The Role of Mothers' Non-Transport Pro-Environmental Behaviours in Their Children's Sustainable Transport Behaviours During Adolescence and Young Adulthood

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Abstract

Promoting sustainable transport behaviours (e.g. choosing public transport and active transport mode such as walking and cycling) among adolescents and young adults is critical for reducing transport-related greenhouse gas emissions. These sustainable transport behaviours fall under the category of pro-environmental behaviours which are defined as behaviours that reduce negative impacts or even positively impact the environment. Other pro-environmental behaviours include, for example, recycling, energy conservation, eco-friendly purchasing, and waste reduction. Previous studies have established the correlation between parents' sustainable transport behaviours during children's socialisation (e.g. during their children's adolescence) and their children's adoption of these sustainable transport behaviours during adolescence and young adulthood. However, the role of parents' other pro-environmental behaviours, such as energy conservation and eco-friendly purchasing (referred to as Non-Transport Pro-Environmental Behaviours (NTPEB) in this thesis), in their children's sustainable transport behaviours during adolescence and young adulthood has not been investigated. Exploring the role of these parental NTPEB is essential since these behaviours exhibit greater susceptibility to intervention measures and have higher participation rates than sustainable transport behaviours. This could create improved intervention opportunities for promoting sustainable transport behaviour among adolescents and young adults.

Given that mothers have a more substantial influence than fathers in shaping their children's education, behaviours, and attitudes, this study primarily investigated mothers' NTPEB in shaping their children's sustainable transport behaviours during adolescence and young adulthood. This U.K.-focused thesis empirically examined four interconnected research questions to achieve this aim.

The first research question investigated the relationship between mothers' NTPEB during their children's adolescence (ages 10–15 years) and their children's choice of sustainable transport modes (e.g. active transport like walking and cycling and public transport like buses and subways) for their journeys to school during this period. This relationship was

investigated via multinomial logistic regression using data from the fourth wave of the UK Household Longitudinal Study (UKHLS). The findings indicated a positive relationship between the frequency of mothers' NTPEB and the likelihood of their adolescent children choosing public transport to school. Importantly, more easily observable mothers' NTPEB hold a stronger strength of correlation with the likelihood of adolescents' use of public transport to school compared to maternal psychological factors like pro-environmental attitudes.

The second and third research questions separately analysed the role of mothers' NTPEB during their children's adolescence in their children's frequency of sustainable transport behaviours (encompassing all travel purposes) and the choice of sustainable transport methods for commuting to work in young adulthood. The second research question was explored through structural equation models, which used data from Waves 4 and 10 of the UKHLS. The findings revealed an indirectly but no directly positive influence of the frequency of maternal NTPEB on children's frequency of sustainable transport behaviours as young adults. This indirectly positive influence was mediated by children's pro-environmental attitudes as young adults. The third research question, which employed an integrated choice and latent variable model, identified a similar indirect correlation between the frequency of maternal NTPEB during their children's adolescence and the likelihood of children's sustainable transport choice for travelling to work as young adults.

The final research question in this thesis validated the hypothesis of an association between mothers' NTPEB during their children's adolescence and the persistent adoption of sustainable transport choices by their children from adolescence through young adulthood. Data from Waves 4 and 10 of the UKHLS were analysed using the integrated choice and latent variable model to validate this hypothesis. Therefore, this thesis's findings provide a new perspective for understanding the determinants of sustainable transport behaviours among adolescents and young adults and reveal pathways of intergenerational transmission of pro-environmental behaviours from mother to children. In addition, this thesis includes implications for developing interventions to promote sustainable transport behaviour.

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List of Publications

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Authors Declaration

I declare that, except where explicit reference is made to the contribution of others, that this dissertation is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution.

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Chapter 1. Introduction

Global temperatures have steadily increased since the pre-industrial period (1850–1900) (Seneviratne et al., 2021; Song et al., 2022). One of the most significant contributors to this phenomenon is burning fossil fuels, which emit greenhouse gases into the atmosphere (Houghton, 2005). These greenhouse gases, especially carbon dioxide, act as heat traps and result in higher surface temperatures than normal (Ramirez-Corredores et al., 2023). As a significant contributor to world greenhouse gas emissions, the transportation industry presents serious environmental problems (Lamb et al., 2021; Olivier et al., 2017). In the United Kingdom, the United States, and Canada, transport sector emissions account for the largest share of total national emissions (Department for Transport, 2021b; Transport Canada, 2021; U.S. Environmental Protection Agency, 2023). Given that cars and taxis account for over one-half of domestic transport emissions in the United Kingdom, encouraging the transition from car use to sustainable modes of transport, such as public transport and active transport, such as walking and cycling, is critical to reducing transport emissions (AlKheder, 2021; Bearman and Singleton, 2014; Byrne et al., 2021; Skippon et al., 2012; Steg, 2007). Sustainable transport behaviours are considered a subset of pro-environmental behaviours, which reduce negative impacts and even positively impact the environment (Fallah Zavareh et al., 2020b; Steg and Vlek, 2009; Stern, 2000). Beyond sustainable transport, pro-environmental behaviours also include, for example, recycling, energy conservation, and eco-friendly purchasing and waste (Kurisu, 2015).

Numerous studies have highlighted the significance of adolescence and young adulthood as crucial periods for the development of sustainable transport behaviours (Haustein et al., 2009; Kuhnimhof et al., 2012a; Silva et al., 2011; Uddin et al., 2019). Although definitions of the age range for adolescence vary across studies—some characterizing it as spanning from 10 to 19 years, while others extend it to 24 years (McDonagh et al., 2018; Sawyer et al., 2018)—the age range of 10 to 15 years, which this thesis focuses on, is widely regarded as the core period of adolescence. Young adulthood (i.e. emerging adulthood) generally occurs between the ages of 18 and 25 (Arnett, 2000; Higley, 2019; Konstam, 2007). Several studies have found that sustainable transport behaviours during adolescence and young adulthood are correlated with their sustainable transport behaviour or car use in

the future (De Vos et al., 2022; Mjahed et al., 2015; Muromachi, 2017). This means that if people develop sustainable transport behaviours at a young age (e.g. adolescence and young adulthood), they are more likely to continue to use sustainable transport modes in the future. This highlights the importance of promoting sustainable transport behaviours from an early age (e.g. adolescence and young adulthood).

In recent decades, the use of sustainable transport among adolescents has declined, while car usage has risen in countries like the Czech Republic, the United States, Brazil, England, and Scotland (de Sa et al., 2015; Department for Transport, 2022; Hands Up Scotland Survey, 2021; Haug et al., 2021; McDonald et al., 2011). For young adults, despite a decrease in car use and mileage, the car remains the dominant mode of transport in the UK (see Section 2.1 for detailed information). For example, in 2023, approximately half of all trips taken by young adults were by car in England (Department for Transport, 2024a). Furthermore, as young adults transition through various life events such as marriage, parenthood, graduation, and moving out of the parental home, these milestones often lead to a shift in their transport preferences toward greater reliance on car travel (Jamal and Newbold, 2020; Newbold and Scott, 2018; Simons et al., 2017a; Simons et al., 2017b). This shift towards a car-dominated transportation mode becomes more evident, especially when young adults enter the workforce (Jamal et al., 2022). Given these trends, it is vital to implement effective interventions that encourage individuals, from adolescence through young adulthood, to consistently choose sustainable transport modes over the long term. Designing these interventions necessitates a thorough knowledge of the elements that influence transportation behaviours during adolescence and young adulthood (Steg and Vlek, 2009).

According to travel socialisation theory, individuals' experiences with transport-related socialisation during childhood or adolescence not only shape their travel behaviours at that time but also influence their future transport choices, including those in young adulthood (Baslington, 2008). Baslington (2008) also emphasized the role of parental behaviours in shaping children's transport habits during this socialisation period. Previous studies have highlighted that parental involvement in sustainable transport behaviours, during children's travel socialisation (e.g., in childhood or adolescence), is positively correlated with their

children adopting similar sustainable transport behaviours during the same period (Beck et al., 2023; Ehteshamrad et al., 2019; Siiba, 2020). For instance, Siiba (2020) found that adolescents whose parents actively commuted (e.g., walking or cycling at least twice a week) were more likely to adopt similar active transport modes for commuting to school. Furthermore, these parental transport behaviours during children's travel socialisation have been linked to their children's transport choices in the future, such as in young adulthood (Klöckner and Matthies, 2012; Sigurdardottir et al., 2013). For example, Klöckner and Matthies (2012) found that a high frequency of public transport use by parents during their children's adolescence (around age 15) had a negative influence on their children's car use behaviours as young adults. These findings suggest that parental transport behaviours during their children's travel socialisation (e.g., during adolescence) play a vital role in shaping their children's sustainable transport behaviours, not only during adolescence but also into young adulthood.

However, as highlighted by the Department for Transport (2024a), cars remain the predominant mode of transport in the UK, with older age groups showing a greater reliance on car travel compared to younger adults. Given that parents, who typically belong to these older age groups, continue to predominantly use cars and depend on them more than younger adults, a significant challenge emerges: the potential intergenerational transmission of unsustainable transport behaviours (such as car use) from parents to their children. Furthermore, altering the transport behaviours of individuals (e.g., parents) who have become habituated to their current mode of transport (e.g., car use) over various life stages is a difficult task (Gutiérrez et al., 2020). Research has demonstrated that while adults are generally more open to engaging in Non-Transport Pro-Environmental Behaviours (NTPEB) such as recycling, green purchasing, or energy conservation within the household, they tend to be less inclined to modify their transport behaviours (Kasemir et al., 2003; Shackley et al., 2004). The question arises as to whether, besides parents' sustainable transport behaviours, other parental NTPEB such as energy conservation and eco-friendly purchasing behaviours are influential during children's adolescent socialisation. For example, are parental NTPEB such as eco-friendly purchasing behaviours (e.g. bringing bags when shopping and buying recyclable products) and energy-saving practices during children's adolescent socialisation also associated with children's sustainable transport behaviours in adolescence and young adulthood?

Parental NTPEB during children's adolescent socialization has been shown to influence adolescents' engagement in similar behaviours by shaping adolescents' various pro-environmental psychological factors, such as pro-environmental attitudes (Ando et al., 2015; Collado et al., 2017; de Leeuw et al., 2015; Wallis and Klöckner, 2018; Jia and Yu, 2021; Gong et al., 2022). Notably, once these psychological factors (e.g., pro-environmental attitudes) are established, they could act as catalysts for a broader range of behaviours, including sustainable transport behaviours, extending beyond the specific NTPEB initially observed in parents. While no research has directly linked parental NTPEB during adolescent socialization to children's pro-environmental attitudes in young adulthood, findings from transport socialization studies suggest that parental transport behaviours are associated with their children's transport-related psychological factors in young adulthood (Van Acker et al., 2019; Mjahed et al., 2015; Sigurdardottir et al., 2013). Building on this, it can be hypothesised that parental NTPEB during adolescent socialization may influence children's sustainable transport behaviours in young adulthood by fostering children's pro-environmental psychological factors, such as pro-environmental attitudes, in young adulthood.

Parental NTPEB like eco-friendly purchasing and energy-saving practices have shown higher engagement rates than parental sustainable transportation choices (Lynn, 2014). In addition, targeted interventions (e.g. environmental education and legislation and promoting environmentally friendly lifestyles through media and community outreach) have been somewhat effective in increasing participation in these NTPEB (Abrahamse, 2019; Ajaps and McLellan, 2015; Hobson, 2001; Kish, 2018; Zsóka et al., 2013). Thus, they present a chance to form children's sustainable transport practices from adolescence and young adulthood through targeted interventions to alter their parents' NTPEB. Nevertheless, it is unknown if parents' NTPEB (e.g. eco-friendly purchasing behaviours and energy conservation) during their children's adolescent socialisation period correlate with their children's sustainable transport behaviours in adolescence and young adulthood.

This thesis prioritises examining the role of mothers' NTPEB during their children's adolescence. This prioritisation is based on several key factors. Firstly, mothers generally

spend more time with their children than fathers (Baxter and Smart, 2011), increasing the likelihood that children observe and internalize their mothers' NTPEB. Additionally, research suggests that mothers' NTPEB may play a more significant role in shaping children's pro-environmental psychological factors and behaviours compared to fathers (Collado et al., 2019). Furthermore, mothers have been shown to exert a greater influence on their children's transport behaviours, further reinforcing their impact on shaping sustainable behaviours over time (Schoeppe et al., 2017; Susilo and Liu, 2016; Motte-Baumvol et al., 2017; Hsu and Saphores, 2014; Tristram et al., 2023).

In particular, three important study gaps in this U.K.-based thesis must be addressed. First, no research has investigated whether mothers' NTPEB throughout their children's adolescence correlate to their children's sustainable transport choices during the same period. Second, whether this correlation in children's adolescence persists into their young adulthood is unknown. In other words, whether mothers' NTPEB during their children's adolescence are associated with their children's sustainable transport behaviour when children reach young adulthood is unclear. Finally, whether the continuity of children's sustainable transport choices from adolescence to young adulthood correlates with their mothers' NTPEB during their children's adolescence is unknown. The results of this thesis present a fresh viewpoint for the novel analysis of the elements influencing adolescents' and young adults' decisions on sustainable transportation. These original insights seek to inform the development of future interventions designed to consistently promote children's use of sustainable transport in adolescence and young adulthood.

1.1 Aims and objectives

This thesis aims to contribute to study on the intergenerational transmission of pro-environmental behaviours between mothers and their children by addressing the earlier identified research gaps. The overarching aim of this thesis is to offer insights into the role of mothers' NTPEB during their children's adolescence in their children's sustainable transport behaviours in adolescence and young adulthood. This investigation is conducted from cross-sectional and longitudinal perspectives (spanning six years). Based on the main academic gaps outlined above, this thesis has four research objectives, as detailed below.

In exploring children's sustainable transport behaviours in adolescence, transport choice on the way to school is key. Therefore, the first objective focuses on the children's choice of transport to school in adolescence.

Objective A: To examine the correlation between mothers' NTPEB and their children's sustainable transport to school during adolescence, based on a cross-sectional analysis

In examining the children's sustainable transport behaviour in young adulthood, two aspects of children's sustainable transport behaviours in young adulthood are considered: the frequency of sustainable transport behaviours and choices of sustainable commuting modes for work. Children's frequency of sustainable transport behaviours in young adulthood reflects their preference for sustainable transport options, which encompasses various transport purposes such as work, leisure, and shopping. The frequency of sustainable transport behaviours helps to understand the overall inclination of children towards sustainable transport daily during young adulthood. In contrast, children's choices of sustainable commuting modes for work specifically reflect their inclination towards sustainable transport in work-related trips during young adulthood. Work-related trips often involve more constraints (e.g. commuting time pressure). Thus, the roles of mothers' NTPEB during their children's adolescence in children's frequency of sustainable transport behaviours and choices of sustainable commuting modes for work in young adulthood are analysed separately.

This thesis aims to differentiate between the generalised influence of mothers' NTPEB on children's overall sustainable transport behaviours in young adulthood and the more specific influence on transport choices to work in young adulthood under different situational constraints. This distinction is crucial because the impact of mothers' NTPEB may vary across different contexts. For example, mothers' NTPEB may significantly shape children's transport choices for leisure transport in young adulthood but have a lesser impact on their commuting choices for work in young adulthood due to external constraints (e.g. commuting time pressure). By analysing these two aspects separately, the

study offers a more accurate and detailed understanding of the role of mothers' NTPEB during their children's adolescence in shaping children's sustainable transport behaviours in young adulthood. Therefore, research objectives B and C were formulated as follows:

Objective B. To investigate the role of mothers' NTPEB during their children's adolescence in their children's frequency of sustainable transport behaviour in young adulthood, from a longitudinal perspective

Objective C. To explore the relationship between mothers' NTPEB during their children's adolescence and their children's choice of sustainable transport for commuting to work in young adulthood, from a longitudinal perspective

Finally, objective D was derived from objectives A and C.

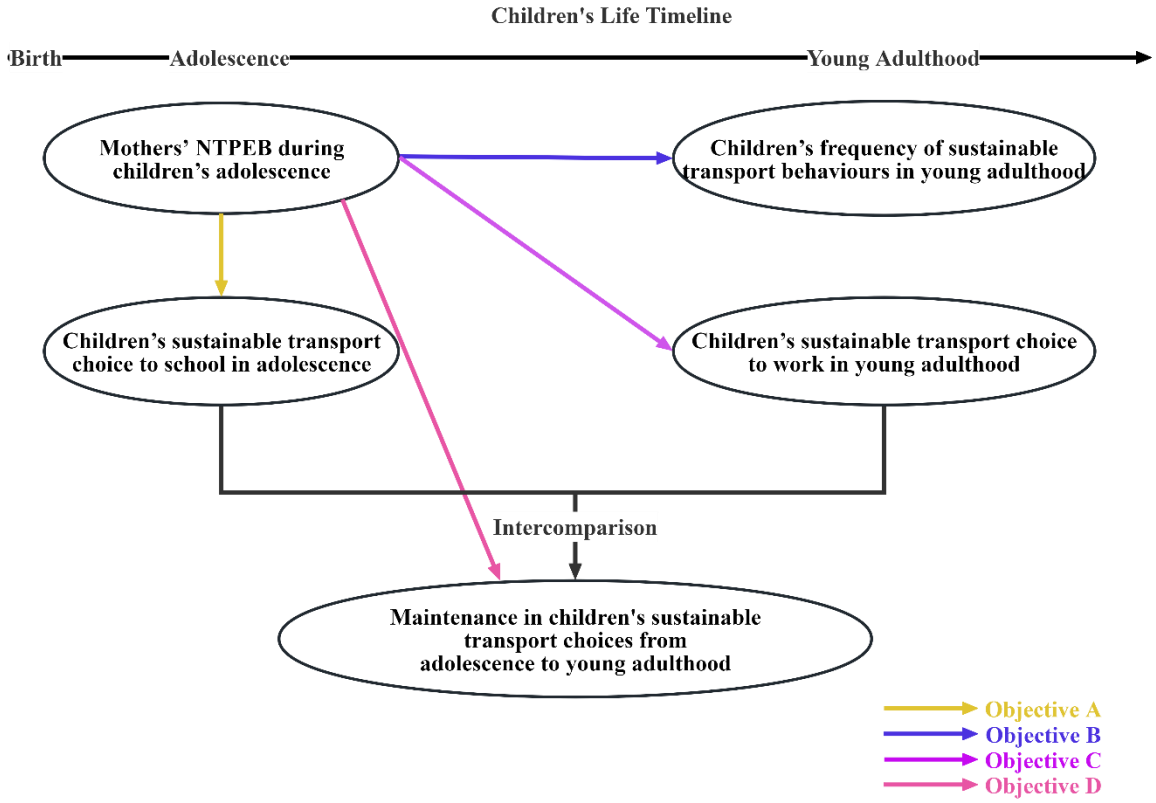
Objective D: To longitudinally explore the relationship between mothers' NTPEB during their children's adolescence and maintaining their children's sustainable transport choices while transitioning from adolescence for school to young adulthood for work.

1.2 The logic of the main objectives

Figure 1-1 illustrates the logical framework underpinning the four primary objectives of this thesis. The figure provides a visual representation of children's life stages to better depict how mothers' NTPEB and children's sustainable transport behaviours in different life stages are intertwined.

Objective A, indicated by the yellow arrows in the figure, constitutes the first focus of this thesis. It investigates the correlation of mothers' NTPEB during their children's adolescence with their children's choice of sustainable transport modes when commuting to school during the same period.

Figure 1-1. The logical framework of the four primary objectives



Objective B, depicted by the blue arrows in the figure, explores the role of mothers' NTPEB during their children's adolescence in their children's overall frequency of sustainable transport behaviours as they transition into young adulthood.

Objective C, represented by the purple arrow in the figure, also explores the potential link between mothers' NTPEB during their children's adolescence and their children's sustainable transport choices when commuting to work as young adults.

Lastly, Objective D, represented by the pink arrow in the figure, focuses on evaluating the correlation of mothers' NTPEB during their children's adolescence with maintaining their children's sustainable transport choices from adolescence to young adulthood. This maintenance is determined by comparing children's transport choices to school in adolescence and children's transport choices to work in young adulthood.

1.3 Research questions

Based on the above research aims and research objectives, this thesis is structured to address four primary research questions (RQs 1–4). Only the primary research questions are discussed here. Each question is accompanied by a set of related research questions that are addressed in the respective section (section 4.1 - 4.4) pertaining to each research question.

RQ 1: Is there a correlation between mothers' NTPEB during their children's adolescence and their children's choice of sustainable transport modes to school during the same period?

RQ 2: What is the connection between mothers' NTPEB during their children's adolescence and the overall frequency of sustainable transportation behaviours as their children transition into young adulthood, and how is this connection manifested?

RQ 3: Does the correlation between mothers' NTPEB during their children's adolescence and their children's frequency of sustainable transportation in young adulthood extend similarly to their children's selection of sustainable transportation modes for commuting to work in young adulthood?

RQ 4: What relationship exists between mothers' NTPEB during their children's adolescence and the continuity of their children's sustainable transport choices from adolescence to young adulthood?

This thesis primarily utilises data from the UK Household Longitudinal Study (UKHLS) (see Subsection 3.2.1 for details) to address these four research questions. Multinomial logistic regression (see Subsection 3.3.1 for details) is the primary method used to address

RQ 1. For RQ 2, structural equation modelling (see Subsection 3.3.2 for details) is employed, while integrated choice and latent variable modelling (see Subsection 3.3.3 for details) is predominantly used for RQs 3 and 4.

1.4 The structure of the thesis

The thesis is structured into six chapters as follows:

Chapter 1 provides the background and context of this thesis and outlines the main research gaps. It defines the research aims, objectives, and research questions. The chapter 1 also provides a logical connection between the main research objectives.

Chapter 2 begins by describing the importance of choosing the research topic of this thesis (Section 2.1). Moreover, Chapter 2 identifies the main academic gap this thesis addresses (Section 2.2) by reviewing the existing literature on the factors influencing sustainable transport behaviours in adolescence and young adulthood. Moreover, based on the existing literature on the intergenerational transmission of NTPEB and several psychological models, this chapter argues for a possible correlation between mothers' NTPEB during their children's adolescence and their children's sustainable transport behaviours during adolescence and young adulthood (Section 2.3). This argument provides the foundation for establishing hypotheses for the subsequent empirical studies in this thesis. Finally, Chapter 2 effectively explains why this thesis focuses on mothers' behaviour (Subsection 2.3.6)

Chapter 3 outlines the overall research methodology. This chapter begins by presenting the hypotheses based on the literature review, which are tested in the subsequent empirical study of this thesis (Section 3.1). In addition, this chapter separately describes the data of the next four empirical studies (Section 3.2). Moreover, the main analytical methods of the subsequent four empirical studies are presented (Section 3.3).

Chapter 4 presents the results of the four empirical studies in this thesis, with a short introduction and methods section for each one.

Chapter 5 then discusses the results of the four empirical studies in this thesis by mainly focusing on interpreting the results of the control variables (Section 5.1) and discussing the results of the hypothesis testing (Section 5.2). Furthermore, Chapter 5 presents potential applications based on the results of the four empirical studies in this thesis (Section 5.3).

Chapter 6 concludes the thesis by highlighting the main contributions of this study to the existing literature (Section 6.1). It also acknowledges the limitations of this thesis and provides direction for future research (Section 6.2).

Chapter 2. Literature review

This chapter reviews the extant empirical research on sustainable transport behaviours in adolescents and young adults by highlighting previous studies' main findings and limitations. In addition, this chapter provides a theoretical and empirical study of parents' NTPEB during their children's adolescence, their children's sustainable transport behaviours during adolescence and young adulthood, and the interactions between them. This process is crucial in laying a solid foundation for the subsequent empirical research questions of the thesis. The chapter is divided into three main sections.

Section 2.1 begins by highlighting the importance and context of the research in this thesis based on some government data and previous studies. Section 2.2 introduces the definitions of sustainable development, sustainable transport, and pro-environmental behaviours. This section also reviews the empirical contributions made by previous studies on factors influencing sustainable transport behaviours in adolescents and young adults. Based on the findings of the reviewed research, this section highlights the main research gaps and research questions of this thesis.

Section 2.3 examines prior empirical studies concerning the influence of parents' engagement in NTPEB on their children's adoption of similar behaviours. Furthermore, this section synthesises diverse psychological theories and models to enhance understanding the intergenerational transmission of NTPEB from parents to children. It extends this discussion to explore the influence of parents' NTPEB on their children's sustainable transport practices during adolescence and young adulthood while suggesting potential linkages and underlying mechanisms. Finally, Section 2.3, based on previous research, explains why this thesis focuses on mothers' NTPEB during their children's adolescence.

The structure of the literature review is designed to ensure a clear and logical progression. Section 2.1 provides the background, establishing the significance and importance of the research topic (transport behaviours during adolescence and young adulthood), setting the

stage for the subsequent discussions. Section 2.2 then reviews existing research on this research topic, highlighting key gaps in the research: relationships between parents' NTPEB during their children's adolescence and their children's sustainable transport behaviours in adolescence and young adulthood. Building on these gaps, Section 2.3 explores the potential mechanisms that underpin these underexplored relationships. Specifically, Section 2.3 offers both empirical and theoretical perspectives on how parents' NTPEB during their children's adolescence are linked to their children's sustainable transport behaviours in adolescence and into young adulthood. A potential framework is provided to elucidate the hypothesised relationships between these seemingly disparate domains of parents' and children's behaviours. This framework lays the groundwork for subsequent empirical research within this thesis.

2.1 Justification of topic

Transport remains one of the largest contributors to carbon emissions in the UK and globally. According to the International Energy Agency (2018), the transport sector is responsible for about one-fifth of global carbon dioxide emissions. Within this sector, road transport accounts for roughly three-quarters of emissions, with passenger vehicles, including cars and taxi, contributing 45.1%, while freight transport, primarily involving trucks, accounts for 29.4% (ibid). Given that transport as a whole contributes 21% to global CO_2 emissions, road transport alone is responsible for approximately 15.7% of global total carbon dioxide emissions (ibid). In the UK, the United States and Canada, the transport sector has overtaken the energy sector to account for the largest share of total national emissions (Department for Transport, 2021b; Transport Canada, 2021; U.S. Environmental Protection Agency, 2023). In the UK, for example, in 2019, the transport sector accounted for 27% of the UK's total emissions, equivalent to 122 million tonnes of carbon dioxide equivalent (Department for Transport, 2021b). The majority of these emissions (91%) originated from road transport, contributing 111 million tonnes of carbon dioxide equivalent (ibid). Among road transport sources, cars and taxis were the largest emitters, responsible for 61% (68 million tonnes of carbon dioxide equivalent), followed by heavy goods vehicles at 18% (19.5 million tonnes of carbon dioxide equivalent) and vans at 17% (19 million tonnes of carbon dioxide equivalent) (ibid). Notably, carbon

emissions from the domestic transport sector have remained relatively stable and have not declined significantly (Department for Transport, 2021c).

Road transport, particularly cars and taxis, account for a large proportion of emissions. In 2020, the total number of domestic passenger kilometres travelled in the in Great Britain was approximately 580 billion. Of these, 92% of domestic passenger kilometres are made by cars, vans and taxis (Department for Transport, 2021c). Between 1960 and 2019, passenger kilometres travelled by cars and taxis in Great Britain grew steadily from 139 billion to 738 billion, reaching an all-time peak in 2019 (ibid). This growth in car travel distance is closely linked to the long-term rise in car ownership. In 1950, in the UK fewer than 20% of households owned a car, but by the mid-1970s, approximately half of all households had one. By 2018, this proportion had increased to 74%, reflecting the continued expansion of car ownership over time (Marsden et al., 2018). Meanwhile, since 1960, the distance travelled by buses and coaches has continued its long-term decline, from 79 billion passenger-kilometres in 1960 to 33 billion passenger-kilometres in 2019. Consequently, there is an over-reliance on car, which results in high levels of emissions from road transport, especially from cars and taxis.

Given that cars and taxis account for over one-half of domestic transport emissions in the UK, encouraging the transition from car use to sustainable modes of transport, such as public transport and active transport, such as walking and cycling, is critical to reducing transport emissions (AlKheder, 2021; Bearman and Singleton, 2014; Byrne et al., 2021; Skippon et al., 2012; Steg, 2007). Numerous studies have highlighted the significance of adolescence and young adulthood as crucial periods for the development of sustainable transport behaviours (Haustein et al., 2009; Kuhnimhof et al., 2012a; Silva et al., 2011; Uddin et al., 2019). As current and future transport participants, the transport behaviours of adolescents and young adults not only influence current transport emissions but also determine the sustainability of future transport. Several studies have found that transport behaviours during adolescence and young adulthood are correlated with their sustainable transport behaviour or car use in the future (De Vos et al., 2022; Mjahed et al., 2015; Muromachi, 2017). For example, Muromachi (2017) pointed out that past experience of using the railway as adolescents to attend high school was statistically significantly and

negatively associated with future intention to use the car as young adults. Moreover, De Vos et al. (2022) pointed out that the frequency of public transport used by university students and their satisfaction with public transport positively affects their willingness to use public transport in later life. This means that if people develop sustainable transport behaviours at a young age (e.g. adolescence and young adulthood), they are more likely to continue to use sustainable transport modes in the future. Conversely, if people dependence on the car is formed during adolescence or young adulthood, this dependence may maintain a lifelong preference for car travel. This highlights the importance of promoting sustainable transport behaviours from an early age (e.g. adolescence and young adulthood).

However, in recent decades, the use of sustainable transport, particularly public transport, has declined among UK adolescents, while the use of cars has risen. For example, in 1995, 43% of adolescents (ages 11-16) in England used active transport to travel to school, with 41% walking and 2% cycling. In contrast, 21% of adolescents used cars (Department for Transport, 2023a). By 2023, the proportion of adolescents using active transport remained at about 43%, but the breakdown shifted to 39% walking and 4% cycling, while car usage increased to 27% (ibid). The use of buses also declined, from 33% in 1995 to 23% in 2023 (ibid). A similar trend has been observed in Scotland. In 2008, 44.4% of Scottish high school students (adolescents) chose active transport to school, with 42.8% walking and 1.6% cycling. At that time, 13.7% used cars to get to school (Hands Up Scotland Survey, 2021). By 2021, while the proportion of students using active transport remained almost the same at 44.1% (42.5% walking and 1.6% cycling), car usage increased to 17.8%. The proportion of students using buses decreased from 37.2% in 2008 to 31.3% in 2021 (ibid). Although the percentage of adolescents using active transport to school has remained relatively stable, it is noteworthy that car usage has increased, accompanied by a decline in bus usage.

Regarding the transport behaviours of young adults, while car use and mileage among this demographic have declined in recent years, the car remains the primary mode of transportation. According to Marsden et al. (2018), the driving distance for individuals aged 17–34 in the UK decreased by 20% in the decade leading up to 2014. In England, individuals aged 17–20—most of whom fall within the young adult category, except for

those aged 17—travelled an average of 4,465 miles per year by car in 2002. By 2023, this distance had dropped to 3,020 miles per year, marking a decline of 1,445 miles. Notably, in 2023, car travel accounted for approximately 61.38% of the total annual travel distance (4,920 miles), significantly exceeding the distance travelled using public transport (including buses, the underground, surface rail, and other public transport modes), which totalled 1,522 miles (Department for Transport, 2024a). In 2002, car travel was the predominant mode of transport among individuals aged 17–20 in England. At that time, 34.6% of trips made by this age group were on foot, 1.75% by bicycle, 52.8% by car, and 18.3% by public transport (ibid). Within the public transport category, 15.1% of trips were taken by bus, while the remaining share consisted of rail, underground, and other public transport options (ibid). By 2023, some shifts in travel behaviours had emerged among this age group. The proportion of walking trips increased to 38.3%, and cycling rose slightly to 2.2% (ibid). Meanwhile, car use declined to 48.3%, whereas public transport usage increased to 20.4%. Within public transport, bus trips accounted for 11.8%, railway trips for 5.9%, and the remaining share included the underground and other public transport services (ibid). Despite an increase in active and public transport use, accompanied by a reduction in car usage and mileage, the car remains the dominant mode of travel for this age group. A similar pattern is observed among individuals aged 21–29, the majority of whom are classified as young adults. In 2023, more than half of their trips were still made by car, Moreover, the total car travel distance for this age group amounted to 4,589 miles, accounting for approximately 69.44% of their total annual travel distance (6,609 miles). This indicates that, despite some shifts in travel behaviours, car use remains widespread within this population group.

Furthermore, as young adults transition through various life events such as marriage, parenthood, graduation, and moving out of the parental home, these milestones often strengthen their preference for car travel (Jamal and Newbold, 2020; Newbold and Scott, 2018; Simons et al., 2017a; Simons et al., 2017b). Young adults are intentionally shifting to a car-oriented culture, especially once they have a job (Jamal et al., 2022). Data from the Department for Transport (2024a) further supports this trend in the UK, indicating that car dependency increases with age. In England in 2023, 51.2% of trips made by adults aged 21–29 was completed by car. This proportion rose to 59.7% for those aged 30–39, 66.5% for those aged 40–49, and 67.7% for those aged 50–59. Among individuals aged 60 and

above, car travel accounted for 67.7% of all trips. These figures highlight that the car remains the dominant mode of transport in England, with older age groups displaying a higher reliance on car travel compared to younger adults. This trend is further reflected in car mileage, where in 2023, individuals aged 30–39 saw 78.9% of their total annual travel distance covered by car. This figure increased to 82.0% for those aged 40–49 and 83.7% for those aged 50–59, demonstrating a growing reliance on car travel as people age. Even in the 60+ age group, car mileage represented 82.3% of their total travel, further emphasizing the persistent role of car use across different age categories (Department for Transport, 2024a).

In this context, the key issue is how to effectively intervene and promote sustainable transport behaviours amongst adolescents and young adults. The UK government and organisations have implemented a range of measures to encourage adolescents and young adults to make sustainable travel choices. For example, for adolescents, the Walking School Bus programme is a structured initiative in which groups of students walk to and from school along a designated route under the supervision of at least one adult volunteer (Larouche and Mendoza, 2018). By incorporating adult supervision, this approach aims to address parents' concerns about their children's safety on the way to and from school, while promoting children to greater use of active transport.

Walking school bus programs have been implemented in various countries, including the UK, Australia, Canada, New Zealand, and the United States, and have demonstrated positive effects in reducing car trips and promoting walk to school among children (Kearns et al., 2003; Mackett et al., 2005; Staunton et al., 2003). For instance, in Marin County, California, as part of the Safe Routes to School program, the walking school bus initiative was combined with a bicycle training program designed to enhance students' cycling skills and safety awareness. Research found that this intervention led to a 64% increase in walking, a 114% rise in cycling, a 91% increase in carpooling, and a 39% reduction in single-student car trips (Staunton et al., 2003). However, since the program also incorporated infrastructure improvements, classroom education, and various walking and cycling activities, it is difficult to isolate the specific impact of the walking school bus component. Nevertheless, the overall findings suggest a notable shift in students' travel

behaviours. Similarly, in St. Albans, England, the introduction of walking school buses contributed to a 30% reduction in car trips for school travel (Kearns et al., 2003). Additionally, Mackett et al. (2005) found that in Hertfordshire, England, walking school buses effectively encouraged students to transition from car travel to walking, with approximately 50% of participating children having previously travelled by car.

In addition, the UK Government's substantial investment in subsidised free school bus encourages the use of school bus for school commutes. This subsidy provides free school bus transport for adolescents living more than three miles from their school in the UK (Department for Education, 2010; GOV.SCOT, 2022; GOV.WALES, 2014). For example, in 2010, the average expenditure by urban authorities on school bus subsidies in England was just under £1 million, while rural authorities spent nearly £9.6 million on average (Van Ristell et al., 2015). The total expenditure on secondary school bus transport for adolescents amounted to £275 million, with almost 83% (£228 million) allocated to school bus services in rural areas (Van Ristell et al., 2015). This substantial subsidy also promotes the use of public transport for school commuting.

In addition, interventions such as environmental education have been designed to sustainable transport behaviours by influencing adolescents' pro-environmental mental factors (Chillón et al., 2011). Environmental education is essential to raise awareness of future environmental challenges and promote environmental protection measures (ibid). Through environmental education or other educational programs on pro-environmental behaviours and sustainable transport behaviours, psychological factors such as attitudes, perceptions, and preferences for pro-environmental behaviours can be influenced directly, which indirectly promote pro-environmental behaviours (Zsóka et al., 2013). Core strategies in this area include advocating for environmentally friendly schools and integrating environmental education into the school curriculum to foster sustainable thinking among students, examples of which have been found in several countries such as USA, Israeli, Indonesia, India and UK (Ajaps and McLellan, 2015; Kerret et al., 2020; Prasetiyo et al., 2020; Verma and Grover, 2022; Wee et al., 2018). A study conducted in the UK by Boyes and Stanisstreet (2012) indicated that environmental education showed promise in promoting students' behaviours such as promoting energy conservation and

recycling. Zaccari and Dirkis (2003) examined an environmental education intervention aimed at reducing transport congestion and pollution caused by car trips to and from school in the Sydney Australia. The outcome of this intervention was a notable 3.4 percent reduction in the number of car trips made to school, indicating its effectiveness in altering transport behaviours. The decline in car use was also greatest in the class with the highest proportion of students who use car to and from school, with a 14 per cent decline (ibid).

It is worth noting that education related to sustainable transport behaviours is no longer limited to children or adolescents, and a growing number of environmental education interventions are now focusing on adult populations. O'Fallon (2010) mentioned the Cycle Now initiative in New Zealand, which aims to combat negative attitudes towards cycling with workshops related to cycling. They found that at a follow-up one year later, 32% of the 675 respondents reported biking to work more often than the year before. One UK's example is Glasgow's Walk to Work intervention, in which active transport is promoted by empowering employees with positive perceptions of walking through education and practical information sharing related to the benefits of walking. After six months, the intervention group was walking more for their commute compared to the control group (Mutrie et al., 2002). In addition to education related to sustainable transport behaviours, the use of prizes to further incentivise young adults' sustainable transport behaviour is a common intervention in the UK. Tsirimpa et al. (2019) extensively explored the role of incentives in sustainable transport behaviours in the UK. Their findings indicated that users who received rewards increased their usage of public transport, walking, and biking more than those who did not receive rewards. The UK government offers employees incentives such as reduced income tax or national insurance to promote cycling to work through the Cycle to Work scheme, which has shown an increase in cycling to work (Swift et al., 2016).

These interventions have been shown to be effective in promoting sustainable transport behaviours among the target group (adolescents and young adults). However, interventions like incentives to encourage participation are effective in the short term, i.e. they may be effective during the period of policy roll-out, but behavioural change is often unsustainable once government support is reduced. It is essential to note that studies have pointed out

that without financial incentives, the sustained impact of interventions may be limited. For example, Scheepers and Hoogendoorn-Lanser (2018) reported on four studies that used various incentives to encourage participation but found that once the incentives were removed, the shift towards sustainable transport patterns was not sustained. Furthermore, regarding interventions such as environmental education, Boyes and Stanisstreet (2012) found that while environmental education effectively encouraged students' NTPEBs, such as energy conservation and recycling, it struggled to bring about lasting changes in transport behaviours (e.g., adopting public transport) among students who were fundamentally uninterested in environmental protection. Additionally, while Walking School Bus programs help address parental safety concerns and increase walking rates among students, they may unintentionally limit opportunities for children to develop the independence needed for future engagement in sustainable transport modes, such as active travel (Mori et al., 2012). In some cases, this could negatively impact students' long-term sustainable transport behaviours. Walking School Bus programs can reinforce the perception that the outdoor environment is unsafe for independent walking (Larouche and Mendoza, 2018). This perception potentially discouraging students from independently using sustainable transport in the future. Therefore, although these interventions significantly encourage sustainable transport behaviour, they do not always ensure its long-term adoption and continuity.

Prior research has emphasized the importance of sustainable transport behaviour interventions being long-lasting (Zhang, 2020). According to the travel socialisation, individuals' transport-related socialisation experiences during childhood or adolescence not only influence their travel behaviours at that stage but also shape their future transport choices, including those in young adulthood. (Baslington, 2008) (see subsection 2.3.1 for details). Baslington (2008) further highlighted the role of parental behaviours in shaping their children's transport-related attitudes and behaviours during travel socialisation. Several studies have found that a correlation between parents' and children's transport behaviours during children's travel socialisation (e.g., in childhood or adolescence) (Beck et al., 2023; Ehteshamrad et al., 2019; Siiba, 2020). For example, Siiba (2020) found a correlation between parents who actively commute (e.g. walking or cycling at least twice a week) and their children choosing similar active modes of transport for commuting to school. It is worth noting that these parental transport behaviours during children's travel

socialisation have also been linked to their children's transport choices in future (e.g., young adulthood). For example, Mjahed et al. (2015) found that parents' preference for cars during their children's travel socialisation leads to children's negative attitudes towards walking in adulthood, which in turn reduces children's walking behaviour in adulthood. Similarly, Van Acker et al. (2019) found that parental car purchasing behaviour during children's travel socialisation hindered their children's use of public transport in young adulthood. These findings suggest that parents' transport-related behaviours during their children's travel socialisation (e.g., adolescence) play a crucial role in shaping their children's transport behaviours—not only during their children's adolescence but also into young adulthood.

However, as highlighted by national transport data (mentioned above), cars remain the dominant mode of transport in UK, with older age groups demonstrating a higher reliance on car travel compared to younger adults. Given that parents (who belong to these older age groups) are still predominantly car users and rely more on cars than younger adults, this raises a significant challenge: the potential intergenerational transmission of unsustainable transport behaviours (car use) between parents and their children. Research has shown that while adults are more willing to engage in NTPEB such as recycling, green purchasing, or energy conservation within the household, they are often less inclined to change their transport habits (Kasemir et al., 2003; Shackley et al., 2004). This resistance to modifying transport behaviours makes it difficult to promote sustainable transport among adolescents and young adults by encouraging their parents to adopt more sustainable travel choices. Furthermore, parents' current reliance on unsustainable transport modes, such as car dependency, is likely to be transmitted to the next generation.

Given the challenges associated with changing parental sustainable transport behaviours, an alternative approach is to explore whether parents' engagement in (NTPEBs—such as energy conservation and green consumption—can influence their children's sustainable transport choices. Compared to sustainable transport behaviours, NTPEB tend to have higher participation rates (Lynn, 2014). For instance, in 2022, 64% of surveyed individuals in the UK reported consistently bringing reusable shopping bags when shopping (Office for National Statistics, 2023). In 2023, over 20% of UK consumers stated that they had

reduced their clothing purchases for sustainability reasons, while a similar proportion reported increasing their purchases of second-hand clothing (Office for National Statistics, 2023). Furthermore, in terms of energy-saving practices, more than half of respondents indicated efforts to conserve water and electricity at home (Office for National Statistics, 2023). Furthermore, studies suggest that targeted interventions—such as environmental education, legislative measures, and media or community outreach programs promoting eco-friendly lifestyles—have been relatively successful in increasing NTPEB participation (Abrahamse, 2019; Ajaps and McLellan, 2015; Hobson, 2001; Kish, 2018; Zsóka et al., 2013). Therefore, leveraging parental NTPEB interventions presents an opportunity to indirectly shape adolescents' and young adults' sustainable transport behaviours. If parental NTPEBs can be shown to have a positive correlation with children's sustainable transport behaviours, future interventions could focus on promoting these more adaptable behaviours as an indirect means of fostering sustainable transport habits among adolescents and young adults. This approach could open a new, long-term pathway for sustainable transport interventions among adolescents and young adults. This thesis aims to explore this potential linkage, highlighting the importance of considering parental NTPEBs as an alternative pathway to fostering long-term sustainable transport behaviours in younger generations.

2.2 Previous studies on sustainable transport behaviour in adolescence and young adulthood

The literature review begins by focusing on the definitions of sustainable development, sustainable transport, and pro-environmental behaviours as the primary research topic of this thesis (Subsection 2.2.1). Additionally, Subsections 2.2.2 and 2.2.3 separately provide the review of the existing research on the determinants of sustainable transport behaviours in adolescents and young adults.

