

Comprehensive Smoke-Free Policies and Smoking in South Korea: Using Synthetic Control Method

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Tobacco Online Policy Seminar



Disclosures

- This work is not supported by any funding.
- The author has received no tobacco-related funding over the past 10 years.

Introduction

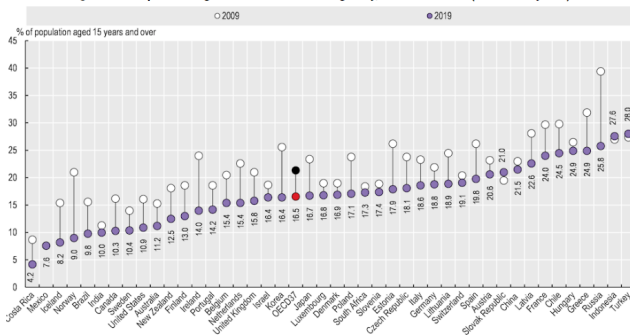
Smoking is a Major Concern in South Korea

- Approximately 58,000 people experience premature death related to smoking each year (Jung et al., 2013).
- Oh et al. (2012) estimated the total economic cost of smoking related cancers reached \$3 billion in 2008.

Introduction

OECD Countries Smoking Prevalence in 2009 and 2019

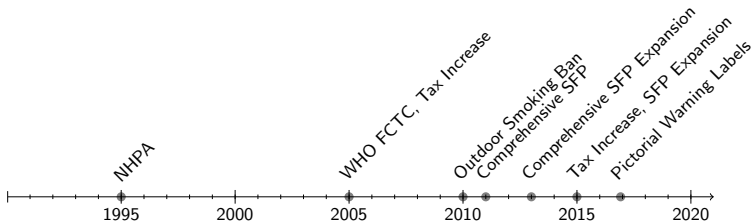
Figure 4.2. Population aged 15 and over smoking daily, 2009 and 2019 (or nearest years)



Source: OECD Health Statistics 2021.

- South Korea is the **8th highest** smoking rates among population aged 15 and over in 2009.

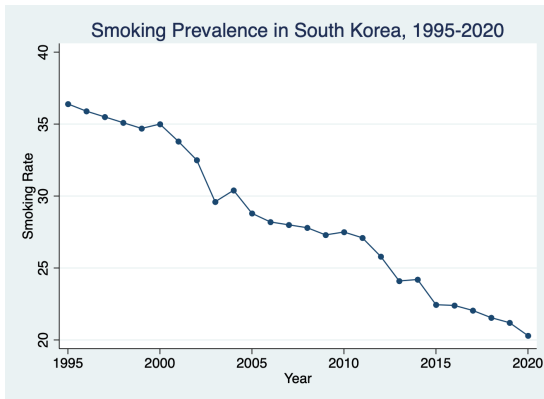
Background



- 1995: National Health Promotion Act (Began partial SFP)
- 2005: Price Increase 25% (\$1.80 to \$2.30), ratified WHO FCTC
- 2010: Local government gained authority to regulate outdoor smoking bans (**Active implementation after 2011**).
- 2011: **Comprehensive SFP**: public transport, government buildings, medical facilities, nurseries, schools, large restaurants and bars, large buildings and theaters.
- 2013: **Comprehensive SFP expansion**: Indoor spaces larger than $150m^2$.
- 2015: **Price Increase 80% (\$2.30 to \$4.10)**, C-SFP expansion to all indoor spaces.
- 2016 Dec: **Mandate Pictorial Warning Labels**.

Background

Smoking Prevalence in South Korea from 1995 to 2020



Source: Korea National Health and Nutrition Examination Survey (KNHANES)

Overview

Research Question

- To plausibly causally estimate the treatment effect of national and simultaneous policy, comprehensive SFP in reducing the smoking rates.

Data

- International Smoking Statistics (ISS)
- Korean National Health and Nutrition Examination Survey (KNHANES)
- World Health Organization (WHO) tobacco use data
- World Development Indicators (WDI) data.

