INAIL

ISTITUTO NAZIONALE PER L'ASSICURAZIONE
CONTRO GLI INFORTUNI SUL LAVORO

SCIENCE-BASED POLICY MAKING IN OCCUPATIONAL SAFETY AND HEALTH

Scientific workshop

Parlamentino Inail

via Quattro Novembre, 144 – Roma

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CNR IRCrES Istituto di Ricerca sulla Crescita Economica Sostenibile

VIPmoving

Progetto realizzato nell'ambito del Bando di Ricerca in
Collaborazione Inail 2019 – ID 18

Dipartimento di Studi Giuridici ed Economici
Sapienza Università di Roma

LA RICERCA VENUTA DAL FUTURO
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Evaluation of the impact of the ISI calls on workplace accidents

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Evaluation of the impact of the ISI calls on workplace accidents

Gabriele D'Amore

October 12, 2023

Objective of the Study

- Assess the effectiveness of ISI grants in reducing accident rates using a quasi-experimental design.
- Utilize the selection process conducted by INAIL to construct a counterfactual analysis.

Methodology

We employ a DID (difference-in-differences) model with both fixed and random effects.

- **Why Difference-in-Differences (DID) Model?**
  - The treatment effects are not instantaneously observable in our Quasi-experiment. A DID model allowes to estimate the **treatment effect over time** between a treatment group and a control group.
- **Why a Linear Mixed Model?**
  - Exogenous variables improve the reliability of estimates by explaining outcome variation and reducing sensitivity to random fluctuations, thus reinforcing the **"common trend assumption"**.
  - micro-founded longitudinal data can be described by a **hierarchical structure** of a mixed-effects model that incorporates shared effects (fixed effects) and unique effects specific to each company within the same cluster (random effects).

