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Structural economic models for policy-making: Coping with parametric uncertainty

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Economists use highly parameterized structural models to investigate economic mechanisms, predict the impact of proposed policies, and inform optimal policy-making [29]. These models represent deep structural relationships of theoretical economic models invariant to policy changes [18]. The sources of uncertainty in such an analysis are ubiquitous [26]. For example, all models are misspecified, there are numerical approximation errors in their implementation, and model parameters are uncertain. Therefore, a proper accounting of uncertainty is a prerequisite for using computational models for decision-making in most disciplines [25, 27].

Our focus is on parametric uncertainty in structural econometric models that are estimated on observed data. Economists often ignore parametric uncertainty and conduct an as-if analysis where the point estimates serve as a stand-in for the true model parameters. We then continue to study the implications of our models at the point estimates [1, 6, 12, 13] and rank competing policy proposals based on the point predictions only [7, 11, 14, 28]. In fact, in their handbook article, [20] state that they are unaware of any applied work that reported the distribution of policy predictions due to parametric uncertainty. To the best of our knowledge, this statement remains true more than a decade later. Consequently, economists run the risk of accepting fragile findings as facts, ignoring the trade-off between model complexity and prediction uncertainty, and not framing policy advice as a decision problem under uncertainty.

In this paper, we develop an approach that copes with parametric uncertainty and embeds model-informed policy-making in a decision-theoretic framework. We follow [24]'s suggestion and, instead of using the parameter estimates as-if they were true, incorporate uncertainty in the analysis by treating the estimated confidence set as-if it is correct. We use the confidence set to construct an uncertainty set that is anchored in empirical estimates, statistically meaningful, and computationally tractable [4]. Instead of just focusing on the point estimates, we evaluate counterfactual policies based on all parametrizations within the uncertainty set.

We rely on statistical decision theory [22] to deal with the uncertainty in counterfactual predictions. This approach promotes a well-reasoned and transparent policy process. Before a decision, it clarifies trade-offs between choices [16]. Afterward, decision-theoretic principles allow constituents to scrutinize the coherence of choices [15], ease the ex-post justification [5], and facilitate the communication of uncertainty [23].

As an example of our generic approach, we analyze the seminal human capital investment model by [21] as a well-known, empirically grounded, and computationally demanding test case. We follow the authors and estimate the model on the National Longitudinal Survey of Youth 1979 (NLSY79) [8] using the original dataset and reproduce all core results. We revisit their predictions for the impact of a tuition subsidy on completed years of schooling. The economics of the model imply that the nonlinear mapping between the model parameters and predictions is truncated at zero. We thus use the Confidence Set (CS) bootstrap [30] to estimate the confidence set for the counterfactuals. We document considerable uncertainty in the policy predictions and highlight the resulting policy recommendations from different formal rules on decision-making under uncertainty.

Our work extends existing research exploring the sensitivity of implications and predictions to parametric uncertainty in macroeconomics and climate economics. For example, [17] study uncertainty propagation and sensitivity analysis for a standard real business cycle model. [9] examine how uncertainties and risks in economic and climate systems affect the social cost of carbon. However, neither of them estimates their model on data. Instead they rely on expert judgments to inform the degree of parametric uncertainty. They do not investigate the consequences of uncertainty for policy decisions in a decision-theoretic framework.

Our work complements a burgeoning literature on the sensitivity analysis of policy predictions in light of model or moment misspecification. For example, [2] and [3] treat the model specification as given and then analyze the sensitivity of the parameter estimates to misspecification of the moments used for estimation. [10] study global sensitivity of the model predictions to misspecification of the distribution of unobservables. [19] provides a local measure for the sensitivity of counterfactuals to model parameters that are fixed before the estimation of the model. This literature does not embed the counterfactual predictions in a decision-theoretic setting.

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