Public transport availability, delayed learning to drive and later life car dependence

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ESRI Working Paper No. 827

June 2026

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Acknowledgements:
This paper was funded by the Department of Transport as part of a research programme on sustainable mobility. We thank members of the programme's steering committee for helpful feedback on the study design and initial findings. We are especially grateful to Deborah John and colleagues at the National Transport Authority for providing access to PTAL scores and helpful guidance on using the index.

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Non-Technical Summary

Road transport is one of the largest contributors to greenhouse gas emissions and reducing car dependence is central to meeting climate targets. Yet most efforts to understand car use focus on current behaviour. Much less attention has been paid to earlier life stages, when people first begin forming travel habits. This study asks whether public transport affects when people learn to drive and, in turn, whether the timing of learning to drive has long-term consequences for how much they drive in later life.

To investigate this, we combined data from a large national survey in Ireland (of more than 2,000 people aged 16 and over) with detailed information on public transport accessibility. We examined two questions:

1. Does better public transport increase the likelihood that people delay learning to drive?
2. Does delaying learning to drive result in less driving as people progress through adulthood?

We found that people living in areas with good public transport learned to drive significantly later. In places with no effective public transport, almost six in ten people began learning to drive by age 20. In areas with high-quality service, the figure was four in ten. This means that improving public transport may slow the early rush to driving and give young adults more opportunities to experience other transport modes.

We also found that people who had learned to drive later are, now, less likely to drive on an average weekday, even accounting for their current public transport access. On days they do drive, they drive less. Over a year, we estimate that a person who learned at age 22 drives over 1,500 kilometres less on weekdays than someone who learned at 17. These differences accumulate over a lifetime, implying a meaningful long-term impact on emissions.

The results are consistent with early adulthood being a formative period for developing travel habits. During this life stage, people may move out, start jobs, form relationships, and build routines. If a person starts this phase already driving, they may be more likely to build their daily life around the car. If they do not drive yet, they are more likely to use and grow comfortable with public transport, cycling, or walking. This can influence later decisions about how to travel.

The results suggest that public transport investments have benefits far beyond the immediate increase in passengers. Improving access can delay the point at which young people start driving, and this delay itself reduces the amount they drive years later. Policies that make public transport cheaper or easier for young people may therefore have lasting effects on long-term car use.

At the same time, most people in Ireland still learn to drive eventually, regardless of access. This means that car dependence is likely to remain high. Decarbonisation will require continued progress in vehicle electrification alongside better public transport.

Abstract

High levels of car dependency are a major challenge for decarbonisation policy. This paper explores how early-life mobility environments shape long-run driving behaviour through two underexplored questions: whether public transport access predicts delayed learning to drive and whether the age at which individuals learn to drive is associated with later driving intensity. We merge nationally representative survey data from Ireland ($N > 2{,}000$) with Public Transport Accessibility Level (PTAL) scores to model (1) age at learning to drive, using survival analysis, and (2) recent driving behaviour, using a hurdle regression model. Higher public transport accessibility is associated with significantly later learning, with individuals in high-PTAL areas 30% less likely to have learned by age 20 than those with no access. Each year of delayed learning predicts a lower likelihood of weekday driving and a 2% reduction in Vehicle Kilometres Travelled (VKT) on driving days. The findings have implications for understanding the long-term benefits of public transport provision.

1 Introduction

Decarbonising road transport is among the most challenging components of national and international climate strategies. Transport accounts for a substantial and stubbornly persistent share of global greenhouse gas emissions, despite significant policy attention (Fleck, 2023; Ritchie, Rosado & Roser, 2020). Projections indicate continued growth in private vehicle use over the coming decades (European Environment Agency, 2024; Shafer & Victor, 2000). In Ireland, transport is the second largest source of greenhouse gas emissions and has proved more resistant to reductions than other sectors (EPA, 2025). Reducing Ireland's car dependency from one of the highest in Europe is central to meeting the legally binding obligation to halve emissions by 2030 (OECD, 2022).

Although car use is often motivated by economic necessity, early-life experiences also play a critical role in shaping long-term travel behaviour. Learning to drive is, for many, a formative milestone associated with independence, economic opportunity and social benefits (Fylan & Caveney, 2018; Scott Parker, King & Watson, 2015). However, obtaining a licence earlier in life may also contribute to car-oriented routines and preferences, resulting in behavioural "lock-in" that persists into adulthood and reinforces higher-emission travel patterns (Seto et al., 2016). If individuals who learn to drive earlier subsequently rely more heavily on private cars, this will have direct implications for transport emissions and decarbonisation pathways and designing more sustainable travel policies.

An existing body of evidence shows that public transport accessibility is associated with reduced car use (Ewing & Cervero, 2010; Clark, Chatterjee & Melia, 2016) and that travel habits formed early in adulthood are particularly durable (Müggenburg, Busch-Geertsema & Lanzendorf, 2015; Scheiner & Holz-Rau, 2013). We address two specific elements of these relationships. First, does access to public transport shape not just how people travel today, but when they become drivers in the first place (i.e., does it predict delayed learning to drive)? Second, does the age at which a person learns to drive have lasting consequences for their subsequent driving behaviour? To our knowledge, this is the first study to empirically test the long-term behavioural consequences of delayed learning to drive.

