THE IMPACT OF EUTHANASIA ON SUICIDE RATES AMONG ELDERLY

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ABSTRACT

Background: Suicide is still often seen as an illegal act to terminate life. Therefore, the legalization of euthanasia is a very controversial topic in many countries. The Netherlands is one of the first countries which legalized euthanasia in 2002.

Aim: We want to investigate if the legalization of euthanasia has an impact on the suicide rate. For our analysis, we focused on elderly people because they are most prone to take the service for euthanasia.

Method: We applied a general synthetic control method approach to estimate the impact on the suicide rate.

Results: The results show for several years after treatment statistically significant negative average treatment effect on the treated (ATT). Some years after treatment have a negative ATT but with higher p values.

Conclusion: We observed a negative impact on the suicide rate among the elderly. This means that the legalization of euthanasia reduced the rate of suicide.

Dedication

We want to thank Prof. Dr. Petro Biroli and Ms. Miriam Venturini for their support. You gave for the whole duration of the project many valuable inputs we really appreciated. As expected, you guided us from our initial ideas to the right topic so that we have a proper setting to apply our methodology.

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1 Introduction

1.1 Background

Close to 800,000 people die due to suicide every year, which is one person every 40 seconds, according to World Health Organization[3]. The most commonly used methods of suicide[1] include hanging, pesticide poisoning, firearms, jump from height, drowning, and drug overdoses. These methods are more concerned with painfulness and disfigurement but people still end their lives by these methods. Why do people still commit suicide even if this process is painful? It is because all these pains pale into insignificance when compared with the pain people suffer from when they were still alive. People would rather die with pain than live with pain. There are two kinds of pain leading people to suicide - physical pain and mental pain. People feel suicidal due to either physical suffering or mental suffering. Physical pain mainly comes from illnesses or accidents while mental pain usually comes from stress, depression, or loneliness. Comparing to people suffering from physical pain, people suffering from mental pain are more likely to commit suicide impulsively.

Some programs/policies have been implemented in some countries to reduce people's pain during suicide. Among these programs, euthanasia[2] is the most controversial one. Euthanasia was originally introduced to contribute to the well-being of patients who suffer from physical pain. Many people think that each person has the right to control his or her body and life so should be able to determine at what time, in what way, by whose hand he or she will die. However, some people also argue that euthanasia should be prohibited since euthanasia may be manipulated and performed against the patient's will and this may lead to some potential ethical issues.

1.2 Motivation

The Netherlands was the first country to legalize euthanasia and relevant law took into effect in 2002. In the Netherlands, euthanasia is understood as "termination of life by a doctor at the request of a patient". In order to prevent any potential ethical or moral issues, the procedure to approve one's request for euthanasia is very strict and complicated. Requests for euthanasia often come from patients experiencing unbearable suffering with no prospect of improvement. Their request must be made earnestly and with full conviction. They see euthanasia as the only escape from the situation. However, patients have no absolute right to euthanasia and doctors have no absolute duty to perform it. We see that there are many conditions and requirements for euthanasia to be performed so only requests from those who are experiencing long-term physical suffering would get approved.

Which age group would be influenced by the legalization of euthanasia most? It makes sense to argue that the elderly are affected most by such a program. On the one hand, elderly people are more wise and mature and less likely to behave impulsively and irrationally. They attempt suicide not so much because of mental pain but because of physical pain. On the other hand, elderly people are the main victims of (age-related) diseases and therefore more likely to suffer from long-term severe chronic diseases. Elderly people are more likely to commit suicide due to physical pain while the availability of euthanasia provides an alternative for elderly patients to die painlessly.

With this setting, we are interested in whether there exists a causal relationship between the legalization of euthanasia and suicide rates among elderly. Without euthanasia put in place, elderly patients commit suicide to end their physical pain, which would count towards suicide rates. With euthanasia put in place, elderly patients request professional assistance in suicide to end their physical pain, which would not count towards suicide rates. We can use euthanasia as a treatment to capture such an impact on suicide rates among elderly. Our prior guess is that the legalization of euthanasia reduces suicide rates among elderly and this can be supported by the following arguments:

- Elderly patients (with physical pain) can turn to professional assistance in suicide instead of doing it themselves.
- Euthanasia may rule out impulsive, involuntary, and irrational decisions from patients.
- Failed suicide attempts may cause serious trauma in patients while euthanasia can prevent this from happening and reduce the second suicide attempts.
- Euthanasia is less painful and traumatizing.

