elucidate the decision-making process. Exploring effective governance and financial models is also crucial, given their significant role in managing P&R projects in Brainport. Comparative research on similar projects may yield insights for establishing a clear governance framework.

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1. INTRODUCTION

As the Netherlands contends with escalating transportation demands driven by demographic and economic expansion, the strain on its road network intensifies (Ministerie van Infrastructuur en Waterstaat, 2022). This pressure is particularly felt in cities as the problems are expected to deteriorate with upcoming housing developments, posing challenges to the quality of life, safety, and the environment (Nugteren, 2022). Responding to these problems demands integral mobility policies and strategies, according to TNO (2023). These challenges are particularly evident in Brainport Eindhoven, a global innovation hub home to major enterprises such ASML, Philips, DAF, NXP, VDL, and numerous start-ups, research institutions, and educational facilities (Brainport Eindhoven, 2023).

ASML faces mobility challenges around its headquarters in Veldhoven, leading to longer employee commutes due to congested roads and crowded public transport (Eppinga, 2022). Despite this, ASML aims to extend its workforce in Veldhoven from 17,000 to 35,000 by 2030 (Dekker, 2022), signaling an imminent increase in transport demand. Without interference, this trajectory poses significant threats to accessibility, resulting in even more congestion, longer commutes, increased emissions, and compromised air quality (Fattah et al., 2022). Mobility policy is needed to mitigate the adverse effects of the increasing traffic in this region.

Mobility management

A key element of modern mobility solutions resides in the concept of mobility management - a combination of policies designed to offer tailored travel solutions that prioritize individual preferences. In this paradigm, public and private stakeholders typically collaborate to encourage intelligent commuting choices, transcending conventional reliance on automobiles (Ministry of Infrastructure & Water, 2023b). This approach is increasingly relevant for both corporations and governments, providing effective measures to promote sustainable travel and alleviate issues associated with vehicular usage.

According to Bruns (2016), mobility management is widely recognized as a method for reshaping travel preferences and proves instrumental in curbing traffic demand and fostering a modal shift towards sustainable transportation. Corporate mobility management offers a nuanced lens into how companies, through policies and incentives, influence employees' commuting behaviors, impacting frequency, timing, and mode choices (Saake et al., 2021; Vanoutrive et al., 2010). This strategic approach is praised for its potential cost-effectiveness (Babapourdijojin & Gentile, 2023) and potential societal benefits, contributing to the energy transition, increased accessibility, reduced environmental impact, enhanced safety, and improved employee health (Robèrt, 2017). Various mobility management measures, encompassing both governmental and corporate initiatives, aim to induce sustainable transport choices (Nijland & Dijst, 2015). However, Saake et al. (2021) recognize the nuanced interplay of psychological factors in influencing behavioral change, with soft measures (e.g., incentives) and hard measures (e.g., infrastructure) playing pivotal roles. Corporate characteristics, national and regional contexts, and environmental settings are influential factors in the effectiveness of these measures (Van Malderen et al., 2012). In particular, collaborative efforts and a shared vision between businesses and public authorities are deemed crucial for the effectiveness of mobility management, necessitating improved infrastructure and strategic measures tailored to both company needs and the regional context (Bartle & Chatterjee, 2019; Jiménez et al., 2020).

ASML and mobility

As ASML continues to expand, the company is acutely aware of the critical mobility challenges it faces. The prospect of doubling its workforce by 2030 presents a daunting scenario where, without intervention, the local traffic could reach a standstill, and parking facilities might be overwhelmed by the surge in car usage. Recognizing this, ASML is proactive in mitigating the adverse mobility effects (Eppinga, 2022). Serving as a cycling ambassador for the Dutch Ministry of Infrastructure & Water, ASML is strategically investing in sustainable travel practices to induce behavioral changes among its employees. Initiatives such as realizing bicycle facilities and providing incentives like mileage allowances and tax privileges for (e-)bicycles emphasize ASML's commitment to encouraging sustainable transport among employees (Ministry of Infrastructure & Water, 2023a).

To gain insight into the potential of diverse mobility measures, on behalf of ASML, Molin & Kroesen (2023b) conducted research into the effectiveness of diverse mobility measures. They designed a choice experiment to capture the preferences of ASML employees regarding commuting mode choices in various scenarios. The collected survey data from 5,642 ASML employees was subsequently analyzed through a multinomial (MNL) model to estimate the effects of a predefined set of mobility measures on the modal split.

An overview of current commuting patterns at ASML in 2022 discloses that approximately 52% of employees commute by car, 35% by (e-)bike, and 13% by public transport. The current high reliance on cars is not viable in the long run, as this would lead to escalating parking problems and highway congestion. ASML aspires to achieve a modal split by 2030 where each travel option constitutes a third of the total share (Molin & Kroesen, 2023b). To realize this goal, ASML has identified various mobility measures, including:

- Introducing a daily reward for opting not to use a car for commuting to ASML.
- Introducing parking fees at ASML in combination with rewarding other modes.
- Lowering travel allowances for cars in combination with increasing allowances for bikes and carpooling
- Introducing the condition to book parking spaces in advance.
- Establishing P&R locations along the route to ASML, where employees can park and continue via e-bike or shuttle bus. The development of 6 multimodal hubs is part of the Brainportdeal 2030. Additionally, a shuttle bus may utilize the emergency lane to navigate through traffic jams.
- Enhancing the service level of the train option by providing (first class) NS business cards and improving the service level of mobility choices from Eindhoven train station to ASML.

From their research, Molin & Kroesen (2023b) concluded that monetary measures, such as introducing parking costs or rewards for non-car modes, will most effectively reduce car use in the current scenario. Alternatively, the option of P&R is anticipated to have significant positive effects, especially in scenarios where average traffic times are increased even further in the future and shuttle buses are allowed to use the emergency lane.

Implementation of P&R facilities in the Brainport region

The implementation of Park & Ride (P&R) facilities stands out as a strategic measure to address the mounting mobility challenges. Unlike other interventions concluded from the study by Molin & Kroesen (2023b), the success of P&R hubs depends on a multi-actor collaboration, underscoring the complex interplay and dependencies among various regional stakeholders in the Brainport region, including corporations like ASML, public authorities, and transportation agencies.

With the road network around Eindhoven's ring road nearing capacity, P&R facilities offer a strategic solution by reducing the flow of traffic into these critical zones (Metropoolregio Eindhoven & Provincie Noord-Brabant, 2020). Positioned at key junctures near highways, these hubs facilitate intermodal transfers, providing commuters with alternatives to complete their journeys into congested urban areas (Aydin et al., 2022; Blad et al., 2022). ASML's headquarters in Veldhoven, situated adjacent to this pressured ring road, exemplifies the urgent necessity for P&R facilities. By diverting some of the vehicle flow to P&Rs, ASML can significantly reduce the congestion that many employees face during the final and most critical segment of their commutes.

The effectiveness of park-and-ride facilities goes beyond physical structures; it is closely tied to the commuting habits of individuals. Implementing tactics that encourage the use of these facilities, alongside incentives for environmentally friendly modes of transportation, holds promise for promoting sustainable commuting practices (Sottile et al., 2017). Given ASML's prominent role as a major employer within the area, it is essential for the company to align with regional transportation strategies and land-use planning in order to shape the conversation around mobility.

Recently, a €1.6 billion master plan was presented to enhance Brainport accessibility, including the realization of six P&R hubs around the city of Eindhoven (Brainport Eindhoven, 2022). Central to this initiative is SmartwayZ.NL, a governmental mobility program engaging over 200 diverse partners, ranging from government entities like the Ministry of Infrastructure and Water Management to local municipalities and private sector players. This initiative strives to create accessible and innovative transport solutions for the southern Netherlands (SmartwayZ.NL, n.d.). In parallel, the 'Brainport Bereikbaar' program unites 21 municipalities in a concerted effort to advance sustainable mobility throughout the Brainport region. They emphasize the integration of public transport and cycling, ensuring seamless last-mile transport from the P&R hubs, and contributing to the sustainable mobility growth in Brainport (ZO Slim Bereikbaar, 2022).

While P&Rs are viewed as pivotal in the broader mobility plan, their implementation presents a complex and time-consuming process. Navigating through a web of diverse stakeholders with various interests adds to the intricacies of the implementation. These P&R facilities have yet to be materialized, but the policymaking process is complex. Unraveling these complexities currently forms a critical aspect for the improvement of the mobility challenges in the region.

1.1 KNOWLEDGE GAPS

Knowledge gap 1
Although the MNL model, applied by Molin & Kroesen (2023b), is a respected and common method for analyzing travel behavior, there are some limitations to the model, which may lead to biased results (Ermagun & Samimi, 2015). Primarily, MNL models do not allow for correlations across

alternatives, which may lead to flawed results. Embedded in the MNL model is the assumption of independence of irrelevant alternatives (IIA), which fails to account for the natural correlations that often exist between certain travel options that might affect the decision-making process of individuals (Allison, 2012). For example, consider a scenario where the travel options consist of car and bus. When the train is introduced as a third alternative, according to IIA, this alternative should take away shares from car and bus equally (i.e., 10% from the car and 10% from the train). However, since trains and buses are more similar to each other as forms of public transport, it is more likely that the train would draw disproportionately from bus users. In this case, the IIA property does not hold true; therefore, utilizing an MNL model in such cases could yield inaccurate findings (Chorus, 2022).

The Mixed Logit (ML) offers a more realistic depiction of substitution patterns under these circumstances, as the correlation between alternatives with similarities can be accounted for by incorporating 'shared components' into the utility functions of related alternatives. These components represent the utility arising from shared attributes of a 'nest' or group of alternatives. For example, when categorizing buses and trains together under a public transport nest. By incorporating a public transport nest in the presented example, trains would be expected to draw more from buses than cars, reflecting a more realistic shift in commuter preferences (Yu & Sun, 2012).

Besides this, the ML model offers the advantage of accommodating correlations across multiple choices by the same individual (Algers et al., 1998). This presents a notable improvement over MNL, wherein each choice is treated as independent, neglecting potential correlations in panel data - data with multiple observations per respondent.

Given the limitations inherent to the MNL model, the incorporation of an ML model with error components and a panel structure on the panel data collected by Molin & Kroesen (2023b) is expected to provide more accurate insights into the impacts of mobility measures on the modal split of ASML employees.

Knowledge gap 2

Although the plans for the hubs, as presented in policy papers by SmartwayZ.NL, are formulated in relatively clear terms, the concretization of these infrastructural measures can be complex. In the Netherlands, zoning and environmental plan procedures must be completed before the realization of projects. The purposes for which buildings and land may be used are determined in zoning plans, which are regulated on a municipal level. The environment plan contains rules covering all parts of the physical environment.

Early plans for regional hubs stem from the initial Accessibility Agenda South-East Brabant 2017-2030, yet these projects are still in the preliminary stages (Brainport Bereikbaar, 2023). Despite the sense of urgency felt by stakeholders in the region, the materialization of the regional hubs remains to be realized. From this, the question arises, “What are the reasons for the long-term nature of these projects?” Little information is publicly available that might provide insight into how the policymaking processes unfold and what causes the complexities for realization. In other words, there is a knowledge gap in understanding the implementation processes for P&Rs in Brainport, including the encountered problems and their causes.

1.2 RESEARCH OBJECTIVES AND RESEARCH QUESTIONS

This research addresses the 2 knowledge gaps described in the previous section. The objectives of this thesis are to provide more accurate insights on the effects of mobility measures on ASML employees' commuting mode choice, as well as to provide insight into the process and the complexities of P&R realization in the Brainport region.

Although these two objectives are related to the mobility challenges in Brainport, they require different approaches with divergent research methods. Therefore, this study is divided into two main research questions; one focuses on analyzing the effects of mobility measures on ASML employee mode choice, and the other focuses on exploring the realization process of P&R facilities in the region. The main research questions and their related sub questions are formulated below:

1. "How do ASML mobility measures influence employee commuting mode choices as estimated by an error component ML model relative to an MNL model?"

1.1 "Which nests of alternatives can be distinguished when modeling for the effects of the ASML mobility measures on employee commuting mode choice?"

1.2 "How do various policy measures affect the mode choice of ASML employees according to the ML model?"

1.3 "How do the ML model's predicted choice probabilities and model fit differ from those of an MNL model when analyzing the effects of mobility policies?"

2. "Which factors contribute to the complex and long-term nature of P&R implementation processes in the Brainport region?"

2.1 "What are the roles, interests, and interrelations of the various actors involved in the implementation process for P&R facilities in the Brainport region?"

2.2 "What is the current status of the implementation process for P&R facilities in the Brainport region?"

2.3 "What are the main challenges and underlying causes encountered in the implementation of P&R facilities in the Brainport region?"

2.4 "How is the development of the P&R facilities anticipated for 2030?"

1.3 RESEARCH APPROACH

Diverse methods are employed to conduct this research. To answer the first research question, a Mixed Logit model is constructed by utilizing the choice experiment data obtained by Molin & Kroesen (2023b). This model scrutinizes the relative preferences for characteristics of travel alternatives, incorporating error components and a panel structure to enhance validity. The identification of meaningful nests of alternatives is an integral part of this process, reflecting commonalities between available options. The Apollo package within the Rstudio program is instrumental in simulating parameter values. Subsequently, a Microsoft Excel model is constructed, in which the estimated parameters are implemented to calculate mode shares under different mobility policies and externalities. This process is carried out for both the standard MNL and advanced ML model, from which the results and implications are compared.

For the second research question, the focus shifts to an examination of the implementation process of P&R facilities in the Brainport region. This involves gathering information through interviews with key stakeholders to gain insights into the policymaking process, its complexities, the main actors and their respective responsibilities. Four interviews were conducted with individuals from various organizations, including employees from ASML and the province of North Brabant who are involved in these processes and project managers of the Brainport hubs. The interview information is assembled and reviewed before the process, and its challenges are thoroughly analyzed.

The described problems are related to the CoSEM master's program in the first place because mobility management involves complex policymaking processes in which multiple actors are involved to cope with the growing demand for mobility. The policymaking processes for P&R realization will be researched with knowledge gained during the master's program. This study also applies discrete choice models to study travel behavior, which is subject to the Transport & Logistics track within the CoSEM program.

1.3 THESIS OUTLINE

The remainder of this thesis is structured as follows. Chapter 2 outlines the methods for choice modeling and P&R implementation analysis. Chapter 3 details the choice experiment design, which provided the data for the study. In Chapter 4, the estimation process for the MNL and ML models is explained. Chapter 5 reveals the impact of mobility policies on ASML employees' commuting choices. The P&R implementation process in the Brainport Region is explored in Chapter 6. Finally, chapter 7 concludes key findings regarding the research questions, discusses limitations, and provides suggestions for future research.

2. METHODOLOGY

This chapter discusses the methodology employed to conduct this research. As the study encompasses multiple stages, it can broadly be divided into two main segments, mirroring the two primary research questions introduced in the previous chapter. Sections 2.1 and 2.2 cover methods for addressing the first research question; section 2.1 introduces choice experiments, and section 2.2 discusses the theory of discrete choice models. Section 2.3 presents the methodology applied to address the second research question, consisting of an analysis of the implementation process for P&R facilities in the Brainport region. Conclusively, a summary is provided in section 2.4.

2.1 STATED CHOICE EXPERIMENTS

As part of their survey, Molin & Kroesen (2023b) designed a stated choice experiment to capture the respondents' preferences regarding mode choice under various conditions. This is a fundamental tool for understanding individual decision-making in transport. This section discusses the theory of choice experiments; Chapter 3 delves into details of the choice experiment design as constructed by Molin & Kroesen (2023b), which provided the data for this research.

Stated choice experiments involve presenting individuals with hypothetical scenarios in which they are required to make choices among a set of alternatives characterized by varying attributes. Stated choice experiments are designed to simulate real-world decision-making, capturing the trade-offs individuals are willing to make when presented with different options (Hensher, 2006). In the context of transportation studies, choice experiments allow researchers to explore how individuals value and prioritize different modes of transport and associated policy measures.

Stated preference (SP) choice experiments contrast with revealed preference (RP) methods, in which preferences are derived from observed behavior. Although RP methods generally lead to a more accurate reflection of people's actual behavior, these methods cannot be applied to collect data on non-existing situations (Abdullah et al., 2011). Stated preference experiments, however, provide a valuable means to explore hypothetical scenarios, understand latent preferences, and estimate the impact of policy measures before their implementation (Rose & Bliemer, 2009).

The stated preference choice experiments provide a controlled environment to systematically vary attributes and observe individuals' choices to generate datasets that are useful for the application of discrete choice models such as MNL and ML. These choice models can then be employed to establish relationships between attributes and choices made in the experiments to predict preferences towards alternatives in different scenarios (Hanley et al., 2001).

2.2 DISCRETE CHOICE MODELS

In this section, the methodology of discrete choice models is discussed. Firstly, the common MNLL model is explained in section 2.2.1. This is followed by an explanation of the ML model in section 2.2.2.

2.2.1 MNL MODEL

The foundation of most discrete choice models, including MNL and ML, lies in the principles of random utility maximization (RUM) theory. This theory assumes that individuals make choices to maximize their expected utility (McFadden, 1974). The utility a decisionmaker obtains from an alternative consists of a systematic component *V* based on observed attributes and a random component *ε* that accounts for unobservable factors. The standard equation for utility *U* for alternative *i* can be specified as:

$$U_i = V_i + \varepsilon_i \qquad (2.1)$$

The observed utility is based on the values of a preselected set of attributes of an alternative that are expected to impact the decision, such as travel time and costs. To determine the relative importance of the observed attributes in people's preferences and choices, taste parameters are estimated by maximum likelihood estimation (MLE) using discrete choice models (Algers et al., 1998). The observed utility for an alternative is defined as the summation of its relevant attributes (x_m) weighted by their taste parameters (β_m).

The error term *ε* accounts for the unobserved aspects of utility, including unmeasured factors, individual-specific preferences, and random noise (Chorus, 2022). The equation for the total utility of alternative *i* can thus be defined as:

$$U_i = \sum_m x_{im} \cdot \beta_m + \varepsilon_i \qquad (2.2)$$

As the name suggests, the random term for the unobserved part of utility is randomly distributed across all alternatives and individual choices, contributing to the stochastic nature of discrete choice models. In MNL models, these error terms are independently and identically distributed (i.i.d.), extreme value (EV) Type I with variance $\pi^2/6$.

However, the error term distributions of MNL models are often unrealistic, generally leading to biased estimation outcomes and predictions. Due to the fact that the error terms are independently and identically distributed (i.i.d.), they are assumed to be uncorrelated, leading to the IIA property of the model (Chorus, 2022). As explained in the introduction, correlations between alternatives may exist because of shared unobserved utilities. Ignoring these correlations often leads to overestimation of choice probabilities for alternatives with shared properties (Train, 2003).

Within discrete choice models the choice probabilities for the alternatives can be estimated, representing mode shares when considering a large sample. In MNL models the choice probabilities *P* can be estimated from the observed utilities of alternatives in set J:

$$P(i) = \frac{e^{V_i}}{\sum_{j=1..J} e^{V_j}} \qquad (2.3)$$

2.2.2 MIXED LOGIT MODEL

The Mixed Logit (ML) model is an extension of the MNL model based on the same (RUM) principles. A key advantage of the ML model over the MNL lies in its ability to account for correlations among unobserved utilities of alternatives, thus relaxing the IIA property (Algers et al., 1998). In ML models, additional error components can be estimated from the data that reflect the degree of correlation between unobserved utility of alternatives. By adding an error component (υ), 2 or more alternatives can be assigned to a 'nest of alternatives', indicating that they share unobserved parts of utility (Train, 2003). The utility of alternative *i* within nest *k* can be specified in an error component model as:

$$U_i = \sum_m x_{mi} \cdot \beta_m + \upsilon_{mk} + \varepsilon_i \qquad (2.4)$$

In ML models, the introduction of error components allows for accommodating unobserved preference heterogeneity within the choice data. These components are assumed to be normally distributed with a mean of zero and a standard deviation of σ; $\upsilon_{n,k}$ ~ N (0, σ_υ). The value for σ_υ reflects the extent of correlation between the utilities of alternatives within the nest. A larger σ-value suggests a wider range of unobserved utility, indicating a stronger correlation.

Each individual is randomly assigned a value for the error component following its distribution; this value is added to all alternatives within that specific nest for that person, introducing a correlation in their preference for these options. Thus, if this includes a positive value, it will increase the likelihood of that individual choosing either of these modes over alternatives outside this nest. By incorporating error components, the ML model allows for more realistic substitution patterns that reflect the shared unobserved factors within nests. If the additional error component parameter turns out to be neglectable, the alternatives are assumed to share no unobserved variance, then the model results resemble those of the MNL model. Thus, by implementing an error component model the IIA assumption is tested (Chorus, 2022).

Furthermore, Mixed Logit enables the incorporation of panel effects by allowing for correlation among individual-specific factors. These effects, observed over repeated choices by the same individual, encompass unique preferences, habits, or inherent characteristics, enhancing the precision of the model estimates (Algers et al., 1998).

When considering the earlier example in which the alternatives bus and train are assigned to a 'transit nest' without car, the error component for transit is then added to the probability function, leading to the following conditional choice probability function for the bus alternative:

$$P_{bus}|\upsilon_{transit} = \frac{e^{V_{bus}+\upsilon_{transit}}}{e^{V_{bus}+\upsilon_{transit}}+e^{V_{train}+\upsilon_{transit}}+e^{V_{car}}} \qquad (2.5)$$

The unconditional choice probabilities can be determined by integrating the conditional choice probabilities over the assumed density function of the error component $f(\upsilon_n)$ ~ N (0, σ_n). The unconditional probabilities can be estimated by:

$$P_i = \int (\prod_{t=1}^{T} (P_i(\beta)|\upsilon_n) f(\upsilon_n) d\upsilon_n) \qquad (2.6)$$

A disadvantage of the ML model is that the choice probability integral does not have a closed-form solution, like the MNL model. The associated values thus cannot be calculated but must be estimated using maximum likelihood simulation, which estimates averages by making draws from a density (Train, 2003). This method involves making R draws from the random parameter distribution (υ_n^r). The unconditional choice probabilities can be examined by repeating the calculations R times and averaging the results, to estimate the parameters describing the model with the highest Log

Likelihood (best fit) (Chorus, 2022). Because the ML model requires making these draws, the computational times are significantly longer than the MNL.

$$\check{P}_i = \frac{1}{R} \cdot \sum_{r=1}^{R} P_i\,(\beta)|\upsilon_n^r \qquad (2.7)$$

The Apollo software is applied for the model estimation. Generally, Halton draws are used to repeat simulations in Apollo. To balance computational efficiency and modeling accuracy, the number of Halton draws is initially determined by doubling the number of draws until variables reach stable values.

2.3 ANALYSIS ON THE P&R IMPLEMENTATION PROCESS

In order to gain an understanding of the implementation process for P&R hubs in the Brainport region, this study employs an exploratory research approach. According to Dudovskiy (2022), exploratory research is instrumental in illuminating complex situations and processes. The chosen methodology facilitates an in-depth exploration of the policymaking processes and challenges inherent to P&R implementation in the Brainport region.

Data Collection

Central to the investigative strategy is the collection of qualitative data through semi-structured interviews, a method suited for unraveling complex subjects, according to Magaldi & Berler (2020). This approach is used to gain insights into the perspectives of key actors involved in the P&R realization in Brainport. Semi-structured interviews allow for a dynamic exchange, combining pre-defined questions with improvised follow-up queries.

Recognizing the multifaceted nature of the implementation process, the selection of interviewees spans various organizations involved in the P&R project. Engaging individuals from diverse backgrounds ensures a comprehensive coverage of aspects and considers different perspectives and interests that contribute to the complexity of the implementation process.

While recognizing the time-consuming nature of semi-structured interviews, the preparation and analysis employed in this study are intended to ensure the reliability and validity of the gathered information (Adams, 2015). Despite the challenges, this approach is essential for providing a nuanced understanding of the implementation process and contributing valuable insights to address the identified knowledge gap.

In addition to the interviews, information regarding the project will be gathered through internet articles and policy papers available to the public, although it is anticipated that this will not provide enough in-depth information on the complexities and current state of the process. Information from these internet articles and policy papers is mostly used for background information on the mobility plans and the P&R projects in Brainport.

Selection of respondents

Individuals from various parties involved in the P&R implementation process were contacted to contribute to this research voluntarily. Multiple actors were approached, representing various organizations engaged in the P&R implementation process. Each respondent was asked to suggest potential interviewees who have been actively involved in the process. This approach is instrumental in capturing diverse viewpoints and thoroughly exploring the subject.

Four interviews were conducted, each offering a unique perspective on the challenges and intricacies of the P&R implementation process. For privacy reasons, the names of the respondents are not disclosed in this thesis. Instead, they will be referred to in broad terms based on their function.

Interview Preparation

To extract accurate and meaningful information, meticulous preparation is invested in crafting sharp, targeted questions. Drawing on available information about the project and past processes, the questions are designed to delve into the intricacies of the policymaking processes, decision-making dynamics, and challenges faced during implementation.

The semi-structured interviews encompass not only inquiries about the roles and responsibilities of the interviewees but also extend to probing their insights into the roles and responsibilities of other involved parties. This deliberate approach aims to build a comprehensive understanding of the broader network of actors and their interactions within the P&R implementation process.

The semi-structured nature of the interviews allowed for flexibility, incorporating both pre-defined questions and improvised follow-up queries, leading to divergent conversations. The main topics addressed in the interviews involve:

- The Involvement of the respondent and its organization in the P&R implementation process
- The distribution of roles and responsibilities among actors and the collaboration dynamics
- The alignment of P&R projects within the overarching Brainport mobility plan
- An inquiry of the current status and the progress of the P&R implementation process
- An inquiry on the respondents' thoughts on the future prospects of the P&R projects

Post-Interview Analysis

The data collected through interviews is thoroughly analyzed, focusing on identifying patterns, themes, and recurring challenges. This analysis is crucial in comprehending the multifaceted policymaking processes associated with P&R implementation in Brainport. Hereby, it is attempted to gain insights into the factors contributing to the complex and long-term nature of P&R implementation processes in the Brainport region.

2.4 SUMMARY

Main takeaways

- The dataset was collected by Molin & Kroesen (2023b) through stated choice experiments.
- Discrete choice models are used to analyze the data. Besides the MNL model, an ML model with error components and panel structure is estimated.
- Regarding the analysis of P&R implementation in the Brainport region, four interviews are conducted with key stakeholders to gain an in-depth understanding of the process.

Chapter 2 of the thesis outlines the methodology used to investigate the effects of mobility policies on commuting choices and the implementation process of P&R facilities. Data collected from stated choice experiments is analyzed through discrete choice models. An MNL model is estimated as a reference similar to the model by Molin & Kroesen (2023b). An advanced ML model is estimated to account for heterogeneity between alternatives and individual choices (panel effects). Meanwhile, in examining the P&R development in Brainport, four semi-structured interviews were conducted with individuals from various stakeholders to gain in-depth and multi-perspective information on the process, the stakeholders, and the challenges they encountered.

3. CHOICE EXPERIMENT DESIGN

This chapter discusses the design of the choice experiment, which was constructed by Molin & Kroesen (2023b) to collect data among ASML employees. ASML employees were invited by e-mail for the online survey, which was open from the 14th of December 2022 until the 17th of January 2023. Data was collected from 5,642 respondents. The stated choice experiment required participants to choose between various transport modes under different circumstances, aligning with the policy measures identified by ASML.

Section 3.1 outlines the overall design of the choice experiment, introducing the considered alternatives. In section 3.2, the policy interventions incorporated into the experiment are outlined. Section 3.3 focuses on the attributes and attribute values considered in the choice experiment. Section 3.4 describes how the choice sets are generated by Molin & Kroesen (2023b). A brief summary in section 3.5 concludes the chapter.

3.1 SPECIFICATION OF THE CHOICE EXPERIMENT

Molin & Kroesen (2023) categorized several transport modes based on these policies: car, bicycle, bus, P&R with last-mile transport (e-bike or shuttle bus), and train with last-mile transport. However, not all alternatives apply to every employee due to individual circumstances. For instance, the train may not be viable if there is no nearby train station, and the bicycle may not be suitable for employees living further away from ASML. To address these variations, Molin & Kroesen (2023) formulated five distinct experiments to which the employees were assigned based on several conditions. These experiments, the conditions and the available alternatives are characterized as follows:

Experiment 1:

- Applicable to employees living within a 10 km radius of ASML or between 11-15 km with NO highway access.
- Alternatives include Bus, Car, Carpool, and Bike.

Experiment 2:

- Applicable to employees living 11-15 km from ASML with access to a highway for at least 10 km.
- Alternatives include P&R at 9 km (with a shuttle bus or e-bike), Car, Carpool, and Bike.

Experiment 3:

- Applicable to employees living 16 km or more from ASML with the option of taking the train.
- Alternatives include P&R at 9 km (with a shuttle bus or e-bike), Train (with shuttle or e-bike), Car, and Carpool.

Experiment 4:

- Applicable to employees living 16 km or more from ASML with no train option.
- Alternatives include P&R at 9 km (with a shuttle bus or e-bike), Car, and Carpool.

Experiment 5:

- Applicable to employees living 16 km or more from ASML with no train option.
- Alternatives include P&R at 13 km (with a shuttle bus or e-bike), Car, and Carpool.

The survey used specific questions to determine the conditions applicable to each respondent, including distance to ASML, highway access, and willingness to consider train travel. Based on these conditions, they were assigned to one of the experiments. It is assumed that the group of respondents in this survey is representative of the ASML population that matches these conditions. Therefore, the share of survey participants who went through each experiment provides an estimate of the proportion within the entire ASML workforce at the Veldhoven campus.

3.2 POLICY MEASURES

Within the choice experiment, respondents had to make decisions in various presented choice sets under different circumstances. These circumstances reflect the policy measures considered by ASML and traffic conditions. The policy interventions incorporated in the choice experiments include:

- Introducing a (daily) reward for not using the car to travel to ASML
- Introducing parking costs at ASML
- Differentiating the travel allowance (up to 20 km) for different modes
- Introducing the requirement to book a parking spot in advance
- Developing P&R locations on route to ASML, with varying levels of service of the mobility
- options from the P&R location to ASML (e-bike /shuttle bus) and the P&R location itself (e.g., parking only or additional facilities like offices)
- Increasing the level of service of the train alternative by offering (first class) NS business cards and by improving the level of service of the mobility options from the Eindhoven train station to ASML (e-bike /shuttle bus)
- Increased congestion, leading to longer average delays (External)

3.3 ATTRIBUTES AND ATTRIBUTE LEVELS

To capture the impact of policy measures on employees' travel preferences, the attribute values within the experiments were systematically varied. The attributes and attribute values based on the policy measures, as identified in the previous paragraph, are discussed in this section. Table 1 provides an overview of all considered attributes and attribute values, though not all attributes are applicable to each experiment. In the table the base levels for the measures are highlighted, representing the current assumed conditions. The attribute levels were varied individually over the choice set while keeping the remaining attributes at the base levels. The key attributes and levels varied over the experiments can be described as follows:

Daily reward and parking costs:
The experiment introduced a daily financial incentive for using transportation modes other than a personal car, such as cycling, carpooling, or public transport. This reward was inversely coupled with equivalent parking fees, meaning employees commuting with alternative modes are rewarded the same amount as car drivers are charged for parking at ASML. Therefore, a €1.50 daily reward will be

met with a parking fee of €1.50, resulting in a relative cost difference of €3.00. A daily reward of €3.00 is combined with a €3.00 parking fee. Naturally, there is the option of neither parking costs nor daily rewards (both €0), resembling the present situation.

Travel allowances:
In a similar fashion, travel allowances for car and bicycle use were set up to be inversely coupled to encourage cycling over driving. An increase in bike allowance is coupled with a similar-sized decrease in car allowance from the base level of 20 ct/km, which leads to 3 possible combinations of travel allowances:

1. Equal allowance: Both car and bicycle users receive 20 cents per kilometer, which reflects the current policy.
2. Increased bicycle allowance: Bicycle allowance is raised to 25 cents per kilometer, while car allowance is reduced to 15 cents per kilometer.
3. Maximized bicycle allowance: Bicycle users receive 30 cents per kilometer when the car allowance is at its lowest, 10 cents per kilometer.

To promote carpooling, an additional per-kilometer allowance can be offered for this option, encouraging both drivers and passengers to share rides since the additional allowances are granted to all passengers. The carpool allowance can be 0, 10, or 20 cents per kilometer per person, in addition to the standard car allowance. This carpool allowance adjusts according to the decrease in car allowance:

- If the car allowance is 15 cents per kilometer, carpoolers receive an extra 10 cents per kilometer, totaling 25 cents per kilometer.
- With a car allowance of 10 cents per kilometer, the carpool allowance rises to 20 cents per kilometer, culminating in a total of 30 cents per kilometer for carpoolers.

Parking reservation requirement:
To discourage car use, the policy of a mandatory parking reservation system was evaluated. This measure compels car users to reserve their parking space in advance, adding an extra step to their commute. While booking does not incur a monetary cost, car users may be disincentivized by such measures as they require time. The options include 'no booking required', 'booking required 24 hours in advance', and 'booking required 1 week in advance'.

P&R facilities:
In experiments 2- 5, P&R facilities were presented as an alternative, located along the commuters' current route to the workplace. The experiment also varied the distance of these facilities from ASML, which is assumed to be 9 kilometers in experiment 4 and 13 kilometers in experiment 5. These distances are based on the existing P&R in Eersel (9 km from ASML) and the planned P&R in Best (13 km from ASML). Furthermore, additional services were considered in the experiments to enhance the attractiveness of the P&R facilities, which include the provision of office and meeting rooms for the employees to work, as well as full-service facilities consisting of pick-up and delivery service, car wash and maintenance, and grocery stores.

Travel modes from P&R:
From the P&R to the workplace, two free transport alternatives are considered: an e-bike and a

shuttle bus, both available at all times without any charge. The time it takes to travel from the P&R to ASML is predetermined and depends on the distance: for a P&R situated 9 kilometers away, the e-bike journey is estimated at 23 minutes, and the shuttle bus is about 9 minutes; for a P&R positioned 13 kilometers away, it is 34 minutes on the e-bike and 13 minutes by shuttle bus.

Shuttle Bus Service Level:

The shuttle bus service level was defined by the bus's capacity (options for 8, 20, or 50 passengers) and the anticipated wait times (5, 10, or 15 minutes). Furthermore, the potential delays for the shuttle bus were set at 0, 20, or 40 minutes, independent of car delays, to evaluate scenarios where the shuttle bus might avoid traffic jams, such as by using dedicated bus lanes. In the experiment, the shuttle bus delay in each choice scenario was matched to the car delay or set to none to ensure a realistic setting.

Train service level:

For train commuters, different service levels were simulated by offering different classes of business travel cards and varying the associated amenities.

In experiment 3, commuting by train was introduced as an additional option. The quality of train service offered varied, with three types of business travel cards: a standard second-class card as is currently available, a second-class card with the option for the user to pay for an upgrade to first class and a premium first-class card. At Eindhoven Central Station, employees could then choose to continue their journey to ASML via e-bike or shuttle bus, with estimated travel times of 20 minutes for the e-bike and 18 minutes for the shuttle bus. The shuttle bus service was similarly assessed for its level of service by altering bus capacity options and the expected wait times, as described for the P&R shuttle option.

External conditions:

In addition to the described policies, Molin & Kroesen (2023b) included three external conditions in their experiment: the car delay due to congestion (0, 20 or 40 minutes), delay by bus (0, 20 or 40 minutes) and the pick-up time for carpool (0, 5 or 10 minutes). The average delay under current conditions is assumed to be 10 minutes, which corresponds with the median difference between free flow time and travel time under usual circumstances, following reports of respondents in the survey.