Our contribution is twofold. First, we add to a small but growing evidence base that public transport access is associated with reduced car reliance, and extend it by quantifying the relationship between a national public transport accessibility index and when people learn to drive. Second, we explore whether learning to drive later predicts lower reliance on private vehicles later in adulthood. These two questions are underexplored pathways through which public transport access may influence long-run car dependence and transport emissions, with direct implications for sustainable mobility policy.

Ideally, these research questions would be addressed by linking longitudinal data on public transport provision to data on when people learn to drive and how much they drive across the life course. Such longitudinal data do not exist in Ireland and cannot be reconstructed retrospectively. We are nevertheless able to adopt a pragmatic strategy that combines cross-sectional survey and administrative datasets originally collected for other purposes. Specifically, we draw on two modules from a recent national survey on car ownership, one that captured motivations for learning to drive and another providing a recent driving diary, and merge respondents' location data with public transport accessibility indicators produced by Ireland's National Transport Authority.

The resulting dataset inevitably includes more measurement error than an ideal longitudinal panel, given that public transport provision and residential location can change over time. Nonetheless, it enables meaningful analysis of the relationships of interest. Any bias resulting from noise in our measures is likely to dampen the estimated effects, meaning that associations we detect can be interpreted as lower-bound estimates of the true effects (i.e., "attenuation bias"; Fuller, 2009). A more substantive challenge is the potential for directional error arising from residential sorting: individuals who learned to drive later may subsequently choose to live in areas with better public transport (Lunke & Böcker, 2025). To address this, we conduct robustness checks exploiting cohort variation. Younger respondents have more recent residential and transport histories and less time in which to sort into high-accessibility areas. Weaker effects among younger respondents would therefore signal evidence of a sorting mechanism, whereas similar results across cohorts strengthens inference. For our second contribution, the dataset supports robust analysis of the link between learning age and current driving behaviour, as both rely on recall of a discrete and salient event (age at learning to drive) or very recent behaviour (driving on the most recent weekday) and we deploy best practice from behavioural science to further limit measurement error.

The next section presents relevant theoretical and empirical context motivating our research questions, followed by a brief note on the public transport context in Ireland. Section 2 describes our data and methods, Section 3 presents the results and Section 4 discusses the findings, their implications and the limitations of the study.

1.1 Relevant Literature

Habit formation theory proposes that behaviours performed repeatedly in stable contexts become automatic, requiring minimal cognitive effort (Verplanken & Aarts, 1999). Applied to travel behavior, this framework implies that modal choices made during formative periods, such as when individuals first gain independent mobility, can establish habits that persist across the life course (Verplanken, Walker, Davis & Jurasek, 2008). Early adulthood is especially influential: residential moves, entry into employment, partnership formation, and other transitions are 'moments of change' in which people develop transport mode preferences that are often durable over subsequent decades (Müggenburg et al., 2015; Scheiner, Chatterjee & Heinen, 2016; Whitmarsh et al., 2025). Learning to drive early in this period may therefore embed car-dependent travel patterns, especially where public transport options are limited, leading to patterns that might thwart later efforts to promote more sustainable travel.

Empirical evidence supports this theoretical perspective. Stated preference studies show that pre-existing car habits reduce sensitivity to improvements in alternative modes, with preferences for driving persisting even when more sustainable modes are cheaper or faster (Gao & Sun, 2018; Innocenti, Lattarulo & Pazienza, 2013). Meta-analyses of interventions to reduce driving find that only substantial measures, such as restrictions on car use, parking removal or financial disincentives, produce reliable behavioural change (Okraszewska et al., 2024; Xiao et al., 2022). These findings reinforce the idea that once car-oriented habits are established, reversing them is challenging.

There is also evidence that public transport accessibility influences car ownership and use. Living closer to a public transport stop is associated with lower levels of driving (2.5% less per mile of added proximity; Ewing & Cervero, 2010; Salon et al., 2012) and reduced car ownership rates (Clark et al., 2016). Panel data from the US further shows that frequent public transport use in early adulthood predicts continued use later in life and reduces the likelihood of acquiring a car (Smart & Klein, 2018).

However, few studies have examined whether public transport accessibility shapes the decision to learn to drive. Existing research, largely from North America, focuses primarily on socio-economic disadvantage and family circumstances as determinants of delayed licensure, mostly in the context of the Graduated Driver Licensing (GDL) (Tefft, Williams & Grabowski, 2014; Thigpen & Handy, 2018; Vaca, Drabo & Li, 2024; Wang, De Vos, Smart & Wang, 2025). Evidence on the role of public transport access elsewhere is comparatively scarce. Exceptions are Bohnet and Gertz (2010), Habib (2018) and Reinfeld and Hagan (2026), who show that living nearby a public transport stop is associated with delayed licensure in Canada and Germany.

Even less evidence concerns the downstream behavioural consequences of learning to drive later. Aside from safety research, which shows that delaying learner permit and licensure age lowers fatal crash rates (McCartt et al., 2010), we could locate no empirical studies linking learning age to long-run driving behaviour. This gap is notable, given the theoretical relevance of formative experiences and habit development.

We investigate the following research questions:

> RQ1. To what extent does public transport accessibility predict learning to drive at a later age?
>
> RQ2. Does learning to drive at a later age predict reduced driving?

By addressing these research questions, we assess how long-run car dependence is influenced not only by providing contemporaneous alternatives to the car, but by delaying when car-based habits are formed.

