

# Energy-efficient LED street lighting in Chilean municipalities

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# Motivation

- ▶ As part of the Chilean National Energy Agenda presented at the beginning of 2014, a street lighting replacement program was addressed by some Chilean municipalities.
- ▶ In the program called "Plan de Eficiencia Energética Sector Municipal" 200,000 public lightings were replaced by LED technology between 2015-2018.
- ▶ The program aimed to enhance energy efficiency and reduce energy consumption.

# LED Street Lighting Program

- ▶ The program was implemented via public-private cooperation: Subsecretaría de Energía and Agencia Chilena de Eficiencia Energética. Approximate cost: US\$100 millions (2018=100).
- ▶ Prioritization criterion: 75% of municipalities with greater dependence on Fiscal Equalization Mechanism, namely Municipal Common Fund (MCF): 48% approximately.
- ▶ The program had a national scope, and it was focused on the subnational governments' street lighting electric consumption.

# LED Street Lighting Program



Figure: Replacement program. Source: Agencia de Sostenibilidad Energética, 2022

# LED Street Lighting Program

| Year | Control | Treated | N     |
|------|---------|---------|-------|
| 2008 | 345     | 0       | 345   |
| 2009 | 345     | 0       | 345   |
| 2010 | 345     | 0       | 345   |
| 2011 | 345     | 0       | 345   |
| 2012 | 345     | 0       | 345   |
| 2013 | 345     | 0       | 345   |
| 2014 | 345     | 0       | 345   |
| 2015 | 344     | 1       | 345   |
| 2016 | 333     | 12      | 345   |
| 2017 | 273     | 72      | 345   |
| 2018 | 322     | 23      | 345   |
| 2019 | 244     | 101     | 345   |
| 2020 | 244     | 101     | 345   |
| 2021 | 244     | 101     | 345   |
| N    | 4,419   | 411     | 4,830 |

# LED Street Lighting Program: Treated municipalities

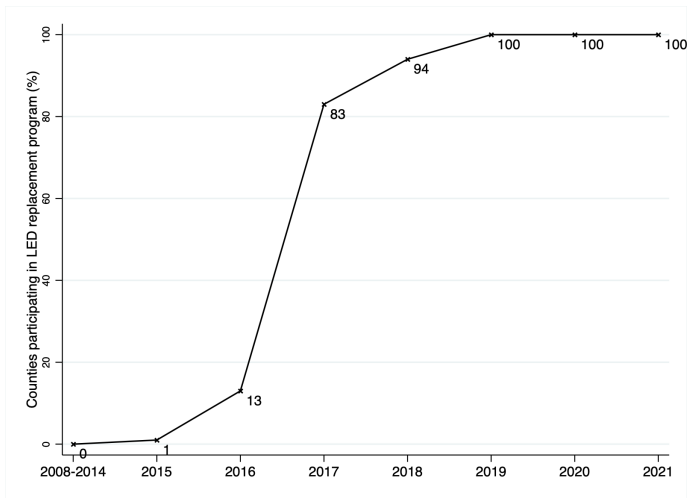
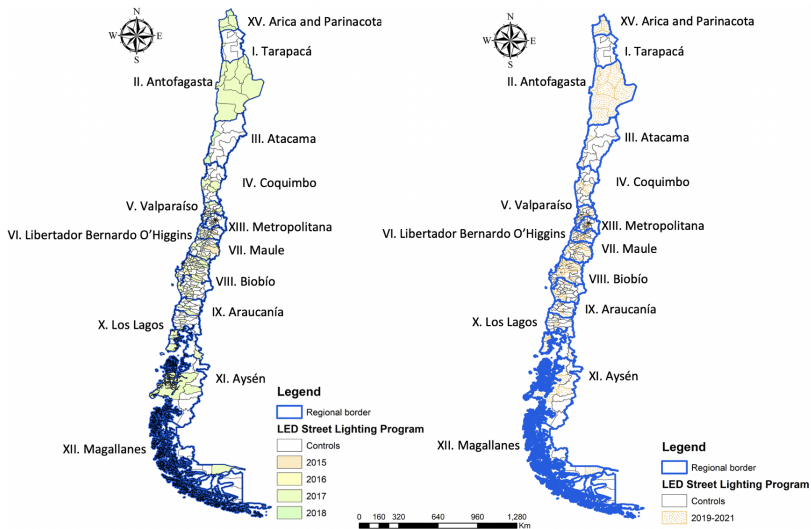


