UNSW SYDNEY

UNSW Research Centre for Integrated Transport Innovation (rCITI)

Bridging Decisions and Destinations:

Advanced Computational Models for Household Decision-Making in Land Use and Transportation

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Research Centre for Integrated Transport Innovation (rCITI)
School of Civil and Environmental Engineering
University of New South Wales (UNSW Sydney)

November 2023

3,200 daily home relocations in **Australia**

1.14 million Australians move house annually

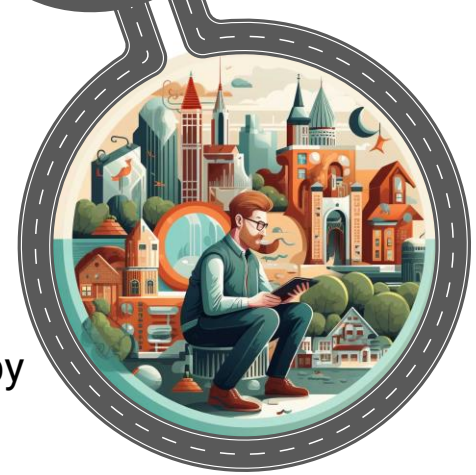
*ABS data 2019-2020

Patterns

Patterns of choices

Cities

Cities shaped considering the policies



Policies

Policies made by policy-makers

Choices

e.g., Relocation

Repeat

Repeats like a cycle

Chain of Positive or Negative Effects

Need for sophisticated mathematical modelling techniques

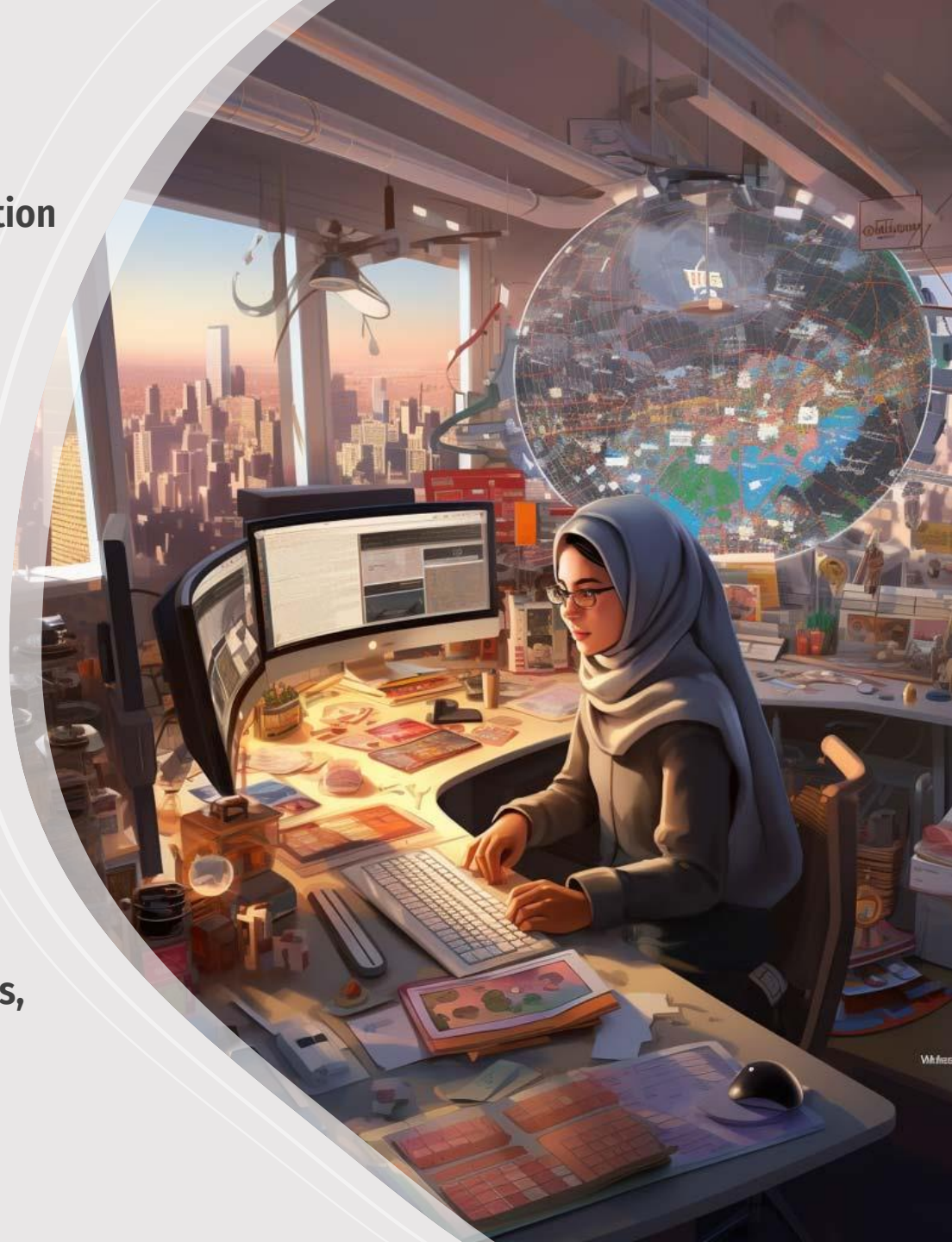
Aim1 Advancement and comparative analysis of residential relocation models

Aim2 Dynamic modelling of household relocation decisions

Aim3 Socio-demographic, economic, and affordability impacts on relocation choices

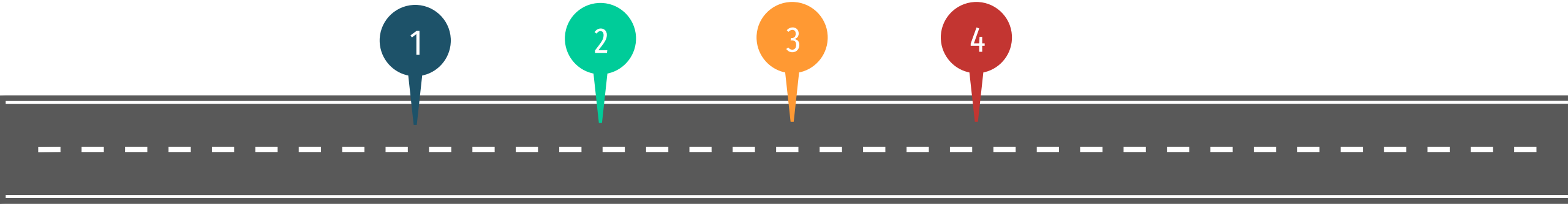
Aim4 Interrelation of residential relocation with major life events

Aim5 Transport-related features, urban and environmental impacts, and sustainability in relocation



Defining projects

1. Domain
2. Decision-making structure modelled
3. Aims
4. Advanced tools used



1 **Project 1** Bayesian survival model for household relocation dynamics in two major cities

2 **Project 2** The co-determination of home and workplace relocation durations using survival copula analysis

3 **Project 3** Machine learning and feature selection methods unpack the whys and whens

4 **Project 4** Towards a realistic model of residential relocation: DDCM's dynamic, future-oriented approach

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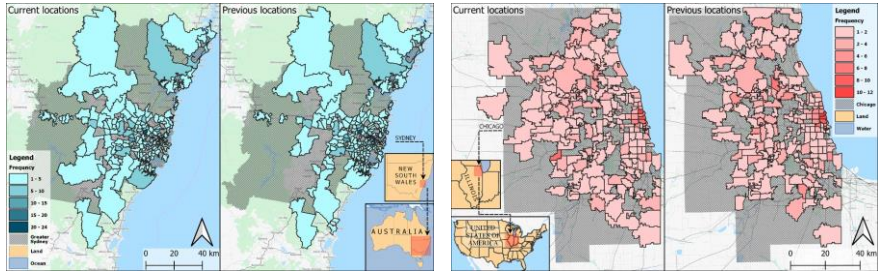

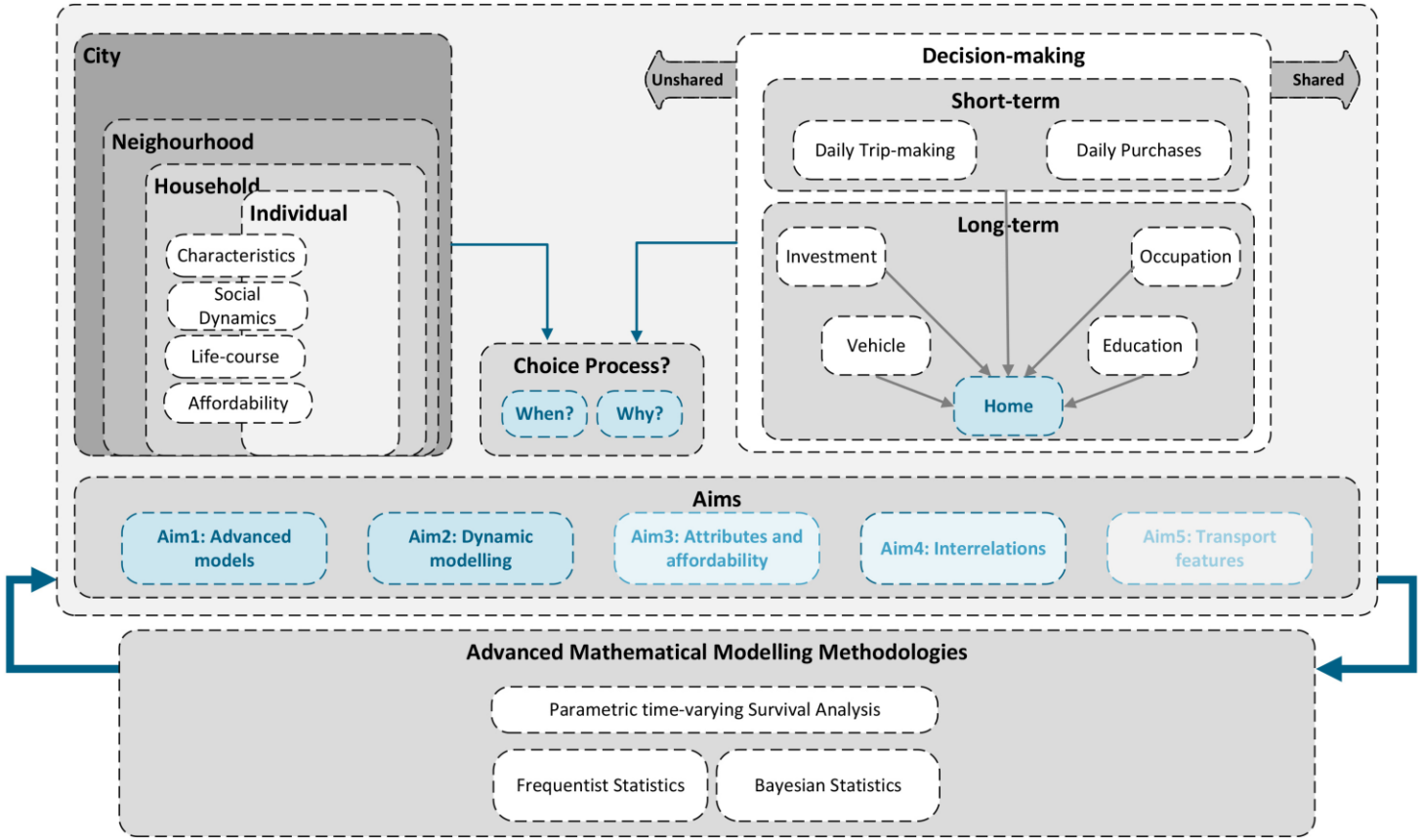

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Project 1 Bayesian survival model for household relocation dynamics in two major cities

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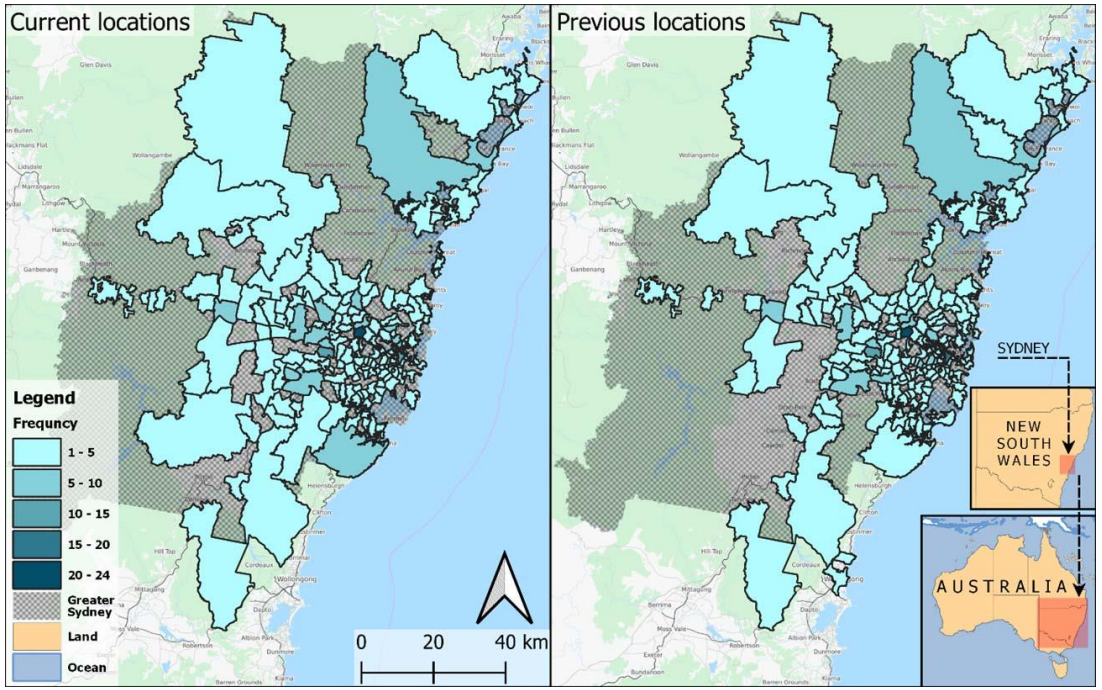

