eMOBILITY LIVE
International Convention Centre, Sydney
Thursday 12th October 2023

The long-term effects of autonomous cars on land use, access and travel

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Agenda

Introduction

Research Program

Value

Land Use

Next Steps

This paper overviews progress in a research program exploring the long term impacts of Autonomous Vehicles (AVs) on land use, access and travel


AUSTRALIAN RESEARCH COUNCIL
Discovery Projects
Proposal for Funding Commencing in 2020

DP

PROJECT ID: DP200100952
First Investigator: Prof Graham Currie
Admin Org: Monash University

Total number of sheets contained in this Proposal: 60

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Australian Research Council

ARC Discovery Project
DP200100952
Long Term Impacts of Autonomous Vehicles on Land Use, Access and Travel

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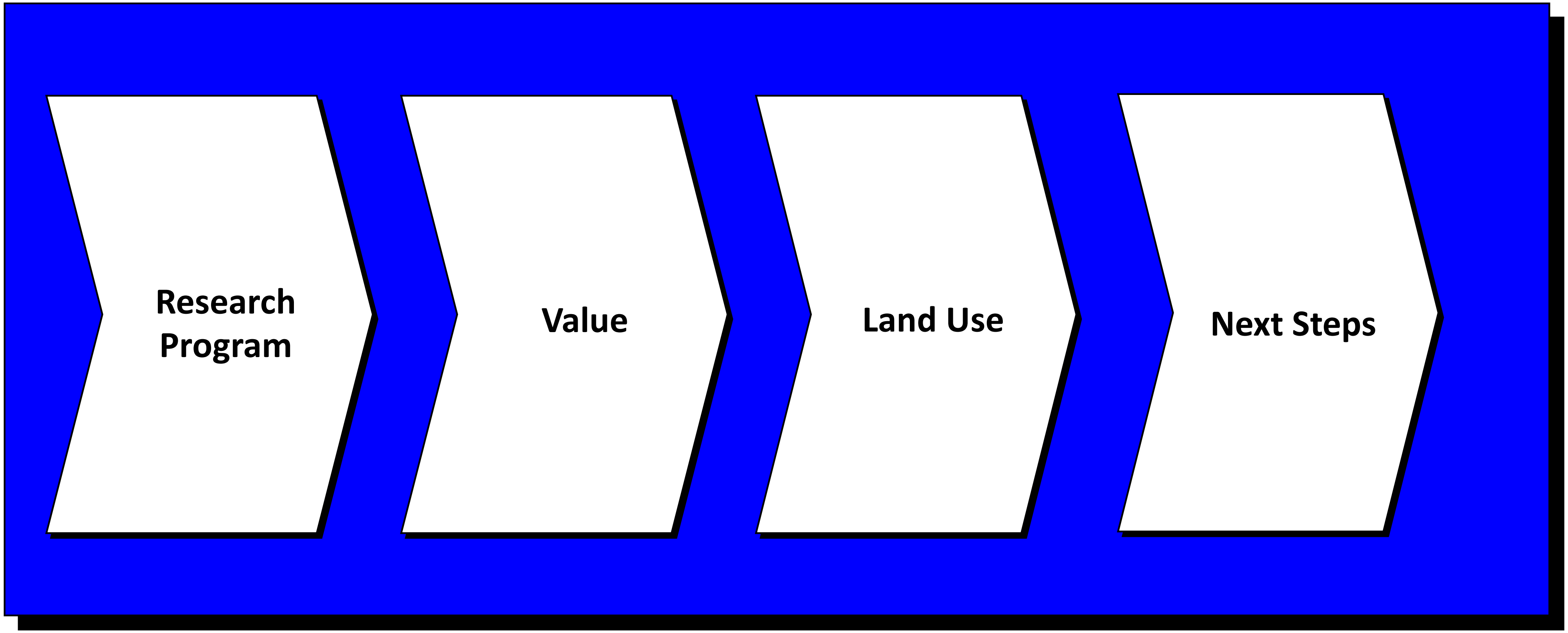
It is structured as follows:



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The program aims to explore long term AV land use impacts by measuring AV Value of Time and Land Use induced growth caused by AV's

Project Aim

- To explore the long-term effects of autonomous cars on land use, access and travel

Project Objectives

1. To determine the **value** of travel time with AVs in order to derive a generalised cost function for accessibility calculation;
2. To model AV induced urban growth and inform **land use** based policy measures to minimise their effects on transportation;
3. To calibrate a transport model to assess land use induced travel demand with AVs.

It hypothesises induced land use effects are generated by AV induced accessibility changes in the long term…

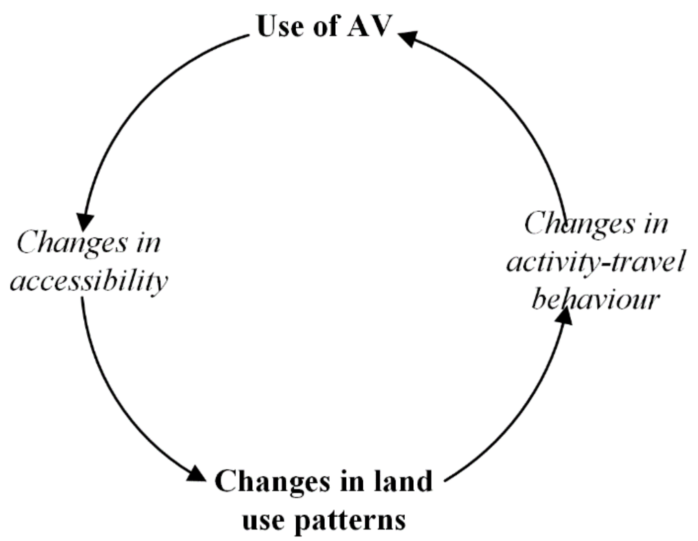


Figure 1: Land use/AV feedback cycle

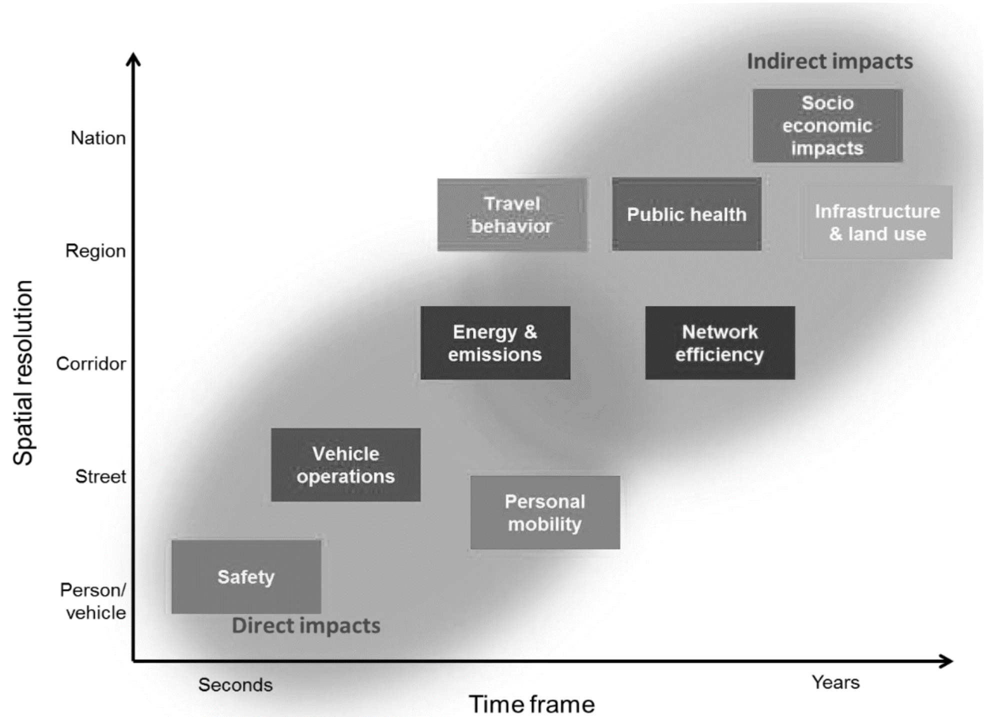


Figure 2: Direct and indirect (induced) effects of AVs in relation to spatial & temporal scales

Source: Engholm, A., A. Pernestål, and I. Kristoffersson, *System-level impacts of self-driving vehicles: terminology, impact frameworks and existing literature syntheses*. 2018, KTH: Stockholm.