2.2.1 Sustainable development, sustainable transport, and pro-environmental behaviours

Sustainable development was first defined by the World Commission on Environment and Development in its Brundtland Report, also known as Our Common Future. According to Brundtland (1987), sustainable development seeks to meet current demands while maintaining the ability of future generations to meet their own. The concept of sustainable transport is generally seen as a manifestation of sustainable development within the transport sector (Banister, 2007). However, no consensus exists on a precise definition of sustainable transport. Various definitions of sustainable transport or sustainable mobility can be found in several studies and policy documents (Janic, 2006). For example, Richardson (1999) described a sustainable transport system as one in which fuel consumption, vehicle emissions, safety, congestion, and social and economic access are maintained at levels that can be sustained indefinitely without causing significant harm to future generations worldwide. The Commission of the European Communities (1999) highlighted that sustainable transport system should limit emissions and waste within the planet's capacity to absorb them, utilise renewable resources at or below their generation rates, and use non-renewable resources at or below the rates of development of renewable substitutes while minimising the impact on land use and noise generation. Transport Canada (1999) emphasised that a sustainable transport system meets the basic access needs of individuals and societies safely in a manner consistent with human and ecosystem health. The Organisation for Economic Co-operation and Development (2001) defined sustainable transport as mobility or movement that enables transport to fulfil its vital economic and social functions while minimising its adverse environmental impacts. Notably, despite the absence of a standardised definition of sustainable transport, public transport modes (e.g. buses, subways, and trains) and active transport modes (e.g. walking, cycling, and skateboarding) can generally be considered sustainable transport options. The choice of these sustainable transport modes for travelling can be understood as sustainable transport behaviour.

In the early 1990s, a substantial change in the philosophy of transport policymaking occurred in the context of sustainable transport. This transition was from the traditional "predict and provide" approach to a more nuanced perspective known as New Realism, which was introduced by Goodwin et al. (1991). The rationale for this change was that the conventional "predict and provide" approach of building additional infrastructure and roads to handle increasing demand of motorised transportation was essentially at odds with

the ideas of sustainable development. This strategy was unsustainable in the long run since it fed the expansion of motor vehicle transportation to some extent. For example, even if the British government made significant investments in road infrastructure before the 1990s, the concurrent rise in traffic congestion increased vehicle emissions that escalated climate change and local air pollution issues while widening the mobility gap between those with access to cars and those without (Goulden et al., 2014). As such, the emphasis of transport policies shifted from "predict and provide" to a "New Realism" paradigm.

The "New Realism" lists five fundamental ideas for creating transport policies (Goodwin et al., 1991). The first principle stresses the need to consider transportation-related problems holistically rather than as discrete parts. The second argues that to encourage fair competition among various transportation options, they should be treated equally and consistently. The third principle promotes a more practical strategy by admitting the impossibility of meeting all transportation requirements and wants. The fourth principle emphasises that transport solutions should consider personal attitudes and behaviours in addition to technology while acknowledging the importance of human aspects and passengers' motives in establishing effective regulations. The fifth principle emphasises prioritising vital transportation demands by differentiating between essential and non-essential transportation (Goodwin et al., 1991).

The fourth of these points emphasises a people-centred perspective. It highlights the need to fundamentally change human transport behavioural patterns to engage in sustainable transport behaviours (Klaniecki et al., 2016; Matthews and Caldeira, 2008; Sachs et al., 2019; Yusliza et al., 2020). In terms of sustainable transport behaviours, encouraging public transport utilisation and active transport engagement has been highlighted in previous studies as a strategy to address the unsustainable aspects of the transport system (AlKheder, 2021; Attard and Shiftan, 2015; Banister, 2007; Neves and Brand, 2019). Sustainable transport behaviours fall under the category of pro-environmental behaviours (Kurisu, 2015). Pro-environmental behaviours are frequently defined as actions aimed at lessening damage to the natural environment and, ideally, increasing its well-being (Steg and Vlek, 2009; Stern, 2000). In addition to sustainable transport behaviours, pro-environmental behaviours generally include energy conservation, waste avoidance, green

consumption (e.g. bringing bags when shopping and buying recyclable products), recycling, and social commitment. According to Steg and Vlek (2009), finding the pertinent elements affecting pro-environmental behaviours, such as sustainable travel behaviours, is the first step to better promoting sustainable transportation practices to enable the focused creation of policies and intervention strategies. The elements affecting the behaviours of sustainable transportation vary among age groups. The influencing elements of sustainable transport behaviours for adolescents and young adults are covered individually in the next two sections because this thesis focuses on these two age groups.

2.2.2 Determinants of sustainable transport to school in adolescence

Regarding the transport behaviour of adolescents, their transport choices for travelling to school are key. Previous studies have identified several influencing factors that may promote or hinder adolescents' adoption of sustainable transport modes when commuting to school. In this subsection, these influencing factors are reviewed. Drawing from the concept framework related to determinates of transport choice proposed by Kafi et al. (2024), these influencing factors can be categorized into three key components: Opportunity, Capability, and Motivation. Firstly, Opportunity refers to external factors that can either facilitate or limit the adoption of sustainable transport options. In the context of adolescents commuting to school, Opportunity encompasses built environment factors such as the distance to school, the residential density of the living area, the location of an adolescent's residence, and the availability and quality of sustainable transport infrastructure, including both active transport options (e.g., walking or cycling) and public transport services. Secondly, Capability component refers to an individual's ability to make sustainable transport choices. According to Kafi et al. (2024), this component is primarily expressed through socio-economic factors as well as demographic factors. In terms of transport choice to school among adolescents, this capacity is largely determined by both personal demographic factors—such as age and gender—and socio-demographic variables of their families, including factors like household income, parental education level, car ownership, and employment status. Finally, Motivation component refers to the internal psychological factors that influence transport choices. In the context of transport choice to school among adolescents, motivation component is shaped by the psychological factors of adolescents' parents. It is crucial to recognize that factors of both the Capability and

Opportunity components can directly influence factors of Motivation component (Kafi et al.,2024). In terms of transport choice to school among adolescents, factors related to the built environment (Opportunity component) and adolescents' demographic characteristics as well as parental socio-demographic factors (Capability component) can influence the transport-related psychological factors of parents (Motivation component). This subsections will present an literature review of existing research on adolescents' transport choices for travelling to school, organized around the three components—Opportunity, Capability, and Motivation.

Considering the Opportunity component, built environment factors have been found as the important determinates of adolescents' transport choice to school. Among built environment factors, the distance between home and school is a common factor hindering active transport choices for commuting between them. Several studies have found a negative correlation between the distance from home to school and the likelihood of adolescents choosing active transport mode for commuting to school (Babey et al., 2009; Campos-Sánchez et al., 2020; Kelly and Fu, 2014; Larsen et al., 2012; Lin and Chang, 2010; Mindell et al., 2021; Panter et al., 2008). Moreover, the residential density around the school is another critical built environment element influencing sustainable transport options for adolescent commuters to school (Braza et al., 2004; Dalton et al., 2011; Larsen et al., 2012; Macdonald et al., 2019). Previous studies have found in Scotland and the United States, a positive relationship between residential density and the likelihood of active transport to school (Braza et al., 2004; Dalton et al., 2011; Macdonald et al., 2019). Existing research found that high residential density might promote active transport choices and lower car traffic by shortening the distance between the origin and destination (Boussauw et al., 2012; Levinson and Kumar, 1997). This is somewhat supported by Campos-Sánchez et al. (2020), who found that the correlation between residential density and the likelihood of adolescents choosing active modes of transport to school was not statistically significant, after simultaneously accounting for school distance and residential density around the school and the neighbourhood. This suggests that density may be indirectly related to the transport choices to school through school distance. However, some alternative outcomes have arisen in different countries. For instance, Larsen et al. (2012) found that higher residential densities negatively correlated with adolescents' active transport choice for commuting to school in England. This may be due to the fact that

higher-density neighbourhoods may have more negative issues related to traffic hazards and personal safety than lower-density neighbourhoods (Chaudhury et al., 2012). Adolescents' concerns about their safety were found to reduce the likelihood of active transport to school (Mohiuddin et al., 2022).

Another Opportunity component influencing adolescents' choices of sustainable transport for commuting to school is the state of active and public transport infrastructure (Aranda-Balboa et al., 2020; Dalton et al., 2011; Lin and Chang, 2010; Molina-García et al., 2020). For example, in the United States and China, sidewalk coverage has been positively correlated with the likelihood of walking to school (Ewing et al., 2004; Lin and Chang, 2010). Considering the state of public transport infrastructure in Australia, public transport accessibility around homes was found to positively correlate with children's public transport choices to school (Zulkefli et al., 2020). In Scotland, the home neighbourhood walkability has positive correlation with choosing active transport mode for commuting to school (Macdonald et al., 2019). In addition, Molina-García et al. (2020) found a positive correlation between choosing active transport to school and positive streetscape characteristics (e.g. having public transport stops, benches, public litter bins and cycle parking racks on the journey to school) in Spain. It is important to note that the positive streetscape characteristics variable used by Molina-García et al. (2020) is a composite concept, derived from the mean values of 17 measurement items related to sustainable transport infrastructure. These items include the number of public transport stops, benches, public trash bins, bicycle parking racks, and other similar features. While this variable includes some elements of public transport infrastructure, it still reflects the overall quality of active transport facilities in the area.

Notably, the correlation between infrastructure and sustainable transport choice to school may be mediated by adolescents' and their parents' psychological factors. This also corresponds to the conceptual framework proposed by Kafi et al (2024) that Opportunity component (built environment factors) can affect transport users' transport choices by influencing users' Motivation component (i.e. psychological factors of transport users). Seraj et al. (2012) found that in the United States, parental psychological factors such as attitudes toward children's active transport to school could be shaped by the state of public

transport infrastructure, such as school accessibility. Parental psychological factors are key in determining whether children can actively travel to school. For example, Fallah Zavareh et al. (2020a) found that parental psychological factors, such as worry about road accidents, were negatively associated with children's walking to school in Iran and China. McMillan (2005) provided a conceptual framework to explain how urban form influences children's transport choices to school. According to this conceptual framework, the lack of excellent pavement on the path to school may lead to parental psychological factors such as negative perceptions of active transport infrastructure and parents' concerns about their children, which influence children's transport behaviours. Fyhri and Hjorthol (2009) supported this conceptual framework and found that in Norway, parents' psychological factors, such as perceptions of road safety on the way to school based on past experiences, mediated the relationship between infrastructure (e.g. the percentage of pavement on the way to school) and their children's transport behaviours.

Nevertheless, some studies have found different results when investigating sustainable transport infrastructure. Among adolescents ages 11 to 13, Larsen et al. (2009) did not detect a relationship between active transport choices for commuting to school and sidewalk lengths around homes and schools in Canada. This finding could be because even under the same active transport infrastructure conditions, parents' or adolescents' perceptions of transport infrastructure not only depend on the quality of real sustainable transport infrastructure, but also depend on past transport experiences. For example, van der Vlugt et al. (2022) found that good experiences with using public transport (i.e. public transport control) influenced positive perceptions of the walkability of infrastructure to some extent. In addition, Cheng and Chen (2015) found that travellers' perceptions of accessibility, mobility, and connectivity towards the same public transport system varied with age, the weekly frequency of physical activity, and pro-environmental attitudes. In essence, this observation underscores that parents in the same neighbourhood may interpret the same infrastructure differently due to past personal transportation experiences and psychological factors, which in turn influence adolescents' sustainable transport choices for commuting to school. Hence, previous studies have found different results in the relationship between sustainable transport options for schooling and sustainable transport infrastructure.

Notably, built environment factors (Opportunity component) are related to the location of adolescents' residences. Several studies have found differences in active transport choices to school among adolescents living in urban and rural areas (Babey et al., 2009; Kaplan et al., 2016; Rodríguez-López et al., 2017; Silva et al., 2011; Simons et al., 2017b). For example, Babey et al. (2009) indicated that in the United States, adolescents from urban areas were more likely to choose active transport for commuting to school. In Germany, urban children were more likely to switch to active transport to school as they grew into adolescents than rural children (Klos et al., 2023). In the UK (Sheffield), students living in the countryside were less likely to choose active transport modes for commuting to school (Ferrari and Green, 2013). Simons et al. (2017b) found that adolescents (secondary school students) living in rural areas in Belgium were less likely to walk to school. Given the lack of consideration of distances to school, they proposed that one potential explanation for this is the longer travel distances faced by adolescents in rural areas, which may discourage the use of active transportation. However, it is important to note that several studies have indicated that even when distance to school are accounted for, living in rural areas continues to be associated with lower rates of active transport to school (Babey et al., 2009; Ferrari and Green, 2013). This suggests that other factors beyond distance may be contributing to the differences in active transport choice to school between urban and rural areas. Christiana et al. (2021) demonstrated differences in active transport choices between adolescents in the rural and non-rural United States. They attributed this difference primarily to the lack of resources, including the low quality and availability of active transport infrastructure, in rural areas. Urban areas tended to have well-developed active transport infrastructure with high walking accessibility (Rahman et al., 2020). It is worth noting that many previous studies have no considered variables on the quality of active transport infrastructure (Babey et al., 2009; Ferrari and Green, 2013). Therefore, differences in the quality of active transport infrastructure between urban and suburban areas may contribute to disparities in active transport choices for school commuting in these areas.

In addition to the built environment factors included in the Opportunity component, the following will examine the Capability component which includes factors such as adolescents' demographic characteristics and parents' socio-economic status. Adolescents' demographic factors also influence adolescents' transport choices to school. In terms of

adolescents' sex, several studies have revealed that male adolescents are more likely than female adolescents to utilise sustainable transport to school (Li et al., 2022; Marzi et al., 2023; Silva et al., 2011; Van Dyck et al., 2010). Van Ristell et al. (2013) found that in the UK, girls were less likely to choose sustainable transport (i.e. buses and non-motorised transport) for commuting to school than boys. Frater and Kingham (2018) provided an explanation for why female adolescents were less likely to cycle to school; they suggested that female adolescents could be discouraged from cycling to school due to needing to wear helmets. Because wearing helmets could detract from their appearance (i.e. hairstyles), female adolescents might have given up cycling to school (ibid). However, this interpretation specifically addresses gender differences in cycling behaviours and does not fully account for the broader gender disparity in sustainable transport choices. In particular, it does not explain why girls are also less likely to walk or take public transport to school, which may be influenced by other factors. Moreover, this interpretation does not apply to all countries. For example, the UK does not legally require helmet use (Chandler, 2023). Therefore, gender differences in cycling behaviours related to helmet use may not be as pronounced in the U.K. context. In addition, Davison et al. (2008) speculated that gender differences in transport choices to school could be because parents were more protective of girls. Research in Australia demonstrated that boys were granted more freedom to travel independently, such as crossing major roads independently, than girls (Carver et al., 2012). Ghekiere et al. (2017) found the same results in Belgium and noted that parental concern for road safety was only associated with independent travel for girls, not boys. Hence, parents were more likely to drive their daughters to school, which limited the likelihood of female adolescents' sustainable transport choices for commuting to school independently. Carver et al. (2013) highlighted that in Australia, the correlation between adolescents' sex and their choice of non-car modes of transport to school was not statistically significant in a model controlling for parental safety concerns. To some extent, this indicates that the observed gender differences in school transport choices may primarily stem from varying parental safety concerns based on the child's gender. It is worth noting that in UK, Van Ristell et al. (2013) did not effectively account for parents' concerns about their children's safety in their research, so it is reasonable to find gender differences in transport choices to school.

Considering adolescents' ages, a positive correlation exists between their ages and the likelihood of choosing sustainable transport methods (active and public transport) for commuting to school (Irawan et al., 2022; Yeung et al., 2008). In England, the likelihood of students opting for sustainable transport (active or public transport) to school increases with age (Department for Transport, 2014; Van Ristell et al., 2013), which may result from parents not letting their younger children travel to school alone (Fyhri and Hjorthol, 2009; Lam and Loo, 2014). Moreover, parents' concerns about threats to their children on the way to school are crucial in preventing their children from going to school alone in Australia and England (Carver et al., 2013; Department for Transport, 2014). Thus, parents may transport their younger children to school by car. However, as children age, parents may become more confident in their children handling potential hazards encountered on the way to school (van den Berg et al., 2020). This increased confidence may diminish parental worries about their children's safety during commutes and subsequently increase the likelihood of adolescents choosing sustainable transport options. He and Giuliano (2017) found that children gained more independence from their parents as they matured.

However, some studies have found opposite results. In the case of high school students (adolescents) in America, older students (e.g. those in the 12th grade) were found to be less likely to choose active transport to school than their younger counterparts in the ninth or 11th grades (Evenson et al., 2003). This phenomenon could be related to extracurricular activities. Twelfth-grade students (i.e. older adolescents) in the United States were found to be more likely to participate in non-sport extracurricular activities (e.g. part-time work) than eighth graders (younger adolescents) (Meier et al., 2018). Wong et al. (2011) found that adolescents who needed to engage in extracurricular activities (e.g. part-time work) were less likely to choose active transport to and from school. Therefore, higher-grade or older adolescents were more likely to travel by car to optimise their time between extracurricular and school activities.

Another demographic factor affecting sustainable transport to school is adolescents' ethnic origins (Baig et al., 2009; Davison et al., 2008; Oliver et al., 2014; Pont et al., 2009; Rothman et al., 2018). The relationship between ethnicity and transport choices to school varies across countries. Existing research has found that in the United States, Hispanic

adolescents are more likely to choose active transport for commuting to school (Rothman et al., 2018). Moreover, in North Carolina, White high school students are less likely to walk or bike to school compared to their non-White counterparts (Evenson et al., 2003). Rothman et al. (2018) identified that due to the unique interplay of race, class, ethnicity, culture, and urban geography in the United States, these findings may not be directly applicable to contexts outside of the country. In the UK, adolescents with White backgrounds are more likely to walk/cycle to school, those with African Caribbean Black backgrounds are more likely to travel to school by public transport, and those with South Asian backgrounds are more likely to drive to school (Owen et al., 2012). A U.K. study offered a potential explanation that White British students travelled the shortest distances to school compared to other ethnicities, so they were more likely to walk or cycle to school (Easton and Ferrari, 2015).

In addition, previous research has suggested that the potential reasons for these differences in the choice of sustainable transport to school by ethnicity may partly stem from cultural differences in parenting styles. For example, Chinese parents are less likely to allow their children to travel alone (Karsten, 2015). This forbiddance limits the likelihood of Chinese children walking or cycling to school alone. In addition, the intersection of racial background with other factors such as socioeconomic status (e.g. income and household car ownership) could be another reason. McDonald (2008a) found that minority groups, particularly Black and Hispanic students, were more likely to use active travel to school than White students in the United States. However, racial differences in transport choices to school disappeared after controlling for household income, car use, and distance between home and school (ibid).

In addition to the adolescents' demographic characteristics, Capability component also includes factors like parents' socio-economic status. Parental and household socioeconomic factors are crucial in shaping adolescents' transport choices to school. In terms of socioeconomic factors, Chinese children were found to be more likely to choose active transport for commuting to school when their parents are unemployed compared to when only the mother is employed (Wang et al., 2022). McDonald (2008b) found that in America, children were less likely to walk or cycle to school if their mothers worked in the

morning. Understandably, these mothers would incorporate driving their children to school during their commute to work. Aibar Solana et al. (2018) found that in Spain, parental commuting to work choices correlated with children's commuting to school choices. In England, aside from distance, the most common reason for driving children to school was that both parents were employed (Ahern et al., 2017). However, the results have been inconsistent. Carver et al. (2013) found that adolescents from families with at least one parent not employed full-time were more likely to be driven to school in Australia. Agyeman and Cheng (2022) found that when parents worked part-time or did not work in Ghana, their children were less likely to walk to school. One possible explanation was that full-time employment could limit the time available for parents to drive their children to school, in contrast to parents who were not required to work full-time. In the United States, mothers who were employed full-time reduced their childcare time by more than 50 minutes per day compared to their unemployed counterparts (Versantvoort, 2010).

In terms of socioeconomic factors (e.g. household income), several studies have found that adolescents from lower-income households were more inclined to opt for active transport and public transport when commuting to school compared to their peers in more affluent families (Assi et al., 2018; Noonan, 2021; Silva et al., 2011; Woldeamanuel, 2016). For example, in England, children from low-income families are more likely to choose buses or non-motorised transport to attend school (Van Ristell et al., 2013). Previous studies have attributed this result to the fact that household income tends to be associated with families owning more cars. The number of cars in a household has been identified as a significant barrier to adolescents' active and public transport to school (Agyeman and Cheng, 2022; Irawan et al., 2022). Another interpretation posits that higher-income families tend to have more options regarding school selection (Burgess and Briggs, 2010; Suppramaniam et al., 2019). School selection (e.g. attending a private school) somewhat increases the distance between home and school. Fyhri et al. (2011) observed that between 1985/86 and 2008, the distance to school for adolescents (11–16 years old) increased in Great Britain. The authors partly attributed this finding to more students attending private schools over time. Due to the long distance from home to school, adolescents in private schools are more likely to travel to school by car than by active transport. In Spain, for example, adolescents who attended private schools were found to be less likely to choose active transport to school than those in public schools (Chillón et al., 2009).

Nonetheless, other studies have found opposing findings. For instance, Panter et al. (2010) found that in the UK, adolescents living in deprived neighbourhoods were less likely to choose to walk or cycle to school, even after controlling for travel distance and car ownership. One explanation posits that variations in residential environments stemming from income disparities contribute to this association. Specifically, research has shown that higher-income families typically live in neighbourhoods with better infrastructure, such as pedestrian and biking facilities (Sallis et al., 2011). Conversely, low-income families are likelier to live in areas with less-than-optimal sustainable transport infrastructure, crime rates, and pedestrian-vehicle accidents (Sallis et al., 2011; Zhu and Lee, 2008). These factors exacerbate the challenge of sustainable commuting to school for children from low-income families. A study by Oliver et al. (2014) supported this interpretation to some extent using bivariate analyses. They found a positive correlation between household income and the probability of children opting for active transportation to school in New Zealand. However, this correlation diminished in statistical significance after controlling for the walkability of the residential area, distance to school, and household car access (ibid).

In terms of parental education level, the higher the level of parental education, the higher the proportion of adolescents using cars to go to school (Assi et al., 2018). Male adolescents whose mothers had lower education were likelier to choose active transport for commuting to school independently (Chillón et al., 2009). In addition, Larouche et al. (2015) found that in Australia, Colombia, Kenya, Portugal, South Africa, the UK, and the United States, the more educated parents were, the less likely their children were to choose active transport to school. Previous studies have similarly attributed this result to the fact that parental educational levels tend to be positively associated with household income and car ownership, which increase adolescents' propensity to be driven to school.

Ermagun and Samimi (2015) provided an alternative explanation that highly educated parents may be more aware of risk, which may discourage them from letting their children use public transport or walk to school independently. In addition, similar to the higher-income families mentioned above, Sandretto et al. (2024) identified that parents play an

important role in selecting schools for their children. Families with highly educated parents are also more likely to select schools for their children rather than enrolling them in the nearest school (Burgess et al., 2011; Jheng et al., 2022; Silvennoinen et al., 2015). School choice tends to be associated with longer commuting distances, which reduces the propensity of adolescents to choose sustainable modes of transport to school.

In addition to the Capability component, Motivation components (e.g., parental psychological factors) also have correlation with their children's transport choice to school in adolescence. Parental psychological factors also affect adolescents' sustainable transport choices to school. As mentioned, parental concerns about children's safety and their perceptions towards sustainable transport infrastructure highlight the role of parental psychological factors in adolescents' sustainable transport choice for commuting to school (Fallah Zavareh et al., 2020a; Fyhri and Hjorthol, 2009; McMillan, 2005). In addition, the means of transportation children choose for their school commutes greatly depend on parental psychological factors related to the natural environment and environmental protection. For example, Black et al. (2001) found that parental awareness of the environment was negatively associated with adolescent children's transport to school by car for attending school after controlling for car ownership, parental employment, parental road safety concerns about their children, and distance to school. Seemüller et al. (2024) explored the relationship between parents' place of residence, demographic factors (such as age and gender), socioeconomic factors (such as education level), and parents' pro-environmental attitudes, which the authors refer to as parental environmental self-identity. Their findings revealed that only the place of residence was significantly associated with parents' pro-environmental attitudes, with rural parents exhibiting weaker pro-environmental attitudes compared to their urban counterparts. Furthermore, Seemüller et al. (2024) found a positive correlation between parents' pro-environmental attitudes and their children's likelihood of choosing active transport to school in adolescence, even after controlling for the distance to school. However, an important limitation of this study is that the authors did not account for other factors, such as parents' place of residence, demographic characteristics, or socioeconomic status, when analysing the relationship between parents' pro-environmental attitudes and their children's active transport choices. This omission may affect the validity of the findings regarding the positive correlation between parents' pro-environmental attitudes and adolescents' active transport choices.

Specifically, the observed positive correlation may stem from the fact that parents with stronger pro-environmental attitudes tend to live in urban areas, where their children (adolescents) are more likely to have access to better active transport infrastructure in urban. As a result, the increased likelihood of adolescents choosing active transport may be more influenced by the availability of infrastructure than by their parents' pro-environmental attitudes. Additionally, Seemüller et al. (2024) did not assess adolescents' pro-environmental attitudes, which could directly impact their attitudes towards active transport behaviours. This omission leaves the underlying mechanisms of the relationship between parents' pro-environmental attitudes and children's active transport choices in adolescence unclear. Seemüller et al. (2024) suggested that future research should consider incorporating adolescents' pro-environmental attitudes to better understand the mechanisms of this relationship.

However, some studies have reached different conclusions. For instance, Mehdizadeh et al. (2019a) found that parents' sense of responsibility for mitigating environmental pollution did not correlate with their children's sustainable transportation choices (active or public transport modes) for school commuting. In response, the authors explained that the study area could lack a built environment that supported sustainable transport options. Hence, even if the parents were aware of the environmental pollution caused by driving their children to school, the built environment factors that did not facilitate sustainable transport choices resulted in parents still choosing to drive their children. In addition, Nasrudin and Nor (2013) highlighted that although most parents are aware of the environmental hazards of car use, parents' concerns about their children's safety result in a reluctance to support their children's use of sustainable transport modes for commuting to school.

Indeed, parental psychological factors related to the natural environment and environmental protection are often expressed in their pro-environmental behaviours (Abrahamse et al., 2009; Bopp et al., 2011; Hidalgo-Crespo et al., 2022). Bopp et al. (2011) reported that people with eco-friendly attitudes (i.e. pro-environmental attitudes) were more likely to engage in pro-environmental behaviours such as sustainable transport behaviours (e.g. choosing active transport modes for commuting) and less likely to drive. Notably, parents' sustainable transport behaviours have been found to correlate to their

children's sustainable transport choices (Beck et al., 2023; Ehteshamrad et al., 2019; Siiba, 2020). Evidence exists of a correlation between parents who actively commute (e.g. walking or cycling at least twice a week) and their children choosing similar active modes of transport for commuting to school (Siiba, 2020). Pro-environmental behaviours arising from parental psychological factors related to the natural environment and environmental protection (i.e. pro-environmental attitudes) can extend beyond sustainable transport behaviours to encompass various NTPEB such as eco-friendly purchasing behaviours and energy savings (Hidalgo-Crespo et al., 2022; Martinsson et al., 2011; Muposhi et al., 2021; Tamar et al., 2021). While the link between parents' sustainable transport behaviours and adolescents' transport preferences has received some attention, a significant research gap concerns the influence of parental NTPEB, such as engaging in eco-friendly purchasing behaviours and adopting energy-saving measures, on adolescents' transport choices to school.

2.2.3 Determinants of sustainable transport behaviours in young adulthood

This subsection reviews the factors influencing sustainable transport behaviour in young adults. The young adult stage is typically defined as occurring between the ages of 18 and 25 (Arnett, 2000; Higley, 2019; Konstam, 2007). In this subsection, the factors influencing the transport behaviour of young adults will continue to be reviewed based on the framework provided by Kafi et al. (2024) (mentioned in subsection 2.2.2). In this framework, influencing factors of young adults' transport behaviours can be categorized into three key components: Capability, Opportunity, and Motivation.

In terms of young adults' transport behaviours, Capability components like young adults' demographic status greatly influences their sustainable transport behaviours. In terms of sex, an existing study found that in Germany, France, the UK, Norway, and the United States, access to cars, measured by possessing a driver's licence and family car ownership, had declined for men and women since the millennium. Moreover, young men's access to cars declined more than young women's since the millennium (Kuhnimhof et al., 2012a). Gender-based differences are apparent in sustainable transport choices. Nash and Mitra (2019) noted that in Toronto, male university students in young adulthood showed a greater

inclination towards walking or cycling for their daily transport needs than their female counterparts. Gender differences in sustainable transport behaviour also appear in commuting behaviour. For example, an Irish study reported that women's participation in cycle commuting was significantly lower than men's (Carroll et al., 2020). Research conducted in North Carolina revealed that female college students, faculty, and staff were less likely to choose non-motorised transport modes (e.g. walking and cycling) for commuting to college than males (Rodríguez and Joo, 2004). Moreover, young adult females may prefer public transport to active transport. Indeed, Newbold and Scott (2018) found that in Canada, females were more likely than males to commute using public transport.

Ethnic background is another important demographic factor (Capability components). Specifically, young adults who are non-White were found to be more likely to use public transit in the United States (Brown et al., 2016). A pertinent study from the UK revealed that Black and Asian individuals typically accumulated fewer car miles than their White British peers (Mattioli and Scheiner, 2022). The authors explained that this disparity stemmed from socioeconomic differences (e.g. differences in car ownership) between racial groups. Klocker et al. (2015) somewhat supported this explanation and indicated that individuals born overseas with immigrant backgrounds and from ethnic minority groups had lower car ownership and fewer car trips.

Moreover, Klocker et al. (2015) highlighted the role of different housing preferences in contributing to differences in transport behaviours between immigrants and Aboriginal people (different ethnic groups). Chatman and Klein (2009) demonstrated that new immigrants' decisions regarding residential location were partly influenced by their preferred and desired mode of daily travel. For example, in Melbourne, Australia, Levin (2012) discovered that Chinese migrants deliberately selected neighbourhoods with convenient access to public transportation, along with educational and shopping amenities. The differences in residential preferences between native-born Australians and Chinese immigrants might also explain the observation made by Klocker et al. (2015) that immigrants were more likely to travel by public transport than native-born Australians.

Moreover, this It also explains why there are differences in traffic behaviour between immigrants and Aboriginal people (different ethnicities).

In addition to the demographic status factors, Capability components also include life changes and socio-economic factors like young adults' level of education, income, and employment status. These socio-economic factors often change in response to life changes, especially those related to the transition from adolescence to young adulthood. Life changes, especially those related to the transition from adolescence to young adulthood, are associated with the transport choices of young adults. For example, when adolescents typically transition to young adulthood, socioeconomic factors such as their level of education, income, and employment status change. These changes correlate with the transport behaviours of young adults (Chatterjee et al., 2018; Jamal and Newbold, 2020; Newbold and Scott, 2018; Simons et al., 2017a; Simons et al., 2017b).

Regarding employment status, young adults can enrol in a tertiary institution (i.e. a college or university) to pursue a higher degree or to start working. Busch-Geertsema and Lanzendorf (2017) observed that in Germany, young adults tended to use cars more and public transit less once they completed their education and began working. Brown et al. (2016) found that among young adults in the United States, being a student had a stronger positive influence on public transit use than employment. Simons et al. (2017b) identified that in Belgium, young adults in university or college were most likely to walk and use public transport, while working young adults were most likely to use a car. In addition, existing research found that in the UK, Australia, and Norway, those who started working in adulthood were more likely to acquire driving licences than those who chose to enter university in pursuit of higher qualifications (Berrington and Mikolai, 2014; Delbosc and Currie, 2014; Hjorthol, 2016). As a result, young adults attending university are more inclined to engage in sustainable transport behaviours than those who are working.

This difference in transport behaviours between working young adults and full-time young adult students may be due to differences in economic pressures and car availability (Busch-Geertsema and Lanzendorf, 2017). Full-time students could be under financial pressure (low income) or without access to a car, so they choose sustainable transport. In terms of

economic factors (e.g. income), this variable has been extensively documented as a key determinant of commuting to work using a private car (Ahmad and Puppim de Oliveira, 2016; Guerra, 2015). Young adults with lower incomes have lower proportions of driving licences and are more likely to use public transit for their journeys (Berrington and Mikolai, 2014; Newbold and Scott, 2018). Young middle-class adults tend towards car-centric behaviour, while the less economically disadvantaged are less inclined to choose the car as a means of transport (Groth et al., 2021). In addition, owning a car has also been claimed to lower the likelihood of utilising sustainable forms of transportation among young adults (Giuliano and Dargay, 2006; Plaut, 2005).

Furthermore, another explanation for the differences in transport behaviour between working and studying young adults is the result of differences in the transport-related infrastructure available between the two groups. Higher education campuses are usually located in densely populated urban areas, which usually means shorter distances to travel and better public transport facilities. Hence, sustainable transport options are more readily available there. Busch-Geertsema and Lanzendorf (2017) found that changes in commuting distances and the availability of railway transport were both associated with changes in the transport behaviour of young adults as they moved from university to employment.

Differences in transport behaviour between working and studying young adults could also be due to differences in their educational qualifications. For example, Newbold and Scott (2018) found that in Canada, young adults with a university degree were more likely to use public transit than those whose highest educational level was high school or lower. Nonetheless, young adults with high education levels are more inclined to sustainable transport behaviours, even when they start working. In Belgium, young adults with higher levels of education were found to commute to work more frequently by train or bicycle than those with lower levels of education (De Vos and Alemi, 2020; Simons et al., 2017a). De Vos and Alemi (2020) suggested a plausible explanation for this phenomenon by positing that young adults with higher educational achievements frequently demonstrated more favourable attitudes towards sustainable transportation while maintaining less favourable attitudes towards car use. Young adults who choose to attend to university rather than start work as they enter young adulthood are often associated with obtaining

higher qualifications. Therefore, studying young adults are more likely to have positive attitudes towards sustainable transportation, which promotes sustainable transport behaviours. This correlation also somewhat explains the differences in transport behaviour between working and schooling young adults.

In addition, moving away from the family home is another important life change for young adults, which is also correlated with their transport behaviours. Bayart et al. (2020) found that in France, young adults living with parents were less likely to have a driving licence and drive for all their trips throughout the day. Young adults who do not live with their parents tend to obtain a driving licence in Toronto (Nurul Habib, 2018). In addition, Zhou (2012) found that in Los Angeles, university students living alone were more likely to commute by car by themselves.

Young adults' marriages and parenthood are also important life changes. They are usually accompanied by a move away from the parental home. These life changes may necessitate young adults to assume the responsibilities and demands of family life, which increases the need for more convenient car transportation (Berrington and Mikolai, 2014; Hjorthol, 2016; Licaj et al., 2012; Newbold and Scott, 2018). Berrington and Mikolai (2014) explained that young adults are more likely to obtain a driving licence when they are married or have children in the UK. In Canada, Norway, and France, young adults who become married or have children in their household are more inclined to drive and get a driver's licence, while the likelihood of using sustainable transport declines (Hjorthol, 2016; Licaj et al., 2012; Newbold and Scott, 2018). Whittle et al. (2022) found that people in the UK were less likely to increase their use of buses and trains when they had children. Thus, marriage and parenthood may partly explain why moving away from the parental home increases young adults' car use.

However, contrasting results have been found. For instance, Kuhnimhof et al. (2012b) noted that in Germany, the change from living with parents to an independent life was correlated with lower car ownership. This transition also reduced reliance on car commuting, possibly because of increased financial difficulties young adults experience when moving away from their parents' homes, which can result in a lower likelihood of

using a car. These financial difficulties could hinder young adults' car use and promote the use of sustainable transport behaviours. Indeed, buying a car or securing a driver's licence heralds young adults' profound life transition, which results in pushing for increased car dependency (Charreire et al., 2021; De Paepe et al., 2018; Licaj et al., 2012; Vale et al., 2018).

In addition to young adults' demographic and socioeconomic factors, in terms of young adults' transport behaviours Capability components could also include young adults' past behaviours and transport habit. Because past sustainable transport behaviours and habits can reflect the ability of young adults to choose sustainable modes of transport. Regarding young adults' past behaviours, several studies have found that young adults' past transport behaviours are correlated with their sustainable transport behaviour or car use (De Vos et al., 2022; Mjahed et al., 2015; Muromachi, 2017). For example, Carrus et al. (2008) argued that the past behaviour of using public transport instead of a car to go to work positively correlated with the desire to use public transport to work. Thøgersen (2006) found that past behaviour is related to public transport behaviour and show that the effects of attitudes towards the use of public transport, perceptions of whether public transport meets personal transport needs and car ownership on bus use are weakened when past behaviour is taken into account. This stems from the concept that repeated past actions might develop into habits (Garling and Axhausen, 2003; Wood and Rünger, 2016).

Habits are memory-based behaviour patterns created by prior events in stable environments or automatic correlations between expected outcomes and certain behaviours (Aarts and Dijksterhuis, 2000; Wood and Rünger, 2016). Bamberg and Schmidt (2003) highlighted the role of transport habits in transport behaviours. Moreover, Busch-Geertsema and Lanzendorf (2017) argued that forming transport habits hindered the possibility of changing commuter transport options. The influence of traffic habits on behaviour is only likely to be interrupted after an event (e.g. moving to a new residence) that causes a change in the traffic scenario (Verplanken et al., 2008).

In addition to the Capability components, Opportunity components such as built environment factors are also correlated with young adults' sustainable transport

behaviours. In terms of built environment factors, the residential location and its surrounding infrastructure play an important role in influencing young adults' sustainable transport behaviours. In terms of residential location, Hjorthol (2016) found that in Norway, the proportion of young adults living outside the city who held a driving licence was much higher than those living within the city. In addition, in Belgium, urban young adults are more likely to walk and less likely to drive than those living in rural areas (Simons et al., 2017b). Licaj et al. (2012) found that in France, controlling for a number of demographic variables, as well as household status (e.g. presence of children at home) and possession of a driving licence, a higher proportion of young people from rural areas and outer suburbs drive compared to those from urban centres. It is worth noting that this may be due to differences in car ownership between rural and urban households. Licaj et al. (2012) found the relationship between residential location and car use disappears after controlling for car ownership. Moreover, differences in transport behaviour between urban and rural areas may also be due to higher population densities in urban areas, where different land uses such as workplaces, educational centres, and recreational facilities are closely linked, thereby reducing transportation travel distances to some extent. This leads to a higher likelihood of travelling by active and public transport modes. Melia et al. (2018) found in the UK, there is a negative relationship between population density and the proportion of young adults driving cars for commuting to work.

In addition, differences in young adults' transport behaviour between urban and rural areas may also be related to the corresponding availability of sustainable transport infrastructure in different areas. Young adults' transport choices are much influenced by active and public transport infrastructure (Ewing and Cervero, 2010; Habib et al., 2018; Hino et al., 2014; Kärmeniemi et al., 2018; Teuber and Sudeck, 2021; Zhou, 2012). In terms of active transport infrastructure, Stankov et al. (2020) reviewed 39 existing studies and found that the development of bike lanes seemed to effectively increase the usage of bicycles. Moreover, Sahlqvist et al. (2015) highlighted the role of constructing active transport infrastructure in Cardiff, Kenilworth, and Southampton (e.g. cycle lanes and footpaths) in promoting a greater proportion of people participating in active travel. According to Goodman et al. (2013), in the UK, the closer people live to the active transport infrastructure, the more likely they are to use the transport infrastructure for active transport travelling. In terms of public transport infrastructure, Stankov et al. (2020) found

that the development of bus rapid transit effectively increased the usage of buses. Arentze et al. (2001) pointed out that in the Netherlands, the completion of the railway station reduced the distance travelled by car.

Notably, integrating active transport facilities and public transport facilities is necessary to promote sustainable transport behaviour better. Another study found that enhancing active transport infrastructure could shift 30% of trips under 5 km from cars and buses to active transport, while improving bus infrastructure could shift 50% of trips over 5 km from cars to buses (Jain and Tiwari, 2011). However, to optimise these outcomes, simultaneously improving active transport and bus infrastructure could increase these effects by 11% (Jain and Tiwari, 2011).

Although the role of transport infrastructure in transport behaviours among young adults has been highlighted, Nash and Mitra (2019) presented a more intricate perspective. They proposed that the initial transport preferences of young adults could influence their decisions about where to live, which subsequently shape their transport behaviours. The authors presented relevant examples that individuals with a preference for cycling might be drawn to neighbourhoods with well-developed cycling infrastructure. In contrast, those with a preference for cars could opt for areas more accommodating to automobile use. This disparity underscores the intricate interplay between transport preferences, residential choices, and ensuing transport behaviours.

Song et al. (2017) found that infrastructure alone might not be sufficient to promote sustainable transport behaviours. Most studies examining the interplay between the built environment and transport behaviours have also considered factors such as individual and household-level socioeconomic attributes. A paradox emerged from these investigations: communities with similar socioeconomic conditions exhibited diverse transport patterns. This finding underscores that although the influence of the built environment and socioeconomic factors at the individual and household levels is critical in young adults' transport behaviours, the difference in transport behaviours implies that additional factors may influence transport behaviours. Early studies, such as one by Semin and Manstead (1979), suggested that psychological attributes should also be considered as determinants

of behaviours. Anable (2005) suggested that psychological factors could be an additional factor influencing young adults' transport behaviour and found that such factors largely outweighed the influence of personal characteristics.

In addition to the Capability and Opportunity components, Motivation such as young adults' psychological factors are also correlated with young adults' sustainable transport behaviours. Existing research has highlighted the role of young adults' psychological factors in their transport behaviours (Hall and Allan, 2014; Jakovcevic and Steg, 2013; Kavta and Goswami, 2022; Matowicki et al., 2023; Scott-Parker et al., 2009; Simons et al., 2017a; van der Werff et al., 2013b). Nilsson and Kuller (2000) called for a focus on the influence of basic attitudes on transport behaviour. Maio et al. (2018) highlighted the role of attitudes in predicting behaviour. Attitudes toward different transport modes have been found to be correlated with young adults' transport behaviours (Busch-Geertsema and Lanzendorf, 2017; Lavieri et al., 2017; Zhou and Wang, 2019). For example, attitudes regarding cars, including pro-car attitudes associated with notions of independence and safety, influence car use (Nash and Mitra, 2019). Matowicki et al. (2023) highlighted that pro-car attitudes were negatively correlated with the willingness to abandon commuting by car. Zhou and Wang (2019) discovered notable distinctions among generational cohorts regarding their attitudes towards cars. Specifically, young adults exhibited less favourable attitudes towards private car ownership compared to older demographics (Zhou and Wang, 2019), which partly illustrates the potential for promoting sustainable transport choices amongst young adults. Moreover, Lavieri et al. (2017) showed that young adults' pro-car attitudes were positively associated with commuting by car, while pro-public transport attitudes contributed to their commuting by public transport.

In addition to attitudes toward different transport modes, young adults' pro-environmental psychological factors such as pro-environmental attitudes, environmental concerns, and attitudes towards environmental damage caused by car use increased the chances of using public and active transport with decreased driving (Bouscasse et al., 2018; Davis et al., 2012; Kim and Lee, 2023; Nash and Mitra, 2019; Nilsson and Kuller, 2000). However, several studies based on general population have reported discrepancies between sustainable transport behaviours and their psychological factors. For example, Gardner and

Abraham (2008) found based on general population, the influence of pro-environmental perceptions on car use behaviour has been found to be quite weak. Squalli (2024) underscored that pro-environmental attitudes were not correlated with using electric cars (a potentially sustainable transport option). The author argued that this attitude reflects environmental hypocrisy, where individuals express pro-environmental attitudes but engage in behaviours that do not align with those beliefs (ibid). The difference between pro-environmental psychological factors and behaviours is even more evident in the choice of commuting transport. Based on general population, Hall and Allan (2014) noted that while there was a correlation between pro-environmental attitudes (e.g. attitudes toward climate change) and energy-saving behaviours and transport choices in specific non-compulsory transport scenarios (e.g. shopping trips), this relationship did not apply to explaining sustainable transport choices on commuting journeys. In addition, pro-environmental attitudes (e.g. eco-beliefs and environmental concerns) were not associated with intentions to choose a sustainable commuting transport mode (de Groot and Steg, 2007; Sivasubramaniyam et al., 2020). A similar disconnect between psychological attitudes and transport behaviours has been observed among young adults. Zhou and Wang (2019) found no statistically significant effect of positive attitudes toward car use—particularly regarding the perceived instrumentality of private vehicles—on car ownership and car use among young adults. Nash and Mitra (2019) also reported that among university students in Toronto, perceptions of buses as being less safe than cars were not linked to their likelihood of using public transport for commuting. Furthermore, while young adults recognize the environmental benefits of cycling, only a small proportion (8%) indicated that reducing traffic congestion or pollution would motivate them to choose cycling as a mode of travel (Swiers et al., 2017). This further underscores the divergence between psychological factors and commuting behaviours among young adults.