Preview of results

- The Korean comprehensive SFP reduced smoking prevalence by an average of **2.3 percentage points ($p < 0.036$)** from the 27.1% smoking rate in 2011 (**8.5% reduction**).

Previous Findings

Evidence in South Korea

- Most studies are pre/post analyses, not causal studies.
 - Comprehensive SFP improved
 - Indoor air quality in bars (Kim et al., 2016).
 - Reduced SHS in hospitals, internet cafes, karaoke, and billiard halls (Park et al., 2019).
 - Increased awareness of SHS harms, and increased support for expanding SF areas (Park et al., 2020).
 - Decreased in adolescent smoking for both boys and girls (Kang et al., 2018).
- Ko (2020) causally estimated the effect of outdoor smoking ban. Ko found no effect on reducing smoking prevalence, but increased quit attempt.

Previous Findings

Evidence in Other Countries

- Several causal studies have shown that SFL or IAL reduced smoking prevalence.
 - In the U.S., Carton et al. (2016) found the comprehensive indoor bans are associated with a 2.3% to 3.3% average reduction in smoking prevalence.
 - In Switzerland, Boes et al (2015) found 1% reduction in smoking prevalence.
 - In Germany, SFP in bars reduced smoking behavior of people who go out to bars often, but no change in average smoking rate (Anger et al., 2011).
- The empirical evidence regarding the effectiveness of comprehensive indoor smoking bans in reducing smoking prevalence is **mixed**.

Research Question & Contribution

Research Question

- To plausibly causally examine how effective was the comprehensive SFP (non-price policy) in reducing the smoking rates in South Korea.
- Using synthetic control method (SCM) to causally estimate treatment effect for national and simultaneous policy.

Contribution

- This study uses SCM to estimate the effect of nationwide, simultaneous policy, case in South Korea.
- Our study contributes to the current literature on non-price tobacco control policies and Korean tobacco control policies.
- Hand-collected country-level panel data on smoking prevalence might be handy for future research.

Data

28¹ OECD Countries from 1995 to 2015

- Smoking Prevalence²
 - International Smoking Statistics (Forey et al., 2016)
 - Korean National Health and Nutrition Examination Survey (KNHANES)
 - World Health Organization (WHO) tobacco use data
- National Indicators
 - World Development Indicators (WDI) provided by World Bank

¹From 38 OECD countries, 10 countries were excluded since there is no consistent data on smoking prevalence.

²Since some countries collect smoking prevalence data in every two or three years, missing data points exist. I assumed a linear trend between missing data points.

Difference-in-Differences is not valid

Path Plot of Smoking Prevalence During 1995-2020: South Korea Versus OECD Average of the 27³ Donor Countries



³27 donor countries include Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, France, Finland, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Israel, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, the United States, and the United Kingdom.

Method

Synthetic Control Method (SCM)

- **Abadie (2021)**; Abadie and Gardeazabal (2003), **Abadie et al. (2010)**, Andersson (2019)

SCM begins from synthesizing the control unit by finding the **weights**.

$$\hat{Y}_{1t}^N = \sum_{j=2}^{J+1} w_j Y_{jt} \quad (1)$$

Weights are chosen $\mathbf{W} = (w_2^*, \dots, w_{J+1}^*)'$ that minimizes Root Mean Squared Prediction Error (RMSPE).

$$\|X_1 - X_0 \mathbf{W}\| = \left(\sum_{h=1}^k v_h (X_{h1} - w_2 X_{h2} - \dots - w_{J+1} X_{hJ+2})^2 \right)^{1/2} \quad (2)$$