1.2 Country Context

Ireland’s public transport trajectory provides context for interpreting the findings. Rail closures during the 1960s and 1970s established a predominantly road-based transport system, with rail density remaining comparatively low and bus services providing the central mode of public transport (Blackwell, 1969; Scannell, 2006). Primary reliance on road transport persisted in the 1980s and 1990s, even in the main urban centre of Dublin (Rau, Hynes & Heisserer, 2016). From the 2000s onwards, investments include a light-rail system in Dublin and improvements to inter-city rail services, but buses continue to dominate public transport, particularly outside the capital (Hynes & Malone, 2020).

As a result, contemporary public transport accessibility is characterised by variation between areas with no or limited service and those with moderate accessibility, while areas with very high accessibility are comparatively rare and concentrated in Dublin. This distribution implies that our analysis is likely to capture variation primarily between no, low, and moderate levels of public transport access, rather than the effect of high-frequency, metro-style provision. This focuses the study’s implications, offering policy-relevant insights about the gains achievable from improving low levels of access, particularly in other bus-dominant systems.

2 Method

2.1 Participants

Participants were 2,086 respondents aged 16 years and over to a nationally representative survey on car ownership and use in July 2025.[1] The survey consisted of multiple modules; analyses reported here use data on licensing age, driving behaviour and socio-demographics (see Timmons, Shier & Lunn, 2026).

2.2 Measures

Variables included in our analyses are described below, with summaries reported in Table 1.

2.2.1 Learning Age

Participants reported whether they held a full or learner's licence and the age at which they started learning to drive. Full licence holders also reported on the age at which they passed their test. The results we report are robust to using licensure age as a robustness check (Supplementary Models (SM)).[2]

2.2.2 Public Transport Availability Level (PTAL)

How well a given location is served by public transport in Ireland is quantified using the National Transport Authority's PTAL index (John & O' Neill, 2024). The methodology is adapted from the PTAL framework originally developed by Transport for London (TfL, 2015). PTAL is calculated as an Access Index based on the combined effects of walking time to the nearest public transport stop (e.g., bus stop, tram stop or rail station), scheduled service frequency and mode-specific reliability factors (whereby rail is weighted as more reliable than bus), for a defined analysis period (we used between 8 and 9am on a weekday).

In practical terms, PTAL increases where high-frequency services are located within short walking distances and decreases where services are infrequent and/or located

[1] Sixteen was selected as the minimum age for completing the study because it is the minimum legal age for learning to drive certain private vehicles (mopeds, motorcycles and some work vehicles).
[2] https://osf.io/6v42j/overview?view_only=8c0d901a4ef14b7485b51642178db96a

further from the origin. For example, a home that is a 5-minute walk to a tram stop, with 4-6 minute service intervals, and is also serviced by several bus routes operating every 8-12 minutes would score higher than a home that is a 10-minute walk to a single bus route operating every 30-60 minutes. Locations beyond standard walk catchments (640m for bus stops and 960m for rail) are treated as having no effective public transport access for PTAL purposes.

The resulting Access Index scores are grouped into bands and categorised as null (i.e., no qualifying public transport access within the defined walk distance or no service operating during the selected time period), low (e.g., a single low-frequency bus service within walking distance), medium (e.g., one or more bus routes operating at 10–20 minute frequencies), medium-high (e.g., multiple high-frequency bus routes and/or proximity to a rail or tram stop), or high (e.g. locations within a short walk of rail, tram, and multiple high-frequency bus corridors, characteristic of city centre and major interchange areas). For analysis, we combined medium-high and high due to the low sample size in the high category (n = 86; 4.3%; though we refer to this category as 'high' for simplicity).

PTAL values were assigned using the most granular location information provided by participants. Participants were first asked to provide their postcode but could opt out and instead provide their local electoral area (LEA) and their electoral division (ED). Ireland is divided into 166 LEAs that are further divided into 3,440 EDs. EDs have an average population of 1,447 and area of 20.4km^2. Half the participants (50.2%) supplied full, valid postcodes and a further 9.5% provided their postcode routing key. Others provided their ED (32.0%) or LEA (5.3%); 3.1% provided no usable location entry. For all but full postcodes, PTAL was calculated from the centroid of the reported area.

The type of location information that participants provided was associated with participants' socio-demographic characteristics, including age, gender and region (see Appendix[3]). Consequently, all analyses include controls for socio-demographic characteristics.

[3] https://osf.io/6v42j/overview?view_only=8c0d901a4ef14b7485b51642178db96a

Because the PTAL score is more precise for participants that provided a full postcode, we tested whether results are sensitive to this precision by re-running the main models including only those who provided their postcodes. There is no change in the statistical significance of effects and coefficient point-estimates become stronger with this more precise sample (SM), as anticipated when measurement error is reduced. In the main model, we retain the full sample and include a control variable for location precision.

2.2.3 Recent Driving Distance

Drivers who had access to a car at home (*n* = 1,567) reported if they had driven their car over the past week. Those who had made at least one weekday trip as the driver of the car (*n* = 1,092; 69.7% of drivers) completed a one-day driving diary. After memory prompts, participants recorded each trip's origin, destination, purpose and an approximate distance, reported in kilometres or miles depending on the participant's preference. Analyses used total driving distance, with all distances converted to kilometres to give each participant's Vehicle Kilometres Travelled (VKT). Over half of respondents (57.9%) omitted their return home journey from the diary. For the main analysis, we use only those journeys included in the diary, but results are robust to models that (i) approximate a return home journey for those that omitted it and (ii) exclude all return home journeys (SM).

