From Theory to Computation: A Simulation-Based Approach for Difference-in-Differences Validation

This document contains supplementary materials describing in more detail the rationale behind the proposed taxonomy and the selection criteria for the included biases.

## Taxonomy

| **Methodology** | **Identifying Characteristics** | **Advantages** | **Disadvantages** |
| --- | --- | --- | --- |
| Traditional Approaches | - Employs conventional econometric techniques.<br>- Includes within-transformation, TSCS methods, Hausman tests, pre-trend analysis, placebo tests, and event study frameworks.<br>- Focuses on indirect testing of model assumptions. | - Relatively straightforward and well-understood.<br>- Can be implemented with standard statistical software. | - Indirect approach; does not conclusively prove assumptions.<br>- Can be limited by data availability and quality. |
| Sensitivity Analysis | - Examines the impact of varying key assumptions (like unobserved confounders) on the results.<br>- Methods include Manski Bounds, Altonji-Elder-Taber approach, and Oster’s approach.<br>- Quantifies the robustness of conclusions under different assumption scenarios. | - Provides a more nuanced understanding of model dependence.<br>- Helps quantify uncertainty due to non-testable assumptions. | - Requires complex calculations and assumptions.<br>- Results can be difficult to interpret for non-experts. |
| Simulation Approaches | - Involves creating data/scenarios to test model performance.<br>- Includes bootstrapping, Monte Carlo simulations, and synthetic control as a simulation tool.<br>- Stress tests the model’s performance under various conditions. | - Directly tests the model's robustness in hypothetical scenarios.<br>- Can uncover model limitations not evident in real data. | - Requires careful design to ensure realistic simulation scenarios.<br>- Computationally intensive and requires technical expertise. |

Distinctive Feature of Simulation Approaches: Unlike sensitivity analysis, simulation approaches do not rely on altering or questioning the model's assumptions but rather on creating data or scenarios to stress test the model's performance. The objective is to see how the model behaves under various simulated conditions, which helps in understanding the robustness and reliability of the model in practical applications.

Breakdown and categorization of biases based on their likelihood of occurrence in real world econometric empirical research and their short, as well as long, term relevance. Since causal effects are relevant locally, because the further into the future we go the higher the likelihood that underlying assumptions are violated, I select the 4 most likely and short-term relevant sources of bias in the DiD framework: Selection bias, Unit-heterogeneity, time-varying confounders, and parallel trends.

| **Bias Type** | **Relevance to Local Treatment Effects** | **Long-Term Relevance** | **Likelihood in Econometrics** | **Example Scenario** |
| --- | --- | --- | --- | --- |
| Selection Bias | High | Moderate | Very High | Firms adopting new technology may inherently be more innovative. |
| Unobserved Heterogeneity | High | High | Very High | Individual characteristics like motivation affecting wage outcomes. |
| Model Specification Error/Omitted Variable Bias | High | High | High | Omitting market trends in fiscal policy impact studies. |
| Violation of Parallel Trends Assumption | High | Moderate | High | Regional labor market conditions independently improving in job training program studies. |
| Measurement Error | Moderate | Moderate | Moderate to High | Inflation affecting real value measurements in trade studies. |
| Time-Varying Confounders | High | High | Moderate | Government policy changes during a subsidy's impact analysis. |
| Dynamic Treatment Effects | Low | High | Moderate | Evolving impacts of a new tax policy over time. |
| Attrition Bias | Moderate | Moderate | Moderate | Wealthier households less likely to drop out in income inequality studies. |
| Spillover Effects | Low | High | Low to Moderate | Regional development programs affecting neighboring areas. |
| SUTVA Violation | Low | Moderate | Low | Peer effects in educational interventions. |

In this table, the relevance to local treatment effects and long-term implications are differentiated. Biases like selection bias, unobserved heterogeneity, and model specification errors are highly relevant for local treatment effect estimation, as they directly impact the validity of short-term causal inferences. On the other hand, dynamic treatment effects and spillover effects have more significant long-term implications, affecting how the treatment's impact evolves or spreads over time.