Indeed, the differences between psychological factors and commuting transport behaviours may be attributed to three reasons. Firstly, attitudes generally influence actual behaviour through behavioural intentions (Ajzen, 1991). According to Zailani et al. (2016), past transport behaviours could influence the intention of transport choices. This idea offers the possibility that past car use may interrupt the transformation of pro-environmental attitudes into sustainable transport commuting behaviours by creating an intention to car commute. Moreover, past transport behaviour is often associated with forming transport habits.

Transport habits (i.e. the habit of using a car) may undermine the transformation of attitudes (e.g. positive attitudes towards trains) into behaviours (e.g. choosing trains) (Verplanken et al., 1994). Moreover, the stronger the traffic habit is, the weaker the attitude-behaviour relationship (Verplanken et al., 1994).

Secondly, travel constraints during commuting to work (e.g. time constraints) can prevent pro-environmental attitudes from being translated into sustainable commuting behaviours. As the time pressures of commuting (especially to work) increase, it is reasonable to choose a more convenient car (Jeekel and Rijkswaterstaat, 2014).

Thirdly, pro-environment attitudes may be less influential than attitudes towards transport modes (e.g. pro-car) when making commuting choices. Although car users are aware of the positive role that transport modes such as walking and cycling play in protecting the environment and health, these alternative modes of transport are not as good as the cars they use in terms of features such as convenience and flexibility (Anable and Gatersleben, 2005). Hence, commuters drive. Moreover, Nogueira et al. (2023) found that while commuters' attitudes related to environmental protection did not affect their transport choices, their attitudes towards transport modes had a significant effect. Kent (2014) also found that beyond choosing a car to save time, individuals' decisions to commute by car stemmed from positive attitudes towards the flexibility and autonomy offered. Overall, these three reasons suggest that although young adults with pro-environmental attitudes have the possibility of choosing sustainable transport options for their commutes, the pressure of commuting time, preference for cars (pro-car attitudes), past experiences of driving, and car use habits lead them to eventually choose cars for their commutes. Ergo, pro-environmental attitudes are inconsistent with sustainable transport choices for commuting.

Notably, in addition to the determinants of young adults' sustainable transport behaviours mentioned above, Haustein et al. (2009) suggested expanding research on the determinants of sustainable transportation behaviours in young adults to encompass factors associated with the socialisation processes they experience before adulthood. This aspect is also not addressed by the conceptual framework proposed by Kafi et al. (2024). Socialisation,

defined by Bugental and Goodnow (1998), is the process through which individuals acquire the skills necessary to function effectively within their social group. This process is a collaborative effort between experienced members and newcomers, where the former helps the latter develop the attitudes, behaviours, values, and motivations essential for social integration. As experienced members, parental behaviours and attitudes during the socialisation phase before the children reach adulthood play an important role in children's behaviours in young adulthood. Evans et al. (2018) found that if mothers demonstrated significant pro-environmental attitudes and behaviours, including those related to sustainable transportation, during their children's socialisation, their children were likelier to emulate such behaviours in adulthood. However, Evans et al. (2018) summarized the pro-environmental behaviours of parents and their children into a generalization that included energy conservation, sustainable transportation, eco-friendly purchasing behaviour, recycling, and social engagement. Previous research has suggested that it is necessary to discuss each pro-environmental behaviour separately rather than as a generalised concept (Karlin et al., 2014; Stern, 2000). Lynn (2014) argued that sustainable transportation behaviours face greater constraints, including time costs, insufficient infrastructure, and the limited accessibility of sustainable transportation modes, than NTPEB, such as energy conservation and eco-friendly purchasing behaviour (e.g. using reusable shopping bags and buying recyclable products). Therefore, a separate analysis is needed concerning the relationship between parents' behaviours and attitudes during their children's pre-adulthood socialisation phase and their children's sustainable transport behaviour in young adulthood.

Considering sustainable transport behaviours, Klöckner and Matthies (2012) found that parental high frequency of public transport behaviours during their children's adolescence (aged 15) negatively influenced their children's car use behaviours as young adults. Moreover, this negative influence could be mediated by children's car use habits as young adults (ibid). Döring et al. (2019) suggested that parents' past attitudes towards car use and commuting trips did not directly correlate with their children's car use in young adulthood. However, building on their previous 2014 research (Döring et al., 2014), Döring et al. (2019) speculated an indirect relationship between parents' past behaviours and attitudes and their children's transport behaviour in adulthood; the children's attitudes towards car use in adulthood acted as a mediating variable. Mjahed et al. (2015) supported this

inference to some extent. Mjahed et al. (2015) identified that parental pro-car attitudes during children's pre-adulthood socialisation (before high school) contributed to their children's negative attitudes towards walking in adulthood, which negatively impacted children's walking habits in young adulthood. Van Acker et al. (2019) showed that parental car ownership in their children's childhood can influence their children's public transport use in adulthood by influencing children's attitudes towards travel in adulthood. Therefore, it is possible that parents' transport related behaviours and attitudes before their children attain adulthood can shape their children's transport behaviours in adulthood by influencing their children's transport attitudes in adulthood.

It is worth noting that Sigurdardottir et al. (2013) found in Denmark, mothers' frequency of bicycle trips during their children's adolescence may indirectly influence their children's intentions to future cycle to work in adulthood by forming their children's negative attitudes towards cars in adolescence. This suggests, to some extent, that the children's transport attitudes in adulthood may have been developed before they reached adulthood by their parents' transport behaviours and attitudes. Moreover, these attitudes developed by children before adulthood may be maintained into adulthood, thus influencing their transport behaviour in adulthood. This may be the underlying mechanism for the relationship between the transport behaviours and attitudes exhibited by parents during their children's pre-adulthood socialization and their children's transport behaviours in adulthood.

Like previous research on adolescents' transport choices to school, previous research on young adults' sustainable transport behaviours has not analysed the role of parents' other behaviours, such as eco-friendly purchasing behaviours and energy-saving behaviours (i.e. NTPEB) and pro-environmental attitudes before their children attain adulthood (i.e. during their children's adolescence) in their children's sustainable transport behaviours as young adults.

2.2.4 Summary of empirical study of sustainable transport behaviour in adolescence and young adulthood

This section emphasizes the importance of a broad range of interconnected influencing factor of sustainable transport behaviours during adolescence and young adulthood by reviewing existing empirical research. In terms of adolescents' sustainable transport behaviours, this thesis focuses on adolescents' sustainable transport choices to school. Existing studies have revealed that adolescents' demographic factors like age, gender, and ethnicity correlate with their inclination towards sustainable transport modes for commuting to school. Moreover, parental factors, including employment status, education level, income, and car ownership, are significantly correlated with their children's choices of sustainable transport modes for commuting to school in adolescence. Adolescents from families with higher socioeconomic status commonly tend to use cars more.

In addition, parental psychological factors such as perceptions of different modes of transport, pro-environmental attitudes, and concerns about their children's safety influence sustainable transport to school during adolescence to some extent. It is worth noting that the correlation between the built environment and adolescent children's transport choices for commuting to school varies across studies. This variability is often linked to the influence of parental psychological factors, which are affected by the parents' own transport preferences, mediating the correlation between the built environment and adolescents' transport choices. The urban or rural living environment also influences adolescents' inclination towards active transport modes. In addition, an association exists between parental sustainable transport behaviour and their children's sustainable transport to schools in adolescence.

In young adulthood, demographic and socioeconomic factors (e.g. gender, ethnic background, employment status, and income level) are influential. Research has shown that young women are more likely to use public transport than men, and higher income often correlates with increased car usage. Key life transitions in young adulthood (e.g. moving to independent living, employment, marriage, and parenthood) significantly influence transport behaviours in young adulthood and often lead to a shift from reliance on

sustainable transport in adolescence to increased car use in young adulthood. Educational attainment remains an important factor, with higher education levels usually associated with lower car ownership and more frequent public transport use.

The characteristics of the living environment, whether urban or rural, along with the built environment, continue to play a significant role in shaping the sustainable transport behaviours in young adulthood, with urban areas typically promoting more sustainable transport behaviours. In addition, transport habits formed by past behaviours impact sustainable transport behaviours in young adults. Furthermore, psychological factors, including young adults' attitudes towards cars and pro-environmental attitudes, are pivotal in determining their transport preferences. It is important to acknowledge that the association between psychological factors and sustainable transport behaviours in young adults could undergo changes due to transportation constraints (such as time constraints during commuting to work) and transport habit formation resulting from past behaviours. Existing studies have also found that parental past sustainable transport behaviour may influence their children's sustainable transport behaviour in young adulthood by influencing children's psychological factors.

In conclusion, this section outlined key variables related to sustainable transport behaviours among adolescents and young adults from the existing empirical research to augment understanding and provided a strong grounding for the subsequent research in this thesis. This section also highlighted a notable research gap based on previous research. Prior studies have established a connection between parental sustainable transport behaviours during their children's socialisation (e.g. children's adolescence) and their children's sustainable transport behaviours during adolescence and young adulthood. However, it has not been explored whether there are similar links between parental NTPEB, such as eco-friendly purchasing behaviours and energy-saving practices, and their children's sustainable transport behaviours in adolescence and young adulthood. The next section argues for these possible links by reviewing studies on the intergenerational transmission of NTPEB from parents to their children.

2.3 Behavioural intergenerational transmission in socialisation

No research has investigated the correlations between parents' NTPEB before their children reach adulthood (e.g. during children' s adolescence) and their children's sustainable transport behaviours during adolescence and young adulthood (the research gap mentioned in Section 2.2). This section is based on previous research, mainly from an empirical and theoretical perspective, which may help explain these potential correlations to some extent. Subsection 2.3.1 discusses socialisation in adolescence. Next, Subsection 2.3.2 reviews existing empirical studies concerning the role of parental NTPEB during children's adolescence socialisation in children's similar behaviours and pro-environmental psychological factors during adolescence and young adulthood. Subsection 2.3.3 explains why there is a correlation between parents' NTPEB during their children's adolescence and their children's pro-environmental psychological factors during the same period based on self-determination theory, as described. Subsection 2.3.4 mainly outlines two psychological models, which suggest that children's these pro-environmental psychological factors, fostered by parental NTPEB, can potentially influence various behaviours, such as sustainable transport behaviours. Additionally, Subsection 2.3.5 highlights the potential correlation between parents' NTPEB during their children's adolescence and children's sustainable transportation behaviours during adolescence and adulthood. Finally, Subsection 2.3.6 elucidates the rationale behind prioritising mothers' behaviours in this thesis.

2.3.1 Socialisation in adolescence

According to Bugental and Goodnow (1998), socialisation based on self-determination theory refers to the process by which individuals acquire the essential skills to function effectively as members of their social group. This process involves an ongoing collaboration between experienced individuals and newcomers, with experienced individuals assisting newcomers in developing attitudes, behaviours, values, standards, and motives necessary for their integration into the social community. The process of socialisation typically begins in childhood. In the case of children, socialisation leads to various outcomes, including the development of self-regulating emotions, thoughts, and

behaviours, as well as the acquisition of attitudes and values (Corsaro and Fingerson, 2006). Moreover, the socialisation process is ongoing and remains a significant factor throughout adolescence, with a role similar to its function in childhood (Smetana et al., 2015). Socialisation has several forms, such as travel and consumer socialisation (Baslington, 2008; Haustein et al., 2009; John, 1999). Travel socialisation mainly focuses on learning processes related to transport behaviours.

According to social learning theory, during socialisation, the acquisition of behaviours often involves observing the behaviours of role models (Bandura and McClelland, 1977). Based on travel socialisation, children learn about transport modes through role models, much like how they learn about other aspects of behaviours (Baslington, 2008). Through qualitative interviews with children, Baslington (2008) showed that role models in the socialisation process influenced children's preferences for different modes of transport and their attitudes towards driving or owning a car in the future. Role models can take various forms in socialisation, including parents, media figures, friends, and teachers. Among them, parents are crucial in the socialisation of their children (Grusec and Kuczynski, 1997).

Although parents' influence is not as strong during their children's adolescence socialisation as it is during childhood, adolescents still show some degree of attachment to their parents (Youniss and Smollar, 1985). Nazneen and Asghar (2018) highlighted that parental modelling plays a significant role in shaping their children's behaviours and attitudes during adolescent socialisation. As role models, parents' behaviours and attitudes correlate with their children's formation of behaviours in socialisation (Grønhøj and Thøgersen, 2012; Guastello and Peissig, 1998; Nazneen and Asghar, 2018). The next subsection reviews empirical research on the relationship between the NTPEB of parents who act as role models during their children's socialisation and their children's behaviour in adolescence and young adulthood.

2.3.2 Empirical study on the role of parental NTPEB in children's behaviours in adolescence and young adulthood

Numerous studies have emphasised the crucial role of parental NTPEB in shaping their children's NTPEB (Ando et al., 2015; Grønhøj and Thøgersen, 2009, 2012; Matthies et al., 2012). These studies have primarily focused on the same NTPEB shared between parents and their children since these adolescents may copy their parents' behaviours.

Grønhøj and Thøgersen (2012) noted that parental NTPEB (e.g. appropriate waste management, environmentally friendly product purchases, and lower power consumption) influence the participation of adolescent children in the same behaviours. Grønhøj and Thøgersen (2012) found that compared with parental NTPEB, parental attitudes toward these behaviours had a less pronounced influence, which underscored that parental actions carry more weight than words in this context. Matthies et al. (2012) argued that the impact of parental behaviour on children varies according to the behaviour. For example, parents' recycling behaviours and praise or punishment can influence how their children recycle (Matthies et al., 2012). However, parents' paper reuse behaviours have a less pronounced effect on this behaviour in their children. Matthies et al. (2012) suggested that this difference is heavily attributed to the fact that behaviours such as reusing paper are less likely to be observed by their children to the extent that they cannot be imitated by their children. Moreover, de Leeuw et al. (2015) found that adolescent children' intentions towards engaging in NTPEB (e.g. environmentally friendly product purchases and lower power consumption) is correlated not only with their own perceived ability to control behaviours but also with descriptive norms. Descriptive norms were defined as adolescents' perceptions of their parents' engagement in NTPEB (ibid). Collado et al. (2019) used structural equation model and found that parents' NTPEB (e.g. waste disposal and resource conservation) and expectations of these NTPEB influenced their adolescent children's similar actions.

Importantly, parents' NTPEB before their children reach adulthood (e.g. during childhood or adolescence) may also shape their children's NTPEB in young adulthood. For example, in a longitudinal investigation, Evans et al. (2018) discovered that when mothers exhibited

substantial pro-environmental attitudes and behaviours before their children reached adulthood, these children were more inclined to adopt similar behaviours as young adults. Consequently, the NTPEB exhibited by parents during their children's adolescence influenced similar behaviours during adolescence and young adulthood.

Nevertheless, transmitting NTPEB from parents to their adolescent children is not solely a result of children observing and copying their parents. More significantly, parental NTPEB contribute to developing adolescent children's pro-environmental psychological factors (e.g. pro-environmental attitudes, value, and intention). Once these pro-environmental psychological factors take root, adolescent children independently make informed decisions regarding NTPEB. For instance, Ando et al. (2015) found that parental NTPEB such as waste management behaviours influenced their adolescent children's same behaviours directly (i.e. by serving as role models) and indirectly (i.e. by shaping their adolescent children's perceptions that their parents expected waste management behaviours from them). Furthermore, de Leeuw et al. (2015) found that adolescent children's NTPEB (including recycling, energy saving and green shopping behaviours) was indirectly related to same behaviours of their parents and others close to them, mediated by adolescent children's intentions of these NTPEB. Similarly, Wallis and Klöckner (2018) identified a indirect association between parents and adolescents engaging in NTPEB such as energy-saving behaviours. This indirect association was mediated by adolescents' perceptions of their parents' actions. Jia and Yu (2021) also reported similar results when examining NTPEB such as energy conservation, waste reduction, and disposal practices among parents and adolescents. Gong et al. (2022) asserted that parents' NTPEB such as environmentally friendly consumption behaviours directly impacted adolescent children's eco-friendly purchasing behaviour values.

Collado et al. (2017) found that parents' pro-environmental behaviour impacted adolescents' pro-environmental attitudes, which, in turn, were crucial in shaping adolescents' pro-environmental behaviours. Collado et al. (2017) employed different methods and scales to measure the pro-environmental behaviours of parents and children. The scale used to measure parents' pro-environmental behaviours was the General Environmental Behaviours (GEB) scale, with over 50 items covering (1) energy

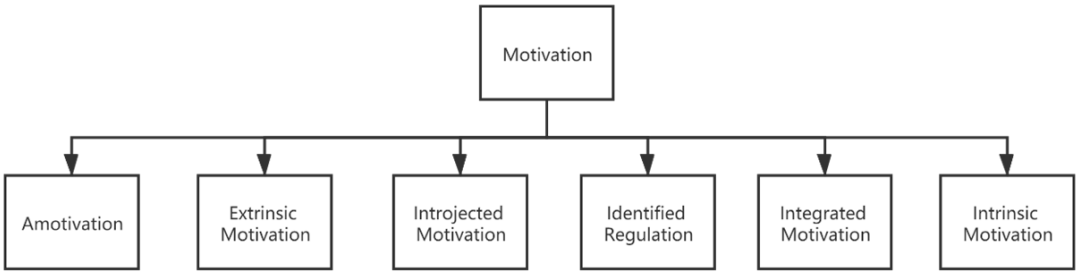
conservation, (2) transportation behaviours, (3) waste avoidance, (4) green consumption, (5) recycling, and (6) social commitment. In contrast, the scale used to measure children's pro-environmental behaviours had only 29 items. Some aspects, such as eco-friendly purchasing behaviour, were not observed. For instance, in measuring children's eco-friendly purchasing behaviour, no items assessed behaviours like purchasing recycled products or refraining from buying products with excessive packaging since young people are generally less likely to engage in shopping independently. This discrepancy suggests that the relationship between parents' and children's pro-environmental behaviours may not be limited to identical behaviours. Moreover, parents' NTPEB influence children's pro-environmental psychological factors (e.g. pro-environmental attitudes) in their children. Once a child's pro-environmental psychological factors are formed, they are reflected in a range of behaviours, such as sustainable transport behaviours beyond the specific NTPEB initially observed in parents.

These findings collectively argue that parents' NTPEB can influence adolescent children's same behaviours by shaping various associated pro-environmental psychological factors, including perceptions, values, attitudes, and intentions. The subsequent subsection uses self-determination theory to explain why parents' NTPEB affect adolescents' pro-environmental psychological factors.

2.3.3 Self-determination theory

Self-determination theory is one approach to analysing human motivation and behaviours. The earliest work leading to self-determination theory began in the 1970s and was formally established in the 1980s (Deci and Ryan, 1980; Deci and Ryan, 1985). Since then, the formal theory and its applications have expanded significantly to a variety of life domains, including education, physical activity, health, and the prediction of pro-environmental behaviours (de Groot and Steg, 2010; Grolnick et al., 1997; Weiner, 1990). The theory suggests that motivation is a complex precursor of behaviours, which depend on various levels of self-determination (Deci and Ryan, 1980). Self-determination theory defines six types of motivation (Deci and Ryan, 2013), which differ according to the regulation type, causality, and associated regulatory processes, as shown in Figure 2-1.

Figure 2-1. Six motivation types in self-determination theory



Firstly, amotivation reflects a lack of control, intention, or action without intent and represents the least self-determined motivation. Amotivation (e.g. not knowing why to participate in NTPEB) is negatively correlated with NTPEB such as recycling behaviours and purchasing environmentally friendly products (Green-Demers et al., 1997). In terms of transport behaviours, de Groot and Steg (2010) found that amotivation was negatively correlated with choosing a car that performed well in terms of environmental aspects.

Intrinsic motivation represents the most self-determined type and is characterised by self-regulation processes driven by personal satisfaction, inherent interest, and enjoyment derived from engaging in the behaviours (Deci and Ryan, 1980). Steg (2016) pointed out that intrinsic motivation to engage in action to pro-environmental is common, given the good sense of self that comes from protecting the environment. Furthermore, Steg (2016) argued that people are more likely to engage in pro-environmental behaviours driven by intrinsic motivation when they perceive that the behaviours engaged in are highly aligned with their own biospheric values. Based on self-determination theory, Tabernero and Hernández (2010) found a positive correlation between intrinsic motivation and engagement of NTPEB such as recycling behaviours. van der Werff et al. (2013a) pointed out that intrinsic motivation was associated with sustainable transport behaviours and NTPEB such as energy conservation, and recycling behaviour.

Between these two extreme motivations are four external motivation types: extrinsic motivation, introjected motivation, identified regulation, and integrated motivation. They are classified based on varying degrees of self-determination (Deci and Ryan, 2013). Individuals with a high level of self-determination regarding engagement in behaviours perceive themselves as the initiators of these actions. Conversely, individuals with lower levels of self-determination, who are coerced into behaviours, perceive a diminished sense of control and autonomy, which leads to an unstable basis for these actions that is unlikely to be sustained over time (ibid). Webb et al. (2013) confirmed this notion and found a statistically significant positive correlation between motivation with higher levels of self-determination, such as identified regulation, integrated motivation, and energy-saving behaviours. In contrast, other motivations (i.e., lower levels of self-determination) did not correlate statistically with energy-saving behaviours. The four types of external motivation are elucidated below.

Extrinsic motivation describes behaviours driven by external demands and expectations that signify a lack of self-determination.

Introjected motivation involves engaging in behaviours to avoid guilt, shame, or disapproval from others and is less of a self-determined form.

Identified regulation is a more self-determined form of external motivation, where individuals see the action as personally important and integrated into their identity.

Finally, integrated motivation is the most self-determined form of external motivation, which indicates that behaviours are fully assimilated into the self and align with the individual's values and attitudes. In terms of behaviour based on integrated motivation, although people may still not consider it interesting, they have accepted the reasons for this behaviour.

Several studies have found that during childhood, engagement in NTPEB is often driven by less self-determined external motivation, such as extrinsic motivation (e.g. parental expectations) or introjected motivation (e.g. guilt) (Ando et al., 2015; Pearce et al., 2021). Extrinsic motivation may be parental requirements and expectations. Ando et al. (2015) noted that parental expectations of children's NTPEB such as paper-saving behaviour influence children's that behaviour. Grønhøj and Thøgersen (2017) explained that children's introjected motivation (e.g. feeling guilty for not engaging in NTPEB, such as sorting waste, buying organic or eco-friendly products, and conserving electricity) might motivate them to adopt these NTPEB. Moreover, introjected motivation might prompt children to emulate their parents' NTPEB to evade guilt or seek parental approval.

However, according to self-determination theory, several investigations have demonstrated that as children grow up as adolescents and young adults, they possess higher levels of self-determined external motivation, such as integrated motivation and identified regulation. These significantly influence the decision to partake in various NTPEB such as recycling and purchasing environmentally friendly products (Green-Demers et al., 1997). Among college students (i.e. young adults), the link between higher self-determined external motivation and NTPEB appears stronger for actions requiring more time, effort, and resources (Green-Demers et al., 1997).

Differences in motivation for NTPEB in childhood, adolescence, and young adulthood may be due to the internalisation of motivation over time. Grolnick et al. (1997) found that extrinsic or introjected motivation (e.g. motivation with lower levels of self-determination) may evolve into more self-determined forms and more internalised motivation as individuals mature. Internalised motivation encompasses forms such as identified regulation and integrated motivation. Hence, although self-determination theory is not strictly a developmental theory, it offers valuable insights into the progression of internalised motivation as individuals mature. Chandler and Connell (1987) supported this developmental progression in internalising motivation with age and found that extrinsic motivation occurred more frequently at younger ages, while internalised motivation (integrated motivation) occurred more frequently at older ages. Chandler and Connell (1987) demonstrated that this shift process is rooted in advancing cognitive abilities.

Renaud-Dube et al. (2010) suggested that as individuals mature, the motivations behind NTPEB such as recycling, paper reuse, and energy conservation may gradually shift from lower self-determined motivation (e.g. extrinsic or introjected motivation) towards greater self-determined motivation (e.g. identified regulation or integrated motivation) and become integrated into their attitudes and value systems. Notably, this transformation from extrinsic or introjected motivation to integrated motivation from childhood to adolescence and young adulthood is coupled with the development of pro-environmental psychological factors such as pro-environmental attitudes.

Transformation from introjected to integrated motivation partly explains why parents' NTPEB correlate with their adolescent children's pro-environmental psychological factors (mentioned in Subsection 2.3.2). Specifically, when children initially engage in NTPEB like reducing electricity use, eco-friendly purchasing behaviours, and recycling, the motivation tends to be derived from parental-influenced external motivation, such as introjected motivation. One explanation for introjected motivation is that children avoid parental disapproval by engaging in the same behaviours as their parents. This phenomenon partly elucidates the resemblance in NTPEB between parents and their children during this developmental stage. However, as children mature, the motivation to engage in NTPEB may be internalised, for example, into identified regulation and integrated motivation. This notion was supported by Grønhøj and Thøgersen (2017), who argued that adolescents do not merely mimic their parents' NTPEB (e.g. eco-friendly purchasing behaviours, waste management, and energy conservation). Instead, adolescents' internalised motivations (e.g. integrative motivations) for NTPEB develop through the continued imitation of parental behaviours.

Parents who consistently practice NTPEB and encourage their children to participate in these activities as family practice not only conveys parental norms but also provide an opportunity for their children to develop an internalised motivation for such behaviours, as demonstrated by Matthies et al. (2012). Internalised motivation (e.g. integrated motivation) is usually aligned with pro-environmental psychological factors, such as pro-environmental attitudes and values. Consequently, a correlation develops between parental engagement in NTPEB and pro-environmental psychological factors in adolescents. Once these pro-

environmental psychological factors are established in adolescence, they catalyse a range of behaviours beyond the specific NTPEB initially observed in parents. The next subsection focuses on the theories related to the influence of pro-environmental psychological factors on behaviour.

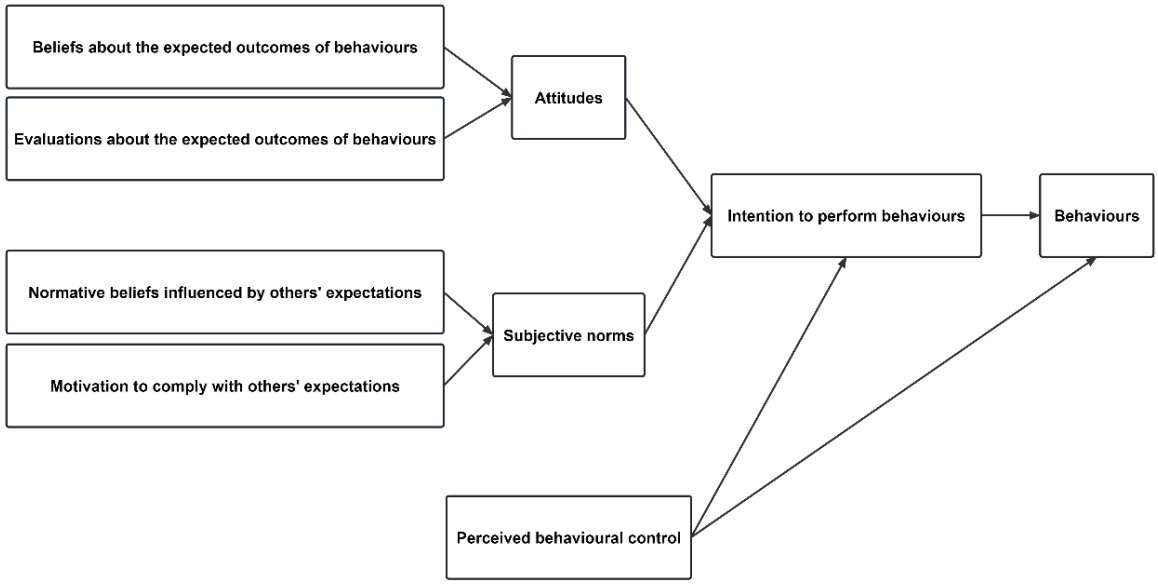
2.3.4 Models and theories related to the relationship between behaviours and psychological factors

Prior studies have demonstrated that parents' NTPEB influence adolescent children's pro-environmental psychological factors such as pro-environmental attitudes and values. This subsection mainly explores two psychological models that separately elucidate the influence of attitudes and values on behaviours.

Within the domain of transport research, theoretical models and theories emphasise the crucial role of psychological factors in shaping sustainable transport-related choices and performances. The psychological literature identifies a strong link between attitude, intention and behaviours, which is fundamental to theories such as the theory of reasoned action (Fishbein and Ajzen, 1977) and the theory of planned behaviour (Ajzen, 1991).

According to the theory of reasoned action illustrated in Figure 2-2, the intention to perform a behaviour directly leads to the behaviour itself, which signifies a conscious choice to engage in the behaviour. This intention is mediated by two primary constructs: the individual's attitudes towards the behaviour and subjective norms. Attitudes towards the behaviour are the extent to which a person potentially evaluates the behaviour in question positively or negatively based on beliefs and evaluations about the expected outcomes of the behaviour (Bohner and Dickel, 2010; Defleur and Westie, 1963; Eagly and Chaiken, 1993). In the context of transport studies, these attitudinal variables often relate to individuals' attitudes towards different modes of transport, attitudes towards the transport infrastructure, and pro-environmental attitudes (Alcock et al., 2017; Arroyo et al., 2020; Đukičin Vučković et al., 2018).

Figure 2-2. Theory of reasoned action and theory of planned behaviour (Ajzen, 1991)



Furthermore, subjective norms add another dimension to the interplay between attitudes and behaviours. Subjective norms pertain to the perceived social pressure that encourages or deters a person from engaging in a particular behaviour (Fishbein and Ajzen, 1977). In the theory of reasoned action, subjective norms are shaped by two main factors. The first is the behavioural decision-maker's normative beliefs, which are influenced by the expectations and desires of others, as necessary to the decision-maker's behaviours as consistent with extrinsic motivation in the self-determination theory described earlier. External factors such as parents' expectations (and those of others important to the children) can influence children's normative beliefs. Children can perceive their parents' expectations, which shape their perceived social pressures, known as subjective norms, which ultimately influence children's behaviours. The subjective norm is consistent with introjected motivation in the self-determination theory. Therefore, according to the theory of reasoned action, normative beliefs (i.e. extrinsic motivation) somewhat form subjective norms (i.e. introjected motivation). Hence, extrinsic motivation can influence the formation of introjected motivation, which supports the internalisation of motivation in Subsection 2.3.3. Another major factor in forming subjective norms is the decision-maker's motivation to comply with these expectations (Fishbein and Ajzen, 1977).

Despite its initial acceptance, the theory of reasoned action has faced criticism for not adequately addressing situations where individuals do not have complete control over their actions. Physical and social barriers and a lack of opportunities to learn certain behaviours can contribute to an inability to control these behaviours and can interfere with intentions and behaviours (Biggar and Ardoin, 2017). Ajzen (1991) developed the theory of planned behaviour to address this limitation as an extension of the theory of reasoned action. As depicted in Figure 2-2, the theory of planned behaviour introduces an additional component known as perceived behavioural control. Perceived behavioural control reflects individuals' confidence in their ability to execute the action and usually consists of perceived control, perceived confidence, and perceived difficulty (Kraft et al., 2005). Perceived behavioural control influences the intention to partake in a behaviour (Sheeran et al., 2002) and directly affects behaviours by determining their feasibility (Terry and O'Leary, 1995). Ajzen and Madden (1986) stated that the theory of planned behaviour predicts intentions and behaviour more accurately than the theory of rational action.

The theory of planned behaviour has been useful in comprehending human behaviour, particularly in the context of sustainable transportation behaviours and NTPEB. The engagement of NTPEB such as recycling (Chan and Bishop, 2013; Mannetti et al., 2004), waste management (Hu et al., 2021), and energy use (Clement et al., 2014) have all been clearly explained using this theory. Furthermore, several studies have shown the effectiveness of the theory of planned behaviour in analysing sustainable transport behaviours, including walking (Rhodes et al., 2006), cycling (Bird et al., 2018), and public transportation (Ali et al., 2023).

Behavioural intention is a fundamental component from the standpoint of psychological elements described in the theory of planned behaviour. Several studies have incorporated behavioural intentions into the analysis of transport behaviour (Abdullah et al., 2021; Huang et al., 2022; Jaiswal et al., 2021). Existing research has found a notable association between intention and actual transport behaviours based on general population (Gardner and Abraham, 2008). By analysing transport behavioural intentions, planners and decision-makers can gain an early understanding of an individual's potential future transport choices (Gehlert et al., 2013).

Among the factors influencing intentions, perceived behavioural control is usually considered the significant factor related to intentions and behaviour within the framework of the theory of planned behaviour. Armitage and Conner (2001) showed that incorporating perceptual behavioural control into a model improves predictive power. In addition, subjective norms are crucial in influencing behaviour (Meng et al., 2024). Previous research on transport behaviours has shown that subjective norms influence behavioural intentions and actual behaviours (Ali et al., 2023).

Finally, the significant role of attitudes in shaping the intention to engage in behaviours is acknowledged, with this intention subsequently determining the behaviours themselves. Numerous studies grounded in the theory of planned behaviour have examined the impact of pro-environmental attitudes on corresponding NTPEB such as waste management, energy efficiency, and water conservation (Liu et al., 2020; Millock and Nauges, 2010). Regarding transport research, Hess et al. (2013) highlighted that respondents who regularly use cars have weak pro-environmental attitudes. In addition, households of individuals who held pro-environmental attitudes possessed fewer cars and utilised them less frequently than those who did not exhibit pro-environmental attitudes (Flamm, 2009).

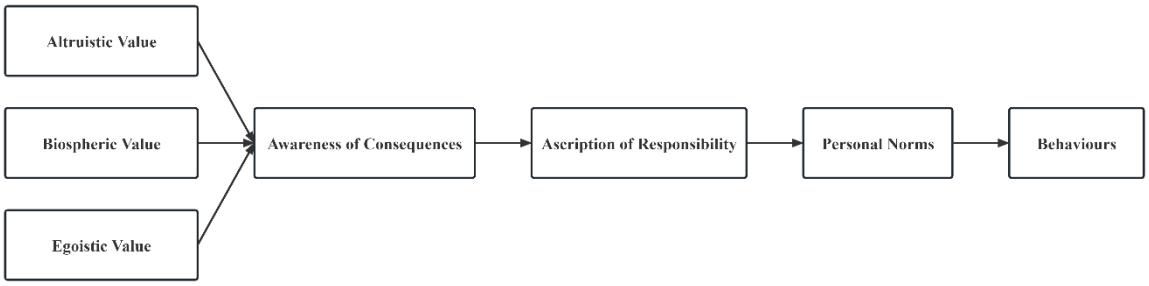
In addition to attitudes, research has found a link between parents' NTPEB and children's values (Gong et al., 2022). The value-belief-norm model also provides a relationship between values and behaviour. The value-belief-norm model is designed to understand the factors that lead to altruistic actions (Schwartz, 1977), specifically those that benefit the environment at a personal cost (Stern et al., 1999). The value-belief-norm model comprises three core elements: the awareness of consequences, the ascription of responsibility, and personal norms, as shown in Figure 2-3.

These elements create a sequential structure predicting altruistic behaviours, including adopting sustainable transport and NTPEB. Firstly, the awareness of consequences involves recognising the negative effects of environmentally harmful behaviours, like using cars (Ünal et al., 2019). Personal values such as altruistic, biospheric, and egoistic

values influence the awareness of environmental consequences and foster a stronger sense of responsibility to mitigate the adverse effects caused by environmentally harmful behaviours (Stern et al., 1999). A link between altruism, biosphere and egoistic values has also been noted (Aoyagi-Usui et al., 2003).

The ascription of responsibility entails the perception of personal accountability for the environmental impact of one's actions. Awareness of consequences and ascription of responsibility emphasises the importance of being aware of the consequences of one's actions and personal responsibility for the consequences of behavioural choices. This awareness and responsibility category may derive from a person's favourable or unfavourable evaluation of behaviour (i.e. attitude) in the theory of reasoned action and theory of planned behaviour. Lastly, the personal norms relate to the individual's sense of moral duty to act for collective welfare (Schwartz, 1977). Personal norms refer to feelings of moral duty or obligation to perform specific actions. For example, a sense of personal responsibility to reduce one's carbon footprint can lead to choosing more sustainable transport options.

Figure 2-3. The value-belief-norm model (Stern et al., 1999)



Research has extensively used the value-belief-norm paradigm to explain many NTPEB like waste sorting, recycling, and sustainable purchasing habits (Nketiah et al., 2022; Setiawan, 2021; Yang et al., 2020). In addition, these models have been extended to study transport-related behaviours (Ashraf Javid et al., 2021; Mehdizadeh et al., 2019a; Mehdizadeh et al., 2019b). For instance, Abrahamse et al. (2009) found that personal

norms, such as feeling a moral obligation to reduce car use and an awareness of the consequences, evaluated by the perceived severity of car-related environmental issues, were negatively correlated with car commuting in Canada. Likewise, personal norms have been demonstrated to forecast sustainable travel preferences in Norway (Lind et al., 2015). Furthermore, an awareness of the consequences influences personal norms, such as the willingness to reduce personal car use among the Swedish (Nordlund and Garvill, 2003).

According to subsection 2.3.2, when parents demonstrate NTPEB, they can develop pro-environmental psychological factors, such as pro-environmental attitudes and biosphere values, in their adolescent children. Pro-environmental attitudes and values can influence various NTPEB and sustainable transport behaviours. Consequently, parental NTPEB could foster a broader spectrum of behaviours in children beyond merely emulating observed parental NTPEB. The next subsection highlights the potential relationship between parents' NTPEB during their children's adolescence and their children's sustainable transportation behaviours during adolescence and young adulthood.

2.3.5 The correlation between parents' NTPEB and their children's sustainable transport behaviours in adolescence and young adulthood

Evidence suggests that parents' NTPEB, such as eco-friendly purchasing behaviours and energy savings, can influence the pro-environmental psychological constructs in adolescent children (mentioned in Subsection 2.3.2). Importantly, according to psycho-behavioural theory mentioned in Subsection 2.3.4, once these pro-environmental psychological (e.g. pro-environmental attitudes) are established, they can catalyse a range of behaviours that go beyond the specific NTPEB initially observed in parents, according to the theory of planned behaviours.

As children become adolescents, their involvement in decision-making and autonomy increases (Horgan et al., 2015; Wray-Lake et al., 2010). As a result, adolescents may be involved in decision-making about school transport options and make appropriate transport decisions based on their psychological constructs (Tristram et al., 2023). Kamargianni et al.

(2015) emphasised the importance of including adolescents' psychological factors (e.g. subjective attitudes) when analysing their transport choices for commuting to school. Therefore, fostering pro-environmental psychological constructs (e.g. pro-environmental attitudes) in adolescents through parental NTPEB can be hypothesised to increase adolescents' inclination toward sustainable transport choice for commuting to school.

In terms of children in young adulthood, although existing research has found a relationship between the NTPEB exhibited by parents during their children's adolescence and children's psychological factors during adolescence, whether this relationship persists into children's young adulthood remains unknown. In other words, the connection between parents' NTPEB during their children's adolescence and children's pro-environmental psychological factors in young adulthood is ambiguous.

However, this relationship may exist to some extent based on previous studies on the relationship between past parental transport behaviours (or factors related to transport behaviours) and children's transport-related psychological factors in young adulthood. For example, Van Acker et al. (2019) showed that parental car ownership can influence children's attitudes towards travel in adulthood. Moreover, parents' past attitudes towards transport modes (before their children attend high school) have a lasting impact on their children's attitudes towards transport modes in adulthood (Mjahed et al., 2015).

Sigurdardottir et al. (2013) found that mothers' frequency of bicycle trips during their children's adolescence may influence children's intentions to cycle to work in adulthood. Therefore, parents' transport behaviours (or other factors related to transport behaviours) before their children attain adulthood may shape children's transport-related psychological factors in adulthood. Hence, parents' NTPEB during their children's adolescence can be hypothesised to potentially influence children's pro-environmental attitudes in young adulthood. Given that pro-environmental attitudes in early adulthood are determinants of sustainable transport behaviours, children's pro-environmental attitudes in early adulthood may mediate the relationship between parents' NTPEB during children's adolescence and their children's sustainable transport behaviours in adolescence and adulthood.

2.3.6 Mothers as the main research target

This thesis primarily aims to analyse the role of parental NTPEB on their children's sustainable transport behaviours during adolescence and young adulthood. Moreover, this thesis prioritises the role of mother's NTPEB. The decision to focus on mothers is underpinned by three key factors.

Firstly, mothers spend more time with their children than fathers (Baxter and Smart, 2011). Given the longer time spent with their children, children may be more likely to observe their mothers' NTPEB. It is important to note that parents' NTPEB are seen as a prerequisite for intergenerational transmission of behaviours (Matthies et al.,2012).

Secondly, mothers are responsible for more childcare than fathers (Hipp and Bünning, 2021). Therefore, mothers' NTPEB may have a greater influence on forming their children's pro-environmental psychological factors and behaviours. Collado et al. (2019) highlighted that adolescents' perceptions of their mothers' NTPEB, such as recycling, have a more significant impact on their recycling behaviours than their perceptions of their fathers' NTPEB. Thus, when mothers and fathers engage in the same NTPEB, the observed NTPEB of mothers have a more substantial influence on their children's NTPEB than the fathers' NTPEB. Moreover, adolescents' perceptions of their mothers' NTPEB may influence their pro-environmental psychological factors such as personal norms (e.g. whether they feel morally obliged to adopt NTPEB). However, adolescents' perceptions of their fathers' NTPEB do not influence their personal norms (Collado et al., 2019).

Lastly, mothers also influence their children's traffic behaviours more than fathers. Research conducted in Belgium, Greece, Hungary, Germany, and Norway has suggested that mothers' health-positive behaviours, including walking and cycling, are likely to have a greater impact on adolescent children than fathers' behaviours (Schoeppe et al., 2017). Additionally, research based on data from the UK National Travel Survey (2002–2006) demonstrated that mothers' behaviours related to car usage have a more substantial impact

on influencing their children's increased use of cars in their daily travel modes during pre-adulthood compared to the influence of fathers (Susilo and Liu, 2016). Therefore, mothers' transport behaviour has a greater impact on their children's transport behaviour before adulthood, compared to fathers. This can be attributed to the fact that mothers often shoulder the responsibility of escorting children to and from school (Motte-Baumvol et al., 2017). When mothers frequently use cars for work commutes, they tend to increase the likelihood of their children school commuting by car, which leads to a higher prevalence of car usage among their children. Hsu and Saphores (2014) further discovered that, in American, even among parents with similar concerns and attitudes regarding chauffeuring behaviours, mothers were more likely than fathers to chauffeur their children to school. A qualitative analysis by Tristram et al. (2023) noted that fathers were usually less aware of their adolescents' travel behaviours and less involved in the decision-making process in Germany. These findings underscore the pivotal role of mothers in shaping their children's behaviours.

2.3.7 Summary of behavioural intergenerational transmission

Section 2.3 explains how parents' NTPEB during their children's adolescence can potentially influence their children's adoption of sustainable transport behaviours during adolescence and young adulthood by reviewing the research on intergenerational transmission of NTPEB from parents to children.

Section 2.3 first explores the concept of adolescent socialisation and its key role in shaping individual attitudes, values, and behaviours. Subsequently, Section 2.3 considers the role of parents' NTPEB during their children's adolescence in their adolescent children's same behaviours. Many studies have convincingly shown that parental NTPEB during their children's adolescence can influence their adolescent children's same NTPEB and pro-environmental psychological factors such as pro-environmental attitudes. Once children's pro-environmental psychological factors instilled by parents' NTPEB are firmly established during children's adolescence, they can extend to various NTPEB and sustainable transport behaviours. This extension may not be confined to the specific NTPEB of the parents that initially shaped their children's pro-environmental

psychological factors. Consequently, this research hypothesises that parents' NTPEB during their children's adolescence may heighten adolescents' inclination towards sustainable transport choice for commuting to school.