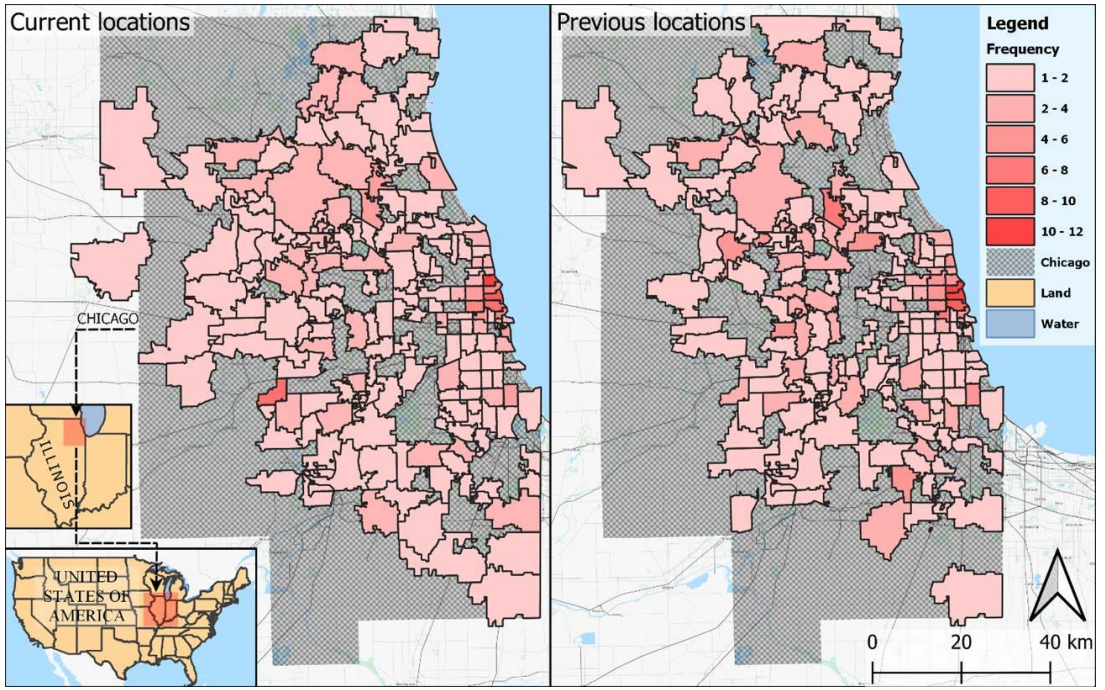

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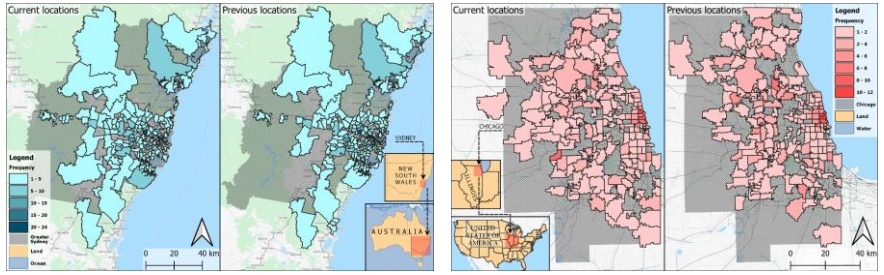

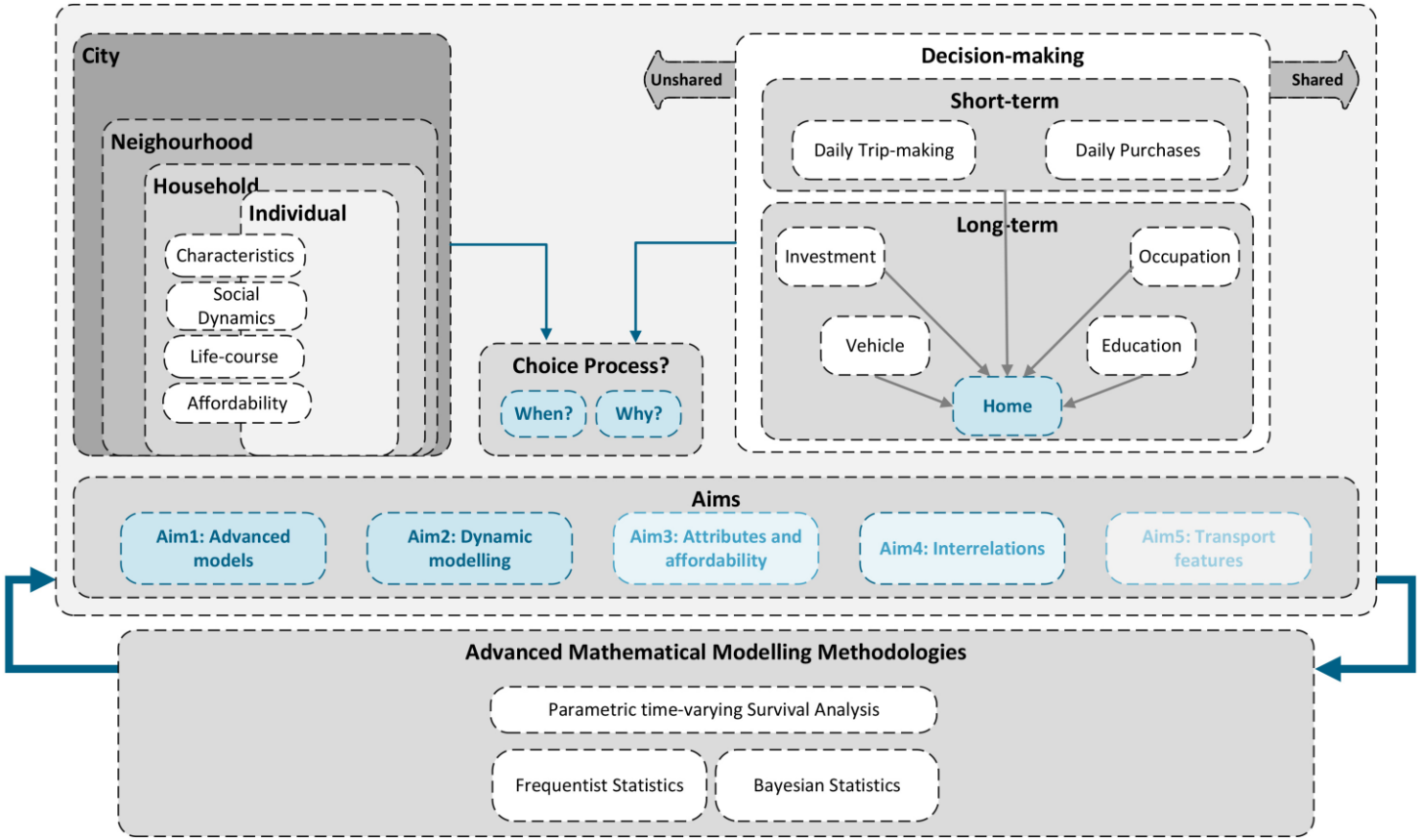

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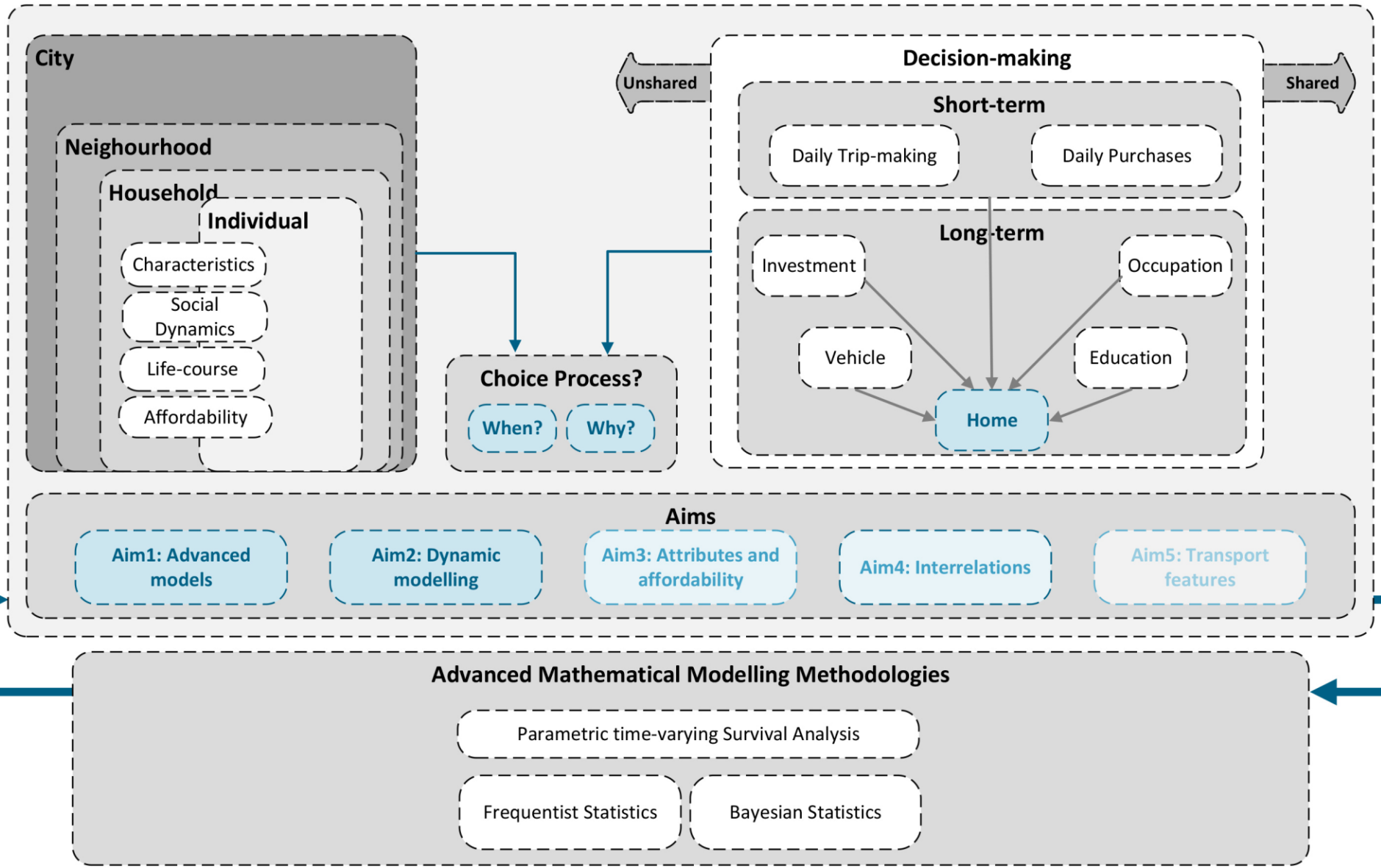

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Project 1 Bayesian survival model for household relocation dynamics in two major cities

1

Insights:

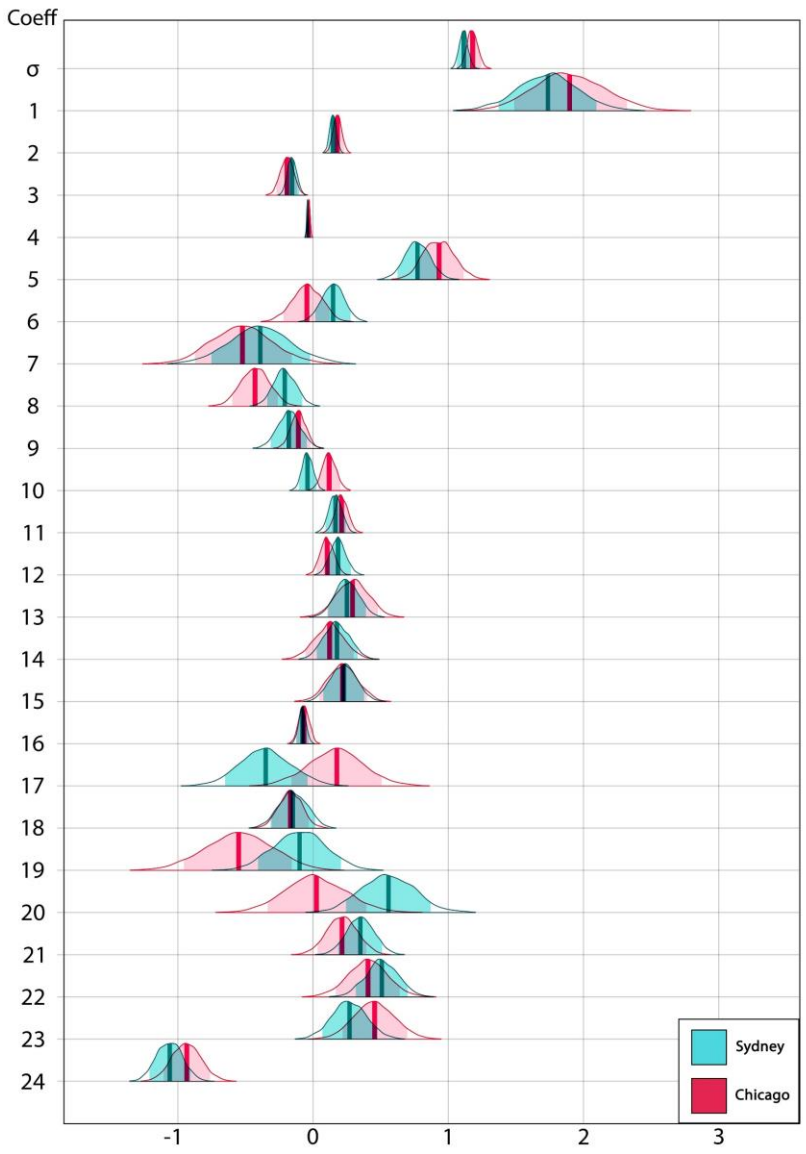
2

- Bayesian Vs Frequentist
- Cross-City comparison

3

- Dynamic -> Time-varying covariate

4



	Sydney		Chicago	
	Mean	S.D	Mean	S.D
σ	1.10	0.04	1.15	0.04
1	1.62	0.26	1.72	0.30
2	0.15	0.03	0.19	0.04
3	-0.15	0.04	-0.19	0.06
4	-0.04	0.01	-0.03	0.01
5	0.78	0.11	0.92	0.13
6	0.17	0.10	-0.02	0.13
7	-0.31	0.27	-0.43	0.26
8	-0.19	0.10	-0.38	0.13
9	-0.17	0.10	-0.10	0.07
10	-0.04	0.05	0.12	0.06
11	0.17	0.06	0.21	0.06
12	0.18	0.07	0.11	0.06
13	0.26	0.11	0.29	0.14
14	0.19	0.11	0.13	0.14
15	0.23	0.11	0.22	0.13
16	-0.08	0.03	-0.06	0.05
17	-0.30	0.23	0.21	0.25
18	-0.13	0.12	-0.15	0.10
19	-0.05	0.23	-0.44	0.28
20	0.56	0.24	0.06	0.27
21	0.34	0.12	0.21	0.14
22	0.51	0.15	0.41	0.18
23	0.28	0.16	0.46	0.18
24	-1.06	0.11	-0.96	0.13

