

# Transport modelling study – options for including digital options

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# Outline

1. Introduction / purpose
2. Methodology
3. Literature review
4. Methods and shortlist
5. Assessment of options
6. Outcomes

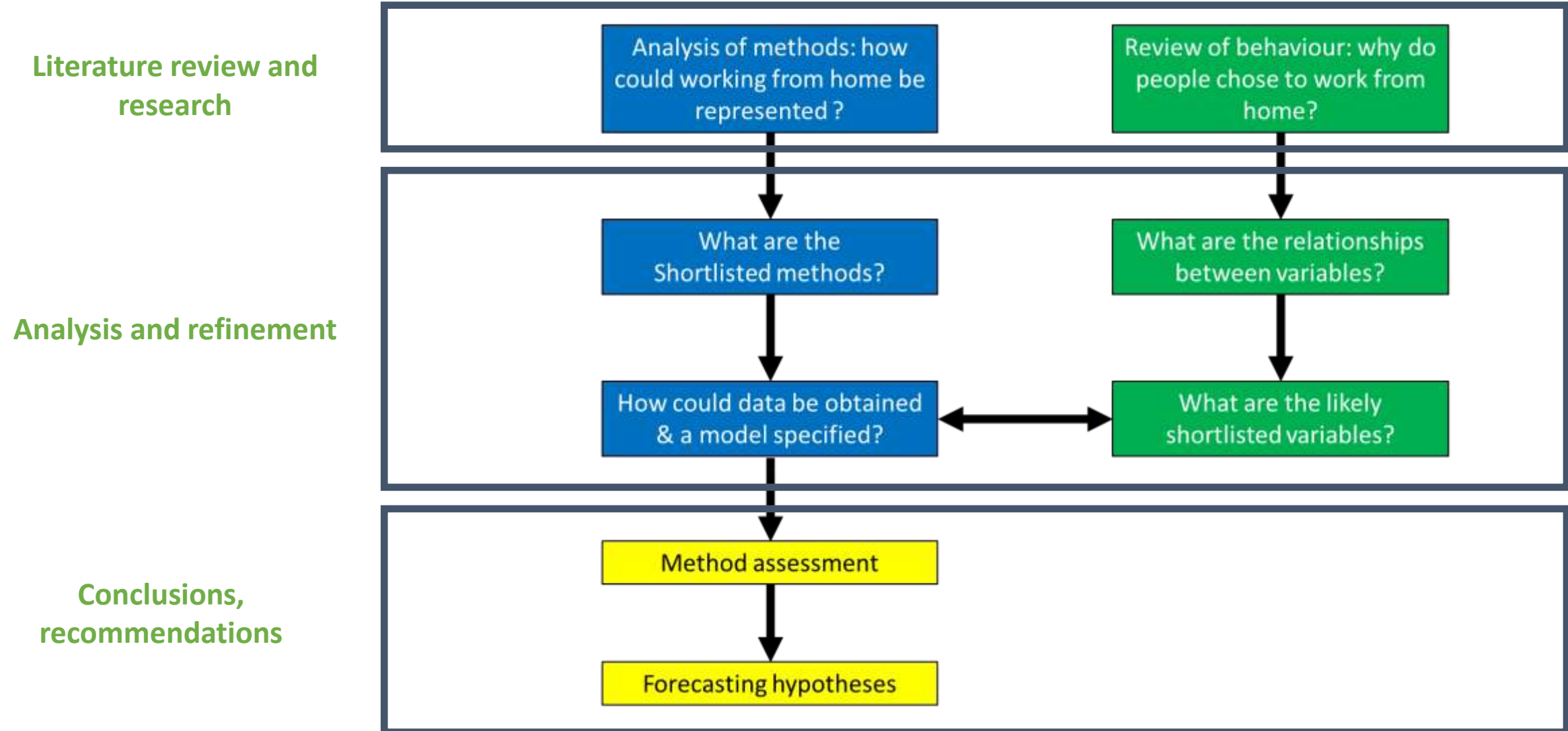
# Introduction

- A COVID-19 induced outcome...
- A 'new normal'
- Potential impacts – a contributor towards outcomes?
- There are challenges including WFH as a 'alternative mode of transport..'
- What tools and methods are available?
- Is this another 'nudge' towards a bigger change to practice?