[1] Suicide is the act of intentionally causing one's own death. However, an accidental death can also be considered suicide in some settings. But in this study, suicide refers to the death caused by intentional self-harm. This should be distinguished from unintentional self-harm (accidental death by mental or behavioral disorder).

[2] Euthanasia has different definitions in different settings. But in this study, euthanasia refers to physician-assisted suicide or active euthanasia. Termination of life by a physician, not the individual concerned.

2 Related Work

There are several research papers, which investigate specifically the Euthanasia practices in the Netherlands. The study by *Rietjens et al.* [10] investigated the research on Euthanasia in the Netherlands of two decades. The extensive research in this field resulted in higher public awareness, the contribution of public debate, and control of euthanasia in the Netherlands. The research showed also that in 2005 eighty percent of the euthanasia cases were reported to the review committees. The unreported cases almost all involve the use of opioids and are not considered to be euthanasia by physicians. The study done by *van der Heide et al.* [11] investigated the different end-of-life practices done under the *Euthanasia Act* in the Netherlands. They figured out that in 2005 they have registered fewer suicides than in 2001 before the *Euthanasia Act* was in place. The method is based on a questionnaire that was filled out by physicians.

There is also related work that investigated the impact on the suicide rate of a certain program/policy. Such policies/programs were: deployment of suicide centers, business cycles, reporting the death of celebrities, or socioeconomic factors [8, 9, 5, 7].

For our project, we use the generalized synthetic control method in order to estimate the missing counterfactual. There are several studies that discuss the synthetic control method. The paper of *Kreif et al.* [6] compared specifically the synthetic control method with the Difference-in-differences (DiD) method. DiD has stronger assumptions regarding potential confounders whereas the synthetic control method allows to change them over time. The work by *Xu* [12] shows that the generalized synthetic control method can be extended with a linear fixed effects model under a simple framework, of which DiD is a special case. This work could be useful for the extension of our project if we want to consider linear fixed effects. *Botosaru and Ferman* [4] investigated the role of covariates in the synthetic control method which also related to some results of our project. They showed that a perfect match on pre-treatment outcomes does not generally imply an approximate match for all covariates.

3 Data

3.1 Data Extraction

Data is extracted from *European Statistics Database* [1]. Data is extracted from regional death rate statistics. We customized the data by selecting **intentional self-harm** as the cause of death and **65 years or over** as the age group. In the process of data extraction, we gave up some regional observations containing missing values[3] We first included many regions (without missing values) as our raw data and then further filtered the data on RStudio. We also made the extracted data available on *Google Drive* [2] for replication.

3.2 Data Visualization

Panel data structure:

- Individual variable: regions from the Netherlands, Sweden, Norway, United Kingdom, France, Spain, and Greece. Only regions from the Netherlands put euthanasia into effect. There are 102 regions in total, 12 treatment regions, 90 control regions.
- Time variable: 1994 to 2010. There are 17 years in total.

In figure 1, we visualize the data we have. The data of suicide rates are obtained by several regions of Europe as written above. The blue and dark-blue fields indicate the regions of the Netherlands, whereas the light-blue fields are regions from other countries. Furthermore, by using blue and dark-blue colors the treatment status is indicated with a cutoff point at year 2002.

The crude suicide rates of all regions in our dataset are visualized in figure 2. From this figure, it is obvious that a treatment group (red lines) cannot be easily compared with another control group (grey lines) since they usually do not follow a parallel pre-treatment trend. In section 4, we exploit the use of a synthetic control group so that we construct by ourselves a comparison group that follows a parallel pre-treatment trend.

[3] Causal/statistical inference is more about evaluation (interpolation) while statistical learning is more about prediction (extrapolation). Missing value imputation is not very common in causal inference since results based on imputed data would be somewhat biased. It is a trade-off. Considering there are many more control units, we decided to give up some control units containing missing values rather than imputing them.