Attention turns to the enduring impact of parental NTPEB during their children's adolescence on children's pro-environmental psychological factors and sustainable transport behaviours in young adulthood. This section posits that the connection between parents' NTPEB during their children's adolescence and the development of children's pro-environmental psychological constructs, such as pro-environmental attitudes, persists into young adulthood. This persistence may contribute to the relationship between parental NTPEB during their children's adolescence and their children's sustainable transport behaviours in young adulthood. Finally, Section 2.3 details why this study prioritises examining mothers' behaviours.

In summary, Section 2.3 underscored mothers' pivotal role as influential role models in shaping their children's pro-environmental psychological constructs and sustainable transport behaviours during adolescence and young adulthood. This section argued for the possible long-term impact of mothers' NTPEB on developing their children's pro-environmental psychological factors, such as pro-environmental attitudes. These pro-environmental psychological factors, in turn, influence children's sustainable transport behaviours during adolescence and young adulthood. This theoretical framework serves as the foundation for the empirical research that follows in this thesis. The next chapter details the methodology used for the empirical research of this thesis.

Chapter 3. Methodology

The purpose of this chapter is to describe the research methodology used for the subsequent empirical research in this thesis. Section 3.1 introduces the research hypotheses derived from the literature review (mentioned in Chapter 2) and the logical framework of these research hypotheses. Additionally, it delineates the adoption of quantitative analysis as the principal research methodology and the rationale for selecting the UK as the research location. Section 3.2 presents the UK Household Longitudinal Study, which constitutes the primary data source for this thesis. Subsequently, Section 3.3 presents an in-depth explanation of the analytical methods and modelling techniques used throughout this dissertation. These methodologies encompass multinomial logistic regression modelling, structural equation modelling, and integrated choice and latent variable modelling. Moreover, section 3.3 considers the theoretical foundations associated with these statistical models.

3.1 Study design

This section describes the research design of this thesis, with the research hypotheses and their logical framework. It also expounds on adopting quantitative analysis as the primary research methodology and provides the rationale for selecting the UK as the research location.

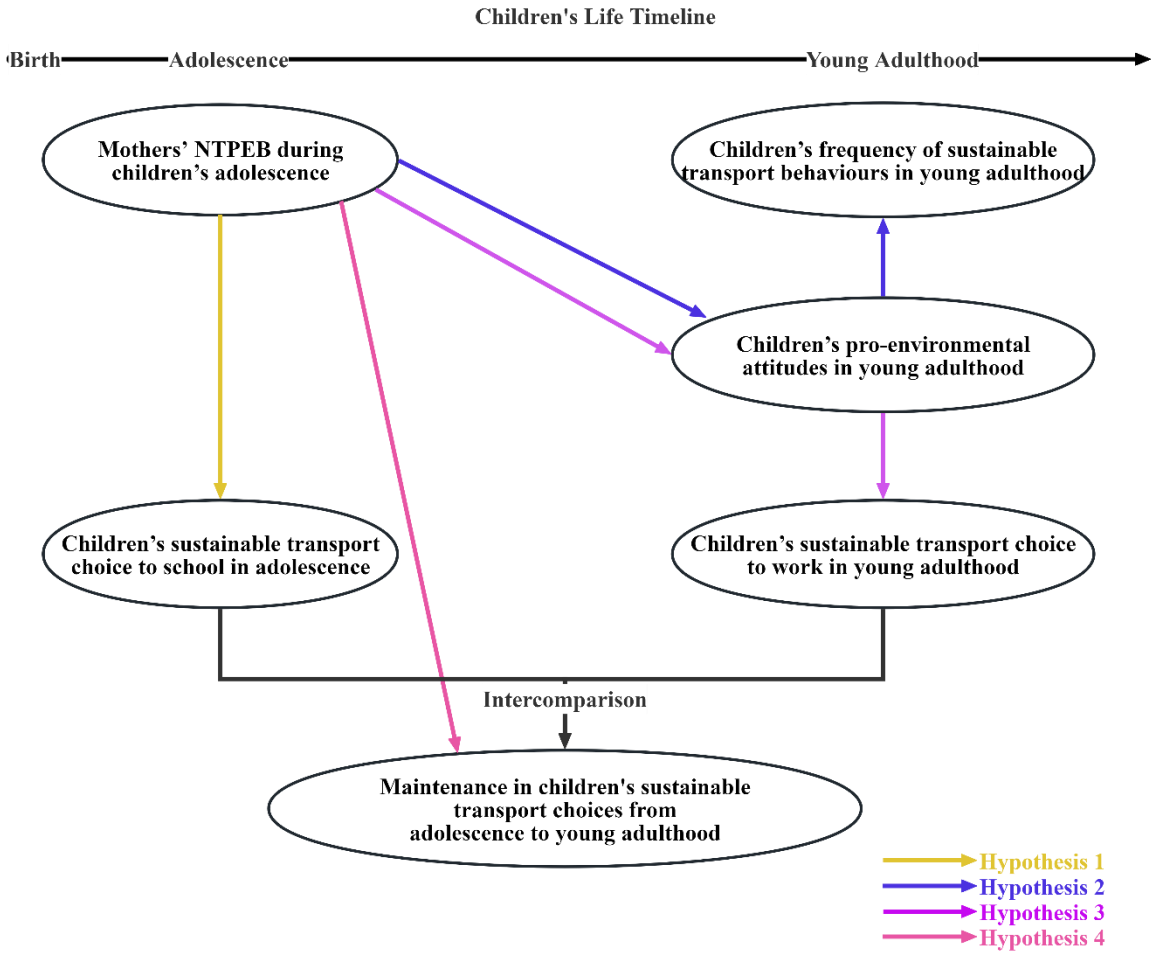
3.1.1 Main hypotheses based on previous studies

This thesis conducted a literature review and provided an in-depth understanding of the research questions posed in Section 1.3. Moreover, hypotheses were formulated for the proposed research questions based on previous studies. Hypotheses are more formal predictions of the research findings (Barroga and Matanguihan, 2022). Based on the literature review, four main hypotheses were formulated for the main research questions. Figure 3-1 exhibits the underlying logic of these hypotheses.

The first hypothesis is that mothers' NTPEB (e.g. eco-friendly purchasing and home energy conservation behaviours) during their children's adolescence are correlated with their children's choice of sustainable transport for commuting to school during adolescence.

The second hypothesis is that mothers' NTPEB during their children's adolescence are related to the frequency of sustainable transport behaviours in their children's young adulthood through children's pro-environmental attitudes during their young adulthood. The frequency of sustainable transport behaviours contributes to understanding children's overall propensity for sustainable transport in their daily lives during young adulthood.

Figure 3-1. Logical framework of the hypothesis



The third hypothesis proposes an association similar to Hypothesis 2 between mothers' NTPEB during their children's adolescence and their children's choice of sustainable transportation modes for commuting to work during young adulthood. Work-related trips often involve more constraints (e.g. time constraints) that may influence transportation choices differently. Therefore, this thesis separately analysed the role of mothers' NTPEB in their children's overall frequency of sustainable transportation behaviours and their choice of sustainable transportation mode for commuting to work in young adulthood. This differentiation was essential to account for potential variations in the impact of mothers' behaviours across different contexts. By examining these aspects separately, this study provided a more precise and detailed understanding of the role of mothers' NTPEB in shaping their children's sustainable transportation behaviours in young adulthood.

Finally, the fourth main hypothesis suggests an association between mothers' NTPEB during their children's adolescence and their children's consistent selection of sustainable transportation choices for commuting to school in adolescence and commuting to work in young adulthood. The subsequent four empirical research tested these four hypotheses sequentially.

3.1.2 Quantitative analyses

The hypotheses presented in this thesis are grounded in the concept of travel socialization. Both quantitative and qualitative research methods have been widely applied in travel socialization studies (Baslington, 2008; Klöckner & Matthies, 2012; Sigurdardottir et al., 2013). In terms of qualitative research methods, Mwita (2022) pointed out that in social science, qualitative methods offer flexibility, allow for in-depth insights, and accommodate diverse data collection approaches, they also help minimize data loss. However, it is important to acknowledge the limitations of qualitative research. Qualitative methods are limited by researcher subjectivity, restricted research scope, and challenges in generalizability and replicability (Mwita, 2022). Given the broad research big scope of this

study, which focuses on the entire UK context, qualitative methods may not be appropriate for testing the hypotheses proposed in this thesis.

Therefore, to empirically test the hypotheses, this thesis adopts a quantitative research approach. The following reasons support the choice to use quantitative methods. Firstly, quantitative research has the advantage of validating or refuting these hypotheses through empirical evidence (Rana et al., 2020; Martin and Bridgmon, 2012). This thesis drew on the existing research to formulate four hypotheses regarding the relationships between mothers' NTPEB during their children's adolescence and their children's sustainable transportation behaviours during adolescence and young adulthood. The quantitative methods allowed for examining correlations between variables and scrutinising theoretical propositions, facilitating rigorous statistical analyses, and testing hypotheses (Rana et al., 2020). In addition, quantitative methods were used to assess the strength and direction of these hypothesised relationships through various data analysis methods to understand these relationships (Rana et al., 2020). Moreover, psychological variables, such as children's pro-environmental attitudes in young adulthood, were addressed in the research questions of this thesis. The quantitative research provided an objective statistical theory and model (e.g. structural equation model and integrated choice and latent variable models) (see Subsections 3.3.3 and 3.3.4) to assess the impact of these psychological variables. Several existing studies have used quantitative research-based methods to analyse the relationship between psychological factors and sustainable transport behaviours (Asgari Toorzani and Rassafi, 2023; Ashraf Javid et al., 2021; Osman Idris et al., 2015). Therefore, this thesis utilizes data from the UKHLS and applies various quantitative research methods (detailed in Sections 3.2 and 3.3) to test the proposed hypotheses.

3.1.3 Research location: the United Kingdom

As described in Section 2.1, over the past few decades, there has been a continuous decline in sustainable transportation behaviours among UK adolescents, coupled with an increase in car usage. Cars remain the dominant mode of transport for young adults in the UK. Therefore, there is a need to identify a long-term influential factor that can effectively promote sustainable transportation behaviours during both adolescence and young

adulthood in the UK. This would provide a basis for long-term, effective UK interventions aimed at fostering sustainable transportation habits in the UK. Moreover, the UKHLS dataset offers a longitudinal dataset that reflects socio-economic and transportation behaviours changes at both the household and individual levels in the UK. This makes it an ideal data source for the research presented in this thesis. Consequently, the UK was selected as the primary research context for this study. Another significant reason for choosing the UK as the research location is that it provides a setting where the behaviours being studied—particularly those related to mothers' NTPEB—are both prevalent and impactful. Additionally, the UK has a well-established transportation system with a variety of options available to adolescents and young adults, further making it an appropriate location for investigating the role of mothers' NTPEB in shaping children's transportation choices during adolescence and young adulthood.

NTPEB such as energy savings and eco-friendly purchasing behaviours have become more prevalent in the UK. Based on nationally representative data from Wave 4 (2012/2013) and Wave 10 (2018/2019) of the UKHLS, Liu et al. (2022) identified three distinct categories of environmental attitudes in the UK: 'Sceptical', 'Concerned', and 'Paradoxical'. The sceptical group tends to downplay the severity of climate change and questions the urgency or even the necessity of taking action. In contrast, the concerned group expresses anxiety about climate change risks and supports proactive measures to mitigate these risks. The paradoxical group acknowledges the reality of climate change impacts but does not endorse actions to reduce them (ibid). Notably, over time (between the two survey waves (2012-2020)), there was a general shift from the sceptical and paradoxical groups toward the concerned group (ibid). This trend suggests a growing awareness of climate change risks and an increasing willingness to support actions aimed at mitigating these risks in the UK. A survey in 2021 showed that three-quarters (75%) of U.K. adults worried about climate change's effects. Moreover, women were found to be more likely than men to be worried about the effects of climate change and anxious about the environment's future (Office for National Statistics, 2021).

In the UK, the concept of "sustainable consumerism" has gained prominence in recent years, driven by heightened awareness of environmental conservation. In 2022, 64% of

respondents reported bringing shopping bags when shopping (Office for National Statistics, 2023). This percentage could also be because the UK implemented rules restricting the use of single-use plastic bags in July 2015, which decreased the use of one-time plastic bags (Kish, 2018). Moreover, more U.K. shoppers have adopted more environmentally friendly shopping practices. In 2023, over one in five U.K. consumers claimed to have reduced their clothing purchases for sustainability reasons, with a similar proportion increasing their purchases of second-hand clothing (Office for National Statistics, 2023). Additionally, regarding energy-saving behaviours, more than one-half of the respondents indicated endeavours to conserve water and electricity at home (Office for National Statistics, 2023).

Another primary rationale for selecting the UK as the focus of this thesis was its road transport system, which effectively caters to diverse travel preferences and requirements among adolescents and young adults. As discussed in subsection 2.1, there is a trend towards diversification of transportation choices among the adolescents and young adult groups. Although car trips still account for a large proportion of trips, the use of active modes of transportation and public transportation is also gradually increasing, and each account for a certain proportion of trips. This phenomenon suggests that the modes of travel of adolescents and young adults are not limited to car, but also include active modes of travel such as walking and bicycling, as well as other options such as public transportation.

According to Pisu et al. (2015), the UK has historically allocated fewer resources to enhance its transportation infrastructure than its counterparts in the United States, France, Canada, and Switzerland. Since 2015, the UK has taken steps to increase its investments in transportation infrastructure by addressing the previous funding deficiency compared to similar nations. According to the Department for Transport (2021a), the total length of roads has increased over time. In 2020, the total length of roads increased by 2,600 miles (a 1.1% increase) from 2010 and 5,000 miles (a 2.1% increase) from 2000. Between 2012 and 2019, the distance (miles) traveled by vehicles on motorways, ‘A’ roads, and minor roads all increased (Department for Transport, 2023b). Per U.K. legislation, individuals must reach the age of 17 to learn to drive a car. Subsequently, completing the theoretical

and practical driving tests at 17 is feasible. After passing these tests, individuals can obtain a full car licence that permits them to drive independently (GOV.UK, 2021).

Regarding public transport systems, the UK has a nationwide rail network that is vital for commuting and long-distance travel. In the UK, the number of rail passenger journeys reached 1.61 billion between April 2023 and March 2024, an increase of nearly 19% during the same period in 2010–2011 (Office of Rail and Road, 2024). Almost 15,846 kilometres of railways stretched across the UK as of March 2023, showing a growth of around 0.6% from 15,755 kilometres in 2014 (Office of Rail and Road, 2023). Moreover, bus services covered a wide range of urban centres and rural areas, while recent reforms aimed to improve the quality of service and environmental friendliness. Between March 2022 to March 2023, bus services in England travelled a total of almost 1 billion miles (Department for Transport, 2024b). As of the year ending March 2023, local bus passenger journeys in England reached 3.4 billion, marking an increase19.3% compared to the previous year ending March 2022 (ibid). Over the period from March 2005 to March 2023, the trend in local bus usage in England shows an increase between March 2005 and March 2009, followed by some fluctuations. However, there was a sharp decline in bus usage during the year ending March 2021, primarily due to travel restrictions imposed to curb the spread of COVID-19 throughout the year (ibid). In addition, some cities have developed tram and light rail systems as efficient urban transport solutions. The number of passengers traveling by light rail and tram steadily increased from 2011 to 2021, rising from 184 million to 266 million in Great Britain (Department for Transport, 2021c).

Furthermore, the UK has promoted active transport modes such as cycling and walking to reduce congestion and improve public health. An illustrative example of such initiatives is the Connect2 programme, which was designed to encourage greater participation in cycling and walking by improving frequently used routes to make them safer and more appealing while increasing accessibility. An investigation examined the effects of infrastructure projects within the Connect2 programme in Cardiff, Kenilworth, and Southampton (Sahlqvist et al., 2015). In 2011–2012, the proportion of participants reporting the use of new infrastructure increased by 3% in Cardiff, 9% in Kenilworth, and 3% in Southampton. These infrastructures were predominantly utilised for recreational

walking, with 17% of individuals using them for commuting versus 39% who used them for leisure in these locations (Sahlqvist et al., 2015). Additionally, a study employing repeated before-and-after cross-sectional analyses of monitoring data from 84 locations in the UK revealed a significant increase in the use of upgraded paths associated with the Connect2 programme (Le Gouais et al., 2021). The median use of these upgraded routes by cyclists and pedestrians surged by 52% and 38%, respectively (Le Gouais et al., 2021). Furthermore, an investigation conducted by Brockman and Fox (2011) delved into a workplace transport scheme implemented at the University of Bristol, which aimed to enhance local road infrastructure and cycling facilities. This study revealed a sustained shift in behaviours, as observed over a nine-year period. Notably, self-reported car usage for commuting to work experienced a significant decline, plummeting from 50% to 33%. Simultaneously, the proportion of respondents who reported walking to and from work frequently (i.e. four to five times a week) witnessed an increase from 19% to 30%. Furthermore, there was a notable rise in the number of respondents who typically commuted by bicycle, which increased from 7% to 12%.

In addition to the Connect2 programme, the U.K. Government's Gear Change: A Bold Vision for Cycling and Walking document set an ambitious programme to transform cycling and walking in England (Department for Transport, 2020). This programme committed to developing better quality, safer, and more accessible infrastructure (e.g. segregated cycle lanes and traffic-free walking routes) and measures (e.g. lower speed limits and better traffic enforcement) to promote cycling and walking. To support the delivery of these objectives, the government committed £2 billion over five years and established Active Travel England to oversee and advise on the delivery of these projects (ibid). In 2024, Active Travel England announced that the government would allocate £101 million in funding to enhance walking and cycling infrastructure across communities in England to improve the quality of these routes and increase public participation in active travel (GOV.UK, 2024). Similarly, devolved administrations in Scotland, Wales, and Northern Ireland each established specific strategies to promote active travel. Scotland's commitment was reflected in its Cycling Action Plan for Scotland (Transport Scotland, 2017). In Wales, active transport was prioritised in the Llwybr Newydd: The Wales Transport Strategy 2021 (The Department for Infrastructure, 2015). Northern Ireland also highlighted its dedication to active travel through the Northern Ireland Changing Gear – A

Bicycle Strategy for Northern Ireland. Hence, efforts have been made to promote active transport behaviour across the UK.

In summary, the transportation systems discussed collectively shape the organisation of transportation in the UK to meet the diverse transportation needs of the populace. A robust transportation system is integral to this thesis since it indicates the availability of various modes of transportation for individuals to choose from when travelling.

3.2 Data and variables

This section first provides an in-depth description and introduction to the UK Household Longitudinal Study (UKHLS), which was the main data source for this thesis. Additionally, it outlines the number of mother-child pairs from UKHLS employed in the subsequent four empirical studies in Subsection 3.2.2. Subsection 3.2.3 also describes the key independent and dependent variables in each subsequent empirical study.

3.2.1 UK Household Longitudinal Study

Since the study focuses on individuals' transport behaviours at different life stages (adolescence and early adulthood), a longitudinal dataset is required. Previous study has relied on retrospective methods, such as self-reported surveys, to collect data on past behaviours and attitudes based on participants' memories (Haustein et al., 2009). However, such approaches are prone to recall bias, leading to discrepancies between reported and actual past behaviours (Müggenburg, 2021). In contrast, within the UK context, the UK Household Longitudinal Study (UKHLS) provides a robust longitudinal dataset, enabling a more accurate examination of individuals' transport behaviours over time.

Therefore, this thesis's empirical research relies on data from the UKHLS, also known as the Understanding Society Survey (University of Essex, 2019). This extensive longitudinal survey was initiated in 2009 with approximately 40,000 households across the UK in its

first wave. Thirteen waves of surveys have been conducted to date. The primary objective of this survey is to gain insights into social and economic changes at the household and individual levels. The Economic and Social Research Council and various government departments fund the survey. The Institute for Social and Economic Research at the University of Essex is responsible for conducting this survey regularly.

Davis-Kean et al. (2017) indicated that the UKHLS closely mirrors the U.K. population. Moreover, the UKHLS data are suitable for social research and policy analysis. Thus, to some extent, the socioeconomic attributes and behaviours observed in the survey sample are effectively generalised to the U.K. population (Davis-Kean et al., 2017). In addition, Fisher (2020) highlighted the similarities between the UKHLS and the UK Family Resources Survey concerning maternal attributes such as age, household size, ethnicity, and region. Hence, the UKHLS effectively represents this demographic within the U.K. population.

In each wave of the UKHLS, the same group of individuals is surveyed at approximately 12-month intervals (University of Essex, 2023b) to ensure the respondents are surveyed in approximately the same month annually. For example, if respondents were surveyed in January 2009 during Wave 1, they would be surveyed in January 2010 for Wave 2. Data collection for each wave of the survey spanned 24 months, which resulted in some overlap in the timing of the survey waves (Carpenter, 2020). For instance, the first data collection wave spanned January 2009 to December 2010 (24 months), while the second wave spanned January 2010 to December 2011. In a few cases, data collection could extend beyond the initial 24-month period, particularly for those who received survey invitations in the last two months of the second year of each wave (Carpenter, 2020). For instance, in cases where respondents were invited to participate in the survey during November or December 2010 during the first wave, it is likely that information about these respondents was not collected by December 2010 and extended into 2011.

The UKHLS is comprised of three primary questionnaires (University of Essex, 2023a).

The first is the **Household Survey (a)**, which focuses on household structure and socioeconomic factors, including geographic location (urban or rural) and household income.

The second is the **Individual Survey (b)**, which gathers data on the sociodemographic characteristics, behaviours, and attitudes of all individuals aged 16 and older in selected households. The survey includes variables such as gender, race, employment status, pro-environmental attitudes, various NTPEB, and sustainable transport behaviours. It is important to note that not all waves of the UKHLS dataset include the NTPEB variables, which are the primary focus of this thesis. Only Waves 1, 4, and 10 contain the NTPEB variables. The questions related to NTPEB variables are asked only every few years, as these variables are expected to change less frequently, which helps to reduce the respondent burden by limiting the number of questions asked in each wave (University of Essex, 2024).

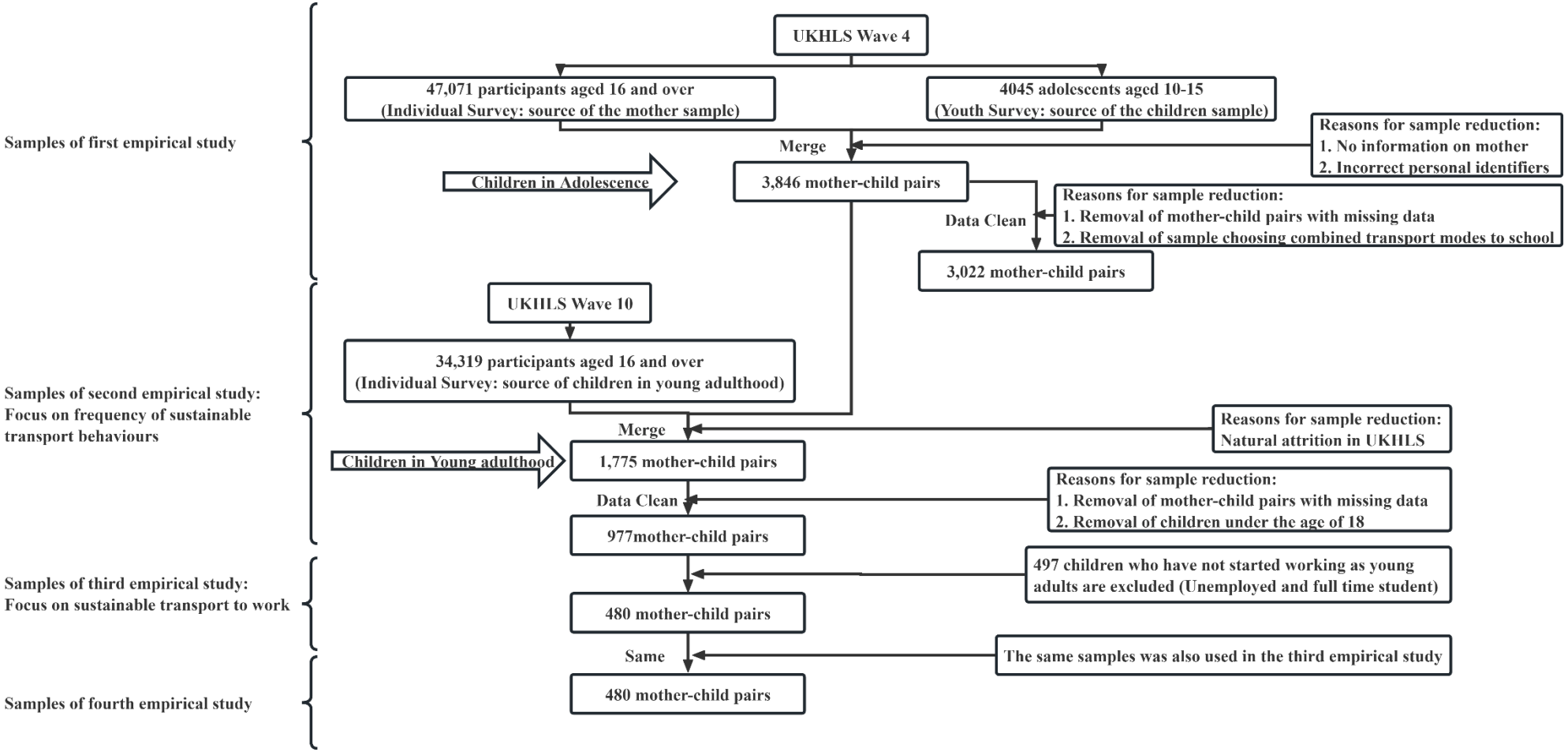
Lastly, the **Youth Survey (c)** is designed to provide insights into the demographic characteristics of adolescents aged 10 to 15 and their behavioural patterns, such as their transport choice for commuting to school.

To ensure consistent tracking of the same respondents across various survey waves, the UKHLS assigns a distinct personal identifier to each participant, regardless of whether they are 16 years and above participating in the Individual Survey (b) or youth aged 10–15 participating in the Youth Survey (c). This personal identifier remains consistent across different questionnaires. This unique identifier facilitates tracing the same individual who completes different questionnaires during various survey waves. For instance, in a scenario where an adolescent participates in the Youth Survey (c) during Wave 4, subsequently transitions into young adulthood, and participates in the Individual Survey (b) during Wave 10, the individual identifier can serve as a means to merge Youth Survey (c) and Individual Survey (b) data. Additionally, to ensure the accurate identification of parents for the adolescent respondents, the Youth Survey (c) separately provides unique identifiers for the mother and father that can be cross-referenced with the personal identifier in the Individual Survey (b).

3.2.2 Mother-child pairs in subsequent empirical studies

Figure 3-2 depicts the process of obtaining studied mother-child pairs and highlights variations in their sizes across the four empirical studies. The first empirical study examined the connection between mothers' NTPEB (e.g. eco-friendly purchasing behaviours and home energy conservation) during their children's adolescence and their children's sustainable transport choices to school during the same period. This study was based on data from Wave 4 (2012/13) of the UKHLS since it contained the most important variables related to NTPEB for this thesis. Wave 4 data provide not only variables related to NTPEB for mothers who completed individual survey (b), but also variables related to transport choices to school for adolescents who completed the youth survey (c). In addition, the second and third empirical studies of this thesis were longitudinal studies of the relationship between mothers' NTPEB during their children's adolescence and their children's sustainable transport behaviours in young adulthood. These studies were based on the Wave 4 and 10 of UKHLS. Therefore, using Wave 4 data in the first study provided an essential baseline for examining these longitudinal relationships. For instance, the children surveyed in Wave 4 as adolescents were tracked as they transitioned from adolescence to young adulthood in Wave 10.

Figure 3-2. The process of mother-child pair acquisition and change in the size of mother-child pairs across the four empirical studies



Wave 4 of the UKHLS surveyed 25,817 UK households. Nearly three-quarters of the families were from England, while those from Wales, Scotland, and Northern Ireland each accounted for less than 10%. The Wave 4 UKHLS dataset comprised responses from 47,071 individuals aged 16 and older who participated in the Individual Survey (b) discussed in Subsection 3.1.1. Additionally, 4,045 adolescents between 10 and 15 years old completed the Youth Survey (c). To match mother-child pairs, this study utilised unique mother identifiers from the Youth Survey (c) completed by adolescent respondents to match the unique personal identifiers from the Individual Survey (b) completed by their mothers. This matching method successfully connected child respondents from the Youth Survey with their mothers from the Individual Survey and resulted in 3,846 mother-child pairs. Because there were 4,045 adolescents in Wave 4, there should logically be 4,045 mother-child pairs. The reduction in the number of mother-child pairs from 4,045 to 3,846 was attributed to two main factors. Firstly, 126 child respondents who resided in households without a mother were excluded. Secondly, the remaining decrease was attributed to issues related to missing or inaccurate personal identifiers within the Individual Survey (b), which hindered the successful matching of mothers and their respective children.

Among the 3,846 mother-child pairs, 557 had missing data on essential study variables for various reasons.

Firstly, respondents could have encountered situations where they lacked the necessary knowledge to answer specific questions, which led to missing values. A total of 60 respondent mothers exhibited this missing data, which was notably prevalent in variables related to NTPEB.

Secondly, some respondents might not have chosen to provide answers, which resulted in missing data. Only one respondent (i.e. a mother) refused to answer a question about NTPEB.

Thirdly, for inquiries related to NTPEB, data were solely collected when respondents were engaged in face-to-face interviews and consented to self-completing the questionnaire or surveyed via phone or the internet. Therefore, this case resulted in 232 respondent mothers with missing data. In the first empirical study, this particular reason was the leading cause of data loss for mother-child pairs.

Fourthly, recording errors by data recorders could have also contributed to the missing values. A total of 112 child respondents had this type of missing data, which was prevalent in the school transport selection variable.

The last reason leading to missing data in the respondents used for the first empirical study of this thesis occurs where the original respondent declined to be surveyed, and as a result, some questions were answered by a family member on behalf of the original respondent. It is important to emphasise that the questions answered by family members on behalf of the original respondent did not encompass inquiries regarding self-reported NTPEB. A total of 179 respondent mothers showed this type of missing data. After excluding mother-child pairs with missing data, 3,289 mother-child pairs resulted. Furthermore, 267 mother-child pairs were omitted from the first study due to the adolescent respondents' selection of a combination of transportation modes for their school commutes in the Youth Survey (b). These exclusions were necessitated by the survey's lack of clarity regarding the specific combination of transport modes chosen by the adolescent respondents. Therefore, the first empirical study analysed 3,022 mother-child pairs.

In the second empirical investigation of this thesis, a longitudinal approach was employed to examine the role of mothers' NTPEB during their children's adolescence in their children's frequency of sustainable transport behaviours. Data from UKHLS Wave 4 (2012/13) and Wave 10 (2018/19) were utilised for this research.

The choice of Wave 10 data from the UKHLS was primarily driven by several key factors. One of the most crucial reasons was its collection period, from January 2018 to December 2019, which preceded the COVID-19 pandemic in the UK. This timing was significant

because the pandemic profoundly impacted sustainable transport behaviours, NTPEB, and attitudes (Downey et al., 2021; Ramkissoon, 2020; Shulman et al., 2022). Using data collected before the pandemic ensured an accurate representation of the behaviours and attitudes under investigation in this thesis. Another important reason for selecting Wave 10 data was their comprehensive coverage of variables essential for the second empirical research. These included NTPEB and pro-environmental attitudes, the frequency of sustainable transport, and choices related to sustainable work commuting. Although the six-year interval between Wave 4 and Wave 10 was shorter than ideal (since not all child respondents aged 10–15 in Wave 4 were over 18 by Wave 10), it was the most feasible timeframe given the various constraints. Longer gaps were impractical due to disruptions caused by the pandemic and the absence of necessary variables in other waves (e.g. Waves 11, 12, and 13 did not contain variables relating to NTPEB and pro-environmental attitudes).

To create the mother-child pairs for the second empirical study, child respondents in the mother-child pairs (from youth survey (b) in wave 4 of UKHLS) of the first empirical study were linked with 34319 respondents aged 16 years and older who took part in the individual survey (b) in Wave 10 of UKHLS, facilitated by a unique personal identifier. The child respondents, initially adolescents (aged 10-15) during the first empirical study in wave 4, had mostly transitioned into young adulthood (aged 18 or older) by the time of the Wave 10 survey. After removing mother-child pairs with missing data, 121 child respondents were found to be under the age of 18 (the details of how to remove mother-child pairs with missing data are explained later). The link between these child respondents and their mother was already established in the first empirical study. As a result, a unified dataset that included information about mothers during their children's adolescence and information about their children during their young adulthood can be constructed for the second empirical study. Ultimately, the study obtained data from 977 mother-child pairs.

A significant reduction in the size of mother-child pairs occurred; the number decreased from 3,022 in the first empirical study to 977 in the second empirical study. This decline was attributed to various factors, including natural attrition as a primary contributor (Benzeval et al., 2020; Carpenter and Burton, 2017; Lynn, 2013). Over time, as the

UKHLS survey progressed from Wave 4 to Wave 10, some respondents surveyed in previous waves dropped out. One contributing factor to this attrition was the movement of child respondents as they grew up and moved away from their parents' homes (James, 2023). Although the UKHLS tried to track and reassign household numbers for those who moved, many individuals could not be traced to their new addresses. The data indicated that, on average, the attrition rate was approximately 15% between each consecutive pair of waves in the UKHLS. As a result, 2,071 mother-child pairs were lost from the first empirical study to the second empirical study, with 1,775 mother-child pairs remaining.

Moreover, the second empirical study included child respondents' pro-environmental attitudes, sustainable transport behaviours in young adulthood, and other relevant factors, which led to fewer respondents than the previous study. This expansion of variables also resulted in missing data; the second empirical study had 1,775 mother-child pairs, yet 798 pairs had missing data for various reasons. For instance, 45 child respondents lacked the knowledge to answer specific questions, while ten chose not to answer certain questions, particularly those related to pro-environmental attitudes. Moreover, 283 child respondents did not complete a face-to-face interview related to pro-environmental attitudes. Furthermore, recording errors by data recorders resulted in missing data for 54 child respondents. Finally, 285 child respondents had family members answer some of the questions on their behalf related to NTPEB. After excluding mother-child pairs with missing data, 1,098 remained in the second empirical study. In addition, as previously mentioned, the second empirical study focused on child respondents who reached young adulthood (aged 18 or above). By excluding child respondents under 18, the number of mother-child pairs was further reduced to 977.

The third empirical study investigated the role of mothers' NTPEB during their children's adolescence in their children's sustainable transport choices for commuting to work and necessitated a further narrowing of the mother-child pairs. This specific analysis concentrated on those child respondents who entered the labour market in young adulthood. Consequently, 497 child respondents from 977 mother-child pairs in the second empirical study who had not yet commenced their professional careers were excluded, which resulted in 480 mother-child pairs in the third empirical study. The fourth empirical

study used these 480 mother-child pairs to analyse the role of mothers' NTPEB in their children's maintenance of sustainable transport choices during adolescence to young adulthood.

It is important to note that, although not the primary focus of this thesis, an attempt is also made to link fathers to their children using the same method outlined above. However, it was found that the number of father-child pairs is significantly lower than the number of mother-child pairs. In the first empirical study, there were only 1,745 father-child pairs, while in the second empirical study, this number dropped to 563 pairs. In the third and fourth empirical studies, the number of father-child pairs further decreased to 278. The primary reason for this data loss is the reluctance of father participants to participate in face-to-face interviews, agree to complete the questionnaire independently, or respond to surveys conducted via phone or the internet. Such substantial data loss undoubtedly impacts the representativeness of the research. This may also explain why, in all of the studies in this thesis, mother-child pairs were prioritized. The next subsection specifies each empirical study's main independent and dependent variables.

3.2.3 Main independent and dependent variables

This subsection focuses on the main independent and dependent variables used in the four empirical studies. Four dependent variables are introduced.

The dependent variable in the first empirical study: The first empirical study was a cross-sectional study of the relationship between mothers' NTPEB during their children's adolescence and their children's sustainable transport choices to school during the same period, based on 3,022 mother-child pairs from Wave 4 of the UKHLS. Therefore, the dependent variable was the child respondents' transport choices to school during adolescence, with three distinct categories: active transport, public transport, and cars.

This categorisation was based on the sustainability of the various modes of transport. Cars were regarded as the most unsustainable mode of transport due to their significant contribution to pollution. Public transport was considered a sustainable mode with a medium level of environmental sustainability. While it was motorised and contributed to environmental pollution, it offered the advantage of accommodating more passengers, which reduced per-capita emissions. Active transport (e.g. walking and cycling) was another type of sustainable transport that reflected the highest sustainability level (Bearman and Singleton, 2014). This categorisation was used in the existing literature on sustainable transport to school (Müller et al., 2008; Nordfjærn et al., 2016).

These three dependent variables were aggregated based on the most frequently used modes of transportation to school, as answered by child respondents in the UKHLS Youth Survey (b) of Wave 4. Adolescents were asked if they usually walked, bicycled, went by car or train, or went by bus or subway to school. Specifically, selections indicating "walk all the way to school" or "bike all the way to school" were amalgamated under the "active transport" category of the dependent variable. The "public transport" category of the dependent variable subsumed those opting for "ride the bus or subway" or "ride the train". The unaltered survey response of "car" continued to denote its distinct category (the "cars" category of the dependent variable).

The dependent variable in the second empirical study: The second empirical study examined the correlation between mothers' NTPEB during their children's adolescence and the frequency of their children's sustainable transport behaviours in young adulthood. Moreover, the role of the children's pro-environmental attitudes during young adulthood in this correlation was also analysed. Hence, the dependent variable was the frequency of sustainable transport behaviours in the children's young adulthood.

Wave 10 of the UKHLS directly provides four survey items related to the frequency of various sustainable transport modes, such as cycling, buses, train and underground, tram or light rail. However, it is important to note that the UKHLS does not include information on the frequency of walking, which is one of the most common forms of sustainable transport. Furthermore, these four survey items related to frequency of transport use does not account

for the impact of travel distance. In addition, Wave 10 of the UKHLS includes two other survey items related to pro-environmental behaviours that can also capture the frequency of sustainable transport behaviour. The first item asks participants about the frequency with which they choose to walk or cycle (i.e., active transport) for shorter journeys, specifically those covering distances of two to three miles. The second item inquiries about the frequency of using public transport, such as buses or trains, instead of using cars. Participants responded on a scale from 1 (never) to 5 (always). These items were designed to capture the frequency of adopting active and public transport modes over car travel, making them reliable proxies for sustainable transport behaviours. By incorporating travel distance restrictions for active transport, the study effectively controls for the potential influence of distance on transport choices. Additionally, the public transport items reflect its role as a substitute for car use, further strengthening the focus on sustainable transport. Therefore, these two survey items were used as the dependent variables in the second empirical study. Moreover, the average of the responses to these two survey items was calculated to derive a composite score representing the overall frequency of sustainable transport behaviours.

The dependent variable in the third empirical study: The third empirical study is an expansion of the second empirical study. The third empirical study aimed to test whether the correlation between mothers' NTPEB and children's overall frequency of sustainable transport behaviours in young adulthood, as analysed in the second empirical study, persisted specifically in the context of children's commuting to work in young adulthood. Since the second empirical study focused on the overall frequency of sustainable transport behaviours, the third empirical study did not need to separate sustainable transport modes into categories like active transport and public transport. Instead, it focused on the overall use of sustainable transport for commuting. Therefore, in the third empirical study, the dependent variable—children's transportation choices for commuting to work—was categorized into two groups: sustainable transport modes and cars.

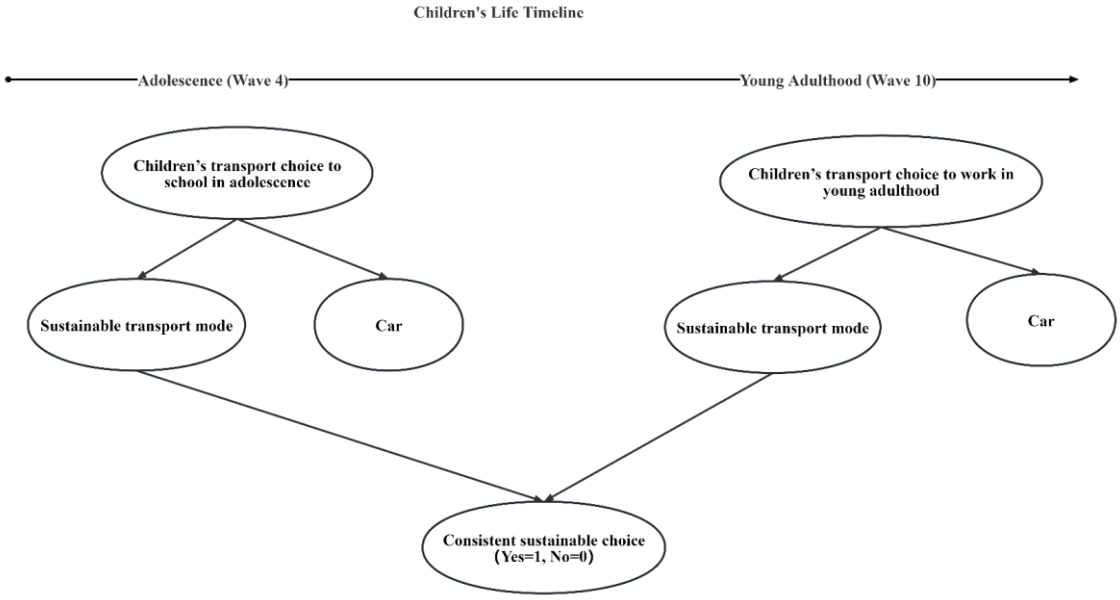
These categories were formulated based on the primary mode of transportation to work, as reported in Wave 10 of the UKHLS. Specifically, responses indicating "drive myself by car or van", "being driven in a family car", "getting a ride from someone outside their family",

"motorbike", and "taxi/minicab" were grouped under the "cars" classification of the dependent variable. Conversely, the "sustainable transport mode" classification encompassed individuals who chose "bus/coach", "train", "walk", "cycle", or "underground/Metro/tram/light railway".

The dependent variable in the fourth empirical study: The fourth empirical study focused on assessing the role of mothers' NTPEB during their children's adolescence in their children's maintenance of sustainable transport choices from adolescence to young adulthood. The dependent variable was the maintenance of sustainable transport choices for children from adolescence to young adulthood.

This research introduced the variable "consistent sustainable choice" (sustainable transport mode during both adolescence and young adulthood) to measure and quantify the persistence of sustainable transport choices among the sampled children from adolescence to young adulthood. As shown in Figure 3-3, this variable was derived from comparing the transport choices of the child respondents when they attended school during adolescence (Wave 4) with the transport choices they made when they went to work as they grew into young adults (Wave 10). If child respondents opted for walking, cycling, taking the train, or using the bus/subway to travel to school during adolescence (referring to the dependent variable in the first empirical study for specifics) and later chose sustainable transport modes for commuting to work as young adults (referring to the dependent variable in the third empirical study for specifics), it indicated a consistent preference for sustainable transportation from adolescence to young adulthood.

Figure 3-3. Measures of maintenance in sustainable transport choices from adolescence to young adulthood



Concerning the independent variables, mothers' NTPEB during their children's adolescence were the main independent variables of all empirical studies in this thesis. Notably, the survey items related to mothers' NTPEB during their children's adolescence were consistent across all empirical studies.

Mother's NTPEB during their children's adolescence: Emphasis was placed on everyday family activities with environmental relevance that mothers often participated in to understand the NTPEB of mothers during their children's adolescence (see Table 3.1). Moreover, the observability of the mothers' behaviours to the offspring was critical. Matthies et al. (2012) found that intergenerational transmission of NTPEB was only possible if the children observed their mothers' NTPEB. Consequently, mothers' eco-friendly purchasing and energy conservation behaviours were chosen, which Grønhøj and Thøgersen (2017) showed to influence similar tendencies in their children. Accordingly, six survey items in Wave 4 were implemented to assess maternal engagement in energy conservation and eco-friendly purchasing practices within households during children's adolescence. The survey items included inquiries about the frequency with which mothers turned off lights in unoccupied rooms and their regular use of their shopping bags when

shopping (see Table 3-1 for the other four survey items). Responses were measured on a scale from 1 (never) to 5 (always), with higher values indicating more frequent behaviours.

