players' decisions are optimal. In contrast, QRE relaxes this optimality assumption by incorporating a random "noise" element, hence, decisions of players might be suboptimal. Equilibrium occurs when the beliefs of a player become consistent with responses of other players. Moreover, QRE can account for experience and learning of a player when playing a game. In transportation, QRE is a relatively new concept, although it has similarities to a stochastic user equilibrium (which include a random term that accounts for errors in agent's perception), which states that no agent can reduce his/her *perceived* travel time by unilaterally changing their route [5].

According to [1], a payoff function (also referred to as utility) for an agent i for selecting a strategy j can be written as

$$\tilde{u}_{ij} = u_{ij} + \varepsilon_{ij}, \qquad (1)$$

where ε_i is a random error/noise term for player i.

If the error terms are assumed to be independent and identically (i.i. d.) extreme value distributed, it leads to well-known logit response function (see [2]), i.e.

$$\sigma_{ij} = \frac{e^{\lambda u_{ij}}}{\sum_{k=1}^{J_i} e^{\lambda u_{ik}}} \qquad (2)$$

where λ is a precision parameter and inversely proportional to the levels of error/noise.

3. QRE in Route Choice Game

The aim of this research is to apply QRE to travel choice behaviour of agents, integrate concepts from experimental design and experiments economics in the design of laboratory experiments, and to integrate concepts from advanced discrete choice theory to analyse the data. To this end, a series of experiments (driving simulator studies) in the Travel Choice Simulation Laboratory (TRACSLab) will be conducted. This world-first facility allows complete control of the environment (this includes the road system, traffic signals and controls, as well as computer-simulated cars as background traffic) and allows capturing all decisions made by a maximum of 10 human drivers in the same virtual environment. Our first experiment is related to route choice, although we will consider also other application contexts such as parking choice. The participants selected for these simulation experiments will be Uber drivers. In each, 10 agents will be simultaneously making choices, with multiple repetitions. Figure 1 shows the proposed route choice experiment.

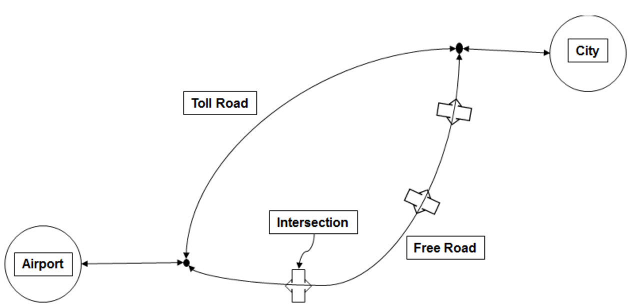

Figure 1: Proposed game for route choice experiment

In this experiment, the agents will be making trips from the airport to the city and vice versa. The purpose is to transport passengers assuming a fixed fee, and hence drivers will want to minimise their travel time. In other words, the faster they go the more people they can pick up, the more money they can make. Drivers can choose between two routes: the toll road and the free road. The toll road guarantees a congestion fee trip, whereas the free road may become congested depending on the number of drivers on the road. The level of congestion can be varied by the analyst by setting traffic controls at three signalised interactions. Each driver, therefore, will make a decision based on their trade-off between time and money, as well as their expectations with respect to congestion and travel time unreliability.

Since agents may have different preferences towards travel times and costs, and may have different skill levels, beliefs, and learning speeds, it is possible that the parameters in the payoff functions as well as the precision parameter λ could be different for each agent. Therefore, we will test for heterogeneity in QRE, which extends the equilibrium definition in traditional QRE.

For these experiments, different scenarios will be developed using simulator software, traffic simulation software, and 3D scenario building software. Data collected in these experiments will be used to estimate behavioural models using novel statistical methods that combine maximum likelihood (borrowed from RUM/DCM) as well as game theoretical techniques (borrowed from experimental economics).

To conclude, our research will develop models which explicitly account for interactions and dynamics between agents under uncertainty and imperfect information. This will enrich and improve existing travel behaviour models and will improve fundamental understanding of these interactive decision processes that may also extend to other decision-making contexts.

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