# Methodology overview





# Literature review



WORK

- Bias towards 'white collar'
- Negotiating strength of employees
- Corporate policies will be a driver
- Size of company



TRAVEL

- Highest degree of confidence
- Difference in WFH outcomes by day of week, between car and PT users
- Quality of digital connectivity could be an attribute – and likely to improve over time



SOCIAL

- Planned behaviour theory
- Role of society and opinions on decisions
- Social progress and changing attitudes
- Children as detractor or enhancer



LAND USE

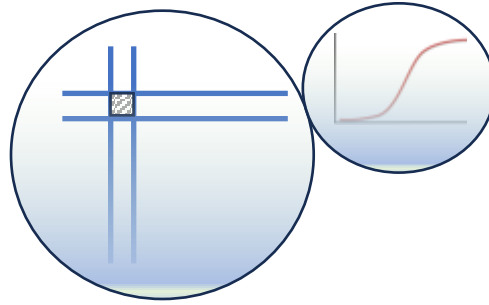
- Home office setup significant
- Role of agglomeration, physical or digital
- Perceived costs of travelling to CBD
- Interaction effect with transport system

- Also, role of habit, previous decisions
- Day of week

|    | Reference   | Used in review | Transport | Land use | Social | Modelling |
|----|---|----------------|-----------|----------|--------|-----------|
| 1  | Arentze & Timmermans (2004)                       | ✓              | ✓         |          |        | ✓         |
| 2  | Arling (2004)                                     | ✓              | ✓         |          | ✓      |           |
| 3  | Asgari (2015)                                     | ✓              | ✓         |          | ✓      | ✓         |
| 4  | Auld et al. (2016)                                |                |           | ✓        |        | ✓         |
| 5  | Beck & Hensher (2020)                             | ✓              | ✓         |          | ✓      |           |
| 6  | Beck & Hensher (2021a)                            | ✓              | ✓         | ✓        | ✓      |           |
| 7  | Beck & Hensher (2021b)                            | ✓              | ✓         | ✓        | ✓      |           |
| 8  | Beck & Hess (2016)                                | ✓              | ✓         |          |        | ✓         |
| 9  | Brewer & Hensher (2000)                           |                |           | ✓        |        | ✓         |
| 10 | Ceccato et al. (2022)                             | ✓              | ✓         |          |        | ✓         |
| 11 | Centre for Economics and Business Research (2019) | ✓              | ✓         | ✓        | ✓      |           |
| 12 | Faber et al. (2023)                               | ✓              | ✓         |          | ✓      | ✓         |
| 13 | Fu et al. (2012)                                  | ✓              | ✓         | ✓        | ✓      | ✓         |
| 14 | Greaves et al. (2022)                             | ✓              | ✓         | ✓        | ✓      |           |
| 15 | Green et al. (2020)                               | ✓              | ✓         |          | ✓      |           |
| 16 | Habib & Anik (2021)                               | ✓              | ✓         | ✓        | ✓      | ✓         |
| 17 | Hensher et al. (2021)                             | ✓              | ✓         | ✓        | ✓      | ✓         |
| 18 | Jain et al. (2022)                                | ✓              | ✓         | ✓        | ✓      | ✓         |
| 19 | Kersting et al. (2021)                            | ✓              | ✓         |          | ✓      | ✓         |
| 20 | Kyriakopoulou & Picard (2022)                     | ✓              | ✓         |          |        | ✓         |
| 21 | Lyons & Davidson (2016)                           | ✓              | ✓         |          |        | ✓         |
| 22 | Mayer & Boston (2022)                             | ✓              | ✓         | ✓        | ✓      |           |
| 23 | Moeckel (2017)                                    | ✓              | ✓         | ✓        |        | ✓         |
| 24 | O'Fallon et al. (2004)                            | ✓              | ✓         |          | ✓      | ✓         |
| 25 | Productivity- Commission (2021)                   | ✓              | ✓         | ✓        | ✓      |           |
| 26 | Shabanpour et al. (2018)                          | ✓              | ✓         | ✓        |        | ✓         |
| 27 | Smargiassi et al. (2020)                          | ✓              | ✓         | ✓        |        | ✓         |
| 28 | Swardh & Algiers (2009)                           | ✓              | ✓         |          | ✓      | ✓         |
| 29 | Thomas et al. (2021)                              | ✓              | ✓         |          | ✓      |           |
| 30 | Wang et al. (2022)                                | ✓              | ✓         |          |        | ✓         |
| 31 | Zheng et al. (2023)                               | ✓              | ✓         | ✓        |        | ✓         |
| 32 | Arentze & Timmermans (2004)                       | ✓              | ✓         |          |        | ✓         |