Method

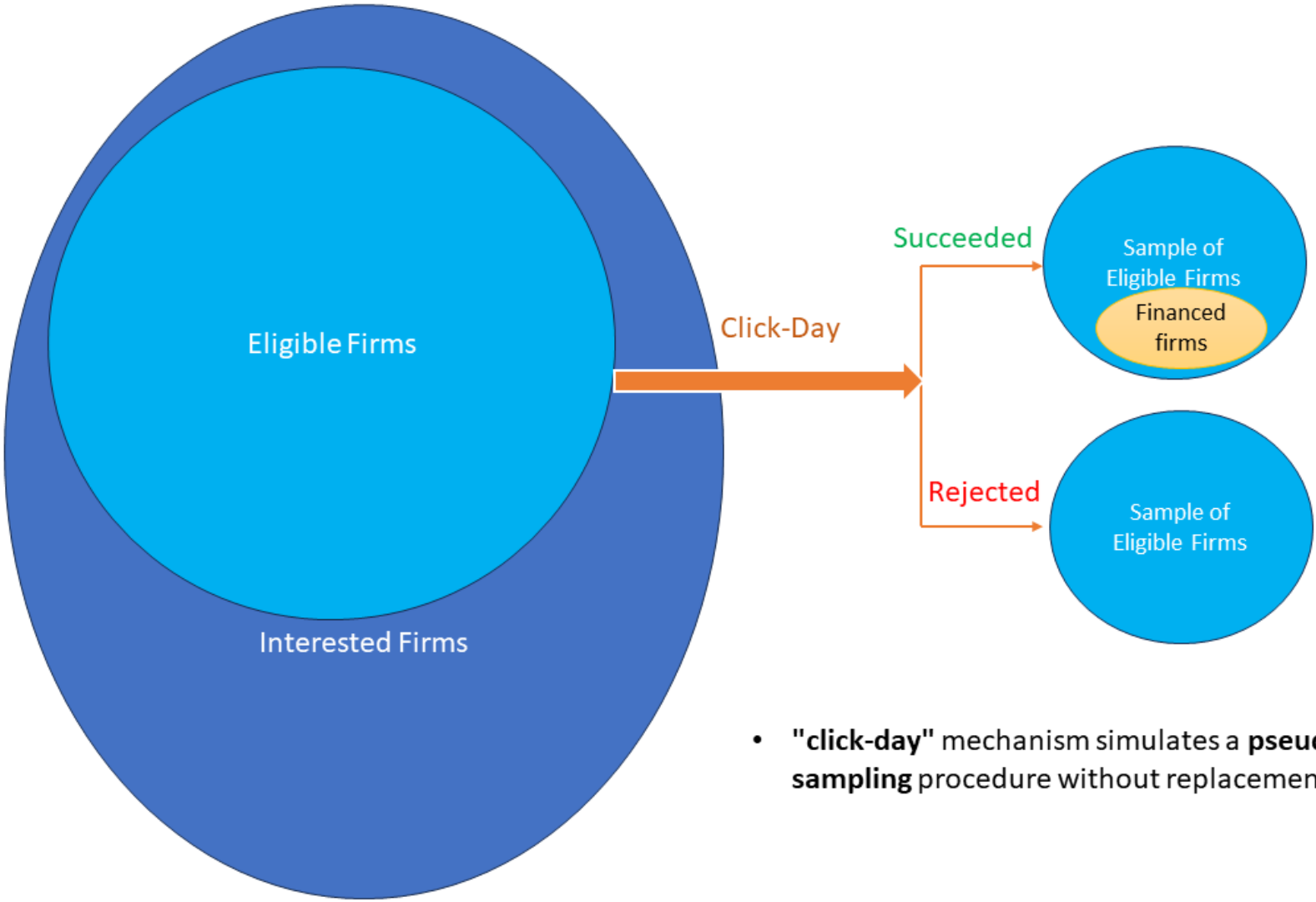
- **Quasi-Experimental Design**
  Our **treatment group** consists of companies that benefited from the ISI financing policy, while the **control group** comprises companies that did not receive this benefit.
- **Technical Issues**
  - **Problem 1:** Unobservable Counterfactual $\rightarrow$ Propensity Score Matching (PSM) (Rosenbaum, P. R., & Rubin, D. B. (1983)) or alternatively, Mahalanobis Distance Matching (MDM) (Cochran, W. G., & Rubin, D. B. (1973); Rubin, D. B. (1979); Rubin, D. B. (1980)).
  - **Problem 2:** Missing Data (MAR) $\rightarrow$ Multiple Imputation by Chained Equations (MICE) for imputation $\rightarrow$ Pooling results using Reiter's Estimator for models on semi-synthetic data.
  - **Problem 3:** Selection Bias $\rightarrow$ Including financial variables in the analysis captures the effect of a company's financial characteristics on accident rates but introduces a selection bias problem with treatment. We address this by isolating the treatment-independent component.

Problem 1: Unobservable Counterfactual

dataset was sorted to represent a **quasi-experiment** where the treatment consisted of granting non-repayable subsidies
First, we arranged the observed statistical units into **two representative groups of eligible firms**:

- (step 1) those that succeeded on **click-day**, and those that were rejected , ("click-day" mechanism was considered to simulate a pseudo-random sampling procedure without replacement).
- (step 2) we subsampled the **treatment** and **control** groups used for the counterfactual study from both these groups .

Problem 1: Unobservable Counterfactual



- **"click-day"** mechanism simulates a **pseudo-random sampling** procedure without replacement