Figure: LED Street Lighting Program start date, by Chilean counties, 2015–2021

# LED Street Lighting Program



**Figure:** LED Street Lighting Program start date, by Chilean counties, 2015–2021

# LED Street Lighting Program: Treated municipalities

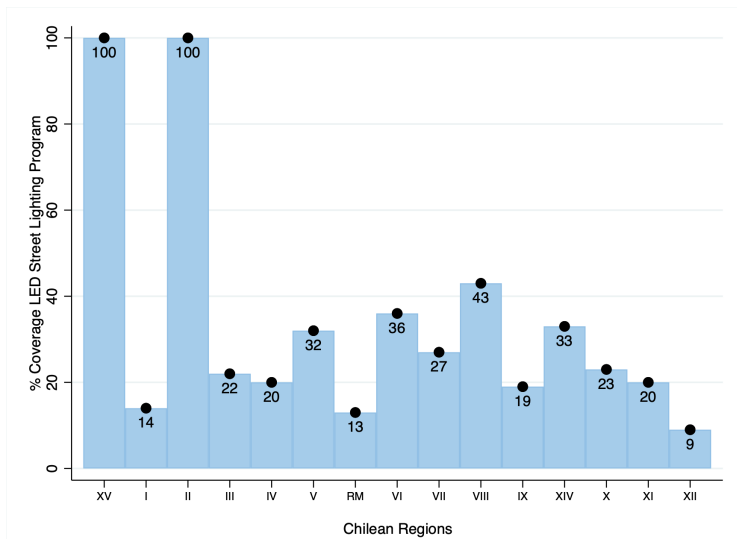


Figure: LED Street Lighting Program start date, by Chilean counties, 2015–2018

# Research Problem

General goal:

This paper aims to assess the impact of the street lighting replacement policy, conventional street lighting by LED technology in terms of its potential to reduce energy consumption and maintenance services costs.

Hypothesis:

- ▶  $H_1$ : The street lighting replacement policy reduces both the electrical consumption and spending on street-lighting Maintenance Services ( $y_{it}$ ) in treated municipalities ( $D_{it}$ ) in Chile.

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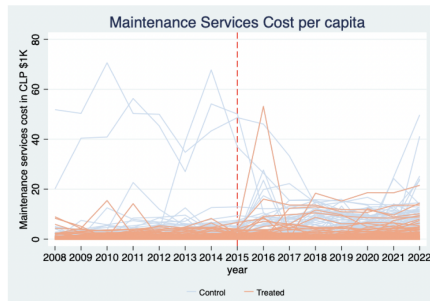
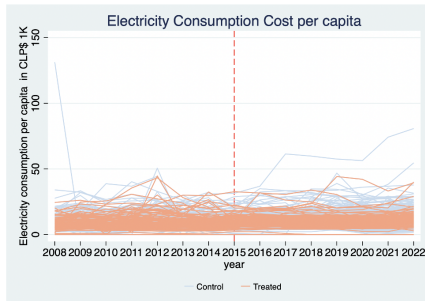
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# Data: outputs



