

# The effect of government subsidies on firm-level productivity

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## Abstract

We empirically analyze government subsidies' impact on individual firms' productivity using data from firms that received subsidies from the Korean government between 2013 and 2022. **We find an increase in the productivity of firms that received subsidies with effects decreasing over time.** When examining the **persistent component of productivity, we find a small but continuous increase after one period of receiving subsidies.** This suggests that subsidies can have a small but long-lasting increase in productivity. Additionally, we identify heterogeneous treatment effects using a Generalized Random Forest.

## Introduction

### Motivation

- Firms facing financial constraints are expected to have difficulty investing in capital, labor, and research and development.
  - These challenges can hinder the firms' growth by limiting productivity growth.
- Government subsidies are anticipated to help such firms overcome financial constraints, thereby increasing firm-level productivity. Since productivity is a key economic variable at both the country and firm levels, analyzing the effect of subsidies on productivity growth is important.
- There is no consensus about the effect of subsidies on productivity growth (Li *et al.*, 2022; Harris and Trainor, 2005; Bernini and Pellegrini, 2011; Criscuolo *et al.*, 2019).
  - Negative effect explanation: firms receiving subsidies do not exert more effort to enhance productivity compared to those without subsidies.

## Data

- Comprehensive dataset that merges firm-level information with administrative data on Korean Small and Medium Enterprise
  - Have firm-level characteristics, financial variables, and government support histories.
- Treatment group: Private firms that participated in a government financial program aimed at firm growth between 2013 and 2022.
  - Exclude firms that received treatment more than once.
- Control group: With propensity score matching, we select private firms similar to the treated firms by treatment year cohort among the never-treated firms.

## Empirical methods

### Productivity Estimation (Wooldridge, 2009)

Generalized Method of Moments setup of the proxy variable approach

Interested in Total Factor Productivity:  $\omega_{i,t} + \eta_{i,t}$

$$y_{i,t} = \alpha + l_{i,t}\beta + k_{i,t}\gamma + m_{i,t}\tau + \omega_{i,t} + \eta_{i,t}$$

$y_{i,t}$ : Logarithm of output

$l_{i,t}$ : Logarithm of labor

$k_{i,t}$ : Logarithm of capital

$m_{i,t}$ : Logarithm of intermediate inputs

$\omega_{i,t}$ : Persistent component (follows Markov process and impacts firm's decision)

$\eta_{i,t}$ : i.i.d component (not known when firm's make decision)

- Use **Difference-in-Difference** with multiple time periods (Callaway and Sant'Anna, 2021), specifically the Doubly Robust estimation method (CS-DID).

Parameter of interest: group-time treatment effect

$$ATT(g, t) = E[Y_t(g) - Y_t(0) | G_g = 1], \text{ for } t \geq g$$

$Y_t(s)$ : Outcome at time  $t$  when the treatment period is  $s$ .  $s = 0$  means not treated.

$t$ : current time period

$g$ : Time period when a unit is first treated

$G_g$ : Group treated at time period  $g$

### Generalized Random Forest (Athey *et al.*, 2019)

A random forest-based approach is used to estimate the heterogeneity of SME support policies non-parametrically.

After training the machine learning model, use Targeting Operator Characteristic (TOC) to assess heterogeneity in treatment effect  $\tau(X)$ . Let  $q \in (0, 1]$  be the fraction of samples treated.

$$TOC(q) = E[Y_t(1) - Y_t(0) | X_i \geq F_{X_i}^{-1}(1 - q)] - E[Y_t(1) - Y_t(0)]$$

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## Results

- Figure 1 contains the estimation results from CS-DID with 99% confidence intervals for productivity. We find that government **subsidies increase firms' productivity**, but the effect decreases over time.
- The overall average treatment effect is estimated to be a 3% increase in productivity after receiving subsidies.
- Figure 2 contains the estimation results for the persistent component. we find a small but significant and positive effect of subsidies as time lapses.
- Overall average treatment effect for the persistent component is insignificant.