Table 1: Attributes and attribute levels used in the experiments

Policy measures	levels
Daily reward for non-car or P+R alternative	**0**, 1.50 or 3 euro
Parking costs for car	**0**, 1.50 or 3 euro
Travel allowance car (up to 20 km)	10, 15 or **20** ct/km
Travel allowance bike (up to 20 km)	**20**, 25 or 30 ct/km
Additional allowance for carpool (for each person)	**0**, 10 or 20 ct/km
Requiring to book a parking spot in advance	**Not required**, 24 hours ahead or 1 week ahead
P+R facilities on route to ASML, including:	
Distance from P&R to ASML	**9** or 13 km from ASML
Level of service	**Only parking**, offices or full-service
E-bike / shuttle bus service from P+R to ASML	8-, **20**- or 50-person shuttle bus
Waiting time shuttle bus	5, 10 or **15** minutes

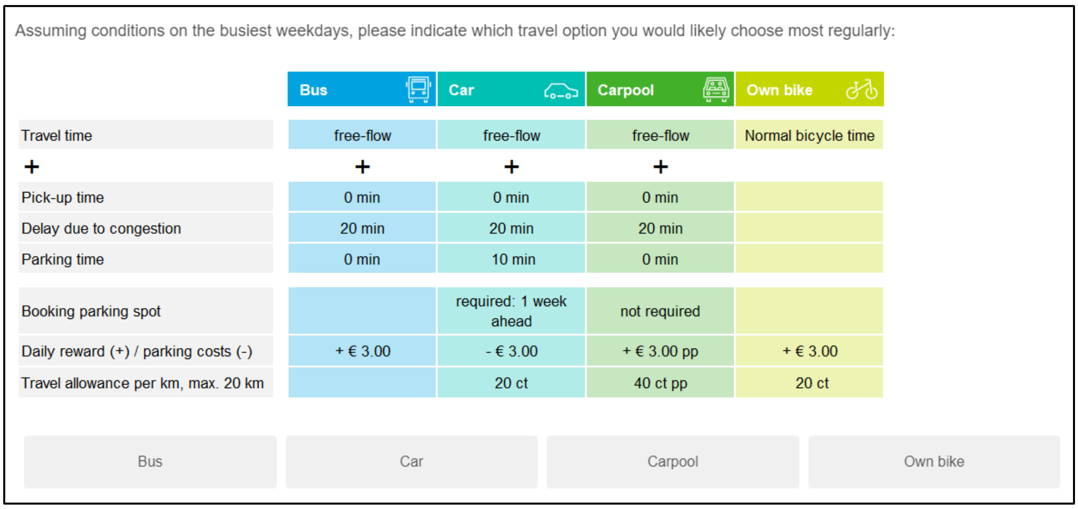
Delay due to congestion shuttle bus	0, **10**, 20 or 40 minutes
Train, including:	
Business card type	**Second class**, second class with option for first class, first class
E-bike/shuttle bus service from station to ASML	8-, **20**- or 50-person shuttle bus
Waiting time shuttle bus	5, 10 or **15** minutes
External conditions	**Attribute levels**
Delay due to congestion (for car alternatives)	0, **10**, 20 or 40 minutes
Delay due to congestion (for regular bus)	0, **10**, 20 or 40 minutes
Pick-up time (carpool)	0, 5 or **10** minutes.

3.4 GENERATION OF CHOICE SETS

The choice sets containing the alternatives available to the respondents were constructed by Molin & Kroesen (2023a) based on prior knowledge. This approach reduces the number of choice sets and respondents required to obtain meaningful data. It employs parameter values estimated from prior research, referred to as priors, to design choice sets efficiently with reasonable parameter values.

Following this experimental design, Molin & Kroesen (2023a) constructed 9 choice sets for experiment 1 and 18 choice sets for experiments 2-5. However, since more than 10 choice sets might lead to respondent fatigue with unreliable results, they divided experiments 2-5 into two blocks of 9 choice sets each. Blocking ensures that within each block, every attribute value is presented an equal number of times (Szinay et al., 2021). In experiments 2-5, every respondent is randomly assigned to one of the blocks, in which they are presented with 9 choice sets in random order. Figure 1- Figure 4 depicts examples of choice sets for the various experiments as they were presented to the respondents. The full explanations of the choice experiments to the respondents can be found in Appendix A.

Figure 1 presents an example of a choice set provided to respondents in experiment 1. Note that the values for the attributes are varied over the various choice sets. Figure 2 shows an example of the choice sets for respondents in experiment 2, while Figure 3 represents the choice set in experiment 3. Experiments 4 and 5 are depicted in Figure 4.


Assuming conditions on the busiest weekdays, please indicate which travel option you would likely choose most regularly:

	Bus	Car	Carpool	Own bike
Travel time	free-flow	free-flow	free-flow	Normal bicycle time
+	+	+	+	
Pick-up time	0 min	0 min	0 min	
Delay due to congestion	20 min	20 min	20 min	
Parking time	0 min	10 min	0 min	
Booking parking spot		required: 1 week ahead	not required	
Daily reward (+) / parking costs (-)	+ € 3.00	- € 3.00	+ € 3.00 pp	+ € 3.00
Travel allowance per km, max. 20 km		20 ct	40 ct pp	20 ct

Bus | Car | Carpool | Own bike

Figure 1: Choice set as provided to respondents in experiment 1 (Molin & Kroesen, 2023a)

Assuming conditions on the busiest weekdays, please indicate which travel option you would likely choose most regularly:

	By car to P+R, then transfer P+R facilities: office and meeting facilities P+R to ASML: 9 km		Continue by car to ASML		By bike from home to ASML
	e-bike	shuttle bus 50p	car	carpool	own bike
Travel time from P+R to ASML	23 min	9 min	9 min	9 min	normal bicycle time
+	+	+	+	+	
Transfer / pick-up time		10 min		0 min	
Delay due to congestion		0 min	40 min	40 min	
Parking time at ASML			10 min	0 min	
Total travel time from P+R to ASML	**23 min**	**19 min**	**59 min**	**49 min**	normal bicycle time
Booking parking spot			not required	not required	
Daily reward (+) / parking costs (-)	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00
Travel allowance per km, max. 20 km			20 ct	20 ct pp	20 ct

P+R & e-bike | P+R & shuttle | Car | Carpool | Own bike

Figure 2: Choice set as provided to respondents in experiment 2 (Molin & Kroesen, 2023a)

Assuming conditions on the busiest weekdays, please indicate which travel option you would likely choose most regularly:

	By train to station, then transfer business card type: second class (option first class) train station to ASML: 7.3 km		By car to P+R, then transfer P+R facilities: office and meeting facilities P+R to ASML: 13 km		By car to ASML	
	e-bike	shuttle bus 8p	e-bike	shuttle bus 8p	car	carpool
Travel time from station/P+R to ASML	20 min	18 min	34 min	13 min	13 min	13 min
+	+	+	+	+	+	+
Transfer / pick-up time		10 min		15 min		5 min
Delay due to congestion				0 min	0 min	0 min
Parking time at ASML					10 min	0 min
Total travel time from station/P+R to ASML	**20 min**	**28 min**	**34 min**	**28 min**	**23 min**	**18 min**
Booking parking spot					not required	not required
Daily reward (+) / parking costs (-)	+ € 3.00	+ € 3.00	+ € 3.00	+ € 3.00	- € 3.00	+ € 3.00 pp
Travel allowance per km, max 20 km					10 ct	20 ct pp

Train & e-bike | Train & shuttle | P+R & e-bike | P+R & shuttle | Car | Carpool

Figure 3: Choice set as provided to respondents in experiment 3 (Molin & Kroesen, 2023a)

Assuming conditions on the busiest weekdays, please indicate which travel option you would likely choose most regularly:

	By car to P+R, then transfer P+R facilities: office and meeting facilities P+R to ASML: 9 km		Continue by car to ASML	
	e-bike	shuttle bus 8p	car	carpool
Travel time from P+R to ASML	23 min	9 min	9 min	9 min
+	+	+	+	+
Transfer / pick-up time		15 min		5 min
Delay due to congestion		0 min	0 min	0 min
Parking time at ASML			10 min	0 min
Total travel time from P+R to ASML	**23 min**	**24 min**	**19 min**	**14 min**
Booking parking spot			not required	not required
Daily reward (+) / parking costs (-)	+ € 3.00	+ € 3.00	- € 3.00	+ € 3.00 pp
Travel allowance per km, max. 20 km			10 ct	20 ct pp

P+R & e-bike | P+R & shuttle | Car | Carpool

Figure 4: Choice set as provided to respondents in experiment 4 (P&R at 9 km) and experiment 5 (P&R at 13 km) (Molin & Kroesen, 2023a)

3.5 SUMMARY

Main takeaways

- The choice experiment encompasses 5 distinct experiments
- Respondents were assigned to one of these experiments based on their commuting distance and the feasibility of transport modes.
- Respondents were presented with different choice sets, including various alternatives based on the experiment they were assigned to.
- Each respondent was required to make 9 decisions on mode choice under various alleged scenarios.

Chapter 3 outlines the design of a choice experiment conducted to examine ASML employees' preferences for various commuting options in different scenarios. The experiment was structured into five distinct experiments, each tailored to employees' specific commuting conditions, such as distance from work and viability of transport options. Respondents were presented with hypothetical scenarios involving varied attributes reflecting certain policies by ASML and average delay. The choice sets, based on prior knowledge, were divided into blocks of a maximum of 9 choices to prevent respondent fatigue.

4. MODEL ESTIMATION

This chapter delves into the model estimation procedure for the choice models. Discrete choice models are applied to evaluate the relative preferences of ASML employees towards characteristics of travel alternatives. Section 4.1 elaborates on the coding of the included variables to give an understanding of how the choice models were constructed before delving into the estimation of the MNL and ML models. Section 4.2 discusses the estimation procedure applied for the MNL models and examines the results. Subsequently, in section 4.3 the estimation process and its results for the ML model are presented. In section 4.4 the model fit of the final models are compared and discussed. The chapter concludes with a summary in section 4.5.

4.1 MODEL CODING

As discussed earlier, the choice experiment was divided into 5 distinct experiments differing in the alternatives available to the employees. Each of these experiments is estimated separately using choice models, except for experiments 4 and 5, which were merged into one model due to their identical alternatives, differing only by the distance of the P&R locations from ASML.

The selection of attributes for the experiment was carefully curated to simulate different policy measures, details of which have been outlined in the previous chapter. In the model, each attribute was assigned a taste parameter, quantifying its influence on the employees' preferences.

The models also incorporated (alternative specific) constants, which play a crucial role in capturing the intrinsic appeal of the alternatives, which are not directly observed by the attributes. They represent the inherent characteristics that contribute to an individual's preference for a particular alternative beyond the explicitly defined attributes.

The choice models integrated dummy variables to represent categorical and nominal data. Dummy variables serve as binary variables, assigning a '1' to denote the presence of a specific attribute and a '0' otherwise. For instance, the availability of first-class train travel is captured with dummy variables because such qualitative attributes lack numerical representation. In scenarios featuring first-class travel, the corresponding dummy variable is set to '1', while the option to upgrade to first-class is set to '0'. If both variables are '0', it indicates that the choice set pertains to second-class travel.

In Table 2 the variables included in the model are clarified. As indicated in the table, the constants for a P&R location at 13 km are only added to the P&R alternatives in the utility functions of experiment 4+5. For each parameter, the metric of the associated attribute is indicated, or whether it relates to a dummy variable.

Table 2: Description of the coded variables used in the model.

Variable	Description
Constants C_x	
car	Constant for car alternative
carpool	Constant for carpool alternative
PRshuttle	Constant for P&R + shuttle alternative
PRbikebike	Constant for P&R + bike alternative

bike	Constant for bike alternative
TRshuttle	Constant for train + shuttle alternative
TRbike	Constant for train + bike alternative
bus	Constant for bus alternative
PRs_13km	Constant for P&R + shuttle when P&R located at 13km (Dummy variable, **only included in experiments 4 and 5**)
PRb_13km	Constant for P&R + bike when P&R located at 13km (Dummy variable, **only included in experiments 4 and 5**)
Taste parameters β_x	
cardelay	Parameter for delay time by car (in minutes)
costdiff	Parameter for cost differences for the car through parking costs and daily rewards for non-car alternatives (in euros)
carallow	Parameter for car allowances (in cent per km)
allowadd	Parameter for additional carpool allowances (in cent per km)
pickup	Parameter for pick-up time by carpool (in minutes)
1week	Parameter for required parking reservation 1 week in advance (dummy variable)
24hour	Parameter for required parking reservation 1 week in advance (dummy variable)
busdelay	Parameter for delay time by bus (in minutes)
PRbuswait	Parameter for waiting time for shuttle at P&R (in minutes)
PRbusdelay	Parameter for traffic delay by shuttle from P&R (in minutes)
TRbuswait	Parameter for waiting time for shuttle with train alternative (in minutes)
PRmeeting	Parameter for meeting rooms at the P&R locations (dummy variable)
PRfullservice	Parameter for full service at the P&R locations (dummy variable)
PR_s20p	Parameter for 20-person shuttle bus from P&R (dummy variable)
PR_s50p	Parameter for 50-person shuttle bus from P&R (dummy variable)
TR_s20p	Parameter for 20-person shuttle bus from train (dummy variable)
TR_s50p	Parameter for 50-person shuttle bus from train (dummy variable)
TR_opt1	Parameter for option to first class upgrade in train (dummy variable)
TR_first	Parameter for first class upgrade in train (dummy variable)

4.2 ESTIMATION OF MNL MODELS

In estimating MNL models, this study follows the precedent set by Molin & Kroesen (2023b), using the same attributes and levels for consistency compared with Mixed Logit results. Notably, all variables are considered in the final model for comprehensive analysis, regardless of their statistical significance. The alternatives considered in the estimation process for each experiment are:

Experiment 1: Car, carpool, bus and (e-)bike
Experiment 2: Car, carpool, P&R + (e-)bike, P&R + shuttle

Experiment 3: Car, carpool, P&R + (e-)bike, P&R + shuttle, train + (e-)bike, train + shuttle
Experiment 4 and 5: Car, carpool, P&R + (e-)bike, P&R + shuttle

Each alternative's utility is characterized by a combination of attributes, parameters, and an error term. In **Error! Reference source not found.** the variables in the utility functions are outlined. For each alternative, the table specifies the applicable constants and attributes and their respective parameters, contributing to the observable part of utility, indicated by (+) or (-). An entire overview of the MNL of the written utility functions is presented in Appendix B.1.

As explained in section 3.3, parking costs are inversely coupled with daily rewards for non-car modes, meaning they can only take on the same values. This is included in the model as a relative cost difference, which is included as a single attribute in the utility function for car (costdiff). Similarly, the car allowance is inversely related to the bike allowance, leading to the inclusion of the car allowance attribute (carallow) with a negative sign in the utility function for the bike alternative, as indicated with (-) in the table.

Table 3: Overview of included parameters and corresponding attributes in the alternative's utility functions

	Car	Carpool	Bus	Bike	P&R + shuttle	P&R + bike	Train + shuttle	Train + bike
Appears in experiments:	1, 2, 3, 4/5	1, 2, 3, 4/5	1	1, 2	2, 3, 4/5	2, 3, 4/5	3	3
Constants:	Car	Carpool	Bus	Bike	P&R + shuttle, PRs_13km*	P&R + bike, PRb_13km*	Train + shuttle	Train + bike
Attributes								
cardelay	+	+						
costdiff	+							
carallow	+	+		-				
allowadd		+						
pickup		+						
1week	+							
24hour	+							
busdelay			+					
PRbuswait					+			
PRbusdelay					+			
TRbuswait							+	
PRmeeting					+	+		
PRfullservice					+	+		
PR_s20p					+			
PR_s50p					+			
TR_s20p							+	
TR_s50p							+	
TR_opt1							+	+
TR_first							+	+

**These constants are added as a dummy variable in experiment 4/5 to indicate the relative difference in utility when the P&R is located 13 km from ASML instead of 9 km.*

From this table, the utility functions for the alternatives can be constructed by implementing the indicated parameters with their corresponding attributes in a formula that includes the error term. As an example, equation 4.1 shows how the utility for car is specified in experiment z.

$$U_{car,z} = C_{car,z} + \text{cardelay} \cdot \beta_{cardelay,z} + costdiff \cdot \beta_{costdiff,z} + carallow \cdot \beta_{carallow,z} + week1 \cdot \beta_{week1} + \text{hour24} \cdot \beta_{hour24,z} + \varepsilon \quad (4.1)$$

For experiments 4 and 5, which consider the distance from the P&R facility to ASML, a dummy variable (*DistancePR)* and its associated taste parameter are introduced to differentiate between a P&R location at 9 km (experiment 4) and 13 km (experiment 5). This variable modifies the utility for P&R-related alternatives (denoted with * in **Error! Reference source not found.**) and indicates the relative utility associated with a P&R at 13 km instead of 9 km for both alternatives.

In this study, the MNL model was estimated for various experiments, resembling the model applied by Molin & Kroesen (2023a). The estimations for the constants and taste parameters are detailed in Table 4, which align with their results despite some minor inconsiderable differences. The constant for car (c_car) is fixed to 0. Therefore, the constants for other alternatives are relative to the car alternative. In a comprehensive overview, the estimation results for each experiment, complete with standard errors, t-statistics, and p-values, are systematically documented in Appendix C.1.

The positive constant for the bike alternative suggests a latent preference for bicycles over cars, particularly in experiment 1 and to a lesser extent in experiment 2. Conversely, the negative constants for other alternatives imply a lower unobserved utility compared to cars, with the option of cycling after P&R demonstrating the least intrinsic appeal. Notably, the dummy constant *PRs_13km,* though insignificant, indicates a higher preference for P&R with shuttle services at a distance of 13 km from ASML, as opposed to a closer location at 9 km.

The taste parameter estimations should be compared cautiously when they differ in metrics, as is the case for most variables. However, time-related parameters are comparable across experiments since they are consistently measured in minutes. Analysis reveals a more negative perception of car delays on longer distances (experiments 3 and 4+5), compared to shorter commutes. Moreover, delays and waiting times for shuttle services in combination with train or P&R are valued more critically than those for cars and buses. Remarkably, many parameters associated with the service levels of P&R and train services, such as full-service P&R amenities and options for first-class train travel, are statistically insignificant across most experiments. An exception is the marginal positive utility derived from the availability of first-class train cards with a taste parameter of 0.083, comparable with a euro cost difference in the same experiment (-0.085). This suggests that employees are willing to pay just 1 euro for the upgrade to a first-class business card – a value that seems negligible compared to ASML's associated expenses to provide this premium option. Strikingly, the presence of a meeting room at P&R sites is associated with a negative utility in experiment 3, which is counterintuitive since this is considered an upgrade. This unexpected finding might be attributed to the high number of parameters within the models in combination with people's indifference towards this attribute. Respondents may have overlooked or misinterpreted this feature due to the lay out of the experiment.

Table 4: Estimation results of the MNL models for the distinct experiments

	Exp 1	Exp 2	Exp 3	Exp 4+5
Constants C_x				
car	0	0	0	0
carpool	-2.075	-1.525	-1.128	-1.486
PRshuttle		-1.010	-1.055	-1.344
PRbike		-1.844	-2.796	-2.082
bike	1.335	0.411		
TRshuttle			-0.326	
TRbike			-0.743	
PRs_13km				0.125
PRb_13km				-0.459
bus	-0.757			
Taste parameters β_x				
cardelay	-0.011	-0.014	-0.028	-0.042
costdiff	-0.088	-0.060	-0.085	-0.094
carallow	0.007	0.006	0.003	0.008
allowadd	0.030	0.006	0.010	0.003
pickup	-0.002	-0.040	-0.025	-0.036
1week	-0.086	-0.112	-0.102	-0.105
24hour	-0.042	-0.103	-0.141	-0.061
busdelay	-0.017			
PRbuswait		-0.056	-0.051	-0.058
PRbusdelay		-0.042	-0.055	-0.064
TRbuswait			-0.054	
PRmeeting		-0.070	-0.126	0.012
PRfullservice		0.135	-0.063	0.099
PR_s20p		0.201	0.008	0.038
PR_s50p		-0.096	-0.026	-0.061
TR_s20p			-0.018	
TR_s50p			-0.063	
TR_opt1			0.046	
TR_first			0.083	

N.B.: All values presented in black are significant at a 95% interval, values in red are insignificant at a 95% interval.

4.3 ESTIMATION OF MIXED LOGIT MODELS

The estimation of ML models addresses the inherent limitations of MNL models, particularly their inability to account for correlations between different alternatives and across multiple choices by the same individual, due to the IIA property. In ML models additional error components are introduced to accommodate nested alternatives and account for panel effects. Before the final model is constructed, the relevant nests must first be identified.

4.3.1 CONFIGURATION OF NESTS

The identification of appropriate nests is crucial for the accuracy of the ML model, as it influences the distribution of the random error terms and, consequently, the estimation of choice probabilities. Alternatives with similar unobserved characteristics are nested together to capture their correlated utilities accurately. This strategic configuration is essential to enhance the robustness of the model and provide more insightful estimations on commuter preferences.

In configuring these nests, Table 5 outlines the main characteristics of each transport alternative, highlighting aspects such as modality, directness of transport, privacy, and exposure to weather. These characteristics inform the grouping of alternatives into nests based on shared unobserved attributes that potentially induce correlations in the choice data.

Table 5: Characteristics of transport alternatives

Alternatives	Multi-modal	Direct (no stops)	Shared mode	Weather-proof	Waiting time inherited	Transport to station/stop	Active mode
Car		X		X			
Carpool			X	X	X		
Bus			X	X	X	X	
Bike		X					X
P&R + shuttle	X		X	X	X		
P&R + bike	X						X
Train + shuttle	X		X	X	X	X	
Train + bike	X		X		X	X	X

Based on the shared characteristics of certain alternatives potential nests can be identified. In addition to the characteristics mentioned above, the alternatives in the experiments contain some of the same (or similar) transport means, for at least part of the journey. Nests regarding certain transport means are also considered within these nests (such as a car nest). Below are the potential nests of alternatives that were considered across all experiments.

<u>Nest for cars</u>
Several alternatives across experiments involve the use of cars. In addition to car and carpool, P&R alternatives involve car usage although in conjunction with a secondary transport mode (bike or shuttle bus). Therefore, two options for this nest are considered possibilities: a car nest without P&R, and a nest including both P&R options.

<u>Nest for public transport</u>
Public transport services in which transportation is operated on a fixed schedule and shared with multiple individuals. The commonality here lies in the structured nature of the travel, often requiring adherence to timetables and the presence of multiple stops, leading to a potential decrease in convenience and control. Both buses and trains share the characteristic of being weatherproof and capable of transporting large numbers of passengers, appealing to those who prioritize

environmental concerns or cost savings. On the other hand, people may be hesitant to use public transport for various reasons such as lack of comfort, convenience, control, freedom and status (as opposed to car use) (Steg, 2003). Although trains generally hold a higher desirability in the Netherlands, offering greater comfort and perceived status, buses are included in the same nest as they fundamentally offer the same structured shared travel experience. This potential nest includes bus, P&R + shuttle, train + bike, and train + shuttle.

Nest for shared transport
The shared transport nest expands upon the concept of collective travel by including carpooling, a mode of transport that allows for a more personal and selective shared experience. In contrast with public transport, carpooling involves a more personal and voluntary grouping, which can mitigate some of the perceived status loss associated with forms of public transport. However, it also introduces a compromise to personal space and autonomy, a commonality it shares with public transport modes. This potential nest embodies the diverse facets of shared travel, including the alternatives carpool, bus, P&R + shuttle, train + bike, and train + shuttle.

Nest for P&R
Two alternatives include the use of a P&R facility, either followed by an (e-)bike or a shuttle bus. They share a commuting approach that involves driving to a parking facility and then switching to a secondary transport mode for the remainder of the journey. The first leg of the journey is characterized by the independence and comfort of personal vehicle use, while the subsequent leg emphasizes a shift towards more sustainable or efficient transport modes. These alternatives might attract individuals who are susceptible to combining the autonomy of car travel with the benefits of cycling or public transit, despite the required commitment to a two-phase commute.

Nest for multimodal transport
Both alternatives involving P&R and those with trains encompass commuting options that involve multiple modes of transport. People might be reluctant to use either of these options due to the need for a transfer between modes, regardless of the transfer time. Therefore, a nest can be considered combining all options, including the use of P&R or train.

Nest for shuttle bus
In experiment 3, which includes both P&R and train options, one of the possibilities for last-mile transport includes a shuttle bus. Consequently, the alternatives ‘P&R + shuttle’ and ‘train + shuttle’ are considered a nest possibility. Note that the option to travel by bus directly is not part of this nest because this alternative is not available in either experiment that includes shuttle bus options.

Nest for bike
This nest caters to the unique preference distribution regarding bicycle use, whether as a primary travel mode or integrated within a multimodal framework. Biking is recognized for its active nature and susceptibility to weather conditions, which significantly influences commuter preferences. The alternatives considered in this potential nest include bike, P&R + bike, and train + bike.

Nest configurations

These nests were varied systematically in different configurations while estimating the error component ML models across the various experiments. The final selection of nests was based on a combination of logical grouping of alternatives by shared characteristics and statistical analysis, considering factors such as the sigma values, t-values, and overall model fit. It was attempted to limit the number of nests while encapsulating the most significant shared characteristics between transport alternatives, because including too many random components may lead to overly complex and potentially unstable models. Four primary nests were established through this process:

1. **The Car Nest** incorporates options involving car use, including carpooling and Park & Ride (P&R) alternatives. This grouping is logical given that each of these options includes a car journey, either exclusively or as the first leg of a multimodal trip.
2. **The Shared Transport Nest** groups modes that involve sharing the journey with others. It includes public transportation options like buses and trains, along with carpooling. Despite showing differences with public transit, carpooling is included here to differentiate shared journeys from solo driving, supported by statistical evidence indicating strong commonality.
3. **The Multimodal Nest** captures the shared heterogeneity of options that require transfers, such as combinations of P&R or train with other modes. This reflects the complexities involved in switching between transport modes during a journey.
4. **The Bike Nest** is dedicated to options involving bicycles, acknowledging the specific preference distribution for cycling, whether as a standalone mode or part of a multimodal commute.

These nests, selected from numerous potential combinations, were found to provide the most statistically robust structure for the ML models. They portray the essential shared characteristics between alternatives without introducing excessive complexity that could destabilize the model, thereby enhancing the model's applicability and reliability. Table 6 gives an overview of the alternatives within each nest.

Table 6: Overview of Nest Compositions

	Car nest	Shared nest	Multimodal nest	Bike nest
Car	X			
Carpool	X	X		
Bus		X		
Bike				X
P&R + shuttle	X	X	X	
P&R + bike	X		X	X
Train + shuttle		X	X	
Train + bike		X	X	X

Given that available transport alternatives differ across the experiments, nest configurations were tailored accordingly. The cars nest, for example, was not included in experiments 4 and 5 since all alternatives inherently include car usage in these experiments. The selections of nests are clarified per experiment in Table 7. The error components are estimated for every alternative within the nests. An overview of the ML utility functions corresponding with these nest compositions is detailed in Appendix B.2.

Table 7: Overview of the configuration of nests per experiment

Experiment	Car Nest	Shared Nest	Multimodal Nest	Bike Nest
1	Car, Carpool	Carpool, Bus	-	-
2	Car, Carpool, P&R + Shuttle, P&R + Bike	Carpool, P&R + Shuttle	P&R + Shuttle, P&R + Bike	Bike, P&R + Bike
3	Car, Carpool, P&R + Shuttle, P&R + Bike	Carpool, P&R + Shuttle	P&R + Shuttle, P&R + Bike, Train + Shuttle, Train + Bike	P&R + Bike, Train + Bike
4 + 5	-	Carpool, P&R + Shuttle	P&R + Shuttle, P&R + Bike	-

In ML models with random components there is a risk of achieving a local optimum, which would result in distorting parameter estimates. To limit this risk, multiple models are estimated with various starting values for the random parameters. The starting values for the random components in each experiment were varied between the values 0, 1, 3 and 5. These variations in starting values led to minimal differences in the random component estimates and model fit of the models. When the number of random parameters was increased, the variation grew slightly larger, however it did not lead to significant different results in the standard estimated ML models. After many simulations, it remained difficult to determine the starting values leading to the best model based on parameter estimates and model fit, therefore all random components were assigned starting value 1.

The simulations for the ML models included 1000 Halton draws for each experiment. Increasing the number of draws did not lead to significantly different parameter changes, therefore the estimated models are considered stable. Implementing the defined nest configurations in an ML model has led to the parameter estimates presented in Table 8 below. The results underscored the high significance of selected error components, highlighted by robust t-values in the tables in Appendix C.2. Moreover, the estimated sigma values for the error components appear to be relatively high, indicating a wide variation in preferences towards certain nests of alternatives. The error components for the car nests are estimated to be among the highest across the experiments, especially for experiment 2, where a sigma value of 8.903 suggests a strong correlation within the nest. The correlation for car alternatives in this experiment is high at 0.84, based on the correlation formula provided by Train (2003, p.114): $\upsilon/(\upsilon + \frac{\pi^2}{6})$.

When comparing the ML with the MNL results, it is apparent that most parameters are more substantial than the same parameters within the MNL model. This is a common feature of ML models over the MNL, according to Chorus (2022), since the inclusion of shared components absorbs a part of the unobserved utility (ε) in the MNL models. As the standard error terms remain random and independently distributed with a fixed variance ($\pi^2/6$), any reduction in unexplained variance due to the inclusion of shared components leads to more pronounced parameter estimates. This effect is particularly strong for the alternative specific constants because the shared components capture the unobserved utilities that are shared among modes within the same nest. For instance, the constant for carpooling in experiment 1 is significantly more negative in the ML model at -7.856, compared to -2.075 in the MNL model; because they share unobserved utility, a portion of that utility is transferred to the joint random component.

In the ML model, cycling continues to stand out with higher intrinsic preference from unobserved aspects, as demonstrated by the positive constants relative to car similar to the MNL model. The constant for the train + shuttle alternative appears insignificant in experiment 3. This may be due to the combined effect of various random components within the alternative's utility function.

Although the parameters are generally larger in the ML model, the overall trends remain relatively consistent with those from the MNL models. Car delays have a more negative impact over longer distances, especially on shorter distances, and are perceived less gravely than delays or waiting times by shuttles after a P&R and train. Most service-related attributes, with the exception of first-class train options, are insignificant. This pattern is evident across the experiments, underscoring the complexities involved in accurately capturing the utility impacts of such service levels.

Table 8: Parameter estimations results from the ML models for distinct experiments.

	Exp 1	Exp 2	Exp 3	Exp 4+5
Constants C_x				
car	0	0	0	0
carpool	-7.856	-5.964	-2.218	-3.281
PRshuttle		-6.231	-1.994	-5.029
PRbike		-6.258	-8.745	-6.163
bike	5.629	1.537		
TRshuttle			-0.323	
TRbike			-2.420	
PRs_13km				-0.096
PRb_13km				-0.951
bus	-1.447			
Taste parameters β_x				
cardelay	-0.044	-0.065	-0.097	-0.117
costdiff	-0.308	-0.236	-0.279	-0.214
carallow	0.028	0.047	0.019	-0.001
allowadd	0.042	0.012	0.027	-0.002
pickup	-0.011	-0.108	-0.067	-0.079
1week	-0.239	-0.470	-0.325	-0.027
24hour	-0.093	-0.314	-0.361	-0.041
busdelay	-0.044			
PRbuswait		-0.182	-0.133	-0.113
PRbusdelay		-0.115	-0.111	-0.118
TRbuswait			-0.171	
PRmeeting		0.122	-0.019	-0.277
PRfullservice		0.525	0.092	-0.171

PR_s20p		0.406	-0.017	0.052
PR_s50p		-0.401	-0.262	-0.342
TR_s20p			-0.145	
TR_s50p			-0.194	
TR_opt1			0.087	
TR_first			0.305	
Sigma's σ_x				
cars	6.924	8.903	5.177	
shared	5.494	4.820	3.836	5.273
multi		4.863	4.009	3.569
bike		3.794	5.615	

4.3.2 HETEROGENEITY WITH RESPECT TO CHOICES FOR ALTERNATIVES

In assessing heterogeneity in preferences for transport alternatives, the ML models revealed high values for certain random components. It is possible that the substantial sigma values are not merely the effect of unobserved heterogeneity between nested alternatives, but also the result of significant variance in preference for the alternatives individually. This indicates a distribution of intrinsic preferences among the population, where specific alternatives may be favored or disfavored for reasons not accounted for by the attributes varied within the experiment's design.

This sentiment is strengthened by the significant proportion of respondents who consistently selected the same alternative in every presented choice set, which is presented in Table 9. These respondents are unaffected in their mode choice under the given ASML policy measures, suggesting a strong preference for a certain transport mode outweighing the potential (dis)utility stemming from the policy interventions. In particular, in experiment 1 a notable 71.3% of participants consistently selected the same mode of transport, from which 59.9% can be ascribed to bicycle use. Since the policies are aimed at encouraging sustainable transport modes like cycling, the high percentage of people persistently choosing bicycles aligns with the expectations, as there is no incentive to change modes when cycling becomes even more appealing. Car use, however, is discouraged through policies, yet a considerable share of respondents was consistent in their choice for cars, particularly on longer distances where train is no option (experiments 4 and 5), with roughly one-third of the drivers resistant to policy shifts. This pattern reveals a preference distribution among respondents, indicating a diverse distribution of inherent biases towards certain transport modes within the population.

Table 9: Percentages of respondents that do not switch between alternatives (Molin & Kroesen, 2023b)

	Exp 1	Exp 2	Exp 3	Exp 4	Exp 5
Car	8.2%	15.1%	10.9%	32.9%	35.1%
Carpool	0.5%	1.2%	3.9%	4.2%	5.2%
Bus	2.7%				
Bike	59.9%	41.0%			
P&R + shuttle		1.2%	0.4%	2.4%	1.3%
P&R + bike		0.0%	1.1%	5.6%	3.6%

Train + shuttle Train + bike			10.5% 14.4%		
Total **N**	**71.3%** 2076	**58.5%** 166	**41.2%** 1167	**44.1%** 720	**45.2%** 672

To elucidate the nuances of both individual and shared preferences in transportation choices, additional ML models with error components (RC) for individual alternatives were estimated. This approach scrutinizes how preferences for individual travel alternatives may influence the shared heterogeneity represented by nests in the models since these random components are expected to be heavily correlated. These models enable a refined analysis of the nesting effect's true magnitude.

In each experiment, three distinct ML models were developed: one with only individual RCs (e.g., RC for the car alternative), another with only joint RCs for identified nests (e.g., RC for the cars nest), and a third that combines both types of RCs into a single model. This comprehensive strategy provides an in-depth examination of the nesting effect.

The results of these heterogeneity models are meticulously analyzed and discussed for each experiment. The combined model's utility functions, which integrate both individual and joint RCs, shed light on the interplay between specific modal preferences and the shared heterogeneity within nests. To illustrate the alteration in model specification, the carpool's utility function in the combined model is presented below in equation 4.2. An overview of all alternatives' utility functions used for the estimation of these combined models is given in Appendix B.3.

$$U_{carpool} = C_{carpool} + cardelay \cdot \beta_{cardelay} + carallow \cdot \beta_{carallow} + allowadd \cdot \beta_{allowadd} + pickup \cdot \beta_{pickup} + \upsilon_{carpool} + \upsilon_{cars} + \upsilon_{shared} + \varepsilon \quad (4.2)$$

It is important to note that with these combined models the number of random parameters increases, introducing more variability when estimating the models, potentially yielding less reliable outcomes. Bhat (2003) suggests against using Halton draws when estimating models with more than 5 random parameters. Therefore, Pseudo-Monte Carlo (pmc) draws have been utilized for simulating models with 5 or more random parameters. This approach necessitates a higher number of draws to achieve consistent results. In this study, the application of 2000 pmc draws for these models has proven sufficient to ensure stability in the findings.

Experiment 1

The estimation outcomes for these various random component models for experiment 1 are presented in Table 10. The results show substantial and significant heterogeneity for the alternatives of car, carpool, and bus as reflected by the high t-statistic ($t > 13$). This indicates a strong variability in individual preferences, especially for the car alternative, which has a notably high sigma value (σ) of 9.338. The joint random components for the cars nest and shared nest also show high significance with sigma values of 6.924 and 5.494, respectively.

When individual and joint random components are included in a single model, all remain significant at a 95% interval level ($t > 1.96$), suggesting that both specific preferences for individual alternatives and shared preferences within nests are influential in mode choice. Notably, the sigma value for the car's random component is still considerable at 7.325, suggesting a high variance in preference for this specific alternative. Although the sigma values for the cars and shared nests decrease over the inclusion of individual preference components, the estimated nesting effects remain substantial.