Table 3-1. Mother's NTPEB during their children's adolescence

Mother's NTPEB (1. Never ~ 5. Always)
Do not keep the tap running while you brush your teeth
Turn off lights in rooms when not in use
Not leaving the TV on standby for the night
Not buying something because of too much packaging
Buying recycled paper products
Taking along a shopping bag for shopping

In addition, the second and third empirical studies involved children's pro-environmental attitudes in young adulthood. The survey items concerning children's pro-environmental attitudes during young adulthood were consistent in both.

Children's pro-environmental attitudes in young adulthood: Six survey items concerning the extent of agreement or disagreement with the notion that "the changes made must be in line with my current lifestyle" that measured children's pro-environmental attitudes toward climate change in young adulthood were included in Wave 10 survey of the UKHLS (see Table 3-2 for the other five survey items). They measured children's pro-environmental attitudes in young adulthood, with responses rated on a 5-point Likert scale (1 = strongly agree; 5 = strongly disagree). In this context, a higher score indicated a stronger pro-environmental attitude or more support for environmental conservation.

These survey items originated from the New Ecological Paradigm Scale (Dunlap et al., 2000), an instrument developed and continually improved by drawing from decades of environmentalist research commencing in the 1970s. These survey items aimed to represent a broad understanding of the environment while capturing fundamental

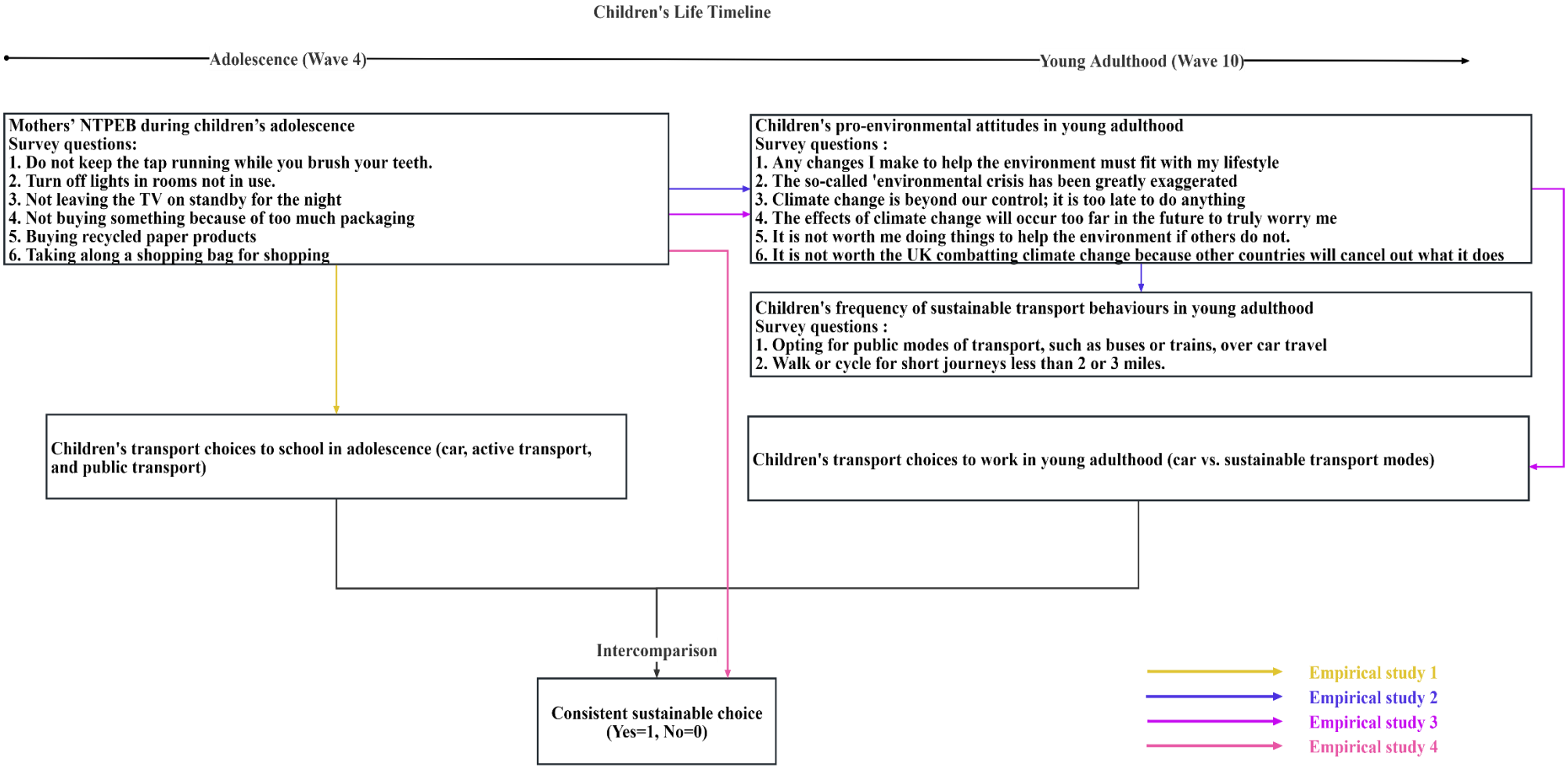
viewpoints and attitudes regarding the interplay between humanity and the natural environment.

Table 3-2. Children's pro-environmental attitudes in young adulthood

Children's Pro-Environmental Attitudes (1 = strongly agree, 5 = strongly disagree)
Any changes I make to help the environment must fit with my lifestyle.
The so-called 'environmental crisis' has been greatly exaggerated.
Climate change is beyond our control; it is too late to do anything.
The effects of climate change will occur too far in the future to truly worry me.
It is not worth me doing things to help the environment if others do not.
It is not worth the UK combatting climate change because other countries will cancel out what it does.

Despite not being the primary independent variable in this thesis, mothers' pro-environmental attitudes in their children's adolescence were included in all empirical studies. All survey items used to measure mothers' pro-environmental attitudes in their children's adolescence were the same as those used to measure their children's pro-environmental attitudes in young adulthood. However, the items used to measure mothers' pro-environmental attitudes in their children's adolescence were taken from Wave 4 of the UKHLS. Figure 3-4 shows the relationship between the main independent and dependent variables for all empirical studies in this thesis, with their sources.

Figure 3-4. The relationship between the main independent and dependent variables



3.3 Data analysis methods

This section focuses on the specific data analysis methods employed for the four empirical analyses in this thesis. The first empirical study examines the relationship between mothers' NTPEB during their children's adolescence and the children's school travel mode choices at the same stage. Given that the dependent variable—school travel mode choice during adolescence—is a categorical variable with three possible outcomes and there is no interaction of latent variables, multinomial logistic regression is employed (see Subsection 3.3.1 for details). The second empirical study investigates the relationship between mothers' NTPEB during their children's adolescence and their children's overall frequency of sustainable travel behaviours in young adulthood. Additionally, it explores the mediating role of children's pro-environmental attitudes in young adulthood. Since the dependent variable in this study is continuous and the analysis involves latent variables (i.e., pro-environmental attitudes in adulthood) as well as mediation effects, structural equation modelling is applied (see Subsection 3.3.2 for details). The third empirical study focuses on the relationship between mothers' NTPEB during their children's adolescence and their children's use of sustainable commuting modes in young adulthood, with children's pro-environmental attitudes in young adulthood as a mediating factor. This study also involves mediation analysis and latent variables; however, given that the dependent variable—sustainable commuting mode in adulthood—is binary, integrated choice and latent variable modelling is adopted (see Subsection 3.3.3 for details). The fourth empirical study extends the analysis by examining the relationship between mothers' NTPEB during their children's adolescence and their children's persistence of sustainable commuting behaviours from adolescence to young adulthood. Similar to the third study, it incorporates mediation analysis and latent variables, and the dependent variable is also binary. Therefore, integrated choice and latent variable modelling is again employed (see Subsection 3.3.3 for details).

3.3.1 Multinomial logistic model

The dependent variable in the first empirical study was the child respondents' choice of transport to school during adolescence. It was set as a categorical variable with three

categories: active transport, public transport, and cars (mentioned in Subsection 3.2.3). In the first empirical study, multinomial logistic regression was chosen, which allowed the dependent variables to be categorical variables with more than two different, separable, and unrelated categories (Kwak and Clayton-Matthews, 2002; So and Kuhfeld, 1995). In transport research, multinomial logistic regression has been applied to various aspects of transport users' decision-making (McCafferty and Hall, 1982; Sharma et al., 2019; Thrane, 2015).

Multinomial logistic regression may be derived using random utility theory, which was first formalised by Manski (1977). Accordingly, decision-maker n (n = 1…, N) chooses an alternative i from a set of I ($i = 1, \dots, I$) alternatives that are mutually exclusive, finite, and collectively exhaustive. The attractiveness of the available alternatives is expressed as the function of the attributes called utility ($U_{n,i}$). Hence, utility is interpreted as the attractiveness of the available alternatives to the decision-maker. This theory hypothesises that each decision-maker (e.g. the transport choice decision-maker) is rational, and each rational decision-maker can choose the alternative (i) that has maximised utility (Cascetta, 2009). The utility ($U_{n,i}$) of each alternative (i) is usually determined by its characteristics or attributes and decision-maker n, which are measurable and observable by a researcher aiming to model the decision-maker's choice behaviours. Notably, utility ($U_{n,i}$) also includes the unobserved factors by the researcher, so $U_{n,i}$ must be represented by a random variable.

According to random utility theory, the subsequent description provides the multinomial logistic regression in mathematical form. The mathematical forms of the first empirical study in this thesis were drawn from the formulas proposed by Sharma et al. (2019) and were modified to suit the specific research questions addressed in this study. In the first empirical study, each child n (n = 1…, 3,022) had a set of mutually exclusive alternatives I (i = 1: active transport, 2: public transport, 3: car). In the first empirical study, alternatives signified the children's choice of transport to school in adolescence. Child n chose alternative i, which yielded utility $U_{n,i}$. Each alternative's utility was described as a function of explanatory variables ($V_{n,i}$) forming the systematic part of the utility (i.e. the deterministic part), and disturbances ($\varepsilon_{n,i}$), which represented the unobserved component

of the utility function of transport choice i for respondent n. The deterministic part $V_{n,i}$ of the utility equation depended on independent variables that could be correlated with children's transport choice to school in adolescence. The choice of independent variables in the first empirical study of this thesis is described in detail in Subsection 4.1.3.2. $\varepsilon_{n,i}$ was assumed to be independent and identically distributed while following the Gumbel probability distribution. Equation 1-1 shows the mathematical formulation of $U_{n,i}$.

$$U_{n,i} = V_{n,i} + \varepsilon_{n,i} \qquad (1\text{-}1)$$

The multinomial logistic regression assumed the disturbances ($\varepsilon_{n,i}$) of utility functions (Equation 1-1) were independent, identically distributed, and followed the Gumbel probability distribution. This assumption led to the probability of child n choosing the alternative i as given by Equation 1-2. Moreover, $y_{n,i}$ was an indicator representing whether child n chose i (Equation 1-3).

$$P(y_{n,i}) = \frac{exp(V_{n,i})}{\sum_{j=1}^{3} exp(V_{n,j})} \qquad (1\text{-}2)$$

$$y_{n,i} = \begin{cases} 1, & if\ U_{n,i} \geq U_{n,j}\ i \neq j \\ 0, & Otherwise \end{cases} \qquad (1\text{-}3)$$

Within the multinomial logistic regression, the baseline category served as a reference point for comparing it with other categories. In the first empirical study, the reference category was represented by the term "car", which resulted in two comparisons: "active transport vs car" and "public transport vs car". For the purpose of model interpretation, odds ratios were computed and employed to investigate how the independent variable influenced the choice of active or public transport compared to the baseline category (i.e. cars). Specifically, the odds ratios for an independent variable indicated the extent of increase (odds ratios > 1) or decrease (odds ratios < 1) in the likelihood of opting for a specific sustainable transport choice (active and public transport) relative to the base category (cars) (Adams and Conway, 2021). The odds ratios of each independent variable were calculated by exponentiating the estimated coefficients of each independent variable.

These odds ratios ranged from 0 to +∞. The multinomial logistic regression model used the maximum likelihood estimation to estimate the regression coefficient.

Concerning the goodness of fit in multinomial logistic regression, a frequently employed criterion is the likelihood ratio index, commonly known as the McFadden pseudo R^2 (McFadden, 1972; Smith and McKenna, 2013). McFadden pseudo R^2 is on a scale ranging from 0 to 1, with higher values indicating better model fit (Hossain, 2023). McFadden pseudo R^2 can be expressed by the following mathematical equation (Abdulhafedh, 2017):

$$McFadden's\ R-square\ =\ 1\ -\ \frac{\ln L_M}{\ln L_0} \qquad (1\text{-}4)$$

Here, L_0 represents the value of the likelihood function for a model with no predictors (i.e. an intercept-only model) while L_M is the likelihood function for the model being estimated (model with all variables). McFadden pseudo R^2 measures the improvement of the full model over the intercept-only model. When comparing two models on the same data, McFadden's pseudo R^2 is higher for the model with the greater likelihood, which indicates a better fit (Abdulhafedh, 2017).

Moreover, the Akaike information criterion was used to assess the fit of the multinomial logistic regression model to the data (Akaikei, 1973). Lower Akaike information criterion values represented a better model fit (Cavanaugh and Neath, 2019). The Akaike information criterion value is related to the goodness of fit and the number of parameters in the model. It penalises a model that uses more parameters. Therefore, if two models have the same fit, the model with fewer parameters has a lower Akaike information criterion score (Cavanaugh and Neath, 2019). Numerous studies have provided empirical support for the effectiveness of the Akaike information criterion value as a measure of model fit when comparing various models (e.g. assessing which model better fits the data) (Cafiso et al., 2010; Ma et al., 2016; Sasidharan and Menéndez, 2014). The Akaike information criterion value is calculated using Equation 1-5, drawn from Sasidharan and Menéndez (2014).

$$\text{Akaike information criterion} = 2q - 2\,ln(L) \qquad (1\text{-}5)$$

where q represents the number of parameters in the model, and L corresponds to the maximum likelihood value of the fitted model.

In addition, the multicollinearity of independent variables was also checked in the first empirical study. Multicollinearity is a statistical issue where independent variables in the multinomial logistic regression model exhibit a linear relationship (Blalock, 1963). This problem can arise from various sources, including variable selection, data collection methods, sampling techniques, and respondent outliers (Schroeder et al., 1990). Multicollinearity reduces the precision of the estimated coefficients and increases the p-value, which results in variables that should be statistically significant but are not (Thompson et al., 2017). Sometimes, multicollinearity even changes the sign of the coefficients (from a positive to a negative correlation). Although multicollinearity affects the coefficients and p-values, it does not influence the prediction of new observations or goodness-of-fit statistics (Neter et al., 1996). The variance inflation factor value is usually used to detect the severity of multicollinearity in multinomial logistic regression (Thompson et al., 2017). It quantifies how much the variance of an estimated regression coefficient is inflated due to collinearity. When the variance inflation factor value exceeds 10, multicollinearity exists in the independent variables (Emmanuel and Maureen, 2021).

3.3.2 Structural equation model

The second empirical study sought connections between mothers' NTPEB during their children's adolescence, their children's pro-environmental attitudes, and their children's frequency of overall sustainable transport behaviour in their adult years. Thus, structural equation model was used.

Structural equation model offers more than just insights into direct relationships between variables; it is adept at unveiling indirect associations via mediating variables (Kaplan, 2008). The influence of one variable on another is categorised into three types: direct effect, indirect effect, and total effect (Kang and Ahn, 2021). Direct effects represent the direct links between the dependent and independent variables, which are unaffected by a mediator. In contrast, indirect effects encompass all effects between two variables that involve a mediating variable. The total effect is the sum of the direct and indirect effects (Bollen, 1987).

This approach aligned seamlessly with the aim of this research: to investigate the mediating role of pro-environmental attitudes of children during early adulthood in the relationship between their mothers' NTPEB during the children's adolescence and the frequency of sustainable transport behaviours these children make in their young adult life. Structural equation model has been used extensively in transport studies (Golob, 2003).

Structural equation model traditionally comprises two main components: a measurement model and a structural model (Ullman and Bentler, 2012). The measurement model establishes a connection between the latent variables (i.e. constructs) and their respective indicators (i.e. survey items) (Hair et al., 2021). Measurement modelling is also called confirmatory factor analysis (Mueller and Hancock, 2001). In the simplest case, a linear factor model is appropriate for describing the mapping of these latent variables on the indicators using the following measurement equation (2-1).

$$IND^{k}_{\mathrm{n,z}} = \Lambda_k \mathrm{latent\ variables}_z + \lambda_{n,k,z} \qquad (2\text{-}1)$$

Here, each respondent n (n = 1…, N) has a set of latent variables z (z = 1…, Z). IND^{k} signifies the indicators k ($k = 1 \ldots, K$) employed to measure the respective latent variables z. $IND^{\mathrm{k}}_{\mathrm{n,z}}$ denotes the indicator (k) used to measure the latent variable (z) of the respondents (n). The coefficients Λ_k (factor loadings) represents the influence of the latent variables (z) within the measurement models. Factor loadings can vary between –1 and 1. The closer the factor loading is to –1 or 1, the greater the effect on the variable. A factor

loading of 0 indicates no effect. In addition, factor loadings of an indicator are inadequate if they are less than 0.3 since they contribute less than 10% to the variation in the latent variable measured (Boateng et al., 2018). Moreover, $\lambda_{n,k,z}$corresponds to the error component of the measurement equation. This error term is characterised by a 0 mean and a predefined standard deviation, which encapsulates the variability unexplained by the model. Corresponding factor scores for the latent variables are calculated after measurement modelling. These scores range from –3.0 to +3.0 and have a mean value of 0, similar to standardised Z-score metrics (DiStefano et al., 2009).

In structural equation model, latent variables are exogenous or endogenous. Structural models measure the influence of exogenous latent variables (τ) on endogenous latent variables (θ). The structural model is formulated as equation (2-2), where α are the regression coefficients to be estimated. The terms η values are random error variables. Without latent variables, structural equation model with only observed variables resembles path analysis.

$$\text{Endogenous latent variables}_{n,\theta} = \alpha * \text{Exogenous latent variables}_{n,\tau} + \eta_n \quad (2\text{-}2)$$

In structural equation model, regression coefficients α are usually estimated by analysis of covariance by finding model parameters α so that the variance and covariance implied by the structural equation modelling system are as close as possible to the observed respondents' variance and covariance (Ullman and Bentler, 2012). In this context, estimation methods of structural equation model include the maximum likelihood, generalised least squares, weighted least squares, the weighted least squares mean adjustment, and the weighted least squares mean square variances adjustment (Tarka, 2017).

Kaplan (2008) highlighted the need to consider each method's underlying assumptions, the variables' scale properties, the respondents' size, and the complexity of the structural equation model when selecting an appropriate estimation method of structural equation model. For instance, the most frequently used estimation method of structural equation

model is the maximum likelihood, predicated on the assumption of the multivariate normal distribution of all continuous endogenous variables (including all observed and latent endogenous variables) in the model (Mindrila, 2010). Nevertheless, this assumption does not hold in empirical studies such as this thesis's second empirical section; thus, deviations from normality led to estimation bias and model non-convergence (Mindrila, 2010). In contrast, the weighted least squares mean square variances estimation does not rely on the normality assumption and alleviates the need for large sample sizes by reducing the computational intensity of traditional weighted least squares estimation (Finney and DiStefano, 2006), which applies to the analyses in the second empirical study.

Regarding model evaluation, various criteria assess overall goodness of fit in structural equation model. For example, the **chi-square statistic** χ^2 is a traditional method of assessing the overall fit of the structural equation model by evaluating the extent to which the covariance matrices of the sample differ from the fitted covariance matrix in the structural equation model constructed (Hu and Bentler, 1999). A smaller χ^2 value typically suggests a better fit of the structural equation model. Regarding the p-value of the chi-square, a well-fitting model should produce an insignificant result. Specifically, for a model to be considered well-fitted at a significance level of 0.05, the p-value should be greater than 0.05. However, the χ^2 statistic is impacted by sample size (Schermelleh-Engel et al., 2003). In the case of large samples, even a minor deviation from a perfect fit can yield statistically significant chi-square test results (Alavi et al., 2020). Therefore, the chi-square statistic does not contribute to understanding the fit of models with large sample sizes (e.g., the model for the second empirical study). To address the negative effect of large sample sizes on the chi-square statistic, relative or normalised chi-squares ($\frac{\chi^2}{d.f.}$) mitigate the effect of sample size. Values ($\frac{\chi^2}{d.f.}$) less than 5 are generally considered acceptable (Wheaton et al., 1977). This adjusted statistic allows for a more robust assessment of model fit, especially in cases where the traditional χ^2 statistic does not provide an accurate assessment due to large sample sizes.

Furthermore, the **normative fit index** measures the degree of fit in structural equation model. The normative fit index evaluates the model by comparing the χ^2 value of the

model to that of the null model, which represents the worst-case scenario in which all measured variables are uncorrelated. A value of the normative fit index above 0.90 generally indicates an acceptable model fit (Marsh and Hau, 1996).

Based on the normative fit index, the **Tucker-Lewis index**, also known as the non-normalised fit index, assesses the difference between the χ^2 of the hypothetical structural equation model and the χ^2 value of the null (empty) model. The Tucker-Lewis index adds a penalty for increased parameters to the normative fit index. The Tucker-Lewis index value above 0.90 or 0.95 is acceptable (Hu and Bentler, 1999).

The **comparative fit index** is an improved version of the normative fit index that considers the respondents' size. It measures the ratio between the discrepancy of the target model and that of the independence model. Values closer to 1 generally indicate an acceptable fit.

The **goodness of fit index** and the **adjusted goodness of fit index** measure how well the proposed model explains the observed covariance. A higher goodness of fit index indicates a better fit. Similarly, value above 0.90 is acceptable.

In addition, the **root mean square error of approximation** assesses the population discrepancy per degree of freedom by considering the effects of model complexity. The root mean square error of approximation values below 0.06 suggest a good fit, while values up to 0.08 represent a reasonable fit.

Finally, the **standardised root mean squared residual** is the square root of the discrepancy between the residuals of the respondent's covariance matrix and the hypothesised covariance model. Values below 0.08 indicate a good fit (Hu and Bentler, 1999).

Attention should also be paid to testing the reliability and validity of multiple indicators used to measure the structure of latent variables in measurements of structural equation model (Hair et al., 2021). The concepts of reliability and validity are essential for assessing the effectiveness of various methods, techniques, and tests. Reliability refers to the consistency with which a certain measurement is obtained (Fornell and Larcker, 1981). Therefore, if the measurement is repeated under similar conditions, the results should be consistent each time (Cheung et al., 2024). In comparison, validity relates to the accuracy of the measurement results. It assesses whether the measurement results accurately reflect the concept or structure to be measured. Thus, reliability is concerned with the measurement process, while validity refers to whether the measurement accurately captures the essence of what is being measured.

In terms of the reliability of indicators, in structural equation model, structural reliability, also known as composite reliability, is often used as a measure of reliability (Raykov, 1997). Hair et al. (2021) stated that the minimum composite reliability value is 0.7, while 0.6 is also feasible in exploratory research. Regarding the validity of indicators, composite reliability focuses on the internal consistency of indicators intended to measure the same construct (Bagozzi, 1981). Hence, different measures or questions to assess the same concept should highly correlate (Carmines and Zeller, 1979). The average variance extracted metric can be used to test convergent validity (Cheung et al., 2024). The average variance extracted metric measures the amount of variance a construct explains in its indicators compared to the total variance. According to the criteria, for a construct to demonstrate acceptable convergent validity, its average variance extracted value should be no less than 0.5 (Cheung et al., 2024). This threshold implies that the construct should explain at least 50% of the variance in its indicators (Fornell and Larcker, 1981).

3.3.3 Integrated choice and latent variable models

The third empirical study assessed the connections between mothers' NTPEB during their children's adolescence and their children's adoption of sustainable transport choices for commuting to work in young adulthood. Hence, the Integrated choice and latent variable

model was employed as a sophisticated analytical framework combining latent variable and discrete choice models.

The latent variable model is a multiple-indicator, multiple-cause model with two components: structural models and measurement models. The latent variable model is consistent with the structural equation model described above, so the formula is not repeated here. This subsection uses the formulas shown in the structural equation model for illustration. Thus, the relationship between exogenous and endogenous latent variables was analysed in the structural model of the latent variable model as represented using Formulation 2-2. The measurement model established a connection between the latent variables and their respective indicators (i.e. questions). In the simplest case, a linear factor model is appropriate for describing the mapping of these latent variables on the indicators, which leads to the following measurement equation (2-1). Another component of the integrated choice and latent variable model, the discrete choice model, was used to assess the relationship of the latent variable and all of its control variables with the dependent variable. The discrete choice model of the integrated choice and latent variable model can be viewed as a multinomial logistic regression model. Therefore, the mathematical formulations (1-1, 1-2, and 1-3) of the multinomial logistic regression model were also consistent with the mathematical formulas of the discrete choice model of the integrated choice and latent variable model.

Two primary methods estimate the parameters within the integrated choice and latent variable model: sequential and simultaneous. The sequential approach is a two-tiered process that initially estimates latent variable models. Next, latent variables derived from the first step are incorporated into choice models (Bahamonde-Birke and Ortúzar, 2014). While this method offers the advantage of simplicity and compatibility with standard software designed for discrete choice and latent variables models (Raveau et al., 2010), it does not account for the interplay among latent variables.

Hence, the empirical studies of this thesis adopted the simultaneous estimation method. The estimation utilised the maximum likelihood approach, while Monte Carlo simulation was employed for integration. However, the integrated choice and latent variable model

was used in the fourth empirical study concerning the role of mothers' NTPEB in children's persistent sustainable transport choices from adolescence to adulthood because the dependent variable was categorical and contained potential independent variables.

3.4 Summary of methodology

This chapter focused on the research data and methodological framework for all empirical studies in this thesis. The Understanding Society Survey (i.e. the UKHLS) dataset was used. The first empirical investigation adopted a cross-sectional methodology for Hypothesis 1 to examine the link between mothers' NTPEB and their children's choice of sustainable transportation modes to school in adolescence. This analysis employed multinomial logistic regression on the dataset comprising 3,022 mother-child pairs from Wave 4 of the UKHLS.

The second empirical study tested Hypothesis 2, which explored overarching sustainable transport behaviours (e.g. the frequency of sustainable transport behaviours) of children in young adulthood. The investigation examined the role of maternal NTPEB during their children's adolescence in the frequency of sustainable transport behaviours of children in young adulthood, alongside the mediating effect of the children's pro-environmental attitudes in young adulthood. This exploration was facilitated through structural equation model, which integrated data from Waves 4 and 10 of the UKHLS involving 977 mother-child pairs. The third empirical study tested Hypothesis 3 with 480 mother-child pairs from Waves 4 and 10 concerning the association between mothers' NTPEB during their children's adolescence and their children's sustainable transport choices for commuting to work in young adulthood using the integrated choice and latent variable model. The reduced size of respondents was because the study of children's sustainable transport behaviours to work as young adults focused only on those children who had started working while excluding those not yet employed. The fourth empirical research persisted with the same subset of 480 mother-child pairs and applied the integrated choice and latent variable model to investigate the correlation of maternal NTPEB during the children's adolescence with the persistence of children's sustainable transport choices from

adolescence to young adulthood. The next chapter presents the results of the four empirical studies.

Chapter 4. Results

This chapter presents the results of the four empirical studies conducted to fulfil each study objective. This chapter also provides an introductory subsection and restates the hypotheses of the studies to provide a clearer picture of each. The primary method used in each empirical study is also described.

4.1 The relationship between mothers' NTPEB and their children's choice of sustainable transport modes for commuting to school during adolescence

4.1.1 Introduction

The section focuses on the first empirical study, which sought to fulfil objective A. As discussed in Subsection 2.2.2, previous research has identified parental factors as determinants of adolescents' school travel choices. These factors include sociodemographic aspects such as parental employment status and education level, as well as psychological components such as parental positive attitudes towards the natural environment and environmental protection (i.e. pro-environmental attitudes), in influencing adolescents' transport choices to school. Parental transport-related pro-environmental behaviours (i.e. sustainable transport behaviours) are important factors related to adolescents' sustainable transport choices.

While prior research has highlighted the correlation of parents' sustainable transport behaviours with adolescents' sustainable transport choices to school, the correlation of parents' other behaviours, such as eco-friendly purchasing behaviours and energy-saving practices (i.e. NTPEB), with adolescents' transport choices for commuting to school has not been examined. According to previous research reviewed in Subsection 2.3.5, a relationship may be apparent. Parents' NTPEB (e.g. energy-saving behaviours, waste management, and resource conservation behaviours) can influence similar behaviours in adolescents by affecting adolescents' pro-environmental psychological factors such as

perceptions, values, and attitudes. It is worth noting that once such pro-environmental psychological factors are developed in adolescents, they may influence not only a range of NTPEB but also sustainable transport behaviours. Hence, as summarised in Subsection 2.3.7, the hypothesis is that mothers' NTPEB (e.g. eco-friendly purchasing behaviours and energy-saving practices) correlate with a greater inclination towards sustainable transport to school among adolescents. The first empirical study sought to test this hypothesis based on objective A of this thesis.

In addition to this primary research objective A, the first empirical study also aims to differentiate the strength of correlation of mothers' NTPEB and pro-environmental attitudes with adolescents' transport choice to school. While prior studies have noted a rise in pro-environmental attitudes and their prevalence, disparities persist between pro-environmental attitudes and behaviours. This is mentioned in subsection 2.2.3.

It is therefore necessary to explore in depth the different strength of correlation of parental pro-environmental attitudes and NTPEB with adolescent behaviours. Grønhøj and Thøgersen (2012) argued that compared to parents' pro-environmental attitudes, their NTPEB, including eco-friendly purchasing behaviour, recycling, and energy conservation, have a more substantial impact on their children's same behaviours. They proposed that parental pro-environmental attitudes indirectly shape adolescent NTPEB, such as shopping, recycling, and energy conservation, primarily through occasional family discussions. These indirect influences are perceived as less potent than the direct effects of parental NTPEB. Hence, it can be assumed that compared with maternal pro-environmental attitudes, maternal NTPEB have a stronger strength correlation with their children's sustainable transport to school in adolescence.

4.1.2 Research hypotheses

The first empirical study was conducted in the UK to test this hypothesis. It focused on adolescents aged 10–15 and their mothers (see the rationale in Subsection 2.3.6). Based on the existing literature, the first empirical study included Hypotheses 1.1 and 1.2:

Hypothesis 1.1: The NTPEB of mothers is correlated with sustainable transport to school for adolescents.

Hypothesis 1.2: Maternal NTPEB have a stronger correlation with adolescents' sustainable transport to school than maternal pro-environmental attitudes.

4.1.3 Methods and data

4.1.3.1 Mother-child pairs

This research conducted cross-sectional studies based on data from the 2012/13 (Wave 4) data of the UKHLS (University of Essex, 2019) to examine these two hypotheses. The final respondents comprised 3,022 mother-adolescent pairs in Wave 4. The details of the respondents' size can be found in Subsection 3.2.2.

4.1.3.2 Variables

The dependent variable was defined as adolescents' mode of transportation to school and included three distinct categories: active transport, public transport, and cars (see Subsection 3.2.3 for details). Moreover, regarding the key independent variables (i.e. mothers' NTPEB), six survey items were implemented to assess the degree of maternal engagement in energy conservation and eco-friendly purchasing practices within households (see Subsection 3.2.3 for details). The items included inquiries about the frequency of mothers turning off lights in unoccupied rooms and regularly bringing shopping bags when shopping (see Table 4-1 for the other four questions). The responses were measured on a scale from 1 (never) to 5 (always), with higher values indicating more frequent behaviours.

Additionally, this research aims to compare the difference in strength of the relationship of mothers' NTPEB and their pro-environmental attitudes with adolescents' sustainable transport choices to school. As a result, mothers' pro-environmental attitudes are also included as an independent variable.

To measure mothers' pro-environmental attitudes, six items (e.g. the extent of agreement or disagreement with the notion that "the changes made must be in line with my current lifestyle") that measured mothers' pro-environmental attitudes towards climate change were included in Wave 4 survey of the UKHLS to measure mothers' pro-environmental attitudes (see Table 4-1 for the other five questions), with responses rated on a 5-point Likert scale (1 = strongly agree; 5 = strongly disagree). In this context, a higher score indicated a stronger pro-environmental attitude or more support for environmental conservation. These six items were consistent with the survey items that measured children's pro-environmental attitudes in the second, third, and fourth empirical studies. More information appears in Subsection 3.2.3.

Table 4-1. Definition of the variables in the first empirical study

Variable	Definition
Adolescents' Demographic Traits	
A_age	Adolescents' ages: 10, 11, 12, 13, 14, 15 years
A_sex	Adolescents' sexes: male or female
A_ethnicity	Adolescents' ethnicity: White or other ethnicities
Mother's Sociodemographic Traits and Travel Behaviours	
M_Job	Mother's employment status at the time of survey: working or not working.
M_Qualification	Mother's education level: degree or higher, or no degree
M_bikefeq	Mother's frequency of travelling by bike: At least one time a week or less than one time a week
M_busfeq	Mother's frequency of travelling by ordinary bus: At least once a week or less than once a week
Household Factors	
Income	Net household income, where "net" refers to the net of taxes on earnings and national insurance contributions: <£1,000, £1,000–£2,000, or >£2,000 per month.
Urban or rural	Binary indicator of whether an address is in an urban or rural area derived from the Office for National Statistics Rural and Urban Classification of Output Areas 2001. The indicator assumes a value of (0) if the address falls within urban settlements with a population of 10,000 or more or (1) otherwise.
Car	Number of cars owned by the household: none, one, or more than one.
Mother's NTPEB (1. Never ~ 5. Always)	
Do not keep the tap running while you brush your teeth.	
Turn off lights in rooms when not in use.	
Not leaving the TV on standby for the night	
Not buying something because of too much packaging	
Buying recycled paper products	
Taking along a shopping bag for shopping	
Mother's pro-environmental attitudes (1-strongly agree, 5-strongly disagree)	
Any changes I make to help the environment must fit with my lifestyle.	
The so-called 'environmental crisis' has been greatly exaggerated.	
Climate change is beyond our control; it is too late to do anything.	
The effects of climate change will occur too far in the future to truly worry me.	
It is not worth me doing things to help the environment if others do not.	
It is not worth the UK combatting climate change because other countries will cancel out what it does.	
Dependent variable	
school transport choice	Transport choices for adolescents commuting to school: cars, public transport, and active transport.

This research incorporated a variety of control variables to enhance the reliability and robustness of the study based on the relevant literature reviewed in Subsection 2.2.2. The variables included adolescents' demographic characteristics (i.e. age, gender, and ethnicity); household factors (e.g. household income; whether they lived in an urban or rural area; and car ownership) and maternal sociodemographic elements (i.e. employment status and education level). This research also considered mothers' sustainable transport behaviours: frequency of cycling and public transportation use. This consideration was important since mothers' travel behaviours could partially reflect the quality of sustainable transport infrastructure and services available in their respective regions. The details of these variables are presented in Table 4-1.

4.1.3.3 Data analysis

This study began with reliability and validity tests for the survey items used to measure mothers' NTPEB as well as their pro-environmental attitudes (see subsection 3.3.2 for more information on the reliability and validity tests). These 6 survey items used to measure mothers' pro-environmental attitudes were found to have acceptable reliability and convergent validity (both Cronbach's α and the composite reliability value exceeds the recommended threshold of 0.7, and the average variance extracted metric for mothers' pro-environmental attitudes exceeded 0.5). Thus, mothers' pro-environmental attitudes can be considered as a latent variable in this study. However, for these 6 survey items used to measure mothers' NTPEB, there was not acceptable reliability and validity (Cronbach's α and the composite reliability value below the recommended threshold of 0.7).

Therefore, in this study, the overall NTPEB score for each mother was calculated by averaging their responses to the six questions, with higher scores indicating greater engagement of NTPEB. The overall NTPEB score for each mother was then used as independent variables in subsequent analyses. The method to determining scores for mothers' NTPEB was informed by research based on UKHLS data of Hand (2020). The rationale behind this method stems from the recognition that NTPEB do not necessarily exhibit internal consistency. For instance, a mother might be actively engaged in certain NTPEB (e.g. turn off the lights) but not in others. As a result, treating NTPEB as a latent

variable, which assumes internal consistency among the behaviours, is not appropriate. Instead, these behaviours are more accurately conceptualized as a formative construct by calculating the mean. In a formative construct of mother's NTPEB, mother's each behaviour contributes to the overall construct of NTPEB, but they do not have to correlate strongly with one another, acknowledges the multifaceted and heterogeneous nature of pro-environmental actions (Coltman et al., 2008).

After completing the initial reliability and validity tests, this research applied confirmatory factor analysis as the measurement model within structural equation model (see Subsection 3.3.2). The confirmatory factor analysis investigated relationships between the latent variables (pro-environmental attitudes) and the observed items (the six questions related to pro-environmental attitudes). The confirmatory factor analysis model was run in R (R Core Team, 2021), using the weighted least squares mean square variances estimator, as all modelled observed variables were ordered as categorical variables with non-normal distributions. R codes were referenced by Beaujean (2014).

Like structural equation model, an essential stage of confirmatory factor analysis involves evaluating the goodness of fit of the proposed model and measuring how well the model matches the observed data (see Subsection 3.3.2 for details). Therefore, the indices discussed in Subsection 3.2.3 were used to assess the goodness of the confirmatory factor analysis for this study. After conducting confirmatory factor analysis, factor scores for pro-environmental attitudes (latent variable) were computed for each mother's responses in this research. These factor scores were then used as independent variables in subsequent analyses.

This research uses the multinomial logistic model (See subsection 3.3.1 for details) to examine the association between sustainable transport modes (active and public transport) employed by adolescents for commuting to school and NTPEB of their mothers. It is worth noting that in order to compare the differences in the strength of the association of mother's pro-environmental attitudes and her NTPEB with adolescents' sustainable transport to school, these two variables were sequentially included in the model. Thus, two multinomial logistic models were formulated. Model 1 was constructed considering only

the mothers' pro-environmental attitudes, while Model 2 further incorporated the mothers' NTPEB. Additionally, each model included 10 control variables. In all the models, the dependent variable was classified into three distinct transport modes employed by adolescents for commuting to school: active transport, public transport, and by car. Among these, the car was designated as the reference category, hence its parameters were fixed at zero. To aid in the interpretation of the models, odds ratios were computed.

Subsequently, all control variables were tested for multicollinearity (see Subsection 3.3.1 for details). The variance inflation factor of most of the controlled variables were <5. Among all the control variables, household car ownership, household income, mother's work status, and frequency of mother's bus travels had the variance inflation factor values >5 but <10. Therefore, this study was free from multicollinearity.

This study also examined the model fit goodness-of-fit statistic such as the Akaike Information Criterion (see subsection 3.3.1 for details). Lower Akaike information criterion values represent better model fit. The Akaike information criterion value is not only related to model fit, but also to the number of parameters in the model. The Akaike information criterion penalises models that use more parameters. Thus, if Model 2 (which considers both mothers' NTPEB and mothers' pro-environmental attitudes) has a smaller Akaike information criterion value than Model 1 (which considers only mothers' pro-environmental attitudes), then it can be argued that the Model 2 model is a better fit for the data. This could also indicate that compared with mothers' pro-environmental attitudes, mothers' NTPEB can better explain children's transport choices to school.

4.1.4 Results

Table 4-2 provides descriptive statistics on survey items related to mothers' NTPEB and pro-environmental attitudes. Among mothers' NTPEB, turning off the lights in a spare room (mean = 3.26), not leaving the TV on standby in the evening (mean = 3.33), carrying a shopping bag (mean = 3.65), and not turning on the tap when brushing the teeth (mean = 4.37) were the more common and frequent behaviours. Conversely, not buying an item

because of excessive packaging (mean = 1.79) and buying recycled paper products (mean = 2.51) were practised less frequently.

Concerning items relating to pro-environmental attitudes, mothers were more likely to disagree with the following: the UK does not deserve to work on climate change because other countries will counteract what the UK is doing (mean = 3.41); it is not worth my while to do something for the environment if other people do not (mean = 3.40); and the impacts of climate change are happening too far into the future for me to really worry about them (mean = 3.48). However, mothers were more likely to agree that any changes to the environment must align with their lifestyle (mean = 2.77). This finding partly explained the different levels of participation in various NTPEB. Since this study included a wide range of NTPEB with different motivations, opportunities, and abilities to participate, some behaviours (e.g. not purchasing goods due to over-packaging and purchasing recycled paper products) could change previous lifestyles. Hence, participation in them was not high. The relatively high standard deviations for the behaviours “not putting the TV on standby at night” (SD = 1.66) and “turning off the lights in a room that is not in use” (SD = 1.79) also suggested a large variation in these behaviours among respondents.

Table 4-2. Descriptive statistics of survey items related to mothers' NTPEB and pro-environmental attitudes in the first empirical study (n = 3,022)

Survey items	**Wave 4 Respondents**
	Mean (SD)
Mother's NTPEB	
Do not keep the tap running while you brush your teeth	4.37 (0.882)
Turn off lights in rooms when not in use	3.26 (1.79)
Not leaving the TV on standby for the night	3.33 (1.66)
Not buying something because of too much packaging	1.79 (1.02)
Buying recycled paper products	2.51 (1.29)
Taking along a shopping bag for shopping	3.65 (1.44)
Mother's pro-environmental attitudes	
Any changes I make to help the environment must fit with my lifestyle.	2.77 (0.881)
The so-called environmental crisis has been greatly exaggerated.	3.06 (0.880)
Climate change is beyond our control; it is too late to do anything.	3.39 (0.896)
The effects of climate change will occur too far in the future to truly worry me.	3.48 (0.923)
It is not worth me doing things to help the environment if others do not.	3.40 (1.03)
It is not worth the UK combatting climate change because other countries will cancel out what it does.	3.41 (0.994)

SD = standard deviation

Table 4-3 displays the standardised factor loadings for latent variable (mothers' pro-environmental attitudes) in confirmatory factor analysis. All standardised factor loadings are statistically significant and are higher than the 0.3 (Boateng et al., 2018). The latent variable "mothers' pro-environmental attitudes" had the greatest effect (and therefore the highest factor loading) on the items ("It is not worth the UK combatting climate change because other countries will cancel out what it does").

Table 4-3. factor loadings and goodness of fit in confirmatory factor analysis of the first empirical study

Survey items	**Wave 4**	**P-value**
Mother's pro-environmental attitudes		
Any changes I make to help the environment must fit with my lifestyle.	0.417	0
The so-called environmental crisis has been greatly exaggerated.	0.533	0
Climate change is beyond our control; it is too late to do anything.	0.661	0
The effects of climate change will occur too far in the future to truly worry me.	0.732	0
It is not worth me doing things to help the environment if others do not.	0.803	0
It is not worth the UK combatting climate change because other countries will cancel out what it does.	0.838	0
Model chi-square	502.08	
***P*-value (model chi-square)**	0	
Goodness of fit index	0.99	
Adjusted goodness of fit index	0.95	
Root mean square error of approximation	0.04	
Comparative fit index	0.98	
Cronbach's α	0.787	
Composite reliability value	0.788	
Average variance extracted metric	0.502	

Table 4-3 also illustrates model fit indices of the confirmatory factor analysis, in which the goodness of fit index, adjusted goodness of fit index, and comparative fit index >0.9, whereas the value of the root mean square error of approximation was <0.05, which indicated an acceptable confirmatory factor analysis fit. Moreover, Table 4-3 provides insight into the reliability and validity indicators for the latent variable construct "mother's pro-environmental attitudes" in the confirmatory factor analysis model. Both Cronbach's α and the composite reliability value exceeded the recommended threshold of 0.7, which established good reliability for the latent variable construct. Additionally, the average variance extracted metric for the latent variable construct exceeded 0.5, which demonstrated that the research scale exhibited acceptable convergent validity. No discriminant validity test was conducted since only one latent variable existed in the confirmatory factor analysis.