**Figure:** Electricity consumption and Maintenance services cost both in per capita, 2018–2022

# Electrical energy consumption

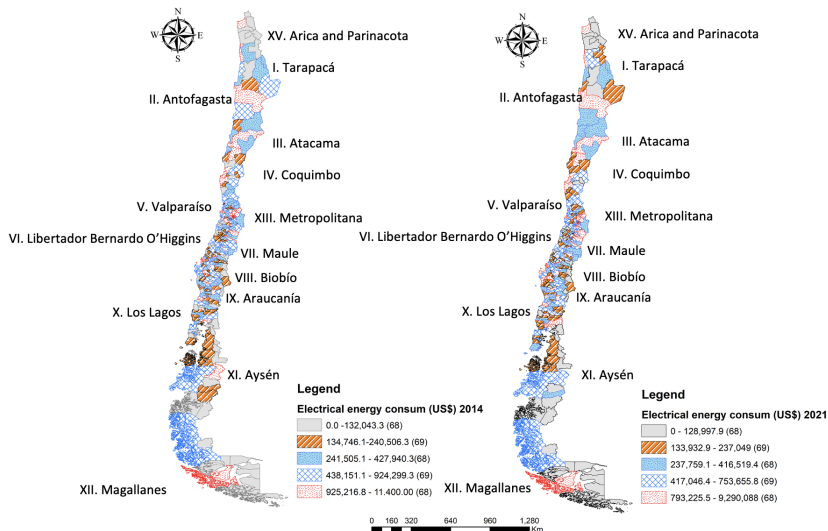


Figure: Electrical energy consumption (US\$), by Chilean counties, 2014-2021

# Street-lighting Maintenance Services

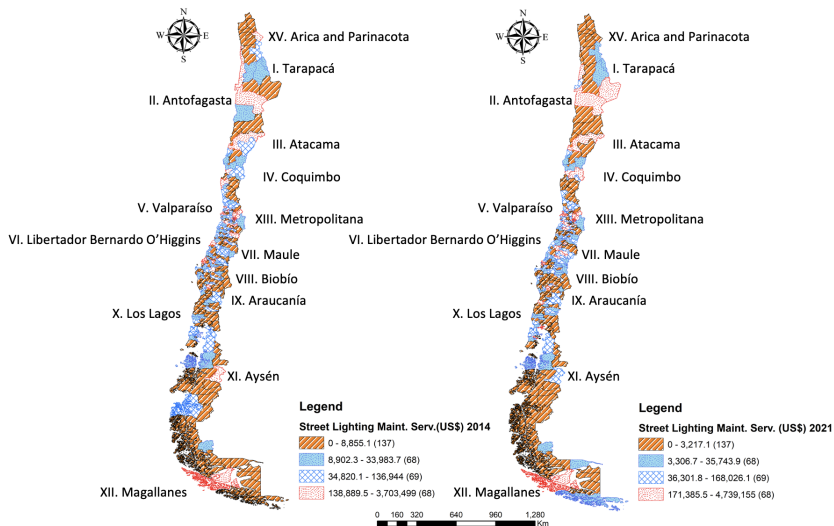


Figure: Street-lighting Maintenance Services (US\$), by Chilean counties, 2014-2021

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# Methodology

We approximate the effect that the replacement program has on the dependents variables:

Model 1: Staggered difference-in-difference (Callaway and Sant'Anna, 2021)

$$Y_{mt} = \alpha + \sum_{K=1}^K \beta_K D_{K_{mt}} + \lambda' X_{mt} + \mu_m + \tau_t + \epsilon_{mt} \quad (1)$$

Where  $Y_{mt}$  is the outcome variable for unit  $c$  at time  $t$ .  $D_{K_{mt}}$  is a binary indicator that equals 1 if unit  $c$  is treated  $k$  periods after the treatment starts, and 0 otherwise. The sum is taken over all possible periods after treatment ( $k$ ).

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# Density: Propensity Score Matching