Read more

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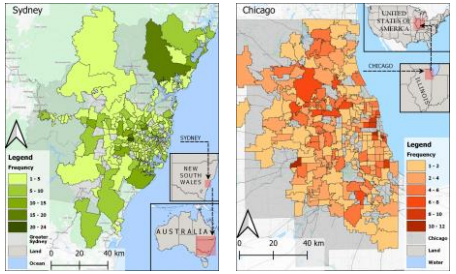

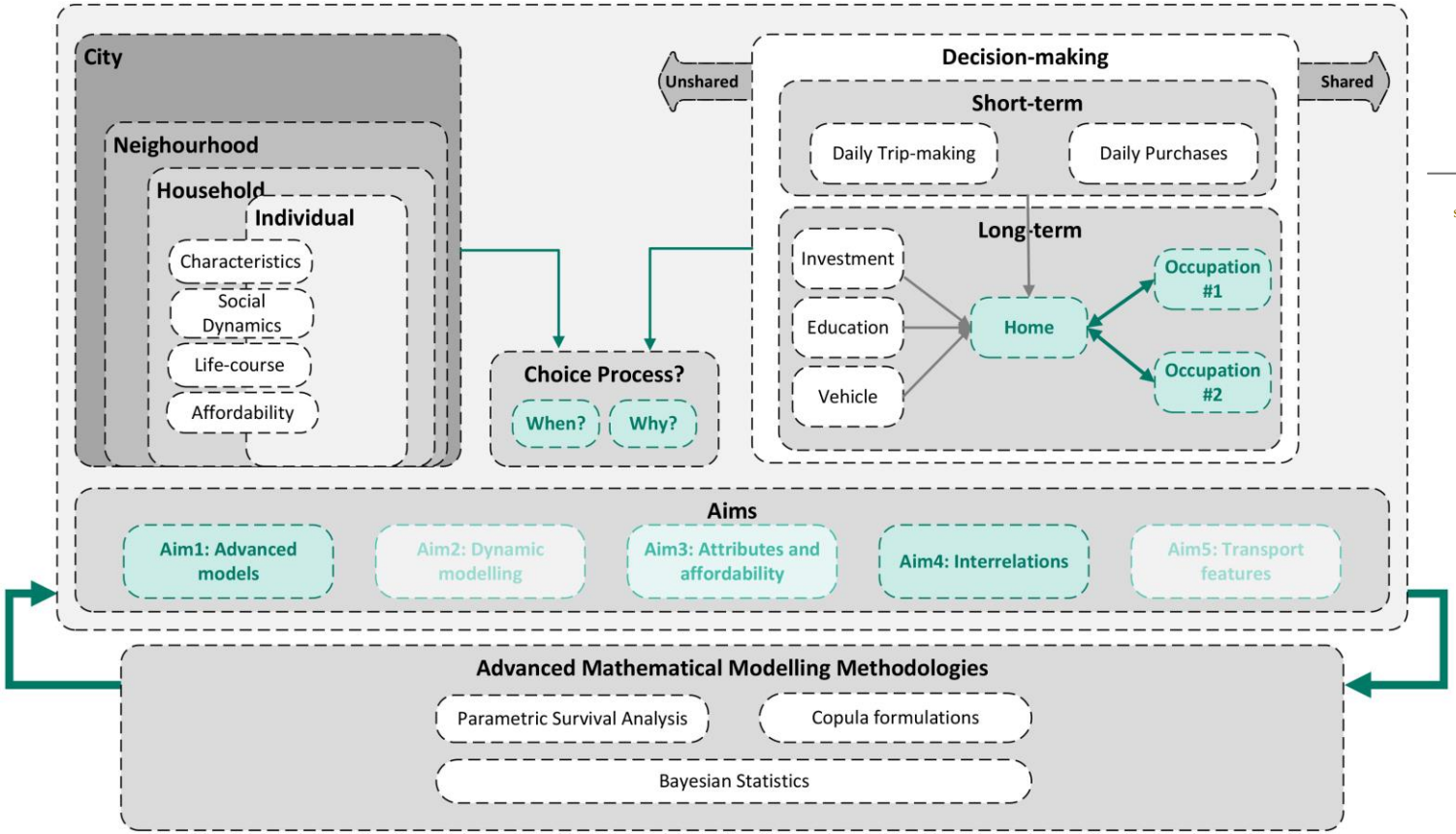

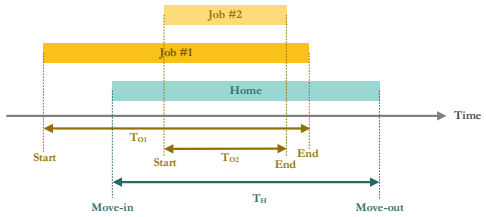

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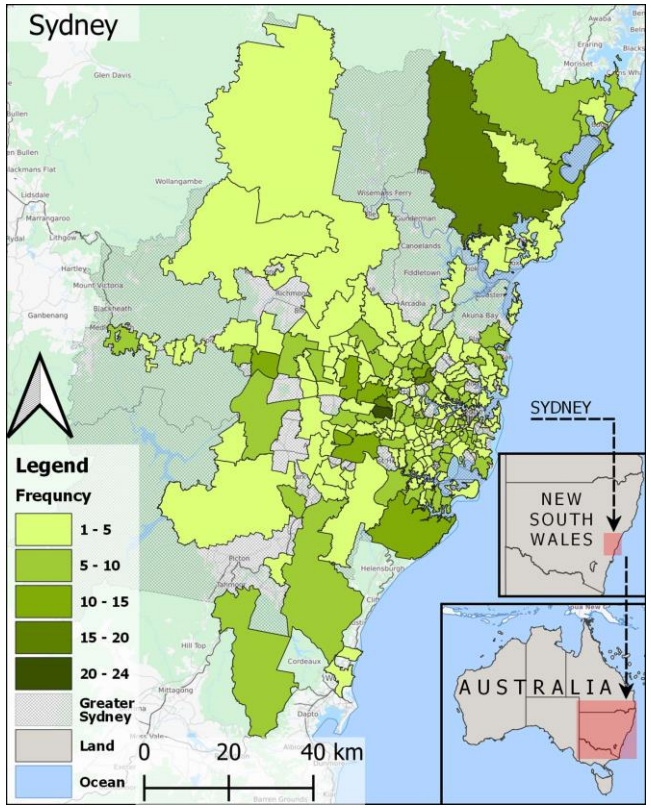

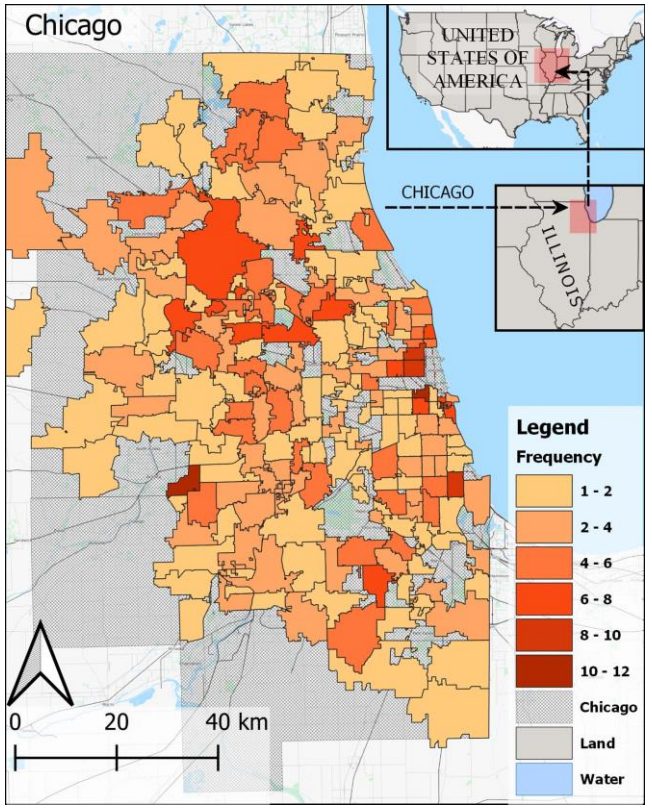

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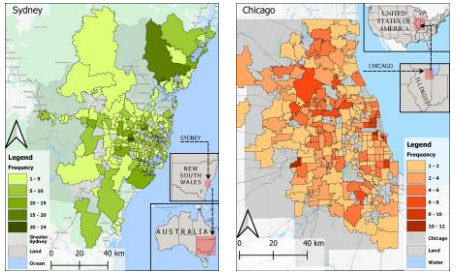

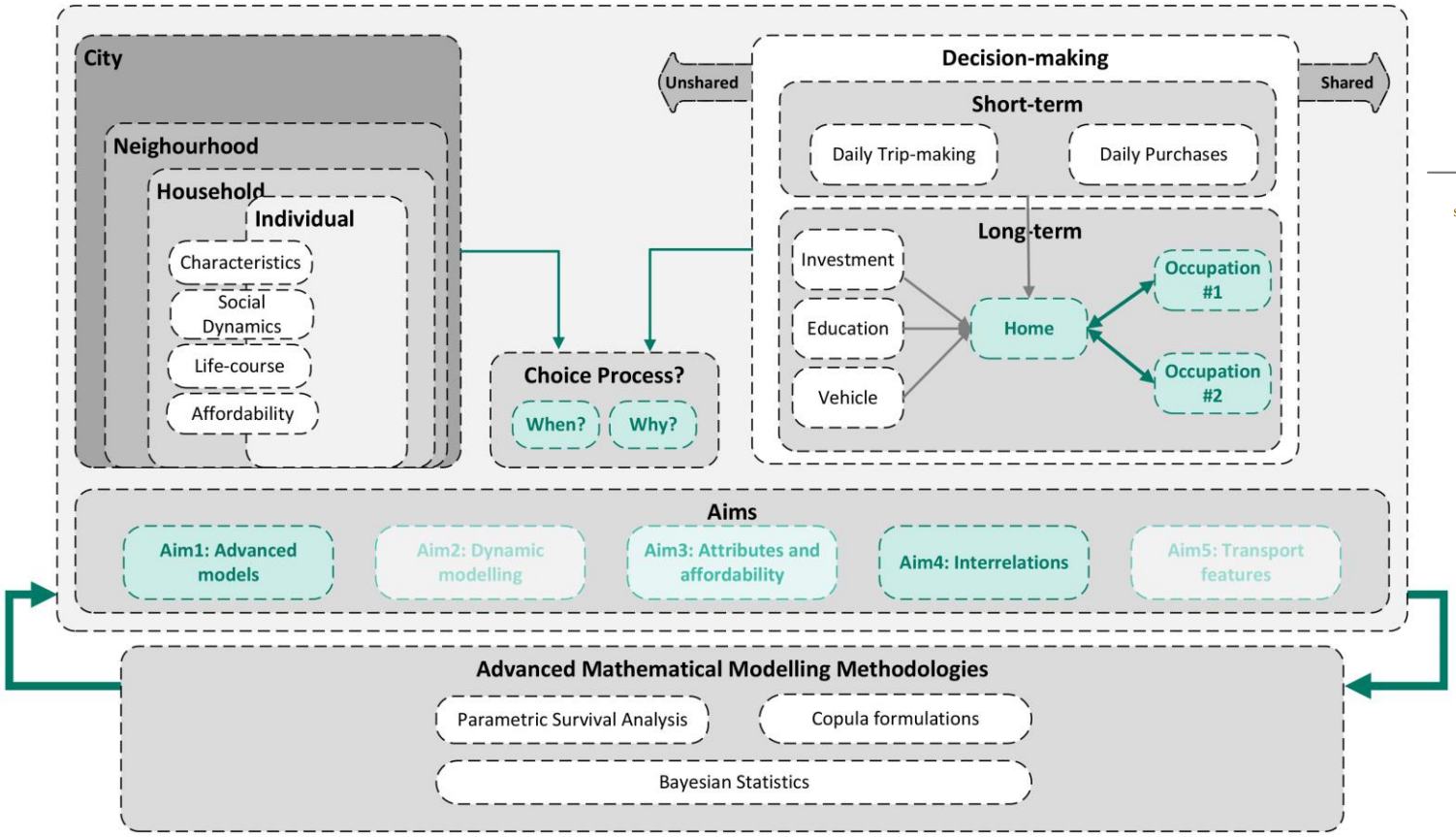

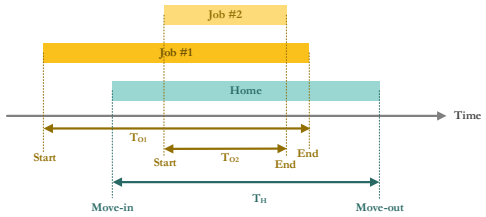

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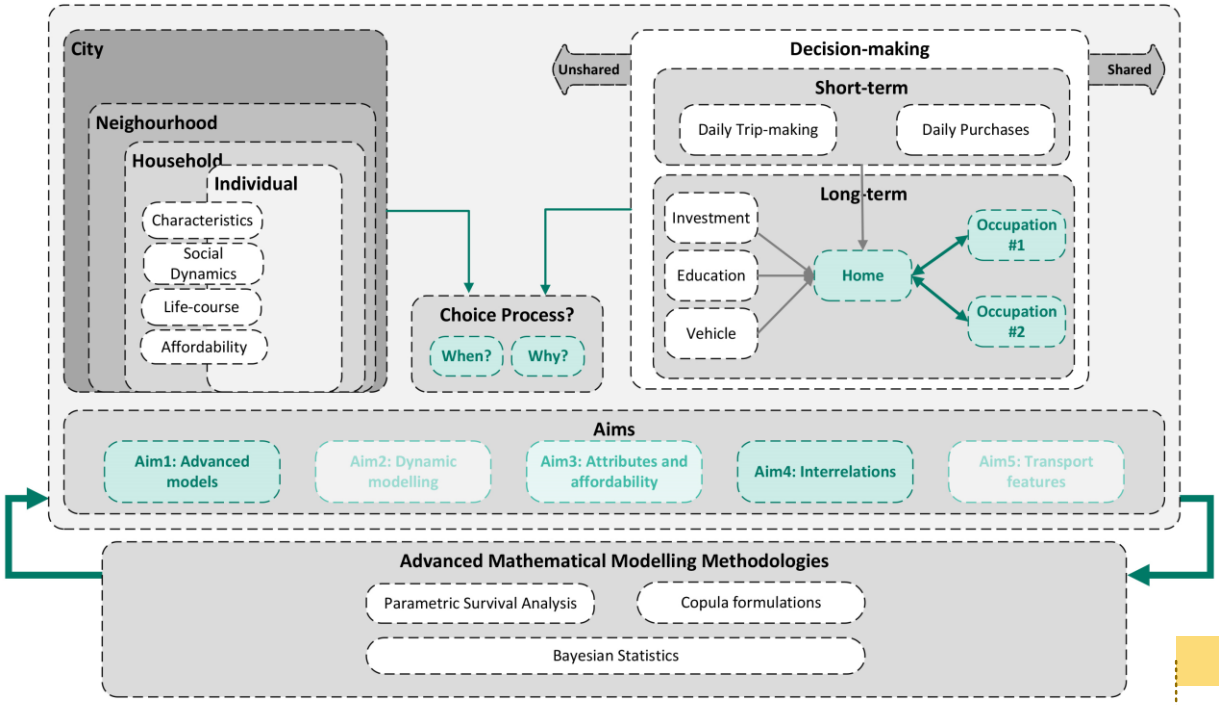