Table 10: Estimates for random components in various model compositions for experiment 1

Random components	Rho^2	Estimated sigma	Robust S.E.	t-stat.
Individual RC model	0.731			
Alternative car		9.338	0.691	13.517
Alternative carpool		6.292	0.328	19.176
Alternative bus		6.076	0.453	13.427
Shared RC model	0.716			
Cars nest		6.924	0.325	21.276
Shared nest		5.494	0.246	22.378
Combined model	0.737			
Alternative car		7.325	0.740	9.893
Alternative carpool		1.986	0.665	2.987
Alternative bus		5.311	0.588	9.026
Cars nest		4.346	0.656	6.626
Shared nest		4.048	0.304	13.334

N.B.: The random components that signify the same nest across the distinct models are denoted by consistent color coding in the table to facilitate easy comparison between the estimation values.

Experiment 2

Table 11 presents the estimated parameters for the various random component models of experiment 2. The estimated results from the individual RC model suggest that there is a particularly high individual preference towards the bicycle alternative (9.420), which corresponds with the earlier observation of consistently chosen bicycle use among respondents. In the shared RC model the random parameter for the cars nest stands out with an estimated value of 8.903. However, when combining the individual and shared RCs into one model, there is a significant decline in the effect of the car nest to 1.789, suggesting that the nesting effect for car-including alternatives can, for a large part, be ascribed to the preference regarding the four alternatives, included in this nest. However, it should be mentioned that in such a model with 9 random parameters, the heterogeneity effects can easily be over- or underestimated. Even with the addition of individual random components, all nests remain significant. According to the results, the random components of the shared and multimodal nests are least affected by individual preference, whereas the individual preference towards the bicycle alternative, with a sigma of 8.726 in the combined model, largely determines the bike nesting effect.

Table 11: Estimates for random components in various model compositions for experiment 2

Model	Rho^2	Estimated sigma	Robust S.E.	t-stat.
Individual RC model	0.6669			
Car		3.326	0.515	6.463
Carpool		5.059	0.735	6.880

P&R + shuttle		3.808	1.521	2.504
P&R + bike		3.024	0.701	4.315
Bike		9.420	1.879	5.014
Shared RC model	0.6666			
Cars nest		8.903	1.074	8.292
Shared nest		4.820	1.770	2.722
Multimodal nest		4.863	0.860	5.654
Bike nest		3.794	0.903	4.204
Combined model	0.6684			
Car		3.325	0.644	5.159
Carpool		2.739	0.656	4.178
P&R + shuttle		2.632	0.401	6.556
P&R + bike		1.374	0.246	5.589
Bike		8.726	1.079	8.085
Cars nest		1.789	0.385	4.647
Shared nest		3.504	0.687	5.101
Multimodal nest		2.977	0.524	5.679
Bike nest		0.834	0.303	2.754

Experiment 3

Table 12 presents the estimated random parameters for the various models of experiment 3. The results, however, show that all nesting parameters remain significant despite the inclusion of 6 individual RCs in the combined model. The shared heterogeneities of the cars and bike nests remain relatively large in this experiment (3.378 and 3.612, respectively), in contrast with the previous case. For cars, this can be explained by the lower percentage of individuals consistently selecting the car alternative. As for the bike nest, its significant shared effect is likely due to the absence of biking as a standalone option in this experiment, underscoring the correlation between choosing biking as a last-mile solution following train or P&R. The inclusion of individual RCs has the highest impact on the shared nest which estimate decreases from 3.836 to 0.668, which can be ascribed to the individual preference towards carpool and train + shuttle, as the P&R + shuttle RC appears to be insignificant.

Table 12: Estimates for random components in various model compositions for experiment 3

Model	Rho^2	Estimated sigma	Robust S.E.	t-stat.
Individual RC model	0.556			
Car		4.144	0.264	15.693
Carpool		4.871	0.512	9.513
P&R + shuttle		1.479	0.458	3.229
P&R + bike		3.283	0.385	8.524
Train + shuttle		5.138	0.299	17.160
Train + bike		5.592	0.327	17.085
Shared RC model	0.544			
Cars nest		5.177	0.282	18.382

Shared nest		3.836	0.191	20.101
Multimodal nest		4.009	0.288	13.916
Bike nest		5.615	0.256	21.955
Combined model	0.556			
Car		4.058	0.303	13.402
Carpool		5.183	0.332	15.628
P&R + shuttle		0.287	0.653	0.439
P&R + bike		1.490	0.437	3.412
Train + shuttle		4.111	0.391	10.505
Train + bike		3.508	0.212	16.517
Cars nest		3.378	0.344	9.819
Shared nest		0.668	0.326	2.053
Multimodal nest		1.300	0.248	5.232
Bike nest		3.612	0.275	13.136

Experiment 4+5

Table 13 presents the estimated random parameters for the individual, shared and combined RC models of experiment 4+5. Like the previous experiments, here all nests remain significant with the inclusion of individual preferences. It is striking that the estimated RC for the multimodal nest shows a slight increase in the combined model, which is likely to be the effect of overlap between the random parameters leading to confusion of the model. In contrast, the RC for the shared nest decreases substantially due to a high estimated preference for carpool. The preference towards the P&R alternative appears to be insignificant.

Table 13: Estimates for random components in various model compositions for experiment 4+5

Model	Rho^2	Estimated sigma	Robust S.E.	t-value
Individual RC model	0.538			
Carpool		5.862	0.429	13.673
P&R + shuttle		4.921	0.220	22.321
P&R + bike		6.506	0.286	22.766
Shared RC model	0.509			
Shared nest		3.569	0.131	27.179
Multimodal nest		5.273	0.217	24.257
Combined model	0.553			
Carpool		6.511	0.467	13.943
P&R + shuttle		0.655	0.372	1.760
P&R + bike		3.671	0.291	12.614
Shared nest		1.329	0.564	2.358
Multimodal nest		5.461	0.272	20.074

Correlations

The estimated sigmas from the shared random components describe the correlation between the alternatives within the nests, which can be calculated through the formula presented in 6.3.1. Table 14 presents these correlations for both the standard shared random component model and the combined model, where individual RCs are also included. The data indicates significant correlations within the standard shared random component model, with values ranging between 0.685 and 0.844. Generally, a correlation above 0.7 suggests a strong association, while values between 0.3 and 0.5 indicate a weak correlation. Those falling in the 0.5 to 0.7 range are deemed to have a moderate level of correlation (Hinkle et al., 2003).

Most substantial changes in the shared components have already been discussed in the analyses of the experiments. However, it is noteworthy to mention there is considerable variation in how individual preferences influence correlations of the same nests across different experiments. For instance, the correlation within the car nest exhibits less change in experiments 1 and 3 in the presence of individual preferences compared to experiment 2. The shared nest correlation sees a notable drop in experiment 3, plummeting from 0.7 to 0.289 with the addition of individual preferences. The multimodal nest also experiences a reduction in correlation from 0.709 to 0.441. Overall, the impact of individual preferences in experiment 2 is largest on the cars and bike nests, in 4+5 the shared nest is affected most, just as in experiment 3, in which also the multimodal nest is influenced by individual preferences.

This variability across experiments underscores the complexity of understanding individual preferences' effects on specific nested choices. Consequently, it is challenging to generalize the findings across all scenarios. However, despite these variances, the importance of the nesting parameters is consistently confirmed, with statistical tests indicating robust significance at a 95% confidence interval.

Table 14: Correlations within the nests in the shared and combined models.

Experiment	Shared random components	Correlations		
		Shared RC model	**Combined model**	**Difference**
Exp 1	Cars nest	0.808	0.725	-0.083
	Shared nest	0.770	0.711	-0.059
Exp 2	Cars nest	0.844	0.521	-0.323
	Shared nest	0.746	0.681	-0.065
	Multimodal nest	0.747	0.644	-0.103
	Bike nest	0.698	0.336	-0.361
Exp 3	Cars nest	0.759	0.673	-0.086
	Shared nest	0.700	0.289	-0.411
	Multimodal nest	0.709	0.441	-0.268
	Bike nest	0.773	0.687	-0.086
Exp 4+5	Shared nest	0.685	0.447	-0.238
	Multimodal nest	0.762	0.769	+0.006

The final model does not incorporate random components for individual alternatives within the nests, as this would result in overly complex models that are challenging to apply for scenario predictions due to the multitude of random variables. Moreover, such models tend to be less stable and reliable. However, it is insightful to see that in the experiments most nest random components play a significant role despite accounting for heterogeneity regarding individual alternatives. This confirms the relevance of the nest configurations in capturing the essential shared utility of transportation options within the model structure.

4.4 COMPARISON OF MODEL FIT

The model fit determines how well a statistical model captures the underlying data patterns to identify models with the highest explanatory power. Also, in determining the nest configurations for the ML models, the model fits of several error component models were evaluated and compared, leading to the final composition of the nests. These results of the estimated ML models for each experiment are compared to those of the resembling MNL model to indicate the difference in explanatory capability.

A common measure to determine the model fit is the rho-square (ρ^2) statistic. It evaluates the proportion of variance in the dependent variable that is predictable from the independent variables, with a higher ρ^2 indicating a better fit (McFadden, 1977). It can be calculated as follows: $\rho^2 = 1 - (\frac{LL_A}{LL_0})$. To compare the likelihoods of two models, the Likelihood Ratio Statistic (LRS) can be computed to ascertain if the more complex model provides a significantly better fit than a simpler one (Chorus, 2022), calculated by: $LRS = -2 \cdot (LL_A - LL_B)$. The LRS is interpreted by comparing it against a critical value from the chi-squared distribution, considering the number of degrees of freedom, which equals the difference in the number of parameters between the two models. An LRS exceeding the critical chi-squared value at a chosen significance level (e.g., $p<0.05$) indicates that the complex model provides a statistically better fit than the simpler one. The critical chi-square values are obtained by the chi-square distribution table presented in Appendix C.3 to confirm the statistical significance of the model improvement.

From Table 15, it can be observed that for all experiments, the ML models have a significantly higher ρ^2 value with a highly significant LRS, indicating these models are more reliable in predicting choices. The ML of experiment 1 is the highest with a ρ^2 value of 0.72, which could be the result of the notable consistency in mode choice among respondents in this experiment addressed in the previous sub section. Apart from experiment 1, the model fit in experiment 3 has improved most significantly compared to the MNL model (ρ^2 from 0.13 to 0.54), followed by experiment 4+5, in which ρ^2 value increased from 0.17 to 0.51. The LRS for these models significantly exceeds the chi-squared distribution critical value at the 99.9% confidence level ($p<0.001$), indicating a substantial increase in explanatory power. For instance, the LRS of 14946 in Experiment 1 is orders of magnitude greater than the critical chi-squared value of 13.816. This pattern persists across all experiments, affirming the ML models' superior performance over the MNL models in capturing the effects of ASML's mobility measures on employees' commuting choices.

Table 15: Comparison of model fit for MNL and ML models per experiment.

	Exp 1	Exp 2	Exp 3	Exp 4+5
MNL model				
# of parameters	11	17	23	18
Null Log likelihood (LL_0)	-25057	-2319	-18123	-16675

Final Log Likelihood (LL_A)	-14566	-1697	-15686	-13848
Rho² (ρ^2)	0.42	0.27	0.13	0.17
ML model				
# of parameters	13	21	27	20
Null Log likelihood (LL_0)	-25057	-2319	-18123	-16675
Final Log Likelihood (LL_B)	-7093	-773	-8268	-8181
Rho² (ρ^2)	0.72	0.67	0.54	0.51
LRS with MNL model	14946	1848	14836	11334
Critical Chi² value (given #df)	13.816	18.467	18.467	13.816
p-value of LRS statistic	<0.001	<0.001	<0.001	<0.001

**N.B.: The critical Chi²-value is at a 99.9% confidence interval, these are substantially exceeded by the LRS, signifying an exceptionally high level of statistical significance.*

4.5 SUMMARY

Main takeaways

- Nest configurations were carefully crafted for ML models to capture shared attributes; the final model includes four nests, including cars, shared, multimodal, and bike transport.
- The estimation results show higher unobserved utility for the bike alternative relative to cars in certain experiments, suggesting an intrinsic preference for cycling. Meanwhile, unobserved utility for the car alternative is typically higher than the other modes.
- Most service-related parameters are insignificant following MNL and ML estimation.
- ML models revealed substantial heterogeneity in individual preferences; however, even when accounting for individual and shared heterogeneity, the nests appeared significant.
- ML models demonstrated a superior fit compared to MNL models across all experiments, indicating significantly higher predictive power.

Chapter 4 outlines the estimation of both the MNL and the ML models to examine the travel preferences of ASML employees. Detailed coding of model variables sets the stage for a nuanced analysis, revealing a pronounced inherent preference for bicycles over cars despite a general favorability towards car usage for unobserved reasons. The chapter methodically navigates through the complexities of model estimation. Nest configurations within the ML models highlight the significant heterogeneity between modes but also regarding individual choices for alternatives. The chapter concluded with a comparative assessment of model fits, revealing the ML model’s enhanced ability to capture the intricacies of commuting decisions, as reflected in its superior rho-square values and likelihood ratio statistics.

5. MODEL APPLICATION

In this chapter the modal split of ASML employees is explored under the different mobility policies as laid out by ASML. Hereby, the expected magnitudes of the policy effects become clear by calculating the ML model next to the MNL model. Section 5.1 explains the model application process. In section 5.2, various scenarios are distinguished based on the application of mobility policies and external factors to determine the choice probabilities in these circumstances. A summary in section 5.3 concludes the chapter.

5.1 CALCULATING CHOICE PROBABILITIES

The choice probabilities can be determined by means of the estimation outcomes from the previous chapter, following the methods described in Chapter 2. By computing the choice probabilities for each alternative in various scenarios, we gain insight into the expected modal split under different policy conditions.

For the application of the MNL model, estimated parameter values are implemented into the utility functions per alternative separately for the various experiments. Below, in equation 5.1 an example of the utility function for cars in experiment 1 with the parameter estimates is shown. To retrieve the obtained utilities for each alternative within different scenarios, the attribute values related to those scenarios can be inserted. Subsequently, the choice probabilities are calculated, providing insight into the anticipated mode shares. The choice probabilities are calculated separately for the 5 experiments, though experiments 4 and 5 are merged; therefore, to derive the modal split, the mode shares within each experiment are multiplied by the percentage of respondents within the experiment. These percentages can be found in Table 16 below.

$$U_{car} = C_{car}(0) + cardelay \cdot \beta_{cardelay}(-0.011) + costdiff \cdot \beta_{costdiff}(-0.088) + carallow \cdot \beta_{carallow}(0.007) + week1 \cdot \beta_{1week}(-0.087) + hour24 \cdot \beta_{24hour}(-0.039) + \varepsilon \qquad (5.1)$$

The ML model offers a refined analysis over traditional models by incorporating random components, which capture the shared preferences across nested alternatives. A synthetic population is generated to assign the values of the random components following the estimated distribution. To avoid extreme draws heavily influencing the results, the number of individual observations from the sample is increased to 72,300. It is assumed that the sample reflects the distributions of main characteristics, such as gender and age of the actual population. Since no socio-demographic information is available on the survey respondents, these factors were not accumulated to the synthetic population to statistical distributions of the actual population.

The model addresses unobserved heterogeneity within nests of alternatives by assigning random component values to each individual in the synthetic population based on a normal distribution with a mean of zero and a standard deviation σ (0, σ). The estimated σ values for the available nests over the various experiments are presented in Table 16. Every individual receives a random preference value for each nest, and this value is consistently applied across all alternatives within the same nest. This procedure captures the correlation between choices within a nest, accounting for shared unobserved utilities that influence decision-making.

For example, the utility of the car alternative (function 5.2) and the carpool alternative (function 5.3) are both augmented by the random component for the 'cars' nest (υ_{cars}). The estimated σ for the cars nest in experiment 1 is 6.924 (indicated by ~6.924 in utility functions). Consider an individual from the synthetic population who is randomly assigned a value of 4.3 for υ_{cars}; this value is simultaneously applied to the utility calculations for both the car and carpool alternatives. This introduces a correlation in the individual's preference for these two transport modes. Conversely, another individual may receive a random component value of -4.3, signifying a relative aversion to travel by car alternatives. This process generates a spectrum of preferences within the population, as the random values vary for each person. The sigma value reflects the width of this variation; a larger σ indicates a wider range of preferences across the population, capturing diverse attitudes towards the transport modes within a particular nest.

$$U_{car} = C_{car}(0) + cardelay \cdot \beta_{cardelay}(-0.044) + week1 \cdot \beta_{week1}(-0.239) + hour24 \cdot \beta_{hour24}(-0.093) + costdiff \cdot \beta_{costdiff}(-0.308) + carallow \cdot \beta_{carallow}(0.028) + \upsilon_{cars}(\sim 6.924) + \varepsilon \quad (5.2)$$

$$U_{carpool} = C_{carpool}(-7.856) + cardelay \cdot \beta_{cardelay}(-0.044) + carallow \cdot \beta_{carallow}(0.028) + allowadd \cdot \beta_{allowadd}(0.042) + pickup \cdot \beta_{pickup}(-0.011) + \upsilon_{cars}(\sim 6.924) + \upsilon_{shared}(\sim 5.494) + \varepsilon \quad (5.3)$$

The utilities and choice probabilities for each individual within the synthetic population are computed by combining the deterministic part of utility with the adjusted random parameters, following the equations in section 2.2.2. Finally, the average choice probabilities across the synthetic population are computed to determine the alternative's shares in given scenarios.

Table 16: Overview of random component distribution within the experiments and the experiment shares

	Random parameters	Percentage of sample
Experiment 1	$\upsilon_{cars} \sim N(0, 6.92)$ $\upsilon_{shared} \sim N(0, 5.49)$	42.92%
Experiment 2	$\upsilon_{cars} \sim N(0, 8.90)$ $\upsilon_{shared} \sim N(0, 4.82)$ $\upsilon_{multi} \sim N(0, 4.86)$ $\upsilon_{bike} \sim N(0, 3.79)$	3.53%
Experiment 3	$\upsilon_{cars} \sim N(0, 5.18)$ $\upsilon_{shared} \sim N(0, 3.84)$ $\upsilon_{multi} \sim N(0, 4.01)$ $\upsilon_{bike} \sim N(0, 5.62)$	24.30%
Experiment 4+5	$\upsilon_{shared} \sim N(0, 3.57)$ $\upsilon_{multi} \sim N(0, 5.27)$	29.25%

5.2 SCENARIO ANALYSIS

In this section various scenarios are examined to analyze the changes in choice probabilities for the transport alternatives. These scenarios reflect the described mobility measures as described by ASML or external factors that might influence mode choice. Firstly, in section 5.2.1 the selection of scenarios is outlined and explained. Section 5.2.2 subsequently presents an analysis of the estimated mode shares for the different scenarios, following the MNL and the ML model.

5.2.1 SCENARIOS

The scenarios described in this section are all compared to the reference scenario, in which the base values are assumed for each attribute, as presented in Table 1 in Chapter 3. Firstly, the choice probability for car usage is calculated for the distinct mobility policies available to ASML, to indicate the decrease in car use per single measure. From this, it becomes evident which policies are expected to have the highest impact on the commuting mode choice of the employees.

Subsequently, a few scenarios have been designed to represent a variety of considerable policy measures in combination with future traffic conditions. These scenarios are explained in detail below.

1. **Monetary package:** In this scenario employees are incentivized to switch from car usage to alternative transportation modes by offering a daily financial reward of €3 for not using the car and charging car parking with €3. To complement this, travel allowances are adjusted to encourage cycling and carpooling, with a higher allowance for cycling (30 ct/km) compared to car travel (10 ct/km). Carpooling is further encouraged by providing an additional allowance of 20 ct/km per person.
2. **Service package:** Alternative multi-modal modes are encouraged by enhancing the attractiveness and service level of these options. This scenario includes upgraded P&R facilities and the introduction of full-service amenities that may include conveniences like office spaces, maintenance services, and shops. The shuttle bus wait time from P&R is reduced from 15 to 5 minutes to streamline the transition from parking to the final destination. For train commuters, the allure of first-class travel is made available, offering a more comfortable and perhaps productive commuting experience.
3. **Congested Roads**: This scenario simulates increased congestion, with average delays to the car commute, making this alternative less appealing. Therefore, scenario **3A** explores the modal split with a slight delay increase of 20 minutes (instead of 10), while a significant delay of 40 minutes is examined in scenario **3B**. The same additional delays are applied to the shuttle bus commute from the P&R, reflecting the impact congestion can have on the last-mile stretch of the journey to ASML.
4. **Congested Roads with Monetary Package**: Combining the conditions of the first scenario with those of the third, this scenario introduces monetary incentives to mitigate the effects of the increased congestion delays. By offering financial rewards for using alternative modes and increasing the cost of car use through parking fees, it tests whether such policies can effectively shift employee preferences away from car use in congested conditions. As in scenario 3, average car delays of 20 and 40 minutes are distinguished in scenarios **4A** and **4B.**
5. **Congested Roads with Direct P&R Shuttle**: To counter the negative effects of road congestion, this scenario maintains the delays for car travel but assumes that the shuttle bus from P&R can bypass traffic on the emergency lane, operating with no delay. This could be enabled by dedicated bus lanes or other measures allowing for faster shuttle transit, thus enhancing the relative convenience and speed of the P&R option during peak congestion

times. Similar to the previous scenarios, 20-minute and 40-minute delays are regarded as distinct situations **5A** and **5B**.

All attribute levels for the base scenario are shown in Table 17. The deviating attribute levels for the given scenarios are presented in Table 18 below.

Table 17: Overview of the attribute levels for the base scenario

Policy measures	Base level
Daily reward for non-car or P+R alternative	0 euro
Parking costs for car	0 euro
Travel allowance car (up to 20 km)	20 ct/km
Travel allowance bike (up to 20 km)	20 ct/km
Additional allowance for carpool (per person)	0 ct/km
Requiring to book a parking spot in advance	Not required
P+R facilities on route to ASML, including:	
Level of service	Only parking
E-bike / shuttle bus service from P+R to ASML	20-person shuttle bus
Waiting time shuttle bus	15 minutes
Delay due to congestion shuttle bus	10 minutes
Train, including:	
Business card type	Second class
E-bike / shuttle bus service from station to ASML	20-person shuttle bus
Waiting time shuttle bus	15 minutes
External conditions	
Delay due to congestion (for car alternatives)	10 minutes
Delay due to congestion (for regular bus)	10 minutes
Pick-up time (carpool)	10 minutes.

Table 18: Overview of scenarios and corresponding attribute values

Scenario and attributes	Attribute values
Monetary package:	
Daily reward for non-car or P&R alternative	€3 per day
Parking costs for car	€3 per day
Travel allowances car (up to 20 km)	10 ct/km
Travel allowances bike (up to 20 km)	30 ct/km
Additional allowance for carpool (per person)	20 ct/km
Service package:	
Level of service at P&R	Full service
Waiting time shuttle bus from P&R	5 minutes
Train business card type	First class
Congested roads:	
Delay due to congestion (for car alternatives)	20 / 40 minutes
Delay due to congestion shuttle bus from P&R	20 / 40 minutes
Congested road with monetary package:	
Delay due to congestion (for car alternatives)	20 / 40 minutes
Delay due to congestion shuttle bus from P&R	20 / 40 minutes
Daily reward for non-car or P&R alternative	€3.00
Parking costs for car	€3.00
Travel allowances car (up to 20 km)	10 ct/km

Travel allowances bike (up to 20 km) Additional allowance for carpool (per person)	30 ct/km 20 ct/km
Congested road with direct P&R shuttle bus: Delay due to congestion (for car alternatives) Delay due to congestion shuttle bus from P&R	 20 / 40 minutes 0 minutes

5.2.2 SCENARIO RESULTS

The results for the various are presented by means of graphs and discussed in this section. Appendix D provides a complementary overview of the scenarios and their results. In this section the effects of the given scenarios are often discussed in terms of relative mode share changes compared to the current (base) scenario, which can be observed for the various scenarios in Table 30 - Table 32 in Appendix D.

Reference scenario

Firstly, the reference or base scenario is calculated by the MNL and ML models, which reflect the current conditions of ASML employees. From the estimated mode shares in, relatively similar percentages for both models can be observed with slight differences. Mode shares for the main transport modes, car and bike, are relatively close together in both models. The car mode share is slightly lower in the ML model at 38.5% compared to 39.5% in the MNL model. Bicycle usage is consistently predicted across both models. Differences become more pronounced in less commonly used modes; notably, the ML model projects a higher uptake in the P&R + shuttle option and a lower share for P&R + bike compared to the MNL model. Additionally, the alternatives carpool and train + bike show significantly higher percentages within the ML model.

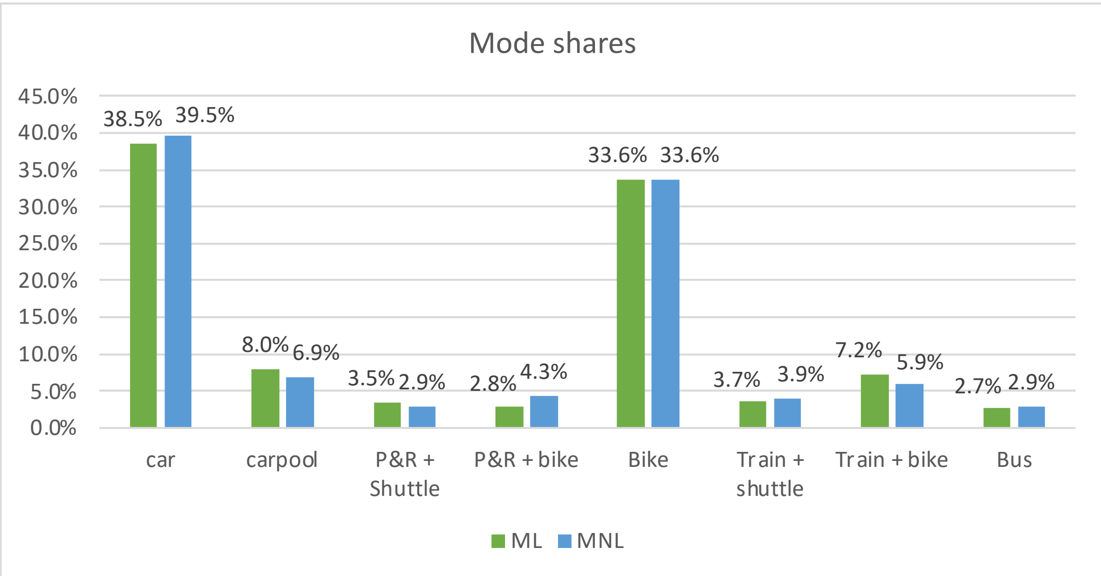


Figure 5: Modal split in reference scenario by estimation of ML and MNL models

To gain insight into how well the models represent reality, Figure 6 compares the mode shares estimated by the models with the actual modal split as determined through a survey by Molin & Kroesen (2023b). The modal split is categorized into 4 main transport modes: car, bicycle, train, and bus. The percentage of car users is determined by summing up car, carpool and the P&R alternatives. It can be observed that the estimated distribution through both the MNL and the ML base models correspond reasonably well with the survey modal split, although train use is somewhat overestimated while the bus share is undervalued.

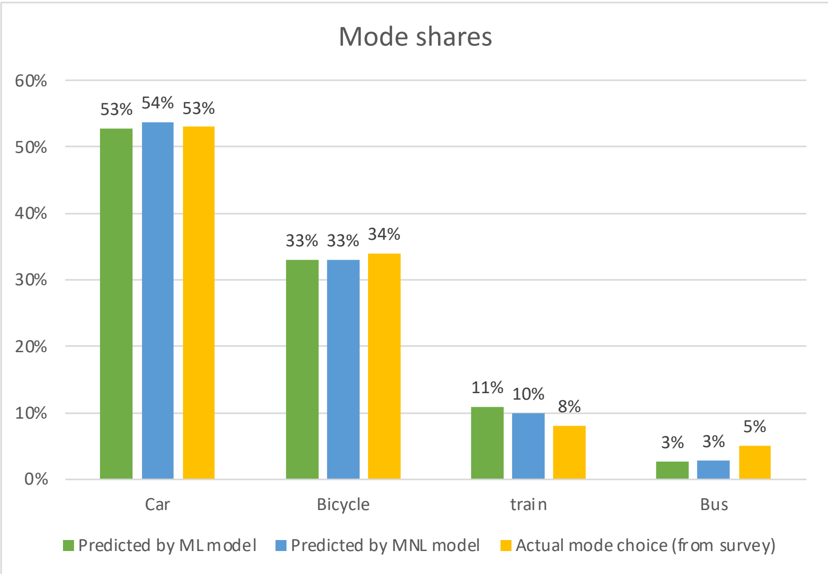


Figure 6: Modal split of the reference scenario compared to actual model split (determined from the survey by Molin & Kroesen (2023b))

Single measure effects

Figure 7 shows the differential impact of individual mobility measures on reducing car use in percentage points. The measures to realize a meeting room at the P&R and larger shuttle busses have been excluded due to their insignificant impact on car use. Clearly, the most effective policies involve charging parking costs and rewarding non-car use; increasing these amounts from €1.50 to €3.00 roughly results in a doubled decline in car usage, as indicated by both models. Decreasing car allowances while increasing bike allowances by 10 cents per kilometer can cause a slight decrease in car use of 1.1%, similar to the effect of requiring to book a parking spot 24 hours in advance, which leads to a 0.9% decrease.

The MNL model generally predicts a higher reduction in car use across the distinct mobility measures compared to the ML model, especially policies that directly modify the cost and convenience of car use. Interestingly, the provision of full-service at the P&R results in a 0.3% decrease in the MNL model, whereas the ML model predicts a slight increase of 0.1%.

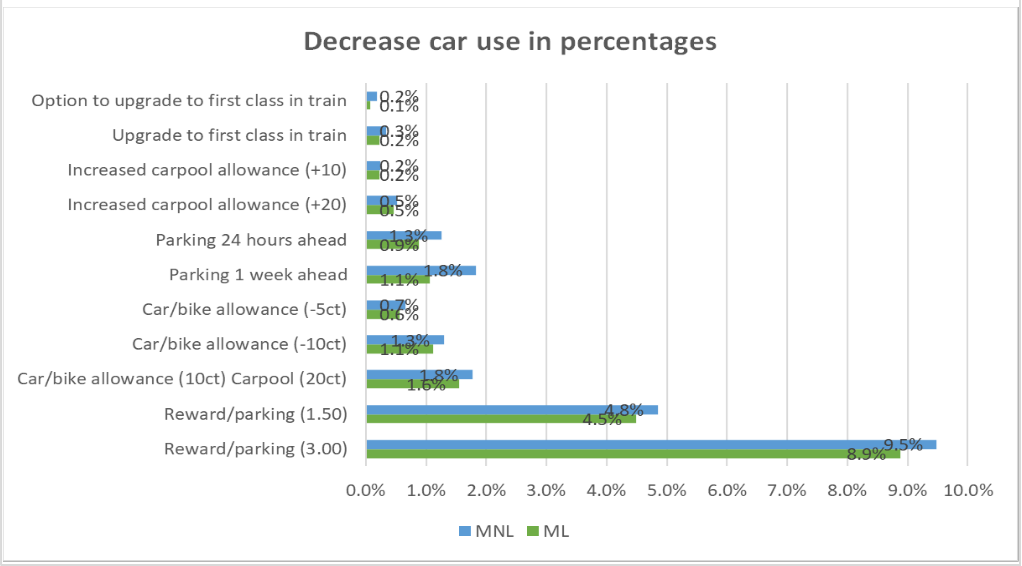


Figure 7: Decrease in car use through implementation of single policy measures as estimated by the MNL and ML

Policy measures offering daily rewards and charging parking costs are most impactful, therefore the modal split is analyzed further for both input values (€1.50 and €3.00). Figure 8 presents the mode shares when prices for both parking and rewarding are set at €1.50. Overall, the increase in alternative mode shares is relatively similar over the models. Bicycle use is expected to rise to 35% in both models. The ML anticipates a larger increase for carpool by 1.5 percent points, making it the third most favored mode. The MNL suggests a relatively higher increase in P&R use, particularly with last-mile bike travel.

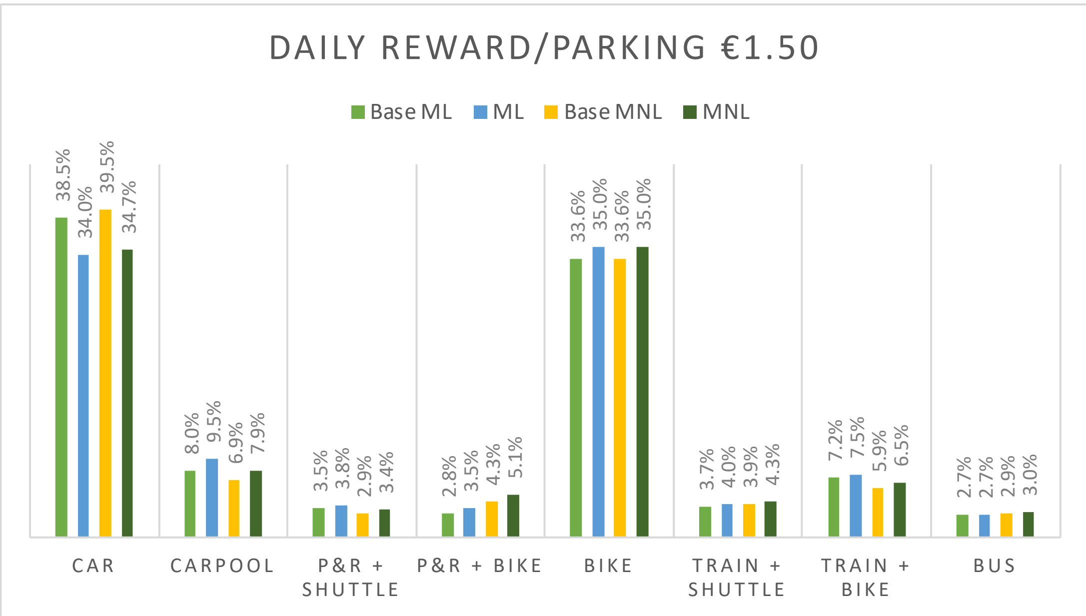


Figure 8 Effects of scenario with €1.50 parking costs and €1.50 reward for options other than car

Doubling the daily reward and parking costs to €3.00 results in a proportional rise in carpooling, with the ML indicating an 11% mode share increase. Both models predict a substantial relative growth in the use of P&R + bike; the ML model forecasts a 54% relative increase (from 2.8% to 4.3%), whereas a relative increase of 38.8% (from 5.3% to 6%) is expected by the MNL. These results demonstrate the significant impact of financial factors on commuters' choices.

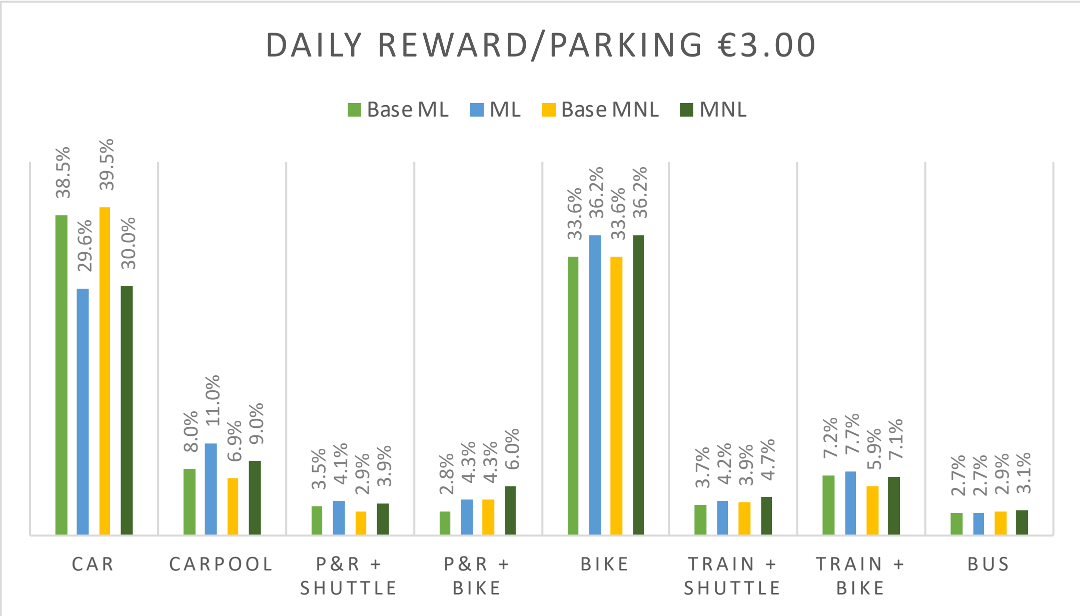


Figure 9: Effects of scenario with €3 parking costs and €3 reward for options other than car on modal split

Scenario 1: Monetary package

Figure 10 presents the effects of a monetary package on the mode shares, which are broadly consistent with the effects observed when only €3.00 daily reward and parking costs are applied. Notably, the ML model predicts a significant absolute increase in bicycle usage mode share to 37.1%, which reflects a 10.1% relative growth from the base scenario. Additionally, a relative increase of 47.6% for the carpool alternative is indicated by the ML model.