…with value of time driving changes in costs, accessibility and changes in land use and AV ownership

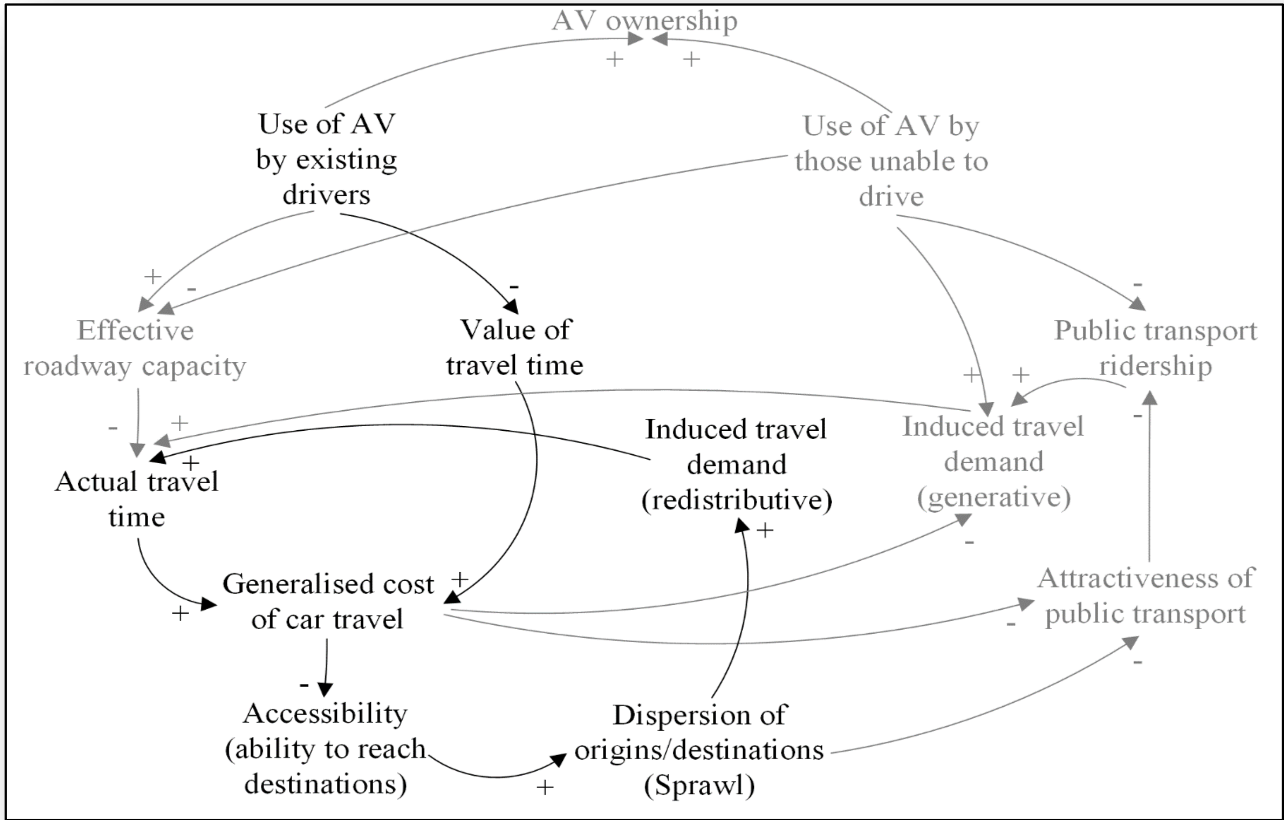
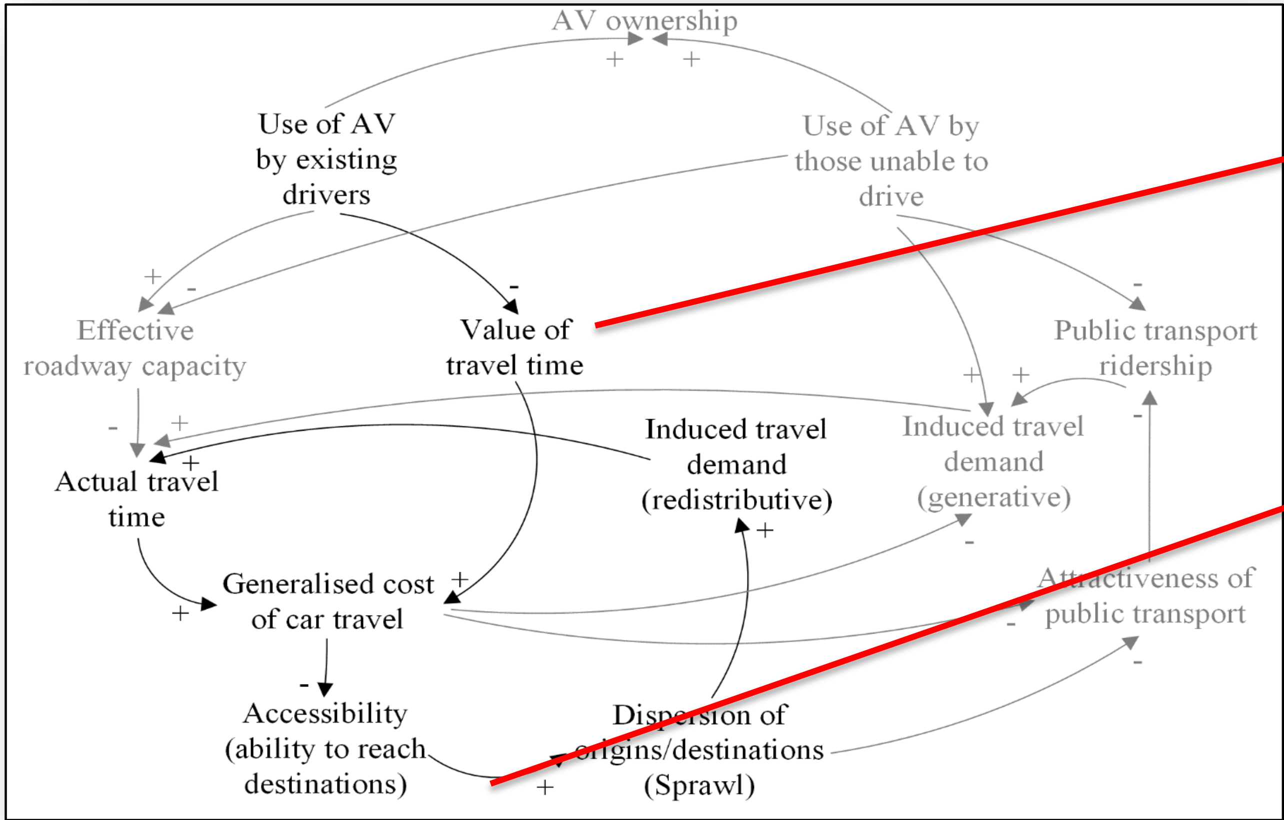


Figure 3: A simplified conceptual framework of AV induced long-term effects

AV Value of time and Land Use effects are thus key components of the research



Value

- AV VoT estimates
- Variation by context, location etc

Land Use

- AV Land Use Impacts
- How accessibility changes induce land use change
- Variation by context, location and time

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The VALUE project started with a meta synthesis of AV VoT estimates which has just been published


TRANSPORT REVIEWS
https://doi.org/10.1080/01441647.2023.2189324

Routledge Taylor & Francis Group

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Understanding the value of autonomous vehicles – an empirical meta-synthesis

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ABSTRACT

Value of Time (VOT) is a key element in transport infrastructure planning decisions. It is widely believed that travellers using autonomous vehicles (AVs) will have a lower VOT than conventional vehicles (CVs) because of improved road safety, increased road capacity, engagement in productive activity during travel and increased mobility. A number of researchers have measured VOT effects of AVs though no consolidation of this evidence has been undertaken to date. This is the first study to provide a quantitative summary and synthesis of the estimated VOT of AV travel including a synthesis of factors affecting AV VOT. Meta-analyses of 24 studies show that mean VOTs for conventional cars, private AVs and shared AVs are respectively 17.3, 12.1 and 19.4 AUS/hr. However, wide variations in these estimates are evident and 12 factors have been identified with statistically significant effects on these variations including geographical context, study experimental characteristics, trip characteristics and socio-economic factors. We found that AV VOT estimates are lower when animated videos are used to demonstrate AV capabilities. Private AVs have the lowest VOT estimates as do commute trips and morning peak periods. Young adults (18–30 years) and people with current driving experience consistently report lower AV VOT while those with higher educational status and higher-incomes report having higher AV VOT. Implications of findings for policy and future research are presented.

ARTICLE HISTORY
Received 19 July 2022
Accepted 25 February 2023

KEYWORDS
Autonomous vehicle; systematic literature review; meta-analysis; value of time; policy implications

1. Introduction

Improvements in technology have transformed the transportation sector … decades. Vehicles are now equipped with modern facilities e.g. … Wi-Fi connection, adaptive cruise control, lane assi…

CONTACT Fuad Yasin Huda … Transport Studies, Department of … Civil Engineering, East …

Project Aim

- a quantitative summary and synthesis of the estimated impacts of AVs on VOT through a meta-analysis of different technical and societal factors from published research.