2.2.4 Socio-demographic Characteristics

The survey collected information on gender, age, region, educational attainment, employment status and country of birth. Participants also indicated whether they had a child under 18 years old at home and whether they had a public transport travel card or pass. Location data were also used to classify participants into one of six urban-rural area classifications used by the Central Statistics Office. Because this variable correlated strongly with PTAL,[4] models include only the PTAL. Robustness checks with PTAL replaced with urban-rural classification are reported in SM.

[4] Spearman's $\rho = .64$, $p < .001$

2.3 Analysis

2.3.1 PTAL on Learning Age

To test the effect of PTAL on learning to drive, we estimated a Cox proportional hazards model of age at learning. Cox regression is a type of survival analysis, which models the timing of an event and accommodates right-censoring, which occurs here for participants who had not yet learned to drive. Survival models are routinely used in medical research and have occasionally been applied to licensing delay (Bohnet & Gertz, 2010; Habib, 2018; Thigpen & Handy, 2018).

For individuals who had learned to drive, their reported learning age served as the event time. For individuals who had not yet learned, we treated their observation as right-censored at their current age. We left-censored the model at 16 as the youngest age at which participants could report learning and the minimum legal age for learning to drive certain private vehicles (mopeds, motorcycles and some work vehicles).

In addition to using PTAL score as a predictor, we controlled for gender, educational attainment, employment status, region and country of birth. Rather than including age directly, we estimated the participant's birth year (2025 minus current age) and grouped these into six birth cohorts (pre-1960, 1960-1969, 1970-1979, 1980-1989, 1990-1999 and post-2000). We then entered cohort as a 'shared frailty' term to account for cohort-level heterogeneity (i.e., we treated cohort as a random effect), which is small but statistically significant.[5] Results are unaffected by instead including cohort as a fixed effect and are also robust to running separate Cox models by cohort (see the SM). The test of the proportional hazards assumption was significant at the highest PTAL score,[6] though not other levels, and also for gender.[7] We therefore entered PTAL and gender as having time-varying effects.

2.3.2 Learning Age on Driving Behaviour

To analyse the effect of learning age on current driving behaviour, we estimated a

[5] $\theta = 0.03$, $\bar{\chi}^2 = 15.73$, $p < .001$
[6] $\rho = -0.07$, $\chi^2 = 6.13$, $p = .013$
[7] $\rho = -0.10$, $\chi^2 = 14.82$, $p < .001$

two-part hurdle model, with a logistic regression for the probability of having driven on a weekday preceding the survey and a log-linear regression for the distance conditional on having driven. To calculate distance, we summed each participant's total driving distance on the most recent weekday. Controls included PTAL, gender, birth cohort, educational attainment, employment status, region, country of birth, whether a child under 18 lives in the household and whether the participant holds a public transport card (pre-paid or entitling free travel).

Table 1. Summary of Relevant Measures

Variable	Statistic or Category		Variable	Category	
Learning Age	Mean (years)	20.6	Region	Dublin	29.0%
	Median (years)	18.0		Rest of Leinster	29.0%
	Std. Dev. (years)	5.59		Munster	25.6%
				Connacht-Ulster	16.5%
PTAL	Null	53.3%			
	Low	16.3%	Educational Attainment	Degree or above	41.6%
	Medium	15.8%		Below degree	58.4%
	(Medium-High or) High	14.7%			
			Employment Status	Full-time	51.6%
VKT*	Mean (km)	41.4		Part-time	14.3%
	Median (km)	20.0		Retired	14.0%
	Std. Dev. (km)	63.1		Student	5.6%
				Not working (incl. not able to)	14.6%
Gender	Man	45.0%			
	Woman	54.6%	Country of Birth	Ireland	81.5%
	Non-Binary / Other	0.4%		Elsewhere	18.6%
Birth Cohort	Pre-1960	13.3%	Child (u18) in Home	Yes	36.5%
	1960-1969	15.3%		No	63.5%
	1970-1979	16.7%			
	1980-1989	22.4%	Travel Card	Free Pass	24.1%
	1990-1999	19.9%		Adult/Student Card	34.0%
	Post-2000	12.4%		None	41.9%

Note. *We exclude two extreme outliers (with reported distances of over 2,000km) as erroneous inputs and model log-transformed distance for the remaining responses to account for skew.

3 Results

3.1 PTAL on Learning Age

Table 2 presents the Cox regression model on age at learning to drive. Effects in a Cox regression are expressed as hazard ratios, which quantify the relative rate at which an event occurs in one group compared with another over time. For ease of interpretation, we set the main hazard ratios at age 20.

Controlling for socio-demographic characteristics, individuals living in areas with higher PTAL scores learned to drive at older ages, indicated by hazard ratios significantly below 1. Tests for equality of coefficients show no significant difference between low and medium PTAL areas,[8] but those in high PTAL areas learn significantly later than those in low and medium areas.[9] To illustrate the size of the effect, Figure 1 presents model estimates indicating that 58% of those living in null PTAL areas will have learned to drive by age 20, compared to around 50% of those in low and medium areas and just 40% of those in high PTAL areas. The figure also shows the breakdown by gender as a comparison of the effect size; the difference between null and high PTAL is over twice the difference between men and women.