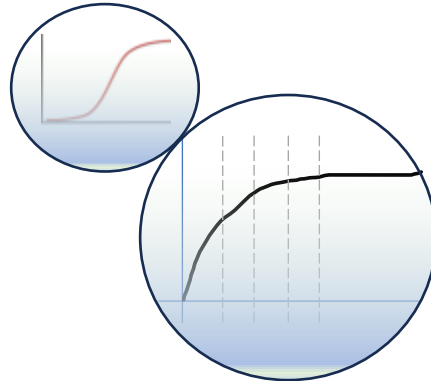
# Summary of methods available

## Four stage models



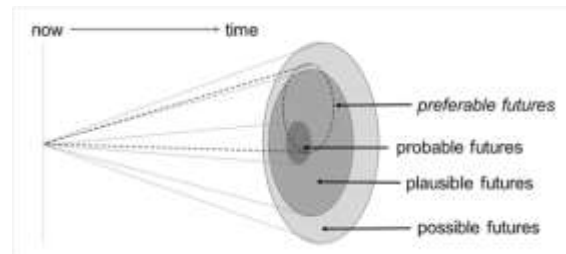
- Accessible, available
- Aggregated in space

## Activity Based models (ABM)



- Emerging
- More 'traction' on certain variables
- Disaggregated in time

## Scenario Planning



- Manages the unpredictable
- Specific process requirements

# Processing variables

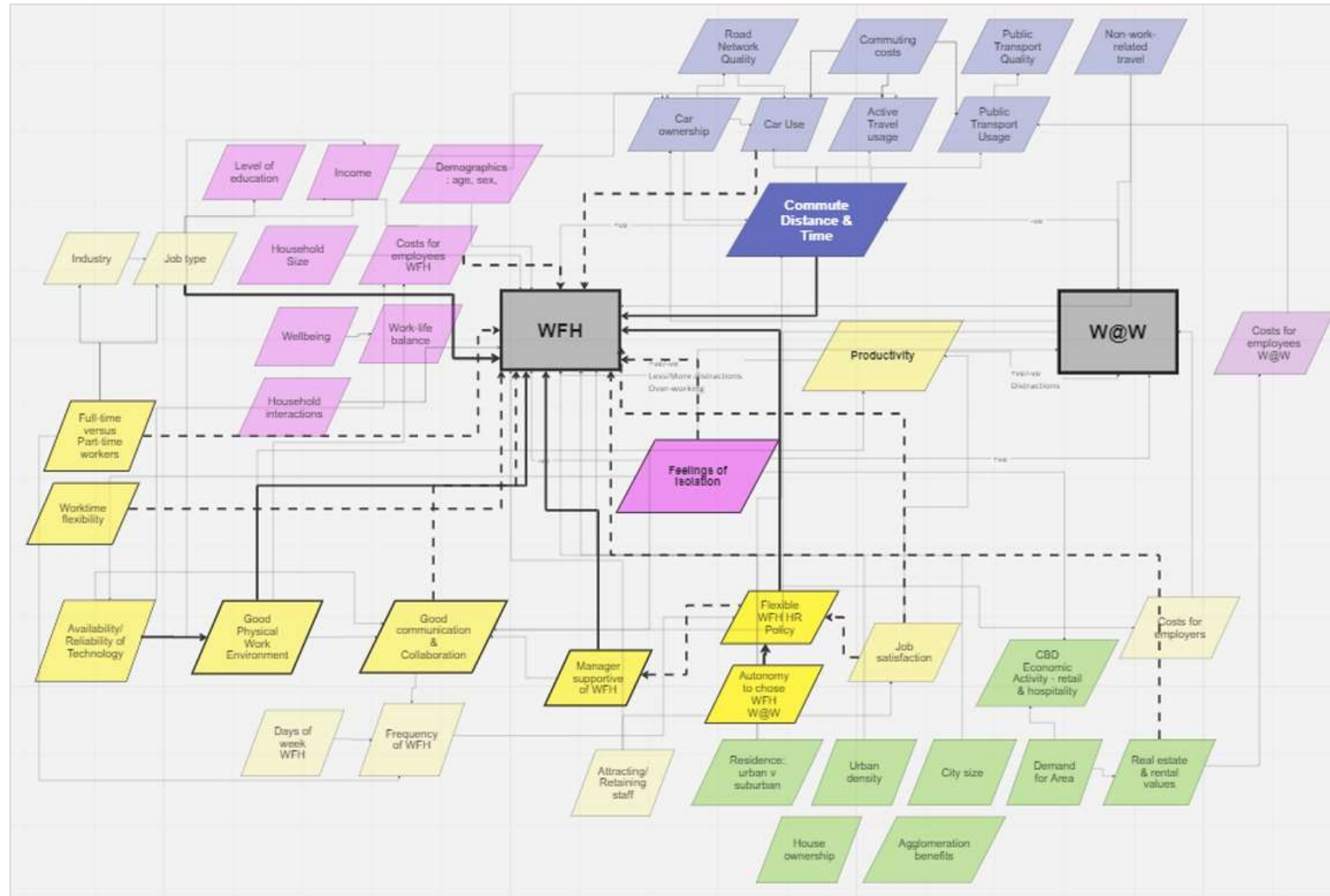
- Variables with evidence suggesting significance are rationalised
- Non-significant, of those lacking evidence are discounted
- Variables considered “confounded” are greyed out
- Those remaining considered in terms of:
  - Identification
  - Transferability
  - Normality (distribution)
  - Stationarity
  - Autocorrelation
  - Heteroskedasticity