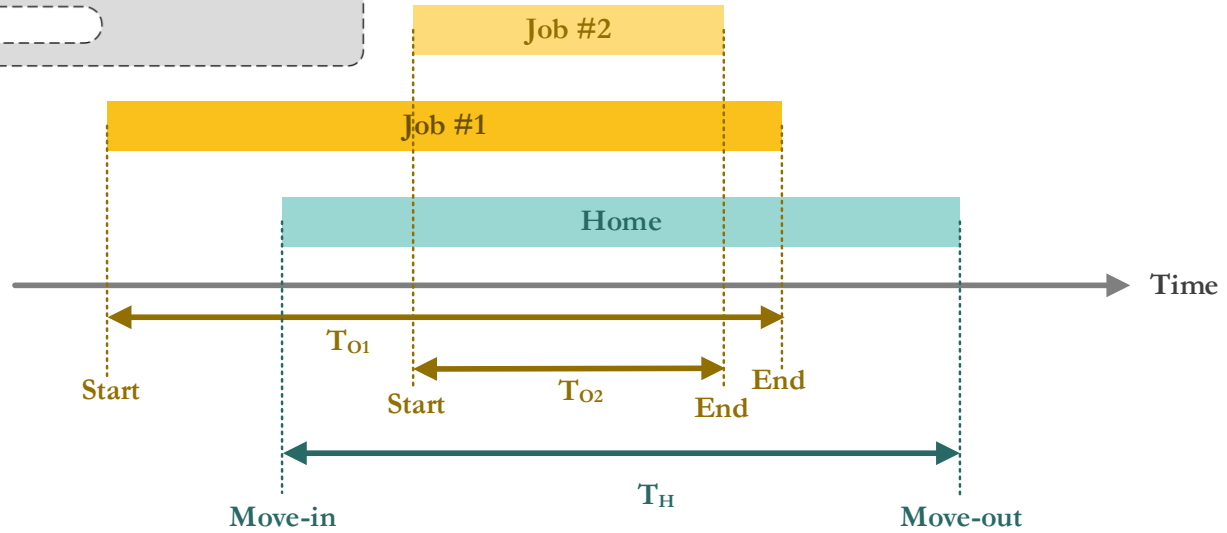

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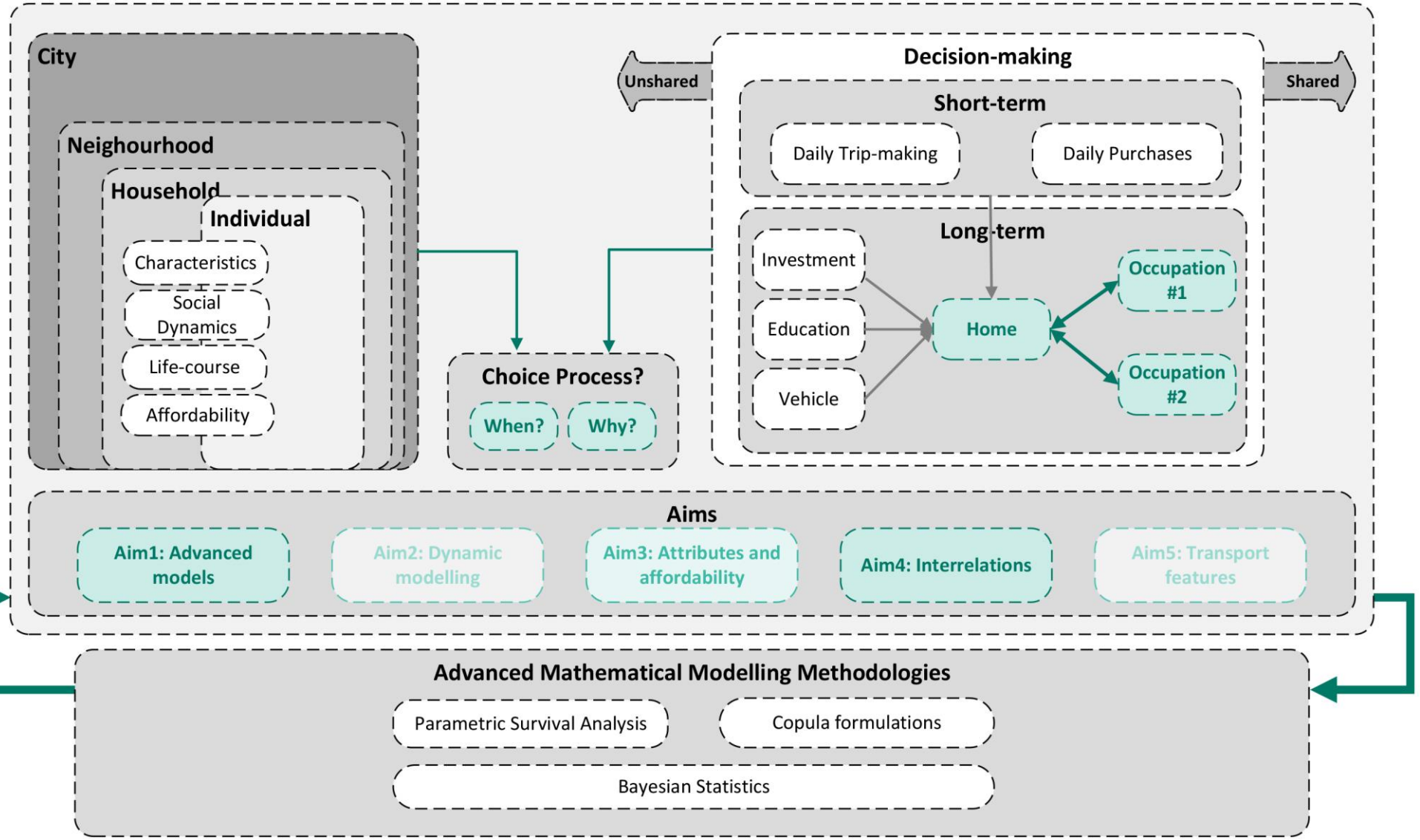

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Project 2 The co-determination of home and workplace relocation durations using survival copula analysis

1

Insights:

2

- Bayesian Modelling -> Optimization efficiency
- Correlation of duration of two jobs in household
- Correlation of job and home are not strong

3

Copula type	Failure Event? 1 = failure, 0 = censored T_H	T_O	Has job?	Term	Likelihood function contribution	Number of observations Sydney	Chicago
-	0	-	No	S_H	S_H	54	5
-	1	-	No	$\frac{\partial S_H}{\partial T_H}$	$-f_H$	101	36
Clayton	0	0	Yes	S_{HO}	$(S_H^{-\theta} + S_O^{-\theta} - 1)^{\frac{-1}{\theta}}$	333	302
	1	0	Yes	$\frac{\partial S_{HO}}{\partial T_H}$	$-S_{HO}^{1+\theta} S_H^{-\theta-1} f_H$	249	221
	0	1	Yes	$\frac{\partial S_{HO}}{\partial T_O}$	$-S_{HO}^{1+\theta} S_O^{-\theta-1} f_O$	125	97
	1	1	Yes	$\frac{\partial S_{HO}}{\partial T_O \partial T_H}$	$(1+\theta) S_{HO}^{1+2\theta} f_O S_O^{-\theta-1} f_H S_H^{-\theta-1}$	162	147
Frank	0	0	Yes	S_{HO}	$-\frac{1}{\theta}\ln\left(1+\frac{(e^{-\theta S_H}-1)(e^{-\theta S_O}-1)}{e^{-\theta}-1}\right)$	333	302
	1	0	Yes	$\frac{\partial S_{HO}}{\partial T_H}$	$\frac{-(e^{-\theta S_O}-1)e^{-\theta S_H}(f_H)}{(e^{-\theta}-1)+(e^{-\theta S_H}-1)(e^{-\theta S_O}-1)}$	249	221
	0	1	Yes	$\frac{\partial S_{HO}}{\partial T_O}$	$\frac{-(e^{-\theta S_H}-1)e^{-\theta S_O} f_O}{(e^{-\theta}-1)+(e^{-\theta S_H}-1)(e^{-\theta S_O}-1)}$	125	97
	1	1	Yes	$\frac{\partial S_{HO}}{\partial T_O \partial T_H}$	$\frac{-\{\theta(e^{-\theta S_O} f_O)(e^{-\theta S_H} f_H)(e^{-\theta}-1)\}}{((e^{-\theta}-1)+(e^{-\theta S_H}-1)(e^{-\theta S_O}-1))^2}$	162	147
Gumbel	0	0	Yes	S_{HO}	$\exp(-R^{\frac{1}{\theta}})$	333	302
	1	0	Yes	$\frac{\partial S_{HO}}{\partial T_H}$	$-\exp(-R^{\frac{1}{\theta}}) R^{\frac{1}{\theta}-1}(-\ln S_H)^{\theta-1}\frac{f_H}{S_H}$	249	221
	0	1	Yes	$\frac{\partial S_{HO}}{\partial T_O}$	$-\exp(-R^{\frac{1}{\theta}}) R^{\frac{1}{\theta}-1}(-\ln S_O)^{\theta-1}\frac{f_O}{S_O}$	125	97
	1	1	Yes	$\frac{\partial S_{HO}}{\partial T_O \partial T_H}$	$-\exp\left(-R^{\frac{1}{\theta}}\right)((-\ln S_O)(-\ln S_H))^{\theta-1}\frac{f_O}{S_O}\frac{f_H}{S_H} R^{\frac{1}{\theta}-2}\left\{(1-\theta)-R^{\frac{1}{\theta}}\right\}$	162	147

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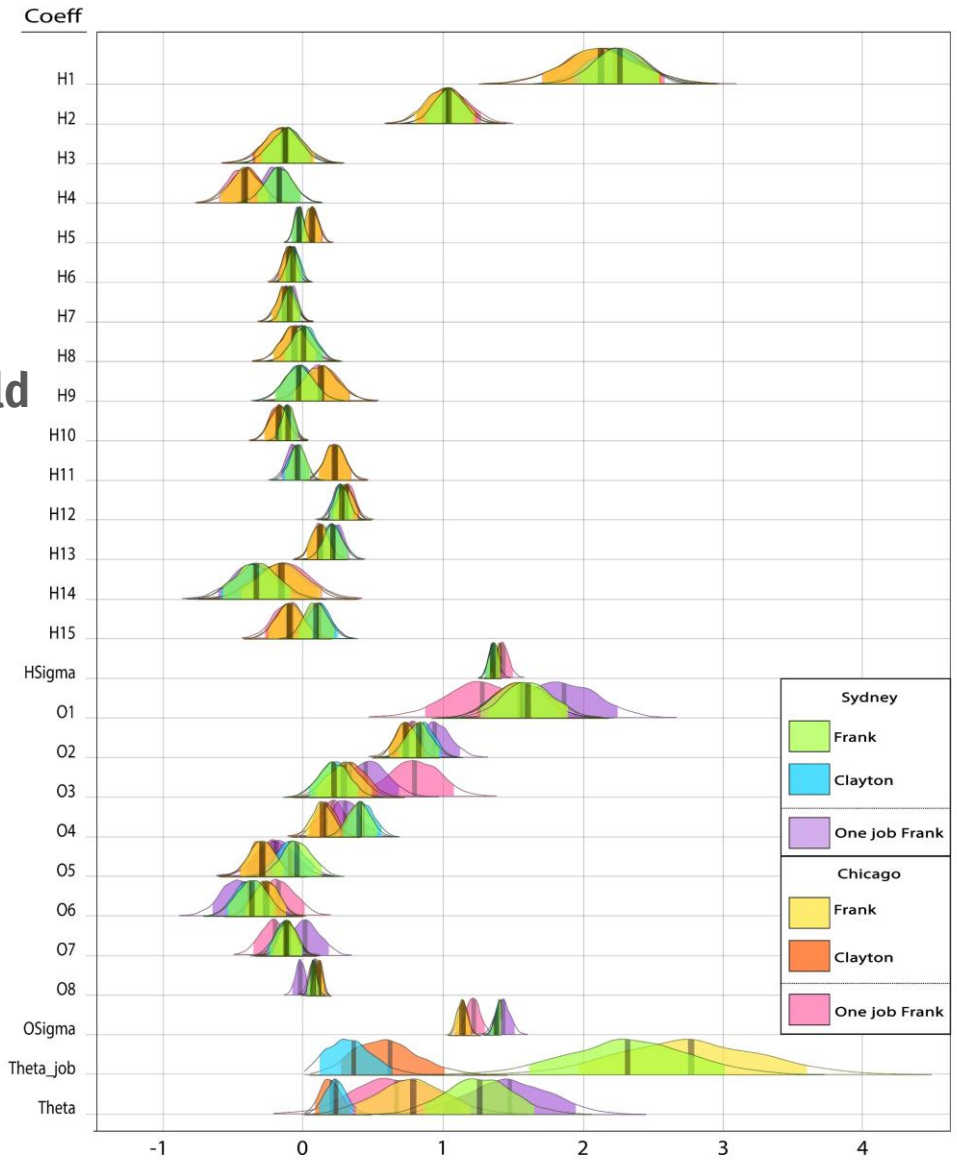

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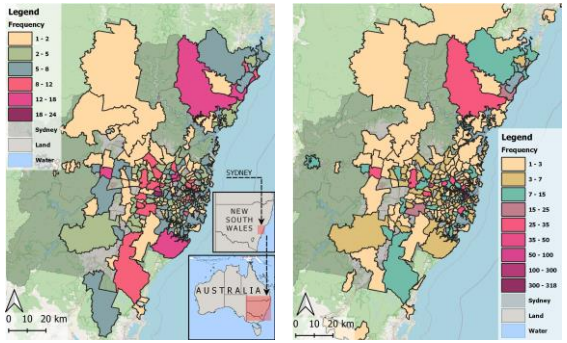