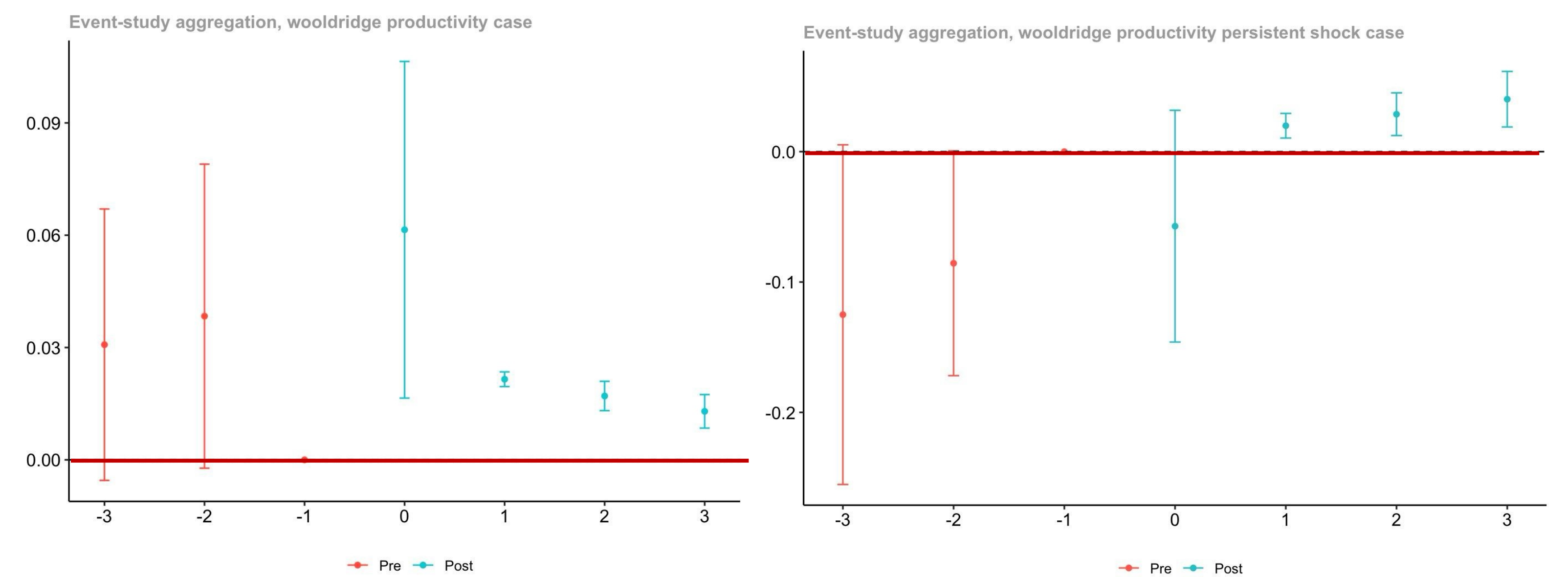


Figure 1. Productivity increase by subsidy lapse

Figure 2. Persistent component increase by subsidy lapse

	Overall	$e = -3$	$e = -2$	$e = 0$	$e = 1$	$e = 2$	$e = 3$
Wooldridge productivity	0.028*** (0.004)	0.031 (0.012)	0.038 (0.014)	0.062*** (0.016)	0.022*** (0.001)	0.017*** (0.001)	0.013*** (0.0016)
Persistent	0.008 (0.008)	-0.125 (0.042)	-0.086 (0.031)	0.057 (0.027)	0.020*** (0.003)	0.029*** (0.006)	0.040*** (0.008)

Note: \*\*\*p<0.01

Table 1. Event study estimation results

## Heterogeneous treatment effects

- We find that firms with lower debt experience more significant increases in productivity than those with higher debt levels.
  - In Figure 3, when the book leverage ratio (Debt / Total Assets) is low, the treatment effect exceeds the average until the full sample is covered.
  - Possible interpretation: firms with high levels of debt may prioritize servicing their liabilities, which could constrain their ability to reinvest earnings into productivity-enhancing activities.
- While heterogeneity is statistically small for the persistent component, firms with medium or high book leverage ratios exhibit a treatment effect that exceeds the average.
  - Suggestive evidence that firms with high debt levels may first prioritize paying off liabilities and then invest in productivity-enhancing activities.