Table 4-4. Descriptive statistics of adolescents' demographic and school transport choice, mothers' sociodemographic, and household factors in the first empirical study (n = 3,022)

Variable		Wave 4
Adolescents' Demographic Traits		
A_gender	Male	1,542 (51.0%)
	Female	1,480 (49.0%)
A_age (years)	10	447 (14.8%)
	11	516 (17.1%)
	12	482 (15.9%)
	13	546 (18.1%)
	14	517 (17.1%)
	15	514 (17.0%)
A_ethnicity	White	2,496 (82.6%)
	Other ethnic groups	526 (17.4%)
Mother's Sociodemographic Traits and Travel Behaviours		
M_Qualification	No degree	1,805 (59.7%)
	Degree or other higher degree	1,217 (40.3%)
M_Job	Working	2,159 (71.4%)
	Not working	863 (28.6%)
M_busfeq	At least one time a week	476 (15.8%)
	Less than one time a week	2,546 (84.2%)
M_bikefeq	At least one time a week	220 (7.3%)
	Less than one time a week	2,802 (92.7%)
Household Factors		
Car	No car	376 (12.4%)
	One car	1,204 (39.8%)
	More than one car	1,442 (47.7%)
Net_Income	Less than £1,000	873 (28.9%)
	£1,000–2,000	1,695 (56.1%)
	More than £2,000	454 (15.0%)
Living area	Urban area	2,246 (74.3%)
	Rural area	776 (25.7%)
Dependent Variable		
A_school transport choice	Active transport	1,381 (45.7%)
	Public transport	775 (25.6%)
	Car	866 (28.7%)
n		3,022

Table 4-4 illustrates the descriptive statistics of the respondents. The demographic composition of the adolescent respondents was predominantly comprised of White individuals, accounting for 82.6%. Approximately half of the adolescents surveyed identified as male. Regarding mothers' employment statuses, 30.5% were unemployed. Additionally, 40.3% reported possessing a degree or higher qualification. Regarding family

characteristics, a significant proportion, 74.3%, resided in urban areas. Car ownership was prevalent among most families. Furthermore, over half of the families reported a monthly net income between £1,000 and £2,000. Notably, the average adjusted household income for all households in the Wave 4 survey of the UKHLS also fell within this range. Regarding the dependent variable, the utilisation of public transport to school among adolescents had the lowest percentage, whereas the adoption of active transport modes for commuting to school had the highest percentage.

Table 4-5 presents the descriptive statistical analysis regarding the NTPEB and pro-environmental attitudes of mothers, which served as the independent variables in this research. The analysis revealed that mothers whose children opted for public transport for their school commute exhibited the highest average scores in pro-environmental attitudes and behaviours. Conversely, the mothers whose children preferred commuting to school by car showed the lowest average scores in these areas. This outcome aligned with expectations.

Table 4-5. The distribution of scores for NTPEB and pro-environmental attitudes of mothers in the first empirical study

	Wave 4		
Transport choice	Active transport (N = 1,381)	Public transport (N = 775)	Car (N = 866)
Mother's NTPEB			
Mean (SD)	3.15 (0.703)	3.22 (0.671)	3.12 (0.686)
Mother's pro-environmental attitudes			
Mean (SD)	–0.00674 (0.385)	0.0208 (0.384)	–0.00961 (0.308)

Note:

- The scores for mothers' NTPEB were computed by taking the average of the responses (ranging from 1, indicating "never", to 5, indicating "always") across all behavioural items.
- Mothers' pro-environmental attitudes were derived from the factor scores obtained through confirmatory factor analysis.

Table 4-6 presents the results of the multinomial logistic regression based on 3,022 mother-adolescent pairs from Wave 4 of the UKHLS. Adolescents' demographic characteristics (i.e. age, gender, and ethnicity), mothers' sociodemographic characteristics and transport behaviours (i.e. mother's job, educational qualifications, frequency of bus and bicycle

trips), and household factors (i.e. car ownership, living in the rural area, household income) were included as control variables in each model. Comparing the differences in the strength of the association between mothers' pro-environmental attitudes and their NTPEB with adolescents' sustainable transport to school required these two variables to be sequentially included in the model. Thus, Model 1 focused on control variables and mothers' pro-environmental attitudes, while Model 2 further included mothers' NTPEB. Each model utilised the same dependent variable categories: active transport (A), public transport (P), and cars (C). Car use was defined as a reference category.

Concerning control variables, several control variables, including adolescent age, ethnicity, mother's job status, bicycle and bus use frequency, car ownership, and living area, showed statistically significant associations with the choices of transport choice to school across all models. Among these variables, the age of the adolescents, status of mothers needing to work are significantly and positively associated with the adolescents' choice of active transport or public transport to school in model 1 and model 2. In contrast, adolescents with Non-White ethnicity, mothers with degree or higher, mothers with lower frequency of bus or bicycle trips, and low household car ownership are significantly negatively associated with adolescents' choice of active transport or public transport to school. Notably with respect to the family's residential address (rural or urban), in Models 1 and 2, adolescents who lived in the rural area were less likely to use active transport to attend school than those who lived in the urban (OR= 0.51, 0.50). However, adolescents living in the rural area were more likely to choose public transport to school than those living in the urban (OR= 2.97, 2.94).

Table 4-6. Odds ratios of multinomial logit model in first empirical study

Variable	Level	Model 1 (attitude): Wave 4		Model 2 (attitude + behaviour): Wave 4	
		Odds Ratio (A|C) and 95% CI	Odds Ratio (P|C) and 95% CI	Odds Ratio (A|C) and 95% CI	Odds Ratio (P|C) and 95% CI
Adolescents' Demographic Traits					
A_age	10 (reference)				
	11	1.26 (0.95, 1.67)	**5.02*** (2.93, 8.60)**	1.25 (0.94, 1.66)	**4.98*** (2.90, 8.55)**
	12	**1.39* (1.02, 1.89)**	**13.7*** (8.05, 23.2)**	**1.39* (1.02, 1.88)**	**13.7*** (8.04, 23.2)**
	13	**1.28* (0.95, 1.73)**	**15.4*** (9.13, 25.9)**	**1.27* (0.94, 1.72)**	**15.3*** (9.07, 25.8)**
	14	**1.60** (1.18, 2.15)**	**12.6*** (7.40, 21.3)**	**1.59** (1.18, 2.15)**	**12.5*** (7.38, 21.2)**
	15	**1.46* (1.07, 1.97)**	**14.2*** (8.40, 24.1)**	**1.44* (1.06, 1.96)**	**14.1*** (8.33, 23.9)**
A_gender	Female (reference)				
	Male	1.02 (0.85, 1.21)	0.89 (0.72, 1.09)	1.01 (0.85, 1.21)	0.88 (0.72, 1.09)
A_ethnicity	White (reference)				
	Other ethnic groups	**0.68** (0.53, 0.86)**	1.01 (0.75, 1.37)	**0.66*** (0.51, 0.84)**	0.99 (0.73, 1.33)
Mother's Sociodemographic Traits and Travel Behaviours					
M_Job	Not working (reference)				
	Working	**1.16* (0.93, 1.45)**	**1.31* (1.01, 1.71)**	**1.19* (0.95, 1.48)**	**1.34* (1.03, 1.75)**
M_Qualification	No Degree (reference)				
	Degree or Other higher degree	**0.77** (0.63, 0.92)**	1.03 (0.82, 1.28)	**0.75** (0.62, 0.91)**	1.01 (0.80, 1.25)

M_busfeq	At least one time a week (reference)				
	Less than one time a week	**0.52*** **	**0.30*** **	**0.53*** **	**0.31*** **
		(0.37, 0.72)	**(0.21, 0.43)**	**(0.38, 0.73)**	**(0.21, 0.44)**
M_bikefeq	At least one time a week (reference)				
	Less than one time a week	**0.63***	0.82	**0.65***	0.85
		(0.44, 0.90)	(0.53, 1.25)	**(0.45, 0.93)**	(0.56, 1.31)
Household Factors					
M_Car	No car (reference)				
	One car	**0.25*** **	**0.24*** **	**0.25*** **	**0.24*** **
		(0.16, 0.39)	**(0.15, 0.39)**	**(0.16, 0.38)**	**(0.15, 0.39)**
	More than 1	**0.18*** **	**0.22*** **	**0.17*** **	**0.21*** **
		(0.11, 0.28)	**(0.13, 0.36)**	**(0.11, 0.27)**	**(0.13, 0.36)**
Urban or rural	Urban area (reference)				
	Rural area	**0.51*** **	**2.97*** **	**0.50*** **	**2.94*** **
		(0.41, 0.64)	**(2.35, 3.76)**	**(0.40, 0.63)**	**(2.33, 3.72)**
Income	Less than £1,000 (reference)				
	£1,000–2,000	0.97	1.02	0.97	1.01
		(0.78, 1.22)	(0.78, 1.34)	(0.77, 1.21)	(0.77, 1.33)
	More than £2,000	1.02	0.99	1.02	0.97
		(0.74, 1.40)	(0.69, 1.44)	(0.73, 1.37)	(0.67, 1.40)
Mother's Pro-Environmental Attitude		1.25	**1.37***	1.13	1.2
		(0.98, 1.59)	**(1.03, 1.83)**	(0.92, 1.52)	(0.95, 1.70)
Mother's NTPEB				1.18	**1.27***
				(0.99, 1.29)	**(1.02, 1.41)**
Akaike information criterion		5,806.79		5,805.29	
McFadden pseudo R^2		0.109		0.11	

Note: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

CI: Confidence Interval

Odds ratios: m|n for an explanatory variable is the odds ratio for a unit increase in the explanatory variable of mode m ∈ (A, P) versus mode n ∈ (C), where A denotes active transport (walking/biking), C denotes car, and P denotes public transport (train, subway or bus).

In terms of independent variables, in Model 1, a positive relationship was detected between a mother's pro-environmental attitudes and her child's use of public transport to school (OR = 1.37, $p < 0.05$). However, in Model 2, this correlation was statistically insignificant after the mothers' NTPEB were included (OR = 1.20, $p > 0.05$). Moreover, there was a statistically significant positive correlation between mothers' NTPEB and adolescents' choice of public transport to school in Models 2 (OR = 1.27, $p < 0.05$). Notably, mothers' pro-environmental attitudes and NTPEB did not correlate with adolescents' choices of active transport to school. Additionally, the model encompassing controlled variables, mothers' pro-environmental attitudes and NTPEB (model 2) offers a superior fit for the data compared to the model that solely incorporates controlled variables and mothers' pro-environmental attitudes (model 1), as indicated by the Akaike Information Criterion (5,806.79>5,805.29).

4.2 The relationship between mothers' NTPEB during their children's adolescence and their children's frequency of sustainable transport behaviour during young adulthood

4.2.1 Introduction

The preceding section identified a noteworthy correlation between mothers' NTPEB during their children's adolescence and their children's adoption of sustainable transport choices to school during the same period. This section shifts to investigate whether this correlation persisted into the young adulthood of these children. Specifically, Section 4.2 focuses on the second empirical study concerning whether the NTPEB exhibited by mothers during their children's adolescent years were a correlating factor in their children's frequency of overall sustainable transport behaviours (for all trip purposes) in young adulthood. The second empirical study focused on objective B of this thesis.

According to subsection 2.3.5, parental NTPEB might foster the children's pro-environmental psychological factors prior to reaching adulthood (e.g. children's adolescence). Although there is no research on the connection between parents' NTPEB

during their children's adolescence and children's pro-environmental attitudes in young adulthood, this relationship could exist to some extent based on previous studies (for more information, please refer to 2.3.5). Therefore, it can be hypothesized that parents' NTPEB preceding the adulthood of their children (e.g., adolescence) have the potential to influence their children's pro-environmental attitudes in adulthood. Moreover, given that pro-environmental attitudes in young adulthood are seen as determinants of sustainable transport behaviours (please refer to 2.2.3), it can be hypothesized that children's pro-environmental attitudes in young adulthood may mediate the relationship between parents' NTPEB during their children's adolescence and children's sustainable transport behaviours in young adulthood.

This longitudinal study (second empirical study in this thesis), therefore, aims to test this hypothesis. This study still focuses on mothers. Specifically, this second empirical study examines the associations between mother's NTPEB during their children's adolescence and their children's frequency of sustainable transport behaviours in young adulthood. It is essential to underscore that this second analysis concentrates on evaluating the frequency of sustainable transport behaviours (for all trip purposes) in young adulthood. This second study explores the role of children's pro-environmental attitudes in young adulthood in shaping these relationships.

4.2.2 Research hypotheses

Based on the previous literature, the second empirical study tested Hypotheses 2.1, 2.2, and 2.3.

Hypothesis 2.1: The NTPEB exhibited by mothers during their children's adolescence influence their children's pro-environmental attitudes in young adulthood.

Hypothesis 2.2: Mothers' NTPEB during their children's adolescence indirectly influence their children's frequency of sustainable transport behaviour in young adulthood.

Hypothesis 2.3: Children's pro-environmental attitudes in young adulthood mediate the relationship between mothers' NTPEB in their children's adolescence and their children's frequency of sustainable transport behaviours in young adulthood.

4.2.3 Method

4.2.3.1 Mother-child pairs

This second empirical study adopted a longitudinal research approach that utilised data from Waves 4 (2012/13) and 10 (2018/19) of the UKHLS (University of Essex, 2019) to examine these three hypotheses. The final respondents comprised 977 mother-child pairs. The details of the respondents' size can be found in Subsection 3.2.2.

4.2.3.2 Variables

The primary variables examined were the pro-environmental attitudes, the frequency of sustainable transport behaviours of children in young adulthood, and the NTPEB of their mothers during their children's adolescence.

According to Subsection 3.2.3, the second study employed two specific survey items in Wave 10 of the UKHLS to gauge the frequency of sustainable transport behaviours of children in young adulthood. The first pertained to the frequency with which child respondents chose to walk or cycle (i.e. active transport) for shorter journeys, specifically those covering a distance of two to three miles. The second survey item was concerned with the frequency of using public transport (e.g. buses and trains) as an alternative to driving. Children's responses ranged from 1 (never) to 5 (always). Regarding the pro-

environmental attitudes of children in young adulthood, the second study incorporated six survey items. For example, an illustrative survey item was, “The ‘environmental crisis’ facing humanity is significantly exaggerated”. Respondents rated their agreement on a 5-point Likert scale, with 1 representing “strongly agree” and 5 denoting “strongly disagree”. In this framework, a higher score signified intensified pro-environmental convictions or heightened endorsement of environmental preservation. The other five research questions are listed in Table 4-7. Regarding mothers’ NTPEB, the measurement of survey items remained unchanged from the first empirical study.

This second empirical study drew from the existing literature (see Subsection 2.2.3 for details) to incorporate a wide range of control variables to understand the sustainable transport behaviours of children in young adulthood, including age, sex, and ethnicity. Household income levels and geographical settings (urban vs rural) were also considered. The study also controlled for children’ socioeconomic attributes in young adulthood by considering their employment situations, whether they owned cars, had driving licences, and lived with their parents. The study also reflected on the past transport behaviour of children during their adolescent years by especially focusing on their transport choices to school.

Previous research has demonstrated that the pro-environmental attitudes of parents contribute to similar pro-environmental attitudes formed by their children (Leppänen et al., 2012). Therefore, the second empirical study considered the pro-environmental attitudes of mothers during their children’s adolescence. The survey items measuring mothers’ pro-environmental attitudes remained unchanged from the first empirical study. Moreover, the study also considered mothers’ frequency of overall sustainable transport behaviours during children’s adolescence. Therefore, as mentioned above, these two survey items were consistent with the children’s frequency of sustainable transport behaviours in young adulthood. The survey items relating to mothers’ sustainable transport behaviours during their children’s adolescence were from Wave 4 of the UKHLS, as were mothers’ NTPEB and pro-environmental attitudes during their children’s adolescence. For a more detailed explanation of each variable, see Table 4-7.

Table 4-7. Definitions of variables in the second empirical study

Variables	Definition
Children's demographic and socioeconomic traits in young adulthood (Wave 10)	
Age	Children's age in young adulthood
Female	Children's sex: categorised as Male = 0, Female = 1
Non-White ethnicity	Children's ethnicity: White = 0, Other ethnicities = 1
Employment	Children's employment status in young adulthood (at the time of survey): categorised as *Full-time student, Employed, and Unemployed*
Highest_qualification (ordered categorical variable)	Children's highest educational level in young adulthood (at the time survey) 1: Below the level of GCSE or without any certifications. 2: Equivalent to GCSE level. 3: Equivalent to A level. 4: Includes diplomas, teaching credentials, and nursing certifications, etc. 5: Bachelor's degree and above, including BSc, BA, MSc, MA, PhD, etc.
Children's life change in young adulthood (Wave 10)	
Have_car_use	Children's access to a car or van for unrestricted use in young adulthood: Yes = 1, No = 0
Have_licence	Children's possession of a driving license: Yes = 1, No = 0
Not_live_parents	Children in young adulthood already not living with parents: Yes = 1, No = 0
Children's past transport behaviour during adolescence (Wave 4)	
Sustainable_transport_to_school	Children use sustainable modes of transport other than cars while going to school during adolescence: Yes = 1, No = 0
Household factors (Wave 10)	
Income	Monthly household net income, denoted post-tax and national insurance deductions (in thousands of GBP), is adjusted for household size and composition using an equivalence scale. This equivalised income is calculated by dividing the net income by the provided equivalisation factor.
Rural	Children live in rural areas in young adulthood: Yes = 1, No = 0 This is derived from the Office for National Statistics Rural and Urban Classification of Output Areas 2001.
Children's pro-environmental attitudes in young adulthood (1. Strongly Agree ~ 5. Strongly Disagree) (Wave 10)	
Any changes I make to help the environment must fit with my lifestyle.	

The so-called environmental crisis has been greatly exaggerated.
Climate change is beyond our control; it is too late to do anything.
The effects of climate change will occur too far in the future to truly worry me.
It is not worth me doing things to help the environment if others do not.
It is not worth the UK combatting climate change because other countries will cancel out what it does.

Children's sustainable transport behaviours in young adulthood (1. Never ~ 5. Always) (Wave 10)

Opting for public modes of transport, such as buses or trains, over car travel
Walk or cycle for short journeys of less than two to three miles.

Mother's NTPEB during their children's adolescence (1. Never ~ 5. Always) (Wave 4)

Do not keep the tap running while you brush your teeth.
Turning off lights in rooms when not in use
Not leaving the TV on standby for the night
Not buying something because of too much packaging
Buying recycled paper products
Taking along a shopping bag for shopping

Mother's sustainable transport behaviours during their children's adolescence (1. Never ~ 5. Always) (Wave 4)

Opting for public modes of transport, such as buses or trains, over car travel
Walk or cycle for short journeys of less than two to three miles.

Mother's pro-environmental attitudes during their children's adolescence (1. Strongly Agree ~ 5. Strongly Disagree) (Wave 4)

Any changes I make to help the environment must fit with my lifestyle.
The so-called environmental crisis has been greatly exaggerated.
Climate change is beyond our control; it is too late to do anything.
The effects of climate change will occur too far in the future to truly worry me.
It is not worth me doing things to help the environment if others do not.
It is not worth the UK combatting climate change because other countries will cancel out what it does.

4.2.3.3 Structural equation modelling

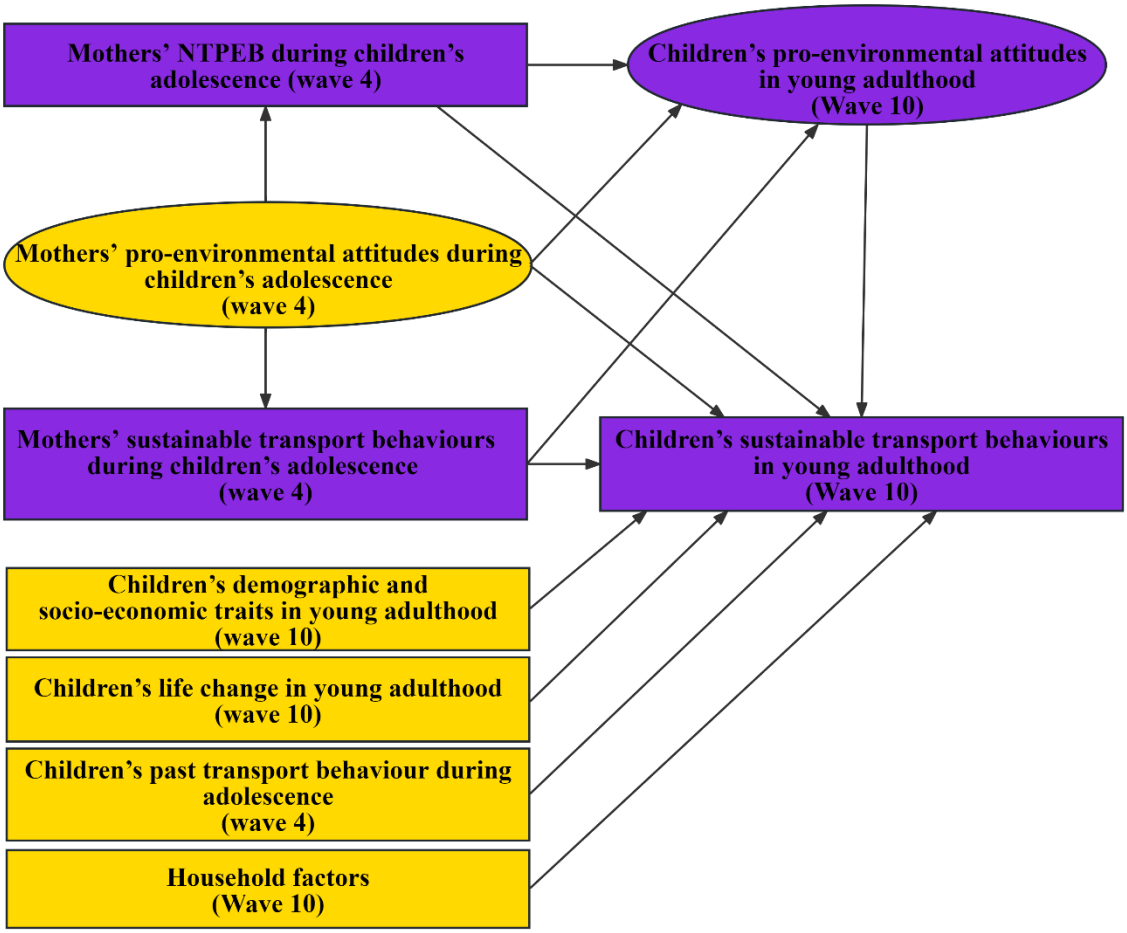
The study utilised structural equation model to uncover intricate connections between mothers' NTPEB during their children's adolescence, their children's pro-environmental attitudes, and the frequency of sustainable transport behaviour in young adulthood. According to Subsection 3.3.2, structural equation model offers insights into direct relationships between variables while unveiling indirect associations via mediating variables. Thus, the overall approach encapsulated direct and mediated influences, which aligned seamlessly with the aim of this research: to investigate the mediating role of pro-environmental attitudes of children during young adulthood in the relationship between their mothers' NTPEB during the children's adolescence and these children's frequency of sustainable transport behaviours in their young adulthood.

According to Subsection 3.3.2, it was necessary to test the reliability and validity of survey items measuring mothers' pro-environmental attitudes, NTPEB, and sustainable transport behaviours during their children's adolescence, as well as their children's pro-environmental attitudes and sustainable transport behaviours in young adulthood before building the structural equation model. This approach helped to decide whether these variables could be used as latent variables in the structural equation model. The validity and reliability (i.e. Cronbach's α and composite reliability value below the recommended threshold of 0.7) of the survey items used to measure NTPEB and sustainable transport behaviours of mothers during their children's adolescence and sustainable transport behaviours of their children during young adulthood were unsatisfactory. Therefore, as in the first empirical study, the score was calculated for each behaviour by calculating the mean of the survey items measuring each behaviour. These scores separately represented the overall frequency of each behaviour, with higher scores indicating higher levels of behavioural engagement. This approach acknowledged the multifaceted and heterogeneous nature of NTPEB and sustainable transport behaviours. However, the validity and reliability of the survey items used to measure mothers' pro-environmental attitudes during their children's adolescence and their children's pro-environmental attitudes during young adulthood were satisfactory. Therefore, mothers' pro-environmental attitudes during their

children's adolescence and their children's pro-environmental attitudes during young adulthood were latent variables.

Utilising structural equation model and considering the available data and factors, a model was constructed to elucidate this study's complex relationships under investigation. As illustrated in Figure 4-1, mothers' pro-environmental attitudes during their children's adolescence and their children's pro-environmental attitudes in young adulthood were latent variables derived from the observable survey items associated with each. The exogenous variables of structural equation model encompassed children's demographic and socioeconomic attributes (i.e. age, gender, race, employment status, and highest educational level achieved), children's life change in young adulthood (i.e. car ownership, possession of a driver's licence, and cohabitation with mothers), children's past transport behaviours (i.e. transport choices to school during adolescence), household attributes (i.e. household income and residential location), and mothers' pro-environmental attitudes during their children's adolescent years. Conversely, the child's pro-environmental attitudes in early adulthood and sustainable transport behaviours were treated as endogenous variables. Since mothers' NTPEB and sustainable transport behaviours during their children's adolescence were shaped by their pro-environmental attitudes, these behaviours also qualified as endogenous variables. In Figure 4-1, ovals denote latent variables, while rectangles signify measured variables. Variables in purple symbolise endogenous factors, and those in yellow illustrate exogenous factors.

Figure 4-1. Conceptual framework illustrating the anticipated associations within the structural equation model



Existing studies have suggested that sustainable transport actions potentially influence transport attitudes in reverse (Kroesen et al., 2017). This suggestion is consistent with the self-perception theory that posits behaviours can shape attitudes (Bem, 1972) since behaviours come before attitudes. Hence, individuals shape or adjust their attitudes by observing their own behaviours and experiences. This phenomenon is attributed to repetitive behaviours enhancing individuals' beliefs in their capabilities to perform these actions, which enhances the perceived behavioural control in the theory of planned behaviours and affects their attitudes and intentions regarding future behaviours. However, this research failed to identify any notable inverse effect when evaluating the two-way relationship between young adults' pro-environmental attitudes and sustainable transport behaviours. Hence, only one-way connections were considered in the final model.

The model was implemented within the Mplus framework by employing the weighted least squares mean square variances estimator, given the non-normal distribution of the dependent ordered categorical variables. Various goodness-of-fit indices were employed to assess the appropriateness of the structural equation model. Typically, Mplus provides metrics such as the chi-squared ($\chi 2$) statistic, the root mean square error of approximation, the Tucker-Lewis index, the comparative fit index, and the standardised root mean squared residual. Since the relationship between various exogenous and endogenous variables was considered, only examining the multicollinearity of all exogenous variables was necessary. None of the exogenous variables had the variance inflation factor values exceeding 10, which indicated freedom from multicollinearity.

4.2.4 Results

Table 4-8 shows each variable's distribution among the 977 mother-child pairs. The data showcased that 53.5% of the child respondents were females. The child respondents had grown to be young adults in the second empirical study. The average age of the child respondents was between 19 and 20 years. Moreover, those from non-White ethnic backgrounds represented 15.1% of the child respondents. A significant 90.7% of child respondents resided with their parents in young adulthood, while 49.1% were paid employees in young adulthood. The slightly higher rate of young adults living with parents in this study could have been due to their younger ages (average 19.4 years, SD = 1.16), as many were not yet ready to move out. Additionally, during the UKHLS survey, tracking respondents who left home was challenging and resulted in the attrition of these respondents, which increased the proportion of respondents reportedly living with their parents.

Table 4-8. Descriptive statistics of variables in the second empirical study (N = 977)

Variables	N (%) / Mean (SD)
Children's demographic and socioeconomic traits in young adulthood (Wave 10)	
Age	19.4 (1.16)
Female	523 (53.5%)
Non-White ethnicity	148 (15.1%)
Employment	
Full-time student	381 (39.0%)
Employed	480 (49.1%)
Unemployed	116 (11.9%)
Highest_qualification (ordered categorical variable)	
1: Below the level of GCSE or without any certifications.	90 (9.2%)
2: Equivalent to GCSE level.	291 (29.8%)
3: Equivalent to A-level.	466 (47.7%)
4: Includes diplomas, teaching credentials, and nursing certifications, etc.	67 (6.9%)
5: Bachelor's degree and above, including BSc, BA, MSc, MA, PhD, etc.	63 (6.4%)
Children's life change in young adulthood (Wave 10)	
Have_car_use	461 (47.2%)
Have_license	520 (53.2%)
Not_live_parents	91 (9.3%)
Children's past transport behaviour during adolescence (Wave 4)	
Sustainable_transport_to_school	771 (78.9%)
Household factors (Wave 10)	
Income	1.81 (0.990)
Rural	259 (26.5%)
Children's pro-environmental attitudes in young adulthood (1. Strongly Agree ~ 5. Strongly Disagree) (Wave 10)	
Any changes I make to help the environment must fit with my lifestyle.	2.85 (0.879)
The so-called environmental crisis has been greatly exaggerated.	3.54 (1.04)
Climate change is beyond our control; it is too late to do anything.	3.51 (0.954)
The effects of climate change will occur too far in the future to truly worry me.	3.66 (1.07)

It is not worth me doing things to help the environment if others do not.	3.34 (1.05)
It is not worth the UK combatting climate change because other countries will cancel out what it does	3.63 (1.07)
Children's sustainable transport behaviours in young adulthood (1. Never ~ 5. Always) (Wave 10)	
Opting for public modes of transport, such as buses or trains, over car travel	2.83 (1.43)
Walk or cycle for short journeys less than 2 or 3 miles	2.99 (1.42)
Mother's NTPEB during their children's adolescence (1. Never ~ 5. Always) (Wave 4)	
Do not keep the tap running while you brush your teeth	3.48 (1.63)
Turning off lights in rooms when not in use	4.41 (0.90)
Not leaving the TV on standby for the night	3.28 (1.79)
Not buying something because of too much packaging	1.81 (1.01)
Buying recycled paper products	2.52 (1.27)
Taking along a shopping bag for shopping	3.79 (1.39)
Mother's sustainable transport behaviours during their children's adolescence (1. Never ~ 5. Always) (Wave 4)	
Opting for public modes of transport, such as buses or trains, over car travel	1.92 (1.21)
Walk or cycle for short journeys less than 2 or 3 miles	2.83 (1.38)
Mother's pro-environmental attitudes during their children's adolescence (1. Strongly Agree ~ 5. Strongly Disagree) (Wave 4)	
Any changes I make to help the environment must fit with my lifestyle	2.82 (0.879)
The so-called environmental crisis has been greatly exaggerated	3.09 (0.889)
Climate change is beyond our control; it is too late to do anything	3.42 (0.885)
The effects of climate change will occur too far in the future to truly worry me	3.52 (0.914)
It is not worth me doing things to help the environment if others do not.	3.42 (1.03)
It is not worth the UK combatting climate change because other countries will cancel out what it does	3.40 (1.01)
n	977

Nearly 80% of the child respondents chose sustainable transport to school during their adolescence. Over half of these child respondents in young adulthood either held or were pursuing an A-level or more advanced qualification. Furthermore, about half of the child respondents in young adulthood possessed a valid driving licence and could access a car without restrictions. A substantial 70% or more resided in urban settings. The adjusted average net household income was £1,810 per month.

In the realm of pro-environmental attitudes measured during Wave 10 for child respondents in young adulthood and Wave 4 for mother respondents, a reverse coding system was used for the pro-environmental attitudes. Thus, higher scores signified a stronger disagreement with the given statements, which translated to more pro-environmental attitudes.

The child respondents cohort demonstrated a distinct pro-environmental leaning due to their evident disagreement with the notion that the effects of climate change would occur too far in the future to truly worry them (mean = 3.66). Similarly, mothers during their children's adolescence also tended to disagree that the effects of climate change would occur too far in the future to truly worry them (mean = 3.52). Regarding sustainable transport behaviour, neither the children nor the mothers preferred public transport (e.g. buses or trains) over car travel. However, a stronger tendency was observed in both groups towards walking or cycling for shorter distances, such as journeys under two to three miles. Concerning mothers' NTPEB during their children's adolescence, behaviours such as turning off lights in rooms not in use were most prevalent (mean = 4.41). Additionally, the practice of carrying shopping bags when shopping was widespread (mean =3.79). However, regarding consumer choices, mothers appeared less inclined to avoid products with excessive packaging (mean = 1.81).

Table 4-9. Factor analysis estimates and model fit indices in the second empirical study (N = 977)

Survey items	Standardised Parameter Estimate	P-Value	Composite Reliability	Average variance extracted
Children's pro-environmental attitudes in young adulthood			**0.8**	**0.593**
Any changes I make to help the environment must fit with my lifestyle	0.377	0.000		
The so-called environmental crisis has been greatly exaggerated	0.714	0.000		
Climate change is beyond our control; it is too late to do anything	0.618	0.000		
The effects of climate change will occur too far in the future to truly worry me	0.771	0.000		
It is not worth me doing things to help the environment if others do not.	0.661	0.000		
It is not worth the UK combatting climate change because other countries will cancel out what it does	0.816	0.000		
Mother's pro-environmental attitudes during their children's adolescence			**0.771**	**0.58**
Any changes I make to help the environment must fit with my lifestyle	0.370	0.000		
The so-called environmental crisis has been greatly exaggerated	0.519	0.000		
Climate change is beyond our control; it is too late to do anything	0.567	0.000		
The effects of climate change will occur too far in the future to truly worry me	0.693	0.000		
It is not worth me doing things to help the environment if others do not.	0.794	0.000		
It is not worth the UK combatting climate change because other countries will cancel out what it does	0.832	0.000		
Goodness-of-fit indices				
Chi-square	846.328 (d.f. = 252, p-value = 0.000)			
Tucker-Lewis index	0.928			
Comparative fit index	0.937			
Root mean square error of approximation	0.049			
Standardised root mean squared residual	0.089			

Table 4-9 presents the goodness-of-fit indices, which suggested that the model was generally well-fitted to the data. This research calculated the values of Tucker-Lewis index, comparative fit index, and root mean square error of approximation. The values of Tucker-Lewis index and comparative fit index exceeded the often-recommended threshold of 0.90, which indicated a good fit. Furthermore, the value of root mean square error of approximation was below the preferred level of 0.05, and the value of standardised root mean squared residual was under the benchmark of 0.08, so the model's robustness was further corroborated (Hu and Bentler, 1999). The standardised parameter estimates for the 12 survey items relating to pro-environmental attitudes among child and mother respondents are provided in the same table. Each observed survey item aligned well with its associated latent factor, as evidenced by the factor loadings. Notably, these loadings were predominantly satisfactory and exceeded the commonly accepted threshold of 0.3 (Boateng et al., 2018). In addition, Table 4-9 provides reliability and validity indicators for each latent variable in the factor analysis model. Composite reliability value exceeded the recommended threshold of 0.7. In addition, average variance extracted metric for latent variables exceeded 0.5, which indicated that the adopted research scales had acceptable convergent validity. In addition, the correlation coefficients between these two latent variables were not higher than 0.7. Therefore, discriminant validity was achieved for all latent variables.

Table 4-10 illustrates the standardised direct and indirect effects of mothers' pro-environmental attitudes, sustainable transport behaviours, and NTPEB during their children's adolescence on the children's pro-environmental attitudes in adulthood. Mothers' pro-environmental attitudes during their children's adolescence significantly positively influenced the children's NTPEB and sustainable transport behaviour during the same period. Given that standardised coefficients could indicate the strength of these influences, the data suggested that the mother's pro-environmental attitudes had a stronger direct influence on their NTPEB than on their sustainable transport behaviours ($\beta = 0.273 > 0.07$).

Table 4-10. Standardised coefficients for direct and total indirect influences among latent variables in the second empirical study

Influence		Direct effect	Total indirect effect
Mother's NTPEB during their children's adolescence	Dependent variable		
Mother's pro-environmental attitudes during their children's adolescence	Independent variable	0.273***	
Mother's sustainable transport behaviours during their children's adolescence	Dependent variable		
Mother's pro-environmental attitudes during their children's adolescence	Independent variable	0.070*	
Children's pro-environmental attitudes in young adulthood	Dependent variable		
Mother's NTPEB during their children's adolescence	Independent variable	0.339***	
Mother's sustainable transport behaviours during their children's adolescence	Independent variable	0.043	
Mother's pro-environmental attitudes during their children's adolescence	Independent variable	0.211***	0.096***
*** Indicates significance at 0.05 level.** **** Indicates significance at 0.01 level.** ***** Indicates significance at 0.001 level.**			

Mothers' pro-environmental attitudes and NTPEB during their children's adolescence directly influenced their children's pro-environmental attitudes in young adulthood (β = 0.211 and 0.339). In addition, the results underscore that compared to the mothers' pro-environmental attitudes, the mothers' NTPEB during their children's adolescence demonstrate a stronger direct influence on their children's pro-environmental attitudes in young adulthood. However, the positive impact of mothers' sustainable transport behaviours during their children's adolescence on their children's pro-environmental attitudes in young adulthood was not statistically significant (β = 0.043, $p > 0.05$).

Table 4-11 presents the standardised coefficients of the direct and indirect influence of 1) various control variables, 2) mothers' pro-environmental attitudes during their children's adolescence, 3) mothers' NTPEB during their children's adolescence, and 4) children's pro-environmental attitudes in young adulthood on their children's overall frequency of sustainable transport behaviours in young adulthood in the structural equation model. Regarding control variables, compared to their White counterparts,

child respondents from non-White ethnicities displayed a heightened propensity towards sustainable transport behaviours in young adulthood ($\beta = 0.167$, $p < 0.05$). Moreover, those employed (with full-time students as the reference group) exhibited a diminished sustainable transport inclination ($\beta = –0.304$, $p < 0.001$). Education level was positively correlated with sustainable transport behaviours among the child respondents in young adulthood ($\beta = 0.079$, $p < 0.001$).

Table 4-11. Standardised coefficients of the direct influence on children's sustainable transport behaviours in young adulthood in the second empirical study

Variables	**Direct effect**	**Total indirect effect**
Children's demographic and socioeconomic traits in young adulthood		
Age	0.022	
Female	–0.050	
Non-White ethnicity	0.167*	
Employment (reference = Full-time student)		
Employed	–0.304***	
Unemployed	–0.162	
Highest_qualification	0.079**	
Children's life change in young adulthood		
Have_car_use	–0.738***	
Have_licence	–0.208**	
Not_live_parents	–0.122	
Children's past transport behaviour during adolescence		
Sustainable_transport_to_school	0.345***	
Household factors		
Income	0.05	
Rural	–0.104*	
Children's pro-environmental attitudes in young adulthood	0.095***	
Mother's NTPEB during their children's adolescence	0.019	0.032*
Mother's sustainable transport behaviours during their children's adolescence	0.140***	0.004
Mother's pro-environmental attitudes during their children's adolescence	0.086	0.044***
*** Indicates significance at 0.05 level.**		
**** Indicates significance at 0.01 level.**		
***** Indicates significance at 0.001 level.**		
Dependent variable is children's sustainable transport behaviour in young adulthood		

As expected, having a driver's license and unrestricted access to a car adversely impacted child respondents' inclination towards the frequency of sustainable transport behaviours in young adulthood ($\beta = –0.208$ and $–0.738$). Past experiences related to sustainable transport to school during child respondents' adolescence (with cars as the reference group) revealed a positive association with their frequency of sustainable transport practices in young adulthood ($\beta = 0.345$, $p < 0.001$). Furthermore, child respondents' pro-environmental attitudes in young adulthood served as vital contributing factors towards the frequency of sustainable transport behaviours in young adulthood ($\beta = 0.095$, $p < 0.001$). Moreover, the maternal frequency of sustainable transport behaviours during children's adolescence impacted the children's frequency of sustainable transport behaviour in young adulthood ($\beta = 0.140$, $p < 0.001$).

The direct effects of mothers' pro-environmental attitudes and NTPEB during their children's adolescent years on their children's sustainable transport behaviours in young adulthood were not statistically significant. However, a significant indirect effect was observed when factoring in the children's pro-environmental attitudes in young adulthood ($\beta = 0.044$ and 0.032, $p < 0.001$). Considering the seven potential mediation paths identified in the research model, a detailed exploration of these mediating influences was undertaken.

Table 4-12 shows the seven paths of indirect influence of mothers' pro-environmental attitudes and NTPEB during their children's adolescence on the frequency of sustainable transport behaviours of those children in their young adulthood. Firstly, mothers' pro-environmental attitudes during their children's adolescence played a pivotal role. When mothers' attitudes influenced their sustainable transport behaviours, they had a ripple effect on their children's sustainable transport behaviours in young adulthood ($\beta = 0.010$, $p < 0.001$).

Table 4-12. Standardised coefficients of the path of specific indirect effects on young adults' sustainable transport behaviours in the second empirical study

Path	Standardised coefficients
Indirect influence of mother's pro-environmental attitudes	
Specific indirect 1 - Mother's pro-environmental attitudes during their children's adolescence→ Mother's NTPEB during their children's adolescence→ Children's sustainable transport behaviours in young adulthood	0.005
Specific indirect 2 - Mother's pro-environmental attitudes during their children's adolescence→ Mother's sustainable transport behaviours during their children's adolescence→ Children's sustainable transport behaviours in young adulthood	0.010***
Specific indirect 3 - Mother's pro-environmental attitudes during their children's adolescence→ Children's pro-environmental attitudes in young adulthood→ Children's sustainable transport behaviours in young adulthood	0.020*
Specific indirect 4 - Mother's pro-environmental attitudes during their children's adolescence→ Mother's NTPEB during their children's adolescence→ Children's pro-environmental attitudes in young adulthood→ Children's sustainable transport behaviours in young adulthood	0.009*
Specific indirect 5 - Mother's pro-environmental attitudes during their children's adolescence→ Mother's sustainable transport behaviours during their children's adolescence→ Children's pro-environmental attitudes in young adulthood→ Children's sustainable transport behaviours in young adulthood	0.0002
Indirect influence of mother's NTPEB	
Specific indirect - Mother's NTPEB during their children's adolescence→ Children's pro-environmental attitudes in young adulthood→ Children's sustainable transport behaviours in young adulthood	0.032*
Indirect influence of mother's sustainable transport behaviours	
Specific indirect - Mother's sustainable transport behaviours during their children's adolescence→ Children's pro-environmental attitudes in young adulthood→ Children's sustainable transport behaviours in young adulthood	0.004
*** Indicates significance at 0.05 level.** **** Indicates significance at 0.01 level.** ***** Indicates significance at 0.001 level.**	

Another statistically significant pathway emerged from the mothers' pro-environmental attitudes during their children's adolescence, which proceeded through their children's pro-environmental attitudes in young adulthood and culminated in children's sustainable transport behaviours in young adulthood ($\beta = 0.02$, $p < 0.05$). Mothers' NTPEB during their children's adolescence influenced their children's pro-environmental attitudes and shaped children's sustainable transport behaviours in young adulthood ($\beta = 0.032$, $p < 0.05$).

4.3 The relationship between mothers' NTPEB during their children's adolescence and their children's choice of sustainable transport modes for commuting to work during young adulthood

4.3.1 Introduction

The previous section elucidated the indirect correlation between mothers' NTPEB during their children's adolescence and the frequency of their children's overall sustainable transport behaviours (for all travel purposes) in young adulthood, mediated by their children's pro-environmental attitudes in young adulthood. This section mainly focuses on the children's sustainable transport choice for specific transport purposes, such as work-related purposes.

Therefore, the third empirical investigation analysed whether an indirect relationship existed between mothers' NTPEB during their children's adolescence and their children's choice of sustainable transport modes for commuting to work during young adulthood, mediated by their children's pro-environmental attitudes in young adulthood. This focus correlated with objective C of this thesis.