Figure: Sampling Mechanism

Problem 1: Unobservable Counterfactual

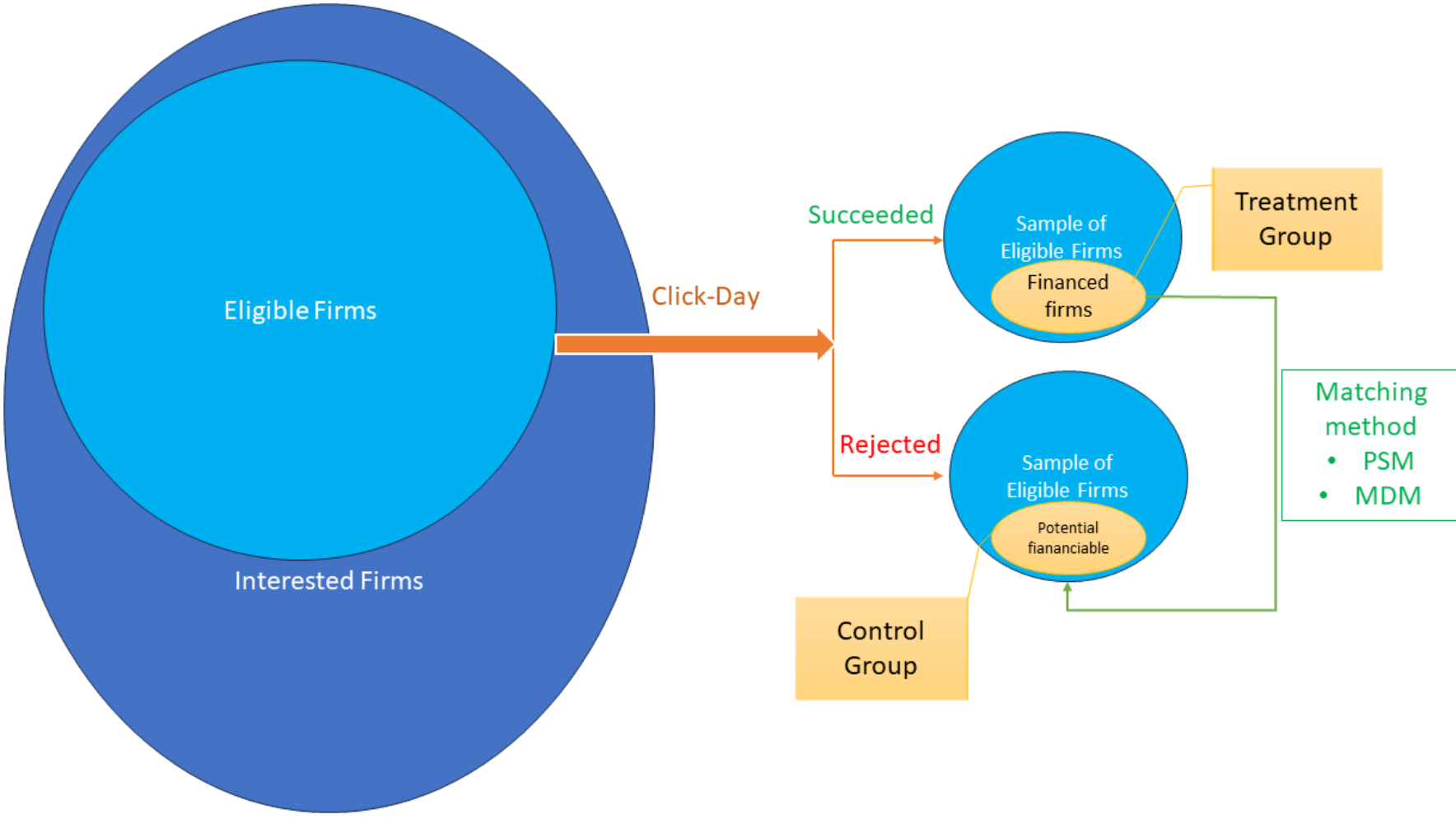


Figure: Sampling Mechanism

Problem 2: Missing Data