| Variable   | Metric   | Significance hypothesis  | Data behaviours |                 |                          |              |                 |                    |
|--|--|--------------------------|-----------------|-----------------|--------------------------|--------------|-----------------|--------------------|
|  |  |                          | Identity issues | Transfer errors | Normality / distribution | Stationarity | Autocorrelation | Heteroskedasticity |
| Industry and Employment type                                     | Category (type)                                  | Probably significant     | ✓               | ✓               | ✓                        |              |                 |                    |
|  | Number of employees                              | Probably significant     | ✓               | ✓               | ✓                        |              | ✓               |                    |
| Employer policy  | Number of days permitted to WFH                  | Probably significant     | ✓               |                 |                          |              |                 |                    |
| Employer and employee costs                                      | WFH set up costs (\$)                            | Probably significant     |                 |                 |                          | ✓            |                 | ✓                  |
| Home working environment quality                                 | Dedicated space (binary)                         | Probably significant     |                 |                 |                          |              |                 | ✓                  |
|  | Comfort (utility)                                | Probably significant     | ✓               | ✓               | ✓                        | ✓            | ✓               |                    |
| Communication, collaboration                                     | Perceived utility                                | Likely significant       | ✓               |                 |                          |              |                 |                    |
| Car usage and ownership  | Number of cars in HH                             | Likely significant       |                 |                 |                          |              |                 | ✓                  |
| Trip characteristics & Quality of access to the transport system | Distance   | Probably significant     |                 |                 |                          |              |                 |                    |
|  | Time   | Probably significant     |                 |                 |                          |              |                 |                    |
|  | Cost of trip                                     | Probably significant     |                 |                 |                          |              |                 |                    |
|  | Generalised cost                                 | Probably significant     |                 |                 |                          |              |                 |                    |
|  | Distance to PT stop (m)                          | Probably significant     |                 |                 |                          |              |                 |                    |
|  | PT headways (time)                               | Probably significant     |                 |                 |                          |              |                 |                    |
|  | Active travel options (relative metric)          | Probably significant     |                 |                 |                          |              |                 |                    |
| Reliability of digital access                                    | Connection reliability                           | Likely significant       | ✓               | ✓               | ✓                        | ✓            | ✓               | ✓                  |
|  | Connection speed                                 | Likely significant       |                 | ✓               |                          |              |                 | ✓                  |
| Household interactions and conflict                              | no. of people per room per dwelling (crowding)   | Likely significant       |                 |                 |                          |              |                 |                    |
| Real estate, rental demands, values                              | Corporate perceived cost                         | Likely significant       |                 |                 |                          |              |                 |                    |
| Income   | Salaried income (NZD)                            | Likely significant       |                 |                 |                          |              |                 | ✓                  |
| Education level  | Highest attained qualification (scaled category) | Likely significant       |                 | ✓               |                          | ✓            |                 | ✓                  |
| Productivity   | Corporate performance                            | Maybe significant        | ✓               | ✓               |                          |              |                 |                    |
| Whanau and social influence                                      | Number of dependants                             | Maybe significant        |                 |                 | ✓                        | ✓            |                 | ✓                  |
| Social connectedness and wellbeing                               | Perceived freedom within social construct        | Maybe significant        | ✓               |                 | ✓                        | ✓            |                 |                    |
| Urban characteristics - city size, density                       | Population, density categories                   | Maybe significant        | ✓               |                 |                          |              |                 |                    |
| Location, proximity to CBDs                                      | Distance from CBD central point (m)              | Maybe significant        | ✓               |                 | ✓                        |              | ✓               |                    |
| Cultural and Social attractions                                  | Perceived utility                                | Maybe significant        | ✓               |                 | ✓                        |              |                 |                    |
| Agglomeration effects  | Density of certain industry types                | Probably not significant |                 | ✓               | ✓                        | ✓            | ✓               |                    |
| Property tenure  |  | Probably not significant |                 | ✓               |                          |              |                 |                    |
| Job satisfaction and career prospects                            |  | Probably not significant | ✓               |                 |                          |              |                 |                    |
| Gender   |  | Probably not significant |                 |                 |                          |              | ✓               |                    |
| Age  |  | Probably not significant |                 |                 |                          |              | ✓               |                    |