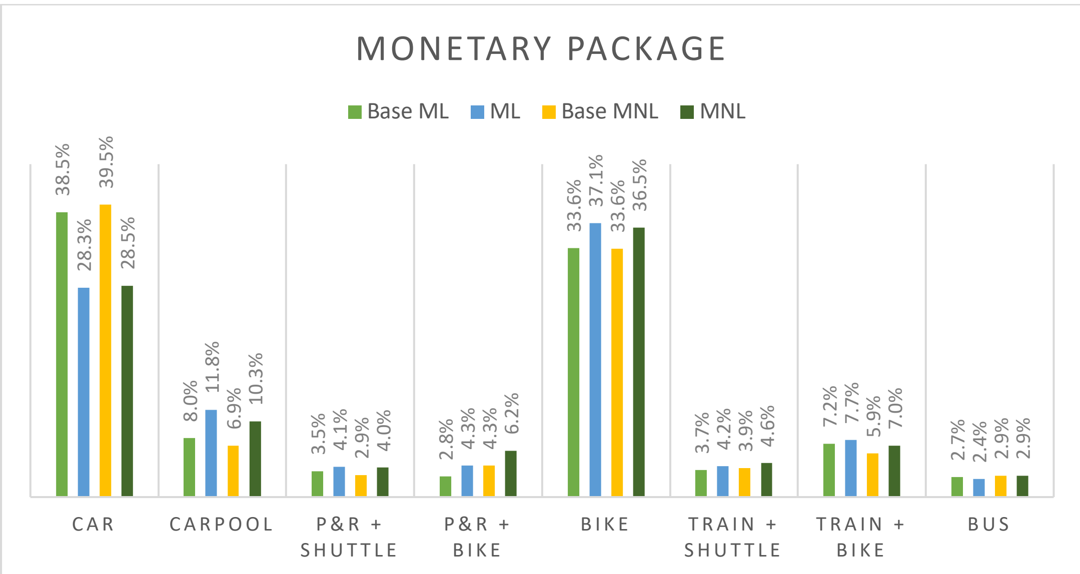


Figure 10: Effects of the monetary package on the modal split

Scenario 2: Service package

Figure 11 illustrates the impact of the 'service package' scenario by improving P&R and train services by offering first-class tickets, higher shuttle frequencies and providing full-service amenities at P&R sites. While these service enhancements do promote a shift from car use, their effect is significantly smaller than the monetary incentives. The ML model forecasts a modest reduction in car usage of 1.7 percentage points.

In this scenario people are more inclined to use shuttles as last-mile transport option due to the increased frequency, while bike last-mile transport becomes less popular, in particular by estimation of the ML model. P&R + shuttle is predicted to increase by 1.6 percent point by the ML model (46.5% relative increase), whereas the P&R + bike option is expected to see a relative decrease of 13.2%. A similar pattern is predicted for the train alternatives. Additionally, the ML model predicts a slight decrease in carpooling in this scenario.

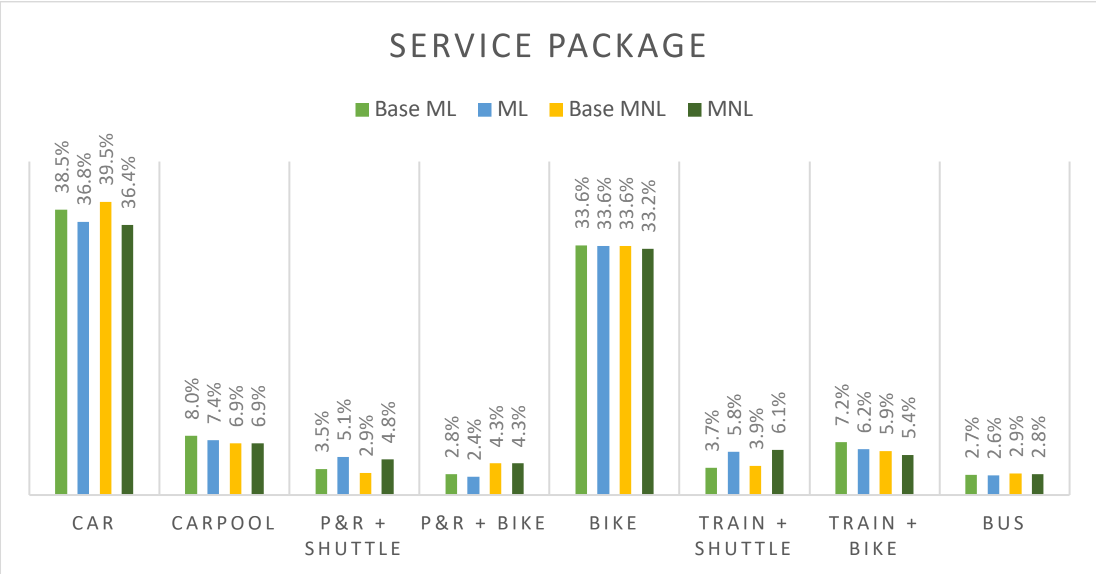


Figure 11: Effects of full-service package on the modal split

Scenario 3: Increased congestion

This scenario examines the impact of two levels of increased congestion: a moderate 20-minute delay (Scenario 3A) and a more severe 40-minute delay (Scenario 3B), affecting car, carpooling, and P&R shuttle travel times. Figure 12 shows the effects of a 20-minute delay. The moderate rise in delay leads to a relative decline of 7.2%, estimated by both the MNL and ML models. This same delay negatively affects the attractiveness of the P&R + shuttle option, leading to its decrease. Conversely, alternatives without added delay become more appealing, such as the train alternatives whose mode shares are expected to rise slightly. The percentage of people traveling by P&R + bike is predicted to grow significantly from 2.8% to 4.5%, representing a 59.8% relative increase.

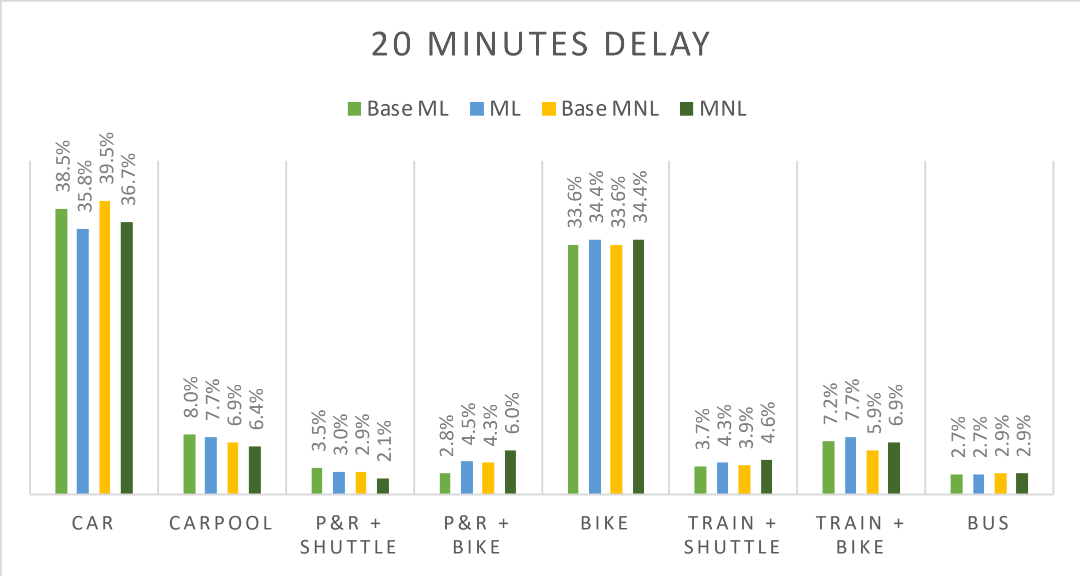


Figure 12: Effects of scenario with an average car delay of 20 minutes

In a scenario where the average delay is 40 minutes, as depicted in Figure 13, the expected reduction in car usage is substantial (roughly 25% for both models). According to the ML model, bicycle use will increase by 2.1 percent points, while P&R + bike gains 6.9 percent points, equal to a relative increase of 247%. The MNL model anticipates a uniform relative increase of 49% for both train travel options. However, the ML model suggests a differentiation in response, with a 49.9% relative increase for train + shuttle and a 22.2% relative increase for train + bike, highlighting the nuanced nesting effects on transportation choices. From these scenarios, the nesting effect for car alternatives is apparent; while certain car alternatives become less appealing due to increased travel times, car users tend to shift more towards other options, like the P&R + bike alternative compared to the MNL model. Conversely, the MNL model shows a relatively higher increase in train alternatives.

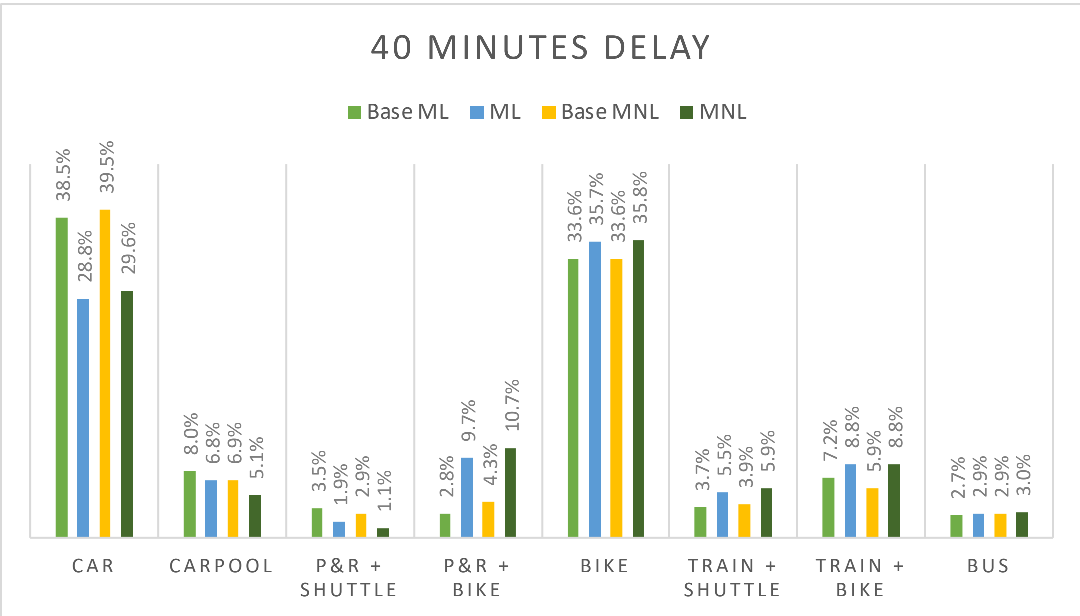


Figure 13: Effects of scenario with an average car delay of 20 minutes

Scenario 4: Increased congestion with monetary package

Scenario 4 investigates the combined effects of congestion delays and a monetary package on commuting choices. As seen in Figure 14, a 20-minute delay coupled with the monetary package leads to a notable decrease in car usage to 25.7%, while bicycle usage rises to 37.6%, as projected by the ML model. The mode share for the P&R + bike option rises significantly from 2.8% to 6.5%. The shares of both train alternatives grow by 1.1 percent point, according to the ML model. Despite the additional delay, carpooling is anticipated to gain 3.2% in this scenario due to the financial incentives.

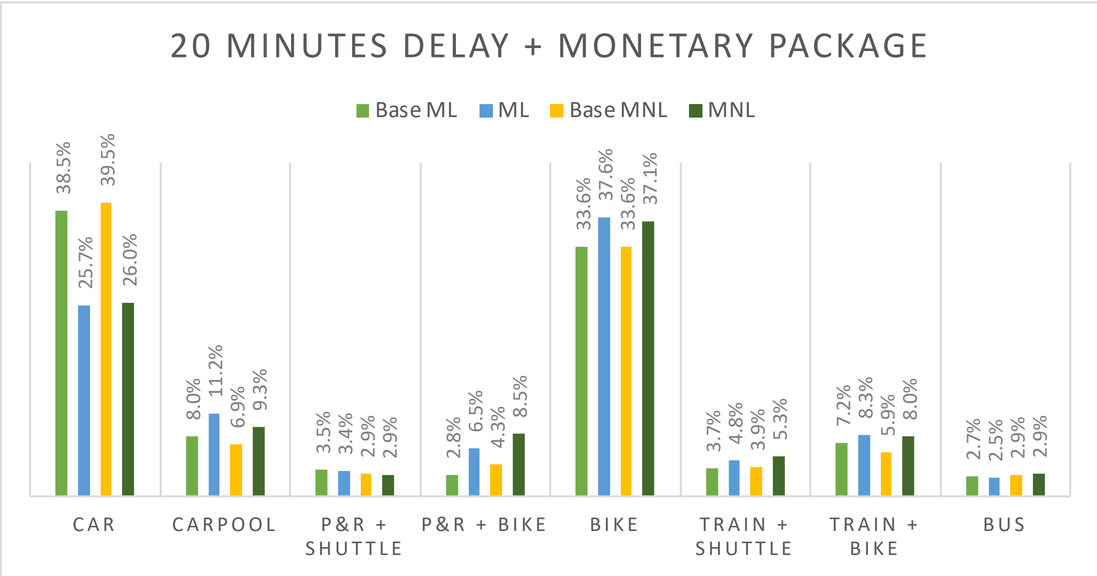


Figure 14: Effects of scenario with an average car delay of 20 minutes and monetary package

As shown in Figure 15, when issuing the monetary package in a more congested scenario with an average 40-minute delay, leads to a 50% reduction in car use, resulting in a 19.2% car share. This significant decline underlines the car's diminished attractiveness in the face of extended delays and the associated costs. The P&R + bike alternative becomes a favored choice, with its share growing to 12.6%. Remarkably, the carpool option shows an increment of 1.5 percent points even with a 40-minute delay. This can partly be attributed to the model's captured heterogeneity in preferences for car-related alternatives since the MNL model suggests only marginal effects.

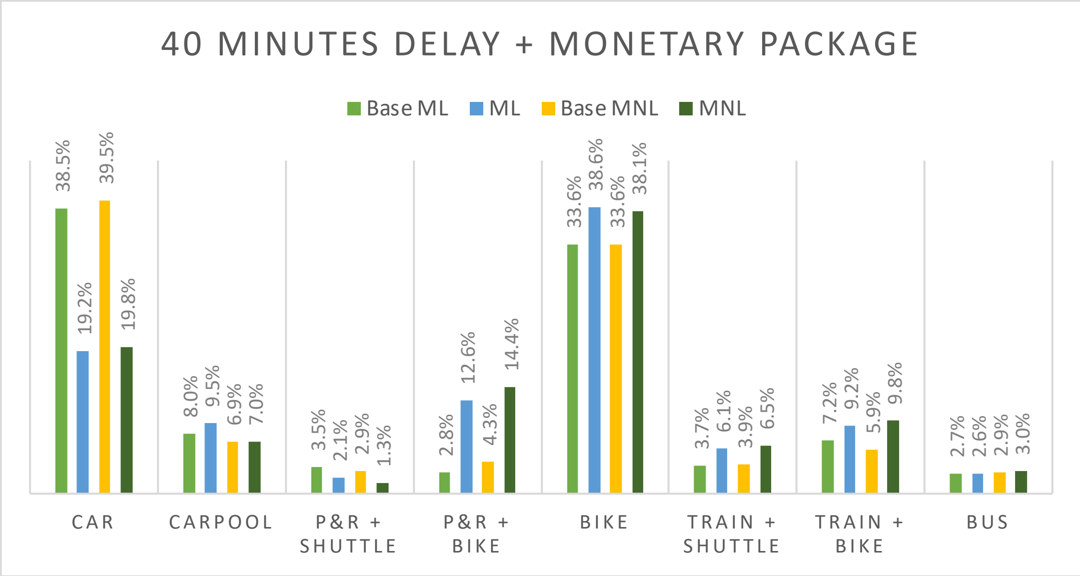


Figure 15: Effects of scenario with an average car delay of 40 minutes and monetary package

Scenario 5: Increased congestion with direct P&R shuttle

Scenario 5A assesses the modal shift when car and carpool users encounter a 20-minute delay, but P&R shuttles operate without delay, utilizing emergency lanes for transit. The mode shares for this scenario are depicted in Figure 16. Compared to scenario 3A, there is a marked decrease in car usage to 34.4% and carpooling to 6.0%, representing a relatively 20% higher reduction for carpool when contrasted with the 20-minute delay scenario without direct shuttles. In this scenario, a modest shift to the P&R + bike (+0.9%) and bike (+0.8%) options is observed. However, the most substantial shift is towards the P&R + shuttle option, which sees an increase of 3.9 percent points, underscoring the enhanced attractiveness of this alternative.

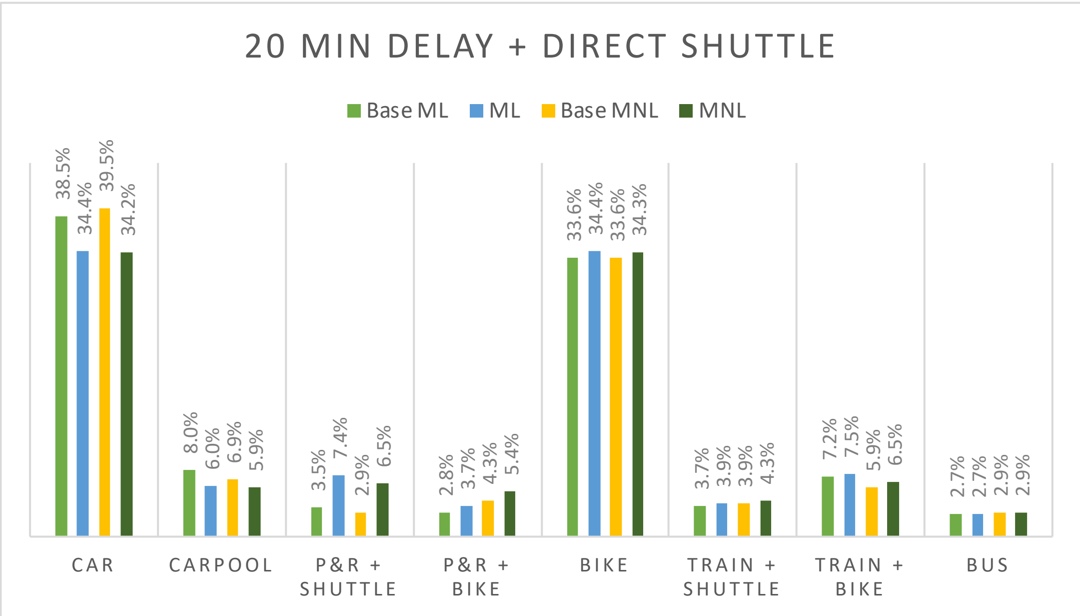


Figure 16: Effects of scenario with an average car delay of 20 minutes and direct shuttle

Figure 17 presents the modal split for scenario 5B, in which regular car traffic suffers a 40-minute delay, but shuttles from P&Rs are direct. Similar to scenario 5A, this scenario predicts a more pronounced decrease in car and carpool usage compared to the 40-minute delay scenario without a direct shuttle. The P&R + shuttle option sees a significant rise, with its share increasing by 7.9 percent points, while the P&R + bike option also grows to 7%. Collectively, these changes result in 18.4% of ASML employees opting for a P&R mode of transport.

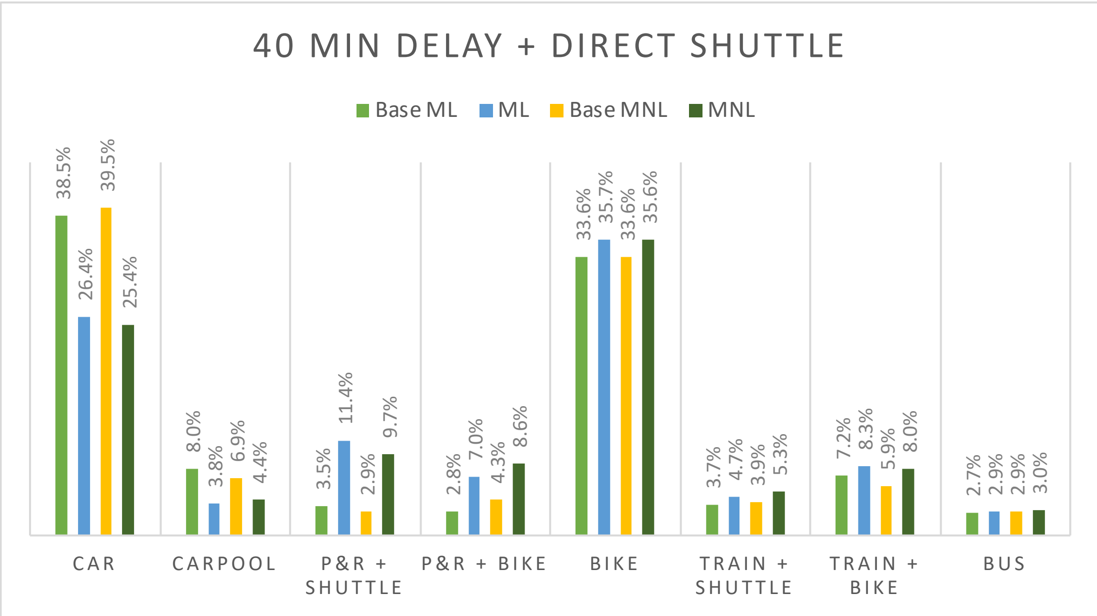


Figure 17: Effects of scenario with an average car delay of 40 minutes and direct shuttle

5.3 SUMMARY

Main takeaways:

- Policies involving monetary disincentives for car use and incentives for alternative modes show the greatest potential to alter commuting patterns. Initiating charges for parking and rewards can lead to car shares of less than 30%, signaling the high responsiveness of employees to direct financial implications.
- Enhancements in service levels, such as upgraded P&R facilities and the provision of first-class train travel, result in a modest decrease in car usage, according to both models. These findings suggest that while service improvements are favorable, they may not be as immediately effective in shifting mode choice as monetary measures.
- Scenarios simulating increased congestion without additional intervention project a noticeable shift away from car usage. Particularly, the scenario with a 40-minute delay due to congestion is forecasted to significantly decrease car use to 28.8%, with the ML model predicting a substantial shift towards bicycle use with and without using P&R facilities.
- When monetary incentives are applied in a scenario with increased congestion, car usage declines to up to just 19.2 in the case that the average delay is 40 minutes, with the ML model showing a pronounced shift towards carpooling, cycling, and the use of P&R with bicycles.

- The introduction of a direct P&R shuttle service, unaffected by congestion, is predicted to attract a notable portion of commuters when delay increases, potentially leading to a total share of 18.4% for P&R alternatives.

This chapter applied MNL and ML models to understand the potential impacts of ASML's proposed mobility measures on employee commuting preferences. The car mode shares by estimation of the ML and MNL are fairly close under the various policies. The ML generally led to relatively higher increases in carpool and P&R alternatives due to heterogeneity regarding alternatives in the car nest. The application of these models provides valuable insights for policymakers at ASML. It becomes evident that a combination of monetary incentives and service improvements can be instrumental in encouraging sustainable commuting behaviors. Moreover, the models suggest that addressing congestion through infrastructure improvements, such as direct P&R shuttles, can be a highly effective strategy.

6. ANALYSIS OF P&R IMPLEMENTATION IN THE BRAINPORT REGION

The outcomes of the MNL and ML models suggest that P&R facilities could be a key component of an effective strategy to mitigate mobility challenges faced by ASML and the broader Brainport region. While these findings point towards a potential solution, the actual realization of P&R hubs entails a lengthy and intricate process. This chapter delves into the implementation process of these hubs, examining the roles of the stakeholders involved, and the challenges they face. Section 6.1 provides a detailed overview of the project, including the overarching Brainport Mobility Plan and the plans for P&R hubs in the region. In section 6.2, the main insights gained from the interviews are discussed to provide a more complete picture of the process. Subsequently, the process is further analyzed in section 6.3 by identifying the key stakeholders and the main observed challenges, followed by a brief outlook on future expectations. Conclusively, section 6.4 provides a summary of the chapter's main findings.

6.1 OVERVIEW OF THE PROJECT

This section provides an overview of the mobility plans in the Brainport region, including the realization of regional mobility hubs or P&Rs. In section 6.1.1, the broader mobility plan is outlined in which the hubs are incorporated. Section 6.1.2 focuses more closely on the P&Rs, discussing the planning, goals, and importance of achieving the region's transport objectives. These subsections build the foundation for the analysis, showing how the P&R project links to the region's overall plan for future mobility.

6.1.1 BRAINPORT MOBILITY PLAN

The consistent economic growth in the Brainport region has drawn an increasing population to live and work in the area. To accommodate this, the Residential Deal, or 'Woondeal' between the national government and the Province of North Brabant has been made to realize 62,000 new homes by 2040. ASML and other thriving multinational corporations are drivers for population and employment growth in Brainport, escalating the demand for housing in the region. With the rise in population and job opportunities, the region faces substantial growth in mobility demands. However, the ring road of Eindhoven, a principal artery for local and through traffic, is reaching its capacity limits, worsening the accessibility of the region (Brainport Eindhoven & Ecorys, 2021).

In response to these challenges, a cooperative agreement aimed at enhancing regional accessibility and livability was signed in December 2018 by 21 municipalities in Southeast Brabant. The Accessibility Agenda Southeast Brabant 2017-2030 set the ambitious goal to execute around 130 projects (SmartwayZ.NL, 2018). These plans are collaboratively funded by the national and regional governments' investment agreement, which allocates roughly €1.6 billion to mobility and housing in the Brainport area (Brainport Bereikbaar, 2023). These projects are scheduled for completion by 2030, ranging from cycling infrastructure improvements to regional hubs to integration of smart mobility solutions across the region initiated by SmartwayZ.NL and ZO Slim Bereikbaar.

SmartwayZ.NL is at the forefront of this mobility program, partnering with both public and private entities to enhance accessibility throughout the Southern Netherlands, including the Brainport region. Their focus is on the adoption of smart infrastructure and services to create a resilient transportation system (SmartwayZ.NL, n.d.). ZO Slim Bereikbaar is a collaboration of the 21 municipalities in Brainport with a focus on advancing mobility strategies within Southeast Brabant (ZO Slim Bereikbaar, n.d.). This concerted effort has given rise to 'Brainport Bereikbaar,' a program dedicated to smart mobility initiatives and campaigns in the region. Notably, in 2021, ZO Slim Bereikbaar's regional projects were seamlessly integrated into Brainport Bereikbaar, signifying a unified approach to addressing the mobility challenges within the region Bereikbaar (ZO Slim Bereikbaar, 2021).

Together, these initiatives are aimed at instigating a mobility transition in the region, moving away from car-centered mobility to more sustainable and space-efficient alternatives. The challenge is to create a balanced transport system that not only supports the region's urban densification but also improves the quality of life by reducing noise, pollution and making better use of public spaces. This change is driven by the need to keep the region accessible and to align with climate goals. Key to this transition is altering people’s travel behavior, by promoting active transport modes and enhancing public transport services (Brainport Eindhoven & Ecorys, 2021).

In alignment with the Brainport mobility strategy, €185 was allocated for the execution of a short-term measures package (Brainport Bereikbaar, 2023), encompassing a vast array of measures to bring about the mobility transition in the region, including:

Regional mobility hubs: Strategically placed near major highways to facilitate the switch from cars to public transport, bikes, or e-bikes. These hubs are intended to reduce traffic congestion and serve as nodes in the overall transport network.

High-quality public transport (HOV) network: A series of rapid, frequent, and reliable public transport lines known as the "Brainport Lines" that link key residential areas with economic hotspots, enhancing the accessibility of public transport and reducing reliance on cars.

Cycling network expansion: Investment in cycling infrastructure, including fast cycling lanes, to promote cycling as a preferred mode of transport for short to medium distances. This initiative caters to the rising popularity of e-bikes and aims to make cycling a safer and more convenient option.

Smart mobility projects: Implementation of innovative transport solutions and infrastructure upgrades, such as intelligent traffic systems and Mobility as a Service (MaaS) platforms, to improve travel efficiency and adaptability to changing mobility needs.

Collaboration with employers: Partnership with local businesses to encourage sustainable commuting. This includes promoting flexible working arrangements, incentivizing alternative modes of transport, and potentially reducing parking spaces to discourage car use.

Behavioral change campaigns: Efforts to influence travel behavior through targeted campaigns that raise awareness about sustainable transport options and encourage a shift from car use to more environmentally friendly alternatives.

Sustainable urban planning: Designing urban spaces that prioritize walking, cycling, and public transport, coupled with the development of car-free zones, to support urban densification and enhance the quality of life.

(Temporary) P&R Initiatives: Temporary and permanent P&R locations that offer commuters convenient options to park their cars and switch to public transport or shared mobility options for the remainder of their journey.

6.1.2 REGIONAL HUBS IN BRAINPORT

The introduction of P&Rs or regional hubs is central to the region's mobility strategy of reshaping its approach to transport. These hubs are envisioned as more than just parking areas; they are multifunctional facilities designed to facilitate a smooth transition for commuters from personal vehicles to public transport or (e-)bikes. The aim is to ease the pressure on the region's roads, especially during peak times. By providing an alternative to driving into city centers, regional hubs are expected to play a significant role in reducing traffic jams and making travel smoother for everyone. They are an essential part of the plan to manage the growing number of people living and working in the area, supporting the region's development without sacrificing the quality of life (Brainport Eindhoven & Ecorys, 2021).

Within the framework of a short-term action plan, six P&R hubs are proposed, surrounding the city of Eindhoven, located strategically along major highways: A2 north (Best), A58 (Oirschot-Best), A50 (Ekkersrijt-Veghel), A67 west (Eersel), A2 south (Maarheeze), and A67 east (Sommeren). Figure 18 depicts the preliminary locations for these regional hubs.

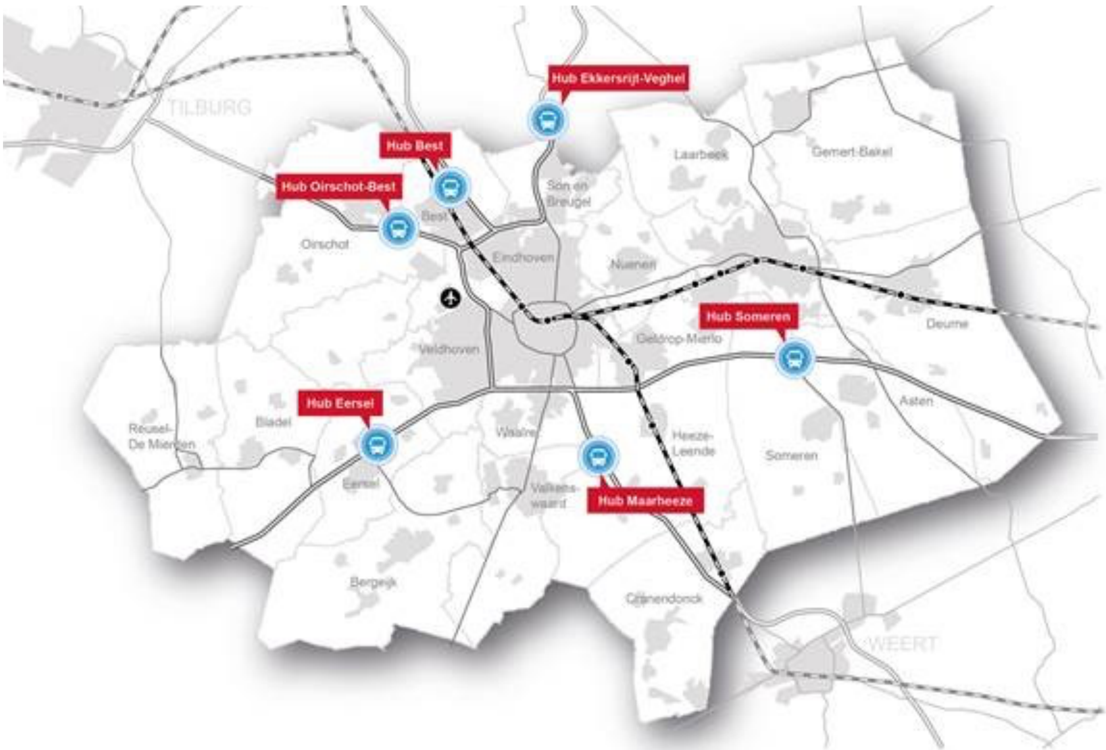


Figure 18: Preliminary locations for regional hubs in Brainport region (APPM, n.d.)

Recognizing the time-consuming and complex nature of the realization processes for these hubs, four locations have been prioritized, including the hubs at A2 North (Best), A58 (Oirschot-Best), A67 West (Eersel), and A2 South (Maarheeze). These hubs are strategically placed to enhance connectivity: Best offers a transit nexus to the west; Oirschot-Best merges transit routes along the A58; Eersel links the south to Eindhoven's core; and the P&R in Maarheeze is set for expansion to support greater commuter capacity. In the meantime, there have been plans to realize temporary P&R locations offering a short-term solution for the increasing congestion problems. In 2021, a temporary P&R with 2,000 parking spaces has been opened in Eersel, financed by ASML (Brainport Eindhoven & Ecorys, 2021).

The success of the regional mobility hubs is tightly linked to complementary policies and transport services. Recognizing that the journey through a hub is typically slower than a direct car trip, the region emphasizes the importance of a robust cycling, public transport, and road network to offer a competitive alternative to car use. However, infrastructure alone is not enough; flanking policies are crucial to ensure that hubs are effectively utilized for commuter traffic. These policies include parking restrictions, incentives and rewards through employer partnerships, and promoting alternative transport options to influence commuting choices (Brainport Eindhoven & Ecorys, 2021).

6.2 INSIGHTS FROM INTERVIEWS

This section presents findings from four in-depth interviews conducted to gain nuanced perspectives on the development of regional hubs within the Brainport region. These discussions involved stakeholders engaged at different levels of the project, each offering unique insights into the realization process. To uphold research ethics concerning confidentiality, respondents are not identified by name but by their professional roles within the project. The first conversation was with an ASML policy manager, giving insight into the corporate perspective of P&R realization. The second interviewee was held with the project manager of hubs in Brainport, providing a holistic view of the project's execution. Insights were also gathered from a local project manager, who is involved in the development of one of the six planned hubs, offering a focused look at local challenges and progress. Lastly, an interview with a provincial project manager involved in the realization processes of hubs in North Brabant offers insights into the processes and perspectives of a regional authority. Detailed summaries of these interviews can be found in Appendix E, providing a comprehensive overview; the main insights from these are discussed in the sections below.

6.2.1 INSIGHTS FROM THE FIRST INTERVIEW

From the first interview with the ASML policy manager, conducted on September 15th 2023, the company's proactive approach to mobility within the Brainport region is highlighted. A comprehensive summary of this interview is presented in Appendix E.1. ASML's mobility policies were developed before the pandemic, around 2019, in response to the unsustainable surge in car usage among its expanding workforce. ASML recognized that growth was untenable without a modal shift to alleviate the burden on local infrastructure. Consequently, the company has been keen to spearhead infrastructural and behavioral changes, promoting cycling and public transport as preferred modes of travel for their employees.

Central to ASML's sustainable commuting initiatives is the focus on strategically located P&Rs. These are not merely envisioned as parking spaces but as integral components of a broader mobility strategy, designed to be conveniently positioned along commuters' routes to ensure effectiveness. To discourage on-site parking, ASML supports the implementation of financial incentives, like paid parking, nudging employees towards using P&R options.