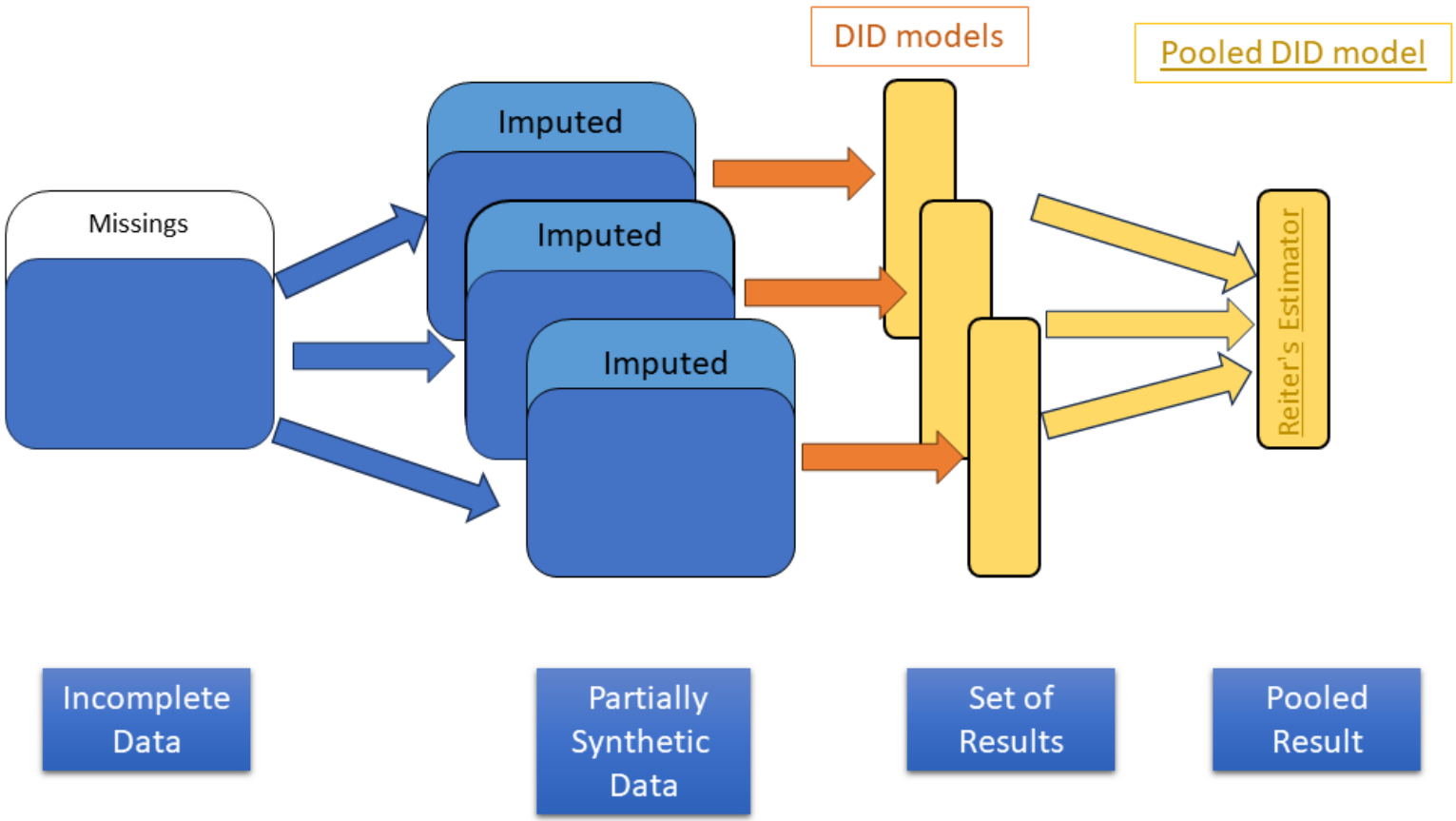
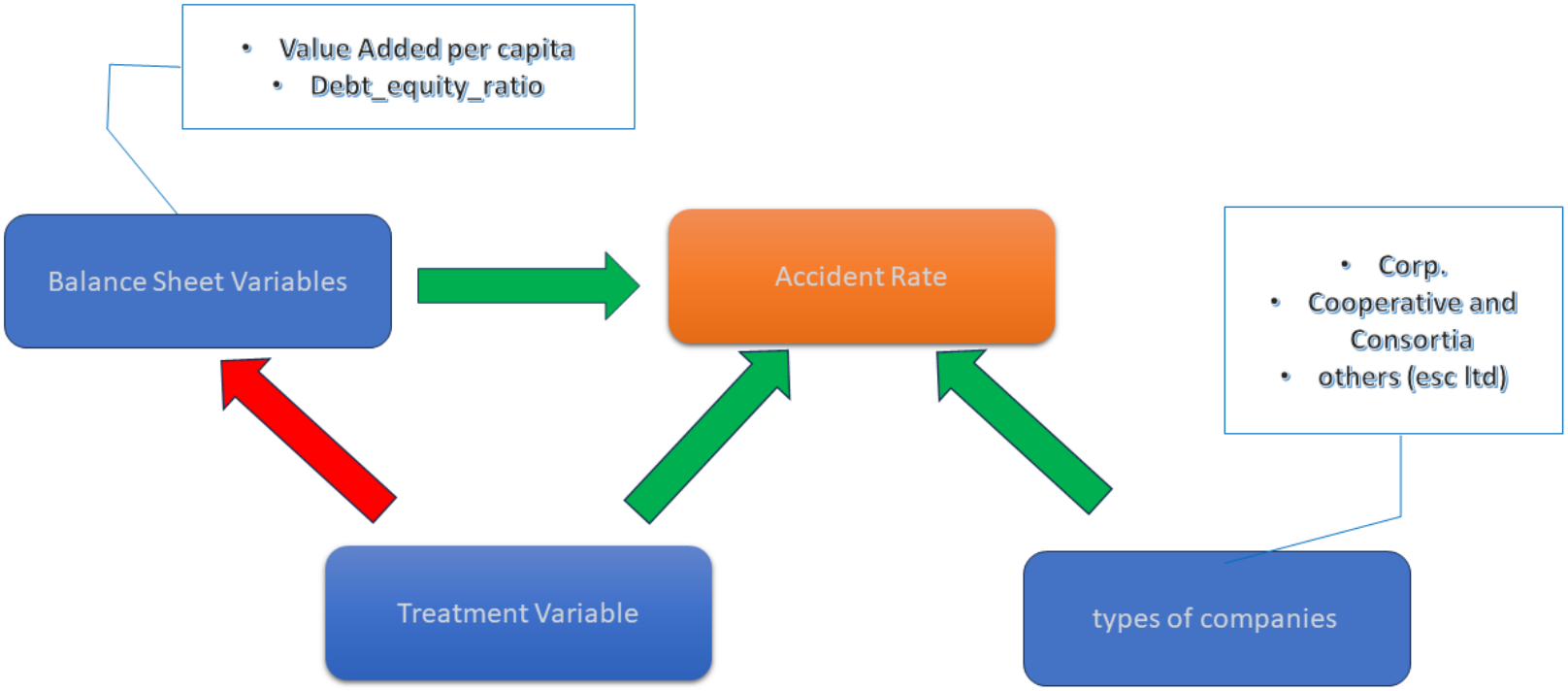