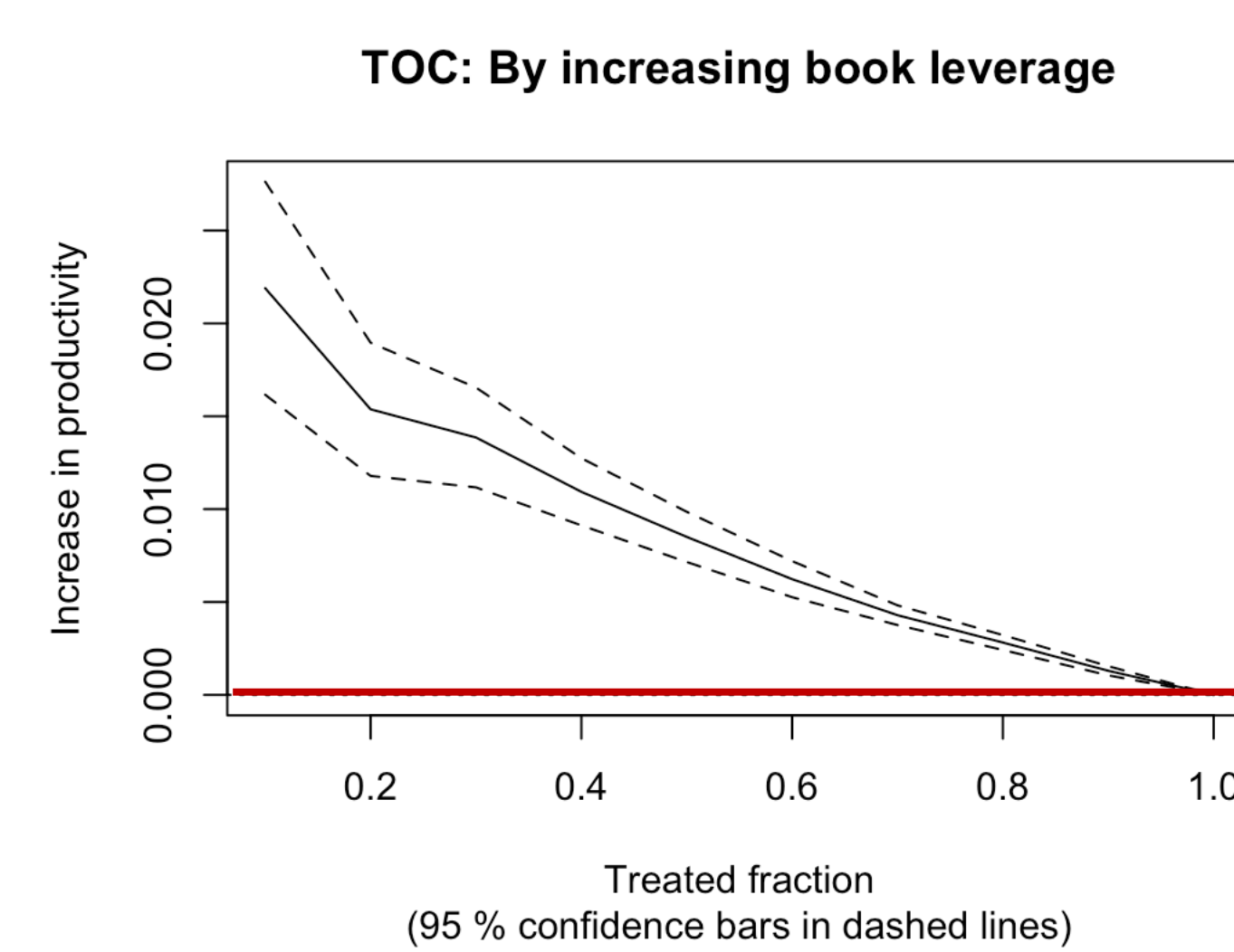


Figure 3. TOC by increasing book leverage ratio

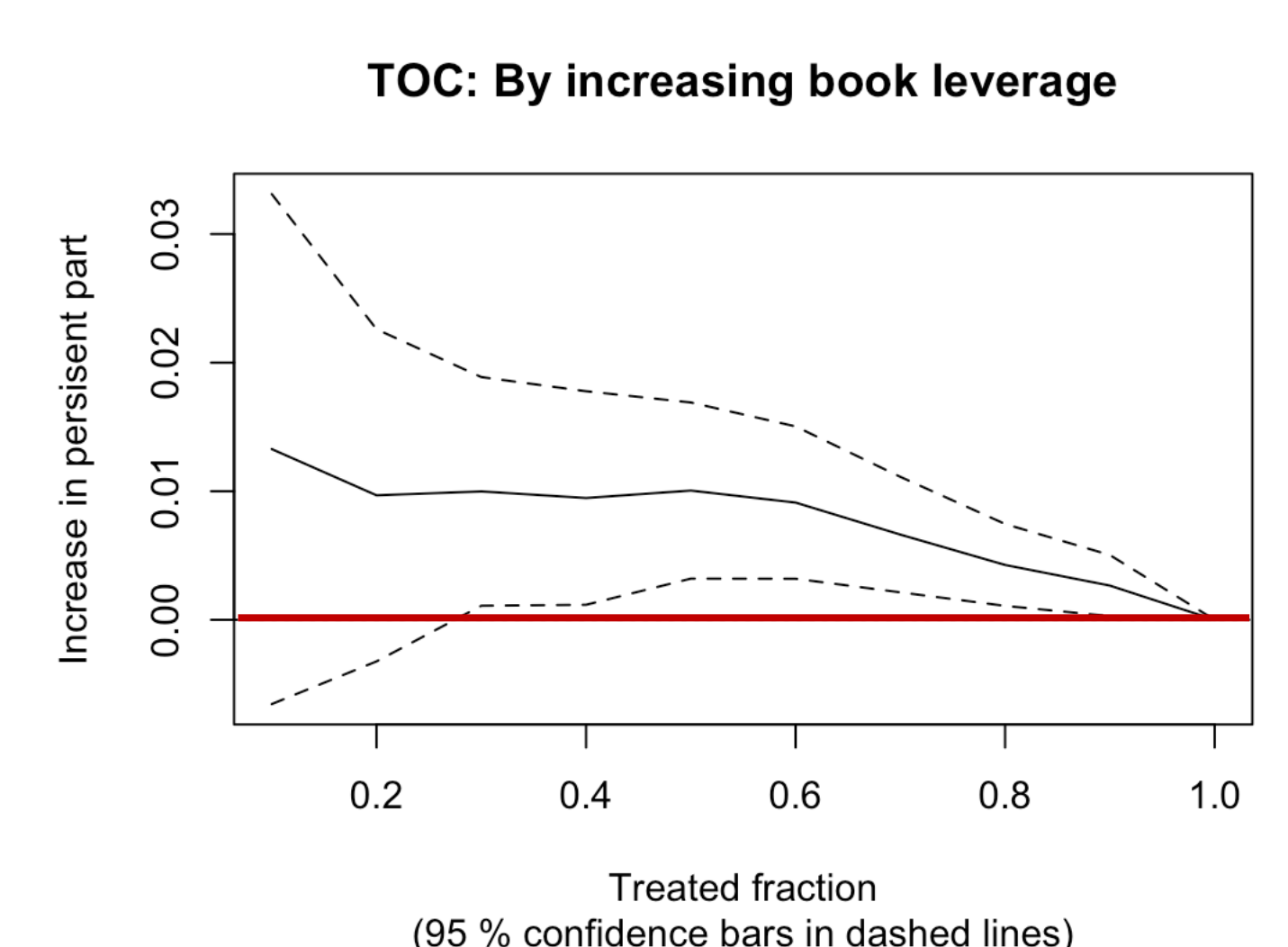


Figure 4. TOC for persistent component by increasing book leverage ratio

## Conclusion and policy implication

- We find that government subsidies increase productivity, but the effect decreases over time. However, the persistent component of firm-level productivity increases as time passes, suggesting subsidies have a small but long-lasting impact on productivity.
- Heterogeneous treatment analysis suggests that targeting firms with low book leverage ratios can further increase productivity, while targeting firms with medium/high levels can further increase the persistent component.

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