Extended **Abstract**

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Paper/Poster Title	Using fuzzy count models to accommodate measurement error in recreation trip count models

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Abstract	***200 words max***
Existing empirical evidence shows that reported recreation trip counts are susceptible to various measurement errors (including recall bias and the tendency to round off counts to focal values). To address these measurement errors, we specify a mixture of likelihood functions that treat reported trip counts as fuzzy numbers from a standard discrete triangular distribution. Through a series of Monte Carlo simulations and empirical data, we show that this fuzzy count model redresses the measurement errors when they exist and has greater power in estimating the parameters of the true counts. We discuss the implications of the results for recreation demand studies.	

Keywords	recreation trip count models, measurement error, fuzzy count models
JEL Code	C13, C25, Q51

Introduction	***100 – 250 words***

In recreation demand surveys, participants are routinely asked to report the number of times they have visited a site. However, reported counts recalled from memory may not always be correct, which is the source of measurement error of this variable. Research indicates a significant recall bias in travel demand data, with avid visitors tending to overreport, a tendency exacerbated over longer reporting periods. Another form of bias involves rounding or heaping reported values, often multiples of 5 or 10, raising concerns about data validity and its impact on modelling. This may occur for various reasons. Higher reported values may lead participants to choose specific rounded numbers, such as 25 or 50. Regular visits or past occurrences during specific periods might prompt participants to use heuristics, potentially leading to incorrect, heaped values (e.g., multiples of 7 or 12). The salience of the location, strategic considerations, and self-deception further contribute to over- or under-reporting.

Whatever the behavioural reasons, using inaccurate visit counts will have consequences for the validity of any estimation of recreation demand and welfare analysis. If the measurement error has a mean of zero, then errors will affect the variance of model parameter estimates but not compromise their consistency. However, existing studies suggest that the mean of this measurement error is unlikely to be zero; hence, bias will ensue. If we accept that reported visit counts are imprecise, one must consider how to accommodate this measurement error in the modelling. This is the objective of this paper.

Methodology	***100 – 250 words***

This paper introduces a "fuzzy" trip count model, employing a mixture of likelihood functions to handle imprecisely reported trip counts. These counts are treated as

imprecise data, represented by fuzzy numbers derived from a standard discrete triangular distribution. We assume the likelihood of competing trip counts aligns with the probability mass function of this distribution.

The approach involves retrieving trip count probabilities for all supported trip counts, and the overall choice probability is a weighted average over these supported counts. Although resembling different dependent variables for each class, this variance aligns with predetermined probability mass functions, aiming for improved trip count predictions, especially with increased fuzziness.

Comparatively, this model resembles a latent class model. However, unlike typical latent class models where class membership functions are estimated, our model predetermines class membership functions for each individual through the standard discrete triangular distribution. Parameter values are determined to maximise the log-likelihood function given predetermined class membership probabilities. Thus, estimated parameters are conditional on the data and assumed fuzziness pattern.

It is crucial to note that the log-likelihood function collapses to the underlying probability distribution when no fuzziness is considered, a key feature of our model. This framework also facilitates the exploration of consequences related to symmetric and asymmetric rounding.

Results	***100 – 250 words***

Our simulations affirm that conventional count data models yield unbiased estimates solely when data exhibit symmetric rounding. Additionally, the simulations demonstrate the capability of the fuzzy count data model to generate unbiased estimates even in the presence of asymmetrically rounded data. However, to achieve this, knowing the spread and direction of the rounding is crucial.

An essential question arises concerning identifying appropriate spreads within the fuzzy distribution. Determining how and to what extent suitable spreads can be identified is a natural concern. Choosing poorly defined interval spreads, where participants are assumed to have rounded their reported counts, can introduce systematic bias. To tackle this challenge, ongoing exploration involves diagnostic tests to identify the suitable fuzzy count data model. This approach is intended to enhance the precision and reliability of the model by ensuring that the chosen interval spreads align with the actual rounding patterns in the data.

Discussion and Conclusion	***100 – 250 words***

Until now, the recreation demand literature has seen limited investigation into the measurement error associated with trip counts despite its apparent significance. Consistent empirical findings indicate a common trend of participants overestimating visit counts. Our study contributes unequivocal evidence that neglecting to account for this error introduces bias, notably in upwardly biased welfare estimates. This implication underscores the necessity for routinely applying such statistical investigations in recreation demand studies. It is proposed that this becomes a recommended practice, offering valuable insights into the sensitivity of estimates in existing studies and enhancing the overall robustness of findings in the field.