According to previous research (Subsection 2.2.3), since transport behaviours are demand-driven by specific transport purposes, any attempt to analyse them would be

incomplete without considering their purposes. In particular, transport behaviours for work-related purposes face stringent constraints, such as time limitations, compared to leisure trips. In such circumstances, individuals often prioritise convenience and time efficiency, which leads to preferring personal vehicles for commuting. Given the heightened constraints on transportation behaviours for work, it was crucial to investigate whether mothers' NTPEB during their children's adolescence continued to exhibit an indirect correlation with their children's sustainable work-purposed transport behaviours in young adulthood. This focus aimed to differentiate between the generalised correlation of mothers' NTPEB on children's overall sustainable transport behaviours in young adulthood and the more specific correlation on transport choices to work in young adulthood under different situational constraints. This distinction was crucial because mothers' impact could vary across different contexts. For example, mothers' NTPEB might significantly shape children's transport choices for leisure transport but have a lesser impact on commuting choices for work due to external constraints like commuting time pressure. By analysing these two aspects separately, the study offered a more accurate and detailed understanding of mothers' NTPEB role in shaping children's sustainable transport behaviours during young adulthood.

Therefore, the third empirical investigation was a longitudinal analysis set in the UK to examine whether an indirect relationship existed between mothers' NTPEB during their children's adolescence and their children's selection of sustainable transport modes for commuting to work in young adulthood. Furthermore, this empirical research analysed the mediating role of the children's pro-environmental attitudes in young adulthood in this indirect correlation.

4.3.2 Research hypotheses

Based on the second empirical study and the previous research, this third empirical study focused on Hypothesis 3.

Hypothesis 3: Mothers' NTPEB during their children's adolescence indirectly correlate with their children's sustainable transport choices for commuting to work in young adulthood by mediating their children's pro-environmental attitudes in young adulthood.

4.3.3 Method

4.3.3.1 Mother-child pairs

The third empirical study adopted a longitudinal approach that utilised data from Waves 4 (2012/13) and 10 (2018/19) of the UKHLS (University of Essex, 2019) to test Hypothesis 3. It included 480 mother-child pairs. Subsection 3.2.2 details the specifics of the number of respondents.

4.3.3.2 Variables

The primary variables were children's pro-environmental attitudes, transport choices for commuting to work in young adulthood, and mothers' NTPEB during their children's adolescence.

The dependent variable was children's transport choices for commuting to work in their young adulthood, delineated into two classifications: sustainable transport mode and cars. These categories were formulated based on primary modes of transportation to work, as reported in Wave 10 of the UKHLS. Specifically, responses indicating "drive myself by car or van", "being driven in a family car", "getting a ride from someone outside their family", "motorbike", or "taxi/minicab" were grouped under the "cars" classification of the dependent variable. Conversely, the "sustainable transport mode" classification encompassed individuals who chose "bus/coach", "train", "walk", "cycle", or "underground/Metro/tram/light railway". Concerning the other key variables, the survey items used to measure children's pro-environmental attitudes in

young adulthood and mothers' NTPEB during their children's adolescence remained consistent with those in the first and second empirical studies. The specific survey items are detailed in Table 4-13.

Table 4-13. Definition of variables in the third empirical study

Variables	Definition
Dependent variable	
Transport choice to work	Children's transport choice to work in young adulthood (Wave 10): Car = 0, Sustainable transport mode = 1
Children's demographic and socioeconomic traits in young adulthood (Wave 10)	
Age	Children's age in young adulthood
Female	Children's sex: categorised as Male = 0, Female = 1
Non-White ethnicity	Children's ethnicity: White = 0, Other ethnicities = 1
Employed full-time	Children's employment status in young adulthood: Part-time = 0, Full-time (i.e. greater than 30 hours per week) = 1.
Highest_qualification (ordered categorical variable)	Children's highest educational level in young adulthood (at the time survey) 1: Below the level of GCSE or without any certifications. 2: Equivalent to GCSE level. 3: Equivalent to A level. 4: Includes diplomas, teaching credentials, and nursing certifications, etc. 5: Bachelor's degree and above, including BSc, BA, MSc, MA, PhD, etc.
Children's life change in young adulthood (Wave 10)	
Have_car_use	Children's access to a car or van for unrestricted use in young adulthood: Yes = 1, No = 0
Have_licence	Children's possession of a driving license: Yes = 1, No = 0
Not_live_parents	Children in young adulthood already not living with parents: Yes = 1, No = 0
Children's past transport behaviour during adolescence (Wave 4)	
Sustainable_transport_to_school	Children use sustainable modes of transport other than cars while going to school during adolescence: Yes = 1, No = 0
Household factors (Wave 10)	
Income	Monthly household net income, denoted post-tax and national insurance deductions (in thousands of GBP), is adjusted for household size and composition using an equivalence scale. This equivalised income is calculated by dividing the net income by the provided equivalisation factor.
Rural	Children live in rural areas in young adulthood: Yes = 1, No = 0. This is derived from the Office for National Statistics Rural and Urban Classification of Output Areas 2001.
Distance	Distance, in miles, of residence from the usual place of work.
Children's pro-environmental attitudes in young adulthood (1. Strongly Agree ~ 5. Strongly Disagree) (Wave 10)	

Any changes I make to help the environment must fit with my lifestyle.
The so-called environmental crisis has been greatly exaggerated.
Climate change is beyond our control; it is too late to do anything.
The effects of climate change will occur too far in the future to truly worry me.
It is not worth me doing things to help the environment if others do not.
It is not worth the UK combatting climate change because other countries will cancel out what it does.
Mother's NTPEB during their children's adolescence (1. Never ~ 5. Always) (Wave 4)
Do not keep the tap running while you brush your teeth
Turning off lights in rooms when not in use
Not leaving the TV on standby for the night
Not buying something because of too much packaging
Buying recycled paper products
Taking along a shopping bag for shopping
Mother's sustainable transport behaviours during their children's adolescence (1. Never ~ 5. Always) (Wave 4)
Opting for public modes of transport, such as buses or trains, over car travel
Walk or cycle for short journeys less than two or three miles
Mother's pro-environmental attitudes during their children's adolescence (1. Strongly Agree ~ 5. Strongly Disagree) (Wave 4)
Any changes I make to help the environment must fit with my lifestyle.
The so-called environmental crisis has been greatly exaggerated.
Climate change is beyond our control; it is too late to do anything.
The effects of climate change will occur too far in the future to truly worry me.
It is not worth me doing things to help the environment if others do not.
It is not worth the UK combatting climate change because other countries will cancel out what it does.
n

The third empirical study incorporated insights from the existing literature and control variables. It considered all control variables from the second empirical study, such as children's age, sex, and educational level in young adulthood, as well as mothers' sustainable transport behaviours and pro-environmental attitudes during children's adolescence. Given that this study focused on children's transport choices for commuting to work during their young adulthood, this study incorporated the commuting distance variable with the control variables from the second empirical study. In addition, regarding employment status, this study considered whether the children had full-time employment in adulthood. All variables are listed in Table 4-13.

The third study continued to represent the extent of mothers' involvement in NTPEB and sustainable transport behaviours during their children's adolescence by calculating the mean of all survey items used to measure these behaviours, as in the second empirical study. Mothers' pro-environmental attitudes during their children's adolescence and their children's pro-environmental attitudes during their young adulthood were considered latent variables.

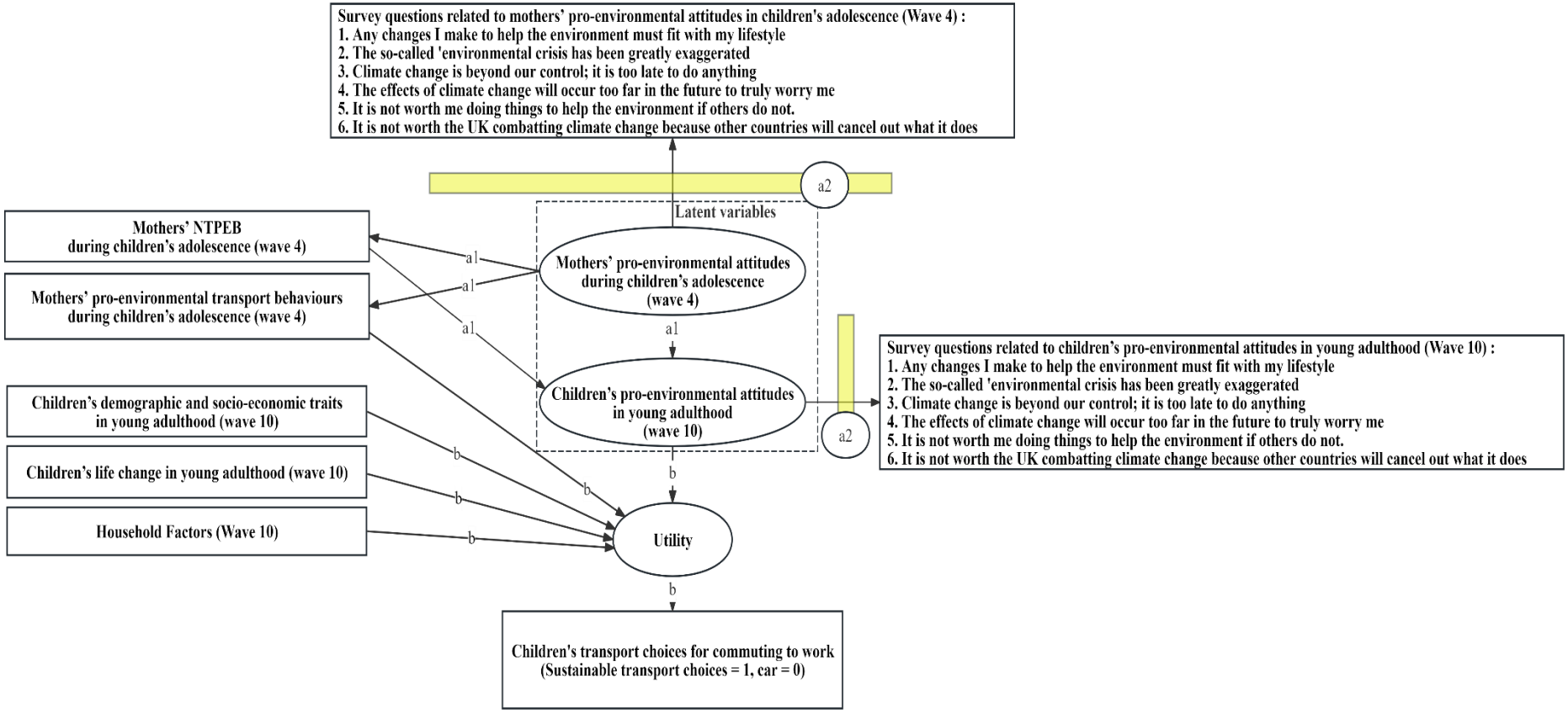
4.3.3.3 Integrated choice and latent variable model

This third empirical study employed an integrated choice and latent variable model to elucidate the intricate connections between mothers' NTPEB during their children's adolescence and their children's pro-environmental attitudes and choices of sustainable transport for commuting to work in young adulthood. According to Subsection 3.3.3, integrated choice and latent variable model offers the advantage of accommodating categorical dependent variables, incorporating multiple latent variables, and the ability to comprehensively analyse direct and indirect relationships between variables.

This analytical approach aligned with the study's objective, which was to investigate the mediating role of children's pro-environmental attitudes in early adulthood in the relationship between mothers' NTPEB during their children's adolescence and the children's sustainable transport choice for commuting to work in their adulthood. The

integrated choice and latent variable model is a complex analytical framework that combines a structural model (a1) and a measurement model (a2) with a discrete choice model (b). Figure 4-2 reveals the analytical framework of this third empirical study.

Figure 4-2. Conceptual framework illustrating the anticipated associations within the integrated choice and latent variable model in the third empirical study



In structural model (a1), the influence of mothers' pro-environmental attitudes and NTPEB during their children's adolescence on their children's pro-environmental attitudes in early adulthood were analysed. Moreover, the influence of mothers' pro-environmental attitudes on their sustainable transport behaviour and NTPEB during their children's adolescence was also considered. The measurement model (a2), which established a connection between the latent variables (i.e. mothers' pro-environmental attitudes during their children's adolescence and children's pro-environmental attitudes in young adulthood) and their respective indicators (i.e. survey items), is emphasised in yellow. The specifics of the indicators (i.e. survey items) used to infer these latent variables are detailed in Table 4-13.

Discrete choice modelling (b) assessed the direct and indirect relationship of the children's pro-environmental attitudes in young adulthood, the mothers' NTPEB during their children's adolescence, and all control variables with children's transport choices for commuting to work in young adulthood (i.e. a categorical dependent variable). Control variables included, for example, children's age, sex, and educational levels in young adulthood, as well as their mothers' sustainable transport behaviours and pro-environmental attitudes during the children's adolescence.

Section 4.2 noted that mothers' NTPEB and pro-environmental attitudes during their children's adolescence did not directly correlate with their children's overall frequency of use of sustainable transport in young adulthood. Therefore, the third empirical study did not explore the direct relationship of mothers' NTPEB and pro-environmental attitudes during their children's adolescence with their children's choice of sustainable transport modes for commuting to work in young adulthood. Instead, it investigated the indirect relationship. Moreover, the third empirical study explored the role of children's pro-environmental attitudes in young adulthood in this indirect relationship.

The dependent variable was a two-category variable that encompassed cars and sustainable transport modes. The "cars" category was the reference group. This third empirical study adopted the simultaneous estimation method (see Subsection 3.3.3 for details). The model's estimation was facilitated using Mplus software. The estimation utilised the maximum likelihood estimation approach, and Monte Carlo simulation was employed for

integration. Multicollinearity should also be noted when performing integrated choice and latent variable modelling analyses. As the potential relationships of the variables (e.g. the relationship between maternal pro-environmental attitudes, their sustainable transport behaviour and NTPEB) were considered, this study only investigated multicollinearity for all control variables and mothers' pro-environmental attitudes. The variance inflation factor values for these variables were all <10, which indicated an acceptable multicollinearity level.

4.3.4 Results

Table 4-14 shows the distribution of variables in the 480 mother-child pairs. The results showed that 56.5% of the children surveyed were female, while the average age was between 19 and 20. Notably, 15% of the children surveyed were from non-White ethnic backgrounds. In addition, 90.5% lived with their parents, while 54.1% were employed full-time. Nearly 80% of the children had chosen a sustainable transport mode to school during adolescence. Over one-half of these sought or had gained qualifications at the A-level or higher. In addition, over one-half had valid driving licences or cars. Of the children surveyed, most (approximately 70% or more) lived in an urban environment. The average adjusted net household income was approximately £1,970 per month, which exceeded the second empirical study. This finding could be because the children in this study were already in the workforce, which undoubtedly increased the family income.

Table 4-14. Descriptive statistics of control variables and survey items measuring mothers' NTPEB and sustainable transport behaviours during their children's adolescence in the third empirical study (N = 480)

Variables	N (%) / Mean (SD)
Dependent variables	
Transport choice to work:	
Sustainable transport mode	228 (47.5%)
Car	252 (52.5%)
Children's demographic and socioeconomic traits in young adulthood (Wave 10)	
Age	19.5 (1.14)
Female	271 (56.5%)
Non-White ethnicity	72 (15.0%)
Employed full-time	260 (54.1%)
Highest qualification (ordered categorical variable)	
1: Below the level of GCSE or without any certifications.	37 (7.7%)
2: Equivalent to GCSE level.	153 (31.9%)
3: Equivalent to A level.	213 (44.3%)
4: Includes diplomas, teaching credentials, and nursing certifications, etc.	44 (9.2 %)
5: Bachelor's degree and above, including BSc, BA, MSc, MA, PhD, etc.	33 (6.9%)
Children's life change in young adulthood (Wave 10)	
Have_car_use	303 (63.1%)
Have_license	323 (67.2%)
Not_live_parents	46 (9.5%)
Children's past transport behaviour during adolescence (Wave 4)	
Sustainable_transport_to_school	386 (80.4%)
Household factors (Wave 10)	
Income	1.97 (0.895)
Rural	145 (30.2%)
Distance	6.73 (8.42)
Mother's NTPEB during their children's adolescence (1. Never ~ 5. Always) (Wave 4)	
Do not keep the tap running while you brush your teeth	3.34 (1.67)
Turning off lights in rooms when not in use	4.43 (0.85)
Not leaving the TV on standby for the night	3.13 (1.80)
Not buying something because of too much packaging	1.75 (0.96)
Buying recycled paper products	2.41 (1.23)
Taking along a shopping bag for shopping	3.74 (1.43)
Mean score	**3.13 (0.70)**
Mother's sustainable transport behaviours during their children's adolescence (1. Never ~ 5. Always) (Wave 4)	
Opting for public modes of transport, such as buses or trains, over car travel	1.80 (1.10)
Walk or cycle for short journeys less than 2 or 3 miles	2.79 (1.36)
Mean score	**2.29 (1.01)**
n	480

Regarding the overall scores for mothers' sustainable transport behaviours and NTPEB during their children's adolescence, mothers were more engaged in NTPEB, consistent with Lynn's (2014) findings.

Table 4-15 displays the distribution of survey items for each latent variable with the standardised factor loadings of these survey items and indicators used to evaluate model goodness in the integrated choice and latent variable model. All standardised factor loadings of the survey items were statistically significant and exceeded the 0.3 critical value. The reliability and validity of the latent variables were satisfactory. According to Subsection 3.3.2, the goodness of fit index, normative fit index, and comparative fit index should ideally exceed 0.9, while the root mean square error of approximation should be 0.06 or lower to indicate a good fit (Hu and Bentler, 1999; Marsh and Hau, 1996). In this third study, all goodness of fit index, comparative fit index, and normative fit index values surpassed 0.9, and the value of the root mean square error of approximation was 0.045. Therefore, the model effectively captured the relationships between the observed survey items and the latent variables, which supported the validity and reliability of the measurement instrument employed in this study.

Table 4-15. Measurement model estimates and model fit indices in the third empirical study (N = 480)

Survey items	Mean (SD)	Factors loading	Composite Reliability	Average variance extracted
Children's pro-environmental attitudes in young adulthood			**0.763**	**0.523**
Any changes I make to help the environment must fit with my lifestyle	2.83 (0.823)	0.329***		
The so-called environmental crisis has been greatly exaggerated	3.42 (1.01)	0.820***		
Climate change is beyond our control; it is too late to do anything	3.47 (0.881)	0.519***		
The effects of climate change will occur too far in the future to truly worry me	3.61 (1.03)	0.537***		
It is not worth me doing things to help the environment if others do not.	3.29 (1.03)	0.722***		
It is not worth the UK combatting climate change because other countries will cancel out what it does	3.54 (1.07)	0.843***		
Mother's pro-environmental attitudes during their children's adolescence			**0.801**	**0.535**
Any changes I make to help the environment must fit with my lifestyle	2.81 (0.886)	0.359***		
The so-called environmental crisis has been greatly exaggerated	3.06 (0.881)	0.678***		
Climate change is beyond our control; it is too late to do anything	3.40 (0.892)	0.752***		
The effects of climate change will occur too far in the future to truly worry me	3.51 (0.932)	0.633***		
It is not worth me doing things to help the environment if others do not.	3.40 (1.04)	0.801***		
It is not worth the UK combatting climate change because other countries will cancel out what it does	3.35 (1.01)	0.809***		
Goodness-of-fit indices				
Normative fit index		0.902		
Comparative fit index		0.907		
Root mean square error of approximation		0.046		
Goodness of fit index		0.901		

Table 4-16 presents standardised correlation coefficients of the structural model in integrated choice and latent variable model. The result indicated significant and positive relationships between mothers' pro-environmental attitudes during their children's adolescence and both types of behaviours (i.e. sustainable transport behaviours and NTPEB; $\beta = 0.106$ and 0.315). Moreover, this result was consistent with the second empirical study, which demonstrated that mothers' pro-environmental attitudes during their children's adolescence had a greater impact on their NTPEB during the same period than sustainable transport behaviours.

Table 4-16. Results of the structural model in integrated choice and latent variable model of the third empirical study

Influence		**Standardised coefficients for direct correlation**	**t-statistic**
Mother's NTPEB during their children's adolescence	Dependent variable		
Mother's pro-environmental attitudes during their children's adolescence	Independent variable	0.315***	3.793
Mother's sustainable transport behaviours during their children's adolescence	Dependent variable		
Mother's pro-environmental attitudes during their children's adolescence	Independent variable	0.106**	2.826
Children's pro-environmental attitudes in young adulthood	Dependent variable		
Mother's NTPEB during their children's adolescence	Independent variable	0.306***	4.642
Mother's pro-environmental attitudes during their children's adolescence	Independent variable	0.266***	3.769

*** Indicates significance at 0.05 level.**

**** Indicates significance at 0.01 level.**

***** Indicates significance at 0.001 level.**

Moreover, mothers' pro-environmental attitudes and NTPEB during their children's adolescence exhibited direct relationships with their children's pro-environmental attitudes in young adulthood ($\beta = 0.266$ and 0.306). Consistent with the findings of the second empirical study, mothers' NTPEB had a stronger influence on their children's pro-environmental attitudes in young adulthood.

Table 4-17 illustrates standardised coefficients of direct correlation of various control variables and the children's pro-environmental attitudes in young adulthood, with children's sustainable transport to work in young adulthood in the integrated choice and latent variable model. Regarding socioeconomic factors, non-White children were likelier to adopt sustainable transport modes for commuting to work in young adulthood than their White counterparts ($\beta = 0.508$, $p < 0.01$). The propensity for sustainable commuting to work was reduced for children in full-time employment in young adulthood compared to those in part-time employment ($\beta = –0.225$, $p < 0.05$). In addition, children's possession of a driving licence and car in young adulthood was negatively associated with their sustainable commuting to work ($\beta = –1.058$ and $–0.873$, $p < 0.001$).

The likelihood of choosing sustainable transportation for commuting to work was negatively correlated with the distance to the workplace ($\beta = –0.126$, $p < 0.01$). Past experiences of choosing sustainable transport options to school during adolescence were statistically significantly related to their choices of sustainable transport modes for commuting to work in young adulthood ($\beta = 0.273$, $p < 0.01$). Moreover, mothers' sustainable transport behaviours during their children's adolescence were positively correlated with their children's sustainable transport to work in young adulthood ($\beta = 0.138$, $p < 0.05$). Importantly, children's pro-environmental attitudes in young adulthood exhibited a positive association with their sustainable transport commuting to work ($\beta = 0.098$, $p < 0.05$). Compared to the results of the second empirical study, the correlation between living in rural areas and sustainable transport choices for commuting to work was not statistically significant in this study.

Table 4-17. Results of the discrete choice model in the integrated choice and latent variable model of the third empirical study

Variables	**Sustainable transport to work (Reference group = car)**	
	Standardised coefficients	**t-statistic**
Young adult's Demographic and Socioeconomic Traits (Wave 10)		
Age	0.135**	2.828
Female	–0.065	–0.651
Non-White ethnicity	0.508**	2.973
Employed full-time	–0.225*	–2.091
Highest_qualification (ordered categorical variable)	0.137	1.502
Young adult's life change (Wave 10)		
Have_car_use	–0.873***	–6.472
Have_license	–1.058***	–7.274
Not_live_parents	0.061	1.386
Household Factors (Wave 10)		
Income	–0.027	–0.492
Rural	–0.055	–0.273
Distance	–0.126**	–2.408
Children's past transport behaviour during adolescence (Wave 4)		
Sustainable_transport_to_school	0.273**	2.119
Mother's sustainable transport behaviours during their children's adolescence	0.138*	2.077
Children's pro-environmental attitudes in young adulthood	0.098*	2.054
Intercepts	–1.219	–1.236
*** Indicates significance at 0.05 level.**		
**** Indicates significance at 0.01 level.**		
***** Indicates significance at 0.001 level.**		
Akaike information criterion	**16,853.90**	
McFadden pseudo R^2	**0.455**	
Initial log-likelihood	**–15,317.315**	
Final Log-likelihood	**–8,343.968**	

Table 4-18 displays the standardised coefficients illustrating the indirect connection of mothers' pro-environmental attitudes and their NTPEB during their children's adolescence with their children's adoption of sustainable transport for commuting to work in young adulthood.

Table 4-18. Standardised coefficients of indirect correlation in the third empirical study

Path	Standardised coefficients	t-statistic
Indirect correlation of mother's pro-environmental attitudes		
Specific indirect 1 - Mother's pro-environmental attitudes during their children's adolescence→ Children's pro-environmental attitudes in young adulthood→ Children's sustainable transport to work in young adulthood	0.026*	2.042
Specific indirect 2 - Mother's pro-environmental attitudes during their children's adolescence→ Mother's NTPEB during their children's adolescence→ Children's pro-environmental attitudes in young adulthood→ Children's sustainable transport choice to work in young adulthood	0.0094	1.018
Indirect correlation of mother's NTPEB		
Specific indirect - Mother's NTPEB during their children's adolescence→ Children's pro-environmental attitudes in young adulthood→ Children's sustainable transport choice to work in young adulthood	0.030*	2.034

*** Indicates significance at 0.05 level.**
**** Indicates significance at 0.01 level.**
***** Indicates significance at 0.001 level.**

The results showed that mothers' pro-environmental attitudes during their children's adolescence indirectly correlated with their children's sustainable transport choices to work in young adulthood through the mediation of their children's pro-environmental attitudes in young adulthood ($\beta = 0.026$, $p < 0.05$). Similarly, children's pro-environmental attitudes in young adulthood also played a mediating role in the indirect correlation between NTPEB exhibited by mothers during their children's adolescence and their children's sustainable transport choices to work in young adulthood ($\beta = 0.030$, $p < 0.05$). Ergo, this study showed that mothers' NTPEB during their children's adolescence were associated not only with their children's overall frequency of sustainable transport behaviours in adulthood but also with their children's sustainable transport choice for commuting to work in young adulthood.

4.4 The relationship between mothers' NTPEB during their children's adolescence and their children's maintenance in sustainable transport choice from adolescence to young adulthood

4.4.1 Introduction

The primary objective of this section was to achieve objective D by analysing the relationship between the NTPEB exhibited by mothers during their children's adolescence and their children's maintenance of sustainable transport choices from adolescence into early adulthood. The first (Section 4.1) and third (Section 4.3) empirical studies found that mothers' NTPEB during their children's adolescence were correlated with their children's choices of sustainable transport mode for commuting to school during adolescence and commuting to work in young adulthood. Hence, mothers' NTPEB during their children's adolescence were hypothesised to play a role in maintaining the adoption of sustainable transport choices for commuting to school during adolescence and commuting to work in young adulthood. The fourth empirical study tested the fourth main hypothesis of this thesis.

4.4.2 Research hypotheses

The fourth empirical study focused on Hypothesis 4, based on the first and third empirical studies.

Hypothesis 4: Mothers' NTPEB during their children's adolescence are correlated with their children's maintenance of sustainable transport choices for commuting to school during adolescence and commuting to work in young adulthood.

4.4.3 Method

4.4.3.1 Mother-child pairs

The fourth empirical study adopted a longitudinal research approach and utilised data from Waves 4 (2012/14) and 10 (2018/20) of the UKHLS. The research included a final sample of 480 mother-child dyads. Specifics regarding the sample size are detailed in Subsection 3.2.2. The mother-child pairs used in this fourth empirical study were consistent with those in the third empirical study of this thesis.

4.4.3.2 Variables

The dependent variable was the respondents' maintenance of sustainable transport choices of children from adolescence to young adulthood. This fourth empirical study introduced the variable "consistent sustainable choice" to measure and quantify the maintenance or consistency of sustainable transport choices among the child respondents from adolescence to young adulthood. In order to achieve this variable, this research compared the child respondents' transport choices to school, answered in Wave 4, with their transport choices to work, answered in Wave 10. This variable was binary, where a value of 1 denoted inclusion with consistent sustainable transportation choices across both waves while a value of 0 denoted otherwise. This variable is described in Subsection 3.2.3.

The primary independent variables were the NTPEB of mothers during their children's adolescence. The survey items used in this study to measure mothers' NTPEB during their children's adolescence were consistent with those used in previous empirical studies in this thesis (see Table 4-19). Moreover, their scores across the six survey items were averaged to gauge the mothers' overall involvement in these behaviours.

Table 4-19. Definition of variables in the fourth empirical study

Variables	Definition
Dependent variable	
Consistent sustainable choice	Whether children consistently choose sustainable modes of transport when they go to school in adolescence and to work in young adulthood Yes = 1, No = 0
Children's demographic and socioeconomic traits in young adulthood (Wave 10)	
Age	Children's age in young adulthood
Female	Children's sex: categorised as Male = 0, Female = 1
Non-White ethnicity	Children's ethnicity: White = 0, Other ethnicities = 1
Employed full-time	Children's employment status in young adulthood: Part-time = 0, Full-time (i.e. greater than 30 hours per week) = 1.
Highest_qualification (ordered categorical variable)	Children's highest educational level in young adulthood (at the time survey) 1: Below the level of GCSE or without any certifications. 2: Equivalent to GCSE level. 3: Equivalent to A level. 4: Includes diplomas, teaching credentials, and nursing certifications, etc. 5: Bachelor's degree and above, including BSc, BA, MSc, MA, PhD, etc.
Children's life change in young adulthood (Wave 10)	
Have_car_use	Children's access to a car or van for unrestricted use in young adulthood: Yes = 1, No = 0
Have_licence	Children's possession of a driving license: Yes = 1, No = 0
Not_live_parents	Children in young adulthood already not living with parents: Yes = 1, No = 0
Household factors in children's young adulthood (Wave 10)	
Income	Monthly household net income, denoted post-tax and national insurance deductions (in thousands of GBP), is adjusted for household size and composition using an equivalence scale. This equivalised income is calculated by dividing the net income by the provided equivalisation factor.
Rural	Children live in rural areas in young adulthood: Yes = 1, No = 0. This is derived from the Office for National Statistics Rural and Urban Classification of Output Areas 2001.
Distance	Distance, in miles, of residence from the usual place of work.
Mother's NTPEB during their children's adolescence (1. Never ~ 5. Always) (Wave 4)	
Do not keep the tap running while you brush your teeth.	
Turning off lights in rooms when not in use	

Not leaving the TV on standby for the night
Not buying something because of too much packaging
Buying recycled paper products
Taking along a shopping bag for shopping

Mother's sustainable transport behaviours during their children's adolescence (1. Never ~ 5. Always) (Wave 4)

Opting for public modes of transport, such as buses or trains, over car travel
Walk or cycle for short journeys less than two to three miles

Mother's pro-environmental attitudes during their children's adolescence (1. Strongly Agree ~ 5. Strongly Disagree) (Wave 4)

Any changes I make to help the environment must fit with my lifestyle.
The so-called environmental crisis has been greatly exaggerated.
Climate change is beyond our control; it is too late to do anything.
The effects of climate change will occur too far in the future to truly worry me.
It is not worth me doing things to help the environment if others do not.
It is not worth the UK combatting climate change because other countries will cancel out what it does.

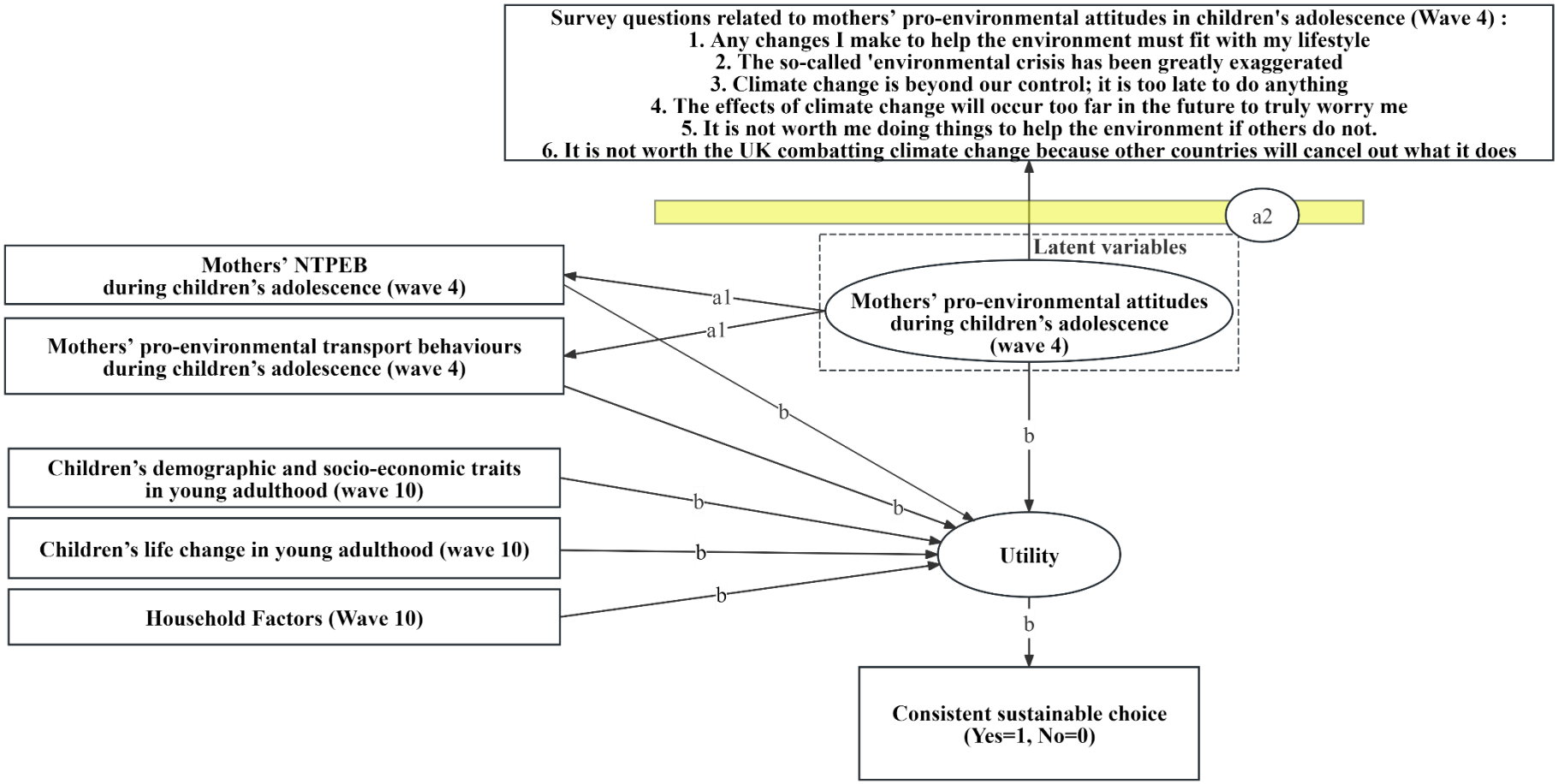
n

This study drew on the existing literature and incorporated a range of control variables to understand the maintenance of children's transport choices from adolescence to young adulthood. As in the third empirical study, this study considered the same control variables related to the children's demographic, socioeconomic traits, and life-change and household factors in young adulthood. In addition, this fourth study considered mothers' pro-environmental attitudes and sustainable transport behaviours during their children's adolescence, similar to the other empirical studies. Moreover, to gauge mothers' overall involvement in sustainable transport behaviours during their children's adolescence, their answers across the two survey items were averaged. Mothers' pro-environmental attitudes during their children's adolescence were treated as latent variables. For a more detailed explanation of each variable, see Table 4-19.

4.4.3.3 Integrated choice and latent variable model

The dependent variable examined in this study was dichotomous. The study incorporated a latent variable: mothers' pro-environmental attitudes during their children's adolescence. Therefore, consistent with the third empirical study, this fourth empirical study used an integrated choice and latent variable model. This study examined the dependent variable "consistent sustainable choice", which signified the continuity in sustainable transportation preference from adolescence to young adulthood. This variable was dichotomous, with a value of 1 indicating the presence of consistent sustainable transportation choices and a value of 0 denoting the opposite. Figure 4-3 illustrates the analytical framework employed in this study. The simultaneous estimation method was also applied. In addition, the maximum likelihood estimation approach was employed for estimation, with Monte Carlo simulation utilised for integration purposes. Since the variables and data used in this study were consistent with the third study's empirical evidence in this thesis, there was no multicollinearity in the variables.

Figure 4-3. Conceptual framework illustrating the associations within the integrated choice and latent variable model in the fourth empirical study



4.4.4 Results

The data in this fourth empirical study were consistent with the third previous empirical study (Subsection 4.3.4), so the distribution of variables across the 480 mother-child pairs was not repeated. This information appears in Tables 4-14 in Subsection 4.3.4. Table 4-20 shows the standardised factor loadings of the survey items related to the latent variable.

Table 4-20. Measurement model estimates and model fit indices in the fourth empirical study (N = 480)

Survey items	**Mean (SD)**	**Factors loading P-Value**
Mother's pro-environmental attitudes during their children's adolescence		
Any changes I make to help the environment must fit with my lifestyle	2.81 (0.886)	0.361***
The so-called environmental crisis has been greatly exaggerated	3.06 (0.881)	0.649***
Climate change is beyond our control; it is too late to do anything	3.40 (0.892)	0.754***
The effects of climate change will occur too far in the future to truly worry me	3.51 (0.932)	0.625***
It is not worth me doing things to help the environment if others do not.	3.40 (1.04)	0.814***
It is not worth the UK combatting climate change because other countries will cancel out what it does	3.35 (1.01)	0.822***
Goodness-of-fit indices		
Normative fit index		0.902
Comparative fit index		0.904
Root mean square error of approximation		0.048
Goodness of fit index		0.903
Cronbach's α		0.780
Composite reliability value		0.782
Average variance extracted metric		0.501

The measurement items of latent variable (i.e. mothers' pro-environmental attitudes during their children's adolescence) were also consistent with the third study. In contrast to the third empirical study, which examined two latent variables, the fourth empirical study focused on a single latent variable: mothers' pro-environmental attitudes during their children's adolescence. As a result, the factor loadings of the survey items differed slightly from those in the third study. Nevertheless, the standardized factor loadings for all items

were statistically significant and surpassed the 0.3 threshold. Furthermore, all indicators used to assess the model's goodness of fit met the required criteria.

Furthermore, Table 4-21 showcases the standardised coefficients of correlation of maternal pro-environmental attitudes with their sustainable transport behaviours and NTPEB during their children's adolescence. The analysis revealed significant, positive correlations between maternal pro-environmental attitudes during their children's adolescence and both categories of behaviours (β = 0.366 and 0.108).

Table 4-21. Results of the structural model in the integrated choice and latent variable model of fourth empirical study

Influence		**Standardised coefficients for direct correlation**	**t-statistic**
Mother's NTPEB during their children's adolescence	Dependent variable		
Mother's pro-environmental attitudes during their children's adolescence	Independent variable	0.366**	3.493
Mother's sustainable transport behaviours during their children's adolescence	Dependent variable		
Mother's pro-environmental attitudes during their children's adolescence	Independent variable	0.108*	2.026
*** Indicates significance at 0.05 level.**			
**** Indicates significance at 0.01 level.**			
***** Indicates significance at 0.001 level.**			

Table 4-22 displays the result of integrated choice and latent variable model, which used "no consistent sustainable choices" as the reference category for the dependent variable.

Table 4-22. Results of the discrete choice model in the integrated choice and latent variable model of the fourth empirical study

Variables	**Consistent sustainable choices (Reference group = NO)**	
	Standardised coefficients	**t-statistic**
Young Adult's Demographic and Socioeconomic Traits (Wave 10)		
Age	–0.102	1.0313
Female	–0.326	–1.235
Non-White ethnicity	0.534	1.281
Employed full-time	–0.339	–1.287
Highest_qualification (ordered categorical variable)	–0.079	–1.056
Young adult's life change (Wave 10)		
Have_car_use	–0.872***	–4.014
Have_license	–0.874***	–3.881
Not_live_parents	–0.198*	–2.083
Household Factors (Wave 10)		
Income	–0.013	–0.150
Rural	–0.297	–1.403
Distance	–0.210**	–3.254
Mother's NTPEB during their children's adolescence (Wave 4)	0.126*	2.492
Mother's sustainable transport behaviours during their children's adolescence (Wave 4)	0.248**	3.374
Mother's pro-environmental attitudes during their children's adolescence (Wave 4)	0.097	0.942
Intercepts	–3.696	–2.770
*** Indicates significance at 0.05 level.**		
**** Indicates significance at 0.01 level.**		
***** Indicates significance at 0.001 level.**		
Akaike information criterion	**9,934.40**	
McFadden pseudo R^2	**0.557**	
Initial log-likelihood	**–11,096.955**	
Final Log-likelihood	**-4,916.20**	

Obtaining a driver's licence or having cars during young adulthood were less likely to maintain sustainable transport options established in adolescence (β = –0.874 and –0.872).

In addition, respondents who moved away from their parents' homes in young adulthood were less likely to persist in choosing sustainable transport modes for commuting ($\beta = -0.198$, $p < 0.05$). As commuting distances to work increased, young adults were less likely to consistently choose sustainable transport modes ($\beta = -0.210$, $p < 0.01$). The results showed that mothers' sustainable transport behaviours during their children's adolescence were positively associated with maintenance in children's sustainable transport choices from adolescence to young adulthood ($\beta = 0.248$, $p < 0.01$). A positive correlation was observed between mothers' NTPEB during their children's adolescence and the maintenance of their children's sustainable transport choices from adolescence to young adulthood ($\beta = 0.126$, $p < 0.05$). This observation directly confirmed Hypothesis 4.

4.5 Summary of the empirical research results

This section focuses on the results of four empirical studies in this thesis. The first empirical study adopted a cross-sectional methodology to test the correlation between mothers' NTPEB and their children's choice of sustainable transportation modes to school in adolescence (Hypothesis 1.1). The findings validated Hypothesis 1.2, which states that maternal NTPEB correlate more strongly with adolescents' sustainable transport to school than maternal pro-environmental attitudes. The first empirical study also found that some control variables, such as mothers' educational level and transport behaviours, correlated with their children's sustainable transport choice to school during adolescence.

The second and third empirical studies separately tested the correlation of mothers' NTPEB during their children's adolescence with the frequency of overall sustainable transport behaviours and sustainable transport choices for commuting to work of children in young adulthood. These two empirical studies demonstrated that mothers' NTPEB during their children's adolescence were associated with their children's pro-environmental attitudes in young adulthood (Hypothesis 2.1). This pro-environmental attitude of children in young adulthood mediated the indirect correlation between mothers' NTPEB during their children's adolescence and their children's frequency of overall sustainable transport behaviours and sustainable transport choices for commuting to work in young adulthood (Hypotheses 2.2, 2.3, and 3). Similarly, both studies found that a range

of control variables in young adulthood (i.e. children's ethnicity, the highest level of education, and possession of a driver's licence or car) were associated with sustainable transport behaviours.

Finally, the fourth empirical study verified Hypothesis 4, based on this thesis's first three empirical studies. It posited that mothers' NTPEB during their children's adolescence was related to their children's consistent choice of sustainable transport from adolescence to young adulthood.

The next chapter focuses on explaining the relevant findings of each of the empirical studies. Furthermore, based on the findings related to the main research variable of this thesis (i.e. mothers' NTPEB), the discussion also suggests potential applications for promoting sustainable transport behaviour among adolescents and young adults.

Chapter 5. Discussion

This chapter begins by individually explaining the results related to the control variables in the four empirical studies (Section 5.1). Next, Section 5.2 highlights the results of the main research variable of this thesis (i.e. mothers' NTPEB during their children's adolescence). Consequently, a series of applications are presented in Section 5.3.

5.1 Interpretation of findings related to control variables

Section 5.1 has three subsections, 5.1.1–5.1.3, which discuss the results of the control variables of the four empirical studies in this thesis. These results relating to the second and third empirical studies' control variables are discussed together in Subsection 5.1.2.

5.1.1 Interpretation of control variables in the first empirical study

The first empirical study focused on the correlation between mothers' NTPEB and their children's sustainable transportation choices for school during adolescence. Several control variables, including the children's age, ethnicity, the mothers' job status, bicycle and bus use frequency, car ownership, and living area type, showed statistically significant associations with the children's transport choices to school in adolescence.