Huda F, Currie G and Kamruzzaman L (2023) Understanding the value of autonomous vehicles – an empirical meta-synthesis, Transport Reviews, DOI: 10.1080/01441647.2023.2189324

A systematic lit review sourced 24 VOT studies; values were normalised and explored using comparative analysis

Methodology

- Systematic Literature Review
- Search terms:
  ["autonomous vehicle(s)" or "autonomous driving" or "connected autonomous vehicle(s)" or "automated vehicle(s)" or "vehicle automation" or "self-driving car(s)"]
  AND
  ["value(s) of time" or "value(s) of travel time" or "VOT" or "time valuation" or "travel time use"]
- Compilation of Value Estimates
- Normalisation of Values using Purchasing Power Parities (PPPs) published by the OECD
- Analytical assessment of value ranges by influences

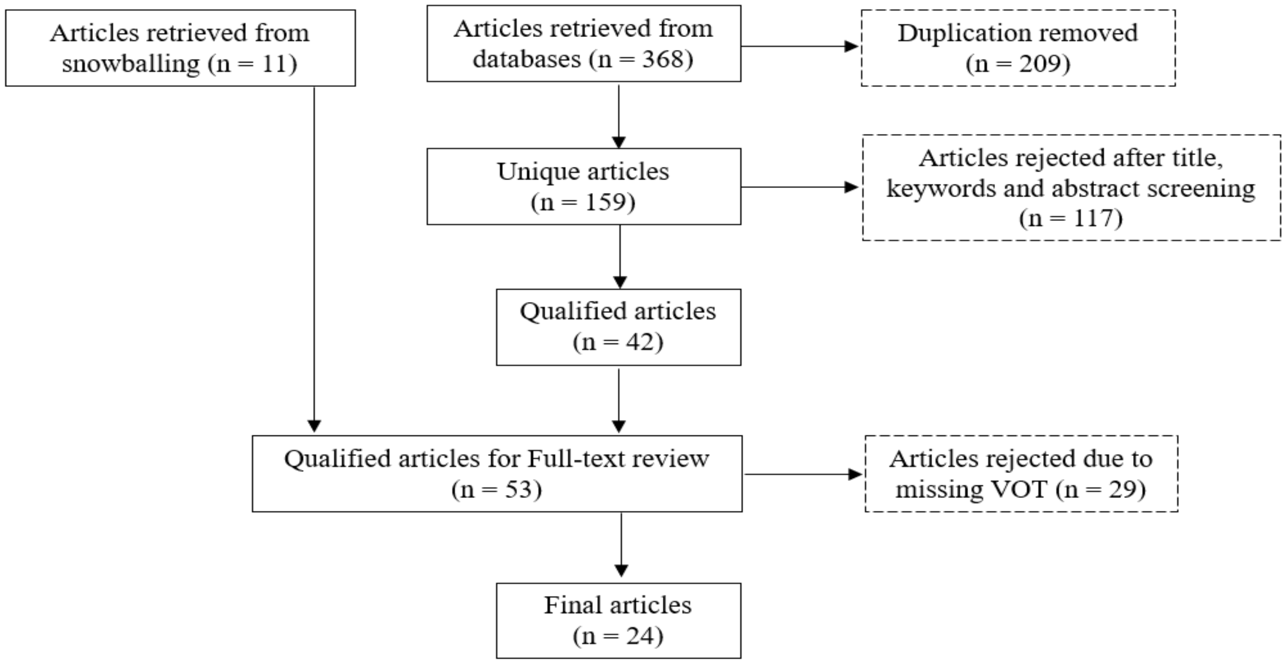

Figure 1. Summary of the comprehensive search procedure (source: authors analysis).

Selected studies

Table A1. Studies along with their major characteristics included in the meta-analysis (ordered by year of publication).

Study	Country	Survey year	Survey type	Sample size	AV mode	AV explanation
Krueger et al. (2016)	Australia	2015	Online	435	Shared	Written
Yap et al. (2016)	Netherlands	2014	Online	761	Shared	Written
Becker and Axhausen (2018)	Switzerland	2018	Paper	N/A	Shared, Pooled	Written
Kolarova et al. (2018)	Germany	2017	Online	485	Private, Shared	Animation
Steck et al. (2018)	Germany	2017	Online	172	Private, Shared	Animation
Wong et al. (2018)	Australia	2017	Online	108	Private	Animation
Correia et al. (2019)	Netherlands	2017	Online	324	Private	Written
Gao et al. (2019)	USA	2018	Online	502	Shared	Written
Hicks et al. (2019)	USA	2019	Online	614	Shared	Written
Kolarova et al. (2019)	Germany	2017	Online	485	Private, Shared	Animation
Kolarova and Steck (2019)	Germany	2017	Online	441	Private, Shared	Animation
Krueger et al. (2019)	Australia	2017	Online	512	Private	Written
Lavieri and Bhat (2019)	USA	2017	Online	1607	Shared, Pooled	Written
Torres-Montoya and Innao (2019)	USA	2018	Online	1717	Private	Written
Etzioni et al. (2020)	Cyprus, UK, Slovenia, Montenegro, Hungary, Iceland	2020	Online	1669[a]	Shared	Written
Sun et al. (2020)	Singapore	2019	Interview	204	Transit	Written
Zhong et al. (2020)	USA	2017	Online	1881	Private, Shared	Written
Szimba and Hartmann (2020)	Germany	2019	Simulation	–	Private	–
Etzioni et al. (2021)	Israel	2019	Online	713	Shared, Pooled, Transit	Animation
Kang et al. (2021)	USA	2019	Online	953	Private, Pooled	Written
Kolarova and Cherchi (2021)	Germany	2017	Online	484	Private, Shared	Animation
Choi et al. (2022)	South Korea	2019	Online	500	Private, Shared	Written
Hamadneh and Esztergár-Kiss (2022)	Hungary	2020	Online	525	Private, Shared	Written
Harb et al. (2022)	USA	2019–20	Interview	71	Private	Chauffeur driven[b]

[a]Cyprus (158), UK (79), Slovenia (274), Montenegro (321), Hungary (285), Iceland (552).
[b]Chauffeur driven personal cars were used as an analogy of personally owned AV.

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VoT Values and Disaggregate Factors Explored in the Analysis ($ Aud, 2021)

Table 2. Variation of mean VOT (AU$/hr) between vehicle types and different variables.

Variable	Category	Private AV (PAV)			Shared AV (SAV)			CAR		
		N	Mean	Std. Dev.	*N*	Mean	Std. Dev.	*N*	Mean	Std. Dev.
Country	Australia	5	9.0	8.9	–	–	–	4	15.6	8.5
	USA	7	18.8	16.5	10	28.6	14.2	9	27.1	17.9
	Germany	42	12.2	5.8	35	10.8	2.6	16	16.6	9.9
	Netherlands	25	11.0	3.0	–	–	–	25	11.8	1.0
	Europe	–	–	–	8	45.4	28.6	2	51.9	40.6
	Asia	2	12.1	0.8	4	18.6	7.3	–	–	–
Geographical location	Rural	26	11.0	3.0	–	–	–	26	11.9	1.0
	Urban	10	14.0	15.8	7	25.5	16.9	9	23.6	19.4
AV demonstration	AV written	25	14.1	9.5	17	34.7	24.4	–	–	–
	Chauffeur written	13	8.9	2.5	2	23.1	7.4	–	–	–
	Video	43	11.9	5.9	39	12.6	6.2	–	–	–
Sample size	Category 1	30	12.1	6.4	25	12.0	8.2	3	22.1	19.8
	Category 2	34	10.5	3.1	7	16.9	13.2	34	13.0	3.6
	Category 3	8	10.4	6.0	11	23.6	18.9	5	13.1	8.9
	Category 4	8	21.1	14.3	14	31.0	23.4	12	30.4	22.3
Sample characteristics	Trader	80	12.2	7.0	45	13.6	9.5	52	15.7	10.4
	Non-trader	–	–	–	13	39.7	22.4	4	38.3	28.9
Trip type	Commute	67	11.6	6.5	42	15.0	10.4	40	15.0	10.6
	Non-commute	14	14.5	8.9	16	31.0	25.2	16	23.1	17.9
Time of day	AM peak	70	11.3	5.0	38	12.1	5.5	42	13.6	6.6
	Others	9	19.3	14.4	18	35.6	22.9	14	28.7	21.0
Trip distance	<20 km	47	11.9	5.8	39	12.0	4.6	19	17.3	9.2
	>20 km	5	9.4	4.9	4	15.9	5.1	7	15.8	6.7
Trip duration	<30 min	31	10.8	3.2	8	18.5	11.4	33	13.3	4.7
	>30 min	11	14.7	14.9	7	23.4	17.7	9	23.8	19.2
Gender	Male	12	13.6	2.8	12	9.8	1.7	–	–	–
	Female	12	11.3	2.7	12	11.0	1.8	–	–	–
Age	<18 years	–	–	–	8	48.1	24.8	–	–	–
	Young adult	8	10.9	2.7	8	9.0	1.5	–	–	–
	Middle aged	8	13.2	2.9	8	11.1	1.7	–	–	–
	Seniors	8	13.3	2.9	8	11.2	1.7	–	–	–
Education	<uni deg	12	10.3	1.9	12	9.1	1.2	–	–	–
	=>uni deg	12	14.6	2.1	12	11.7	1.4	–	–	–
Income	Low	7	7.0	4.4	4	11.3	5.7	6	10.5	5.2
	Medium	7	10.0	6.7	3	11.3	1.5	6	16.4	8.1
	High	5	17.4	12.1	4	19.5	5.2	5	23.0	12.9
License	No	12	14.0	14.4	18	34.4	23.7	13	26.3	23.0
	Yes	69	11.7	4.9	40	12.7	6.2	43	14.6	7.2