ASML takes a consultative and potential financing role in the planning of P&Rs, advocating for locations that align with their goal of significantly reducing car use by 2030. Although other companies in the region have shown interest, they take on a more passive stance, waiting for ASML's lead. Meanwhile, ASML remains flexible and anticipates alternative measures, such as enhancing current parking facilities, to mitigate the slow progress in P&R development.

Despite the clear strategy and initiatives by ASML, the actual development of P&Rs has encountered delays. The process is complicated by bureaucratic and environmental challenges, particularly around nitrogen emissions regulations, which delay decision-making and implementation. Recently, there has been a drive towards smaller, more strategically placed hubs to address the immediate needs, which ASML is willing to co-finance.

6.2.2 INSIGHTS FROM THE SECOND INTERVIEW

The second interview with the project manager of hubs, held on September 28th 2023, reveals the intricate dynamics of planning and implementing P&R facilities in the Brainport region. The conversation sheds light on the need for new P&R hubs as solutions for the growing traffic from expanding job centers. Currently in the early planning stages, the project faces the task of coordinating with multiple municipalities, each with its own interests and strategic goals. A detailed summary of this interview can be found in Appendix E.2.

There is a shared vision for shifting away from adding more roads to adopting alternative transportation methods. In collaboration with SmartwayZ.NL, the project manager is actively involved in negotiations with the national government and the administration of funds designated for immediate mobility solutions. The project's regional scope introduces challenges, in particular, due to the involvement of multiple municipalities and the need for coordinated efforts across various independent projects. Deciding where to place these hubs involves extensive traffic studies and spatial planning, and it is a process still unfolding with no final decisions yet. Ownership and management of the proposed hubs pose a significant challenge. Municipalities are willing to facilitate the planning process but often hesitate to assume long-term ownership and operational responsibilities. The Metropole Regio Eindhoven (MRE) plays a facilitative role in the Brainport region yet lacks the robust legal authority and financial autonomy of entities like the VRA in Amsterdam or the MRDH in the Rotterdam-The Hague region. Therefore, obtaining support for projects like regional hubs would require approval from 21 municipal councils.

ASML stands out as a company for its proactive role, showing strong involvement due to its pressing growth and transport needs. While other large companies like VDL and Philips raised concerns about infrastructure congestion before the pandemic, only ASML continued to actively pursue alternatives during the crisis. They have explored temporary hubs but faced lengthy permitting processes and environmental issues regarding nitrogen emissions.

The financial contributions from companies could take different forms, from shared ownership of the hubs to committing to long-term leases of parking spaces. Currently, there is a financial impasse at the regional decision-making level, with a need for innovative approaches to kickstart the first hub, which could then act as an example for others.

The project manager acknowledges that the timeline for establishing P&R facilities may extend beyond initial projections, hindered by environmental regulations and unresolved issues regarding ownership and financial responsibilities. The demand for the amount of parking spaces might be overestimated, considering the shift towards remote working and the popularity of e-bikes. It is suggested that when Eindhoven becomes less accessible to cars, P&Rs will emerge as a more appealing option for commuters, which could potentially accelerate the process.

6.2.3 INSIGHTS FROM THE THIRD INTERVIEW

The interview with the local project manager was conducted on October 18th 2023, and provided an understanding of the intricate process of implementing P&R facilities in the Brainport region on a local level in Best. An elaborate summary of this interview can be found in Appendix E.3.

The role of the Hub Manager in Best is pivotal, evolving from a broad examination of 11 potential sites to a concentrated selection of two viable options. This selection process was comprehensive, taking into account factors such as proximity to the highway, environmental impact, and local traffic conditions. The involvement of ASML was significant as their needs led to a reevaluation of the required parking capacity, upscaling the original estimate from 800-900 spots to 2500.

Collaboration lies at the core of this project, involving a multidisciplinary team of municipal staff and external consultants who collectively navigate the complexities of urban design, traffic, and economic planning. The decision-making structure requires a coordinated effort between this team, the municipal executive board, and the city council, emphasizing a governance approach that reflects the voices of both the municipality's leadership and its citizens.

The interviewee emphasizes the challenges of aligning multiple mobility initiatives within the region, a task complicated by the absence of a central regional authority to oversee and synchronize efforts. This issue extends to the funding aspect, where a considerable portion of the budget is in place, yet the distribution of these funds among municipalities and securing business contributions remains unresolved. A particular challenge is the absence of a clear owner for the hubs post-construction. The municipality of Best is willing to cooperate and contribute to the process, although it does not present itself as a financial leader or owner of the hub.

Regarding the project's future, the Hub Manager postulates a lengthy process extending beyond 2027. Legal procedures, potential appeals, and the requirement of a comprehensive environmental review add layers of complexity and potential delays. Moreover, the project's fate is intertwined with securing a consensus on financial and governance responsibilities, with hopes of advancing discussions to establish a specialized entity to streamline the project's management.

The interview concludes with an acknowledgment of the varied interests at play, from ASML's significant involvement to other companies' engagement through mobility brokers. The process of implementing P&Rs in Brainport is depicted as multifaceted, with the need for a regional approach that harmonizes stakeholder interests, financial strategies, and governance structures. The success of the project depends on collaborative efforts, the establishment of a regional authority, and the community's willingness to embrace these changes for long-term benefits.

6.2.4 INSIGHTS FROM THE FOURTH INTERVIEW

The final interview with the provincial project manager held on 3 November 2023, unveils the intricate roles and challenges faced in the development of hub facilities within the North-Brabant region, specifically in the context of the Brainport area. The interview outlines the provincial approach to developing these hubs, which serve as critical nodes in the broader strategy to address transportation needs and enhance regional accessibility. An elaborate summary of this interview can be found in Appendix E.4.

The provincial role is described as facilitative, providing support and guidance to municipalities, especially smaller ones that face capacity and funding challenges in developing P&R facilities. The employee underscores the complex nature of constructing new hubs in the Brainport area, which involves a multitude of stakeholders and requires intricate coordination. While the province is not directly responsible for the hubs, it plays an integral role in fostering collaboration among various entities, including municipalities and transportation providers. This includes the enhancement of existing public transport locations and the introduction of innovative services like flexible transportation options and shared mobility.

The main challenges in establishing Brainport hubs lie in the complex interplay between smaller municipalities and the need for a collective regional approach to governance and funding. While the province acts as a supportive backbone, the smaller municipalities struggle with ownership issues, operational viability, and the absorption of financial risks associated with the development of these new P&R facilities. The province is involved in ensuring the hubs' development aligns with the larger mobility strategy, which is part of the comprehensive "Brainport Bereikbaar" plan, a joint effort by SmartwayZ.NL and the MRE to preserve regional accessibility.

Currently, the mobility hub initiative is in the early stages of site selection and research. The governance around hubs is addressed as a particularly challenging issue, with the need for clarity on the division of responsibilities, ownership, and financial risks. The interviewee emphasizes the necessity for a solid governance framework that can provide clear direction and manage the financial implications of hub development.

The discussion on the involvement of businesses in the hubs' development highlights ASML's proactive participation and the potential for more involvement from other businesses. The challenge lies in securing financial contributions from businesses, which is necessary to ensure the utilization and success of the hubs.

Looking forward, the provincial employee is hopeful about the progressive realization of the mobility hubs and the establishment of a supporting bus network. Achieving this in the next two to three years is seen as ambitious, given the complexities of governance and funding that still need to be resolved.

6.3 PROCESS ANALYSIS

This section presents an analysis of the implementation process of regional hubs in Brainport, mostly based on the information collected from the interviews. Firstly, the main stakeholders are identified in section 6.3.1, delving into their roles, interests and cooperation. Subsequently, the primary challenges indicated by the interviewees are elaborated on in section 6.3.2, giving insight into the intricacies of hub realization in Brainport. Finally, section 6.3.3 touches upon the future prospects of the hub projects as viewed by the interviewed respondents.

6.3.1 KEY STAKEHOLDERS

The development of regional hubs in the Brainport area involves a complex interplay among a range of stakeholders, each with unique goals and contributions. The project spans across various sectors, demanding coordinated action to ensure its success. Below, the main stakeholders are identified, elaborating on their respective roles, interests, and interplay. An overview is presented subsequently Table 19.

SmartwayZ.NL
SmartwayZ.NL operates as a collaborative government initiative, partnering with both public and private sectors to enhance mobility within Brabant and Limburg (Noord-Brabant, n.d.). As the principal orchestrator for the development of the Brainport region's mobility hubs, SmartwayZ.NL leads the coordination and conducts critical negotiations with government entities, along with managing extensive research for potential P&R sites. The project managers, assigned by SmartwayZ.NL, navigate complex regional multi-actor dynamics, which requires the alignment of multiple stakeholders. Their leadership is especially critical in managing the diverse interests that converge in the Brainport area.

Brainport Bereikbaar
Brainport Bereikbaar is a governmental program aimed at enhancing accessibility in the Brainport. They particularly focus on innovative mobility solutions and promoting behavioral change towards sustainable commuting options (interview 2, 2023). While it does not directly manage hub projects like SmartwayZ.NL, Brainport Bereikbaar contributes by integrating individual projects into the wider regional mobility strategy. It has a more supervisory role within the mobility landscape of the Brainport region as it facilitates discussions on a local level with municipalities, as indicated by the local hub manager in interview 3 (2023). The main challenge lies in their limited direct implementation power and dependence on the cooperation with SmartwayZ.NL and municipalities to realize initiatives.

Municipal Governments
The development of P&R facilities in the Brainport region is a collaborative venture involving multiple municipalities. Since the P&R facilities are planned in the surrounding municipalities of Eindhoven, these local governments play a critical role in planning and zoning, directly influencing the feasibility and integration of P&R sites within their jurisdiction, as discussed in interview 3. Their interests lie in ensuring local accessibility, urban planning, community welfare and environmental preservation. The major challenge for them is to balance the regional demands with local interests, which may sometimes conflict.

The municipalities of Best, Oirschot, Eersel, and Maarheze are integral in facilitating spatial procedures, yet they generally do not intend to invest or manage the P&R facilities due to their regional service purpose, as pointed out in interviews 2 and 3. Locally, several specialists of the municipality collaborate closely with the hub managers appointed by SmartwayZ.NL and external consultants in the decision-making process, as described in interview 3. While in some instances municipalities own the land for potential P&R sites, other scenarios may require the acquisition of private land, further complicating the process, as noted in Interview 3.

Metropole Regio Eindhoven (MRE)

The Metropole Region Eindhoven (MRE) is a key player in shaping the regional development strategies in Brainport, functioning more as a policy-making body in contrast to the project-oriented role of SmartwayZ.NL. The MRE is responsible for coordinating a cohesive mobility vision across the involved municipalities, which is also coordinated with the provincial authorities, as discussed in interview 4 (2023). Their interests lie in enhancing mobility and ensuring the accessibility of the region, which is essential for its economic vitality and the well-being of its residents. From interview 3, we learned that the municipalities rely on the MRE to facilitate discussions, distribute funds, and harmonize actions across the region, which includes the development of P&R facilities. However, the MRE faces governance challenges due to the absence of a central authority, necessitating consensus among its municipalities to align with the "Brainport Bereikbaar" plan, as highlighted in Interview 2.

Provincial Authorities

As indicated in interview 4, the province plays a facilitative and supportive role in the development of P&R facilities in the Brainport region. This includes initiating projects, facilitating stakeholder collaboration, and sometimes providing financial support, with a focus on maintaining regional accessibility. The Provincial authorities work closely together with municipalities and the MRE, where they serve as intermediaries, coordinating between the region and various municipalities. Their goal is to maintain and improve regional accessibility and economic health. They assist in ensuring that the mobility hubs align with the larger strategic vision of the MRE.

National Government

The national government is important in addressing the mobility challenges in Brainport, through various agreements with provincial and municipal authorities they address urbanization and accessibility challenges (SmartwayZ.NL, 2020). As indicated by the interviews their role is primarily as a regulatory authority and co-financer. They provide the necessary legal framework for the implementation of hubs, including environmental regulations, zoning laws, and other aspects. The national government contributes financially to the overall Brainport mobility plans, supporting the region's efforts to enhance economic growth and regional accessibility, as discussed in interview 4.

Private sector companies (ASML)

Private companies in the Brainport region stand to benefit from regional hubs to mitigate the adverse mobility effects of regional economic growth. The various interviews highlight the proactive engagement of ASML due to its rapid expansion. Their involvement extends to participating in planning for P&R facilities, suggesting locations, and potential co-financing of projects, as highlighted in interview 1 (2023). ASML views P&R hubs as essential for reducing car usage and achieving a balanced modal split.

While ASML's active role is evident, other large enterprises in the region have been more passive; they are engaged in negotiations through mobility brokers to involve them in financial contributions and parking space allocations, as noted in Interviews 3 and 4. These companies face less pressing challenges compared to ASML, hence their more reserved approach.

External Consultancy Firms

External consultancy firms are engaged in the planning of P&R facilities for their technical knowledge and guidance. These firms offer specialized expertise in various aspects of the P&R projects, including site selection, traffic engineering, economic planning, and environmental impact assessments, as denoted in interview 3. At least in Best, these firms have been given a place in the project team, where they conduct comprehensive evaluations of potential P&R locations, assessing the feasibility, traffic impact, and overall integration with the existing infrastructure. Their inputs are instrumental in shaping project outcomes and ensuring that the developed hubs meet the region's transportation and environmental objectives effectively.

Public transport companies

Public transport companies in Brainport play an important role in connecting the regional hubs with the broader transportation network. As highlighted in the interviews, their involvement is essential for ensuring the effectiveness of P&R hubs as they provide the necessary public transit options for commuters who park at these facilities. The success of P&R initiatives heavily relies on the efficiency, reliability, and integration of these transport services.

Local residents and communities

Local residents and communities are key stakeholders as their environment and daily lives are affected by these projects. Interview 3 addressed the importance of including them in the decision-making process, particularly in the design stage when a location has been decided on. Residents often express concerns about the impact of these developments on their local environment and quality of life, which might lead to resistance ("Not in My Backyard"). Despite their initial resistance, local residents are likely to benefit from enhanced regional mobility through the realization of hubs. Their involvement is crucial in ensuring that the hubs not only meet regional transportation needs but also align with local interests and priorities. Balancing these local viewpoints with broader regional objectives is a key aspect of the successful development and integration of P&R hubs in the region.

Table 19: Overview of key stakeholders and their stakes

Stakeholder	Role	Interests	Challenges	Actions & Timing
SmartwayZ.NL	Project initiator and manager	Streamlining mobility, implementing smart solutions, project execution	Coordinating stakeholders, consensus building	Initiates and manages specific projects
Municipal Governments	Local authority, planning, and zoning	Accessibility, urban planning, community welfare, environmental care	Aligning local and regional needs	Involved in planning, zoning, and local approvals
Metropole Region Eindhoven (MRE)	Policy-making body, regional coordinator	Regional mobility strategy, network integration, regional development	Synthesizing municipal inputs, distributing funds	Sets policies, coordinates regional efforts
Brainport Bereikbaar	Supervisor of the overall mobility plan	Accessibility, promoting	Limited implementation	Oversees project integration into mobility strategy

		sustainable commuting	power, partner reliance	
Provincial Authorities	Supporter, mediator, financial support	Regional access, economic health, sustainable development	Managing municipal dynamics, financial support	Facilitates stakeholder collaboration and provides financial aid
National Government	Regulatory body, co-financier	Economic growth, infrastructure development	Policy and funding coordination	Provides legal framework and financial support
Private sector companies (ASML)	Stakeholder, potential financier, advisor	Sustainable growth, resolving mobility challenges from expansion	Bureaucratic and environmental challenges	Potentially articipates in planning and could offer financing options
External Consultancy Firms	Technical advisors	Providing expert analysis for hub development	Dependent on stakeholder decisions	Offers expertise in planning and assessments in planning stages
Public Transport Companies	Service operators	Integration of transport services, quality experiences	Reliant on P&R hub success, service planning	Provides public transport connections
Local Residents & Communities	Stakeholders affected by projects	Livability, property value maintenance, minimal traffic disruption	Concerns about construction and traffic increase	Engaged in consultation and feedback processes

Conflicting interests and ambiguous responsibilities

While the overarching goal of improving accessibility in the Brainport region is shared among the key stakeholders, the stakeholder analysis reveals a web of conflicting interests and intricate responsibilities that complicate the establishment of regional mobility hubs. Governmental programs like SmartwayZ.NL, Brainport Bereikbaar, the MRE, and provincial authorities are aligned in their mission to implement mobility-enhancing measures. However, the involvement of multiple municipalities, coupled with constraints in resource allocation by the overarching authorities, results in a challenging and time-consuming decision-making process.

A pivotal issue arises from the need for consensus across numerous municipal councils, particularly when the discussions involve financing and ownership. This entails a comprehensive set of responsibilities, including financing the construction, ensuring regular maintenance, managing day-to-day operations, and assuming any associated financial risks. The municipalities assigned to host the hubs are cooperative in facilitating the processes, but they are unwilling to take individual responsibility for financing and ownership of these hubs, as these are designated for regional benefit. This standoff underscores the potential for large private sector companies to step in with financing, despite varying degrees of engagement among such companies. ASML's proactive stance and willingness to co-finance contrast with the more expectant posture of other firms, leading to potential discrepancies.

These governance issues must be sorted out before the hubs can go into the next phase of realization. Like any infrastructural implementation, the hubs must adhere to their respective municipalities' zoning and environmental plans, which could lead to frustration among companies and other stakeholders. Moreover, once locations are selected, resistance from local communities to large-scale developments or increased traffic could introduce further complications.

Municipalities hold the responsibility of balancing regional needs with local preferences, a task that may occasionally lead to disputes. Moreover, synchronizing the plans for mobility hubs with public transportation strategies and broader Brainport mobility initiatives adds layers of intricacy. Moving ahead requires careful harmonization of stakeholder interests and a concerted effort to define responsibilities and secure funding. This alignment is the key to transitioning from plans to practice and turning the vision of enhanced regional accessibility into a reality.

6.3.2 KEY IMPLEMENTATION CHALLENGES

1. **Location and Infrastructure constraints**:

Selecting suitable locations for the establishment of the P&R facilities is pivotal to the success of the mobility strategy within the Brainport region. Interviews 1 and 2 emphasize the need for the strategic placement of these hubs near major access roads along commuter routes to ensure their effectiveness. While preliminary zones have been identified in the early stages, as shown in Figure 18, selecting the exact locations within these areas requires thorough research and time. This demands extensive evaluation to balance factors such as proximity to major roadways, environmental considerations, (public transport) infrastructure feasibility, land ownership and the potential for future expansion.

Interview 3 with the local hub manager highlights the rigorous process of narrowing down from numerous possibilities to the optimal site, considering all necessary criteria. Some potential sites can easily be discounted by failing the boundary conditions, such as accessibility to highways or being in ecologically sensitive zones. Subsequently, further in-depth studies are conducted, including fitting studies, traffic impact assessments, and business case viability, to understand the costs and implications of each site, as detailed in interview 3. The selection process is not merely a matter of availability of space but also involves ensuring that the hub's location aligns with broader urban planning and sustainability goals. Each potential hub location within Brainport undergoes this evaluation process. In Best, for instance, this led to two viable locations. Land ownership remains a critical factor since privately owned land requires acquisition before any development can proceed.

The local project manager acknowledges that the envisioned capacity of 2500 vehicles, set to match ASML's anticipated growth, has been reduced in Best due to spatial restrictions from environmental and urban development strategies. This reflects the intricate balance between development ambitions and the preservation of natural and urban spaces. Moreover, the regional project manager in interview 2 noted the difficulty of realizing as much as 10.000 to 15.000 parking spaces in the short term. Both interviewees point out that establishing temporary ground-level P&R locations of this scale is bound to even more location constraints.

Ultimately, decisions on the hub's locations may be faced with 'not in my backyard' resistance. Residents often question the benefits of such projects to their community, expressing concerns about increased traffic and changes to the local environment. This resistance underscores the necessity for stakeholder engagement and consensus-building, ensuring that P&R initiatives align with the interests and expectations of local communities while contributing to the broader regional mobility strategy.

While, the intricate selection process of locations is typical to major infrastructural projects, as acknowledged by the hub managers in interviews 2 and 3, the Brainport hubs face additional challenges. Uncertainties regarding the governance and financing of the hubs adds complexity to the selection process, as multiple municipalities are involved in the planning process.

2. **Inter-municipal stakeholder dynamics**:

The multi-stakeholder dynamics within the Brainport region illustrate a complex challenge for the implementation of P&R facilities. Due to the regional scope of the project, additional complexity arises from aligning the interests of multiple smaller municipalities with those of other stakeholders, like the province or major companies such as ASML. While there is a general consensus on the necessity of a mobility transition, the practical execution of specific projects presents significant challenges, as outlined in interview 2. A practical illustration of conflicting stakeholder interests emerges from a situation recounted by the local hub manager in interview 3. Initially, a promising site for a P&R facility in Best was situated on the east side of the highway, however this location was dismissed because the municipality prioritized environmental conservation and recreation for that area. Consequently, the ambitious plan to create parking for 2500 vehicles was significantly scaled back, limiting potential expansion to the western urban areas of Best where space is more constrained. This decision has led to a potential mismatch between the scale of the P&R facility that can be realized and the expectations of other stakeholders involved.

Stakeholder participation and coordination are crucial to navigating through the intricate landscape of municipal politics, regional planning, corporate expectations, and local interests (interviews 2 and 4). Central to these collaborative efforts are the MRE and the provincial authorities. The MRE, as a collaborative body of the 21 involved municipalities in Brainport, strives to harmonize their diverse interests and policies towards a regional goal. Meanwhile, the province serves as an intermediary, providing strategic guidance and financial support where necessary, as was delineated in interview 4. These entities work closely with the municipalities, project managers and external expert consultants, facilitating negotiations and contributing to advancing the project development.

Despite the coordination efforts, the project is complicated by the absence of a single centralized authority, as pointed out by the hub managers in interviews 2 and 3. Unlike entities such as the MRDH in the Rotterdam-The Hague Region and the VRA in Amsterdam, which wield substantial legislative and financial power, the MRE acts more as a facilitator of dialogue and policies among the 21 involved municipalities, without the same level of direct authority. The planned P&R hubs, intended primarily to enhance access to Eindhoven, are to be situated within neighboring municipalities, which adds layers of complexity to the decision-making process. The current governance structure requires a consensus among multiple municipalities, each with its own set of priorities and constraints, often leading to delays.

The engagement of companies in the region is regarded as important for the initiative’s success. ASML is particularly involved, not merely as end-users but also as participants in the planning and potential co-financing of the P&R facilities. This contrasts with other companies in the area, which adopt a more passive approach, as indicated by the interviews. This diversion in engagement levels among companies introduces an additional layer of complexity to the stakeholder dynamic, influencing the pace and direction of the P&R development process.

3. **Governance and financial planning**:

The ambition to create regional P&R hubs in the Brainport area is contingent upon overcoming significant governance and financial challenges. General governance questions regarding identifying the responsible parties for operation, ownership, and financial risk form a complex problem that requires strategic coordination. As consistently highlighted in Interviews 2, 3, and 4, these foundational issues must be addressed to pave the way for construction and operational activities.

The financial planning for P&R hubs must strike a balance between initial construction costs and the pursuit of long-term operational sustainability. Interview 4 denotes that parking facilities typically operate at a deficit, which raises the question of how to manage ongoing costs against the expected revenues. For example, while parking fees may provide a steady revenue stream, they may not cover the extensive operational expenses, such as maintenance, security, and integration with transport services.

In the Brainport region, the governance framework is further complicated by the distribution of P&R hubs across multiple municipal territories adjacent to Eindhoven. This contrasts with a scenario where hubs fall within jurisdiction of a single city, which could allow for streamlined funding and management by one municipal body. However, with hubs dispersed across various local authorities, a cohesive and unified approach is necessary to combine resources and decision-making. This is particularly challenging in the absence of a central authority with the power to oversee financing and management across the region.

While the municipalities involved in the project have been willing to facilitate the spatial and legal frameworks, they are hesitant to engage financially or take ownership due to the regional nature of the P&R services. Although €50 million has been made available from the €185 million short-term action funds, the distribution is subject to approval by individual municipal councils prolonging the process, as detailed in interview 3. According to the project manager in interview 2, innovative financial strategies are being explored, such as co-development between public and private organizations or long-term leasing of parking spaces. However, most companies remain hesitant about financial commitments or governance roles without a solid business case that benefits their operational and corporate goals.

Addressing governance and financial structuring is critical for the hubs' realization. This includes transparent land acquisition processes, particularly for favored sites on privately owned sites, as detailed in Interview 3. These foundational steps are vital to ensure the sustainable financial viability of the hubs from the start.

4. **Legal and Environmental Regulations**:

Legal and environmental regulations present a significant challenge in the development of infrastructure projects like P&R facilities. The need for zoning approvals and environmental impact assessments can lead to a lengthy and complex approval process. These procedures, especially problematic in Brainport due to a heightened emphasis on nitrogen emission regulations in the region, have increasingly become a bottleneck for construction permits across Brabant (Linders, 2023). The project managers, highlighted in interviews 2 and 3, stress that Brainport's initiatives suffer from these heightened environmental constraints, contributing to the time-consuming and complex nature of the implementation processes.

While some zoning procedures might proceed relatively quickly, such as the existing Maarheze P&R upgrade, the project managers note that appeals and objections can significantly prolong the process if they arise. If the process reaches the regional court, delays can easily take a year, which can even further extend if cases escalate to the Council of State.

The bureaucratic and political framework emphasizes the difficulty in moving projects from the planning stage to actual development and the significant delays that can occur when local objections are raised. Even when the governance issues are addressed in the short term, the process remains subject to zoning and environmental procedures, creating architectural designs, contracting construction companies, and simultaneously developing public transport links, as detailed in interview 4.

For ASML, these extended legal and environmental processes significantly impede their mobility strategy. The temporary P&R solutions proposed by ASML, which could serve as interim measures to alleviate immediate transportation pressure, are also entangled in the same time-intensive legal and environmental procedures. Meanwhile, ASML explores alternative solutions such as a new office hub in Den Bosch. However, the possibility remains that ASML may have to resort to constructing additional parking facilities, to support their expansion, as mentioned in interview 1.

5. **Integration with the Brainport mobility plan**:

The integration of P&R facilities within the extensive Brainport mobility plan is pivotal for their success. As noted in the interviews, these facilities must be strategically interconnected with public transit systems, to provide efficient transport from P&Rs to employment centers. The proposed HOV line is crucial, designed to link various hubs and facilitate commutes for numerous users. The strategy also emphasizes upgrading cycling paths to encourage sustainable travel modes and seamless transitions from bikes to P&Rs. Each of the individual projects must be carefully aligned in the planning stages.

This requires effective coordination, which is facilitated by regional bodies like SmartwayZ.NL, Brainport Bereikbaar and the MRE, as mentioned in Interview 3. They ensure that the multiple layers of mobility developments are integrated well. In interview 4 the provincial employee underscores the importance of synchronizing the development and activation of P&R facilities with the initiation of corresponding transport services. It is crucial that these facilities, once operational, are immediately integrated with fast and reliable transport links. Delays in any part of this integrated system can reduce the effectiveness and appeal of the P&Rs.

The interviews also highlight the need for incentivization to make P&R use more appealing than direct car travel. Interview 2 suggests that financial incentives, such as parking fees at workplaces, higher city-center parking costs or car-free zones could encourage commuters to opt for P&R facilities. Ultimately, the successful integration of P&Rs into the Brainport mobility strategy does not only involve infrastructure development but also the implementation of policies and incentives that align with the users' behaviors and preferences.

6.3.3 PROGRESS AND FUTURE PROSPECT

The development of P&R facilities in the Brainport region is in its beginning stages, with substantial groundwork laid in terms of research, site selection and preliminary planning. For the hub A2 North in Best, two viable sites have been selected from a selection of 11 potential locations, as highlighted by the local project manager. The hub A58 and the Hub A67 West near Eersel are still undergoing detailed feasibility studies, with several sites shortlisted for each. In Maarheeze, plans are to expand the existing P&R facility to a regional hub with an extensive range of services, as detailed in the second interview. According to interview 4, the location studies for the remaining hubs on the A50 and A67 East have not started, as the current focus is on the other four hubs.

While the location selection process has largely gone through for these hubs, the need to address governance structures is crucial, as highlighted in the interviews. The project managers in interviews 2 and 3 indicate that a more centralized authority might be required to further progress the development of regional hubs. The interviews underscore that governance clarity is imperative for the project's advancement, as without it, the development of regional hubs cannot proceed.

The next critical steps in the development process are the initiation of zoning and environmental procedures, as indicated in Interview 2. These steps are vital for establishing the hubs legally and for addressing environmental impacts, including navigating the stringent nitrogen emissions regulations that have previously impeded construction in the region. The zoning and environmental procedures will lay the groundwork for the architectural design, construction contracts, and the development of accompanying transport services, marking a significant phase in moving the projects from planning to actual development. Additionally, the emergence of appeals and legal objections can cause delays in future stages of the project.

The transition to the actual construction of P&R facilities is moving slower than the project managers and ASML had anticipated, revealing the intricacies and challenges of large-scale regional infrastructure development. ASML's interest in realizing (temporary) P&Rs in the short term is equally subject to extensive legal and environmental regulations. Meanwhile, ASML explores alternative solutions such as a new office hub in Den Bosch. However, the possibility remains that ASML may have to resort to constructing additional parking facilities, to support their expansion, as mentioned in interview 1.

To conclude, express caution about the feasibility of completing four hubs by 2030 due to complex inter-municipal coordination, governance complications, and stringent nitrogen emission regulations. While aiming for four hubs is ambitious and not aligned with the current pace, two hubs appear to be a more achievable target. The development trajectory must remain flexible to shifting transportation trends, evolving environmental standards, and the specific needs of expanding companies like ASML.

6.4 SUMMARY

Main takeaways

- The key stakeholders include SmartwayZ.NL, Brainport Bereikbaar, Eindhoven and the surrounding municipalities, the MRE, provincial and national authorities, regional companies, consultancy firms and residents.
- The strategic placement of the P&R's location is essential to their success. These procedures require extensive research in which multiple parties are involved. These processes have largely been completed for the 4 prioritized hubs, but only for the hub in Maarheze, the exact location is yet known; for the others, 2 or 3 potential destinations remain.
- Harmonizing the interests of numerous stakeholders is challenging, including the municipalities, the province, companies and local communities. The absence of a central authority leads to delays as consensus is needed across the board. Different levels of engagement from companies add complexity to the dynamics.
- Governance structures and financial planning are critical obstacles. There is ambiguity over ownership, management, and financial risk after development. The lack of a centralized authority is felt since municipalities are not interested in ownership or investment. These are key issues that must be solved before transitioning into the next phase.
- The rigid legal and environmental regulatory framework are underlying the complexity of the decision-making process. In particular restrictions regarding nitrogen emissions are challenging. Moreover, legal objections can cause significant delays when the plans are met with local resistance.
- Effective integration with the overall Brainport mobility plan is critical for P&R’s success. The development of transport services like the HOV line and cycling infrastructure must be timely and well-coordinated. Incentives to encourage P&R use over direct car travel are crucial, requiring policy support and alignment with commuter behavior.

In this chapter, the implementation process of P&R in Brainport was analyzed, focusing on the roles of key stakeholders, the main challenges, and future prospects. Data collected through four interviews with involved individuals revealed the complexity and time-consuming nature of the project. Despite available funding from governments and potential corporate financing, many uncertainties remain over the hubs' developmental trajectories. The establishment of four regional hubs in Brainport by 2030 is viewed as ambitious considering the current pace of the project.

7. CONCLUSION

This chapter consolidates the main insights and conclusions of this research. Firstly, section 7.1 summarizes the main discoveries and their implications. Next, section 7.2 provides a reflective look at the study's limitations. Finally, recommendations for further research are provided in section 7.3.

7.1 KEY FINDINGS

This section synthesizes the key findings in relation to the proposed research objectives and the corresponding research questions. Section 7.1.1 addresses conclusions drawn to the choice modeling analysis regarding the first research question and follow-up questions, and section 7.1.2 delves into the sub-questions linked to the second research question. The broader implications of the findings are discussed within the respective sections.

7.1.1 CHOICE MODEL CONCLUSIONS

In the first part of this study, choice models were estimated to examine the effects of ASML policy measures on the employees' mode choice. This research was built upon the foundational study by Field Molin & Kroesen (2023b), who designed a choice experiment and gathered data on commuting patterns from 5,623 ASML employees. They utilized an MNL model to evaluate the influence of various mobility policies. However, recognizing the limitations of the MNL model, particularly related to the flawing IIA, this study advanced the analysis by applying an error component ML model to the same dataset. In this study an error ML model was estimated on the same choice experiment data to establish more accurate outcomes. The ML model was employed to derive more precise insights into the effects of the policy measures on employees' commuting choices, and its outcomes were compared to those of an MNL model.

The error component ML model development required the initial identification of nests representing groups of alternatives with correlated preferences, which are unobserved by the selected attributes in the choice experiment. This provided a nuanced understanding of preference groups within the commuting options. Following the estimation of the (random) parameters, the ML model was applied to investigate the specific impacts of various ASML policy measures on the mode choice of ASML employees. This detailed analysis also encompassed a comparison between the choice probabilities and the goodness-of-fit of the ML model against the estimated MNL model resembling the model from Molin & Kroesen (2023b). Such comparison provides an understanding of the differences in predictions and the extent to which each model captures the underlying patterns in the data.

Configuration of nests

In establishing the nest configurations for the ML model, strategic decisions were made based on both the transport characteristics and statistical evidence from the model outcomes, considering the significance of the error components, the estimated sigma values, and the model fit. Each nest was defined to encapsulate significant shared characteristics between alternatives, surpassing the IIA property. The configuration aimed to capture the essence of commuter behavior while maintaining model simplicity and robustness. In the end, 4 nests were established:

1. Cars Nest: Includes the use of private cars, carpooling, and P&R options where the trip begins with car usage. This grouping is due to the commonality of the car's role in the journey's initial segment, whether the trip continues with another individual or transitions to a different mode.

2. Shared Nest: encompasses modes involving collective use, such as (shuttle) buses, trains, and carpool. It captures the shared experience of travel, aligning alternatives that trade personal space for communal transit. Carpooling is included here to emphasize the shared travel aspect, despite its differences from public transport, based on its performance in the model.

3. Multimodal Nest: Captures alternatives that require a transition between modes, addressing preferences for last-mile connections. It includes P&R with shuttle or bike and train with shuttle or bike, reflecting the complexity of choices when journeys involve multiple modes.

4. Bike Nest: Dedicated to bicycle use, including options where biking is integral to the commute, either solely or in combination with P&R or train, recognizing the distinct preference for active travel.

Policy effects

The ML model offers a comprehensive analysis of ASML mobility policies, revealing that direct financial measures are most effective in commuting preferences. The imposition of €3 parking fees coupled with a €3 reward for not using cars stands out as the most effective policy, leading to a significant reduction in car usage from 38.5% to 29.6%. In contrast, service-oriented enhancements, such as the provision of first-class train cards or advanced services at P&R facilities, are less impactful. A combination of improving P&R sites, first-class train cards, and increasing shuttle frequencies is predicted to only effectuate a 1.7% decrease in car use. If these predictions are accurate, incentivizing employees through monetary measures is significantly more effective and efficient, considering the costs associated with enhancing these service measures.

A future scenario with longer average congestion results in elevated use of alternative transport modes. A moderate increase to 20 20-minute delay results in a reduced car share from 38.5% to 35.8%, while a 40-minute delay could lower this share up to 28.8% without any policy intervention. The introduction of a direct P&R shuttle that surpasses congestion can further decline car usage under these conditions, with the ML projecting an overall P&R share of 18.4%. When longer congestion is met with monetary incentives, the preference for car use drops significantly, potentially as low as 19.2%

The insights from the ML model emphasize the primary importance of cost and time considerations in commuting decisions, suggesting that ASML's policy measures should prioritize these factors to influence employee commuting patterns effectively.