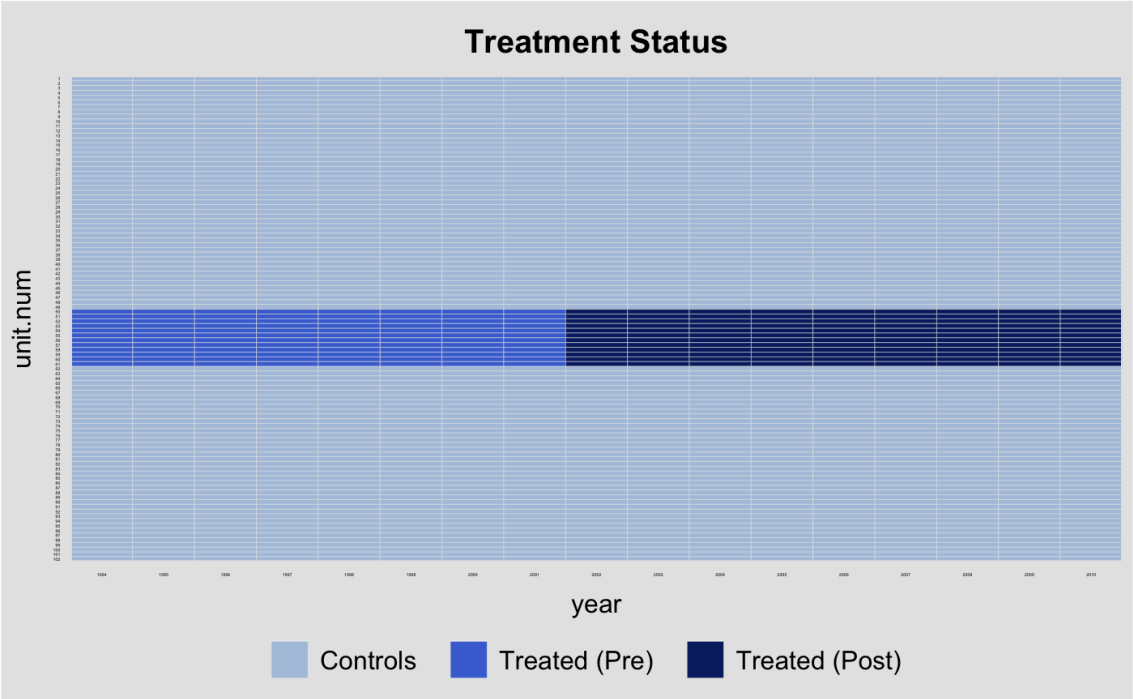

Figure 1: Data structure

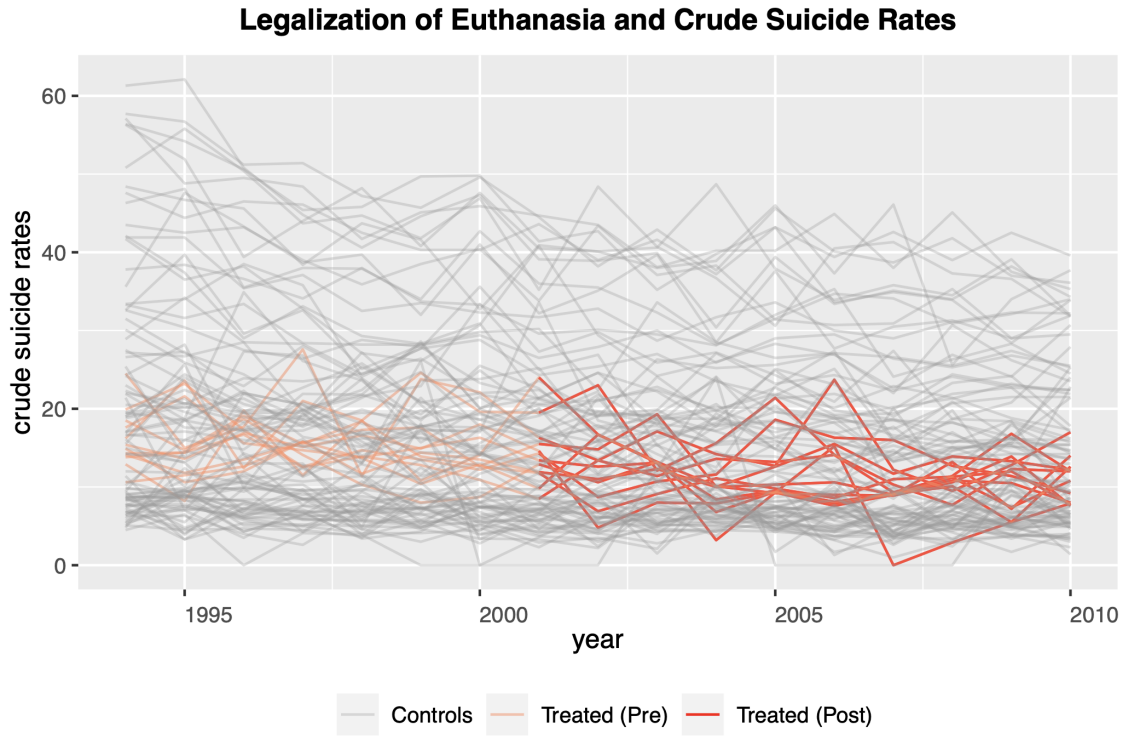

Figure 2: Crude suicide rates of all groups.

4 Methodology

In order to answer the question of whether the legalization of euthanasia in the Netherlands had an impact on suicide rates, we use the *Generalized Synthetic Control Method*. We have many treated units so *Synth* [4] package is not helpful for our analysis. Therefore, we use *gsynth* [5] package for our project.

4.1 Why Generalized Synthetic Control

Outcome and treatment:

- Outcome variable: regional suicide rates among elderly (65 years or over).
- Treatment variable: the legality of euthanasia within the region.

We know that the Netherlands legalized euthanasia in 2002 while other countries did not during the whole period. Regional observations are not evenly balanced between treated and untreated. Therefore, we use the *Generalized Synthetic Control Method* (GSC) to synthesize comparable control units by giving them different weights.

This method is in the spirit of the synthetic control method in the sense that by essence it is a reweighting scheme that takes pre-treatment treated outcomes as benchmarks when choosing weights for control units and uses cross-sectional correlations between treated and control units to predict treated counterfactuals. Unlike the synthetic matching method, however, it conducts dimension reduction prior to reweighting such that vectors to be re-weighted on are smoothed across control units. The method can also be understood