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# The effect of prior probabilities on quantification and propagation of imprecise probabilities resulting from small datasets

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**Abstract**

This paper outlines a methodology for Bayesian multimodel uncertainty quantification (UQ) and propagation and presents an investigation into the effect of prior probabilities on the resulting uncertainties. The UQ methodology is adapted from the information-theoretic method previously presented by the authors (Zhang and Shields, 2018) to a fully Bayesian construction that enables greater flexibility in quantifying uncertainty in probability model form. Being Bayesian in nature and rooted in UQ from small datasets, prior probabilities in both probability model form and model parameters are shown to have a significant impact on quantified uncertainties and, consequently, on the uncertainties propagated through a physics-based model. These effects are specifically investigated for a simplified plate buckling problem with uncertainties in material properties derived from a small number of experiments using noninformative priors and priors derived from past studies of varying appropriateness. It is illustrated that prior probabilities can have a significant impact on multimodel UQ for small datasets and inappropriate (but seemingly reasonable) priors may even have lingering effects that bias probabilities even for large datasets. When applied to uncertainty propagation, this may result in probability bounds on response quantities that do not include the true probabilities.

*Keywords:* Uncertainty quantification, Uncertainty propagation, Data-driven, Imprecise probability, Prior probabilities, Multimodel inference, Bayesian inference, Importance sampling

## 1. Introduction

Uncertainty quantification (UQ) is the science of quantitatively characterizing and, if possible, reducing uncertainties in the computational evaluation of engineering/mathematical systems. It is used to determine how likely certain outcomes are if some parts of the system are not exactly known. Practically speaking, UQ is playing an increasingly important role in performance prediction, reliability analysis, risk evaluation and decision making. Uncertainty can be broadly classified into two categories [1]: *epistemic*, resulting from a lack of complete knowledge and modeling approximations, and *aleatory*, resulting from inherent

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