Factors Explored

- Country
- Rural/Urban
- AV Demonstration Approach
- Sample Size
- Sample Characteristics
- Trip Type
- Trip Distance
- Trip Duration
- Gender
- Age
- Education
- Income
- License

Normalised VoT ($Aust) is $11.00 Private (n=81) and $12.30 Shared AV (n=58) plus $17.20 for Pooled AV's (n=10)

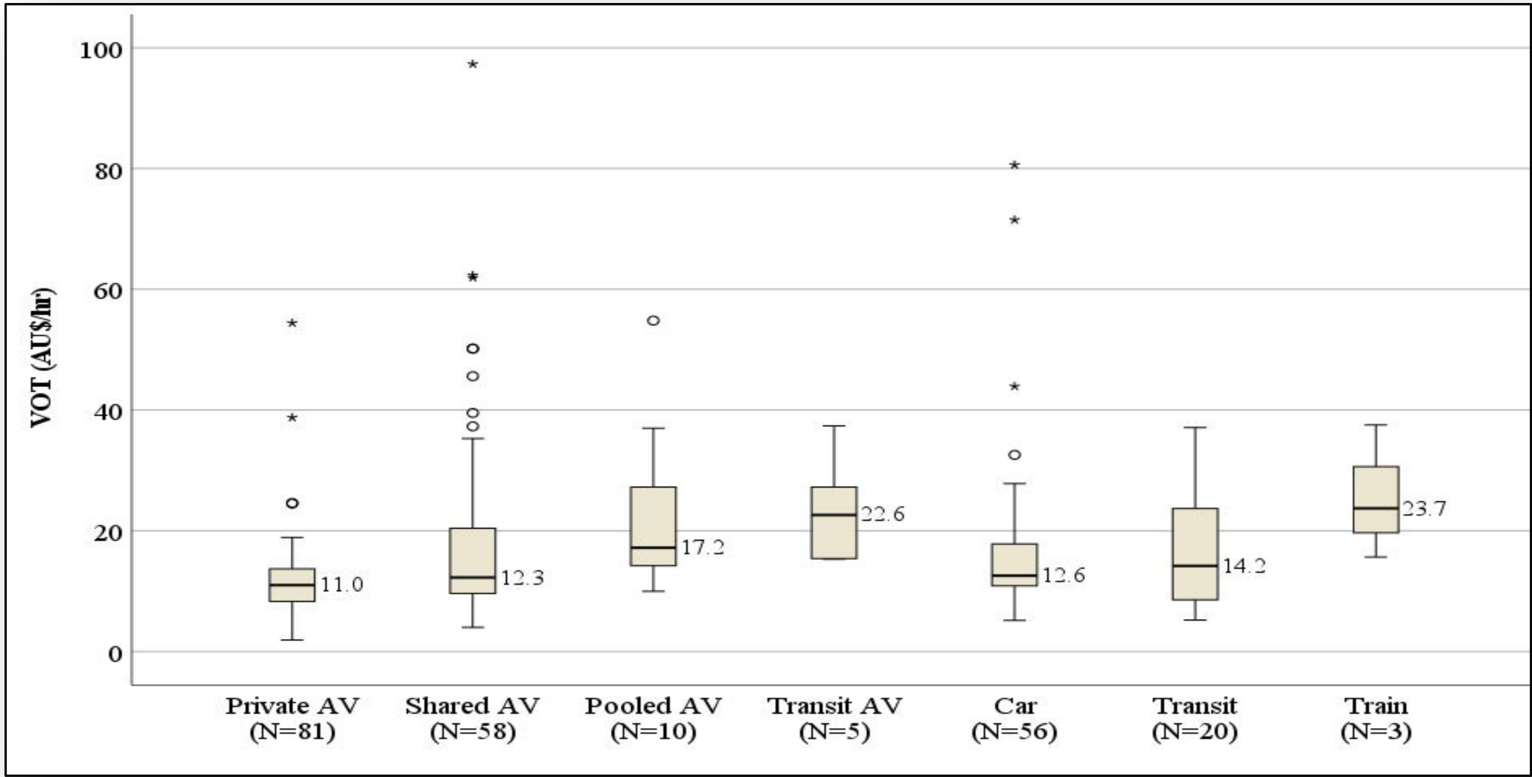

Figure 2. Box plot distribution of the estimated VOT for different types of vehicle.

Private AV VOT has lower than Shared AV's; Private and Shared AV's were lower than all modes notably car and transit

Table 1. Difference in VOT (in %) among vehicle categories (row minus column) .

	Private AV	Shared AV	Pooled AV	Transit AV	Car	Transit	Train
Private AV	–	−10.6	−36.0	−51.3	−12.7	−22.5	−53.6
Shared AV	–	–	−28.5	−45.6	−2.4	−13.4	−48.1
Pooled AV	–	–	–	−23.9	36.5	21.1	−27.4
Transit AV	–	–	–	–	79.4	59.2	−4.6
Car	–	–	–	–	–	−11.3	−46.8
Transit	–	–	–	–	–	–	−40.1
Train	–	–	–	–	–	–	–

Note: Colour code indicates the significance criterion, green = significant, orange = not significant.

13 Factors were found to significantly impact AV VoT

Table 4. Factors influencing the VOT estimates for AV travel.

Variables	Comments
Vehicle type	VOT will be lowest for private AV.
Country	VOT is found to be lower in Germany and the Netherlands then Australia and the US.
Geographical location (rural vs. urban)	AVs will be popular to urban residents.
AV demonstration approach	VOT will be lower when showing animation video.
Sample size	VOT will be higher for sample size of more than 500.
Sample characteristics	VOT will be lower if the responses from the "non-traders" are excluded.
Trip type	Commuters will experience lower VOT.
Time of the day	VOT will be lower in the morning peak.
Trip distance	In short trips both PAV and SAV will exhibit lower VOT compared to CAR but in long trips, PAV will yield lower VOT.
Age	VOT will be lower for young adults (18–30 years).
Education	VOT will be higher for highly educated people.
Income	VOT will be higher for high-income group.
Driving license	VOT will be lower for people having current driving experience.

Note: gender and trip time not significant

One factor was AV demonstration approach; video/animation generates lower VoT than written explanations; this raises questions about SP validity

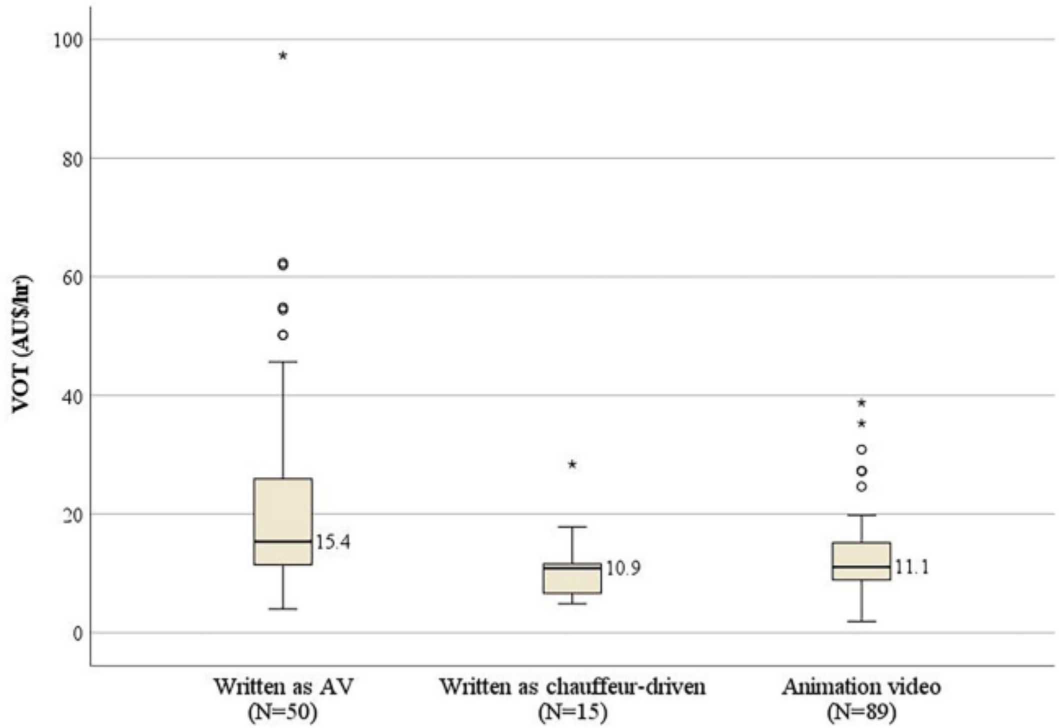

Figure 3. VOT distribution classed by AV demonstration approach.