as a bias correction procedure for IFE (Interactive Fixed Effects) models when the treatment effect is heterogeneous across units. It treats counterfactuals of treated units as missing data and makes out-of-sample predictions for post-treatment treated outcomes based on an IFE model [12].

4.2 Theoretical Framework

For our methodology, we have a theoretical framework. This framework requires the following assumptions.

Functional Form:

$$Y_{it} = \delta_{it} D_{it} + \lambda_i f_t + \epsilon_{it}$$

where

- Y_{it} is the outcome of interest of unit i at time t, i.e., crude suicide rate of region i at time t.
- D_{it} is the treatment indicator. D_{it} equals 1 if region i has been exposed to treatment prior to time t and equals 0 otherwise, i.e., $D_{it} = \mathbf{1}[t \geq 2002] \times \mathbf{1}[country = Netherlands]$.
- δ_{it} is the heterogeneous treatment effect on region i at time t.
- f_t is the observed common factor and λ_i is the unknown factor loadings.
- ϵ_{it} represents unobserved idiosyncratic shocks for region i at time t. Assume $\mathbb{E}(\epsilon_{it}) = 0$ holds.

The average treatment effect on the treated (ATT) at time t (when $t > T_0$):

$$ATT_{t,t>T_0} = \frac{1}{N_{treated}} \sum_{i \in \mathcal{T}} [Y_{it}(1) - Y_{it}(0)] = \frac{1}{N_{treated}} \sum_{i \in \mathcal{T}} \delta_{it}$$

where

- $N_{treated}$ denotes the number of treated of treated units.
- $\mathcal{T}$ denotes the set of units in treatment group.
- T_0 denotes the year when the treatment was implemented in treatment group.