# Relationships

- Cognitive mapping exercise (please see main report for full version)
- Bias minimisation: 'belief based' sections delegated
- Colours denote variables 'families'
- Boldness denotes expected strength of relationship



# Format of framework

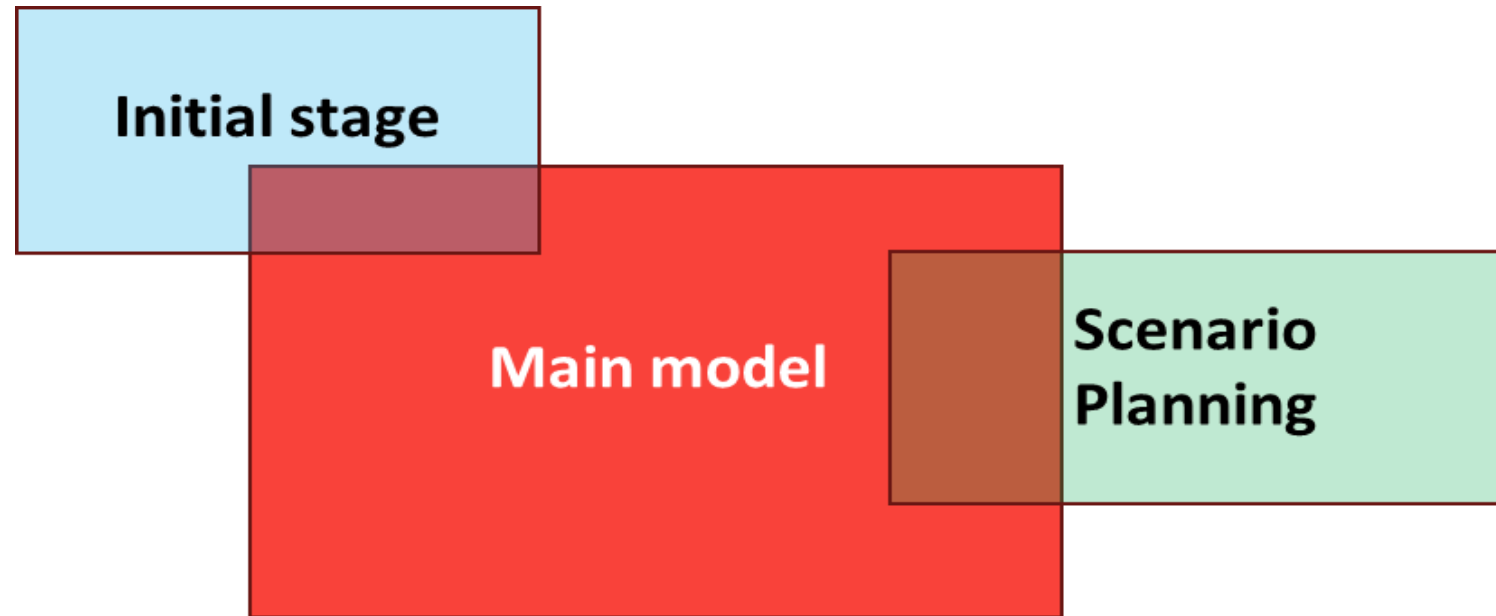
## Initial stage options

- Structural Equation modelling
- 'Fuzzy logic'

## Main model options

- ~~Multi Nomial Logit (NML)~~
- Nested (hierarchical) Logit (NL)
- Mixed Logit (ML)
- Hybrid / Heteroskedastic Mixed Logit (HML)

## Scenario Planning



# Scoring summary

Trade-offs – none clearly ‘worst’ or ‘best’