New research – Meta-Regression results:

Table 3: Estimation results of the meta-regression analysis. (outcome variable: Value of Travel Time, AU$/hr)

Variable	Marginal effect	Std. Error
Constant	6.344	4.320
Sample size	0.003	0.008
Vehicle type (ref: private AV)		
Shared AV	2.085	2.806
Pooled AV	2.318	3.109
Transit AV	2.572	5.985
TripType (ref: commute)		
Others	0.035	2.214
Income (ref: low)		
Middle	1.263	2.430
High	8.049	2.379
Geo-location (ref: urban)		
Rural	-6.468	2.647
Analysis (ref: HCM)		
ML	-1.154	2.426
AV Demo (ref: written as AV)		
Animated video	-3.870	5.842
License (ref: No)		
Yes	-3.668	5.409
R^2 value	0.615	
F-statistic	3.630	
Significance (p)	0.004	

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The LAND USE project aims to conceptualise land use impacts of AV using a systematic review of the literature – this has also just been published

Project Aim

- This study aims to develop conceptual frameworks in the form of causal loop diagrams to enhance understanding through a systematic review of the literature.

Pimenta AR Kamruzzaman M and Currie G (2023) "Long-term effects of autonomous vehicles on the built environment: a systematic scoping review towards conceptual frameworks" TRANSPORT REVIEWS
DOI: 10.1080/01441647.2023.2189325

A systematic lit review sourced 82 studies; results split into 6 dimensions and interactions captured using causal loop diagrams

Methodology

- Systematic Literature Review
- Search terms:

  “autonomous vehicles” OR “driverless vehicles” OR “automated vehicles” OR “self-driving vehicles”
  AND
  “built environment” OR “land use” OR “urban environment” OR “parking” OR “accessibility” OR “density” OR “urban sprawl” OR “city” OR “cities” OR “urban system” OR “urban planning” OR “urban area” OR “urban design” OR “housing” OR “urban form” OR “urban transport” OR “urban development” OR “neighbourhood”
- Data extracted into 6 sets of Built Environment Dimensions
  - Explores effect size/direction
- Causal Loop Diagrams to understand links between built environment factors
- Disaggregate results for:
  - AV Type (Private, Public, Private and Public)
  - Citywide, CBD, Suburban

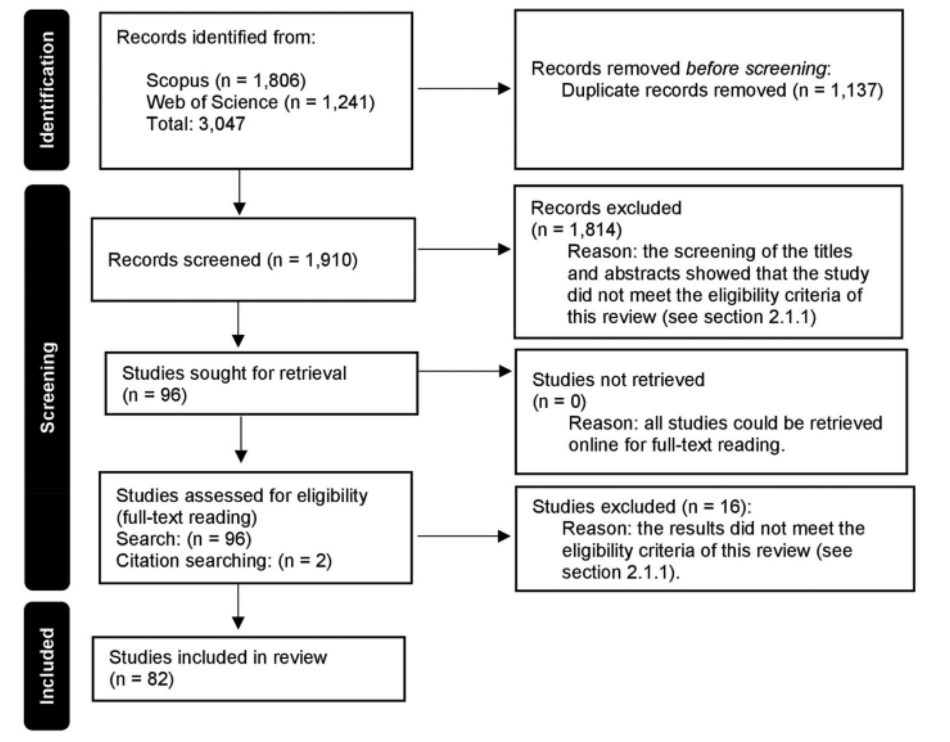

Figure 1. Systematic search process based on the PRISMA framework and search outcomes (Page et al., 2021).

A systematic lit review sourced 82 studies; results split into 6 dimensions and interactions captured using causal loop diagrams

Methodology

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- Data extracted into 6 sets of Built Environment Dimensions
  - Explores effect size
- Causal Loop Diagrams to understand links between built environment factors
- Disaggregate results for:
  - AV Type (Private, Public, Private and Public)
  - Citywide, CBD, Suburban

Table 1. Indicators used to extract data for each built environment dimension.

Built Environment Dimension	Data Extraction Indicators
Parking	Demand for both off-street and on-street parking, measured by: 1. Number of parking spaces per vehicle/household. 2. Size of parking spaces per vehicle/household.
Destination Accessibility	Job and residential accessibilities represented by time, monetary and land use indicators.
Density	Population and number of jobs per unit of area.
Distance to CBD	Commute distance/time, average travel distance, urban area and household relocation.
Diversity of Land Uses	Land use entropy and parcel area disaggregated by type (i.e. commercial, residential, industrial, government, civic, education, etc).
Design	Changes in urban geometry and infrastructure, measured by: 1. Intersection density/block sizes. 2. Sizes of sidewalks, car lanes and cycle lanes. 3. Street network density (i.e. street area/total urban study area). 4. Pavement and utilities.

PARKING is expected to reduce notably in CBD’s ; some parking relocation and empty cruising (for PAVs); PAVs may increase ownership SAV reduce

Parking Findings Overview

- AVs expected to significantly reduce the demand for both curbside and off-street parking since will :
  - reduce car ownership (Legacy et al., 2018).
  - AVs capable of cruising empty for vacant parking spots in suburban areas, or even move back to residential home garages (Milakis et al., 2017, Millard-Ball, 2019).
- This may enable replacement of parking spaces by other land uses in high-density areas, such as affordable housing (Riggs et al., 2020, Yigitcanlar et al., 2019) and commercial services (Hawkins and Nurul Habib, 2018).
- For buildings, the total costs of construction may drop by -20 to -25% if structural parking is no longer needed due to the replacement of human-driven vehicles by SAV systems and PAVs (Riggs et al., 2020).

Private AV’s

- PAVs are expected to reduce parking demand in CBDs due to their ability of cruising empty to low-density suburbs where parking spots are often more vacant, free or cheaper than the CBD.
- Kang et al. (2022) estimated that, approximately, 25%-32% of current parking areas could be repurposed owing to PAV capability of parking at their origins.
- PAVs may increase vehicle ownership:
  - lower acquisition and operational costs
  - inclusion of new users who are unable to drive, such as the elderly, disabled people and children

AV’s Parking Efficiency

- Less space needed for AV parking; could increase parking capacity

DESTINATION ACCESSIBILITY will mainly benefit suburbs suggesting sprawl.

Destination Accessibility Overview

- Overall expected increases in travel utility caused by AVs will primarily benefit suburban and exurban areas by enhancing job accessibility,
  - consequently drive urban sprawl in cities
- Regarding CBD accessibility impacts, relationships varied by AV modes.
  - PAV only, accessibility was found to increase between 17% to 187% (Cordera et al., 2021).
  - SAVs only, accessibility changes varied from -4% to 21% (Zhong et al., 2020).
  - For mixed PAVs and SAVs together, negative accessibility variations were found in two different studies
- PAVs tend to benefit suburban accessibility more than SAVs. Therefore, if PAVs become dominant in suburbs, a significant accessibility increase is expected;
  - However, experts have claimed that induced travel demand may offset these potential long-term

URBAN DENSITY will increase in CBD's due to parking loss; but decline in suburbs due to sprawl

Urban Density Overview

- Residential and employment densities in city centres and suburbs will be affected by AVs in different ways.
  - Reductions in parking space demands in city centres will permit more housing and commercial land uses, creating denser urban cores (Llorca et al., 2022, Milakis et al., 2018, Stead and Vaddadi, 2019),
  - whereas suburban and exurban areas will likely face more urban sprawl and lower residential density development owing to lower disutility of travel time, and lower transportation costs (Duarte and Ratti, 2018, Gelauff et al., 2019, Heinrichs, 2016, Hiramatsu, 2022, Kyung-Hwan et al., 2015, Moore et al., 2020).
  - Interestingly none of the modelling studies considered the potential contribution to density caused by the replacement of parking by other land uses, and only two considered home relocation caused by lower disutility of time, and lower transportation costs (Gelauff et al., 2019, Hiramatsu, 2022)

Land use DIVERSITY will change in mixed patterns; new land uses will be created (e.g. AV charging/activity stations)