[4] This package only applies to the case where there is only one treated unit while there are many control units.

[5] R package for generalized synthetic control method in causal inference.

- $Y_{it}(1)$ is the observed outcome for treated region i in post-treatment time t.
- $Y_{it}(0)$ is the missing counterfactual for treated region i in post-treatment time t.

The main objective is to construct missing counterfactuals for each treated region in post-treatment periods, i.e., $Y_{it}(0)$.

$$Y_{it}(0) = \sum_{j \in \mathcal{C}} w_j^* Y_{jt}(0)$$

where

- $\mathcal{C}$ denotes the set of units in control groups.
- $Y_{it}(0)$ is the missing counterfactual for treated region i in treatment group at time t.
- $Y_{jt}(0)$ is the observed outcome for untreated region j in control groups at time t.
- w_j^* is the optimal weights.

Additional assumptions for identification:

- Strict exogeneity, i.e., $\mathbb{E}(\epsilon_{it} \mid D_{it}, \lambda_i, f_t) = 0$
- Weak serial dependence of the error terms.
- Regularity conditions.
- The error terms are cross-sectionally independent and homoscedastic.

Our goal is to construct the optimal missing counterfactuals. We can search for optimal weights of control units for each treated unit using *gsynth* algorithm. We select potential synthetic control units based on the following criteria:

- In *Estimated ATT* plot (figure 4), ATT curve stabilizes at zero horizontal line (with some small fluctuations) prior to treatment but dramatically deviates from zero after treatment.
- In *Treated and Counterfactual Averages* plot (figure 3), the estimated curve for missing counterfactuals fits the observed outcome as well as possible in pre-treatment periods while the curve evolves differently from the observed outcome in post-treatment periods.
- *Mean Squared Prediction Error* is minimized.

Note:

- We used two-way fixed effects to adjust for unobserved region-specific and time-specific confounders at the same time.
- When a policy was implemented, it is usually not obvious to see its impact just after its implementation. In our setting, We allow treatment effects to vary across different periods so we can see how treatment effects evolve over periods.

5 Results

5.1 Interpretation for Plots

The generalized synthetic control (GSC) method constructs missing counterfactuals. In figure 3, we see that untreated counterfactuals fit the outcomes very well during pre-treatment periods, and the mean squared prediction error is minimized, which is exactly what we expected. During post-treatment periods, GSC uses cross-sectional correlations between treated and control units to predict treated counterfactuals and we observed that treated counterfactuals and treated outcomes evolve differently and counterfactuals are above outcomes. We see a negative impact of euthanasia on suicide rates.

In figure 4, we can visually gain a general idea of how large such a negative impact is on the regional suicide rates among elderly in the Netherlands. In particular, we see a statistically significant reduction in the third year after treatment where the confidence interval is completely below the baseline.