As children age, the likelihood of choosing active transport over cars increases, even more so for public transport. This assertion is consistent with the results of previous studies (Irawan et al., 2022; Yeung et al., 2008). It is important to note that, in this study, 10-year-old adolescents (the reference group) could have shorter commute distances compared to adolescents of other ages, such as those aged 11-15 years. This may be due to the fact that 10 year olds are still attending primary school and will be moving on to secondary school at the age of 11-12 years, which usually requires an increase in the distance travelled to school. For example, in England in 2023, 52% of students aged 5-10 years had a school commute of less than one mile, while 22% commuted between one and two miles, 17%

between two and five miles, and 9% commuted over five miles (Department for Transport, 2023c). In contrast, for students aged 11-16, 33% had a school commute of less than one mile, 26% between one and two miles, 24% between two and five miles, and 18% commuted over five miles (ibid). This difference suggests that older adolescents (11-15 years old) typically face longer school commuting distance compared to younger adolescents (10 years old) in the study, which should be associated with a lower likelihood of using sustainable transport. However, both previous research and the present study indicate that as children grow older, they are more likely to use active transport or public transport to get to school. This shift may be attributed to increasing independence from parents as children age. For instance, He and Giuliano (2017) found that children gained more independence from their parents as they aged. As children mature, parents may become more confident in their ability to cope with potential dangers encountered on the way to school. This may somewhat reduce parental safety concerns about their child's commuting safety (van den Berg et al., 2020) and increase the likelihood of their children travelling to school independently and, correspondingly, the likelihood of choosing a sustainable mode of transport. Since parental safety concerns were not considered in the model of the first empirical study, a statistically significant correlation between the children's age and active and public transport to school was seen.

Additionally, the first empirical study found that compared with children with White ethnicity, children from Non-White ethnic backgrounds exhibited a lower propensity to opt for active transport to school. This is consistent with the findings of a previous UK study (Owen et al., 2012). Owen et al. (2012) found that in the UK, adolescents with White backgrounds are more likely to walk/cycle to school, those with African Caribbean black backgrounds are more likely to travel to school by public transport, and those with South Asian backgrounds are more likely to go to school by cars. Easton and Ferrari (2015), also studying the UK offer the potential explanation that White British students travel the shortest distances to school compared to other ethnicities, which leads to them being more likely to walk or cycle to school.

Regarding socioeconomic variables, this first empirical study found that the number of private vehicle in a household was negatively correlated with the likelihood of choosing

active and public modes of transport to school. This is reasonable, and several previous studies have found the same result (Agyeman and Cheng, 2022; Irawan et al., 2022). In addition, the first empirical study found a clear relationship between working mothers and an increased likelihood of adolescents choosing active and public transport to school. This finding is somewhat consistent with the findings of Agyeman and Cheng (2022), who showed that children of full-time working parents were likelier to walk to school than parents who worked part-time or did not work. One possible explanation is that full-time employment may limit the time for parents to drive their children to school, while parents who are not required to work full-time have more time to do so. Hence, parents' long working hours reduce their chances of escorting their children to school (He and Giuliano, 2017) and decrease the likelihood of driving them to school in a car.

In addition, the first empirical study found that when mothers had a degree or higher qualification, their children were less likely to choose active transport to school as adolescents. Larouche et al. (2015) found the same result in Australia, Colombia, Kenya, Portugal, South Africa, the UK, and the United States. Ermagun and Samimi (2015) explained that highly educated parents may be more aware of risk, which may discourage them from letting their children use public transport or walk to school independently. In addition, parents with higher levels of education are more likely to choose schools (e.g. selecting private schools) for their children (Burgess et al., 2011; Jheng et al., 2022). The selection of private schools could increase the distance between home and school. Fyhri et al. (2011) partly attributed the increases in distance to school for adolescents (11–16 years old) in Great Britain to more students attending private schools over time. In the UK, the number of students enrolled in private schools in 2022 rose by 16.9% over 1990 (Coe, 2023). According to the Independent Schools Council (2023), 554,316 pupils in 2022 were enrolled in private schools across the UK, which represented approximately 5.9% of the total student population. As the distance to school increases, the likelihood of using active transport diminishes, particularly since parents with higher levels of education are more likely to choose private schools, which further extends the distance their children must travel.

Furthermore, the first empirical study found a negative relationship between net household income and the preference of adolescents to choose active and public transport options. This is consistent with the result of previous research in the UK. For example, in England, children from low-income families are more likely to choose buses or non-motorised transport to attend school (Van Ristell et al., 2013). Previous studies have attributed this result to the fact that household income tends to be associated with families owning more cars. However, in the first empirical study, the negative correlation between household income and the likelihood of choosing sustainable transport to school remained after controlling for household car ownership. Therefore, there may be another interpretation for the differences in the transport choice for commuting to school for adolescents in households with different incomes level. Another interpretation posits that higher-income families tend to have more options regarding school selection (Burgess and Briggs, 2010; Silvennoinen et al., 2015; Suppramaniam et al., 2019). This ability also results in longer travel distances to school and, consequently, a reduced likelihood of using sustainable transport to school.

The first empirical study found that children living in rural areas were less likely to choose active transport for commuting to school. This finding is consistent with findings from previous research. For example, Babey et al. (2009) indicated that adolescents from urban areas were more likely to choose active transport for commuting to school. Simons et al. (2017b) found that adolescents living in rural areas were less likely to reach their schools via active transport. Disparities in the state of the built environment related to active transport in urban and rural areas could also explain this difference. Christiana et al. (2021) demonstrated differences in active transport choices between adolescents in rural and non-rural areas and attributed this difference primarily to the lack of resources, including the low quality and availability of active transport infrastructure in rural areas. Compared with rural areas, urban areas have well-developed active transport infrastructure with high walking accessibility (Rahman et al., 2020). These amenities also somewhat increase the likelihood that urban adolescents choose active transport for commuting to school.

In contrast, the results of the first empirical study showed that children residing in rural areas were more likely to use public transport to travel to school than those living in urban

areas. This finding may be due to differences in school bus subsidies between rural and urban authorities. This subsidy provides free school bus transport to schools for adolescents over three miles from the school in the UK (Department for Education, 2010; GOV.SCOT, 2022; GOV.WALES, 2014). Since most of the studied mother-child pairs in the first empirical study were from English households, the example of England is used here. According to 2010 data in England, the average expenditure by all urban authorities on school bus subsidies was just under £1 million, while the average expenditure of rural authorities was nearly £9.6 million (Van Ristell et al., 2015). The total expenditure on secondary school bus transport for adolescents (the adolescent group was the same as the group first studied in this thesis) was £275 million, of which nearly 83% (£228 million) was spent on school bus services in rural areas (Van Ristell et al., 2015). The difference in school bus subsidies between rural and urban authorities made adolescents living in rural areas likelier to choose school bus trips than those living in urban areas. Since the public transport categories of the dependent variable in this first empirical study of the thesis also included school buses, this explanation is somewhat plausible.

In addition, the first empirical study found that children whose mothers cycled infrequently (less than once weekly) demonstrated a lower propensity for selecting active transport modes to school in adolescence than those whose mothers engaged in cycling at least once per week. This observation aligns with Siiba (2020), who documented a positive correlation between parental the frequency of active transport behaviours and their offspring's the likelihood of active transport to school. It is worth noting that the first empirical study also found that mothers who used buses less frequently each week were less likely to have children who chose either active or public transport to school than those who used buses at least once per week. This discovery expands upon Siiba (2020) by demonstrating that not only parental active transport behaviours are linked to adolescents' active commuting to school, but also parental public transport behaviours are connected to adolescents' active transport to school.

One potential explanation for these results is that children may mimic their mothers' sustainable transport behaviours and develop sustainable transport preferences. Moreover, mothers' sustainable transport behaviours significantly influence their adolescent children's

negative attitudes towards car use (Sigurdardottir et al., 2013). Children's negative attitudes towards car use, in turn, influence their sustainable transport choices when commuting to school. In addition, since the first empirical study could not successfully control for the quality of sustainable transport-related infrastructure around the household, a potential explanation is that mothers and children may live in the same community surrounded by high-quality, sustainable transport-related infrastructure, which somewhat contributes to the consistency of sustainable transport behaviours between mothers and children.

5.1.2 Interpretation of control variables in the second and third empirical studies

The second and third empirical studies focused on the indirect correlation of mothers' NTPEB during their children's adolescence with their children's overall frequency of sustainable transport behaviours and sustainable transport choices for commuting to work in young adulthood. Moreover, the second and third empirical studies also explored the mediating role of children's pro-environmental attitudes as young adults in these indirect correlations. Both empirical studies considered the same control variables (except for distance from the workplace, which was considered in the third empirical study). Therefore, the results of these control variables are discussed together in Subsection 5.1.2.

Regarding control variables, non-White ethnicity children showed a higher overall frequency of sustainable transport behaviours in adulthood and were more likely to choose sustainable transport modes to go to work compared to their White counterparts. This is consistent with results of previous British study (Mattioli and Scheiner, 2022). Prior research has indicated that variations in transport behaviours among different ethnic groups are primarily attributed to socioeconomic disparities (e.g. differences in car ownership) between these groups (Klocker et al., 2015; Mattioli and Scheiner, 2022). However, in this thesis's second and third studies, even after controlling for variables related to young adults' socioeconomic status (i.e. household income, car ownership, and employment status), differences in sustainable transport behaviours among ethnic groups remained observable. Thus, other influencing factors contribute to differences in transport behaviour

between different ethnic groups. Klocker et al. (2015) emphasised that variations in housing preferences contributed to differences in transport behaviours among ethnic groups. For instance, Levin (2012) found that non-White ethnic groups (e.g. Chinese ethnic groups) deliberately selected neighbourhoods with convenient access to public transport, which increased their likelihood of relying on public transport. As the second and third empirical studies was unable to include detailed spatial information in its analyses, it is not possible to directly assess the extent to which the lower level of car use among non-white ethnics reflects their concentration in areas with good public transport provision and/or walkability.

The second empirical study found that those employed (with full-time students as the reference group) exhibited a diminished sustainable transport inclination. Busch-Geertsema and Lanzendorf (2017) observed the same result: young adults tended to use cars more and public transit less once they completed their education and began working. Moreover, Brown et al. (2016) found that the full-time student status of young adults had a greater positive impact on public transit use than the employment status of young adults. Simons et al. (2017b) underscored that young adults studying in university or college were likelier to walk and use public transport while working young adults were likelier to use cars. This difference in transport behaviours between working young adults and full-time young adult students may be due to differences in economic pressure and car availability (Busch-Geertsema and Lanzendorf, 2017). Another explanation for these differences is the differences in the available transport-related infrastructure between the two groups. Geertsema and Lanzendorf (2017) found that changes in commuting distances and the availability of railway transport were associated with changes in the transport behaviour of young adults as they moved from university to employment. Higher education campuses are usually located in densely populated urban areas, which usually means shorter distances to travel and better public transport facilities. Hence, sustainable transport options are more available for full-time students.

The third empirical study found that young adults were less likely to choose sustainable transport modes for commuting to full-time work than part-time work. This finding is somewhat consistent with the findings of Newbold and Scott (2018). A study in the UK

reported that full-time workers spent much more time commuting to work than part-time workers (McQuaid and Chen, 2012), perhaps because full-time workers had longer commutes that were more time-intensive than part-time workers. Therefore, full-time workers were more inclined to choose potentially faster or more convenient car travel options.

The second empirical study also found that education levels were positively correlated with the overall frequency of sustainable transport behaviours among children in young adulthood. Several studies have found the same results. For example, Newbold and Scott (2018) found that young adults with a university degree were likelier to use public transit than those whose highest educational level was high school or less. Young adults with higher levels of education commuted to work more frequently by train or bicycle than those with lower levels of education (De Vos and Alemi, 2020; Simons et al., 2017a). De Vos and Alemi (2020) suggested a plausible explanation for this phenomenon by positing that young adults with higher educational achievements frequently demonstrated more favourable attitudes towards sustainable transportation while maintaining less favourable attitudes towards car use. Children's favourable attitudes towards sustainable transportation in young adulthood somewhat correlate to their frequency of overall sustainable transport behaviour for all trip purposes.

However, considering greater time pressures, the third empirical study did not find a statistically significant relationship between educational levels and sustainable transport choices for commuting to work. According to the theory of planned behaviour mentioned in Subsection 2.3.4, attitudes usually influence actual behaviour and are mediated by intentions. However, perceived behavioural control can severely influence behavioural intentions (Webb et al., 2013; Zailani et al., 2016), which interferes with the transition from attitude to behaviour. Perceived behavioural control reflects people's control perceptions, confidence levels, and behavioural difficulties (Kraft et al., 2005). Perceived difficulties in commuting using sustainable transport due to commuting time pressures disrupt the pathways by which children's positive attitudes towards sustainable transport in young adulthood influence their actual sustainable transport choice for commuting to work. For example, higher educational attainment is associated with forming positive attitudes

towards sustainable transport, which can encourage intentions to choose sustainable modes for commuting. However, time pressures on the commute to work may compel young adults to prioritise faster or more convenient car journeys over sustainable transport modes. Hence, a link with education level was observed for overall sustainable transport behaviour, but no such result was observed for sustainable transport choices for specific commuting to work.

As expected, the second and third empirical studies found that having a driver's licence and unrestricted access to a car negatively correlated with children's overall frequency of sustainable transport behaviours in young adulthood and their sustainable transport choices for commuting to work in young adulthood. These observations align with prior research findings (Vale et al., 2018). In addition, the third study found a negative correlation between distance to work and the likelihood of children choosing sustainable transport to work in young adulthood. This result was also expected.

In the second empirical study, children living in urban areas were more likely to engage in sustainable transport behaviours as young adults than those living in rural areas. Licaj et al. (2012) found the same result, with a higher proportion of young adults from rural areas or outer suburbs driving than those from urban centres. Urban young adults are more likely to cycle than those living in rural areas (Simons et al., 2017b), which may be due to differences in travel distances between urban and rural areas. Champion (2009) noted that in England, commuting distances are longer in rural than urban areas. However, the third empirical study found no statistically significant correlation between living in urban areas and children's choice of sustainable transport options for commuting to work as young adults, which may be the reason for controlling for distance to work in the third empirical study.

Moreover, the second and third empirical studies also found that children's past experiences related to sustainable transport to school during adolescence (with cars as the reference group) revealed a positive association with children's overall frequency of sustainable transport practices and sustainable transport to work in young adulthood. Several studies have found the same results (De Vos et al., 2022; Mjahed et al., 2015;

Muromachi, 2017), which emphasise the enduring nature of early-life transport behaviours. Chronic repetitive transport behaviours in adolescence tend to evolve into ingrained habits in adulthood. When adolescents consistently choose sustainable transport options, this behaviour becomes the default choice in later years. Hence, promoting sustainable transport habits early on can yield long-term benefits and steer choices in adulthood. Moreover, since neither the second nor third empirical study controlled for the built environment related to sustainable transport behaviours around the household, another possible explanation for results of consistency between past transport behaviours and current transport behaviours is that children in young adulthood are likely to remain in the same areas with well-developed sustainable transport infrastructure as they did as adolescents. Thus, they continue to prefer sustainable transport behaviours in adolescence and young adulthood.

The maternal frequency of sustainable transport behaviours during children's adolescence positively correlated with children's frequency of sustainable transport behaviour and sustainable transport choice for commuting to work in young adulthood in the second and third empirical studies. According to Sigurdardottir et al. (2013), mothers' sustainable transport behaviours during their children's adolescence may indirectly influence their children's intention to commute in sustainable transport as young adults. Children's intentions to commute using sustainable transport can determine their actual transport behaviour in young adulthood. Furthermore, according to social learning theory, another possible explanation is that if mothers predominantly engage in sustainable transport methods (e.g. public transport, walking, or bicycling) instead of primarily relying on cars, their children are likely to emulate these behaviours. In the long run, consistent exposure to these sustainable practices may form a habit of children using these same sustainable modes. This ingrained habit from adolescence can then carry forward and influence their transport preferences as young adults. Klöckner and Matthies (2012) somewhat supported this explanation and found that parents' sustainable transport behaviour during their children's adolescence influenced their children's transport behaviour in adulthood by shaping their children's transport habits. Similarly, a potential explanation could be that even after moving out, children in their young adult years often reside in the same areas with well-developed sustainable transportation infrastructure as they did during adolescence. This situation may lead to a resemblance between the sustainable

transportation behaviours observed in parents during adolescence and those of the children in adulthood.

Moreover, the second empirical study also considered the relationship between mothers' sustainable transport behaviours during their children's adolescence and their children's pro-environmental attitudes in young adulthood. While not the main focus of this thesis, it was still worth specifying. The results suggested that mothers' sustainable travel behaviours during their children's adolescence did not directly affect their children's pro-environmental attitudes in adulthood. A plausible explanation for this observation may be that children may not perceive their mothers' sustainable transport choices as a deliberate environmental action due to the myriad of constraints associated with sustainable transport. The multiple constraints surrounding sustainable transport may inadvertently obscure the pro-environmental motivations behind these decisions. As a result, children may fail to recognise and internalise the pro-environmental concepts behind their mothers' sustainable transport choices so that they do not influence their pro-environmental attitudes as adults. This notion emphasises the need to enhance children's understanding of the motivations behind their parents' sustainable transport. Previous research has posited that meaningful conversations between parents and their children about environmental protection can be instrumental in aiding the younger generation to truly understand and appreciate the motivation behind parental pro-environmental behaviours.

5.1.3 Interpretation of control variables in the fourth empirical study

The fourth empirical study focused on the relationship between mothers' NTPEB during their children's adolescence and their children's consistent choice of sustainable transport modes for commuting from adolescence to young adulthood. Notably, as commuting distances increase, young adults are more inclined to forego sustainable transport options, given that longer distances often necessitate faster and more direct modes of transportation (e.g. cars). Whether using sustainable transport or driving a car to school in adolescence, driving to work is more likely when faced with longer commuting distances in adulthood. Unsurprisingly, life changes from adolescence to young adulthood, such as obtaining a driver's licence, owning a car, and moving out of the parental home, are often associated

with changes in children's transport choices from adolescence to young adulthood. This is also consistent with previous findings (Charreire et al., 2021; De Paepe et al., 2018; Licaj et al., 2012; Vale et al., 2018; Bayart et al., 2020).

Moreover, the results of the fourth empirical study showed that mothers' sustainable transport behaviours during their children's adolescence were positively associated with maintaining children's sustainable transport choices from adolescence to young adulthood. As mentioned earlier, parental modelling is crucial, especially during adolescence. Thus, mothers' sustainable transport behaviours during their children's adolescence help their children develop corresponding sustainable transport habits, which are often also deeply rooted and continue from adolescence to young adulthood.

5.2 Results of examination of research hypotheses

Section 5.2 mainly discusses the hypotheses that were tested in each empirical study.

5.2.1 Research hypotheses in the first empirical study

The first empirical study found a positive correlation between the degree to which mothers engaged in NTPEB during their children's adolescence and the likelihood of their children using public transport to attend school in adolescence. This result confirmed Hypothesis 1.1 in Subsection 4.1.2.

One possible interpretation of this correlation is that mothers can invariably convey the importance of environmental protection to adolescents through their daily NTPEB, such as energy conservation and environmentally conscious shopping. These habits foster adolescents' pro-environmental psychological constructs, such as pro-environmental attitudes and awareness of responsibility for environmental protection. Once formed, these adolescents' psychological constructs may catalyse a range of behaviours, such as public

transport to school, beyond the scope of parental NTPEB that initially influenced the form of psychological constructs. This finding enriches the existing literature on the intergenerational transmission of pro-environmental behaviours. Therefore, this transmission should not be limited solely to similar behaviours between parents and children. Significant intergenerational transmission may also occur among different pro-environmental behaviours between parents and children.

The first empirical study also discovered the positive connection between mothers' pro-environmental attitudes and children's use of public transport when travelling to school in adolescence. This could be because that parental pro-environmental attitudes indirectly correlate with their children's choices in using sustainable transport methods to school, primarily through the parents' sustainable transport practices. However, in this study, when controlling for mothers' sustainable transport behaviour, mothers' pro-environmental attitudes remained associated with their children's public transport to school in adolescence. However, this correlation became statistically insignificant after the mothers' NTPEB were included in the model. In other words, the association between mothers' pro-environmental attitudes and children's public transport to school in adolescence was no longer statistically significant when mothers' NTPEB and sustainable transport behaviours were considered. Therefore, this result underscores the intricate link between maternal pro-environmental attitudes and adolescents' transport choices to school. The correlation between mothers' pro-environmental attitudes and adolescents' use of public transport to school may be mediated by mothers' transport behaviours and by NTPEB.

Moreover, the model encompassing mothers' pro-environmental attitudes and NTPEB offers a superior fit for the data compared to the model that solely incorporates mothers' pro-environmental attitudes, as indicated by the Akaike information criterion value. Therefore, this result also demonstrates that mothers' NTPEB have a stronger correlation with adolescents' public transport choice of commuting to school than mothers' pro-environmental attitudes. This conclusion aligns with Hypothesis 1.2 in Subsection 4.1.2.

Notably, compared to other factors, such as mothers' frequency of public transportation use, bicycle use, family car ownership, and residential location (rural vs. urban), the

strength of associations between mothers' pro-environmental attitudes, NTPEB and the likelihood of their adolescent children choosing public transportation for school are weaker. These associations are likely indirect, mediated by adolescents' own pro-environmental psychological factors, whereas the direct relationships between the other variables and adolescent children's school travel mode choice are relatively stronger. Although the strength of relationships between mothers' pro-environmental attitudes, NTPEB and the likelihood of their adolescent children choosing public transportation for school is smaller, this study confirms the existence of these association—a key objective of this research. This finding offers a novel perspective for analysing school travel behaviours among adolescents.

5.2.2 Research hypotheses in the second and third empirical studies

The second and third empirical studies tested whether the correlation found in the first empirical study (i.e. between mothers' NTPEB during their children's adolescence and their children's sustainable transport behaviour during adolescence) persisted into children's young adulthood. Specifically, the second and third empirical studies underscored the indirect correlation of mothers' NTPEB during their children's adolescence with the frequency of sustainable transport behaviours and the choice of sustainable transport for children's commuting to work in young adulthood. Children's pro-environmental attitudes in young adulthood mediated this indirect correlation.

Firstly, the second and third empirical studies examined the direct and indirect associations between mothers' pro-environmental attitudes, sustainable transport behaviours, NTPEB during their children's adolescence, and their children's pro-environmental attitudes in young adulthood. For children's pro-environmental attitudes in young adulthood, mothers' pro-environmental attitudes and their NTPEB during their children's adolescence directly influenced the children's pro-environmental attitudes later in life. This result also directly supported Hypothesis 2.1 in Subsection 4.2.2. The direct influence of mothers' NTPEB may be due to the observation and internalisation of these behaviours by their children during adolescence, which subsequently facilitates the development of pro-environmental attitudes.

Moreover, the results of the second and third empirical studies underscored that mothers' NTPEB during their children's adolescence demonstrated a stronger direct influence on their children's pro-environmental attitudes in adulthood than mothers' pro-environmental attitudes observed within the same period. This finding aligns with Grønhøj and Thøgersen (2012), who found that mothers' NTPEB, rather than pro-environmental attitudes, more significantly influenced their children's NTPEB. This finding highlights the pivotal role of maternal behaviours in instilling lasting pro-environmental attitudes and practices in subsequent generations.

Secondly, the results of the second and third empirical studies found that the direct correlation between mothers' NTPEB during their children's adolescent years and children's sustainable transport behaviours in young adulthood were not statistically significant when factoring in the young adults' pro-environmental attitudes. In this case, a significant indirect correlation was observed. This finding supports Hypothesis 2.2 in Subsection 4.2.2, which proposed that the NTPEB of mothers during their children's adolescence indirectly influence the children's sustainable behaviours in young adulthood. Moreover, these two studies found that the mothers' NTPEB during their children's adolescence were related to these children's pro-environmental attitudes in young adulthood. Hence, the mothers' behaviours indirectly correlate with their children's overall frequency of sustainable transport behaviours and sustainable transport to work in young adulthood.

These findings validate Hypotheses 2.3 and 3 in Subsections 4.2.2 and 4.3.2 and suggest that mothers' NTPEB during their children's adolescence indirectly shape their children's sustainable transport behaviours in young adulthood by moulding their pro-environmental attitudes. The results highlight the broader influence of mothers' pro-environmental attitudes and behaviours and suggest that promoting mothers' pro-environmental attitudes or any form of sustainable behaviour, even if not directly related to transport, can indirectly shape sustainable transport actions in future generations. This finding presents a novel perspective for promoting sustainable travel behaviours in future endeavours.

Similarly, the strength of indirect associations between mothers' pro-environmental attitudes and NTPEB during their children's adolescence and the children's sustainable transport behaviours in young adulthood are weaker than the direct associations of other factors, such as children's car access in adulthood, driver's license acquisition, and their own pro-environmental attitudes in young adulthood. Notably, the relatively weaker strength of the indirect associations compared to the direct relationships is expected. Despite the smaller strength, the findings confirm the existence of these associations between mothers' pro-environmental attitudes and NTPEB during their children's adolescence and the children's sustainable transport behaviours in young adulthood, aligning with the objectives of the second and third research.

5.2.3 Research hypotheses in the fourth empirical study

The main aim of the fourth empirical study was to test the hypothesis established based on the findings of the first (Section 4.1) and third (Section 4.3) empirical studies. The hypothesis asserted a relationship between the NTPEB exhibited by mothers during their children's adolescence and their children's maintenance of sustainable transport choices from adolescence into early adulthood.

The results of the fourth empirical study directly confirmed Hypothesis 4 (see Subsection 2.4.2). This finding agrees with the previous literature and can be attributed to the role of mothers' NTPEB during their children's adolescence that foster children's pro-environmental psychological factors (e.g. pro-environmental attitudes) during adolescence. These attitudes nurtured during adolescence promote sustainable transport choices to school. Furthermore, these psychological factors tend to endure into young adulthood and influence individuals' sustainable transport choices as they transition to the workforce in adulthood.

5.3 Implications

The central finding of this thesis is the link between mothers' pro-environmental behaviours (i.e. NTPEB and sustainable transport behaviours) during their children's adolescence and their children's adoption of sustainable transport behaviours in adolescence and young adulthood. These results have several significant implications. Firstly, these results suggest that interventions promoting sustainable transport behaviours among adolescents or young adults should extend beyond the immediate target demographic to include mothers (i.e. parents). Jaime et al. (2023) noted that enduring changes in children's pro-environmental behaviours require direct interventions targeting children with additional strategies focused on parents. Indeed, increasing mothers' consciousness about their pivotal role in nurturing sustainable transport habits in their children could have a profound impact. Campaigns targeting parents should emphasise that mothers act as pivotal role models in promoting sustainable transport behaviours among their children, even as they mature. In addition, due to the findings indicating that mothers' NTPEB wield greater influence than their pro-environmental attitudes, mothers should be encouraged to make their pro-environmental actions visible to their children.

Secondly, the result demonstrating the correlation between mothers' NTPEB during children's adolescence and children's sustainable transport during adolescence has crucial implications for assessing interventions to enhance NTPEB in mothers. Previous studies have highlighted the significance of comprehensively assessing the effectiveness of interventions aimed at fostering environmentally friendly behaviours (Steg and Vlek, 2009). This thesis argues that interventions targeting mothers' NTPEB could influence their children's behaviours beyond NTPEB, such as sustainable transport behaviours. Therefore, when evaluating the effectiveness of interventions aimed at fostering NTPEB within the target group, it is crucial to consider the potential changes in the diverse behaviours of the target group's children. For example, when assessing the impact of an intervention on maternal energy-saving or eco-friendly purchasing behaviours, it is necessary to include an evaluation of any shifts in children's sustainable transport behaviours, which may arise concurrently with changes in maternal practices.

Thirdly, the second and third empirical studies highlight that the pro-environmental attitudes of children in young adulthood significantly influence their sustainable transport

behaviours in young adulthood. This finding underscores the importance of targeted interventions to foster pro-environmental attitudes among this demographic, including incorporating environmental education into school and higher education syllabuses (Jaime et al., 2023). Additionally, given the significant role of new media in the lives of young adults, it can serve as a platform for disseminating content related to sustainability issues to foster the development of pro-environmental attitudes and engagement with sustainable transport behaviours (Shen et al., 2023). This perspective emphasises the dual strategy of education and media engagement to inspire pro-environmental attitudes in young adults and promote their sustainable transport behaviour.

Fourthly, the results of the second and third empirical studies suggest that mothers' sustainable transport behaviours during their children's adolescence do not directly affect their children's pro-environmental attitudes in adulthood. This finding may be due to the multiple constraints surrounding sustainable transport. Therefore, children may fail to recognise and internalise the pro-environmental concepts behind their mothers' sustainable transport choices so that they do not influence their pro-environmental attitudes as adults. Therefore, the need exists to enhance children's understanding of the motivations behind their parents' sustainable transport behaviours. Previous research has suggested that meaningful conversations between parents and their children about the contribution of sustainable transport to environmental protection can be instrumental in helping children truly understand and appreciate the motivation behind parental behaviours (Jia and Yu, 2021), which can lead to children's sustainable behaviours.

Chapter 6. Conclusion

The thesis presented four empirical studies that sought to establish the correlation between mothers' NTPEB during their children's adolescence and the sustainable transport behaviours exhibited by their children during adolescence and young adulthood. These studies effectively addressed research gaps in the current empirical literature by offering several noteworthy academic contributions. Section 6.1 summarises these academic contributions, while Section 6.2 concludes with the limitations of this thesis and proposes future research in this domain.

6.1 Main contribution

6.1.1 The role of mothers' NTPEB

This thesis found a statistically significant correlation between mothers' NTPEB during their children's adolescence and their children's use of public transport to school during adolescence. This finding contributes to the existing literature on the intergenerational transmission of pro-environmental behaviours between parents and children. It indicates that this transmission is not solely confined to similar behaviours between parents and children. Instead, significant transmissions can occur across different pro-environmental behaviours between parents and children. In addition, this thesis found that this intergenerational transmission may persist into children's young adulthood.

Specifically, this thesis underscores the indirect correlations of mothers' NTPEB during their children's adolescence on their children's frequency of sustainable transport behaviours and sustainable transport choice for commuting to work in young adulthood, mediated by the children's pro-environmental attitudes in young adulthood. These findings suggest that mothers' NTPEB are not solely linked to their children's sustainable transport behaviours during adolescence but may extend into adulthood. Another contribution of these results suggests potential mechanisms for the intergenerational transmission of mother-child pro-environmental behaviours: mothers' NTPEB during their children's adolescence shapes their children's pro-environmental attitudes in young adulthood, which

subsequently influences their children's pro-environmental behaviours such as sustainable transport behaviours in adulthood.

The findings of the first and third empirical studies found a correlation between mothers' NTPEB during their children's adolescence and their children's adoption of sustainable transport to school during adolescence, as well as their sustainable transport choices for work in adulthood. Thus, a potential link exists between mothers' NTPEB during their children's adolescence and their children's consistent engagement in sustainable transport behaviours from adolescence to young adulthood. This thesis was designed to investigate this hypothesis, and the results confirmed its validity. This finding contributes to the existing research by demonstrating that mothers' NTPEB during their children's adolescence influence their children's adoption of sustainable transport behaviours in adolescence and young adulthood, with the potential to steer their children towards consistent engagement in sustainable transport behaviours from adolescence to young adulthood.

6.1.2 Mothers' pro-environmental attitudes versus mothers' NTPEB

This thesis examined mothers' NTPEB as the primary research variable while considering mothers' pro-environmental attitudes. Firstly, this thesis suggests that the strength of the correlation between mothers' NTPEB and adolescents' choice of public transport for commuting to school is greater than that of mothers' pro-environmental attitudes. This assertion reaffirms the previous finding that parents' NTPEB exert a stronger influence on children's similar behaviours than parents' pro-environmental attitudes do while providing a deeper understanding of this result and the continued application of this rule in the intergenerational transmission of different behaviours between parents and children.

Moreover, this thesis also reveals that mothers' pro-environmental attitudes and their NTPEB during their children's adolescence directly impact their children's pro-environmental attitudes in young adulthood. Notably, these studies have demonstrated that mothers' NTPEB during their children's adolescence exert a stronger direct influence on

their children's pro-environmental attitudes in young adulthood than the mothers' pro-environmental attitudes observed within the same period. This finding echoes a previously identified pattern: in the realm of parental influence on adolescents' NTPEB, parental behaviours consistently exhibit a more pronounced impact than their attitudes (Grønhøj and Thøgersen, 2012). Therefore, this thesis significantly extends this understanding by emphasising that this principle also holds when examining parental influences on the pro-environmental attitudes of their offspring in their adult years.

6.1.3 The role of mothers' sustainable transport behaviours

Regarding mothers' sustainable transport behaviours during their children's adolescence, although this variable was not the focus of this thesis, the findings deepened the understanding of this variable's role in their children's sustainable transport behaviours. The first three empirical studies established a correlation between mothers' adoption of sustainable transport practices during their children's adolescence and their children's embrace of sustainable transport behaviours during adolescence and subsequent young adulthood, which corroborated prior research findings. However, the fourth empirical investigation uncovered a novel relationship wherein mothers' sustainable transport behaviours during their children's adolescent years significantly correlated with their children's continued preference for sustainable transport options from adolescence to young adulthood. This relationship underscores the pivotal role of parental modelling, particularly during adolescence, in shaping children's practical, sustainable transport habits while instilling deeper values and attitudes behind sustainable transport choices. By embodying sustainable transport practices, mothers impart intrinsic attitudes and long-term benefits related to sustainable transport behaviours to their children and foster the development of pro-sustainable transport attitudes as they transition into young adulthood, which reinforces a steadfast commitment to sustainable commuting.

Moreover, this thesis found that, unlike mothers' NTPEB during their children's adolescence, the correlation between mothers' adoption of sustainable transport practices during their children's adolescence and their children's uptake of sustainable transport behaviours during adolescence and subsequent young adulthood was not mediated by their

children's pro-environmental attitudes in adulthood. According to the results of the second and third studies, mothers' sustainable transport behaviours during their children's adolescence do not directly affect their children's pro-environmental attitudes in adulthood. A plausible explanation for this observation may be that the constraints surrounding sustainable transport, such as inadequate infrastructure, may inadvertently obscure the pro-environmental motivations behind these decisions. As a result, children may fail to recognise and internalise the pro-environmental concepts behind their mothers' sustainable transport choices so that they do not influence their pro-environmental attitudes as adults.

6.2 Limitations

The four empirical studies in this thesis had limitations. Generally, the four studies focused on maternal behaviours and omitted the influence of fathers and other family members. While including fathers and other family members was beyond the scope of this PhD research, it opens a valuable direction for future studies. Furthermore, due to limitations in data availability, this research focused only on mothers with female biological sex without considering non-heteronormative family structures or parents from the LGBTQI+ community. This limitation underscores a gap in the current literature and indicates a pertinent area for future research. In addition, all four empirical studies used UKHLS data. While most households participating in the UKHLS survey were from England, a smaller proportion of households were from Wales, Scotland, and Northern Ireland. Due to the disproportionately high representation of families from England in the sample, the findings of this thesis are likely more reflective of the situation in England and less representative of Wales, Scotland, and Northern Ireland, which affects the generalizability and external validity of the research. Additionally, the regional bias in the sample may hinder the study's ability to capture these regions' unique social, economic, and cultural factors while overlooking the impact of regional differences.

In the empirical studies of this thesis, there are varying degrees of limitations when controlling for built environment factors, primarily due to the lack of relevant variables in the UKHLS dataset. Previous transport studies using the UKHLS dataset have explored alternative methods, such as incorporating built environment factors based on Lower Super

Output Areas (LSOAs) (Clark et al., 2016a; Clark et al., 2016b). The UKHLS dataset includes a special release dataset (which requires a specific request) containing LSOA codes for each wave of respondents. LSOAs are population-based geographical units, and by utilizing these LSOA codes, the standard UKHLS data (the primary dataset used in this thesis) can be linked to other government datasets containing LSOA-level built environment factors, such as the number of bus stops within each LSOA. In terms of population, for example, LSOA areas in England and Wales typically consist of between 400 and 1,200 households, with a usually resident population ranging from 1,000 to 3,000 individuals in 2021(Office for National Statistics, 2021). In Scotland, data zones (the equivalent of LSOAs) typically have a smaller population, ranging from 500 to 1,000 people (GOV.SCOT, 2022).

However, this approach does not appear to be suitable for the four empirical studies in this thesis. Previous studies that used LSOA-based built environment factors have focused solely on the English regions, without considering Scotland, Wales, or Northern Ireland (Clark et al., 2016a; Clark et al., 2016b). This differs from the research in this thesis, which examines the entire UK. Additionally, the geographic size of LSOAs varies considerably. As LSOAs are population-based, those with lower population densities tend to cover larger geographic areas, while those with higher population densities are geographical smaller. Larger geographic areas are more likely to encompass a greater amount of sustainable transport infrastructure (e.g., bus stops), leading to spatial discrepancies that complicate the fair comparison of the quality of sustainable transport infrastructure across different LSOAs. As a result, using LSOA-based built environment factors could lead to errors stemming from these geographic size variations.

Lack of built environment factors does affect the interpretation of some findings in this thesis. For example, the second and third study found that children who used sustainable transport during adolescence were more likely to continue doing so in young adulthood. Existing research suggests this might be due to habits formed during adolescence carrying over. However, it could also be because children lived in areas with strong sustainable transport infrastructure both during adolescence and adulthood, which could have supported these sustainable behaviours throughout. Similarly, although the second and

third empirical studies controlled the children's places of residence (urban vs rural), lack of built environment factors limitation impacted the precision in understanding the reasons behind the observed relationship, such as the relationship between mothers' sustainable transport behaviours during their children's adolescence and their children's sustainable transport behaviours in adulthood. Consequently, this research could only offer potential explanations, as listed below. Firstly, mothers' behaviours during their children's adolescence might influence their children's attitudes towards sustainable transport in adulthood and children's transport behaviours in young adulthood. Secondly, even after moving out in young adulthood, children might continue living in areas with built environments suitable for sustainable transport similar to their adolescence, which leads to a connection between mothers' transport behaviours during children's adolescence and children's behaviours in young adulthood.

It is important to note that the absence of built environment data may not undermine the validity of the core contribution of this thesis: the association between mothers' NTPEB during their children's adolescence and their children's sustainable transport behaviours over time. The transport-related built environment is not directly associated with whether mothers engage in NTPEB. For instance, living in an area with good public transportation does not necessarily increase the likelihood of engaging in behaviours such as recycling or energy conservation. There is no evidence to suggest that areas with better sustainable transport infrastructure are associated with greater engagement in NTPEB. The transport-related built environment typically associates with transport behaviours by mediating psychological factors, such as individuals' perceptions of safety or convenience (see more details in subsection 2.2.3). However, this thesis demonstrates that mothers' NTPEB during their children's adolescence are associated with their children's sustainable transport behaviours through children's pro-environmental attitudes. This indicates that the pathways through which the transport-related built environment and mothers' NTPEB are associated with children's transport behaviours are distinct. Therefore, while the inclusion of built environment data could have provided additional insights, its absence does not undermine the validity of the main contribution of this thesis.

In addition to these general limitations, each study had weaknesses, as described next. Given the secondary data (i.e. UKHLS) used in the first empirical study, certain pertinent variables, such as maternal safety concerns, transport-related attitudes, and adolescents' pro-environmental attitudes could not be accounted for since they were not included in the original dataset. Despite this limitation, their absence did not fundamentally diminish the credibility of this research for these reasons. Firstly, the impact of maternal safety concerns on adolescents' school transport choices is expected to decrease with child age. The target population, adolescents aged 10–15 years, is a group in which these concerns are less influential. Secondly, while the first empirical study did not thoroughly investigate maternal transport-related attitudes and potentially introduced an omitted variable bias, it importantly considered maternal transport behaviours. Such behaviours inherently mirror transport attitudes and serve as their practical manifestations. Therefore, indirectly accounting for these maternal transport behaviours encapsulated the corresponding attitudes to mitigate potential biases. Finally, adolescents' pro-environmental attitudes, while of interest, are potentially an intermediary variable as parental NTPEB could shape them and may correlate with adolescents' sustainable transport choice to school. As the first empirical study primarily examined the relationship between parental behaviours and adolescents' school transport choices, the absence of data on adolescents' attitudes was unlikely to skew results significantly.

Moreover, the first empirical study excluded children who used multiple transport modes to attend school since the UKHLS dataset did not indicate transport modes (see Subsection 3.2.3 for more details). The exclusion of adolescents who used multiple transport modes could bias the results for certain sustainable transport choices, given that multimodal journeys likely involve at least one eco-friendly method, such as walking, biking, or public transport. Despite this limitation, the "multiple modes" category constituted a small fraction of the total responses (8% from Wave 4), so its exclusion was unlikely to significantly skew this research's overall analysis and findings. Additionally, the first empirical study solely focused on walking and cycling as active transport modes to school while overlooking other active transport forms such as scooters. However, according to the Department for Transport (2022), in England, the utilisation of these other active transport forms for adolescents commuting to school was less than 1% in 2014 (during the data

collection for Wave 4 of the UKHLS). Therefore, the lack of other active transport modes was unlikely to seriously affect this overall analysis and results.

The second and third empirical studies also had limitations due to their reliance on secondary data, which hindered control over psychological factors like attitudes towards specific transport modes and built environment factors. Moreover, in the second and third empirical studies, only the socioeconomic factors of the children in adulthood were considered, without accounting for the socioeconomic factors of the family during the children's adolescence. In addition, the third empirical study, like the first, ignored other modes of commuting, such as scooter-electric bikes. However, the proportion of these other transport modes was too small to impact the study results.

In addition, the fourth empirical study only focused on one scenario where children consistently chose sustainable transport modes for commuting from adolescence to young adulthood. This delimitation was made because, based on the results of the first and third empirical studies, one could only hypothesise about a correlation between the mothers' NTPEB during their children's adolescence and the children's consistent choice of sustainable transport modes for commuting from adolescence to young adulthood. However, three other changes occur in children's transport commuting choices from adolescence to young adulthood: 1) the persistent use of a car for commuting from adolescence to young adulthood, 2) the shift from car commuting to sustainable transport commuting from adolescence to young adulthood, and 3) the shift from sustainable transport commuting to car commuting from adolescence to young adulthood. These changes were not considered in the fourth empirical study.

In conclusion, although this thesis provides insights into the relationship between mothers' NTPEB and their children's sustainable transport behaviours during adolescence and young adulthood, it is important to acknowledge several limitations outlined across all empirical studies. A primary constraint is the reliance on secondary data across all four studies, which omitted relevant variables such as mothers' safety concerns, transport-related attitudes, and built environment factors due to their absence from the original

dataset. In addition, this thesis did not consider the potential role of the behaviours of fathers and other family members.

6.3 Future research

This thesis suggests several avenues for future research that could further enhance the understanding of the relationship between parental NTPEB and children's sustainable transport behaviours during adolescence and young adulthood. A natural next step in this line of future research would be to address the role of the NTPEB of fathers and other family members in shaping adolescents' sustainable transport behaviours. Given the role of mothers' NTPEB in children's sustainable transport behaviours observed in this thesis, it would be valuable to expand the analysis to include the contributions of fathers and other family members to better understand the intergenerational transmission of sustainable transport behaviours.

Additionally, further research could examine whether the relationship between mothers' NTPEB and children's transport behaviours varies across the four nations of the UK—Northern Ireland, Wales, England, and Scotland. Moreover, extending the research beyond the UKHLS dataset to include participants from other countries or cultural backgrounds would offer the opportunity to assess the generalizability of the findings. This would allow for an evaluation of whether the relationships between parental NTPEB and children's transport behaviours are consistent across different socio-economic, cultural, and policy contexts, contributing to a broader understanding of the global applicability of these findings.

Given that this study tracked the relationship between mothers' NTPEB during children's adolescence and children's sustainable transport behaviours during young adulthood over a six-year period, a longer-term longitudinal study would offer deeper insights into how this relationship evolve over time. Moreover, this thesis focused primarily on mothers' NTPEB, such as green shopping and energy-saving behaviours. Future research could expand this focus to include other types of NTPEB, such as recycling, to assess whether the corrlation

between mother's NTPEB and children's sustainable transport behaviours identified in this thesis are specific to certain mothers' NTPEBs.

Building on the limitations noted in this thesis, future research could also integrate built environment data—such as neighbourhood walkability, access to public transport, and urban density—to examine how contextual factors interact with parental NTPEB in shaping their children's transport behaviours. Additionally, employing different data collection methods, including qualitative approaches such as interviews or focus groups, could provide richer insights into the mechanisms through which parental transport behaviours and pro-environmental attitudes are transmitted across generations.

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