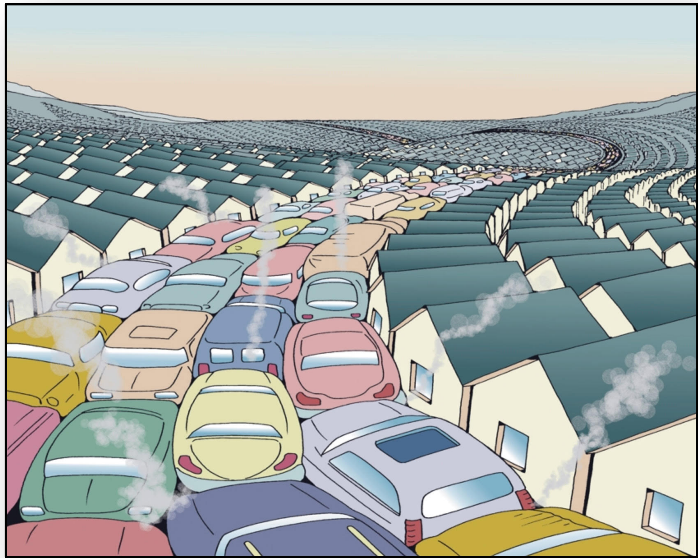
Diversity Overview

- CBD parking reduction may transform current parking spaces into commercial, residential and mixed-use hubs (Hawkins and Nurul Habib, 2018).
- Introduction of AVs tends to attract more commercial land use to suburbs due to accessibility gains.
  - Bridgelall and Stubbing (2021), the average trip rate for commercial land use might triple by 2050, and commercial land use may shift towards lower density suburbs.
  - Kumakoshi et al. (2021), commercial land use area may increase by 35% owing to parking reductions after the introduction of SAVs.
  - On the other hand, a simulation study in Seoul, found that commercial land use area may significantly decrease in a scenario with fully autonomous SAVs, whereas industrial and residential land use areas tend to largely increase (Kang and Kim, 2019).
- Researchers have suggested that AVs may firstly be adopted in single-use zones rather than mixed-use areas (Nodjomian and Kockelman, 2019). This is due to the potential reduction in the disutility of travel, and higher accessibility, especially for those who currently need to commute long distances by human-driven vehicles.
- It has also been suggested that some land uses will become obsolete due to the adoption of AVs while some new uses will be created. For instance, it will be necessary to implement local depots for the cleaning, maintenance, charging and repairs of SAVs in service (Heinrichs, 2016). Charging stations may function as mobile office locations, gas station and private garages will be replaced by other uses (e.g. shops, schools, etc) (Yigitcanlar et al., 2019), and car-park area will be significantly reduced (Zhang and Guhathakurta, 2017).

DISTANCE TO CBD is expected to increase as travellers relocate and travel further due to lower AV VoT

Distance to CBD Overview

- Most studies found positive correlations between AV availability and willingness to relocate home further from city centres (Bansal and Kockelman, 2018, Guan et al., 2021, Nodjomian and Kockelman, 2019).
  - These findings support the view that population density in middle suburbs may be significantly reduced.
- Modelling results also showed that distance to the CBD would overall increase after the implementation of AV systems.
  - Llorca et al. (2022) predicted an increase of about 8% in the average commute time to CBD.
  - Liu et al. (2021) found that higher automation levels may lead to an increase in average travel time if the highway capacity is less elastic than the value of travel time for on-demand AVs.
  - However, potential improvements in road capacity and traffic flow may contribute to counterbalance these effects. For instance, Szimba and Hartmann (2020) found that AV automation levels 4 and 5 may, respectively, reduce average commute time by 20% and 27%.



URBAN DESIGN results are mixed and conflicting; some suggest improvement others problems for pedestrian access

Urban Design Overview

- Urban design features, such as sidewalks, cycle lanes, car lanes, block sizes and street network density might be significantly reshaped due to the introduction of AVs. AVs will impact rights-of-way, travel lanes and intersections (Fraedrich et al., 2019, Riggs et al., 2020).
- Experts suggest that AVs may overall increase safety for pedestrians and cyclists in the long-term (Botello et al., 2019). Nevertheless, lane segregation by mode, and multi-level crossing with AVs and non-motorized modes may be necessary to ensure safety and appropriate AV traffic flow (Botello et al., 2019).
- Segregated street platform spaces for SAV drop-off and pick-up lanes, autonomous delivery services and curbside parking may also be necessary (Fayyaz et al., 2022). Survey results show that the possibility of AV lane segregation seems to be the most important factor to encourage AV adoption (Carrese et al., 2019). However, AV-only lanes may also hinder walkability (Botello et al., 2019). than door-to-door (Soteropoulos et al., 2021).

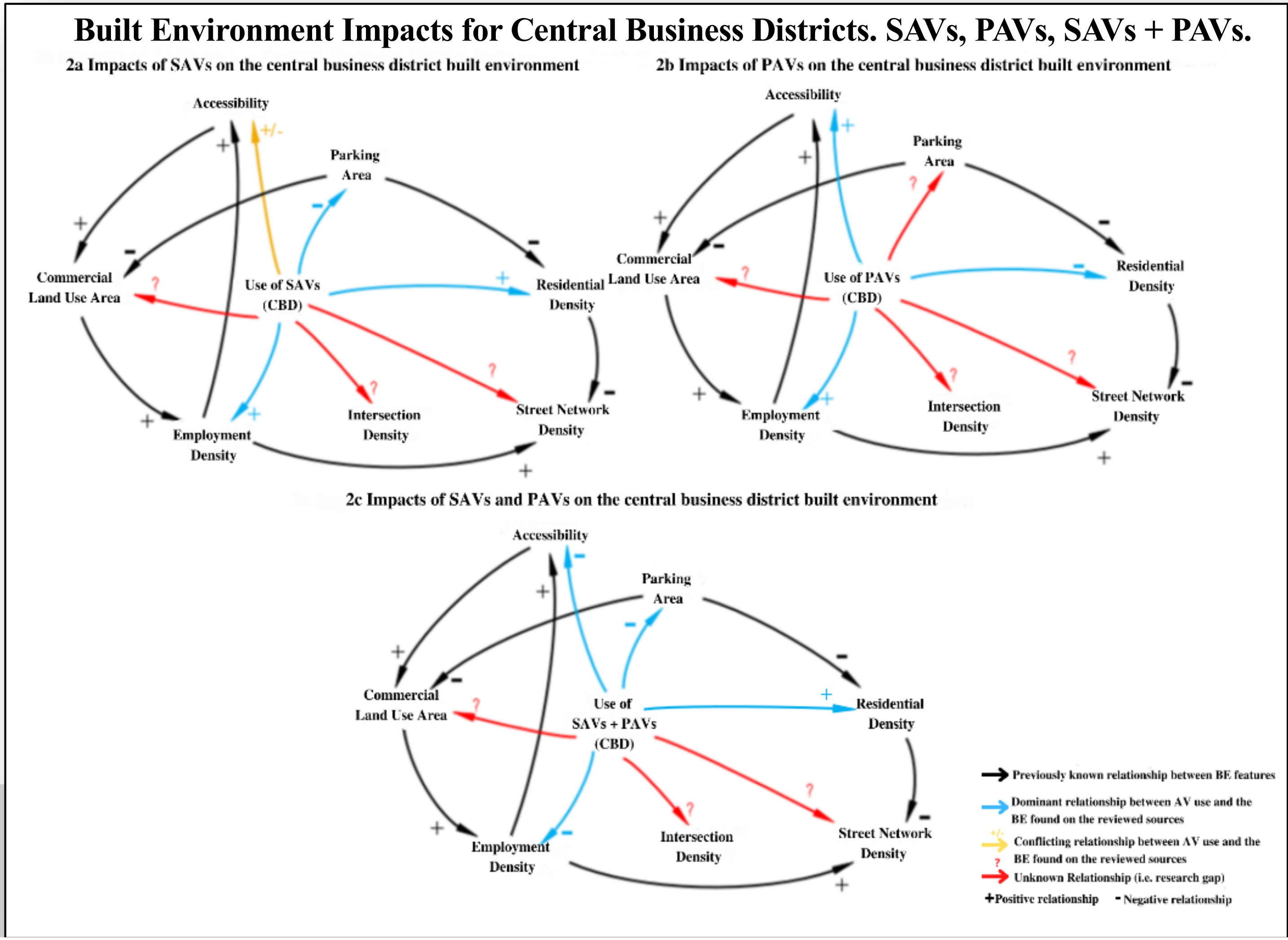
?

A synthesis of results suggests CBD parking and sprawl are major land use effects of AV's ; both have larger impact with PAV's rather than SAVs

Synthesis of Drivers and Impact on Built Environment Dimensions for PAV's and SAV's

Driver of Change	Private Avs						Shared Avs					
	Parking	Dest Acces	Den Sity	Diver Sity	CBD Dist	Design	Parking	Dest Acces	Den Sity	Diver Sity	CBD Dist	Design
Reduced car ownership	--											
Increase car ownership	+											
Empty Cruse Parking	---						-					
Space Efficient Parking	-											
Reduced VoT		CBD + 17-189% SUBURB ++	Subu rban --	Sub urba n +	+			CBD + 4-21% SUBURB ++	Subur ban --	Sub urba n +	+	
Induced Travel	+?	-						--				
Reduced CBD Parking			CBD +	+								
Home Relocation					+						+	
Ped Access/Street Design						?						?
Single Use Zones				-						-		
New Land Uses				+						?		