Comparison between MNL and ML models

When comparing the model fits, the ML models consistently outperform the MNL models across the various experiments, evidenced by the higher rho-square (ρ^2) values in all experiments, suggesting a more accurate representation of the actual choice behavior of ASML employees. Notably, the ML model for Experiment 1 stands out with the highest rho-square value of 0.72, signaling the model's significant predictive power. This high value may be the result of the high percentage of respondents consistently choosing the same alternative in this experiment (71.3%), mainly with respect to the bicycle alternative (59.9%), indicating a preference towards certain alternatives or nests.

The most notable improvement in model fit was observed in Experiment 3, where a relatively low rho-square value increased from 0.13 in the MNL model to 0.54 in the ML model. Similarly, Experiments 4+5 showed a significant increase from 0.17 to 0.51. These increases in rho-square values are substantiated by highly significant Likelihood Ratio Statistics (LRS), confirming that the additional complexity introduced in the ML models is justified and results in a considerably better fit.

When comparing the policy effects on the choice probabilities between both models, they are quite similar in the predicted car shares over the various scenarios. Although the MNL model predicts a slightly higher percentage of car users in the current scenario, this difference is compensated for by a higher decline in car use under the proposed policies.

The ML model was not expected to predict vastly different mode shares than the MNL model drawing from the same dataset to predict commuter mode choices, however there are some notable differences that can be ascribed to the effect of the shared components. The nesting effects can be observed in the relatively higher increase of car-related alternatives such as carpool and P&R modes in scenarios with monetary incentives and increased congestion. To counterbalance these effects, the MNL model assigns a larger percentage to the P&R + bike alternative for example, which reaches 4.3% compared to the ML model's 2.8%. Although there are discernible differences between the models, they tend to balance out across multiple scenarios, indicating that both models have their unique ways of adjusting to the same conditions.

Conclusions and implications

The research objective related to this segment was to provide more accurate insights into the effects of ASML mobility measures on employees' commuting mode choices. Through the employment of an error component ML model, the effects of mobility measures on the commuting mode choices of ASML employees are accurately determined. The robustness of the ML model is evident from its superior model fit when compared to the MNL model. The capacity to incorporate random effects and account for unobserved heterogeneity provides a more nuanced and reliable analysis of the effects of mobility policies on employees' mode choice, as compared to the MNL models.

The conclusions for the ML model are relatively similar to those of the MNL model. Financial incentives, particularly parking fees and commuting rewards, are identified as the most effective tools, leading to a significant decrease in car usage and encouraging the adoption of sustainable transport modes. By providing a monetary incentive package including €3 parking costs and rewards for non-car users coupled with allowance differences, the proportion of private car commuters can be decreased by more than 10%. A significant share will move to cycling, and according to the ML, a larger percentage will shift to carpooling under this policy compared to the MNL. On the other hand, service-related enhancements have a relatively small impact, as was concluded from the MNL model.

Furthermore, the influence of travel time is critical; as congestion intensifies from external conditions, employees are naturally inclined to move away from cars to alternative modes without the effect of ASML policy measures. The introduction of direct P&R shuttles offers a compelling alternative to mitigate traffic delays, with the ML model predicting an even more significant uptake in P&R usage than the MNL model. In a highly congested scenario, with an average 40-minute delay, implementing direct shuttles can lead to a total P&R share of 18.4%.

These findings highlight that ASML's most effective strategy for influencing commuting behaviors involves prioritizing financial incentives within its mobility policy. In most scenarios, a significant number of employees will shift towards cycling, as seems to be the focus of ASML. However, this is not a viable alternative for employees living further away. The deployment of direct shuttle buses has the potential to significantly boost P&R utilization, however this strategy necessitates a legal framework that permits shuttles to use emergency lanes for bypassing traffic. Moreover, this strategy requires the development of additional P&R facilities, positioning them as viable alternatives for commuters from various directions. The development of such substantial transport hubs demands extensive time for planning and relies heavily on governmental coordination and support.

7.1.2 CONCLUSIONS REGARDING THE P&R IMPLEMENTATION PROCESS

Building on the conclusion which highlights the potential effectiveness of P&R facilities for reducing car usage by ASML employees initially drawn by Molin & Kroesen (2023b) endorsed by the ML models, part of the study focused on the P&R implementation process within the Brainport region. These regional mobility hubs have been an integral component of the Brainport mobility plan since the initiation of the Accessibility Agenda South-Brabant, however their implementation has proven challenging and time-consuming.

This part of the research aimed to investigate the factors influencing the prolonged and intricate nature of P&R deployment in the region. Firstly, the interplay was examined among stakeholders involved in the development of P&R hubs, focusing on their respective roles, interests, collaboration, and potentially conflicting needs. The current status of the P&R implementation process was taken into consideration while identifying the key implementational challenges. Furthermore, the study casts an eye toward the future, speculating on the development of P&R infrastructure by 2030.

To provide answers to these questions, interviews were conducted with four individuals from various organizations involved in the P&R initiative to gather multi-perspective in-depth information. These discussions have provided valuable insights into the multifaceted process and challenges of P&R implementation in the Brainport region.

Stakeholder involvement

The P&R implementation process in the Brainport region involves an intricate web of stakeholders holding different roles and representing various interests. Aligning these stakeholders is pivotal for the success of the project. SmartwayZ.NL functions as the principal instigator, steering the project's direction, managing location research and negotiating with governmental bodies. Together with Brainport Bereikbaar, they oversee that the various projects of the mobility plan are aligned. The municipalities around Eindhoven, in which the regional hubs are intended, are instrumental in the spatial planning and local implementation. The municipalities are crucial for spatial planning and implementation, as they facilitate essential zoning and environmental procedures that precede design and construction.

The local project leaders go through the location research procedure in association with diverse specialists from the municipalities and expert consultancy firms. ASML stands out as a proactive participant, advocating for the development of P&R options and willing to contribute financially, driven by their substantial workforce expansion plans. Other companies are considered important stakeholders in potential financial contributions and incentivization of employees, although their engagement in the decision-making process is more passive compared to ASML. This could be attributed to the less immediate infrastructural pressures they face, the geographical dispersion of these firms across the Brainport area away from Veldhoven, and the absence of immediate expansion plans similar to ASML's.

Aligning all these different stakeholders requires well-organized coordination. The Metropole Region Eindhoven (MRE) and provincial authorities act as coordinators and intermediaries, harmonizing inter-municipal efforts towards the regional mobility goals and providing strategic guidance. Public transport companies are engaged in integrating the hubs into the wider transport network, ensuring the hubs serve their intended purpose. Finally, local residents and communities are key stakeholders whose interests must be balanced against the broader regional objectives. They are typically involved in the later stages of implementation, as they may have concerns about local impacts and traffic changes.

Current status

The implementation process for Park and Ride (P&R) facilities in the Brainport region is still in its early stages, primarily engaged in site selection and planning. Four of the six proposed hubs have been prioritized due to their strategic importance and current advancements. The existing P&R at A2 South in Maarheze is set for an upgrade to a full-service regional hub. In Best, along the A2 North, 11 potential locations have been narrowed down to two viable sites. Similar evaluations are underway for the A58 and A67 West areas, where selected locations are being examined for feasibility. For the two remaining hubs, the location studies have not started yet, as the progress of the prioritized hubs is awaited.

Despite the advancements in site selection, initiating the necessary zoning and environmental procedures remains a critical next step. These processes are essential for the legal establishment of the hubs and will address various environmental impact considerations, involving comprehensive assessments regarding traffic impact, local road network integration, and environmental considerations. Zoning and environmental procedures will lay the groundwork for the architectural design, construction contracts, and the development of accompanying transport services. This will pave the way for moving projects from planning to actual development.

Main challenges

The challenges and underlying causes in the implementation of P&R facilities in the Brainport are multifaceted due to their scale and regional nature. The major challenges identified in Chapter 6 include:

1. Location and Infrastructure Constraints:
   The selection of appropriate locations for P&R facilities is a critical challenge due to the necessity to align with strategic commuter routes and accommodate future growth. Constraints arise from environmental considerations, existing infrastructure, land ownership issues, and potential expansion.

2. Inter-municipal Stakeholder Dynamics:
   The complexity of aligning interests among numerous smaller municipalities, the province, and companies like ASML contributes significantly to the challenges. While the need for a mobility transition is acknowledged, the absence of a centralized authority results in a governance structure that depends on consensus, often leading to project delays.

3. Governance and Financial Planning:
   Uncertainties about who will own, manage, and bear the financial risk for the P&R facilities post-construction are significant obstacles. Municipalities are reluctant to commit to investment or ownership, pointing to the need for a clear governance structure and financial model that ensures long-term sustainability and addresses the operational deficit common to such facilities.

4. Legal and Environmental Regulations:
   The intricate legal and environmental permitting process, particularly regarding nitrogen emissions regulations, poses a considerable challenge. This process, which includes zoning approvals and environmental impact assessments, may be protracted by legal challenges and objections that can lead to lengthy delays.

5. Integration with the Brainport Mobility Plan:
   Ensuring that P&R facilities are effectively integrated into the broader regional mobility framework is crucial. This integration necessitates timely and coordinated development of transport services and infrastructure, along with incentives and policies, to make P&R an attractive alternative to driving directly to the destination.

Future prospects

The development of P&R facilities in the Brainport region is anticipated to progress cautiously, focusing on overcoming the primary challenges of stakeholder alignment, governance and legal compliance. Even when the location selection procedures are finalized now, the process from planning to execution spans several years. This timeline may extend further if the project is faced with legal appeals or objections, which take at least a year. Plans for temporary P&Rs have encountered the same zoning and environmental constraints, especially when considering expansive ground-level parking areas.

The region's commitment to a broader mobility strategy and the integration of P&R facilities into this framework underpins the effort to push forward. However, the realization of these hubs by 2030 seems ambitious. A more conservative yet realistic goal may involve the activation of two primary hubs, which could then set a precedent for the subsequent development of additional facilities.

Conclusions and implications

In conclusion, the challenges encountered in the implementation of P&R facilities in the Brainport region are deeply rooted in the need for strategic coordination among a diverse set of stakeholders, a clear governance and financial framework, and the ability to navigate complex regulatory environments, all while ensuring alignment with the region's overarching mobility goals. Overcoming these multifaceted challenges will be key to realizing the vision of an efficient and sustainable mobility system within the region by 2030. With the current trajectory, focusing on the successful completion of two primary hubs appears more feasible, potentially serving as a blueprint for the eventual completion of the additional hubs.

The findings imply a need for a more centralized governance model to streamline decision-making and resource allocation. There's a call for innovative financial models that address the operational deficit of P&R facilities post-construction. Legal and environmental regulatory frameworks may require reforms to facilitate infrastructure development without compromising environmental standards. Additionally, the integration of P&R hubs with the overall mobility strategy underscores the importance of incentives and policies that promote sustainable commuter behavior.

7.2 LIMITATIONS AND REFLECTIONS

The findings of this study should be interpreted with an awareness of limitations. An inherent limitation stems from its reliance on data from stated preference experiments. It remains uncertain whether the decisions made in the experiment reflect people's actual mode choices. Nonetheless, these experiments are considered invaluable for evaluating the potential impacts of policies not yet implemented since there is no real-life data on which to base the choice models.

The used data for this research was assumed to be representative of all ASML employees, however there are indications, as pointed out by Molin & Kroesen (2023b), that car drivers might be underrepresented and cyclists overrepresented in the sample, which could lead to a slight overestimation of the car usage rates in different scenarios. This potential discrepancy suggests that interpreting the mode share outcomes of various policies should be approached with caution. The focus should instead be on the relative effects of the policies, since this provides a broader and more reliable understanding of how different mobility policies might influence commuting choices without excessive emphasis on the specific mode shares derived from this experiment's data.

Moreover, not all alternatives were available to each respondent since the choice set was determined by the respondents' conditions. For example, employees living further than 15 km from ASML were not presented with the option of commuting by bike as this share was considered to be negligible, however survey results indicated a higher percentage than expected. This suggests that the actual inclination towards cycling is understated in the study's outcomes. If a considerable number of long-distance commuters are indeed willing to cycle, incorporating this option into the choice sets could shift the mode shares and potentially alter the perceived effectiveness of policies aimed at promoting sustainable transport modes.

The relatively low effect of service attributes and the mandatory parking reservation system may stem from the experiment design, as pointed out by Molin & Kroesen (2023b). It is possible that the survey participants paid more attention to immediate and measurable factors, such as travel expenses and time, as they were presented more prominently. They might have overlooked the less tangible but equally important factors, such as the quality of service and reservation requirements.

This could have led to an underestimation of the actual impact these service attributes have on commuting decisions, as they could play a more significant role in real-life situations where employees experience them directly.

Furthermore, the final estimated ML models accounted for the variability in employee preferences towards alternatives by including shared random components, known as nests. This resulted in high random component sigma values, suggesting a high level of dispersion within these nests. However, additional models with error components for individual alternatives confirmed a pronounced preference regarding specific alternatives. Although combined models, which accounted for both the shared and the individual preference distribution, showed the significance of the established nests, it became clear that the nesting effect was overestimated to varying extents over the models. While these findings were insightful, they were not incorporated into the final ML model to avoid overly complex and unstable models from an excess of random variables.

In reflecting on the configuration of nests within choice models, it is clear that the way in which transport alternatives are grouped based on shared characteristics has significant implications for the distribution of choice probabilities. This study attempted to encapsulate the most significant commonalities within the fewest possible nests while ensuring statistical significance and model fit. There are numerous possibilities of significant nest compositions imaginable, therefore the decision on how to cluster the alternatives is pivotal. For instance, carpooling was included in the same shared nest as public transport modes. Admittedly, carpooling possesses distinct attributes that set it apart from other forms of public transport, such as the level of familiarity, social interaction and flexibility in terms of route and timing. Nevertheless, its categorization into the shared nest was a strategic choice, rationalized by the need to distinguish between the singular experience of private car usage and the communal aspect of car travel. This decision was empirically justified, as the resulting nest demonstrated enhanced model fit and robust statistical indicators in terms of improved t-statistics and sigma values.

This research concentrated on the aspects of enhancing accessibility, adopting a unilateral approach that inevitably restricts its scope regarding other essential dimensions of mobility. Notably, there is a limited focus on environmental advantages that might result from shifting commuting patterns. For instance, while P&R facilities might reduce individual car usage and traffic congestion in and around cities, they do not offer the same level of environmental benefits as more sustainable transport modes such as bicycles or trains. This is because P&R still involves car travel to the parking site, which may not significantly reduce the total vehicle kilometers traveled or the environmental footprint. Therefore, some crucial elements of mobility in determining policies might have been disregarded when determining the most effective strategies.

In the evaluation of the P&R implementation process within the Brainport region, this study focused mostly on the input and viewpoints of primary organizational stakeholders. The research provided a detailed analysis of the macro-level strategies and policies shaping the development of P&R facilities throughout the region. However, it is important to note that the study may not fully capture the localized issues that can impact the establishment of each hub or the unique challenges faced by individual sites. By engaging with a local hub manager, the study aimed to shed light on local procedures and obstacles at a single location, providing insight into the operational dynamics and challenges of P&R realizations. While this offers valuable context, it is recognized that this single perspective may not capture the spectrum of challenges across all planned hubs in the region, potentially disregarding difficulties in the P&R implementation process. Additionally, the study did not explore the perspectives of various businesses and local communities individually, as the primary aim was to analyze the complexity of the broader implementation process rather than isolated local challenges.

This study's exploration of the P&R implementation in the Brainport region primarily concentrated on the identification of stakeholders and challenges rather than an in-depth examination of the decision-making process itself or its management. It did not extensively compare the Brainport experience with similar cases elsewhere, nor did it venture into detailed scenario planning or forecasting. Consequently, while the study sheds light on the immediate strategic and policy implications, it does not provide a detailed analysis of the decision-making mechanics or compare alternate methodologies that could offer additional insights into process efficiency or the potential variability in outcomes across different regions and contexts.

7.3 RECOMMENDATIONS FOR FURTHER RESEARCH

In future research, a cost-benefit analysis could be conducted to weigh the economic costs of proposed mobility measures against their potential benefits. This analysis would provide a comprehensive view of the financial and societal impacts. It should consider the direct and indirect costs, such as infrastructure investment and operational expenses, as well as the benefits, including environmental, health, and congestion-related improvements.

Further studies could include environmental impact assessments, comparing the ecological footprint of the various policy measures. Additionally, research could explore a variety of other relevant factors, such as the social implications of mobility changes, economic impacts on local communities, and the potential for these infrastructure projects to shape regional development in the longer term. This would provide a more balanced view of the trade-offs in pursuing different transportation strategies and contribute to a more nuanced debate on sustainable mobility planning.

Regarding the implementation process of regional hubs, studies could map out the decision-making process in more detail, including perspectives from a wider array of smaller local stakeholders. This could include in-depth case studies on stakeholder engagement strategies to identify strategies for aligning diverse interests and facilitating consensus in these projects. The process can be analyzed thoroughly using project and process management theories to address the weaknesses within the decision-making process.

Lastly, future research could focus on governance or financial models that can effectively manage the P&R projects in Brainport since this has been identified as a major obstacle. Such investigation should encompass scenario analysis to predict the consequences of specific policy interventions. Additionally, comparative studies on different regions could offer valuable insights into how a clear governance and financial framework can be realized in Brainport. Understanding how to construct a clear governance and financing structure is crucial for the success of such initiatives in Brainport and can serve as a blueprint for similar projects.

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APPENDICES

APPENDIX A. EXPLANATIONS OF EXPERIMENTS

In this appendix the explanations of the experiments are presented. These include examples of choice sets for each experiment as they were provided to the ASML employees. These explanations originate from the official report from Molin & Kroesen (2023a).

A.1 EXPLANATION OF EXPERIMENT 1

The experiment is all about making hypothetical commute choices when you have different options to choose from. In this hypothetical scenario, the starting point for your choice is that you must travel to campus on the busiest days of the week, Tuesday and Thursday.

In the tables, you are presented with different commute options for how to commute to campus. All of the choices have their pros and cons listed, time-wise and cost-wise. Choose the commute option you like best when you compare the options with each other. The commute options presented are generic and don't apply to your specific travel needs, so you have to imagine all presented options are a real possibility for you.

Note: keep in mind these are hypothetical commute options, and they might differ from policies and rewards that are now in place within ASML.

Assuming conditions on the busiest weekdays, please indicate which travel option you would likely choose most regularly:

	Bus	Car	Carpool	Own bike
Travel time	free-flow	free-flow	free-flow	Normal bicycle time
+	+	+	+	
Pick-up time	0 min	0 min	0 min	
Delay due to congestion	20 min	20 min	20 min	
Parking time	0 min	10 min	0 min	
Booking parking spot		required: 1 week ahead	not required	
Daily reward (+) / parking costs (-)	+ € 3.00	- € 3.00	+ € 3.00 pp	+ € 3.00
Travel allowance per km, max. 20 km		20 ct	40 ct pp	20 ct

Figure 19: Choice set as provided to respondents in experiment 1 (Molin & Kroesen, 2023a)

In the table, we use various terms:

- Free flow travel time: This is the travel time from your house to ASML without any delays. Note that buses may use emergency lanes or free bus lanes to pass traffic jams.
- Carpool: You travel with one or more colleagues. For this experiment, we calculate an extra travel time of 0, 5 or 10 minutes for pick- up. Free parking spaces are reserved for carpooling next to building 7.

- Booking parking spot: This is a hypothetical policy where you need to make a reservation for a parking spot (when not carpooling).
- Reward / parking costs car: This is a hypothetical policy where you have to pay for parking at ASML or receive a reward if you travel to ASML by another means of transport. The amounts listed in the table are per day.
- Travel allowance: A reimbursement you receive for the travel costs per kilometer, up to a maximum of 20 kilometers. Note that ASML always fully reimburses public transport costs.
- Fuel reduction. Keep in mind that if you travel by a means of transport other than by car, you will save fuel (electricity) and therefore save costs.
- ASML's bicycle plan: As part of ASML's bicycle plan, once every three years you can purchase a (e-)bike up to €2,000 using your gross salary.

A.2 EXPLANATION OF EXPERIMENT 2

The experiment is all about making hypothetical commute choices when you have different options to choose from. In this hypothetical scenario, the starting point for your choice is that you must travel to campus on the busiest days of the week, Tuesday and Thursday.

In the tables, you are presented with different commute options for how to commute to campus. All of the choices have their pros and cons listed, time-wise and cost-wise. Choose the commute option you like best when you compare the options with each other. The commute options presented are generic and don't apply to your specific travel needs, so you have to imagine all presented options are a real possibility for you.

Note: keep in mind these are hypothetical commute options, and they might differ from policies and rewards that are now in place within ASML.

Assuming conditions on the busiest weekdays, please indicate which travel option you would likely choose most regularly:

	By car to P+R, then transfer P+R facilities: office and meeting facilities P+R to ASML: 9 km		Continue by car to ASML		By bike from home to ASML
	e-bike	shuttle bus 50p	car	carpool	own bike
Travel time from P+R to ASML	23 min	9 min	9 min	9 min	normal bicycle time
+	+	+	+	+	
Transfer / pick-up time		10 min		0 min	
Delay due to congestion		0 min	40 min	40 min	
Parking time at ASML			10 min	0 min	
Total travel time from P+R to ASML	**23 min**	**19 min**	**59 min**	**49 min**	normal bicycle time
Booking parking spot			not required	not required	
Daily reward (+) / parking costs (-)	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00
Travel allowance per km, max. 20 km			20 ct	20 ct pp	20 ct

P+R & e-bike | P+R & shuttle | Car | Carpool | Own bike

Figure 20: Choice set as provided to respondents in experiment 2 (Molin & Kroesen, 2023a)

In the table, we use various terms:

- Park + Ride (P+R): You travel with your car to a Park + Ride (P+R) location, located along your route. You then transfer to either a shuttle bus or an e-bike. Note that ASML pays for all P+R-related costs, i.e., parking, e-bike and shuttle bus use.
- P+R facilities: In addition to parking, the P+R location may offer office and meeting rooms, where you can work and meet other people, and/or full-service facilities, including pick-up and delivery service, car wash and maintenance, and grocery shops.
- Travel time from P+R to ASML: This is the travel time from the P+R location to ASML. Note that the shuttle may use emergency lanes or free bus lanes to pass traffic jams.
- Carpool: You travel with one or more colleagues. For this experiment, we calculate an extra travel time of 0, 5 or 10 minutes for pick-up. Free parking spaces are reserved for carpooling next to building 7.
- Booking parking spot: This is a hypothetical policy where you need to make a reservation for a parking spot (when not carpooling).
- Reward / parking costs car: This is a hypothetical policy where you have to pay for parking at ASML or receive a reward if you travel to ASML by another means of transport. The amounts listed in the table are per day.
- Travel allowance: A reimbursement you receive for the travel costs per kilometer, up to a maximum of 20 kilometers. Note that ASML always fully reimburses public transport costs.
- Fuel reduction. Keep in mind that if you travel by a means of transport other than by car, you will save fuel (electricity) and therefore save costs.
- ASML bicycle plan: As part of ASML's bicycle plan, once every three years you can purchase a (e-)bike up to €2,000 using your gross salary.

A.3 EXPLANATION OF EXPERIMENT 3

The experiment is all about making hypothetical commute choices when you have different options to choose from. In this hypothetical scenario, the starting point for your choice is that you must travel to campus on the busiest days of the week, Tuesday and Thursday.

In the tables, you are presented with different commute options for how to commute to campus. All of the choices have their pros and cons listed, time-wise and cost-wise. Choose the commute option you like best when you compare the options with each other. The commute options presented are generic and don't apply to your specific travel needs, so you have to imagine all presented options are a real possibility for you.

Note: keep in mind these are hypothetical commute options, and they might differ from policies and rewards that are now in place within ASML.

Assuming conditions on the busiest weekdays, please indicate which travel option you would likely choose most regularly:

	By train to station, then transfer business card type: second class (option first class) train station to ASML: 7.3 km		By car to P+R, then transfer P+R facilities: office and meeting facilities P+R to ASML: 13 km		By car to ASML	
	e-bike	shuttle bus 8p	e-bike	shuttle bus 8p	car	carpool
Travel time from station/P+R to ASML	20 min	18 min	34 min	13 min	13 min	13 min
+	+	+	+	+	+	+
Transfer / pick-up time		10 min		15 min		5 min
Delay due to congestion				0 min	0 min	0 min
Parking time at ASML					10 min	0 min
Total travel time from station/P+R to ASML	**20 min**	**28 min**	**34 min**	**28 min**	**23 min**	**18 min**
Booking parking spot					not required	not required
Daily reward (+) / parking costs (-)	+ € 3.00	+ € 3.00	+ € 3.00	+ € 3.00	- € 3.00	+ € 3.00 pp
Travel allowance per km, max 20 km					10 ct	20 ct pp

Train & e-bike | Train & shuttle | P+R & e-bike | P+R & shuttle | Car | Carpool

Figure 21: Choice set as provided to respondents in experiment 3 (Molin & Kroesen, 2023a)

In the table, we use various terms:

- Train: You travel by train to Eindhoven Central station, where you transfer to either e-bike or shuttle bus (both free of cost). ASML will provide you with a second class NS travel card, a second-class NS travel card with the option to upgrade it to a first class travel card (at your own expense), or a first class NS travel card.
- Park + Ride (P+R): You travel with your car to a Park + Ride (P+R) location, located along your route. You then transfer to either a shuttle bus or an e-bike. Note that ASML pays for all P+R-related costs, i.e., parking, e-bike and shuttle bus use.
- P+R facilities: In addition to parking, the P+R location may offer office and meeting rooms, where you can work and meet other people, and/or full-service facilities, including pick-up and delivery service, car wash and maintenance, and grocery shops.
- Travel time from station/P+R to ASML: This is the travel time from the station / P+R location to ASML. Note that the shuttle may use emergency lanes or free bus lanes to pass traffic jams.
- Carpool: You travel with one or more colleagues. For this experiment, we calculate an extra travel time of 0, 5 or 10 minutes for pick-up. Free parking spaces are reserved for carpooling next to building 7.
- Booking parking spot: This is a hypothetical policy where you need to make a reservation for a parking spot (when not carpooling).
- Reward / parking costs car: This is a hypothetical policy where you have to pay for parking at ASML or receive a reward if you travel to ASML by another means of transport. The amounts listed in the table are per day.
- Travel allowance: A reimbursement you receive for the travel costs per kilometer, up to a maximum of 20 kilometers. Note that ASML always fully reimburses public transport costs.
- Fuel reduction. Keep in mind that if you travel by a means of transport other than by car, you will save fuel (electricity) and therefore save costs.

A.4 EXPLANATION OF EXPERIMENT 4+5

Experiment 4 (P+R at 9 kilometer) and Experiment 5 (P+R at 13 kilometer)

The experiment is all about making hypothetical commute choices when you have different options to choose from. In this hypothetical scenario, the starting point for your choice is that you must travel to campus on the busiest days of the week, Tuesday and Thursday.

In the tables, you are presented with different commute options for how to commute to campus. All of the choices have their pros and cons listed, time-wise and cost-wise. Choose the commute option you like best when you compare the options with each other. The commute options presented are generic and don't apply to your specific travel needs, so you have to imagine all presented options are a real possibility for you.

Note: keep in mind these are hypothetical commute options, and they might differ from policies and rewards that are now in place within ASML.

Assuming conditions on the busiest weekdays, please indicate which travel option you would likely choose most regularly:

	By car to P+R, then transfer P+R facilities: office and meeting facilities P+R to ASML: 9 km		Continue by car to ASML	
	e-bike	shuttle bus 8p	car	carpool
Travel time from P+R to ASML	23 min	9 min	9 min	9 min
+	+	+	+	+
Transfer / pick-up time		15 min		5 min
Delay due to congestion		0 min	0 min	0 min
Parking time at ASML			10 min	0 min
Total travel time from P+R to ASML	**23 min**	**24 min**	**19 min**	**14 min**
Booking parking spot			not required	not required
Daily reward (+) / parking costs (-)	+ € 3.00	+ € 3.00	- € 3.00	+ € 3.00 pp
Travel allowance per km, max. 20 km			10 ct	20 ct pp

P+R & e-bike | P+R & shuttle | Car | Carpool

Figure 22: Choice set as provided to respondents in experiment 4 (P&R at 9 km) and experiment 5 (P&R at 13 km) (Molin & Kroesen, 2023a)

In the table, we use various terms:

- Park + Ride (P+R): You travel with your car to a Park + Ride (P+R) location, located along your route. You then transfer to either a shuttle bus or an e-bike. Note that ASML pays for all P+R-related costs, i.e., parking, e-bike and shuttle bus use.
- P+R facilities: In addition to parking, the P+R location may offer office and meeting rooms, where you can work and meet other people, and/or full-service facilities, including pick-up and delivery service, car wash and maintenance, and grocery shops.
- Travel time from P+R to ASML: This is the travel time from the P+R location to ASML. Note that the shuttle may use emergency lanes or free bus lanes to pass traffic jams.
- Carpool: You travel with one or more colleagues. For this experiment, we calculate an extra travel time of 0, 5 or 10 minutes for pick-up. Free parking spaces are reserved for carpooling next to building 7.
- Booking parking spot: This is a hypothetical policy where you need to make a reservation for a parking spot (when not carpooling).

- Reward / parking costs car: This is a hypothetical policy where you have to pay for parking at ASML or receive a reward if you travel to ASML by another means of transport. The amounts listed in the table are per day.
- Travel allowance: A reimbursement you receive for the travel costs per kilometer, up to a maximum of 20 kilometers. Note that ASML always fully reimburses public transport costs.
- Fuel reduction. Keep in mind that if you travel by a means of transport other than by car, you will save fuel (electricity) and therefore save costs.

APPENDIX B. MODEL SPECIFICATION

In this appendix the alternative's utility functions within the various experiments are presented. Appendix B.1 shows the utility functions used in the MNL model, Appendix B.2 reveals the utility functions for the ML model.

B.1 UTILITY FUNCTIONS MNL MODELS

For the MNL model the utility functions of the various alternatives are comparable in experiments 1 to 3, only the available alternatives and parameter values may vary over the experiments. Therefore, the functions for these experiments are combined (. The utility functions for the merged experiment 4+5 is slightly different due to the inclusion of an additional constant, these are presented separately.

Experiment 1 – Experiment 3

$$U_{car,z} = C_{car,z} + cardelay \cdot \beta_{cardelay,z} + week1 \cdot \beta_{week1,z} + hour24 \cdot \beta_{hour24,z} + costdiff \cdot \beta_{costdiff,z} + carallow \cdot \beta_{carallow,z} + \varepsilon \tag{B.1}$$

$$U_{bus,z} = C_{bus,z} + busdelay \cdot \beta_{busdelay,z} + \varepsilon \tag{B.2}$$

$$U_{carpool,z} = C_{carpool,z} + Cardelay \cdot \beta_{cardelay,z} + carallow \cdot \beta_{carallow,z} + allowadd \cdot \beta_{allowadd,z} + pickup \cdot \beta_{pickup,z} + \varepsilon \tag{B.3}$$

$$\mathrm{U_{bike,z} = C_{bike,z} - carallow \cdot \beta_{carallow,z} + \varepsilon} \tag{B.4}$$

$$U_{PRbike,z} = C_{PRbike,z} + PRmeeting \cdot \beta_{PRmeeting,z} + PRservice \cdot \beta_{PRservice,z} + \varepsilon \tag{B.5}$$

$$U_{PRshuttle,z} = C_{PRshuttle,z} + PRmeeting \cdot \beta_{PRmeeting,z} + PRservice \cdot \beta_{PRservice,z} + PRbuswait \cdot \beta_{PRbuswait,z} + PRbusdelay \cdot \beta_{PRbusdelay,z} + PR\_s20p \cdot \beta_{PR\_s20p,z} + PR\_s50p \cdot \beta_{PR\_s50p,z} + \varepsilon \tag{B.6}$$

$$U_{TRbike,z} = C_{TRbike,z} + TR\_opt1 \cdot \beta_{TR_{opt1},z} + TR\_first \cdot \beta_{PRservice,z} + \varepsilon \tag{B.7}$$

$$U_{TRshuttle,z} = C_{TRshuttle,z} + TR\_opt1 \cdot \beta_{TRopt1,z} + TR\_first \cdot \beta_{TR\_first,z} + TRbuswait \cdot \beta_{TRbuswait,z} + TRs20p \cdot \beta_{TRs20p,z} + TRs50p \cdot \beta_{TRs50p,z} + \varepsilon \tag{B.8}$$

Experiment 4/5

$$U_{car} = C_{car,} + cardelay \cdot \beta_{cardelay} + week1 \cdot \beta_{week1} + hour24 \cdot \beta_{hour24} + costdiff \cdot \beta_{costdiff} + carallow \cdot \beta_{carallow} + \varepsilon \tag{B.9}$$

$$U_{carpool} = C_{carpool} + cardelay \cdot \beta_{cardelay} + carallow \cdot \beta_{carallow} + allowadd \cdot \beta_{allowadd} + pickup \cdot \beta_{pickup} + \varepsilon \tag{B.10}$$

$$U_{PRbike,} = C_{PRbike} + DistancePR \cdot C_{PR\_b13km} + PRmeeting \cdot \beta_{PRmeeting} + PRservice \cdot \beta_{PRservice} + \varepsilon \tag{B.11}$$

$$U_{PRshuttle} = ASC_{PRshuttle} + DistancePR \cdot C_{PR_{s13km}} + PRmeeting \cdot \beta_{PRmeeting} + PRservice \cdot \beta_{PRservice} + PRbuswait \cdot \beta_{PRbuswait} + PRbusdelay \cdot \beta_{PRbusdelay} + PR\_s20p \cdot \beta_{PR\_s20p} + PR\_s50p \cdot \beta_{PR\_s50p} + \varepsilon \tag{B.12}$$

B.2 UTILITY FUNCTIONS ML MODEL

Experiment 1

$$U_{car} = C_{car} + cardelay \cdot \beta_{cardelay} + week1 \cdot \beta_{week1} + hour24 \cdot \beta_{hour24} + costdiff \cdot \beta_{costdiff} + carallow \cdot \beta_{carallow} + \upsilon_{cars} + \varepsilon \tag{B.13}$$

$$U_{bus} = C_{bus} + busdelay \cdot \beta_{busdelay} + \upsilon_{shared} + \varepsilon \tag{B.14}$$

$$U_{carpool} = C_{carpool} + cardelay \cdot \beta_{cardelay} + carallow \cdot \beta_{carallow} + allowadd \cdot \beta_{allowadd} + pickup \cdot \beta_{pickup} + \upsilon_{cars} + \upsilon_{shared} + \varepsilon \tag{B.15}$$

$$U_{bike} = C_{bike} - carallow \cdot \beta_{carallow} + \varepsilon \tag{B.16}$$

Experiment 2

$$U_{car} = C_{car} + cardelay \cdot \beta_{cardelay} + week1 \cdot \beta_{week1} + hour24 \cdot \beta_{hour24} + costdiff \cdot \beta_{costdiff} + carallow \cdot \beta_{carallow} + \upsilon_{cars} + \varepsilon \tag{B.17}$$

$$U_{carpool} = C_{carpool} + cardelay \cdot \beta_{cardelay} + carallow \cdot \beta_{carallow} + allowadd \cdot \beta_{allowadd} + pickup \cdot \beta_{pickup} + \upsilon_{cars} + \upsilon_{shared} + \varepsilon \tag{B.18}$$

$$U_{PRbike} = C_{PRbike} + PRmeeting \cdot \beta_{PRmeeting} + PRservice \cdot \beta_{PRservice} + \upsilon_{cars} + \upsilon_{multi} + \upsilon_{bike} + \varepsilon \tag{B.19}$$

$$U_{PRshuttle} = C_{PRshuttle} + PRmeeting \cdot \beta_{PRmeeting} + PRservice \cdot \beta_{PRservice} + PRbuswait \cdot \beta_{PRbuswait} + PRbusdelay \cdot \beta_{PRbusdelay} + PR\_s20p \cdot \beta_{PR_{s20p}} + PR\_s50p \cdot \beta_{PR\_s50p} + \upsilon_{cars} + \upsilon_{multi} + \upsilon_{shared} + \varepsilon \tag{B.20}$$

$$U_{bike} = C_{bike} - carallow \cdot \beta_{carallow} + \upsilon_{bike} + \varepsilon \tag{B.21}$$