Method

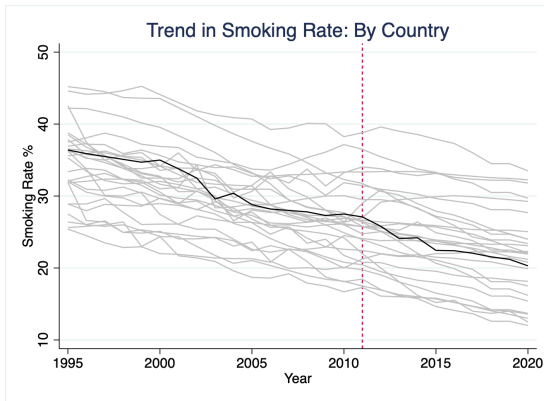
and Treatment Effects are estimated as follows:

$$\hat{\tau}_{1t} = Y_{1t} - \hat{Y}_{1t}^N = Y_{1t} - \sum_{j=2}^{J+1} w_j Y_{jt} \quad (3)$$

- The synthetic control unit is synthesized by finding the weights.
- The weights are chosen that minimizes the mean squared prediction error for predictors in pre-intervention period.
- The treatment effects are estimated by taking simple difference of outcomes between the treated units and the synthesized control unit in post-intervention period.

Method

SCM are not good for synthesizing outliers.



Donor Pool

28 OECD Countries

- From 38 OECD countries, 10 countries were excluded since there is no consistent data on smoking prevalence.
Chile, Colombia, Costa Rica, Latvia, Lithuania, Luxembourg, Mexico, Slovak Republic, Slovenia, Turkiye
- Treated unit: South Korea
- Donor pool to synthesize the control unit
Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, France, Finland, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Israel, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, United State, United Kingdom

Predictors

Outcomes

- Smoking rate in 2000
- Smoking rate in 2006
- smoking rate in 2010

Covariates

- log of GDP per capita
- Proportion of Population aged 20-29
- Proportion of Agricultural, Forestry, and Fishery
- Alcohol consumption per capita

Descriptive Statistics on Real Korea vs. Synthetic Korea

Table: Descriptive Statistics

	Real Korea	Synthetic Korea
log GDP per Capita	9.84	10.16
Percent Aged 20-29	33.57	30.72
Industry: Agriculture & Forestry & Fishery	3.36	3.36
Alcohol Consumption per Capita	10.95	10.95
Smoking Rate 2000	35.00	34.09
Smoking Rate 2006	28.20	28.70
Smoking Rate 2010	27.50	27.22

Weights

Table: Composition of Synthetic Korea (Weights)

Country	Weight	Country	Weight
Australia	0	Greece	0.16
Austria	0.10	Hungary	0
Belgium	0	Ireland	0.17
Canada	0	Iceland	0.17
Switzerland	0	Israel	0.12
Czech Republic	0.28	Italy	0
Germany	0	Japan	0
Denmark	0	Netherlands	0
Spain	0	Norway	0
Estonia	0	New Zealand	0
Finland	0	Poland	0
France	0	Portugal	0
United Kingdom	0	Sweden	0
United States	0		

Main Results

Figure: SCM: Plot Path of Smoking Prevalence

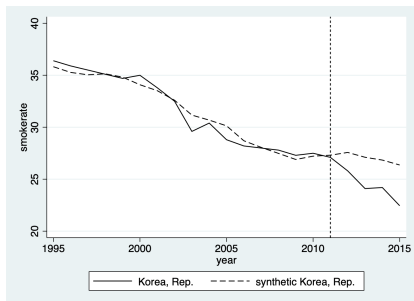
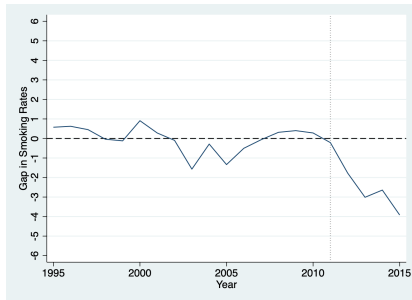


Figure: SCM: Gaps



● ATT: -2.3117 sd: 0.6275 [▶ Appendix](#) [▶ Price](#) [▶ Other Tobacco](#)

Placebo Test: In time

Figure: The Placebo Treatment Introduced in 2005.