Table 2. Cox Regression Model on Age at Learning to Drive

	Hazard Ratio	Std. Err.	*p*
PTAL (Ref: Null)			
Low PTAL	0.79**	(0.06)	.003
Medium PTAL	0.84*	(0.07)	.033
High PTAL	0.62***	(0.06)	< .001
Man (Ref: Woman)	1.29***	(0.07)	< .001
Degree (Ref: Below degree)	1.22**	(0.07)	.001
Employment Status (Ref: Full-time)			
Part-time	0.83*	(0.07)	.025

[8] $\chi^2 = 0.19, p = .667$

[9] $\chi^2 = 6.97, p = .008$; $\chi^2 = 9.21, p = .002$, respectively

Unemployed	0.63***	(0.05)	< .001
Retired	0.77*	(0.09)	.028
Student	0.74	(0.13)	.085
Region (Ref: Munster)			
Dublin	0.97	(0.08)	.729
Rest of Leinster	1.03	(0.07)	.649
Connacht-Ulster	1.04	(0.09)	.607
Born in Ireland (Ref: Elsewhere)	1.00	(0.07)	.949
Time Varying Coefficients			
PTAL (Ref: Null)			
Low PTAL	-0.22	(0.33)	.502
Medium PTAL	-0.35	(0.34)	.298
High PTAL	-0.80*	(0.39)	.038
Man (Ref: Woman)	-0.96***	(0.25)	< .001
Cohort θ	0.03	0.03	
N	1,700		

Note. ****p* < .001; ***p* < .01; **p* < .05. Hazard ratios are presented at age set to 20 for clarity (as the default output sets age to 0). The table omits the hazard ratio for non-binary and other gender due to very low cell size. θ is significantly different from 0, $\chi2 = 15.73$, $p < .001$.

The time-varying effects show that the effect of living in a high PTAL area becomes stronger with age. Figure 1 plots the hazard ratios by age compared to null PTAL. The chart shows that, for those who have not yet learned to drive, the *relative* probability they do so at any given age falls sharply for those in high PTAL areas, but shows a shallower and non-significant decline among those in low and medium areas. The pattern for the high PTAL areas is consistent with Thigpen and Handy (2018)'s general finding for age. However, we interpret effects at older ages with caution, as just 8.5% of our sample had learned after turning 30. This effect of PTAL is robust to restricting the model to include only those who had learned by 30 (or are aged under 30) (SM). The proportional hazards assumption holds for this model. The effect is also observed when the model is split across cohorts (Appendix and SM).

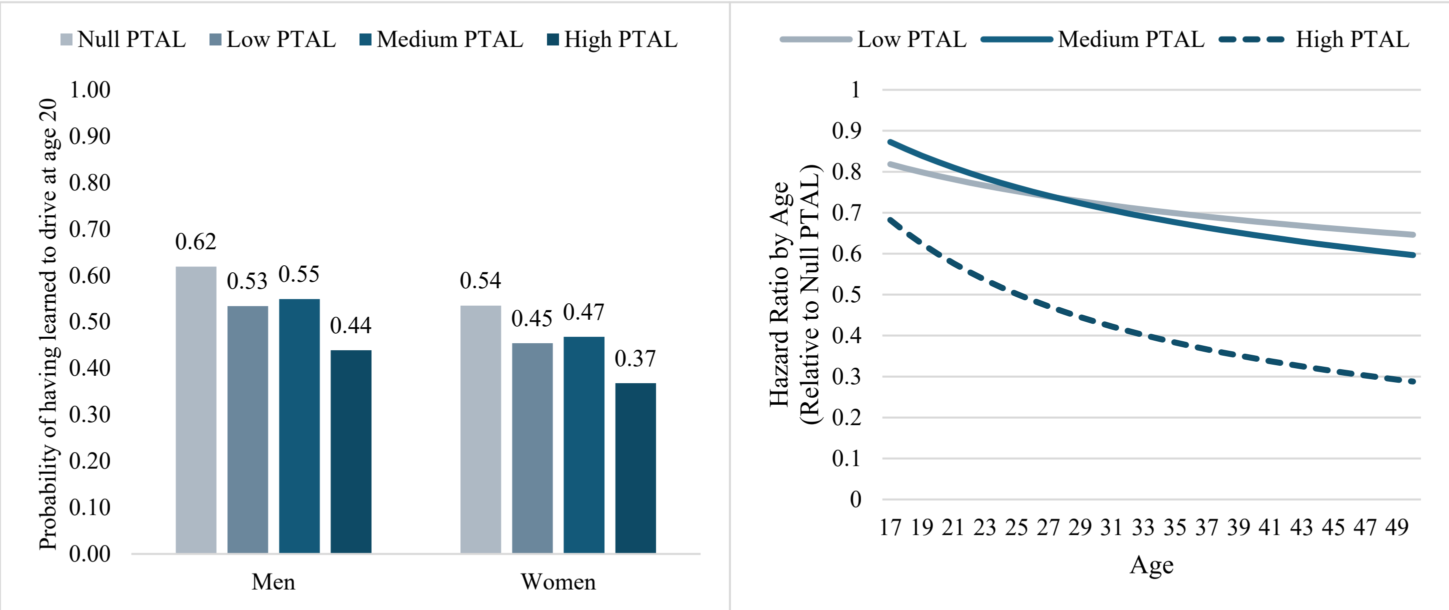

Figure 1. Effects of PTAL on learning to drive. The left panel shows the predicted probability of having learned to drive by age 20 broken down by gender. The right panel shows the hazard ratios by age, relative to living in a null PTAL area.

