Risk Compensation after COVID-19 Vaccination

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Introduction

- Vaccine take-up is essential to address the COVID-19 pandemic.
- But, some concerns about its risk compensation effect.
  - vaccination $\uparrow \Rightarrow$ infection risk $\downarrow \Rightarrow$ social distancing $\downarrow$?
  - A medical study shows 3.2-fold increase in exposure would halve vaccination benefit.
- Our Question: Does COVID-19 vaccination reduce social distancing behaviors?
  - Exploit RD design based on birth date cutoff of vaccine rollout in South Korea
  - Use comprehensive data: survey data and credit card data
- Our Finding: No evidence of risk compensation effect

COVID-19 vaccine rollout in South Korea

- During 2021, due to vaccine shortage, the govt prioritized immunizing old people.
- Eligibility dates were determined by date of birth.

Year of birth	1st dose	2nd dose
–1946	Apr 1	Apr 22
1947–1956	May 27	Aug 12
1957–1961	June 7	Aug 23
1962–1966	July 26	Sept 6
1967–1971	Aug 16	Sept 27
1971–	Aug 26	Oct 7

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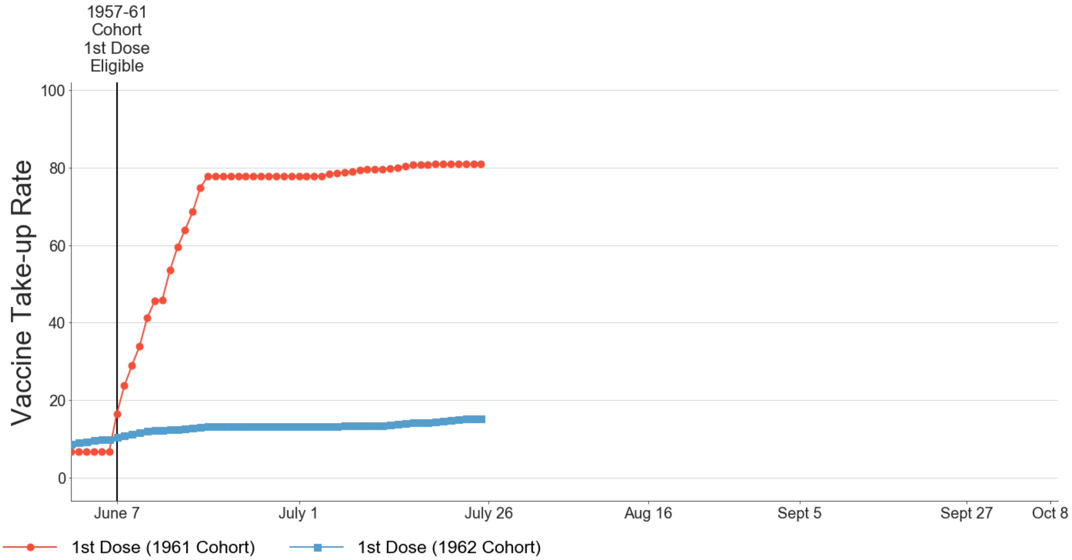
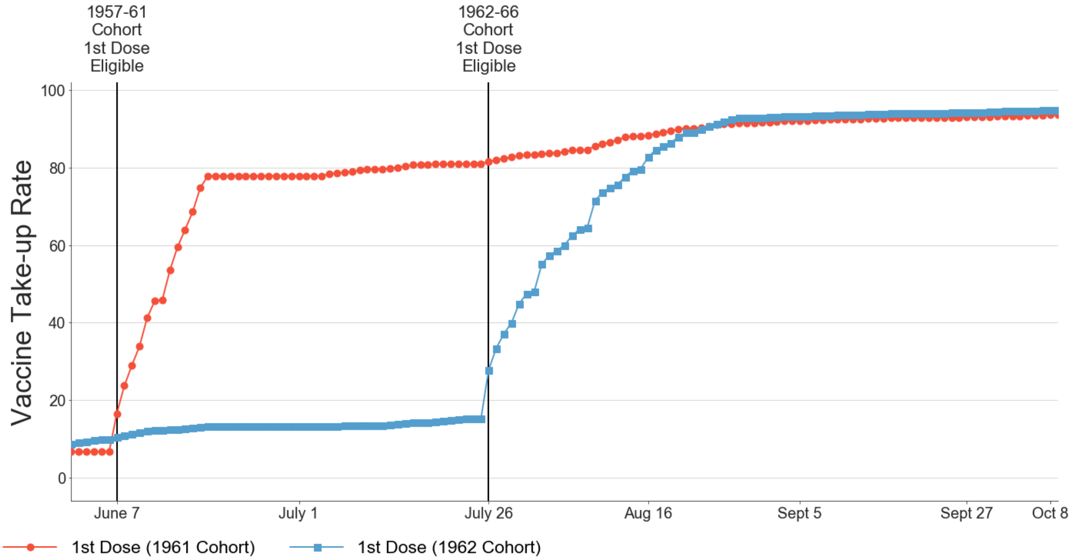
- Our main cutoff: 1961 cohort vs 1962 cohort