Figure: Multiple Imputation by Chained Equations (MICE)

Problem 3: Selection Bias - Confounding Variable



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Problem 3: Selection Bias - Confounding Variable

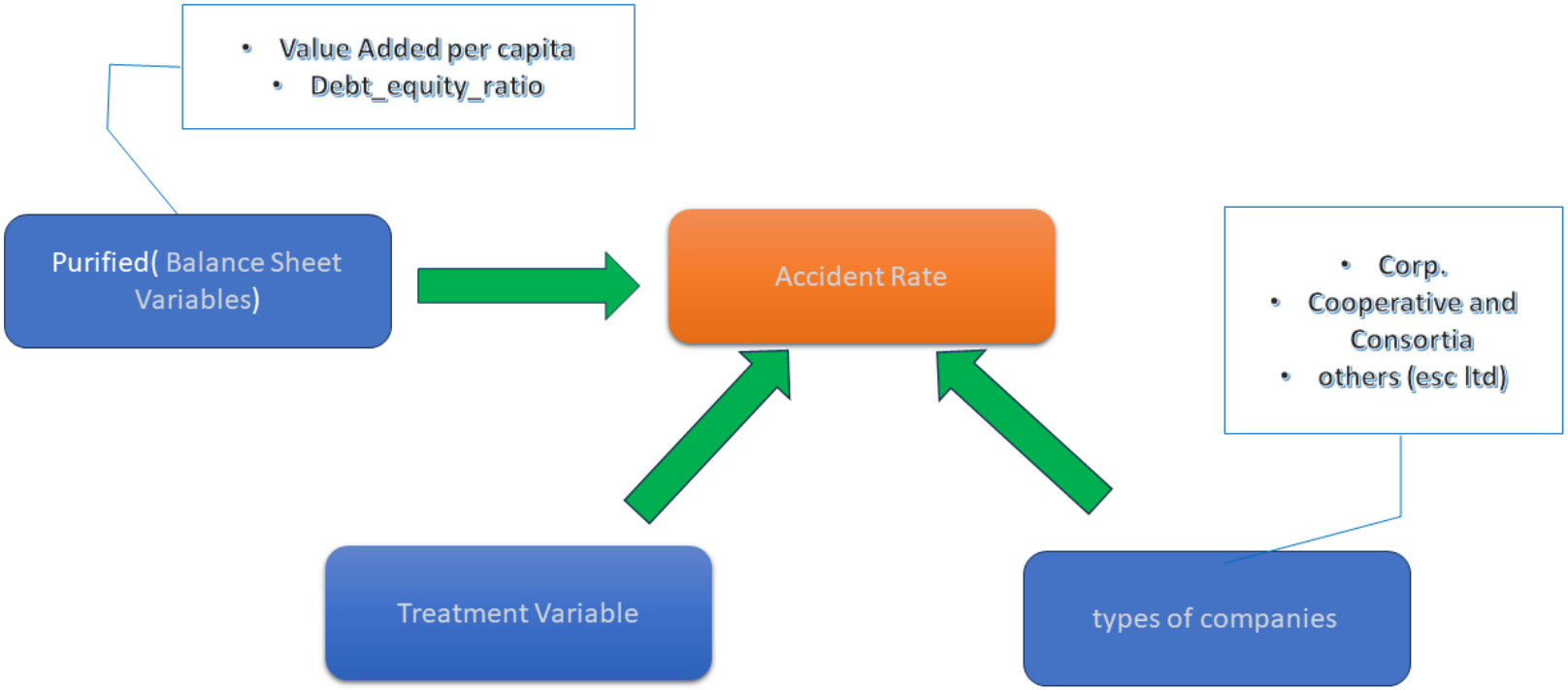

Figure: Multiple Imputation by Chained Equations (MICE)

Dataset Organization for Quasi-Experiment

- Data Sources:
  - The dataset used in this study combines information from three sources:
    - ISI call participants (INAIL database),
    - workplace accident records (INAIL database),
    - AIDA (Bureau van Dijk database) dataset containing financial data of monitored corporate companies.
- Rationale for 2013 Data:
  - We chose to work with ISI call data from 2013 due to the need for a **sufficiently long follow-up period** to observe policy impacts.
  - This edition offered a significantly higher grant amount, covering up to **65% of investment costs**, with a maximum of 130,000 euros.
- Data Cleaning:
  - exclusion of companies that had won ISI calls held before and/or after 2013. (isolate the impact of a single ISI call);
  - companies rejected at click-day are defined as those rejected at the click-day for at least one project but did not succeed on the same click-day with other projects in the same year.

Data

- Model Description (Show Formula)

$$Y_{it} = \gamma_0 + \gamma_{1i} T_i + \gamma_{2i} t + \gamma_3 DID_{it} + \gamma_4 X_{it} + u_i + \varepsilon_{it}$$

Where:

- Y_{it} outcome value for individual i at time t;
- T_i dummy vector indicating whether the firm i belongs to the treatment group;
- t dummy vector showing if the observations are got the period before or after the tretment time;
- DID_{it} Difference In Difference parameters which provides the marginal deviation from the parallel trend assumption in the treated group, after the treatment has occurred;
- X_{it} matrix of deterministic variables;
- γ_0, γ_3 and γ_4 are the deterministic coefficients of the model;
- u_i random intercept for the firm i;
- γ_{1i}, γ_{2i}, are random slopes;
- ε_{it} residual error term.

Figure: Model Description

Data

- Variables for Fixed Effect:
  - TipoAz (1 - Ltd., 2 - Corp., 3 - Cooperatives, 4 - other)
  - Tecno (High, Low)
  - Debt_equity_ratio (debt-to-equity ratio)
  - VA_pc (value added per employee)
- Variables for Random Effect:
  - PROVINCIA (territorial affiliation)
  - ATECO (type of productivity sector)
  - DIM_AZI (company size)

Fixed Effects - Covariates

The chosen variables are based on indications from the scientific literature:

- **TipoAz**: Different legal structures can influence safety policies (Scott & Nyaga, 2019).
- **Tecno**: Technological intensity can correlate with workplace safety (cf. Kogi, 2002; Zwetsloot, Schmitt-Howe, & Nielsen, 2020).
- **Debt_equity_ratio**: Companies with high levels of debt may tend to invest less in workplace safety (see Wu, X., Li, Y., & Yu, Y., 2023)
- **VA_pc**: Value added per employee can reflect resources available for safety. (Fernández-Muñiz, B. et al., 2009; Veltri et al., 2007, Ashford , 1997; Priest et al., 1979)

Random Effects - Cluster-level covariates

The random effects allow capturing the **variation unexplained** by the fixed terms of the model and modeling the **correlation** among observations within the specified groups The cluster-level covariates are:

- **Provincia:** Represents the Italian provinces to account for territorial heterogeneity. It is assumed that there is a random deviation from the overall model mean for each level of Province.
- **ATECO:** Refers to the predominant economic activity type (ATECO divisions) used to differentiate temporal trends. The associated random effects measure the additional effect of **time** differently based on the predominant economic activity type (ATECO divisions).
- **Dim_Azi:** Represents company size, measured in Annual Labor Units (ULA) of the production unit referred to in the PAT. 'Annual Labor Units' (ULA) correspond to the average number of full-time employees in a year. The associated random effects capture the residual effect of the **treatment**

Results

Table 1 Linear Mixed DID model – Fixed Effects	2011-2013 2015-2019	2011-2013 2016-2019
(Intercept)	0.0165***	0.0132***
	(0.0006)	(0.0006)
filter(Debt_equity_ratio)	0.0256	0.0615***
	(0.0132)	(0.0114)
filter(VA_pc)	−0.0262*	−0.0612***
	(0.0132)	(0.0114)
TipoAz_Corp.	−0.0073***	−0.0056***
	(0.0007)	(0.0007)
TipoAz_Cooperatives	−0.0088**	−0.0058*
	(0.0028)	(0.0026)
TipoAz_other (esc ltd.)	−0.0105***	−0.0080***
	(0.0008)	(0.0007)
Tecno_Low	0.0012	0.0029***
	(0.0006)	(0.0006)
DID	−0.0024**	−0.0027**
	(0.0009)	(0.0009)
Imputations	50	50

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Figure: Estimates

Results: Check 1

Table 2 Linear Mixed DID model – Fixed Effects	2011-2013 2015-2019	2011-2013 2016-2019
(Intercept)	0.0167***	0.0130***
	(0.0005)	(0.0005)
Debt_equity_ratio	0.0014***	0.0007
	(0.0004)	(0.0004)
VA_pc	0.0007*	0.0017***
	(0.0003)	(0.0003)
TipoAz_Corp.	−0.0071***	−0.0056***
	(0.0007)	(0.0007)
TipoAz_ Cooperative and Consortia	−0.0093**	−0.0060*
	(0.0028)	(0.0027)
TipoAz_other (esc ltd.)	−0.0107***	−0.0081***
	(0.0008)	(0.0007)
Tecno_Low	0.0012	0.0029***
	(0.0006)	(0.0006)
DID	−0.0034***	−0.0023***
	(0.0007)	(0.0007)
Imputations	50	50

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Figure: Estimates

Results: Check 2 - Falsification Test

Table 3 Linear Mixed DID model – Fixed Effects Falsification Test	**2011 2012**
(Intercept)	0.0150^{***}
	(0.0007)
filter(Debt_equity_ratio)	0.0260
	(0.0265)
filter(VA_pc)	−0.0254
	(0.0265)
TipoAz_Corp.	-0.0042^{***}
	(0.0009)
TipoAz_Cooperative and Consortia	-0.0092^{*}
	(0.0042)
TipoAz_ others (esc ltd)	-0.0080^{***}
	(0.0009)
Tecno_Low	−0.0004
	(0.0008)
DID	−0.0002
	(0.0010)
Imputations	50

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Figure: Estimates

Conclusions

- The results suggest that ISI calls result in a reduction in the accident rate by an average of 230 to 340 fewer accidents per year for every 100,000 employees.
- The most reliable estimate suggests **an average reduction of 278.5 accidents** per year for every 100,000 employees.

Thank you for your attention!