CBD results show parking effects critical – network/intersection and commercial land use effect are unknown.

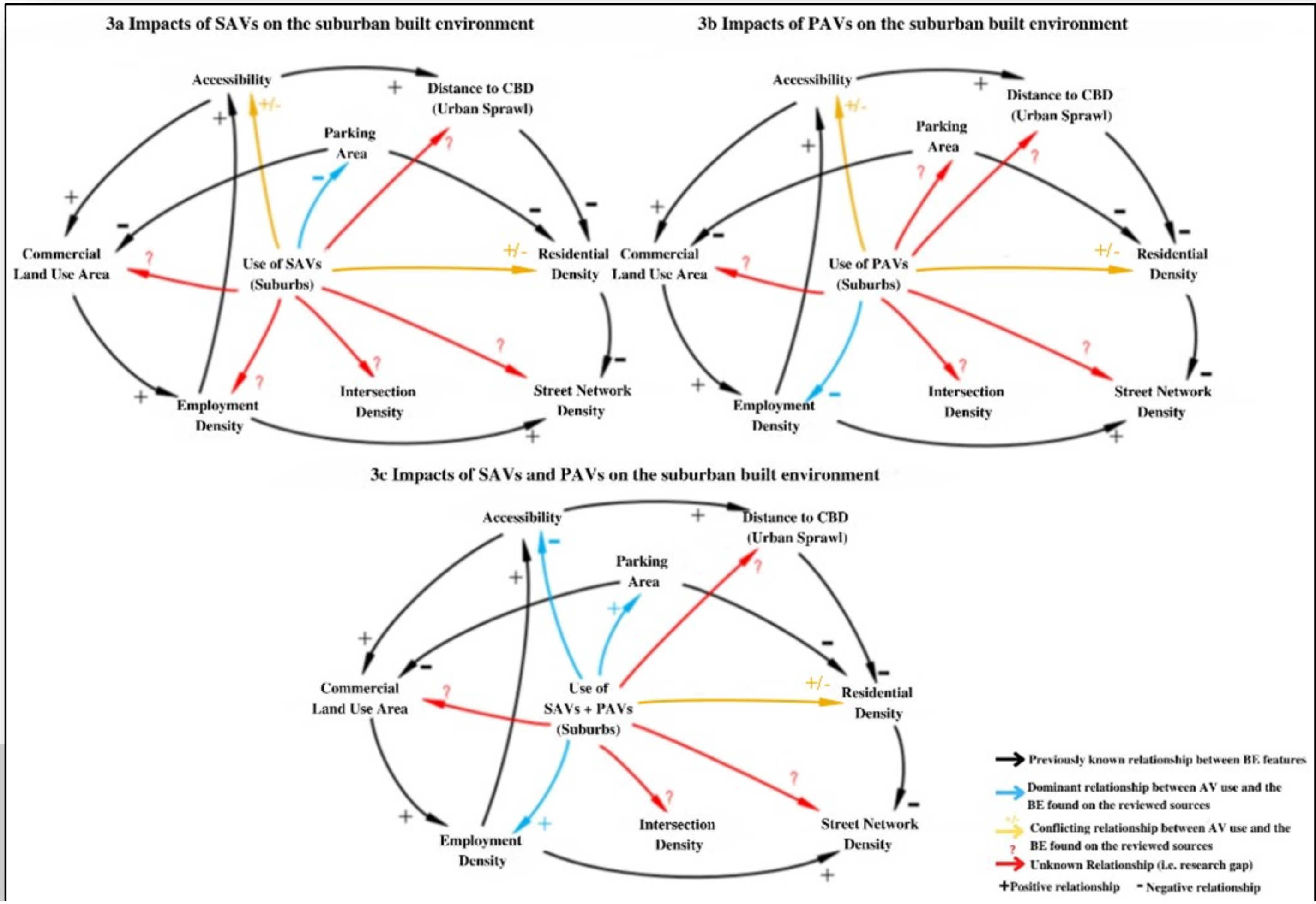


Key Points

- SAVs reduce CBD parking increasing commercial/residential use and employment density.
- Existing SAV impacts on accessibility in the CBD are conflicting, and more studies are needed to comprehend this relationship.
- When SAV and PAV are combined (Figure 2c), decreases in parking demand, accessibility and employment density were found, whereas other effects are still unknown.

Suburban results conflict; sprawl and density effects are unclear

Built Environment Impacts for Suburbs. SAVs, PAVs, SAVs + PAVs.

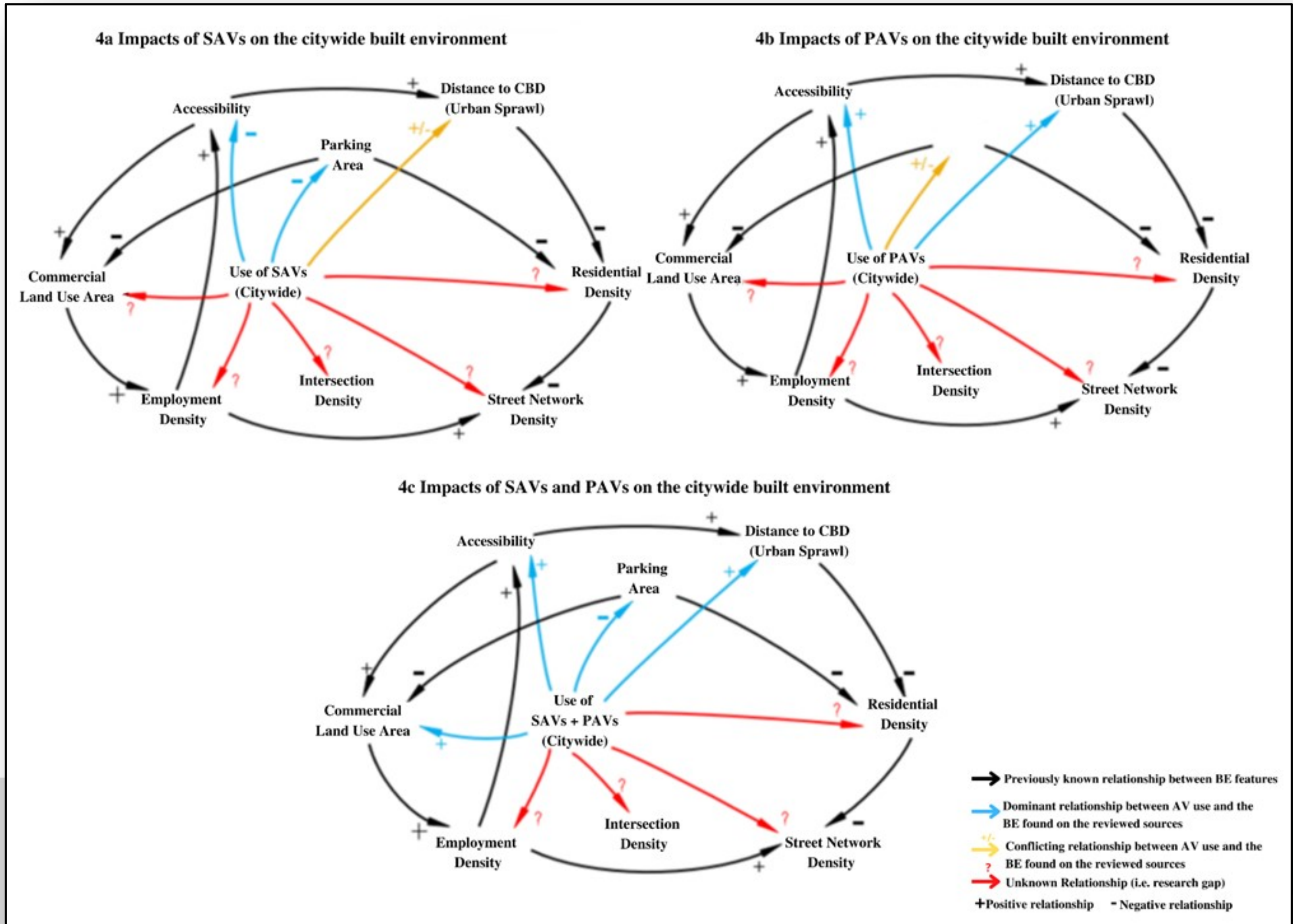


Key Points

- SAVs may likely reduce parking area in suburbs and subsequently free up spaces to develop other land uses. However, results for SAV impacts on residential density in suburbs are divergent. It is also not clear yet how accessibility will be impacted by SAVs on suburban areas.
- PAV impacts on residential density are also divergent. PAVs reduce suburban employment density.
- Results for accessibility are conflicting, and the impacts on other variables are still unknown limiting the assessment of other indirect effects.
- For mixed-AV modes, parking area and employment density are likely to increase, whereas accessibility tends to decrease.