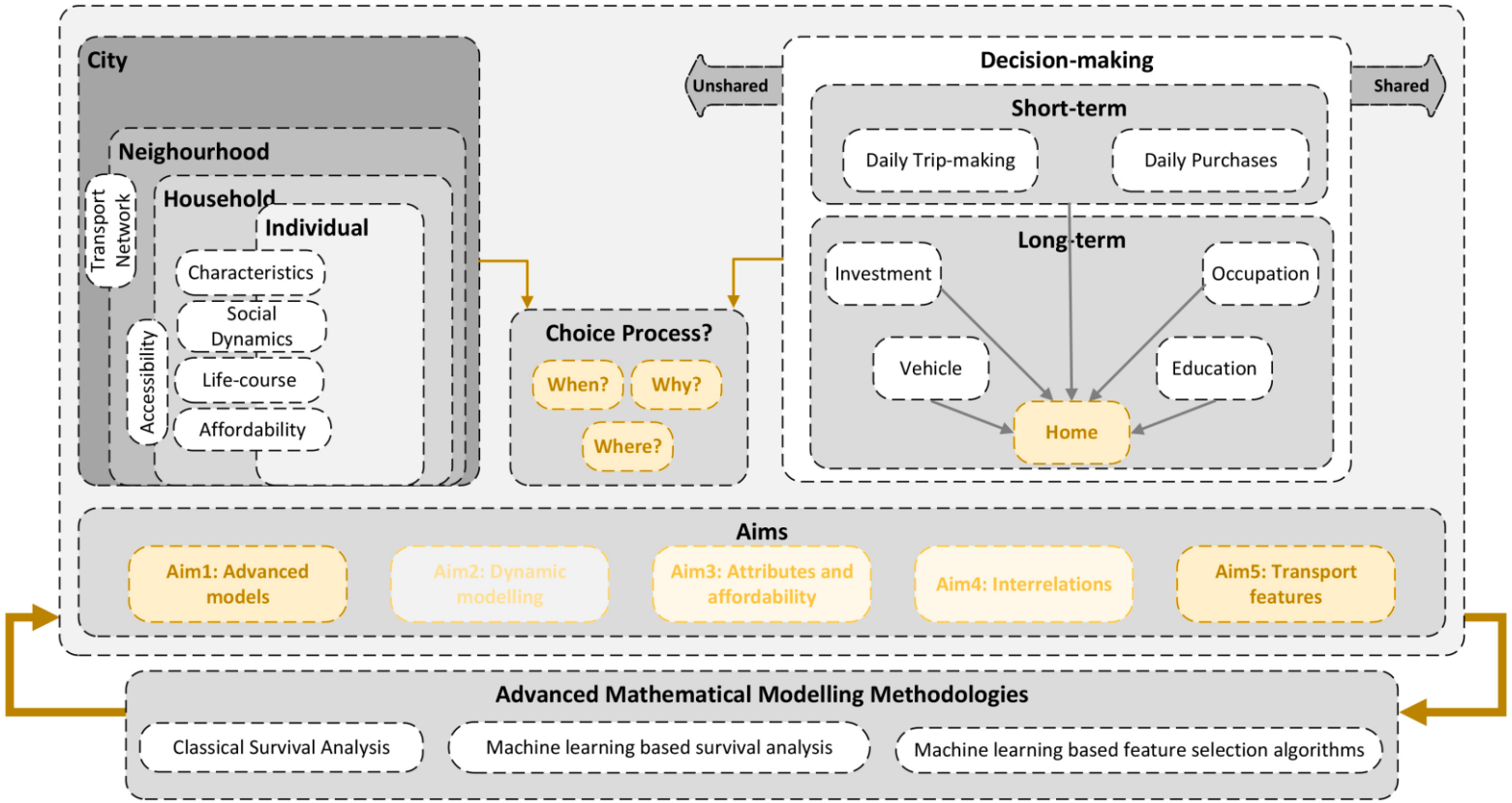

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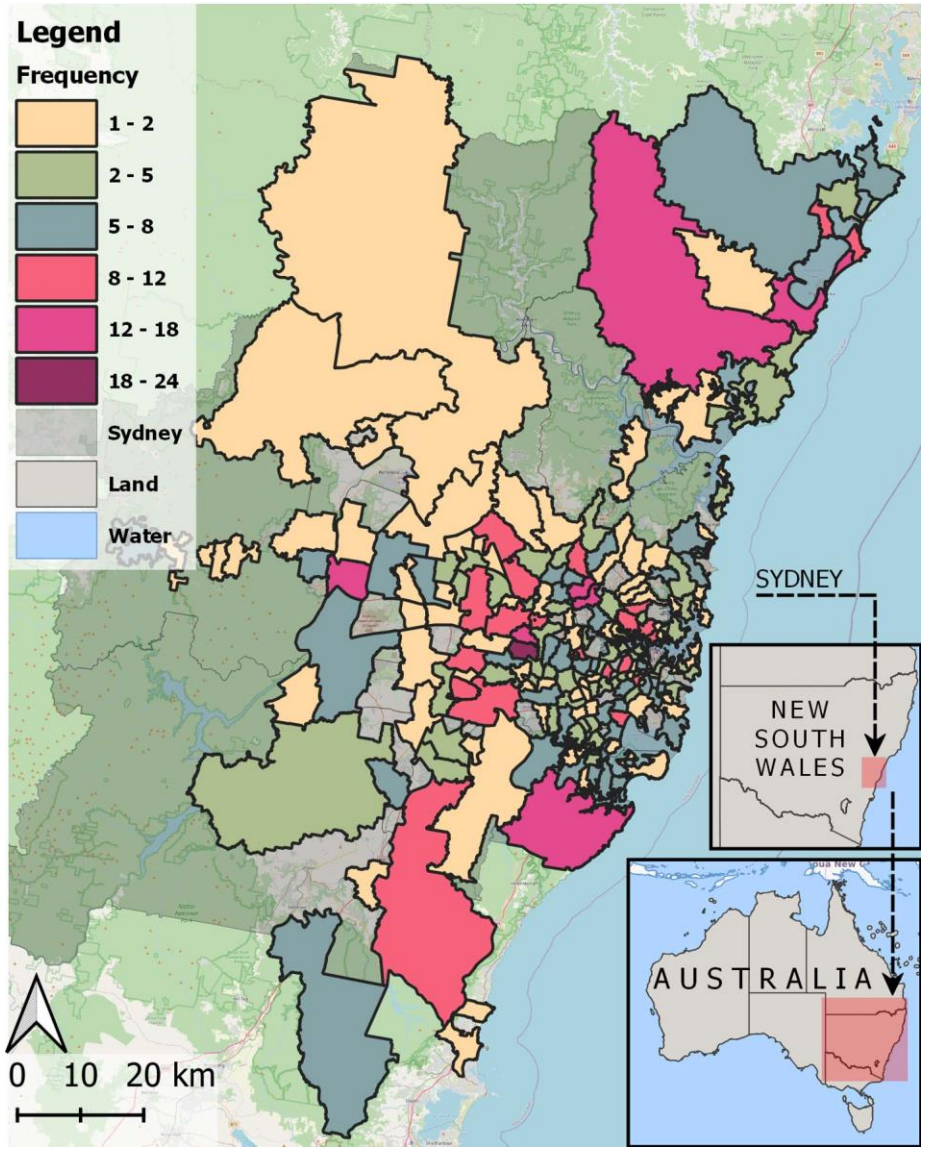

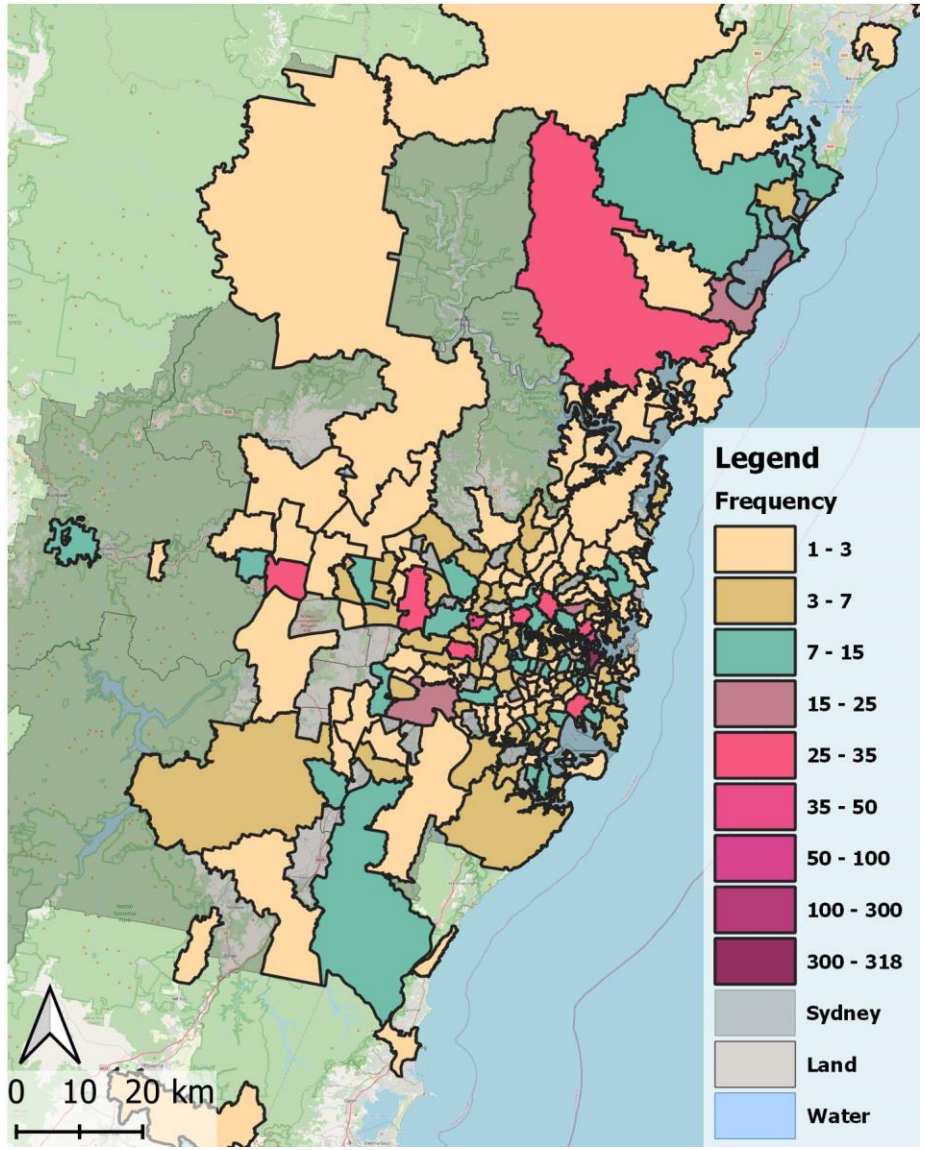

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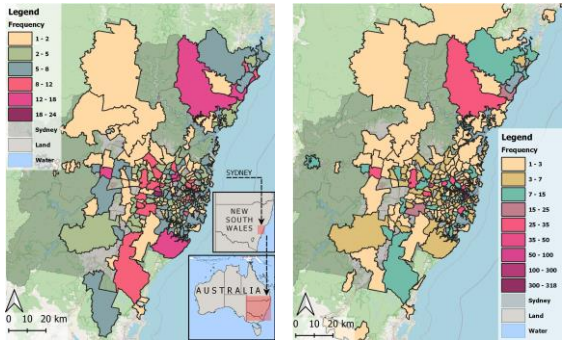