Source: Korea Disease Control and Prevention Agency



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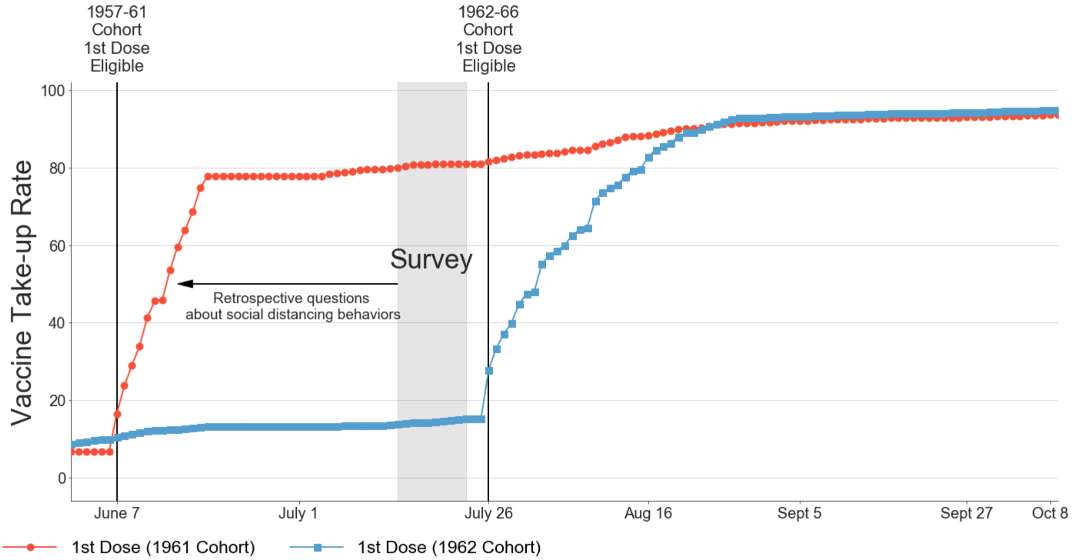

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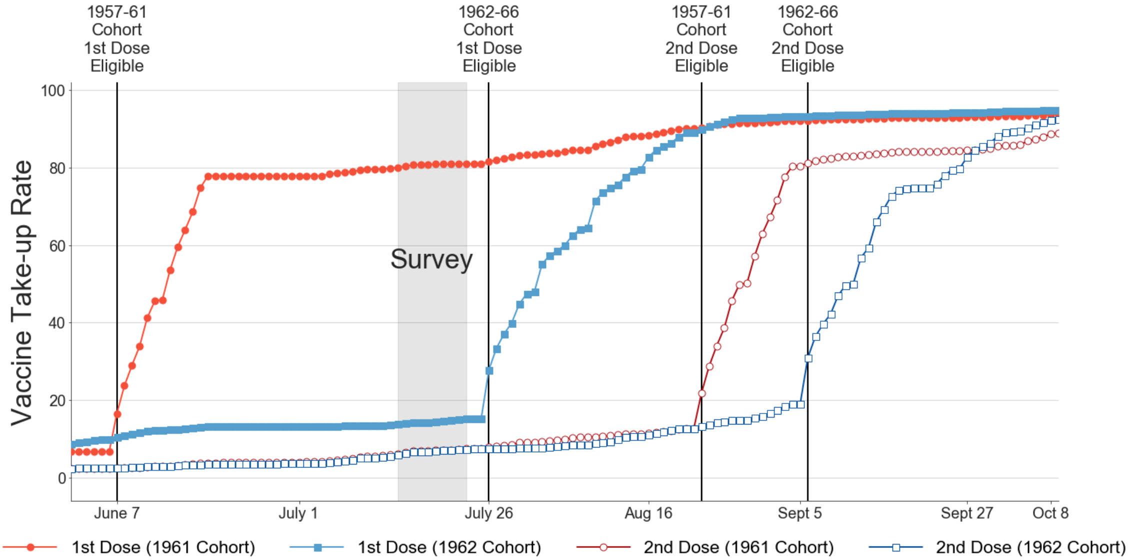