Experiment 3

$$U_{car} = C_{car} + cardelay \cdot \beta_{cardelay} + week1 \cdot \beta_{week1} + hour24 \cdot \beta_{hour24} + costdiff \cdot \beta_{costdiff} + carallow \cdot \beta_{carallow} + \upsilon_{cars} + \varepsilon \tag{B.22}$$

$$U_{carpool} = C_{carpool} + cardelay \cdot \beta_{cardelay} + carallow \cdot \beta_{carallow} + allowadd \cdot \beta_{allowadd} + pickup \cdot \beta_{pickup} + \upsilon_{cars} + \upsilon_{shared} + \varepsilon \tag{B.23}$$

$$U_{PRbike} = C_{PRbike} + PRmeeting \cdot \beta_{PRmeeting} + PRservice \cdot \beta_{PRservice} + \upsilon_{cars} + \upsilon_{multi} + \upsilon_{bike} + \varepsilon \tag{B.24}$$

$$U_{PRshuttle} = C_{PRshuttle} + PRmeeting \cdot \beta_{PRmeeting} + PRservice \cdot \beta_{PRservice} + PRbuswait \cdot \beta_{PRbuswait} + PRbusdelay \cdot \beta_{PRbusdelay} + PR\_s20p \cdot \beta_{PR_{s20p}} + PR\_s50p \cdot \beta_{PR\_s50p} + \upsilon_{cars} + \upsilon_{multi} + \upsilon_{shared} + \varepsilon \tag{B.25}$$

$$U_{TRbike} = C_{TRbike} + TR\_opt1 \cdot \beta_{TRopt1} + TR\_first \cdot \beta_{TR\_first} + \upsilon_{shared} + \upsilon_{multi} + \upsilon_{bike} + \varepsilon \tag{B.25}$$

$$U_{TRshuttle} = C_{TRshuttle} + TR\_opt1 \cdot \beta_{TR_{opt1}} + TR\_first \cdot \beta_{TR_{first}} + TRbuswait \cdot \beta_{TRbuswait} + TR\_s20p \cdot \beta_{TR_{s20p}} + TR\_s50p \cdot \beta_{TR\_s50p} + \upsilon_{shared} + \upsilon_{multi} + \varepsilon \tag{B.26}$$

Experiment 4+5

$$U_{car} = C_{car} + cardelay \cdot \beta_{cardelay} + week1 \cdot \beta_{week1} + hour24 \cdot \beta_{hour24} + costdiff \cdot \beta_{costdiff} + carallow \cdot \beta_{carallow} + \upsilon_{cars} + \varepsilon \tag{B.27}$$

$$U_{carpool} = C_{carpool} + cardelay_{carpool} \cdot \beta_{cardelay} + carallow_{carpool} \cdot \beta_{carallow} + allowadd \cdot \beta_{allowadd} + pickup \cdot \beta_{pickup} + \upsilon_{cars} + \upsilon_{shared} + \varepsilon \tag{B.28}$$

$$U_{PRbike} = C_{PRbike} + DistandePR \cdot C_{PRb13km} + PRmeeting_{PRbike} \cdot \beta_{PRmeeting} + PRservice_{PRbike} \cdot \beta_{PRservice} + \upsilon_{cars} + \upsilon_{multi} + \upsilon_{bike} + \varepsilon \tag{B.29}$$

$$U_{PRshuttle} = C_{PRshuttle} + DistancePR \cdot C_{PRs13km} + PRmeeting_{PRshuttle} \cdot \beta_{PR\_meeting} + PRservice_{PRshuttle} \cdot \beta_{PR\_service} + PRbuswait \cdot \beta_{PR\_buswait} + PRbusdelay \cdot \beta_{PR\_busdelay} + PRs20p \cdot \beta_{PRs20p} + PRs50p \cdot \beta_{PRs50p} + \upsilon_{cars} + \upsilon_{multi} + \upsilon_{shared} + \varepsilon$$

(B.30)

B.3 UTILITY FUNCTIONS COMBINED ML MODELS WITH INDIVIDUAL AND SHARED RANDOM COMPONENTS

Experiment 1

$$U_{car} = C_{car} + cardelay \cdot \beta_{cardelay} + week1 \cdot \beta_{week1} + hour24 \cdot \beta_{hour24} + costdiff \cdot \beta_{costdiff} + carallow \cdot \beta_{carallow} + \upsilon_{car} + \upsilon_{cars} + \varepsilon$$

(B.31)

$$U_{bus} = C_{bus} + busdelay \cdot \beta_{busdelay} + \upsilon_{bus} + \upsilon_{shared} + \varepsilon$$

(B.32)

$$U_{carpool} = C_{carpool} + cardelay \cdot \beta_{cardelay} + carallow \cdot \beta_{carallow} + allowadd \cdot \beta_{allowadd} + pickup \cdot \beta_{pickup} + \upsilon_{carpool} + \upsilon_{cars} + \upsilon_{shared} + \varepsilon$$

(B.33)

$$U_{bike} = C_{bike} - carallow \cdot \beta_{carallow} + \varepsilon$$

(B.34)

Experiment 2

$$U_{car} = C_{car} + cardelay \cdot \beta_{cardelay} + week1 \cdot \beta_{week1} + hour24 \cdot \beta_{hour24} + costdiff \cdot \beta_{costdiff} + carallow \cdot \beta_{carallow} + \upsilon_{car} + \upsilon_{cars} + \varepsilon$$

(B.35)

$$U_{carpool} = C_{carpool} + cardelay \cdot \beta_{cardelay} + carallow \cdot \beta_{carallow} + allowadd \cdot \beta_{allowadd} + pickup \cdot \beta_{pickup} + \upsilon_{carpool} + \upsilon_{cars} + \upsilon_{shared} + \varepsilon$$

(B.36)

$$U_{PRbike} = C_{PRbike} + PRmeeting \cdot \beta_{PRmeeting} + PRservice \cdot \beta_{PRservice} + \upsilon_{PRbike} + \upsilon_{cars} + \upsilon_{multi} + \upsilon_{bike} + \varepsilon$$

(B.37)

$$U_{PRshuttle} = C_{PRshuttle} + PRmeeting \cdot \beta_{PRmeeting} + PRservice \cdot \beta_{PRservice} + PRbuswait \cdot \beta_{PRbuswait} + PRbusdelay \cdot \beta_{PRbusdelay} + PR\_s20p \cdot \beta_{PR_{s20p}} + PR\_s50p \cdot \beta_{PR\_s50p} + \upsilon_{PRshuttle} + \upsilon_{cars} + \upsilon_{multi} + \upsilon_{shared} + \varepsilon$$

(B.38)

$$U_{bike} = C_{bike} - carallow \cdot \beta_{carallow} + \upsilon_{bike(individual\ RC)} + \upsilon_{bike(nest)} + \varepsilon$$

(B.39)

Experiment 3

$$U_{car} = C_{car} + cardelay \cdot \beta_{cardelay} + week1 \cdot \beta_{week1} + hour24 \cdot \beta_{hour24} + costdiff \cdot \beta_{costdiff} + carallow \cdot \beta_{carallow} + \upsilon_{car} + \upsilon_{cars} + \varepsilon \tag{B.40}$$

$$U_{carpool} = C_{carpool} + cardelay \cdot \beta_{cardelay} + carallow \cdot \beta_{carallow} + allowadd \cdot \beta_{allowadd} + pickup \cdot \beta_{pickup} + \upsilon_{carpool} + \upsilon_{cars} + \upsilon_{shared} + \varepsilon \tag{B.41}$$

$$U_{PRbike} = C_{PRbike} + PRmeeting \cdot \beta_{PRmeeting} + PRservice \cdot \beta_{PRservice} + \upsilon_{PRbike} + \upsilon_{cars} + \upsilon_{multi} + \upsilon_{bike} + \varepsilon \tag{B.42}$$

$$U_{PRshuttle} = C_{PRshuttle} + PRmeeting \cdot \beta_{PRmeeting} + PRservice \cdot \beta_{PRservice} + PRbuswait \cdot \beta_{PRbuswait} + PRbusdelay \cdot \beta_{PRbusdelay} + PR\_s20p \cdot \beta_{PR_{s20p}} + PR\_s50p \cdot \beta_{PR\_s50p} + \upsilon_{PRshuttle} + \upsilon_{cars} + \upsilon_{multi} + \upsilon_{shared} + \varepsilon \tag{B.43}$$

$$U_{TRbike} = C_{TRbike} + TR\_opt1 \cdot \beta_{TRopt1} + TR\_first \cdot \beta_{TR\_first} + \upsilon_{TRbike} + \upsilon_{shared} + \upsilon_{multi} + \upsilon_{bike} + \varepsilon \tag{B.44}$$

$$U_{TRshuttle} = C_{TRshuttle} + TR\_opt1 \cdot \beta_{TR_{opt1}} + TR\_first \cdot \beta_{TR_{first}} + TRbuswait \cdot \beta_{TRbuswait} + TR\_s20p \cdot \beta_{TR_{s20p}} + TR\_s50p \cdot \beta_{TR\_s50p} + \upsilon_{TRshuttle} + \upsilon_{shared} + \upsilon_{multi} + \varepsilon \tag{B.45}$$

Experiment 4+5

$$U_{car} = C_{car} + cardelay \cdot \beta_{cardelay} + week1 \cdot \beta_{week1} + hour24 \cdot \beta_{hour24} + costdiff \cdot \beta_{costdiff} + carallow \cdot \beta_{carallow} + \upsilon_{car} + \upsilon_{cars} + \varepsilon \tag{B.46}$$

$$U_{carpool} = C_{carpool} + cardelay_{carpool} \cdot \beta_{cardelay} + carallow_{carpool} \cdot \beta_{carallow} + allowadd \cdot \beta_{allowadd} + pickup \cdot \beta_{pickup} + \upsilon_{carpool} + \upsilon_{cars} + \upsilon_{shared} + \varepsilon \tag{B.47}$$

$$U_{PRbike} = C_{PRbike} + DistandePR \cdot C_{PRb13km} + PRmeeting_{PRbike} \cdot \beta_{PRmeeting} + PRservice_{PRbike} \cdot \beta_{PRservice} + \upsilon_{PRbike} + \upsilon_{cars} + \upsilon_{multi} + \upsilon_{bike} + \varepsilon \tag{B.48}$$

$$U_{PRshuttle} = C_{PRshuttle} + DistancePR \cdot C_{PRs13km} + PRmeeting_{PRshuttle} \cdot \beta_{PR\_meeting} + PRservice_{PRshuttle} \cdot \beta_{PR\_service} + PRbuswait \cdot \beta_{PR\_buswait} + PRbusdelay \cdot \beta_{PR\_busdelay} + PRs20p \cdot \beta_{PRs20p} + PRs50p \cdot \beta_{PRs50p} + \upsilon_{PRshuttle} + \upsilon_{cars} + \upsilon_{multi} + \upsilon_{shared} + \varepsilon \tag{B.49}$$

APPENDIX C ESTIMATION RESULTS

In this appendix the estimation results for each experiment are provided. In appendix C.1 the estimated parameters of the MNL models are presented, and appendix C.2 shows the parameters as estimated by the ML model. Subsequently, in appendix C.3 the estimated parameter results of the

ML model are compared to models in which error components are added to account for the heterogeneity with respect to individual alternatives.

C.1 MNL MODEL ESTIMATION RESULTS

Experiment 1

Table 20: Final MNL estimation results for experiment 1

	Estimate	Robust S.E.	Robust t-stat.	p-value
Constants C_x				
car	0.000	-	-	-
carpool	-2.075	0.127	-16.371	0.000
bike	1.335	0.070	19.080	0.000
bus	-0.757	0.079	-9.598	0.000
Taste parameters β_x				
cardelay	-0.011	0.001	-12.191	0.000
costdiff	-0.088	0.007	-12.875	0.000
allowcar	0.007	0.001	5.862	0.000
allowadd	0.030	0.004	7.373	0.000
pickup	-0.002	0.008	-0.263	0.396
week1	-0.086	0.026	-3.343	0.000
hour24	-0.042	0.025	-1.718	0.043
busdelay	-0.017	0.002	-10.394	0.000
Model statistics				
Null Log-Likelihood	-25057.27			
Final Log-Likelihood	-14566.46			
Rho-square	0.419			
# of parameters	11			

Experiment 2

Table 21: Final MNL estimation results for experiment 2

	Estimate	Robust S.E.	Robust t-stat.	p-value
Constants C_x				
car	0.000	-	-	-
carpool	-1.525	0.282	-5.403	0.000
PRshuttle	-1.010	0.317	-3.183	0.001
PRbike	-1.844	0.259	-7.126	0.000
bike	0.411	0.208	1.976	0.024
Taste parameters β_x				
cardelay	-0.014	0.003	-4.330	0.000

costdiff	-0.060	0.017	-3.490	0.000
carallow	0.006	0.004	1.674	0.047
allowadd	0.006	0.006	0.901	0.184
pickup	-0.040	0.015	-2.647	0.004
week1	-0.112	0.088	-1.270	0.102
hour24	-0.103	0.086	-1.193	0.116
PRbuswait	-0.056	0.018	-3.116	0.001
PRbusdelay	-0.042	0.012	-3.461	0.000
PRmeeting	-0.070	0.121	-0.575	0.283
PRservice	0.135	0.115	1.169	0.121
PR_s20p	0.201	0.219	0.914	0.180
PR_s50p	-0.096	0.176	-0.545	0.293
Model statistics				
Null Log-Likelihood	-2319.2			
Final Log-Likelihood	-1723.13			
Rho-square	0.268			
# of parameters	17			

Experiment 3

Table 22: Final MNL estimation results for experiment 3

	Estimate	Robust S.E.	Robust t-stat.	p-value
Constants C_x				
car	0.000	NA	NA	NA
carpool	-1.128	0.094	-12.057	0.000
PRshuttle	-1.055	0.135	-7.838	0.000
PRbike	-2.796	0.144	-19.460	0.000
TRshuttle	-0.326	0.100	-3.251	0.001
TRbike	-0.743	0.087	-8.508	0.000
Taste parameters β_x				
cardelay	-0.028	0.001	-19.000	0.000
costdiff	-0.085	0.008	-10.203	0.000
carallow	0.003	0.004	0.843	0.200
allowadd	0.010	0.003	4.044	0.000
pickup	-0.025	0.005	-4.666	0.000
week1	-0.102	0.035	-2.887	0.002
hour24	-0.141	0.038	-3.752	0.000
PRbuswait	-0.051	0.007	-7.316	0.000
PRbusdelay	-0.055	0.004	-12.319	0.000
TRbuswait	-0.054	0.005	-10.672	0.000
PRmeeting	-0.126	0.062	-2.038	0.021
PRservice	-0.063	0.064	-0.981	0.163

PR_s20p	0.008	0.079	0.098	0.461
PR_s50p	-0.026	0.080	-0.319	0.375
TR_s20p	-0.018	0.061	-0.289	0.386
TR_s50p	-0.063	0.037	-1.683	0.046
TR_opt1	0.046	0.060	0.766	0.222
TR_first	0.083	0.047	1.762	0.039
Model statistics				
Null Log-Likelihood	-18123.65			
Final Log-Likelihood	-15686.84			
Rho-square	0.135			
# of parameters	23			

Experiment 4+5

Table 23: Final MNL estimation results for experiment 4+5

	Estimate	Robust S.E.	Robus t-stat.	p-value
Constants C_x				
car	0.000		-	-
carpool	-1.486	0.074	-20.101	0.000
PRshuttle	-1.344	0.116	-11.567	0.000
PRbike	-2.082	0.118	-17.687	0.000
PRs_13km	0.125	0.111	1.125	0.130
PRb_13km	-0.459	0.116	-3.960	0.000
Taste parameters β_x				
cardelay	-0.042	0.002	-25.097	0.000
costdiff	-0.094	0.007	-14.032	0.000
carallow	0.008	0.003	2.603	0.005
allowadd	0.003	0.002	1.702	0.044
pickup	-0.036	0.004	-8.306	0.000
week1	-0.105	0.027	-3.836	0.000
hour24	-0.061	0.033	-1.847	0.032
PRbuswait	-0.058	0.005	-12.148	0.000
PRbusdelay	-0.064	0.003	-21.370	0.000
PRmeeting	0.012	0.035	0.358	0.360
PRservice	0.099	0.044	2.258	0.012
PR_s20p	0.038	0.053	0.709	0.239
PR_s50p	-0.061	0.051	-1.187	0.118
Model statistics				
Null Log-Likelihood	-16675.73			
Final Log-Likelihood	-13848.89			
Rho-square	0.170			

# of parameters	18

C.2 ML MODEL RESULTS

Experiment 1

Table 24: Final ML estimation results for experiment 1

	Estimate	Robust S.E.	Robust t-stat	p-value
Constants C_x				
car	0	-	-	-
carpool	-7.856	0.420	-18.694	0.000
bike	5.629	0.341	16.484	0.000
bus	-1.447	0.320	-4.527	0.000
Taste parameters β_x				
cardelay	-0.044	0.003	-13.407	0.000
costdiff	-0.308	0.022	-14.298	0.000
allowcar	0.028	0.004	6.582	0.000
allowadd	0.042	0.008	5.513	0.000
pickup	-0.011	0.010	-1.109	0.134
week1	-0.239	0.086	-2.786	0.003
hour24	-0.093	0.059	-1.581	0.057
busdelay	-0.044	0.004	-11.855	0.000
Sigma's σ_x				
cars	6.924	0.325	21.276	0.000
shared	5.494	0.246	22.378	0.000
Model statistics				
Null Log-Likelihood	-25057.27			
Final Log-Likelihood	-7093.63			
Rho-square	0.717			
# of parameters	13			

Experiment 2

Table 25: Final ML estimation results for experiment 2

	Estimate	Robust S.E.	Robust t-stat	p-value
Constants C_x				
car	0	-	-	-
carpool	-5.964	2.486	-2.399	0.008
PRshuttle	-6.231	2.480	-2.512	0.006

PRbike	-6.258	1.120	-5.586	0.000
bike	1.537	0.950	1.618	0.053
Taste parameters β_x				
cardelay	-0.065	0.012	-5.439	0.000
costdiff	-0.236	0.058	-4.084	0.000
carallow	0.047	0.018	2.657	0.004
allowadd	0.012	0.017	0.708	0.240
pickup	-0.108	0.037	-2.927	0.002
week1	-0.470	0.297	-1.583	0.057
hour24	-0.314	0.312	-1.007	0.157
PRbuswait	-0.182	0.040	-4.520	0.000
PRbusdelay	-0.115	0.025	-4.655	0.000
PRmeeting	0.122	0.317	0.385	0.350
PRservice	0.525	0.352	1.494	0.068
PR_s20p	0.406	0.455	0.892	0.186
PR_s50p	-0.401	0.526	-0.763	0.223
Sigma's σ_x				
cars	8.903	1.074	8.292	0.000
shared	4.820	1.770	2.722	0.003
multi	4.863	0.860	5.654	0.000
bike	3.794	0.903	4.204	0.000
Model statistics				
Null Log-Likelihood	-2319.2			
Final Log-Likelihood	-773.17			
Rho-square	0.667			
# of parameters	21			

Experiment 3

Table 26: Final ML estimation results for experiment 3

	Estimate	Robust S.E.	Robust t-stat.	p-value
Constants C_x				
car	0	-	-	-
carpool	-2.218	0.259	-8.578	0.000
PRshuttle	-1.994	0.355	-5.620	0.000
PRshuttle	-8.745	0.372	-23.528	0.000
TRshuttle	-0.323	0.339	-0.954	0.170
TRbike	-2.420	0.311	-7.777	0.000
Taste parameters β_x				
cardelay	-0.097	0.005	-19.007	0.000
costdiff	-0.279	0.024	-11.785	0.000

carallow	0.019	0.012	1.589	0.056
allowadd	0.027	0.007	3.713	0.000
pickup	-0.067	0.014	-4.963	0.000
week1	-0.325	0.114	-2.846	0.002
hour24	-0.361	0.127	-2.850	0.002
PRbuswait	-0.133	0.014	-9.301	0.000
PRbusdelay	-0.111	0.007	-16.395	0.000
TRbuswait	-0.171	0.013	-12.701	0.000
PRmeeting	-0.019	0.017	-1.107	0.134
PRservice	0.092	0.136	0.676	0.250
PR_s20p	-0.017	0.027	-0.652	0.257
PR_s50p	-0.262	0.201	-1.302	0.096
TR_s20p	-0.145	0.200	-0.724	0.235
TR_s50p	-0.194	0.041	-4.744	0.000
TR_opt1	0.087	0.047	1.855	0.032
TR_first	0.305	0.109	2.795	0.003
Sigma's σ_x				
cars	5.177	0.282	18.382	0.000
shared	3.836	0.191	20.101	0.000
multi	4.009	0.288	13.916	0.000
bike	5.615	0.256	21.955	0.000
Model statistics				
Null Log-Likelihood	-18123.65			
Final Log-Likelihood	-8268.13			
Rho-square	0.544			
# of parameters	27			

Experiment 4+5

Table 27: Final ML estimation results for experiment 4+5

	Estimate	Robust S.E.	Robust t-stat	p-value
Constants C_x				
car	0	-	-	-
carpool	-3.281	0.165	-19.839	0.000
PRshuttle	-5.029	0.291	-17.270	0.000
PRbike	-6.163	0.302	-20.410	0.000
PRs_13km	-0.096	0.125	-0.769	0.221
PRb_13km	-0.951	0.330	-2.882	0.002
Taste parameters β_x				
cardelay	-0.117	0.005	-24.464	0.000
costdiff	-0.214	0.016	-13.460	0.000

carallow	-0.001	0.001	-0.954	0.170
allowadd	-0.002	0.001	-2.207	0.014
pickup	-0.079	0.009	-8.896	0.000
week1	-0.027	0.014	-1.858	0.032
hour24	-0.041	0.027	-1.516	0.065
PRbuswait	-0.113	0.010	-11.268	0.000
PRbusdelay	-0.118	0.005	-24.220	0.000
PRmeeting	-0.277	0.095	-2.908	0.002
PRservice	-0.171	0.120	-1.426	0.077
PR_s20p	0.052	0.048	1.077	0.141
PR_s50p	-0.342	0.084	-4.046	0.000
Sigma's σ_x				
shared	3.569	0.131	27.179	0.000
multi	5.273	0.217	24.257	0.000
Model statistics				
Null Log-Likelihood	-2319.2			
Final Log-Likelihood	-8181.71			
Rho-square	0.509			
# of parameters	20			

C.3 CHI-SQUARE TABLE

Table 28: Chi-square table (MedCalc, n.d.)

	P										
DF	**0.995**	**0.975**	**0.20**	**0.10**	**0.05**	**0.025**	**0.02**	**0.01**	**0.005**	**0.002**	**0.001**
1	0.0000393	0.000982	1.642	2.706	3.841	5.024	5.412	6.635	7.879	9.550	10.828
2	0.0100	0.0506	3.219	4.605	5.991	7.378	7.824	9.210	10.597	12.429	13.816
3	0.0717	0.216	4.642	6.251	7.815	9.348	9.837	11.345	12.838	14.796	16.266
4	0.207	0.484	5.989	7.779	9.488	11.143	11.668	13.277	14.860	16.924	18.467
5	0.412	0.831	7.289	9.236	11.070	12.833	13.388	15.086	16.750	18.907	20.515
6	0.676	1.237	8.558	10.645	12.592	14.449	15.033	16.812	18.548	20.791	22.458
7	0.989	1.690	9.803	12.017	14.067	16.013	16.622	18.475	20.278	22.601	24.322
8	1.344	2.180	11.030	13.362	15.507	17.535	18.168	20.090	21.955	24.352	26.124
9	1.735	2.700	12.242	14.684	16.919	19.023	19.679	21.666	23.589	26.056	27.877
10	2.156	3.247	13.442	15.987	18.307	20.483	21.161	23.209	25.188	27.722	29.588
11	2.603	3.816	14.631	17.275	19.675	21.920	22.618	24.725	26.757	29.354	31.264
12	3.074	4.404	15.812	18.549	21.026	23.337	24.054	26.217	28.300	30.957	32.909
13	3.565	5.009	16.985	19.812	22.362	24.736	25.472	27.688	29.819	32.535	34.528
14	4.075	5.629	18.151	21.064	23.685	26.119	26.873	29.141	31.319	34.091	36.123
15	4.601	6.262	19.311	22.307	24.996	27.488	28.259	30.578	32.801	35.628	37.697
16	5.142	6.908	20.465	23.542	26.296	28.845	29.633	32.000	34.267	37.146	39.252
17	5.697	7.564	21.615	24.769	27.587	30.191	30.995	33.409	35.718	38.648	40.790
18	6.265	8.231	22.760	25.989	28.869	31.526	32.346	34.805	37.156	40.136	42.312
19	6.844	8.907	23.900	27.204	30.144	32.852	33.687	36.191	38.582	41.610	43.820
20	7.434	9.591	25.038	28.412	31.410	34.170	35.020	37.566	39.997	43.072	45.315

APPENDIX D POLICY EFFECTS

This appendix provides a comprehensive overview on the input and output of the defined scenarios. In Table 29 the attribute levels are presented as well as the predicted mode shares.

Table 29: Overview the attribute levels for the given scenarios with the estimated choice probabilities

Scenios:	0. Reference	1. monetary package	2. Service package	3.A Medium congestion	3.A High congestion	4.A Mid congestion + monetary package	4.B High congestion + monetary package	5.A Mid congestion + direct shuttle	5.B High congestion + direct shuttle
Attributes									
Daily reward	€ 0	**€ 3**	€ 0	€ 0	€ 0	**€ 3**	**€ 3**	€ 0	€ 0
Parking costs	€ 0	**€ 3**	€ 0	€ 0	€ 0	**€ 3**	**€ 3**	€ 0	€ 0
Allowance car	20 ct/km	**10 ct/km**	20 ct/km	20 ct/km	20 ct/km	**10 ct/km**	**10 ct/km**	20 ct/km	20 ct/km
Allowance bike	20 ct/km	**30 ct/km**	20 ct/km	20 ct/km	20 ct/km	**30 ct/km**	**30 ct/km**	20 ct/km	20 ct/km
Add allow carpool	0 ct/km	**20 ct/km**	0 ct/km	0 ct/km	0 ct/km	**20 ct/km**	**20 ct/km**	0 ct/km	0 ct/km
Parking booking	Not required	Not required	Not required	Not required	Not required	Not required	Not required	Not required	Not required
P&R:									
Service level	parking	parking	**Full-service**	parking	parking	parking	parking	parking	parking
Shuttle bus size	20 people	20 people	20 people	20 people	20 people	20 people	20 people	20 people	20 people
Waiting time shuttle	15 min	15 min	**5 min**	15 min	15 min	15 min	15 min	15 min	15 min
Delay shuttle (P&R)	10 min	10 min	10 min	**20 min**	**40 min**	**20 min**	**40 min**	**0 min**	**0 min**
Train:									
Business card type	2nd class	2nd class	**1st class**	2nd class	2nd class	2nd class	2nd class	2nd class	2nd class
Shuttle bus size	20 people	20 people	20 person	20 people	20 people	20 people	20 people	20 people	20 people
Waiting time shuttle	15 min	15 min	**5 min**	15 min	15 min	15 min	15 min	15 min	15 min
External conditions									
Congestion delay car	10 min	10 min	10 min	**20 min**	**40 min**	**20 min**	**40 min**	**20 min**	**40 min**
Congestion delay bus	10 min	10 min	10 min	10 min	10 min	10 min	10 min	10 min	10 min
Pick-up time carpool	10 min	10 min	10 min	10 min	10 min	10 min	10 min	10 min	10 min
Mode shares for scenarios with given attribute levels									
MNL model									
Car	39.3%	28.5%	36.4%	36.7%	29.6%	25.0%	19.8%	34.2%	25.4%
Carpool	6.8%	10.3%	6.9%	6.4%	5.1%	9.0%	7.0%	5.9%	4.4%
PR + Shuttle	2.9%	4.0%	4.8%	2.1%	1.1%	5.0%	1.3%	6.5%	9.7%
PR + Bike	4.2%	6.2%	4.3%	6.0%	10.7%	8.1%	14.4%	5.4%	8.6%
Bike	33.6%	36.5%	33.2%	34.4%	35.8%	37.0%	38.1%	34.3%	35.6%
Train + Shuttle	4.1%	4.6%	6.1%	4.6%	5.9%	5.2%	6.5%	4.3%	5.3%
Train + Bike	6.2%	7.0%	5.4%	6.9%	8.8%	7.8%	9.8%	6.5%	8.0%
Bus	2.9%	2.9%	2.8%	2.9%	3.0%	2.9%	3.0%	2.9%	3.0%
ML Model									
Car	38.7%	28.3%	36.8%	35.8%	28.8%	25.2%	19.2%	34.4%	26.4%
Carpool	8.1%	11.8%	7.7%	7.7%	6.8%	10.2%	9.5%	6.0%	3.8%
PR + Shuttle	3.4%	4.1%	5.1%	3.0%	1.9%	5.6%	2.1%	7.4%	11.4%
PR + Bike	2.3%	4.3%	2.4%	4.5%	9.7%	6.0%	12.6%	3.7%	7.0%
Bike	33.5%	37.1%	33.6%	34.4%	35.7%	37.6%	38.6%	34.4%	35.7%
Train + Shuttle	3.7%	4.2%	5.8%	4.3%	5.5%	4.7%	6.1%	3.9%	4.7%
Train + Bike	7.5%	7.7%	6.2%	7.7%	8.8%	8.2%	9.2%	7.5%	8.3%
Bus	2.8%	2.4%	2.6%	2.7%	2.9%	2.5%	2.6%	2.7%	2.9%

In Table 30 - Table 32 the mode shares in the given scenarios are presented comprehensively for both models, these shares can easily be compared to the base scenario in terms of relative changes. Table 30 provides an overview of the scenarios without any increase in delay, including the monetary package and the service package.

Table 31 presents the scenarios with a moderate congestion, including a 20-minute delay without additional policy measures, a 20-minute delay with the employment of the monetary package and a 20-minute delay with the introduction of a direct P&R shuttle.

Table 32 shows the mode shares in scenarios with substantial congestion, including a 40-minute delay without additional policy interventions, 40 minutes delay in combination with the monetary package and 40 minutes delay with a direct P&R shuttle.

Table 30: Comparison of modal split for scenarios 1 and 2 relative to the reference scenario

	0. Base scenario	1. Monetary package		2. Service package	
	Base ML	ML	%Δ	ML	%Δ
Car	**38.5%**	28.3%	**-26.5%**	36.8%	**-4.4%**
Carpool	**8.0%**	11.8%	**47.6%**	7.4%	**-8.2%**
P&R + Shuttle	**3.5%**	4.1%	**17.6%**	5.1%	**46.5%**
P&R + bike	**2.8%**	4.3%	**54.3%**	2.4%	**-13.2%**
Bike	**33.6%**	37.1%	**10.1%**	33.6%	**-0.2%**
Train + shuttle	**3.7%**	4.2%	**14.3%**	5.8%	**58.2%**
Train + bike	**7.2%**	7.7%	**8.0%**	6.2%	**-13.4%**
Bus	**2.7%**	2.4%	**-9.0%**	2.6%	**-1.5%**
	Base MNL	MNL	%Δ	MNL	%Δ
Car	**39.5%**	28.5%	**-27.8%**	36.4%	**-7.9%**
Carpool	**6.9%**	10.3%	**48.3%**	6.9%	**0.3%**
P&R + Shuttle	**2.9%**	4.0%	**36.4%**	4.8%	**63.1%**
P&R + bike	**4.3%**	6.2%	**44.5%**	4.3%	**-0.9%**
Bike	**33.6%**	36.5%	**8.6%**	33.2%	**-1.0%**
Train + shuttle	**3.9%**	4.6%	**17.8%**	6.1%	**55.7%**
Train + bike	**5.9%**	7.0%	**17.8%**	5.4%	**-9.3%**
Bus	**2.9%**	2.9%	**0.9%**	2.8%	**-0.8%**

Table 31: Comparison of modal split for scenarios 3A, 4A and 5A relative to the reference scenario

	0. Base scenario	3A. 20 min delay		4A. 20 min delay + monetary		5A. 20 min + direct shuttle	
	Base ML	ML	%Δ	ML	%Δ	ML	%Δ
Car	**38.5%**	35.8%	**-7.2%**	25.7%	**-33.4%**	34.4%	**-10.8%**
Carpool	**8.0%**	7.7%	**-4.1%**	11.2%	**39.6%**	6.0%	**-24.6%**
P&R + Shuttle	**3.5%**	3.0%	**-15.3%**	3.4%	**-2.8%**	7.4%	**110.3%**
P&R + bike	**2.8%**	4.5%	**59.8%**	6.5%	**133.9%**	3.7%	**33.4%**
Bike	**33.6%**	34.4%	**2.2%**	37.6%	**11.8%**	34.4%	**2.1%**
Train + shuttle	**3.7%**	4.3%	**16.4%**	4.8%	**32.0%**	3.9%	**6.3%**

Train + bike	**7.2%**	7.7%	**8.0%**	8.3%	**15.7%**	7.5%	**4.7%**
Bus	**2.7%**	2.7%	**2.1%**	2.5%	**-7.1%**	2.7%	**2.1%**
	Base MNL	**MNL**	**%Δ**	**MNL**	**%Δ**	**MNL**	**%Δ**
Car	**39.5%**	36.7%	**-7.2%**	26.0%	**-34.1%**	34.2%	**-13.6%**
Carpool	**6.9%**	6.4%	**-7.7%**	9.3%	**34.3%**	5.9%	**-14.2%**
P&R + Shuttle	**2.9%**	2.1%	**-27.3%**	2.9%	**-2.3%**	6.5%	**119.8%**
P&R + bike	**4.3%**	6.0%	**38.5%**	8.5%	**97.3%**	5.4%	**25.9%**
Bike	**33.6%**	34.4%	**2.3%**	37.1%	**10.4%**	34.3%	**2.1%**
Train + shuttle	**3.9%**	4.6%	**16.9%**	5.3%	**35.0%**	4.3%	**9.8%**
Train + bike	**5.9%**	6.9%	**16.9%**	8.0%	**35.0%**	6.5%	**9.8%**
Bus	**2.9%**	2.9%	**2.1%**	2.9%	**2.3%**	2.9%	**2.1%**

Table 32: Comparison of modal split for scenarios 3B, 4B and 5B relative to the reference scenario

	0. Base scenario	3B. 40 min delay		4B. 40 min delay + monetary		5B. 40 min delay + direct shuttle	
	Base ML	**ML**	**%Δ**	**ML**	**%Δ**	**ML**	**%Δ**
Car	**38.5%**	28.8%	**-25.3%**	19.2%	**-50.0%**	26.4%	**-31.5%**
Carpool	**8.0%**	6.8%	**-14.8%**	9.5%	**19.1%**	3.8%	**-52.7%**
P&R + Shuttle	**3.5%**	1.9%	**-46.3%**	2.1%	**-41.4%**	11.4%	**224.1%**
P&R + bike	**2.8%**	9.7%	**247.0%**	12.6%	**352.2%**	7.0%	**150.8%**
Bike	**33.6%**	35.7%	**6.2%**	38.6%	**14.7%**	35.7%	**6.1%**
Train + shuttle	**3.7%**	5.5%	**49.9%**	6.1%	**67.0%**	4.7%	**26.7%**
Train + bike	**7.2%**	8.8%	**22.2%**	9.2%	**28.8%**	8.3%	**15.5%**
Bus	**2.7%**	2.9%	**6.0%**	2.6%	**-3.5%**	2.9%	**6.0%**
	Base MNL	**MNL**	**%Δ**	**MNL**	**%Δ**	**MNL**	**%Δ**
Car	**39.5%**	29.6%	**-25.0%**	19.8%	**-49.8%**	25.4%	**-35.7%**
Carpool	**6.9%**	5.1%	**-26.4%**	7.0%	**1.6%**	4.4%	**-36.9%**
P&R + Shuttle	**2.9%**	1.1%	**-64.2%**	1.3%	**-54.4%**	9.7%	**230.0%**
P&R + bike	**4.3%**	10.7%	**149.3%**	14.4%	**234.1%**	8.6%	**100.2%**
Bike	**33.6%**	35.8%	**6.5%**	38.1%	**13.5%**	35.6%	**6.1%**
Train + shuttle	**3.9%**	5.9%	**49.0%**	6.5%	**65.2%**	5.3%	**34.1%**
Train + bike	**5.9%**	8.8%	**49.0%**	9.8%	**65.2%**	8.0%	**34.1%**
Bus	**2.9%**	3.0%	**5.8%**	3.0%	**4.9%**	3.0%	**5.8%**

APPENDIX E SUMMARIES OF INTERVIEWS WITH INVOLVED ACTORS IN P&R IMPLEMENTATION PROCESS

This appendix provides the summaries of the conducted interviews with the involved stakeholders in the P&R implementation process.