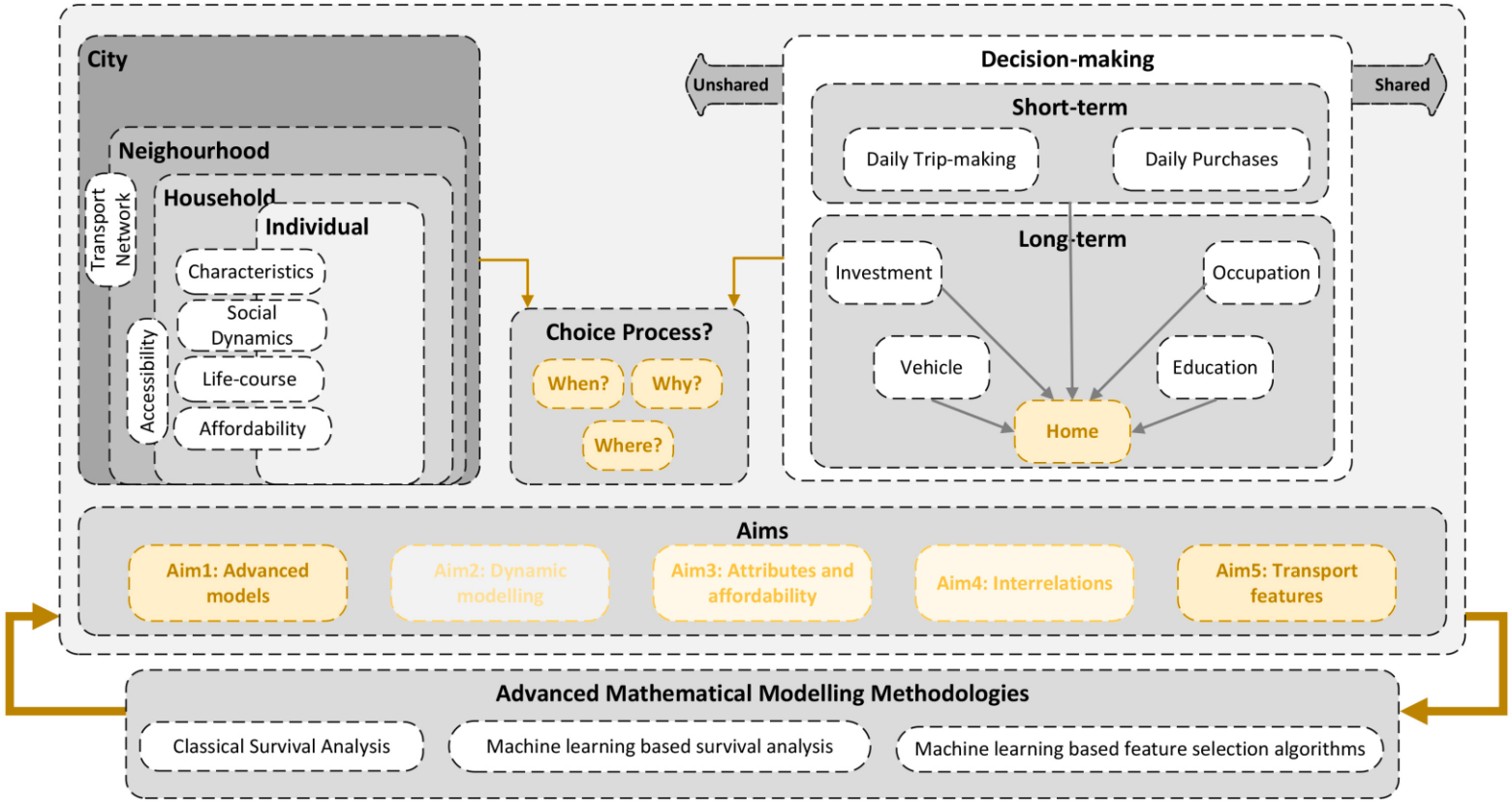

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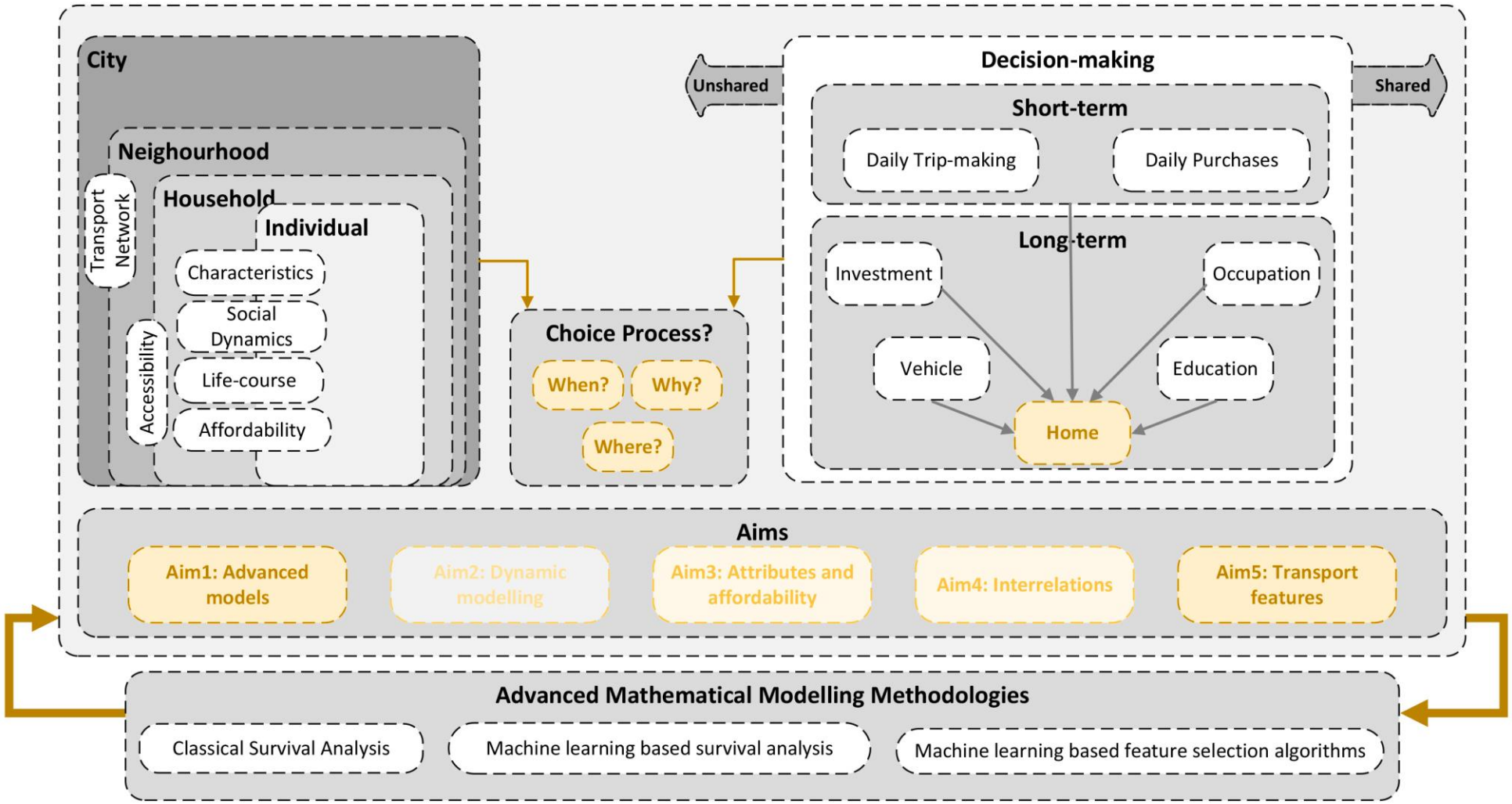

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Project 3 Machine learning and feature selection methods unpack the whys and whens

1

Insights:

2

- Use of machine learning, ensemble models, feature selection
- Accessibility of the current home or the future home?

3

			None	UNI	MRMR	IMP	DEPTH	HUNT	RANGER	
Classical	Cox-PH	Cox PH	0.491	0.757	0.704	0.765	0.765	0.762	0.767	
	AFT-Log-normal	Surv Reg Log	0.502	0.759	0.710	0.763	0.766	0.764	0.763	
	AFT-Weibull	Surv Reg Weib	0.516	0.751	0.707	0.763	0.765	0.752	0.766	0.4
Regularized Cox-PH	Ridge	Ridge	0.732	0.746	0.711	0.753	0.752	0.751	0.752	0.45
	Elastic Net	Elastic Net	0.752	0.748	0.726	0.757	0.756	0.757	0.753	0.5
	Lasso	Lasso	0.746	0.744	0.716	0.752	0.757	0.750	0.744	0.55
Gradient boosting	GBM	GBM	0.773	0.772	0.723	0.771	0.768	0.772	0.775	0.6
	Glmboost	Glmboost	0.739	0.739	0.724	0.736	0.739	0.738	0.737	0.65
	Xgboost lm	Xgboost lm	0.720	0.725	0.687	0.721	0.727	0.730	0.724	0.7
Tree-based	Xgboost tree	Xgboost tree	0.760	0.766	0.773	0.756	0.760	0.760	0.759	0.75
	Rpart	Rpart	0.696	0.707	0.700	0.716	0.715	0.716	0.713	0.8
Random Forest	Random Forest SRC	Random Forest SRC	0.759	0.758	0.771	0.759	0.754	0.753	0.759	
	Ranger	Ranger	0.740	0.750	0.747	0.757	0.750	0.749	0.753	

4

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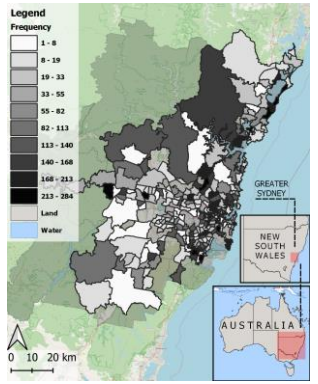
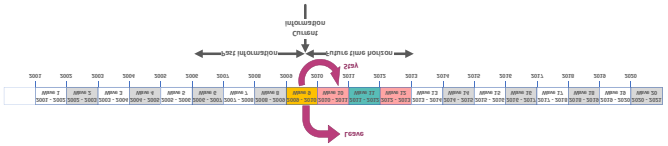
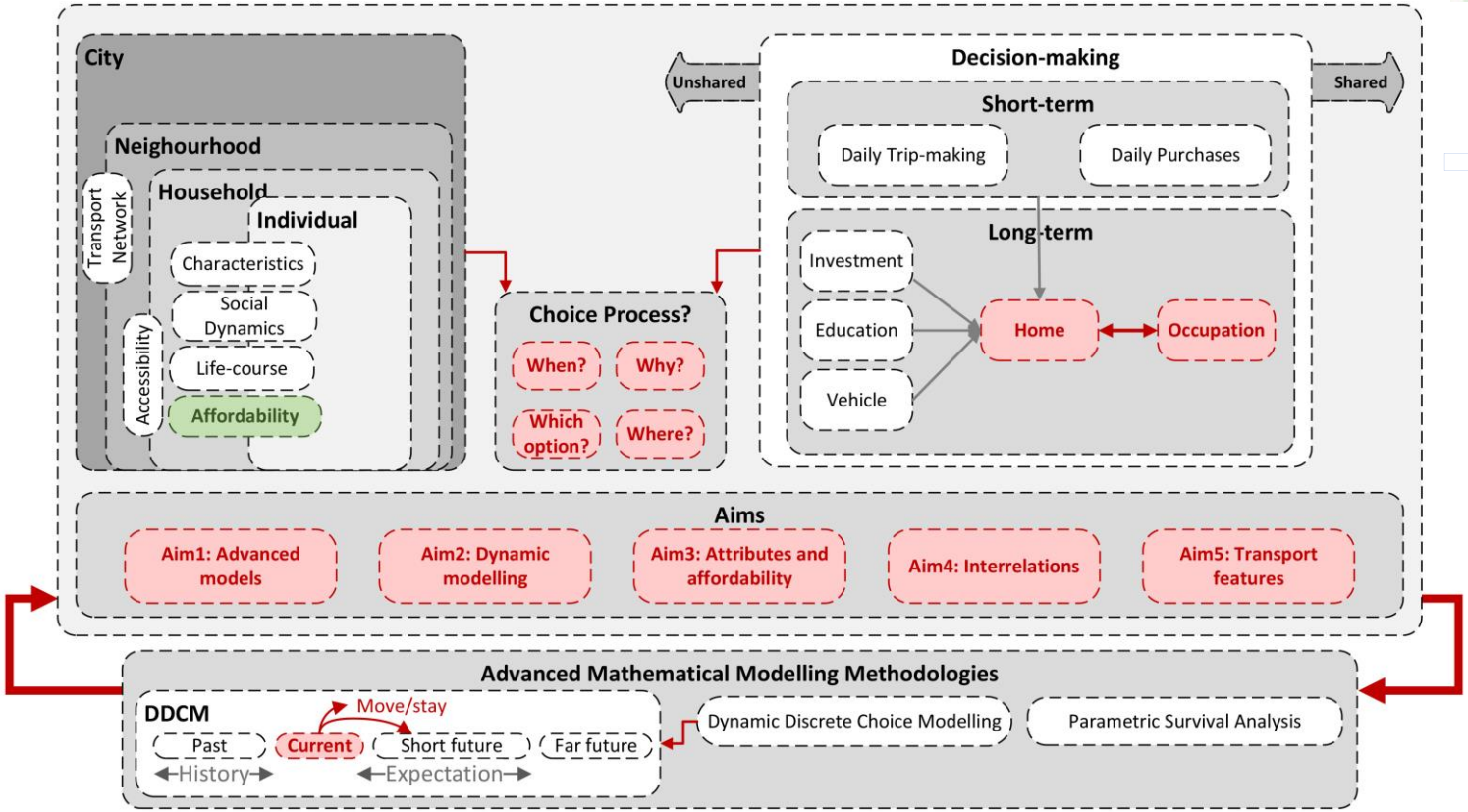


LIVING IN AUSTRALIA HILDA
Household, Income and Labour Dynamics in Australia





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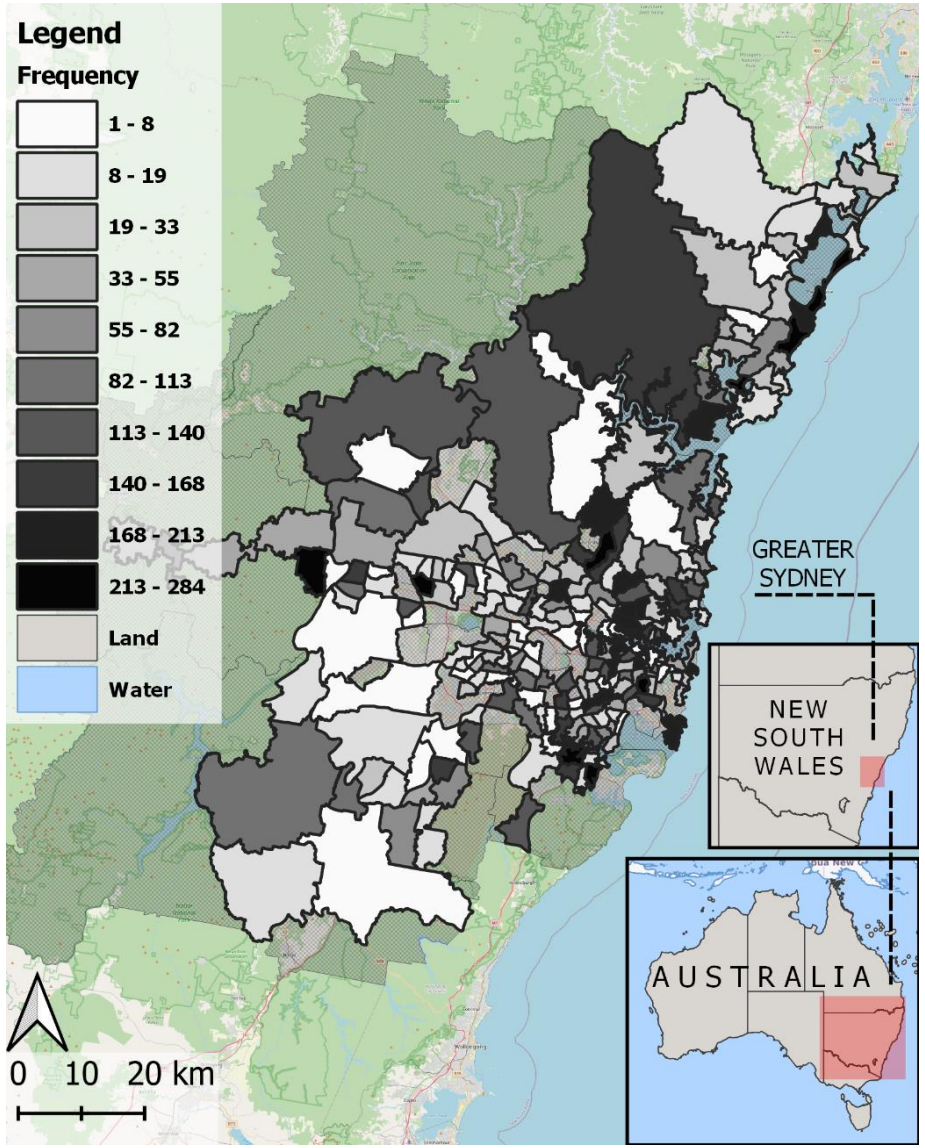