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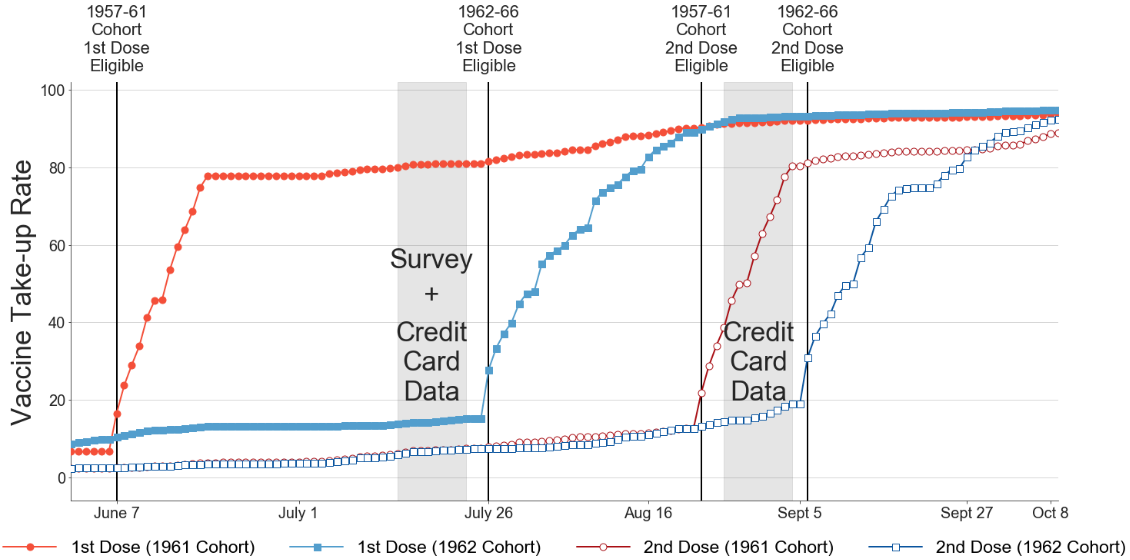

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Data

1. Survey data
   - Conduct survey for 3,018 individuals of cohort 1961–1962
   - Collect vaccine status, social distancing behaviors, individual characteristics, and perception of vaccine
   - Outcome Variable: mean of indicators for the 10 types of self-reported social activities

2. Credit card data
   - Shinhan Card: a credit card company with the largest market share (21.5%)
   - Record credit card usage by category (e.g., restaurant, travel, offline retail)
   - Outcome Variable: daily number of offline transactions

Empirical Strategy

- Fuzzy RD model using the cutoff of date of birth (DOB_i)

$$
\begin{aligned}
\text{(First Stage)} \qquad & D_i = \beta_{\text{FS}} \cdot \mathbb{I}\left(\text{DOB}_i \geq \tau\right) + f\left(\text{DOB}_i\right) + \varepsilon_i \\
\text{(Intention-To-Treat)} \qquad & Y_i = \beta_{\text{ITT}} \cdot \mathbb{I}\left(\text{DOB}_i \geq \tau\right) + f\left(\text{DOB}_i\right) + \varepsilon_i
\end{aligned} \tag{1}
$$