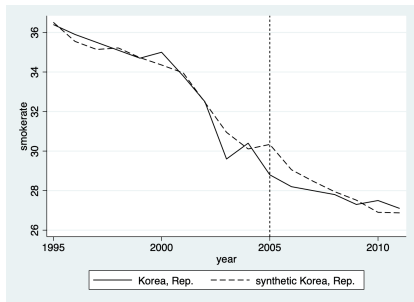
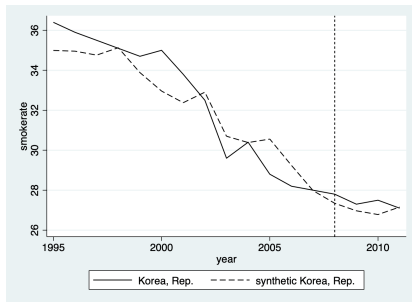


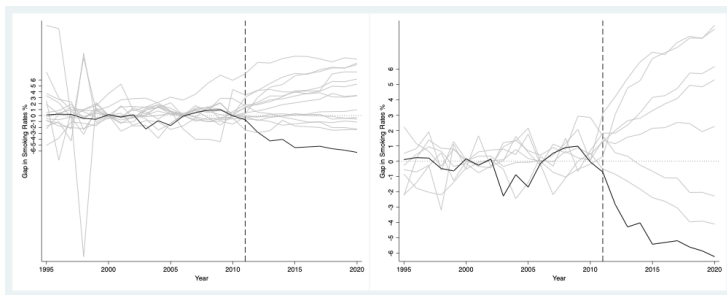
Figure: The Placebo Treatment Introduced in 2008.



- We find that this placebo treatment doesn't result in a post-placebo-treatment divergence in the trajectory of smoking prevalence between South Korea vs. its synthetic control.

Placebo Test: In place

Figure: In Place Placebo Test: Left Panel 27 Countries and Right Panel 7 Countries



- The placebo treatment is introduced to each countries in the donor pool: Left panel includes 27 countries. Countries that have RMSPE larger than 1.25 are excluded to form the right panel. The p -value of estimating a gap of this magnitude is $1/28 = 0.036$.

Augmented Synthetic Control Method

Ben-Michael et al. (2021)

Figure: ASCM: Plot Path of Smoking Prevalence

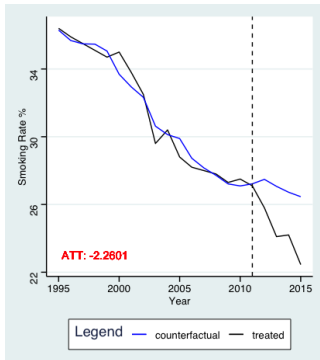
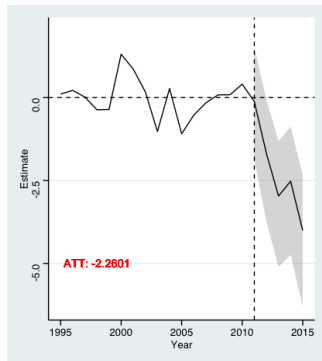


Figure: ASCM: Gaps



Conclusion & Discussion

Conclusion & Discussion

- Considering tobacco control policy implementation and the increase in cigarette prices in other countries, the estimated effects is the **lower bound estimation**.
- Comprehensive SFP in Korea significantly reduced smoking prevalence by an average of 2.3%p ($p < 0.036$) from the 27.1% smoking rate in 2011.
- This represents an 8.5% reduction when compared to a scenario without the policy.
- Robust to placebo tests and using augmented SCM.
- In other words, the comprehensive SFP deterred approximately 1.2 million people from smoking.
 - Encouraging smokers to quit.
 - Preventing the initiation of new smokers.