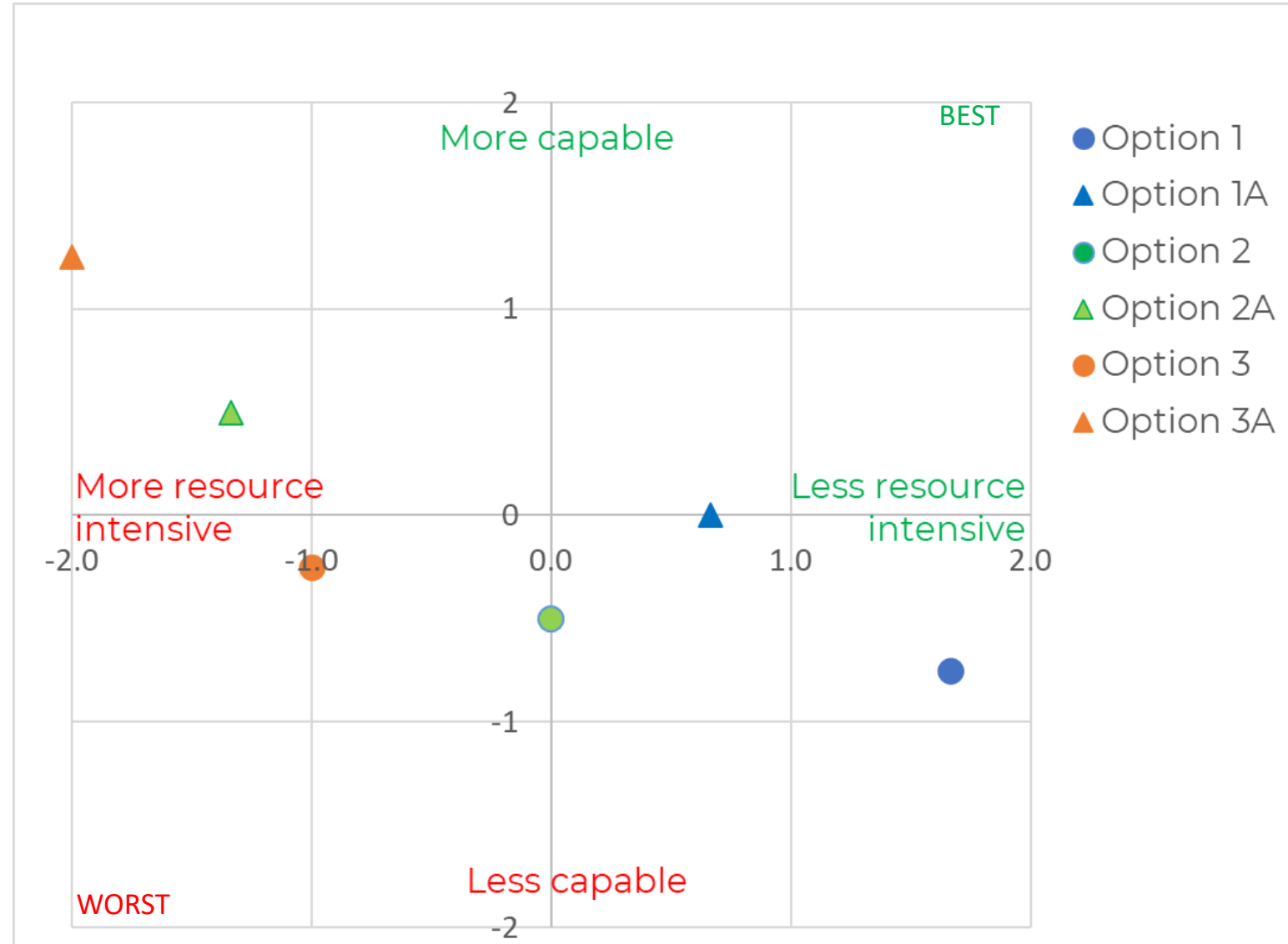
Assessment categories summarised into:

- Capability
- Resource requirements

Scoring is relative (i.e. -2 is ‘not as good’, rather than ‘bad’)

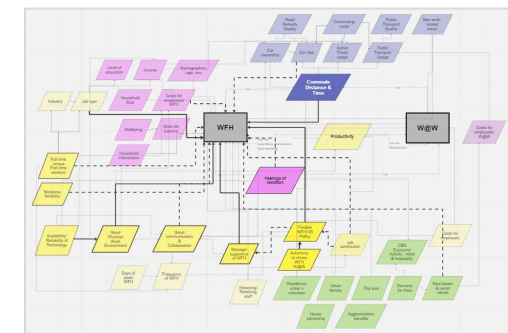
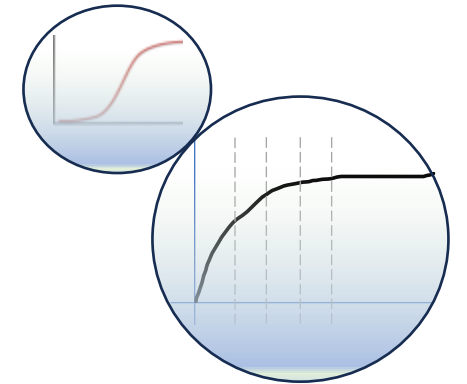
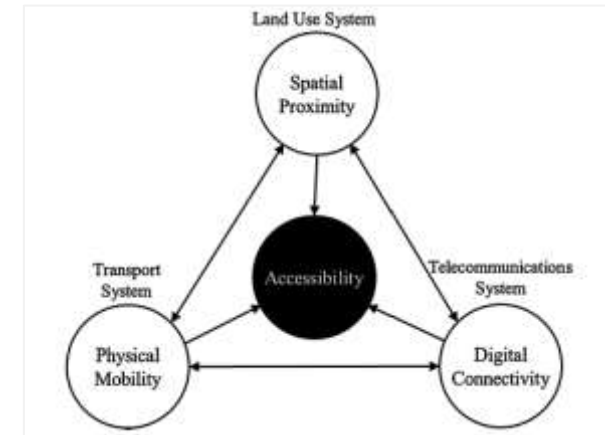
More capable models would be more resource intensive