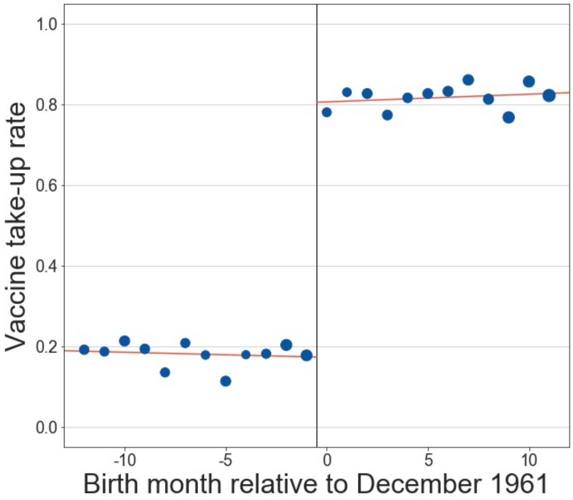
with

  - D_i: indicator of vaccine take-up
  - Y_i: outcome variable of social activities
  - τ: eligibility cutoff (Dec 31, 1961)

- Then we can identify LATE from $\beta_{\text{LATE}} = \beta_{\text{ITT}} \big/ \beta_{\text{FS}}$.
  - Interpretation of $\beta_{\text{LATE}} \Rightarrow$ risk compensation effect of vaccine compliers

First Stage Effect

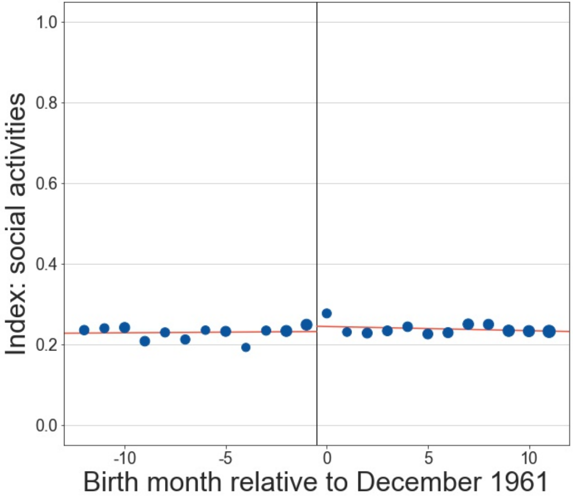
Survey Data



- A huge increase in vaccine take-up among those in the eligible group
  - $\beta_{\text{FS}} = 0.634$ (Std. Err. 0.029)
- In other words, 63.4% of those at the cutoff are vaccine compliers.

LATE

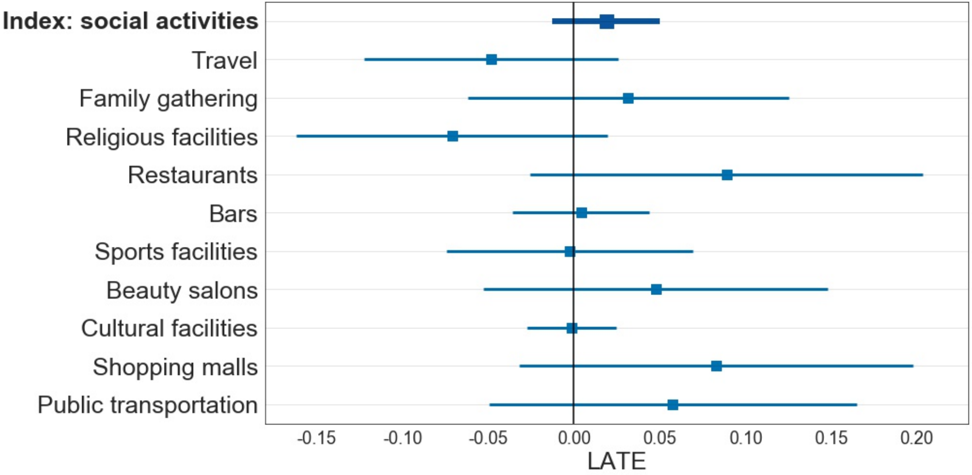
Survey Data



- No increase in social activities among those in the eligible group
  - $\beta_{\text{ITT}} = 0.012$ (Std. Err. 0.010)
- Thus, no evidence of risk compensation effect among vaccine compliers
  - $\beta_{\text{LATE}} = 0.012/0.634 = 0.019$ (Std. Err. 0.016)
- Precisely estimated zero
  - 95% confidence interval can rule out even modest effect (at most 5% point ↑)