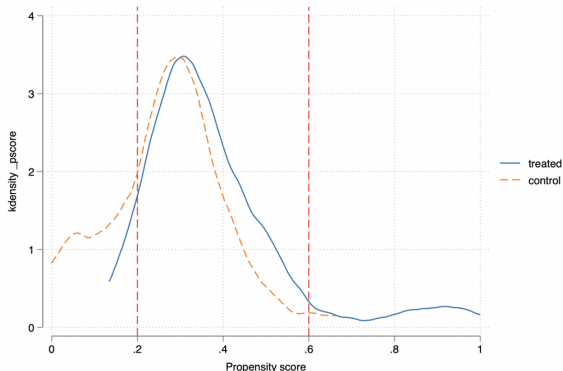


Figura 4: Probabilidad predicha derivada de la estimación del modelo logit

Figure: Results

# Staggered DID Eq(1) with PSM

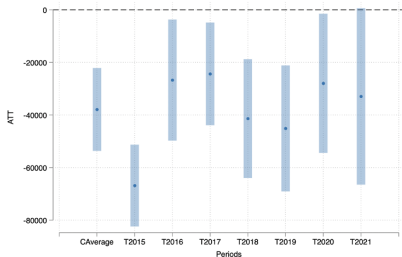


Figura 5: ATT por año de tratamiento sin el PSM

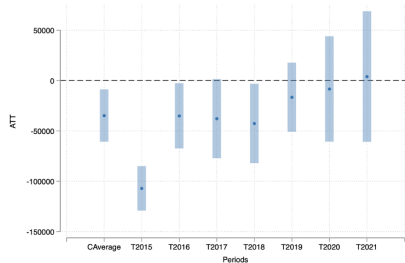


Figura 6: ATT por año de tratamiento con el PSM

Figure: Results

# Staggered DID Eq(1) with PSM

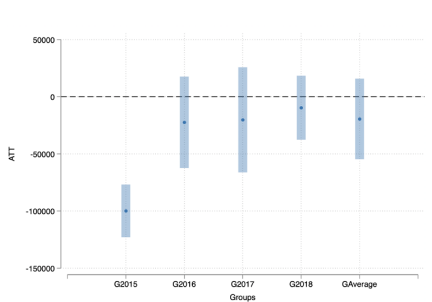


Figura 7: ATT por grupo de tratamiento sin el PSM

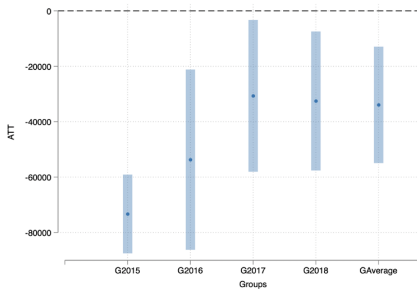


Figura 8: ATT por grupo de tratamiento con el PSM

Figure: Results

# Staggered DID Eq(1) with PSM

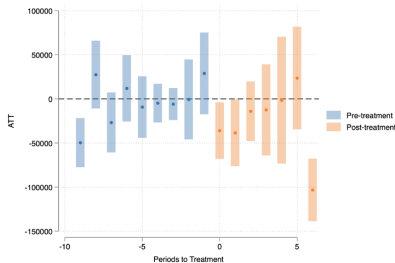


Figura 9: ATT antes y después del tratamiento sin el PSM

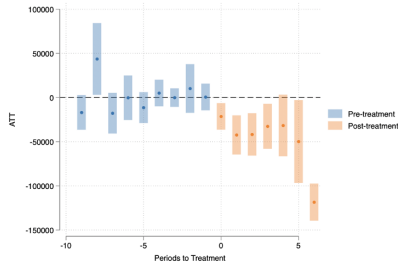


Figura 10: ATT antes y después del tratamiento con el PSM

Figure: Results

# Challenges: Spatial Autocorrelation

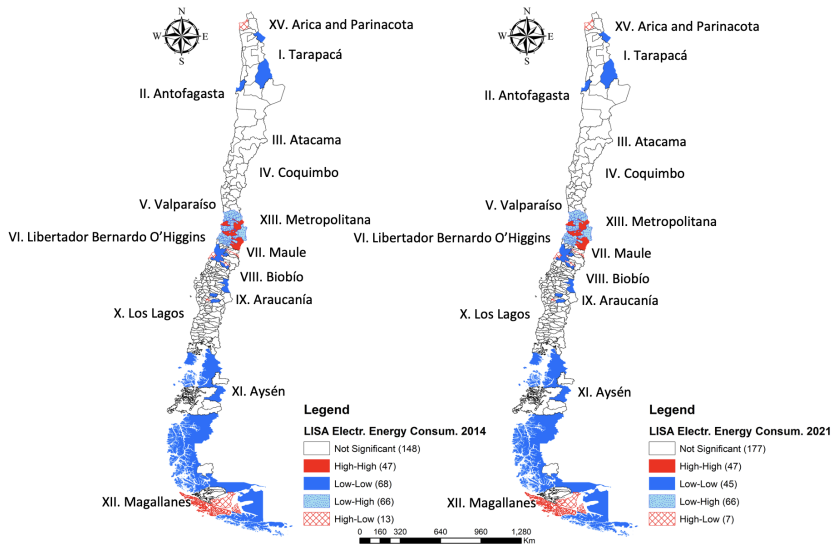


Figure: LISA Analysis: Electrical energy consumption (US\$) by Chilean counties, 2014-2021

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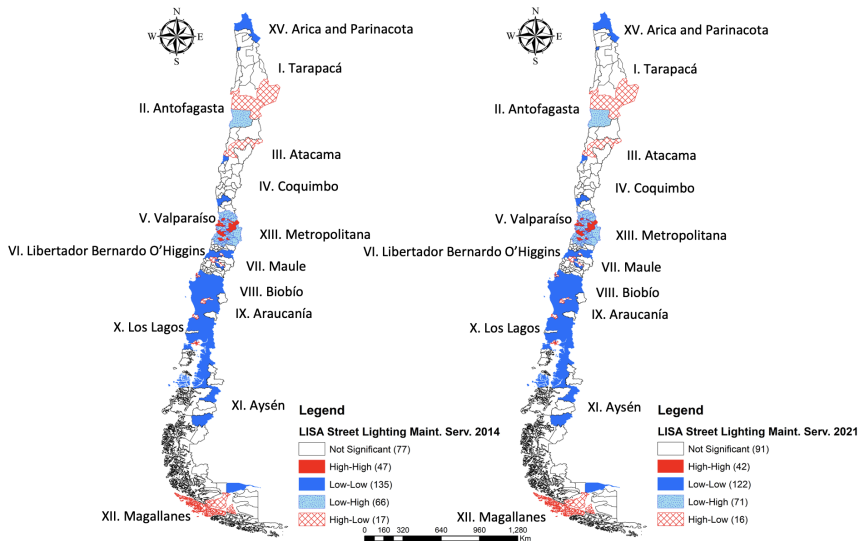


Figure: LISA Analysis: Street-lighting Maintenance Services (US\$) by Chilean counties, 2014-2021

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# Preliminary conclusions

- ▶ The LED policy in Chilean municipalities successfully reduced energy consumption costs, but there are concerns about its long-term sustainability.
- ▶ As you progress in the design, it is essential to consider spatial distribution and apply strategies such as spatial propensity matching.
- ▶ Beyond economic savings, the policy also has significant indirect effects, specifically in terms of its environmental impact.

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