Turning to the socio-demographic controls, Table 2 shows that men were more likely to have learned to drive at age 20 than women, but the difference in learning likelihood between men and women narrows with age, as evidenced by the significant negative time-varying coefficient. Individuals educated to degree level or higher were more likely to have learned to drive at age 20, while those currently in full-time employment learned to drive younger than all other employment categories (part-time, unemployed, retired and students).

3.2 Learning Age on Driving Behaviour

Table 3 presents our models of current driving behaviour. Model 1 is a logistic regression model, predicting whether a licence-holder with access to a household car drove on a weekday preceding the survey. Results show a significant effect of learning age. Controlling for socio-demographic characteristics, including PTAL, learning to drive one year later is associated with lower odds of having driven on a given weekday. To convey the size of this effect, we compared the predicted probability of driving behaviour across the interquartile range of learning ages (17 years versus 22 years). A driver who started learning at 22 is 10.5% more likely not to have driven during a given week, compared to someone who started learning at 17 (32.6% vs. 29.5%, respectively).

Table 3. Regression Models of Recent Driving Behaviour

	Model 1 Drove in Past 5 Weekdays		Model 2 VKT Most Recent Day	
Learning Age	-0.03*	*p* = .002	-0.02**	*p* = .007
	(0.01)		(0.01)	
PTAL (Ref: Null)				
Low PTAL	0.39	*p* = .025	-0.12	*p* = .258
	(0.17)		(0.11)	
Medium PTAL	-0.20	*p* = .249	-0.41**	*p* = .001
	(0.17)		(0.12)	
High PTAL	-0.55**	*p* = .007	-0.09	*p* = .569
	(0.20)		(0.17)	
Man (Ref: Woman)	-0.10	*p* = .414	0.01	*p* = .908
	(0.12)		(0.08)	
Cohort (Ref: Pre-1960)				
1960-1969	0.27	*p* = .370	-0.15	*p* = .438
	(0.30)		(0.19)	
1970-1979	0.10	*p* = .756	0.07	*p* = .753
	(0.33)		(0.22)	
1980-1989	-0.43	*p* = .190	0.04	*p* = .847
	(0.33)		(0.22)	
1990-1999	-0.81*	*p* = .012	0.27	*p* = .216
	(0.32)		(0.22)	
Post-2000	-1.08**	*p* = .003	0.06	*p* = .808
	(0.37)		(0.26)	
Degree (Ref: Below degree)	0.35**	*p* = .004	0.04	*p* = .648
	(0.12)		(0.08)	
Employment (Ref: Full-time)				
Part-time	0.22	*p* = .235	-0.23	*p* = .062
	(0.19)		(0.12)	
Unemployed	-0.29	*p* = .126	-0.50***	*p* < .001
	(0.19)		(0.14)	
Retired	0.32	*p* = .258	-0.28	*p* = .098
	(0.28)		(0.17)	
Student	-0.80*	*p* = .036	0.34	*p* = .341
	(0.38)		(0.36)	
Region (Ref: Munster)				

Dublin	-0.28 (0.18)	*p* = .137	-0.22 (0.14)	*p* = .113
Rest of Leinster	0.23 (0.16)	*p* = .143	0.26** (0.10)	*p* = .008
Connacht-Ulster	-0.14 (0.38)	*p* = .417	0.14 (0.12)	*p* = .159
Born in Ireland (Ref: Elsewhere)	0.38** (0.15)	*p* = .009	0.07 (0.11)	*p* = .519
Has Child u18 (Ref: No Child)	0.20 (0.13)	*p* = .127	0.07 (0.11)	*p* = .519
Travel Card (Ref: No Card)				
Pre-paid (Adult/Student)	-0.00 (0.15)	*p* = .975	-0.15 (0.11)	*p* = .147
Free Pass	-0.21 (0.21)	*p* = .317	0.05 (0.15)	*p* = .750
Constant	1.34** (0.42)	*p* = .001	3.43*** (0.29)	*p* < .001
N	1,574		1,090	

Note. ****p* < .001; ***p* < .01; **p* < .05. Model 2 excludes two extreme outliers.

Model 2 is an OLS regression model of (natural) log-transformed VKT over the selected weekday. The model shows that each year of delayed learning is associated with a 2.0%[10] reduction in VKT among those who drove. This effect is comparable to the reduction in VKT associated with increased parking pricing or increased proximity to public transport (Salon et al., 2012). To convert this effect to kilometres driven, we calculated drivers in our sample to drive 10,764km per year on weekdays.[11] To then estimate an annual difference in VKT, we ran a third logistic regression on the likelihood of having driven the day before completing the study, which showed those who learned at 22 are 5% less likely to have driven that day compared to those who learned at 17 (SM). Taking both driving distance and driving likelihood into account, compared to a driver who started learning at 17, a driver who

[10] Exp(-0.02) = 0.98; 100 x (0.98-1) = -2.0%

[11] Participants drove an average of 41.4km, which gives 10,764km for total annual weekday driving (41.4km*260 weekdays). This estimate compares reasonably well to the official annual figure of 16,000km per car (CSO, 2019); ((10,764/5)*7) gives 15,070km, and this excludes some return home trips. The model predicts 2.0% less driving per year of delayed learning, giving 10.0% less comparing 17 with 22.

started learning at 22 is predicted to drive 1,561km less per year on weekdays.[12]

Turning to other predictors, these have stronger relationships with whether an individual drove than with VKT. Living in a high PTAL area, being younger, and being educated to degree level or above are associated with lower odds of driving on a weekday, but not with VKT among those who drove. The exception is region: those living in Leinster (outside of Dublin) are both more likely to have driven and to have higher VKT than those living Dublin.[13] This finding probably reflects commuting patterns.