LATE

Survey Data



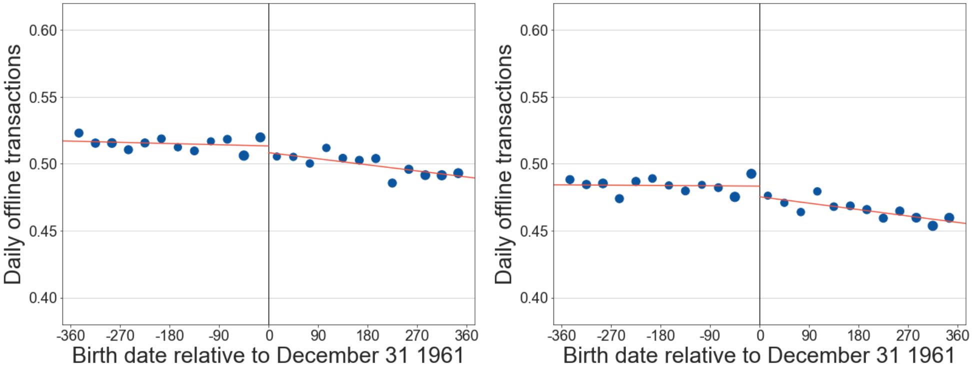
- No evidence of risk compensation effect in any social activities

Intention-to-Treat Effect

Credit Card Data

1st Dose (July 1–July 25)

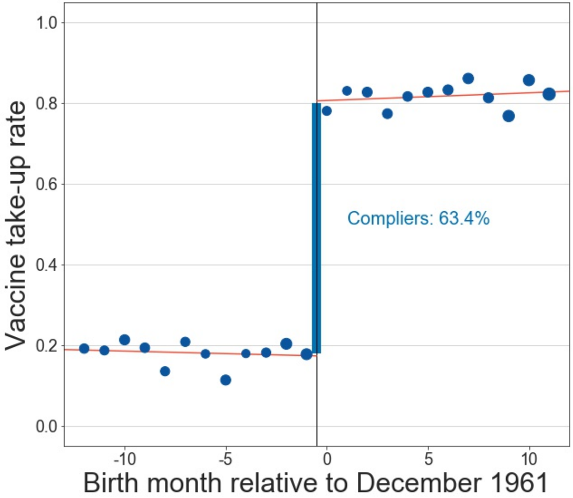
2nd Dose (Aug 26–Sept 4)



- No increase in offline transactions among those in the eligible group (if any, negative)
- We can infer no evidence of risk compensation effect.

Compliance Groups

Identification: Graphical Intuitioin



- Previous no risk compensation effect is only for vaccine compliers ($P_C = 64\%$).
- But their effect could differ from other compliance groups if they have heterogeneous characteristics.