HILDA data (waves 1-21)

- Sydney metropolitan area residents
- Residential relocation behaviour
- Household characteristics
- Job relocation
- Education information

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Household, Income and Labour Dynamics in Australia

External data

- SEIFA measure
- Travel-time to CBD
- Average rent and sale price at each SA2
- Population and employment
- Inflation

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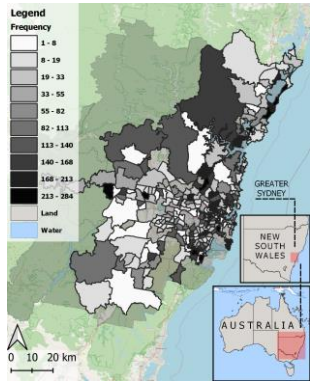

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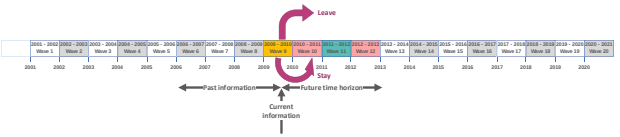
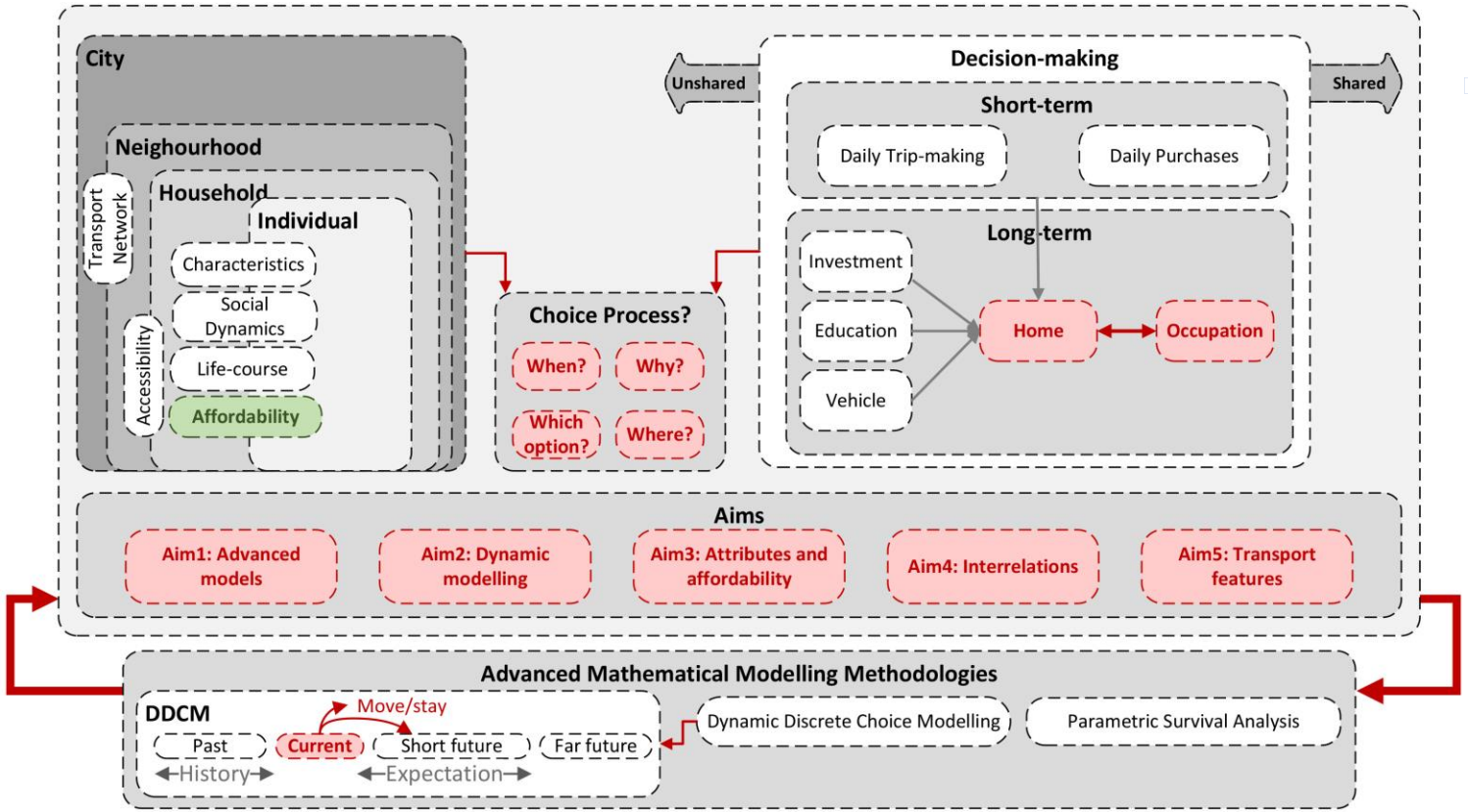
Household, Income and Labour Dynamics in Australia





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Project 4 Towards a realistic model of residential relocation: DDCM's dynamic, future-oriented approach

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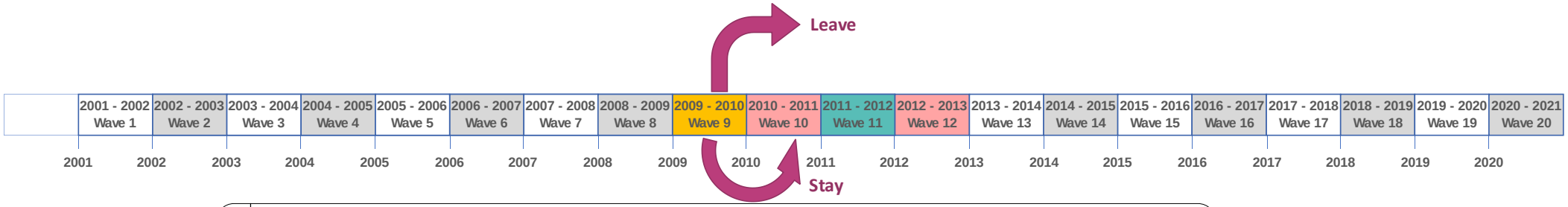

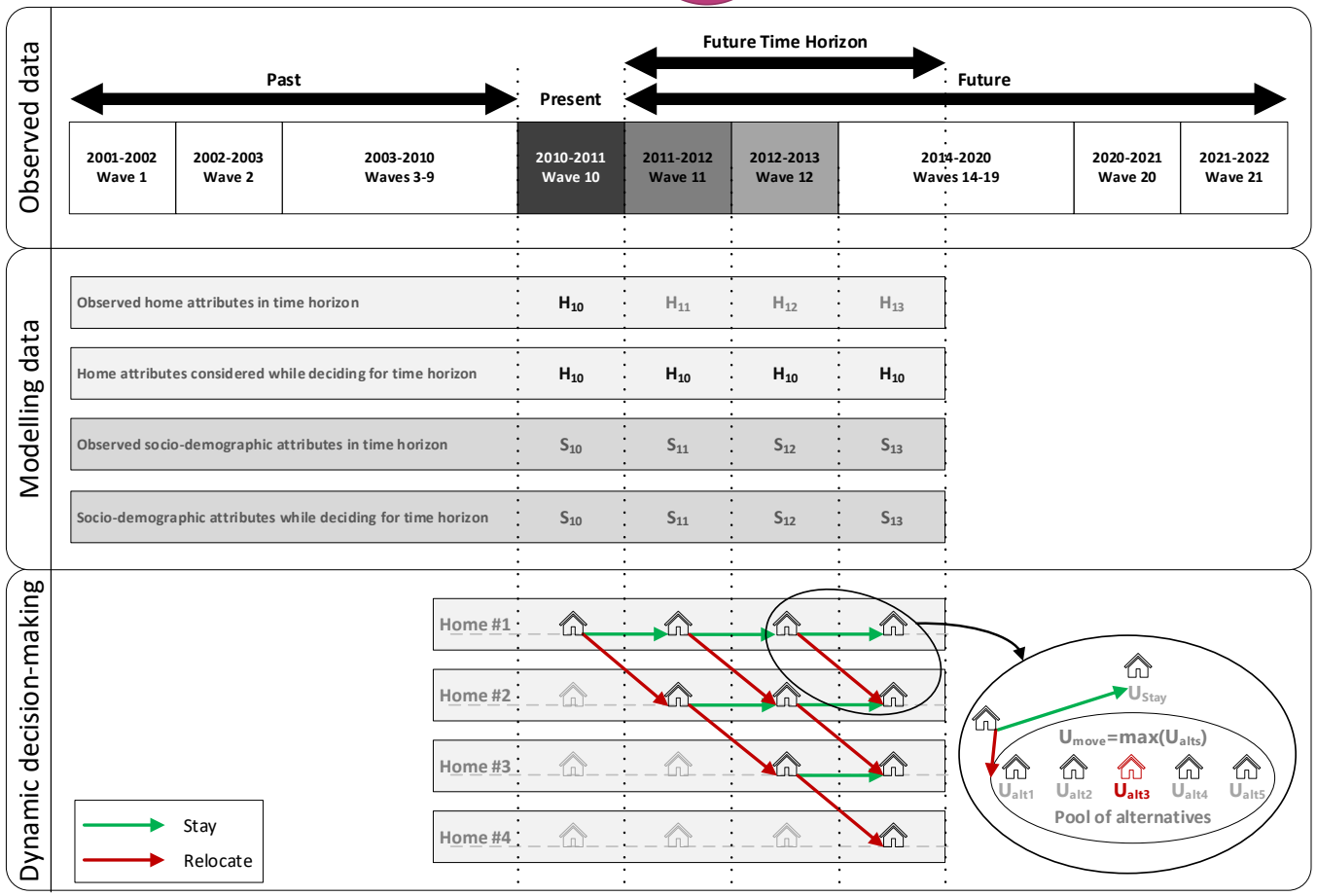

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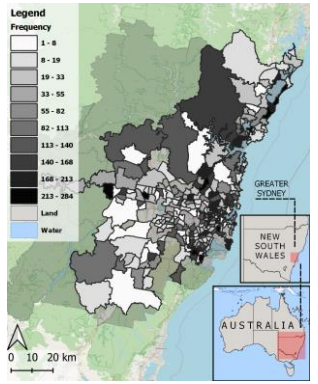
1. Domain
2. Decision-making structure modelled
3. Aims
4. Advanced tools used



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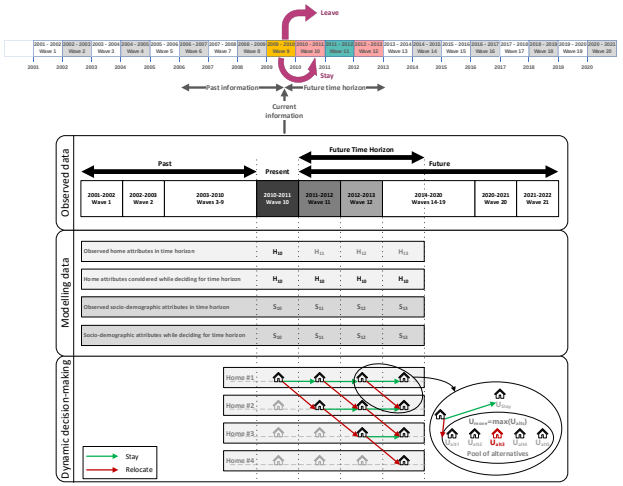