APPENDIX E.1 SUMMARY OF INTERVIEW 1

Introduction to research: The interview begins with an introduction to the research, some background is provided on the thesis subject and its goals. It is explained that the implementation process of P&Rs in the Brainport region is the main focus of the interview.

Start of ASML's mobility approach:

Question: When did ASML begin addressing mobility and its measures?

Summary: ASML's approach to mobility started before the pandemic, driven by the recognition of the unsustainability of car usage among employees due to the company's growth. The former head of communication and later of community engagement, spearheaded the program, recognizing the need to address the infamous "ASML traffic jam.", in collaborations with various government levels to support and finance necessary changes. These efforts infrastructure improvements like the Kemperbaan exit and campaigns to encourage behavioral changes towards cycling and public transport use. They have also improved wayfinding and cycling infrastructure, and there are plans for a new bicycle tunnel under the ring of Eindhoven to enable conflict-free travel from the city center to ASML.

Cycling as a major focus:

Question: Is there a significant emphasis on cycling in the area?

Summary: With a substantial portion of ASML employees living within a 15 km radius of the workplace, cycling is heavily promoted as a viable option, supported by the increasing popularity of e-bikes. The company observed a surprising trend of employees willing to cycle much longer distances than anticipated, which led to a reevaluation of potential cycling outreach.

P&R as a key mobility solution:

Question: How is P&R currently viewed as part of mobility strategy?

Summary: The interviewee emphasizes that for supporting measures like P&R to be effective, they must be conveniently located on the commuters' route. If P&R is not on the way, it won't succeed. Additionally, to discourage parking on the campus, there should be a financial disincentive such as implementing paid parking. The strategy is to create a situation where it's less attractive to park at the workplace, thereby encouraging the use of P&R facilities.

ASML's Role in P&R Implementation:

Question: How is ASML involved in the P&R plans?

Summary: ASML has an advisory and directional role in P&R planning, suggesting potential locations and expressing willingness to co-finance. The company aims to significantly reduce car usage by 2030, relying on the creation of P&R hubs to achieve a balanced modal split.

Collaboration with Other Entities:

Question: Are other employers or parties involved in the process?

Summary: While there is interest from other employers, they are taking a passive stance, waiting for ASML to lead the initiative. Most companies do not cope with the same growth and accessibility challenges as ASML. On top of that the High-Tech campus is more accessible than the Run in Veldhoven.

Project advancements

Question: What has been realized so far?

Summary: Substantial research by Smartwayz and advisors has been conducted on the potential locations and sizes of P&R hubs, with a current inclination towards smaller hubs, but the interviewee is unaware of the current status of these. The latest developments include plans for allowing busses on emergency lanes, considered critical for the success of P&R facilities, as it would allow buses to bypass traffic jams, offering a tangible advantage over driving. This aligns with findings from research indicating that time and cost are the main factors influencing people's commuting choices.

Challenges in P&R development:

Question: Why does the P&R development process take so long?

Summary: The interviewee highlights several challenges, including bureaucratic hurdles, political dynamics, and environmental concerns, particularly regarding nitrogen emissions. These factors contribute to a slow and complex decision-making process, compounded by local resistance in some areas.

Prospects of P&R Projects:

Question: What is the current progress and future outlook for P&R development?

Summary: Plans for six P&R sites around Eindhoven are progressing slower than hoped, with doubts about achieving all targets by 2030. The interviewee is hopeful for at least two P&Rs but notes that if progress remains slow, ASML may need to consider alternative measures like additional parking facilities, as the current parking garages are at maximum capacity. The interviewee stresses the importance of supporting policies encouraging the motive to use P&Rs, at the moment using and parking cars is still too attractive in the center of Eindhoven.

Solutions and Moving Forward:

Question: What could expedite the building of P&Rs?

Summary: Finding a solution to speed up the P&R development is complex, with no clear answer at hand. The necessity of navigating local regulations and obtaining permits adds to the timeline. The interviewee mentions that a pilot project is planned to start at the end of the current year or early next year, which involves opening an office hub in Den Bosch. This initiative will allow employees commuting from Amsterdam to work in Den Bosch instead of traveling all the way to Veldhoven, thus reducing travel time and possibly easing traffic congestion.

APPENDIX E.2 SUMMARY OF INTERVIEW 2

Introduction to research: The interview begins with an introduction to the research, some background is provided on the thesis subject and its goals. It is explained that the implementation process of P&Rs in the Brainport region is the main focus of the interview.

Plans for P&Rs in the Region:

Question**:** Can you describe the regional plans for P&Rs?

Summary**:** The project manager explains the evolving transportation needs of the Brainport Eindhoven region, noting the expansion of employment areas away from the city center and the inadequacy of existing infrastructure to support the projected growth in housing and jobs. The region cannot continue expanding roads indefinitely and must find alternative mobility solutions. As a result, the concept of mobility hubs has been introduced. These hubs are essentially enhanced P&R facilities situated near major access roads into the region, designed to cater to commuters who rely on cars but aim to reduce traffic on congested routes like the A2 and N2. Currently, potential hub locations are being explored along the A2 North and South zones, A58, and A67 West, with future considerations for the A50 and additional sites along the A67. However, the project faces complexity due to its regional nature, involving multiple municipalities and the need for coordinated efforts across various independent projects. The development plan has been established in the end of 2020, the project manager joined roughly 6 months later

Relation to Brainport mobility plan

Question: How does this relate to the larger mobility project in Brainport?

Summary: While there is agreement at the policy level on the need for mobility transition, local apprehensions arise when specific projects are proposed. This reflects a broader challenge where theoretical consensus on mobility strategies confronts practical resistance at the local implementation stage.

Hub locations and selection:

Question**:** Are the hub locations decided yet?

Summary**:** In the process of planning for mobility hubs, a comprehensive approach is adopted, starting with identifying potential sites based on logical assumptions, traffic analysis, and spatial integration. This often results in the elimination of many potential locations, narrowing down to one or two viable options. In Best, two potential sites have been shortlisted for a hub, but a final decision is pending. The A2 South area's existing hub at Maarheze is set to be upgraded significantly. The A58 zone and A67 West are undergoing detailed studies to assess the feasibility and suitability of proposed sites, considering traffic flows and local road network capacity to handle increased vehicle volume. These studies ensure that a hub, if implemented, can be properly accessed, with adequate infrastructure for bus routes and turns, and without causing adverse local traffic impacts. This planning phase is critical for local government collaboration and involves in-depth research, taking into account not just the hub itself but also its integration with the surrounding transport network.

Working with municipalities and ownership issues:

Question**:** Are you in the middle of getting agreements with municipalities?

Summary**:** The project manager highlights a significant challenge in the hub development process: the lack of clarity on who will own the hubs once they are realized. Although local municipalities are willing to facilitate spatial procedures as authorized bodies, they do not intend to invest in or own these Park and Ride (P&R) facilities. The responsibility is expected to fall on the regional collaboration of 21 municipalities, which does not function like a single entity with assets like the VRA in Amsterdam (Vervoersregio Amsterdam) (VRA) or the Metropoolregio Rotterdam-Den Haag (MRDH). This lack of a clear governance structure poses a considerable challenge to advancing the project.

Involvement of Brainport Bereikbaar

Question: Does Brainport Bereikbaar play a role in these challenges?

Summary: The interviewee explains that Brainport Bereikbaar is a collaborative initiative without a legal entity, primarily focused on behavioral measures like cycling promotions and awareness campaigns. There are no substantial systemic changes or large investment projects within this group; such tasks are allocated elsewhere. The Metropole Region Eindhoven (MRE) is exploring ways to establish itself more robustly with greater powers and responsibilities, but progress is ongoing. Currently, obtaining support for projects like hubs would require approval from 21 municipal councils, a process that's impractically long. The project faces complex administrative challenges, particularly around governance issues like ownership and risk management. Each municipality hesitates to build without clear ownership and understanding of associated risks, creating a significant barrier to progress.

Role in the process

Question: What is your role in the process

Summary: The interviewee's role is the project leader for regional mobility hubs, which fall under the broader, complex organizational structure of the region. They work with Smartwayz, a collaboration across Brabant and Limburg, engaging in negotiations with the national government and managing funds for short-term mobility measures, including bike paths and minor road improvements. Each hub has a local project leader responsible for involving all relevant municipal and business parties to ensure a collaborative process and create a joint effort.

Involvement of Big Companies in the P&R Process:

Question: How involved are big companies in the process?

Summary: ASML is significantly involved in the regional development of mobility hubs due to the urgency created by their rapid growth and the need for transportation solutions. Other large companies like VDL and Philips raised concerns about infrastructure congestion before the pandemic, but only ASML continued to actively pursue alternatives during the crisis. They've explored temporary hubs but faced lengthy permitting processes and environmental (nitrogen) issues.

Financial participation of companies:

Question: How financially will the costs be shared with companies that will benefit from P&Rs?

Summary: The approach to involving businesses in the development of mobility hubs can vary by each hub. One method is co-development, where businesses and government share ownership, similar to a cooperative structure observed at Utrecht Science Park. Alternatively, businesses can commit to leasing parking spaces over a long term, contributing financially to the hub's operational costs. The overall investment strategy requires initial construction costs to be excluded to achieve a positive return over 30-40 years. This model has been observed internationally, such as in Antwerp, where the government funded the construction of P&Rs and the operational expenses are expected to be self-sustaining after an initial period. By removing annual depreciation from the operational costs, a small profit is feasible.

For over a year, there has been an impasse in decision-making at the regional level regarding who will take responsibility for the hubs. The project team is exploring innovative solutions to ensure the realization of the first hub, which could then serve as a model or learning opportunity for the development of subsequent Park and Rides.

Challenges for P&R realization in Brainport

Question: What are the reasons for the long and complex nature of realizing P&Rs in Brainport specifically? Does this differ from other regions?

Summary: The construction of P&Rs in the Brainport region of Eindhoven is a lengthy process for several reasons. While the initial research and narrowing down of potential sites is a standard procedure, it becomes more time-consuming when starting from a broader range of possible locations. Legal procedures for spatial planning are standardized in the Netherlands, so no significant time differences occur there. However, the issue of nitrogen emission regulations has halted all building permits in Brabant, presenting a unique challenge. A significant difference compared to cities like Den Bosch, Rotterdam, or Amsterdam is that those cities have their own parking companies to manage P&Rs, with clear governance and decision-making within their territories.

Current Progress of P&R Projects:

Question: Have any P&Rs been completed?

Summary: Only a temporary P&R has been set up in Eersel; the rest are still being planned or waiting for legal go-ahead. The current state of P&R initiatives in the Eindhoven region is in the early stages, involving research and spatial planning procedures. Local authorities have expressed a preference for constructing built-up, socially safe, and efficiently organized P&R facilities that assure parking availability and ease of access due to the region's limited space. The scarcity of space in Eindhoven means that accommodating 1000 to 1500 parking spots at ground level is impractical and considered irresponsible for permanent solutions, given the extensive area it would require.

Effective connecting transport services are essential for the success of P&R facilities. Without a proper link to public transportation and cycling routes, a P&R is deemed to fail. Plans for a dedicated HOV Brainport line and autonomous buses on segregated lanes are in the works but are not imminent. HOV plans, which involve constructing bus lanes through residential areas, are also subject to lengthy legal processes and potential delays from Council of State (RvS) procedures. Temporary solutions, such as allowing buses to use the emergency lane to bypass traffic, are being considered. The goal is to offer commuters tangible time savings and a more pleasant journey compared to driving, despite the need to transfer from car to bus.

Feasibility of realizing P&Rs in the near future:

Question**:** Do you think the 2025 goal for P&Rs is realistic?

Summary**:** The project manager thinks realization of P&R facilities by 2025 in the Brabant region is unlikely due to nitrogen emission regulations currently halting construction permits. Some zoning plan procedures could proceed relatively quickly, such as in Maarheze where an existing traffic destination can be expanded upwards. However, objections can significantly prolong the process, potentially taking at least a year if legal challenges arise, and even longer given the current backlog in the courts. Furthermore, there's complexity in deciding who will own and assume the risks associated with the P&Rs, contributing to the delays. The imminent changes with the new Environmental Law may also affect the timeline and processes for these developments.

Expected Development in the Near Future:

Question**:** How do you expect things to develop in the next few years?

Summary**:** The project manager anticipates that as Eindhoven's accessibility worsens, P&R facilities will become a more viable alternative for commuters, especially if parking costs in the city increase, creating incentives to seek other options. He believes that the necessity for P&Rs will prompt local authorities to act, despite current reluctance. However, they question the projected need for as many as 10,000 to 15,000 parking spots, citing that similar facilities in cities like Rotterdam or Amsterdam require far less spots. With the possibility of remote work and the growing use of e-bikes, the demand for such extensive parking may be overestimated. He suggests that the actual requirement might be less, especially considering the feasibility of biking distances up to 10 km in the Brainport region.

APPENDIX E.3 SUMMARY OF INTERVIEW 3

Introduction to research: The interview begins with an introduction to the research, some background is provided on the thesis subject and its goals. It is explained that the implementation process of P&Rs in the Brainport region is the main focus of the interview.

Background on hubs

Question**:** To begin with, if I understood correctly, the initial plan was to realize 6 regional mobility hubs in the Brainport region, one of which you are project manager of, is that correct?

Summary**:** The interviewee confirmed being the project manager for the Park & Ride (P&R) facility in Best, part of a plan initially considering six locations around Eindhoven. These P&Rs are conceived within a broader mobility vision to address traffic congestion, particularly from Utrecht and Den Bosch towards the Brainport region via the A2 highway, which is expected to worsen by 2040.

Respondent's role:

Question**:** Can you tell something about the plans for the P&R and what your role is?

Summary**:** Initially, an expectation to accommodate 800-900 cars was set based on model analyses for the future. However, following discussions with ASML the estimated need expanded to a large number of 2500 parking spots, emphasizing the significance of selecting suitable locations. The project manager detailed the process of narrowing down from 11 potential P&R sites to a final selection of 2 possible choices in two years, to determine the most viable locations for the hub. This involved a detailed analysis using a set of criteria to assess each site's suitability based on proximity to the highway, environmental impact, and specific local challenges such as traffic bottlenecks. 5 sites were quickly discounted for failure to meet these boundary conditions. For instance, being too far from the highway or located in ecologically sensitive areas, particularly on the east side of the highway, which the municipality of Best is keen to preserve as a green belt for nature conservation and recreational purposes.

The project scope was refined to six locations after applying these criteria, and further in-depth studies were conducted, including fitting studies, traffic impact assessments, and business case viability, to understand the costs and implications of each site. Ultimately, only two locations were deemed suitable. However, the initial ambition to create parking for 2500 vehicles was scaled down, largely due to the municipality's strategic decision to avoid development on the east side, limiting potential expansion to the western urban areas where space is more constrained. The protection of natural areas and the preference for recreational expansion on the east side were the driving factors behind this decision.

Location selection process:

Question**:** So, you are responsible for the selection of a location?

Summary**:** The respondent explains that they have been hired to lead the project, holding the role of local project leader. This position doesn't operate in isolation but collaborates closely with the municipality, involving specialists from various disciplines such as sustainability, traffic, economic planning, spatial planning, and urban design. A project group is formed depending on the phase of the project, which includes not only municipal employees but also external partners. Specifically, they've engaged a company called 'Krachten', alongside two other firms specializing in traffic consultancy and architectural and economic planning services. This collaborative team has undertaken a comprehensive evaluation of potential locations for the mobility hub, considering the advantages and disadvantages of each site, identifying the target audience, assessing the potential to redirect traffic, and planning the possible development at each site. They also considered necessary modifications to the road layout and the financial implications of these developments.

During the initial phases, ASML, as a key stakeholder due to its growth and traffic impact, was involved in the deliberations.

Involved stakeholders in decision-making process:

Question**:** How does the decision-making process unfold?

Summary**:** The project team comprises roughly seven municipal staff members who are consistently engaged in the project. Additionally, they have contracted an advisory firm composed of three organizations with about six or seven people who specialize in providing guidance on the building's design, traffic engineering, and the broader impact of the project. While these advisors are not involved throughout the entire phase of the project, their contributions have been significant in shaping the outcome and delivering a key product or result for the project's development.

The project's decision-making process involves initial preparation and consultation with an advisory firm, which develops and regularly give feedback to the municipal project group. Various municipal departments collaborate in this preparatory phase. However, the final decisions are taken by the municipal executive board and the city council, reflecting the governance structure of the municipality. The mayor, who is administratively responsible for the regional mobility hub in Best, is regularly consulted and involved in discussions. Key decisions, such as narrowing down from 11 to 6 locations and then to 2, are made by the executive board. If these decisions are particularly complex or deviate from the established vision, the matter is referred to the city council for a decision, as they represent the citizens of Best and are authorized to make such decisions.

Integration within broader mobility plan:

Question**:** These hubs are clearly part of an overarching mobility plan in the region, how do you ensure that the various components are aligned?

Summary**:** The interviewee highlights the complexity of coordinating various mobility projects within the Brainport region, including P&Rs, cycling paths, and public transport. Local consultations between councilors are part of a broader regional dialogue that involves municipalities within a sub region within the MRE, such as North West Eindhoven. These meetings facilitate the alignment of various mobility-related themes within discrete areas. Additionally, the municipality Best has currently one mobility officer who makes sure the different parts of the plans come together. The same can be said for the region.

While there's a supervisory role from initiatives like Brainport Bereikbaar or SmartwayZ, the absence of a central regional authority like MRDH in Rotterdam-The Hague area complicates coordinating regional parties and their activities. This absence makes synchronizing various regional projects challenging, both in terms of their physical implementation and financial aspects. The distribution of funds among different projects like hubs, cycle routes, and bus services is not yet clear. The interviewee suggests that a regional entity is needed to take responsibility for these projects, a role neither Eindhoven nor the province currently fulfills, and calls for a solution to this governance issue.

Financial challenges:

Question**:** Are problems regarding the financing of the hubs evident?

Summary: The financing of the mobility hubs is drawn from a short-term action fund that amounts to approximately 185 million euros, of which 50 million is currently available. This fund is contributed to by the national government, the province, municipalities, and businesses. Although a distribution formula has been established, each municipality must still agree to this allocation within their respective councils, a process which has been completed by some but not by others. Securing the portion of funding expected from businesses poses a challenge.

Question: On what basis are these distributions determined, for companies I can imagine that one company is involved in the process while others are not, whereas they might both benefit from the realization of a P&R.

Summary: Mobiliteitsmakelaars (mobility brokers) are engaged in discussions with regional companies to involve them in the mobility hub project. However, the progress in these engagements seems slow. ASML, as a major stakeholder, is significantly involved due to their direct interest in the success of the mobility hubs.

Initial identification of hub locations:

Question: Okay, on some point it has been decided to develop a number of hubs around Eindhoven, how where the initial municipalities decided in which the hubs where assigned?

Summary: The municipality of Best has been actively involved in studies and regional discussions facilitated by Brainport Bereikbaar and ZO Slim Bereikbaar, with a focus on how to support the region's growth. Best has been forward-thinking and positive towards development, recognizing the regional importance and its potential benefit to the locality. Although Best acknowledges the need for regional mobility solutions, it prefers not to invest municipal funds since it views P&Rs as a regional facility, hence expecting financing to come from broader sources. The municipality is willing to support the project through spatial planning processes but does not wish to assume a leading financial role.

Distribution of responsibilities:

Question: So it is still unclear how the responsibilities are distributed for a potential hub in Best?

Summary: Currently yes, which makes it difficult at the moment, as there currently are two potential sites for the mobility hub in Best, one on municipal land and the other on privately-owned land, with the latter being the preferred location. Acquiring this preferred plot requires funding, which is not yet available, as no decision has been made to allocate funds for this purpose, complicating the project's progression.

The project for the mobility hub in Best is currently on hold, in part due to the absence of regional governance that would allow for overarching decision-making and priority setting. This lack of a centralized regional authority to steer the project is creating challenges in moving forward with the development of the preferred P&R locations.

Development process

Question: Suppose one of the locations would be chosen now, how does the rest of the process look like? Are there any permits yet?

Summary**:** Currently, no permits have been issued for the development of the mobility hubs in Best. The decision-making process involves choosing a preferred location, which is then ratified by the Metropool Regio Eindhoven (MRE) during the Portfolio Meeting, where holders of the mobility portfolio, including the alderman from the municipality of Best, are represented. Once a decision on the location is made, and if funding is available (which it currently is not), the next step is acquiring the land, unless it is already municipally owned. To date, preliminary studies have been conducted to understand how the hubs could be integrated into the selected sites, considering potential traffic adjustments and the overall design. Each location has a conceptual design, but moving forward would require a more detailed design process, culminating in definitive plans that can be tendered for construction. The interviewee thinks the design process will cost at least a year.

The process to establish mobility hubs in Best involves intricate planning under current legislation, which requires a comprehensive environmental procedure or a change in zoning plans. These procedures can take several years but can be carried out simultaneously with design studies. Once spatial frameworks are set, the process of establishing a new zoning plan, termed as an BOPA or 'Buitenplanse omgevingsplanactiviteit' (Exterior Plan Environmental Activity), can commence, based on preliminary designs. This zoning plan specifies the intended use of the location, the rules to be adhered to, and the permissible activities. Following this, the actual permit application and preparations for construction, which may include demolition, can begin. The construction of a mobility hub of substantial size is estimated to take about one to one and a half years to complete.

The successful implementation of a new mobility hub necessitates subsequent modifications to the surrounding infrastructure, which may vary based on the chosen location. These adjustments could include adding extra lanes, widening highway exits or entries, or modifying intersections to accommodate additional traffic lanes. Traffic signals will also require updates to manage the changed traffic patterns effectively. Additionally, existing rapid cycling routes may need rerouting to integrate with the new hub. Ensuring a well-connected bus service is also a critical aspect of this development to provide comprehensive transportation solutions.

Duration of the process:

Question**:** How long would the entire process take in your estimation?

Summary**:** The project manager outlines that even if a decision on the location for the mobility hub is made immediately, the process—from planning to completion—would likely extend until at least 2027, and this timeline is considered optimistic.

Question**:** So, this is assuming that no objections will be raised?

Summary**:** The project manager notes that during the zoning or permitting process, appeals and objections can significantly prolong the timeline, often by one to one and a half years, especially if the case reaches the Council of State. This right to appeal is an inherent part of the process and can be exercised by residents, nearby businesses, or environmental organizations. While the appeal process for zoning plans can quickly escalate to the Council of State, a permitting process first goes through a regional court, potentially extending the duration even further.

Start of respondent's involvement:

Question: Since when were you involved in the process?

Summary: The respondent indicates that the project in Best began in 2021, the preparations started somewhat earlier. They were not yet involved at this point, as they joined the process in the summer of 2021.

The project team has conducted location studies, fitting studies, and engaged in partial participation by consulting with local stakeholders. ASML's request for a temporary parking solution at Boslaan Zuid introduced some delays and uncertainty into the process. One of the main challenges highlighted is the absence of a regional entity willing to take charge of investment, ownership, and management of the mobility hubs, leading to a standstill in project progression. Without these foundational elements resolved, further steps towards the project's development cannot be taken.

ASML involvement:

Question: How is ASML involved in the process?

Summary: ASML is significantly involved in the regional mobility hub as a key stakeholder due to their projected growth and corresponding increase in regional parking needs. Their growth expectations have led to a substantial increase in the planned number of parking spots. While ASML has submitted requests for temporary Park and Ride (P&R) solutions across the region, these have been retracted in Best due to feasibility issues, with a realization that the time-consuming legal and procedural requirements make temporary solutions inefficient compared to building permanent hubs. The company has also explored options like bus lanes on emergency lanes, but this was deemed unfeasible in some areas due to safety concerns. The effectiveness of any P&R is also dependent on the availability and efficiency of subsequent transportation like bus services to ensure smooth transit from the parking locations to final destinations.

Temporary P&Rs:

Question: What happens to temporary P&Rs once the regional mobility hub is realized?

Summary: The possibility exists of building a mobility hub with 2000-2500 spots, that may not be used effectively if subsequent transport links are inadequate, which is highly undesirable. The project manager indicates he thinks that ASML initially expected a quicker resolution through the procedural steps to establish these P&Rs, but the process has proven to be more challenging and time-consuming than expected, prompting the need to explore alternative solutions.

Other companies' involvement:

Question: Are there any other companies, apart from ASML, involved

Summary: Unlike ASML, which is heavily involved in the mobility hub project, other businesses are engaged through mobility brokers. These brokers discuss potential financial contributions to the project or the future allocation of parking spaces. They also work to ease traffic on the highways by encouraging companies to promote biking and public transport use among their employees. The exact businesses involved are not specified, but the focus is on tailoring mobility solutions for each company.

Project complexities:

Question**:** To summarize, what makes the implementation process for P&Rs complex in Brainport?

Summary**:** The complexity in realizing Park and Rides (P&Rs) in the Brainport region stems from the diversity of stakeholders involved, including various organizations, businesses, multiple government levels, landowners, and residents of local towns like Best, Eersel, Maarheze, and Oirschot. Each stakeholder has distinct interests, complicating the process. Additionally, the region is simultaneously managing multiple projects like bike paths, bus services, hubs, and business strategies. A regional entity to coordinate these efforts is currently lacking, although there are discussions and research underway to establish one. However, immediate results from these efforts are not anticipated in the short term.

Provincial involvement:

Question**:** So the province is not involved in that way?

Summary**:** The Province of North Brabant is involved in various thematic areas relevant to the project, but they have clarified that they will not finance or lead the project. It is acknowledged that a specialized entity is needed for effective management and coordination. This entity could be similar to a metropolitan region organization (like the MRDH in Rotterdam-The Hague) or a regional transportation organization. However, the exact nature and structure of this proposed entity are not yet determined.

Aligning stakeholders' interests:

Question**:** How do you manage the large number of stakeholders, municipalities, residents and their varying interests?

Summary**:** The project manager indicates that addressing the diverse interests of stakeholders, municipalities, and residents regarding the Park and Ride (P&R) project is challenging but integral. The key is to involve these parties timely in the decision-making process. Although residents of Best weren't involved in the initial site study due to its complexity, they will be included in later stages, especially in designing the hub, to address their needs and concerns effectively. It's crucial to present a balanced narrative, highlighting both the opportunities and challenges P&Rs bring, and to emphasize the long-term benefits to the community, such as reduced traffic congestion.

The concept of "Not in My Backyard" (NIMBY) is common in such developments, with some residents favoring development elsewhere. The project approach involves listening to both supporters and opponents, understanding their underlying reasons, concerns, and fears. A well-thought-out participation strategy, considering regional dynamics, is essential to address these diverse viewpoints and foster a collaborative development process.

Future prospects:

Question**:** To conclude the interview, how do you see the project unfold in the near future, do you think it will be realized before 2030?

Summary: The advancement of the P&R project in Best is dependent on regional collaboration and the emergence of a dedicated entity with the necessary mandate, funding, and decision-making power. While the municipality of Best is open to supporting the project, they are not inclined to lead it, considering it a regional initiative. The project's progress thus far, including preliminary studies like location selection and integration analysis, awaits further action.

Current discussions revolve around whether the project can continue in the upcoming year, dependent on the fulfillment of critical conditions such as financing, regional cooperation, and aligning with other projects. The project faces potential delays, with the risk that preferred locations might not be available later. The capacity of these sites varies, with the municipal site accommodating fewer vehicles than the privately owned site. The future of the project is uncertain, reliant on financial resources and willingness from parties like ASML or other local investors to participate. Potential collaborations with entities like Eindhoven Airport are also being explored, underscoring the project's regional significance and the need for a comprehensive approach.

APPENDIX E.4 SUMMARY OF INTERVIEW 4

Introduction to research: The interview begins with an introduction to the research, some background is provided on the thesis subject and its goals. It is explained that the implementation process of P&Rs in the Brainport region is the main focus of the interview.

Respondent's role

Question: Can you describe your involvement or role in the realization of hubs?
Summary: The interviewee, a project leader for mobility hubs at the provincial level, discusses their involvement in developing and enhancing existing public transportation nodes across the Brabant region. Their efforts are part of a broader initiative to incorporate additional services such as flexible transportation options and shared mobility into these hubs. The work is structured around public transport concessions, with a current focus on West-Brabant and upcoming plans for East-Brabant. This includes conducting research to identify locations for potential new hubs.

The interviewee also describe a collaborative approach with various stakeholders, such as municipalities and transportation providers, to develop these hubs. The responsibility for these hubs often lies with the municipalities, especially for smaller locations where the municipality is typically the ground owner and takes the lead in development. For larger hubs, the municipality is often the main initiator, while the provincial government provides support, including financial contributions when necessary. The interviewee emphasizes their role is not one of direct responsibility but rather facilitation, coordination, and support in the development process.

Provincial Role in Hub Construction:

Question: What exactly is the province's role in constructing hubs?

Summary: The interviewee explains that the provincial role in the development of mobility hubs often involves enhancing existing public transportation locations like bus stations to add services or shared mobility solutions, which is typically straightforward. However, the process is more complex with Brainport hubs, which are new P&R facilities aimed at reducing vehicular congestion by intercepting cars and facilitating alternative transportation to the outskirts of Eindhoven and large employers like ASML.

These hubs are located within smaller municipalities that lack the capacity and funds for development, raising questions about ownership, operation, and financial risk. The challenges would be less if these hubs were within the jurisdiction of a larger entity like the municipality of Eindhoven.

The province's role includes initiating projects, facilitating stakeholder collaboration, and sometimes providing financial support, with a focus on maintaining regional accessibility.They aim to address the increasing congestion on highways such as the A2 and N2 and believe these hubs could be an effective solution.

Stakeholder coordination:

Question**:** Who are the parties involved in coordination?

Summary**:** The project is managed by Smartwayz, which appoints project leaders for each hub location. These project leaders ensure that all relevant parties are coordinated. The province is often consulted by the region and various municipalities for direction and to ensure progress when it stalls. The primary goal is to maintain and improve regional accessibility, which is crucial for the economy, by alleviating congestion on major roads such as the A2 and N2. The province's role is not to directly bring parties together for the hubs' development, as this is already happening through the project's structure.

Connection to a Larger Mobility Plan:

Question**:** How are the hubs connected to the larger mobility strategy in Brainport?

Summary**:** The mobility hubs are a component of the broader Mobility vision of the Metropole Region Eindhoven (MRE). The MRE is a collective of 21 municipalities working on a mobility vision to maintain and enhance the region's accessibility. This effort is coordinated together with the provincial authorities. As part of this initiative, strategic measures and annual action plans are developed. There's an existing agreement within the Brainport deal, which includes commitments to enhance the Eindhoven station, bus station, HOV lines, the creation of six regional hubs, and the development of rapid cycling routes. Funding for these projects has been secured in collaboration with the national government, and the region is actively working to turn these plans into concrete projects and phases.

Progress in the Hub Development Process:

Question**:** What stage are the hubs at currently?

Summary**:** The process of developing mobility hubs is currently in the initial stages. Site investigations have been conducted at four locations, with one location narrowed down to a single potential site, while the remaining three have two potential sites each. There is also a fifth site where location research has yet to begin, and another where it will start shortly. The main challenge in this phase is addressing the governance issues, such as determining which parties are involved, who will be responsible, who will own the hubs, who will manage them, and who will assume the financial risk. These foundational governance aspects need to be resolved before progressing with the actual building and operational plans for the hubs.

Governance and Organizational Structure:

Question**:** Is governance examined for each location?

Summary**:** Governance issues are addressed collectively for all potential hub locations. To make the hubs economically viable, they are exploring how to engage businesses to purchase parking spaces, thereby generating revenue. However, since similar parking facilities often operate at a loss, they must consider who will cover the financial shortfall. No clear insights have been provided yet regarding who will assume the financial risk. To address these governance questions, a consultancy has been tasked with working on this aspect, collaborating with all relevant stakeholders, including the provincial authority, the Metropolitan Region Eindhoven (MRE), and the municipalities involved.

Determination of Hub Locations:

Question**:** How are the locations determined?

Summary**:** Specific locations for the mobility hubs have not been finalized; they are still under investigation and have been marked on the map as areas of interest. A consulting agency has been tasked with evaluating potential sites within these areas, considering multiple factors such as ownership of the land—preferring municipal over private ownership for ease of development—accessibility by car, proximity to highways for quick access, and the feasibility of bus routes servicing the location. From the initial group of potential sites, they narrow down the options based on these criteria and then conduct more detailed studies on the most promising locations.

Bus Traffic Coordination:

Question**:** Can you tell me something about the a plan for buses on emergency lanes?

Summary**:** The project involves using the emergency lane as a dedicated bus lane on three major roadways—A67, A2, and A50—to support the mobility hub network. This initiative is part of a broader system designed to facilitate the proposed Brainport line, which will connect various hubs and businesses. Separate lanes for buses or using emergency lanes is intended to ensure reliability in bus schedules by avoiding delays caused by traffic congestion, providing a consistent and timely public transport option for commuters.

Collaborative Challenges:

Question**:** Do collaborations pose challenges?

Summary**:** The collaboration among different municipalities and parties presents challenges due to each party advocating for its own interests. Small municipalities where mobility hubs are proposed have their own concerns and priorities, which sometimes conflict with regional interests. There are complexities in working within the Metropoolregio Eindhoven (MRE), which includes 21 municipalities that must reach a consensus on decisions, including financial contributions to projects like the Eindhoven station, based on the concept of regional benefit. Although decision-making is not necessarily stalling, the governance structure is a significant bottleneck. This requires clear leadership and financial backing, as smaller municipalities are hesitant to proceed without a determined entity to take on the financial risks and responsibilities associated with the development of these hubs.

Involvement of Businesses:

Question**:** Are businesses involved in the process and contributing to the governance issue?

Summary**:** In the discussion about the involvement of businesses in the development of mobility hubs, it is noted that while ASML is particularly involved, there have been communications with other significant business parks, the High Tech campus, and central schools. These entities are engaged, but there is room for more extensive involvement. Pre-agreements with employers are deemed necessary to ensure the utilization of the hubs. Regarding the financial aspect and the governance issue, it's challenging to get businesses to contribute to the cost. While ASML might have the capacity to contribute due to its size, smaller businesses might find it more difficult. There's an expressed need for greater involvement from businesses, but it remains unclear whether they can be involved in the governance aspect.

Future Development of the Process:

Question**:** How do you envision the process developing?

Summary**:** The respondent is optimistic that in the coming years, the process will progressively move toward the actual implementation of the mobility hubs. The goal is to have these hubs operational, with buses servicing them. Achieving this within the next two to three years would be considered a rapid development and is seen as an aspirational target. The realization of the hubs will be approached incrementally.

If Governance Issues Were Resolved:

Question**:** What do you think will happen if governance issues would be resolved?

Summary**:** Resolving governance would be a significant step, but it does not guarantee the hubs' construction. Adequate funding is still required, beyond the currently secured finances. Realization would involve preparing zoning and environmental plans, creating architectural designs, and engaging construction firms to begin work. In parallel, a bus line needs to be established, with buses running along it, in collaboration with the local municipality to ensure the hub's accessibility.

Addressing nitrogen issues:

Question**:** How is the nitrogen issue being addressed?

Summary**:** Regarding the nitrogen issue in Brabant, the respondent indicates that further investigation is needed to understand the possibilities and address this concern effectively. It is mentioned that the construction phase may not pose significant problems if managed cleverly, but challenges could arise during the usage phase. This aspect requires more research to find solutions.

Complexity of P&R Implementation:

Question**:** What makes implementing P&Rs particularly complex?

Summary**:** The complexity in realizing P&R facilities in the Brainport area stems from the need to establish ownership and governance of hubs situated on the territories of smaller municipalities, which are intended to serve larger cities like Eindhoven and Veldhoven and their peripheral businesses. The challenge is determining who will own, operate, and financially manage these hubs. This regional issue contrasts with simpler cases like Den Bosch, where P&R facilities are clearly managed by the municipality. The regional approach requires coordination and agreement among multiple stakeholders, making the process more complex.