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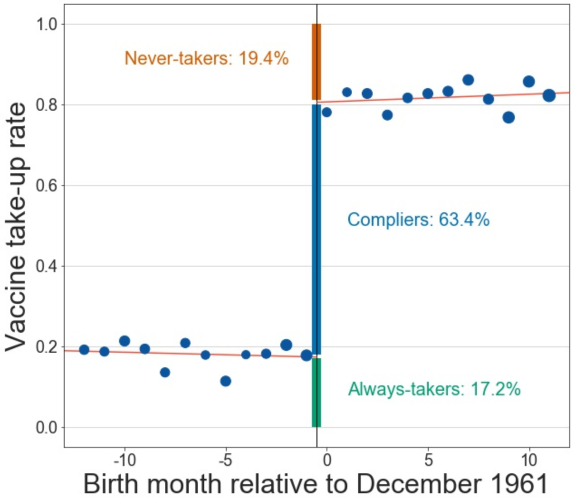
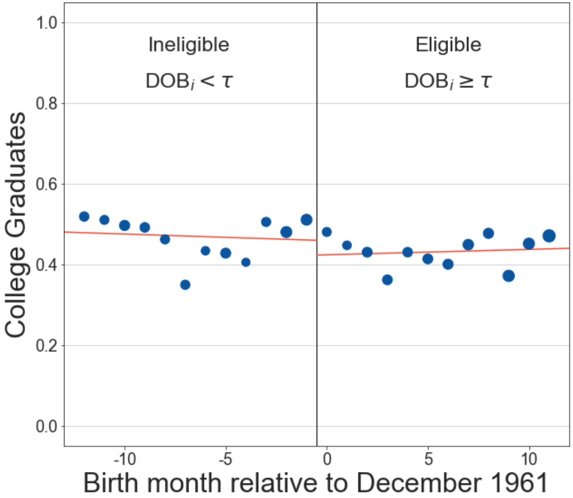


- Previous no risk compensation effect is only for vaccine compliers ($P_C = 64\%$).
- But their effect could differ from other compliance groups if they have heterogeneous characteristics.
- Definition of other compliance groups:
  - Never-takers: $\text{DOB}_i \geq \tau$ but $D_i = 0$
  - Always-takers: $\text{DOB}_i < \tau$ but $D_i = 1$

Selection Heterogeneity

Identification: Graphical Intuition



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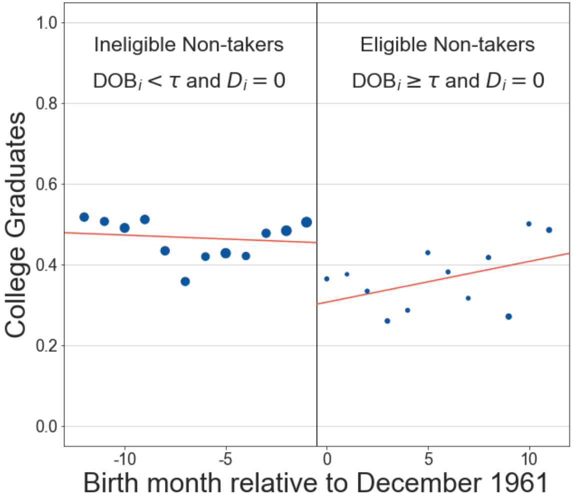

- Restricting non-takers sample $(D_i = 0)$

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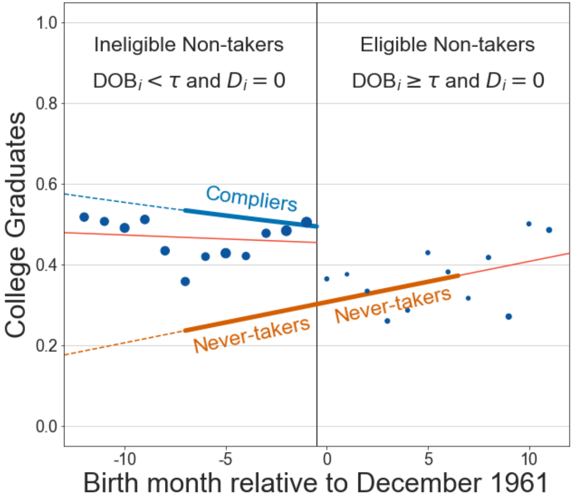

- Restricting non-takers sample $(D_i = 0)$
- $\mathbb{E}\left[X \mid \text{Ineligible Non-takers}\right]$ equals to

$$\frac{P_C}{P_C + P_N}\mathbb{E}\left[X \mid C\right] + \frac{P_N}{P_C + P_N}\mathbb{E}\left[X \mid N\right]$$