[12] If we take an annual distance of 10,764km for 17-year-old-learners, 22-year-old-learners drive (10,764*.90*0.95)km, which accounts for the 10% reduction in distance on driving days and the 5% reduction in driving likelihood on a given day, giving 9203km.
[13] Test of coefficients for Model 1: $\chi^2 = 7.85$, $p = .005$; and Model 2: $\chi^2 = 14.91$, $p < .001$.

4 Discussion

This study provides new evidence on the potential origins of car dependence. First, we quantify the relationship between public transport access, as recorded using an official national index, and when people learn to drive. Second, we provide an empirical test of whether the age at which a person learns to drive has lasting consequences for their subsequent driving behaviour. Our results show that people living in areas better served by public transport begin driving later and that longer delays are associated with less driving on a given weekday later in life and lower VKT among those who do drive. Together, these findings suggest that public transport access shapes both contemporaneous modal choice and long-run driving trajectories.

4.1 Public Transport Access and Learning to Drive

The finding that public transport access predicts delayed learning to drive is consistent with substitution accounts of travel behaviour: where alternatives exist, it is less urgent for young people to obtain a driving licence (Fearnley et al., 2018). This finding adds to a small literature showing similar effects of proximity the US, Canada and Germany (e.g., Thigpen & Handy, 2018) and extends it by using a national index that incorporates not only distance to services but also service frequency and reliability. In areas of null PTAL, where public transport is effectively absent, 58% of individuals are estimated to have begun learning to drive by age 20, compared to approximately 50% of those in low and medium access areas and just 40% of those with high access. This 30% reduction (or 18%-point gradient) across the PTAL index represents a substantial effect and suggests that the structural transport environment meaningfully influences when young people learn to drive.

One concern is that the association could be driven by residential sorting, if individuals who delay learning subsequently select into high-access areas. Two features of our analysis make this explanation unlikely. First, our main analysis explicitly accounts for cohort variation. Second, the estimated PTAL effects are similar in magnitude across cohorts, including the youngest cohort (see Appendix), who have the least scope for post-licensure sorting. If sorting were the primary driver, we would expect materially weaker or null effects among the youngest respondents; instead, the stability of estimates across cohorts supports an interpretation of accessibility as a genuine predictor of delayed licensure.

As such, functional substitution is a likely mechanism, whereby young people have less need to drive if they have access to reliable public transport. However, the relationship may also reflect broader urban-rural differences. High PTAL areas are disproportionately urban, where driving tends to carry less social and practical salience during the transition to adulthood (Soza-Parra & Cats, 2023). In rural areas, cars are more central to identity, independence and social participation – factors that motivate first car acquisition (Fylan & Caveney, 2018). These differences are likely shaped by the inability to substitute between transport modes. Disentangling functional substitution and the broader normative environment surrounding mobility in different geographic contexts is not straightforward.

A further contribution of this paper is showing that the effect is graduated rather than binary. Improvements from no access to low or medium access are associated with substantial reductions in the likelihood of early learning, suggesting that incremental increases in public transport provision are associated with meaningful differences in driving behaviour, with implications for how investment in transport infrastructure is evaluated. However, the next substantial reduction occurs only at high levels of access, implying that the behavioural impact of public transport quality may be nonlinear.

4.2 Delayed Driving and Reduced Vehicle Kilometres Travelled

Our second set of findings, that delayed learning to drive is associated with reduced driving likelihood and reduced VKT among those who drove, are perhaps more novel. These effects control for current PTAL and a range of socio-demographic characteristics. To contextualise the size of the effect, the reduction in VKT among drivers is comparable to meta-analytic estimations of reductions associated with increased parking pricing or living nearby public transport stops (Salon et al., 2012), two of the most widely studied levers in demand management. This suggests that the timing of driving acquisition may be a non-trivial determinant of driving behaviour, of comparable policy relevance to interventions that have received considerably more attention.

In absolute terms, we estimate drivers in this sample to travel approximately 10,800km per year on weekdays. This estimate excludes many return-home journeys and is based on driving in early July, which likely omits other routine driving such as school trips, and should thus be treated as a conservative estimate (though it compares reasonably well with national driving statistics; CSO, 2019). Relative to a driver who began learning at age 17, a driver who began at age 22 is predicted to drive over 1,500 kilometres less per year. This reduction omits the fact that 22-year-old-learners accumulate fewer years of driving, suggesting that the life-course emissions impact may be even larger.

Several non-exclusive mechanisms may account for these effects. The most theoretically compelling is habit formation during a sensitive period of travel behaviour development (Ramos, Bergstad & Nässén, 2020; Verplanken et al., 2008). Early adulthood is characterised by residential, occupational and social change in which travel patterns are relatively malleable (Müggenburg et al., 2015). Individuals who acquire a driving licence early in this period may come to rely on the car as a default mode during a formative window, with this reliance becoming increasingly entrenched as life circumstances organise themselves around car access. Those who enter this period without a licence may, by contrast, make decisions that are compatible with or dependent on alternatives.

A second, related mechanism concerns familiarity with alternative modes (Dällenbach, 2020). Those with good access to public transport during early adulthood probably become more familiar with navigating public transport systems, including how to plan routes, boarding and alighting norms, fares and passes, payment systems, and so on. This accumulated familiarity and competence may reduce psychological barriers to continued use later in life, whereas those without early exposure may perceive public transport as unfamiliar or cognitively effortful and instead default to the car.