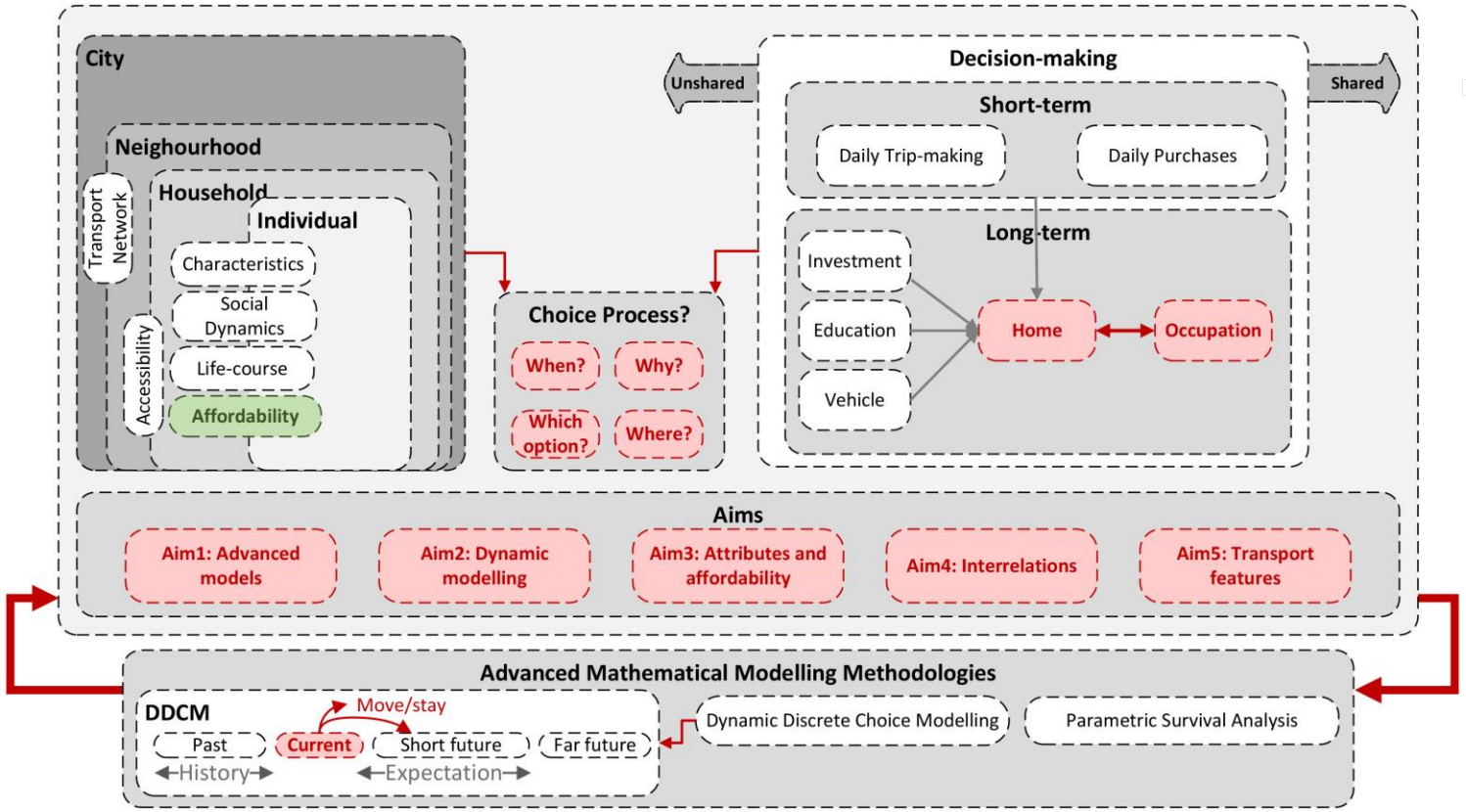

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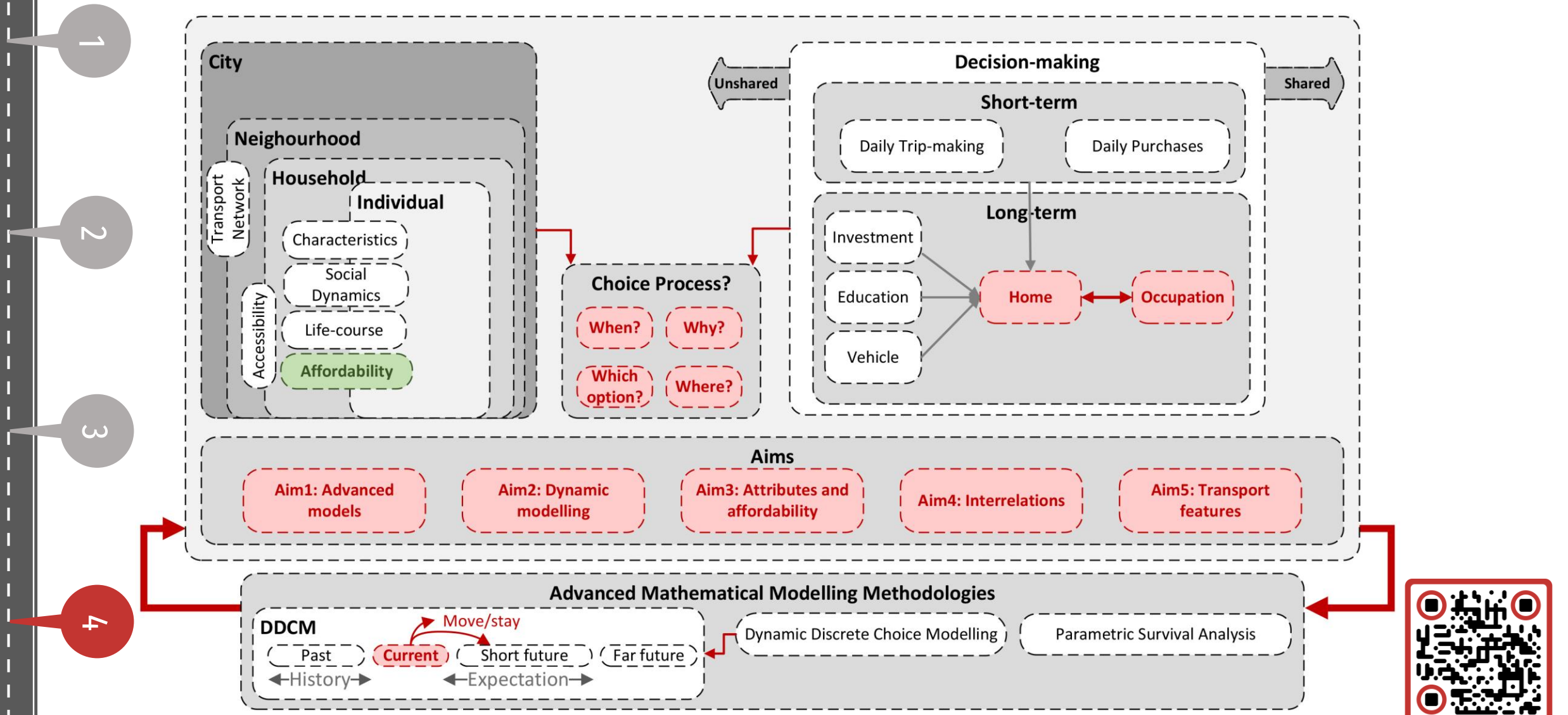

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1

Insights:

2

- Longitudinal datasets efficiency
- Future-looking nature of households
- Affordability's impact

3

4

Variable	Coefficient	t-statistic	P-value	Significance
Utility of stay				
Constant	1.481	17.3	3.5E-67	***
Number of adults	0.034	6.4	1.9E-10	***
Number of members aged 5 to 9	0.011	0.5	5.8E-01	
Current home variables				
Is apartment?	0.055	1.7	9.7E-02	**
Is renter?	-0.254	-7.0	2.1E-12	***
Residing duration (in year)	0.012	11.5	9.9E-31	***
Actual current home price (in 1,000,000 AU$)	0.069	1.4	1.5E-01	*
SEIFA's IRSAD - 1 to 5 decile	0.160	4.3	1.7E-05	***
SEIFA's IER - 1 to 5 decile	-0.087	-2.6	9.0E-03	***
Affordability of renting a unit in the current suburb²	0.119	1.9	5.9E-02	**
Affordability of Purchasing a house in current suburb	-0.186	-1.8	7.3E-02	**
Travel time to CBD by car (in hours) × petrol price	-0.010	-17.3	2.1E-67	***
Suburb's average house price (in 1,000,000 AU$)	0.037	0.7	4.8E-01	
Job variables				
Total full-time workers	-0.040	-1.4	1.7E-01	.
Probability of job relocation	-1.000	-3.7	2.1E-04	***
Life-course variables				
Relocation during last year	-0.271	-5.8	6.4E-09	***
A birth during last year	-0.187	-2.6	8.7E-03	***
A job promotion during last year	-0.226	-3.2	1.3E-03	***
An improvement in income during last year	-0.219	-2.5	1.3E-02	***
Marriage during last year	-0.254	-3.2	1.3E-03	***
Separation during last year	-0.384	-5.1	4.2E-07	***
Years binary variables				

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Project 4 Towards a realistic model of residential relocation: DDCM's dynamic, future-oriented approach

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Insights:

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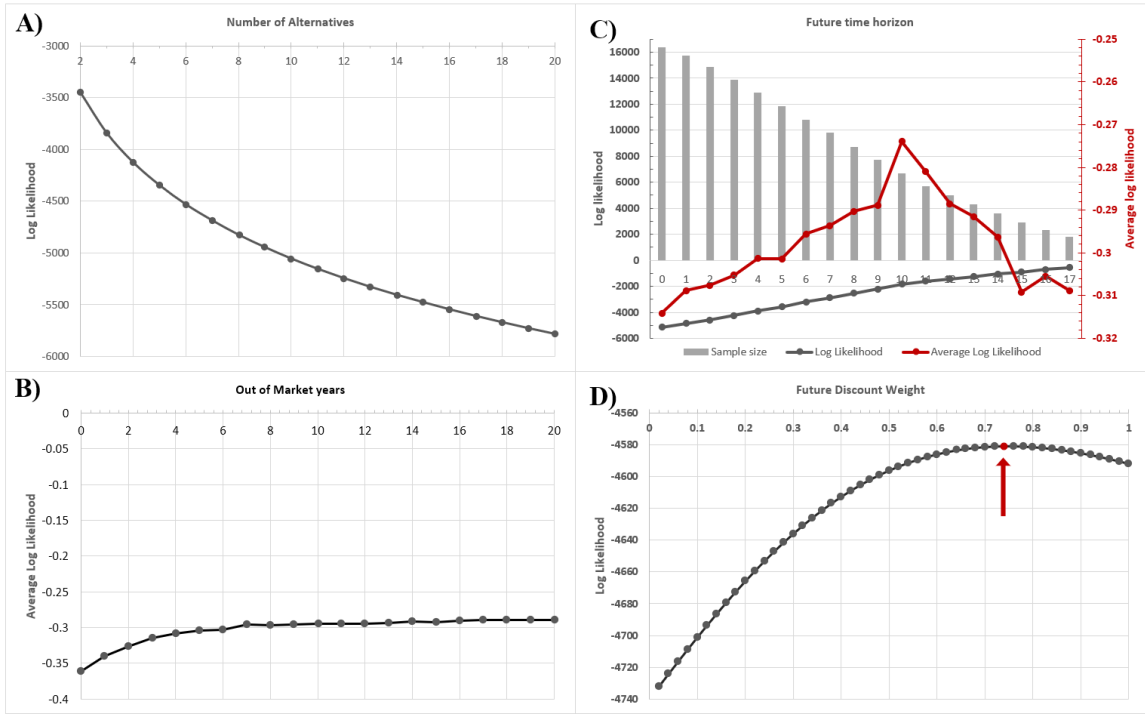
Variable	Coefficient	t-statistic	P-value	Significance
Year 2007 to 2009	0.252	3.7	2.1E-04	***
Year 2017 to 2019	-0.117	-1.6	1.1E-01	*
year 2020 and 2021	0.111	0.6	5.3E-01	
Utility of move				
Travel time to CBD by car (in hours)	-1.176	-5.9	3.6E-09	***
SEIFA's IER score	0.003	4.7	2.3E-06	***
SEIFA's IEO score	0.001	1.8	7.9E-02	**
Alternative and current home				
Current home to alternative travel time (in hours)	-4.094	-28.9	4.0E-183	***
$(Population)_{alt}$ - $(Population)_{current}$ (in 10,000)	0.121	2.6	1.0E-02	***
$(SEIFA's\ IRSAD\ score)_{alt}$ - $(SEIFA's\ IRSAD\ score)_{current}$	0.001	1.5	1.3E-01	*
$(AVG\ unit\ rent)_{alt}$ - $(AVG\ unit\ rent)_{current}$ (in 1K AU$)	-4.587	-8.3	9.1E-17	***
$(AVG\ house\ price)_{alt}$ - $(AVG\ house\ price)_{current}$ (in 1M AU$)	-0.525	-3.4	5.8E-04	***

4



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1 **Project 1** Bayesian survival model for household relocation dynamics in two major cities

2 **Project 2** The co-determination of home and workplace relocation durations using survival copula analysis

3 **Project 3** Machine learning and feature selection methods unpack the whys and whens

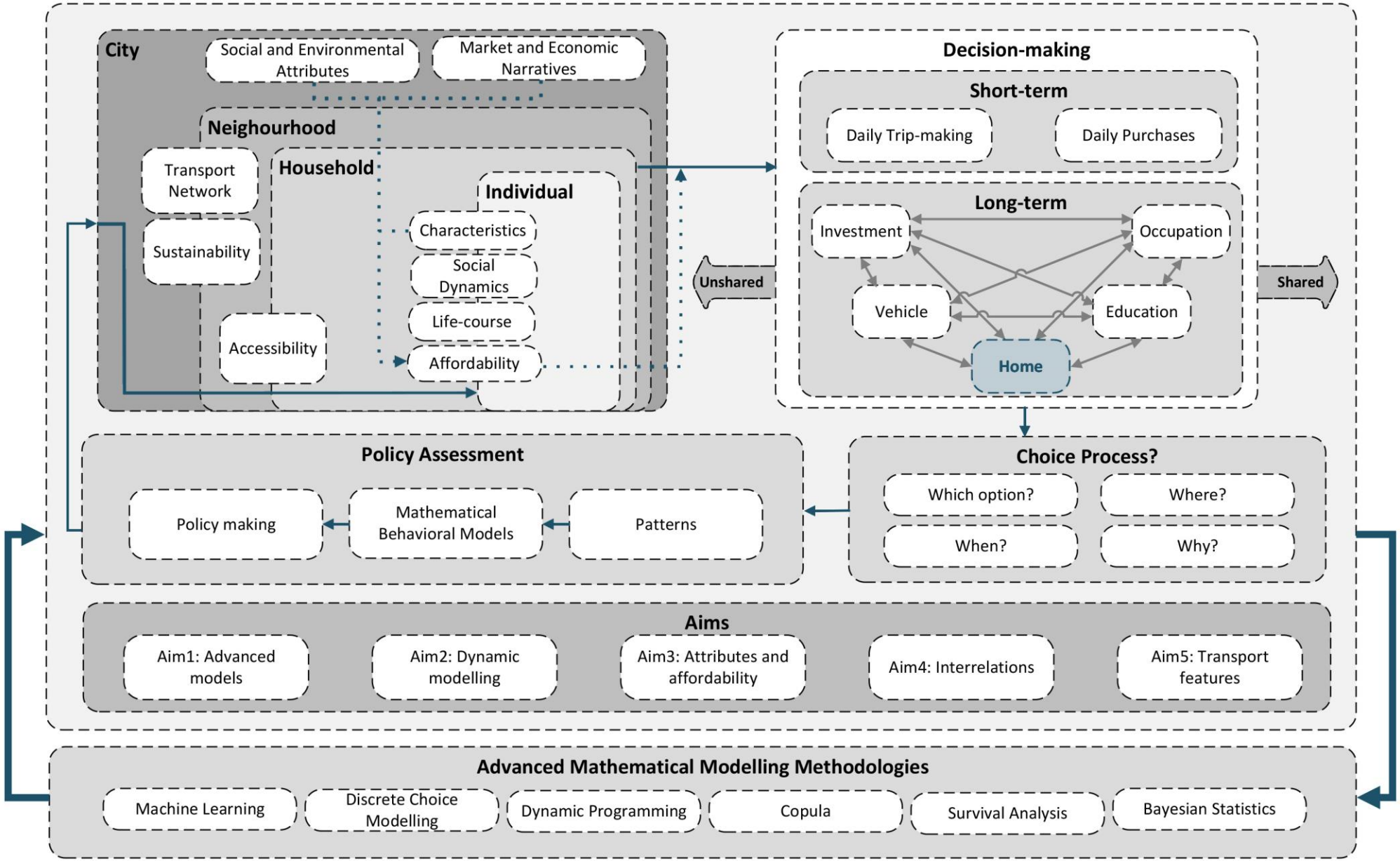
4 **Project 4** Towards a realistic model of residential relocation: DDCM's dynamic, future-oriented approach

1 Project 1

2 Project 2

3 Project 3

4 Project 4



1 Project 1

2 Project 2

3 Project 3

4 Project 4

? Future direction?

- Decisions -> Dynamic and future-looking
- Affordability's impact
- DDCM

Thank you!

Bridging Decisions and Destinations | Maryam Bostanara | TRANSW-2023

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