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Tobacco Control Policies in Other Countries

Tobacco control policies in countries that received positive weights in synthetic Korea

▶ Main Results

- Austria (0.10)
 - 95: Federal Tobacco Act
 - 05: Signed WHO FCTC
 - 08: Expansion on No Smoking signs
 - 16: Mandate on pictorial warning labels
 - 19: Total ban on smoking bars and restaurants
- Czech Republic (0.28)
 - 95: Advertisement regulation on tobacco
 - 03: Mandate on text warning labels
 - 05: Smoke free zone on schools, medical facilities, and public area
 - 12: Signed WHO FCTC
 - 16: Mandate on pictorial warning labels

Tobacco Control Policies in Other Countries

Tobacco control policies in countries that received positive weights in synthetic Korea (Cont.)

- Greece (0.16)
 - 03: Advertisement regulation on tobacco
 - 06: Signed WHO FCTC
 - 09: Smoke free zone on schools, healthcare facilities, indoor working area, and public area
 - 16: Mandate on pictorial warning labels
- Ireland (0.17)
 - 04: Smoke free zone on schools, healthcare facilities, indoor working area, public area, restaurants, and bars
 - 05: Signed WHO FCTC
 - 16: Mandate on pictorial warning labels

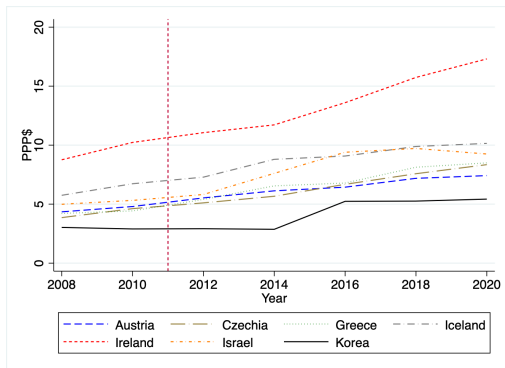
Tobacco Control Policies in Other Countries

Tobacco control policies in countries that received positive weights in synthetic Korea (Cont.)

- Iceland (0.17)
 - 02: Smoke free zone on schools, healthcare facilities, indoor public gatherings
 - 03: Mandate on text warning labels
 - 05: Signed WHO FCTC
 - 07: Smoke free zone on public area and business
 - 16: Mandate on pictorial warning labels
- Israel (0.12)
 - 83: National tobacco controls began, no smoking in public spaces
 - 02: Mandate on text warning labels
 - 05: Signed WHO FCTC
 - 12: Smoke free zone on schools and hospitals

Tobacco Prices in Other Countries

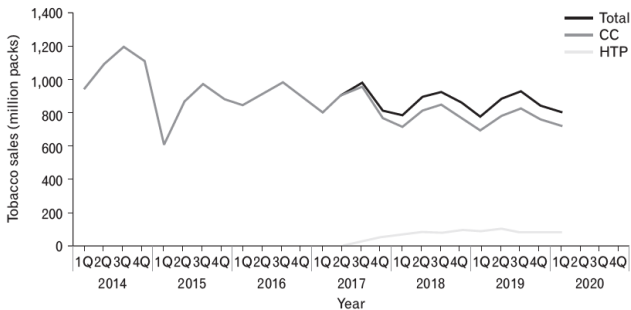
Most sold brand of cigarette prices in PPP\$ by countries that received positive weights in synthetic Korea [▶ Main Results](#)



Source: Global Health Observatory Data

Heated Tobacco Products

Trends in Heated Tobacco Sales in Korea, 2014-2020

[▶ Main Results](#)

Source: Lee (2020)

Electronic Nicotine Delivery System

The prevalence of e-cigarette among adults between 2013 - 2015

▶ Main Results

- In 2013, 0.9%.
- In 2014, 1.4%
- In 2015, 2.6%
- However, the increasing prevalence of e-cigarette may not significantly bias our results due to the high rate of dual use between conventional cigarettes and e-cigarettes.