A third mechanism concerns residential, locational and occupational sorting (Lunke & Böcker, 2025). Individuals who do not learn to drive in early adulthood may be more likely to choose residential locations that are well-served by public transport or amenable to active travel or jobs that do not require a commute by car. These choices may reinforce non-car travel in ways that persist, even after a licence is obtained. However, two findings suggest that sorting cannot fully explain our results. First, we observed consistent effects across cohorts, including the youngest respondents. If sorting lay behind the relationships, they should be stronger among those who have had longer to sort. Second, excluding work-related driving from distance estimates does not change our results (SM).

A fourth more attitudinal mechanism concerns the relationship between early experience and modal identity. Individuals who navigate early adulthood without a car may develop a stronger sense of themselves as non-drivers in ways that persist even when driving becomes available. This is consistent with qualitative evidence that modal identity shapes travel behaviour independently of instrumental factors such as cost and convenience (Berão & Sarsfield Cabral, 2007). Importantly, this mechanism is merely a pathway to explain the effects we observe, rather than a potential confound.

While we cannot adjudicate between these mechanisms from the available data, doing so presents fruitful opportunities for further research.

4.3 Policy Implications

Transport policy typically treats public transport and car use as contemporaneous substitutes: improving public transport is presumed to reduce car use at the same time and place. Our findings of an additional, temporally extended mechanism suggests that this perspective limits appreciation of the broader effects of public transport provision. Public transport access during early adulthood reduces the probability of learning to drive in adolescence (with possible road safety benefits; McCartt et al., 2010) and this delay itself is a determinant of subsequent VKT. This perspective aligns with growing literature on life course approaches to travel behaviour and on identifying significant ‘moments of change’ that can have lasting implications for sustainability (Scheiner et al., 2016; Whitmarsh et al., 2025). Three policy implications follow.

First, the results imply that improving public transport provision in areas currently unserved may generate long-run reductions in car use by reducing functional and normative pressure to acquire a licence early. Conventional appraisal frameworks that fail to capture these behavioural effects, such as standard cost-benefit analysis, my underestimate the long-term return on investment (Song et al., 2025).

Second, the findings have implications for policies that lower barriers to public transport for young people. Reduced fares and frequent, reliable services to-and-from residential areas and locations frequently visited by young people may have enduring effects on driving behaviour. The results are thus consistent with policies such as the 50% reduction in fares associated with the Young Adult TFI Leap Card in Ireland, free bus travel for under 22-year-olds in Scotland and discounted monthly passes for young people in Germany and Austria. By sustaining the feasibility of non-car travel during a formative developmental window, such policies may help reduce lifetime VKT and associated emissions.

Third, the results reinforce the case for land use and planning policies that prioritise use of public transport and reduce car dependence, especially during life stages in which travel habits are formed. Planning for higher-density, mixed-use environments with viable transport alternatives not only provides public transport access in the present but may also yield environmental benefits that extend well beyond the immediate catchment area.

It is also important to recognise what the findings do not imply. Despite meaningful increases in delayed learning to drive in high-access areas, overall rates of learning to drive remain high across the population and the majority eventually obtain a licence. This suggests that car dependence is likely to remain substantial in Ireland for the foreseeable future, even under optimistic scenarios for public transport expansion. While improving public transport access and delaying driving acquisition can meaningfully reduce lifetime VKT, these behavioural shifts alone fall far short of the emissions reductions required, in terms of both scale and speed. Car use is likely to remain structurally embedded in many households' mobility patterns. Thus, transitioning the existing and future driving population toward electric vehicles, coupled with expanded renewable electricity generation, remains a necessary complement to demand-reduction strategies (Cassidy & de Bruin, 2025).

4.4 Limitations

Notwithstanding the above, in this section we acknowledge limitations and needs for additional research. First, the cross-sectional nature of the data limits strong causal inference. While the temporal ordering of age at learning to drive and recent driving behaviour is logically constrained, longitudinal data would better capture the role of mobility histories, sorting processes, attitudes and interactions between life events and travel behaviour. Second, our PTAL scores reflect current access rather than access at the time individuals learned to drive. This is not a confound but rather introduces measurement error that would be likely to weaken estimated relationships; detecting associations under these conditions strengthens confidence in the underlying relationship. Third, we lack measures of socio-demographic characteristics during adolescence, including household income and parental variables. Importantly, while these would be helpful controls for our analysis on learning to drive, they are less relevant for later life driving behaviour. Fourth, driving behaviour was measured using a single weekday diary with self-reported distances. Self-reported distances present another contributor to measurement noise. Moreover, if weekend driving and discretionary trips are more responsive to alternative travel modes, our effect size estimates may be further biased downwards. Finally, the study draws on a single national context; replication in settings with different licensing regimes and transport systems would help to establish generalisability.

4.5 Conclusion

We demonstrate that access to public transport is associated with delayed learning to drive and that delayed learning to drive is, in turn, associated with reduced lifetime VKT. The reductions observed – a 30% reduction in early driving rates between null and high PTAL areas and the 1,500km per year reduction in VKT across the interquartile range of driving ages – indicate that the transport environment meaningfully shapes long-run driving behaviour. Transport policy appraisal frameworks that overlook these life-course reductions may underestimate the long-term environmental returns on investment in public transport. More broadly, the findings highlight the value of life-course perspectives in designing policies to reduce car dependence and meet decarbonisation targets.

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