Citywide results link SAV and reduced CBD parking with density growth but accessibility decline; Urban sprawl dominates PAV results

Built Environment Impacts for Citywide. SAVs, PAVs, SAVs + PAVs.



Key Points

- Most studies used citywide
- Overall, SAVs decrease parking area in cities – THUS increase land use densities. Accessibility tends to decrease with SAVs across the city; this would drive more urban sprawl. Nevertheless, there were conflicting findings on the direct impacts of SAVs on the average distance to CBD, indicating that urban sprawl may not be a dominant trend for SAVs on cities.
- Urban sprawl dominant for PAVs across the city due to improved accessibility level. Effects on parking are not clear yet
- 4 dominant relationships in mixed AV
  - accessibility, distance to CBD and commercial land use area will likely increase, parking area tends to decline citywide.
  - Increases in the average home distance to the CBD leads to a

A range of research gaps were identified

Research Gaps

- Overall, no quantitative result was found for AV impacts on intersection density and street network density.
- In city centres and suburbs, it is also unknown how AVs will quantitatively impact commercial land use areas. There are speculative studies that forecast the replacement of vacant parking land by commercial land use in suburbs and city centres, but these impacts have not been quantified yet.
- No quantitative result was found for PAV impacts on parking areas in city centres and suburbs.
- Unknown how average commute distances between suburbs and CBD will be affected by SAV, PAV and mixed-AV mode scenarios.
- SAV impacts on employment density in suburbs, mixed-AV mode impacts on residential density in suburbs and AV impacts on residential density citywide.
- ALSO Results were considered divergent when the findings are conflicting to each other in assessing the impacts of a particular type of AVs on a specific built environment attribute.
  - For example, SAV impacts on accessibility in the CBD were reported to be both positive and negative depending on scenario assumptions in Zhong et al. (2020).
  - Likewise, divergent accessibility results were found for SAVs (Zhong et al., 2020) and PAVs (Cordera et al., 2021) in suburbs for different scenarios.
  - Citywide, divergent results were found for SAV impacts on distance to CBD, and PAV impacts on parking. Therefore, more studies are needed on these relationships to draw a precise conclusion

MONASH University

Agenda

Introduction

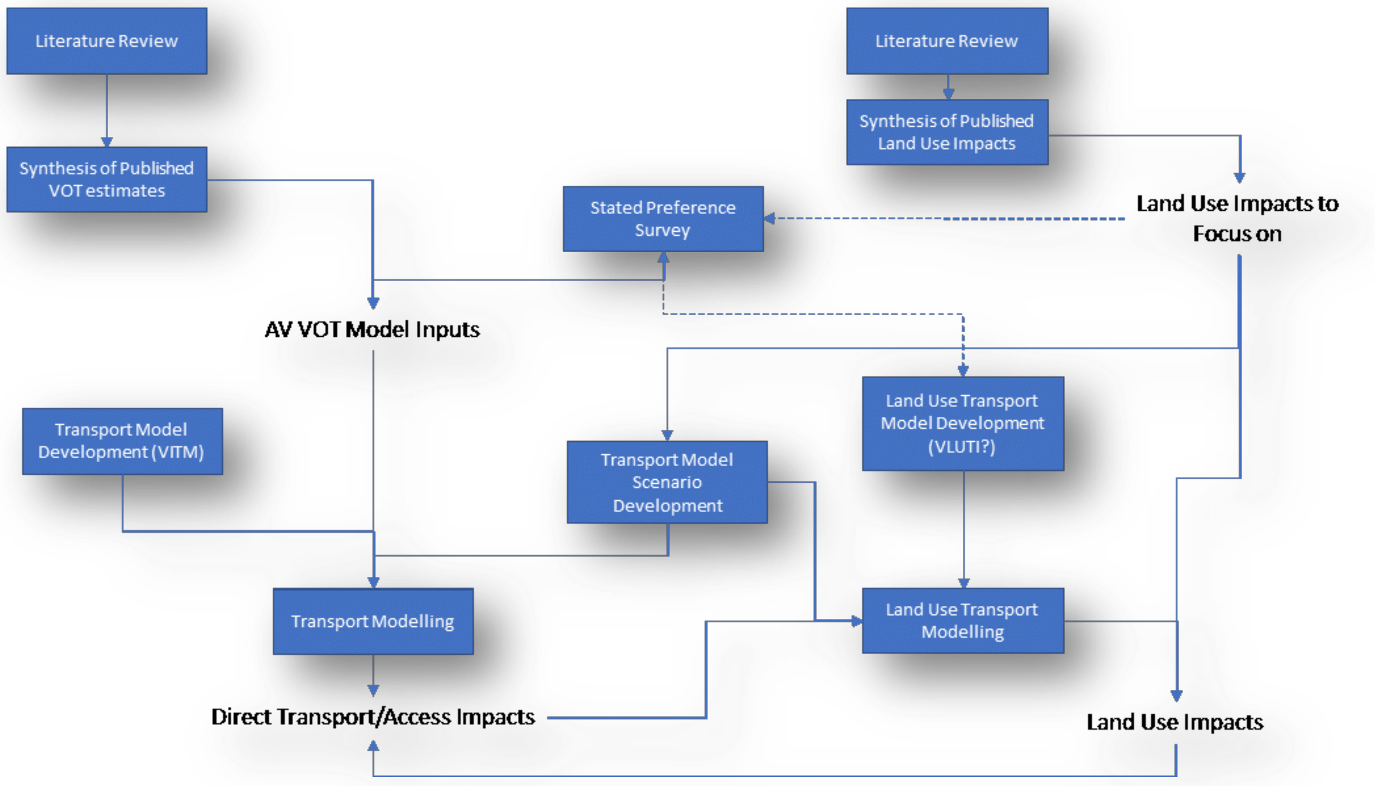
Research Program

Value

Land Use

Next Steps

The research program will proceed by estimating VoT and land use using an SP survey and land use transport modelling

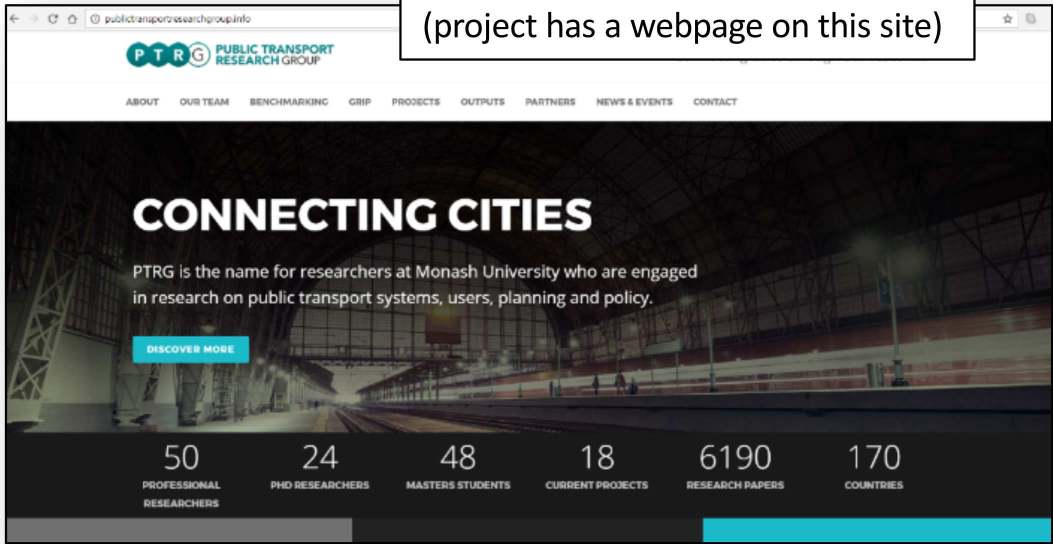


Concept Methodology

Please reach out for more information

graham.currie@monash.edu

W: ptrg.info
(project has a webpage on this site)



RT5 – Long term impact of COVID-19 on Travel Behaviour

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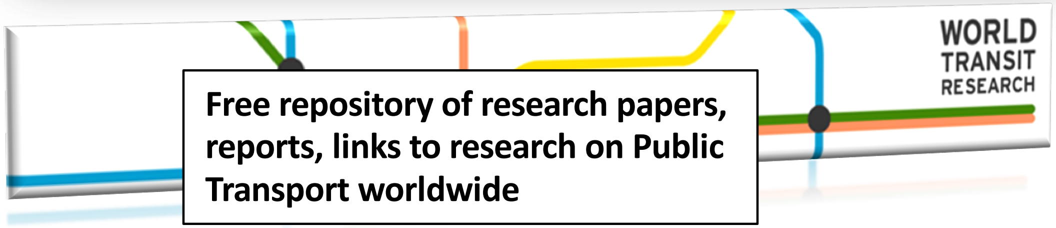

Free repository of research papers, reports, links to research on Public Transport worldwide