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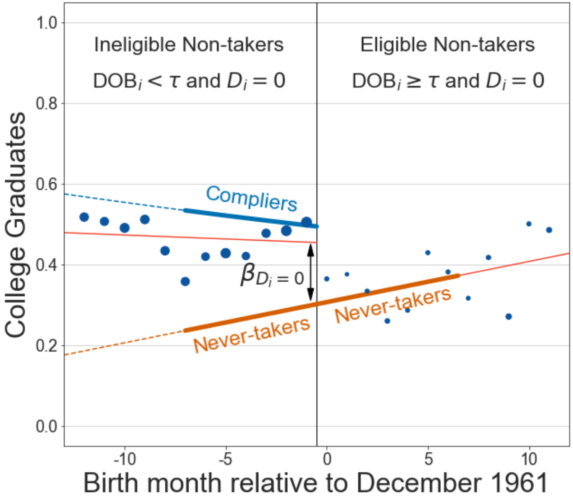

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- Identification of selection heterogeneity between N and C near the cutoff:

$$\mathbb{E}[X \mid N] - \mathbb{E}[X \mid C] = \frac{P_C + P_N}{P_C} \cdot \beta_{D_i=0}$$

- Similiarly, if restricting $D_i = 1$,

$$\mathbb{E}[X \mid A] - \mathbb{E}[X \mid C] = -\frac{P_C + P_A}{P_C} \cdot \beta_{D_i=1}$$

Selection Heterogeneity

Estimation Result

Variable	(1) Always-takers – Compliers	(2) Never-takers – Compliers
Male	-0.031	-0.108
	(0.093)	(0.089)
Married	0.042	0.002
	0.062	0.065
Middle school or less	-0.003	0.146**
	(0.054)	(0.066)
College or more	0.043	−0.192**
	(0.081)	(0.093)
White-collar job	-0.037	−0.207***
	(0.073)	(0.070)
Conservative	0.111	0.115
	(0.088)	(0.082)
Belief about vaccine effectiveness	-0.217	−1.605***
	(0.517)	(0.482)
Worry about vaccine side effects	-0.164	2.126***
	(0.596)	(0.566)

: 95%, *: 99%

- No difference between Always-takers and Compliers
- Compared to Compliers, Never-takers
  - are less educated
  - have less white-collar jobs
  - have negative belief about vaccine effects
  - worry about side effects

External Validity

Testable Restrictions

- Let $G_i \in \{A, C, N\}$ denote the compliance types.

- Our study has external validity if

$$G_i \perp \left(Y_i\left(0\right), Y_i\left(1\right)\right) \mid \mathrm{BOD}_i \tag{2}$$

- Testable restrictions of external validity near the cutoff:

$$\mathbb{E}\left[Y\left(0\right) \mid \mathrm{N}\right] - \mathbb{E}\left[Y\left(0\right) \mid \mathrm{C}\right] = \frac{P_{\mathrm{C}} + P_{\mathrm{N}}}{P_{\mathrm{C}}} \cdot \beta_{D_i=0} = 0 \tag{3}$$

$$\mathbb{E}\left[Y\left(1\right) \mid \mathrm{A}\right] - \mathbb{E}\left[Y\left(1\right) \mid \mathrm{C}\right] = -\frac{P_{\mathrm{C}} + P_{\mathrm{A}}}{P_{\mathrm{C}}} \cdot \beta_{D_i=1} = 0 \tag{4}$$

- The failure to reject the joint test of (3) and (4) lends support to external validity (Bertanha and Imbens 2020).

External Validity

Test Result

Variable	(1) Always -takers	(2) Treated compliers	(3) Untreated compliers	(4) Never -takers	$(1)-(2)$	$(3)-(4)$	$(1)-(2)=0$ and $(3)-(4)=0$
	Means at the cutoff				Difference in Means		Joint F-Test
Index: social activities	0.250 (0.019)	0.248 (0.012)	0.227 (0.021)	0.223 (0.008)	0.002 (0.026)	0.004 (0.023)	0.039 [0.981]

- We can conclude that selection in vaccine take-up does not necessarily imply treatment effect heterogeneity.

Conclusion

- We study the causal effect of COVID-19 vaccination on social distancing behaviors.
    - Exploit RD design based on birth date cutoff of vaccine rollout in South Korea
    - Use comprehensive data: survey data and credit card data

- Find no evidence of risk compensation effect for all vaccine compliance groups

Thank you!