ABM (triangles) expected to be both more capable and resource intensive than four stage modelling



# Conclusions and discussion

- **Limitations:**
  - Still conceptual / hypothetical
  - Requires highly specialised surveying and resourcing
- **Further research / modelling work:**
  - Socialise proposal with field
  - Make case for investment
  - Related concepts: work from anywhere, Travel Demand Management
- **Implementation:**
  - Involve a diverse team: who's world views will prejudice outcomes?
  - Hypothesis rejection or non-rejection
  - Learn lessons from the past – the past is important!
- **Opportunity:**
  - Digital access = efficient access 'capacity'
  - More WFH = (probably) lower emissions
  - Towards insight – travel preferences based on amenity, not speed



# Discreet choice models

## Multi Nomial

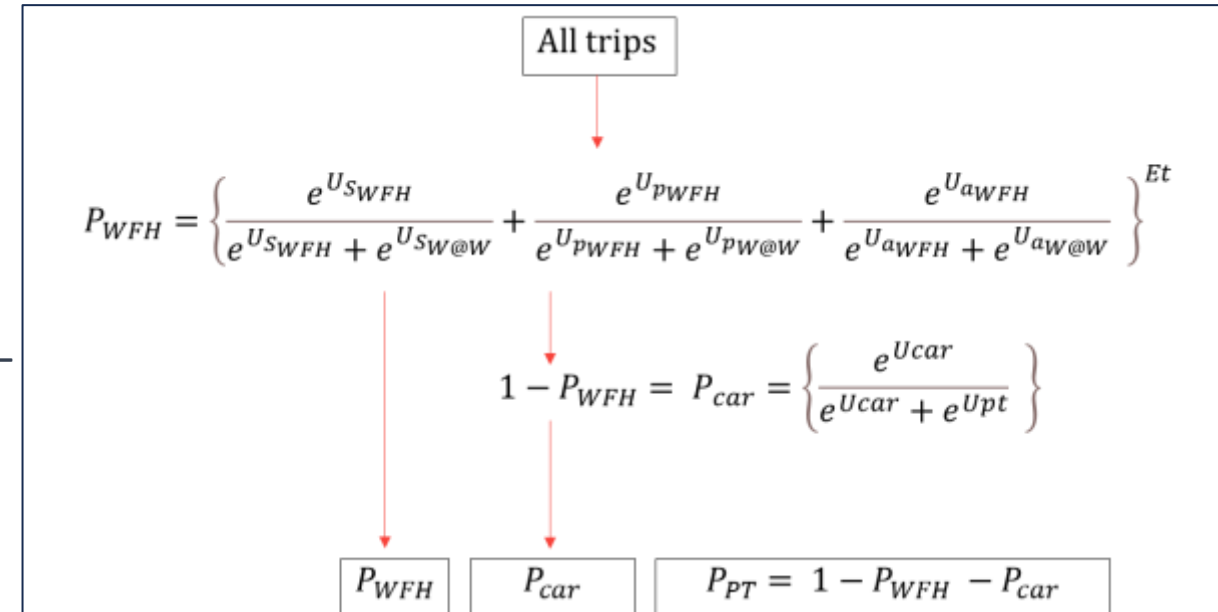
- Simple but limited

$$P_{WFH} = \left\{ \frac{e^{U_{WFH}}}{e^{U_{WFH}} + e^{U_{W@W}}} \right\}$$

$$P_{WFH} = 1 - P_{W@W}$$

## Nested:

- Widely used
- Correlation between subsets of choices
- Grouping of variables in accordance with similarities – deals with heterogeneity



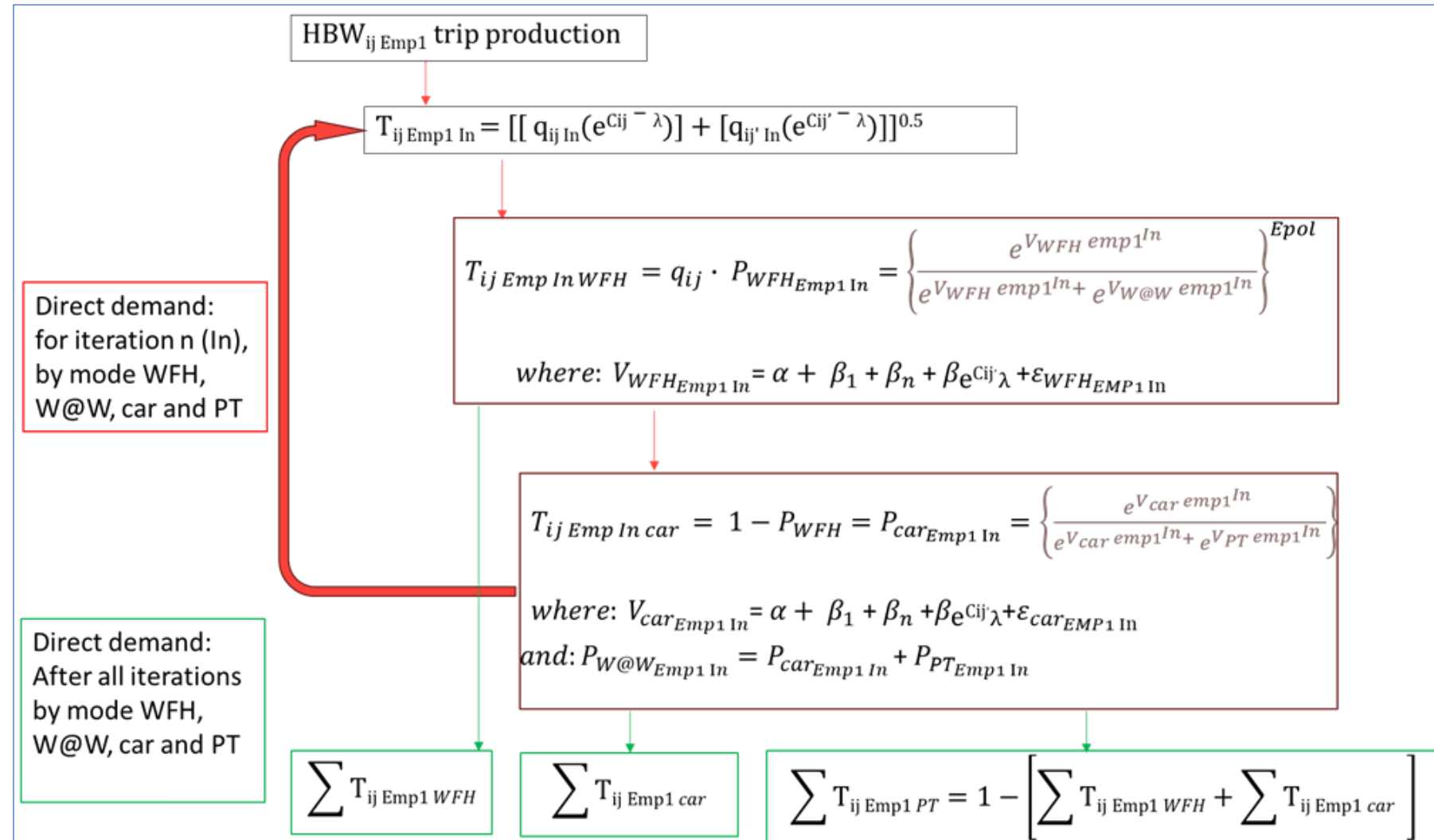
## Mixed / hybrid:

- All of the above, and
- Integration of many models - taste variations, time series
- Overcomes many issues
- Specialised

$$P_{iq} = \int_{\theta_q} \prod_{t=1}^T \left( \frac{e^{V_{jqt}(\theta_q)}}{\sum_{A_{i \in A_t(q)}} e^{V_{iqt}(\theta_q)}} \right) f(\theta_q | b, \Sigma) d\theta_q$$



# Concept – working inside a Direct demand model



A man with glasses and a beard, wearing a dark suit jacket over a light blue shirt, is seated on a train. He is looking down at a white smartphone held in his hands. The background is blurred, showing other passengers and the interior of the train. A large white circular graphic is partially visible in the top right corner.

Questions?