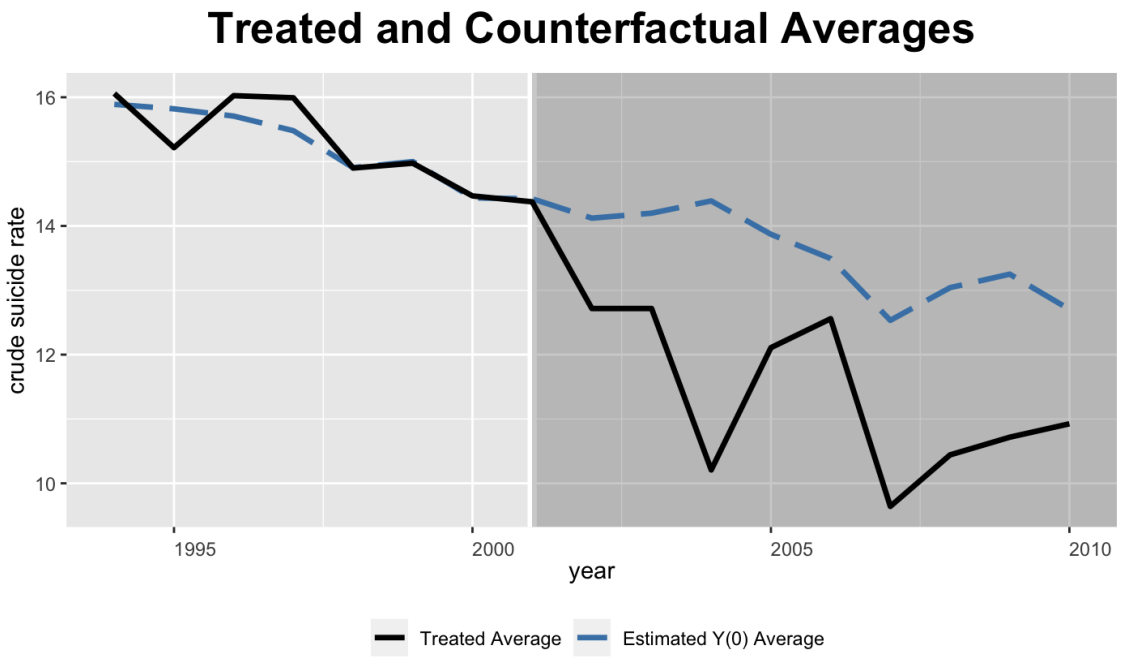

Figure 3: Treated and Counterfactual Averages

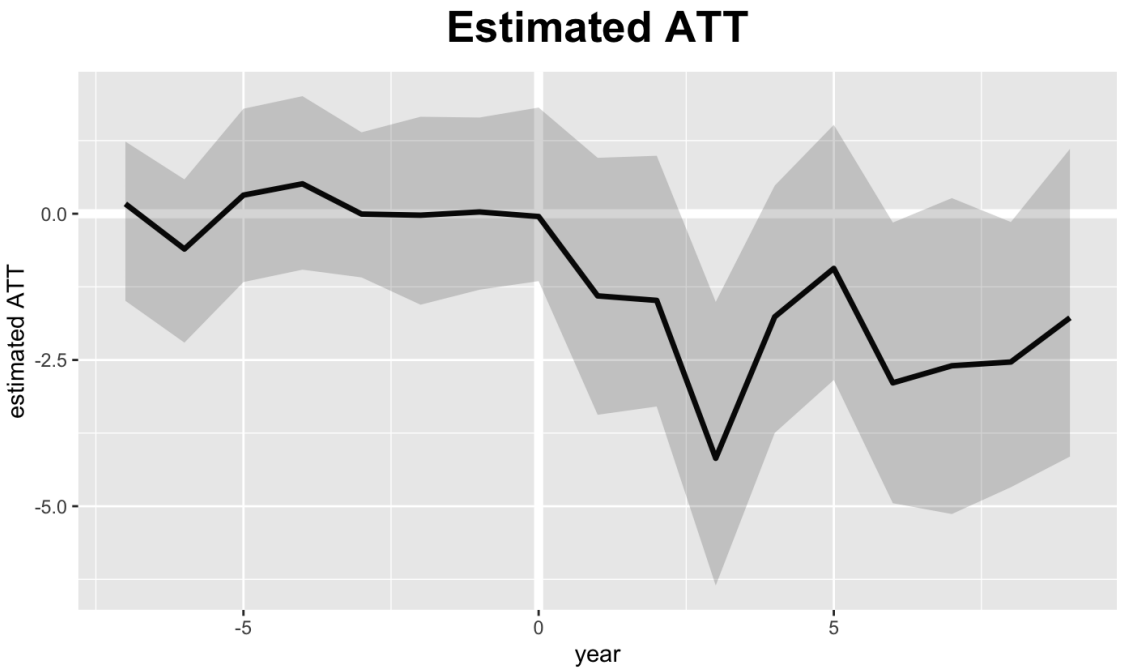

Figure 4: Estimated ATT

5.2 Interpretation for Tables

The table 1 shows in more detail what the figure 4 represents. We have in the first column the average treatment effect on the treated and also their respective standard errors for each period. Furthermore, the table also provides the upper and lower bounds of the confidence interval for the ATT per period and also the p values. In particular, the p values are diverse. The p value for the ATT is below 0.05 for the third, sixth, and eighth year after the legalization of euthanasia. For the other years, we see also a lower ATT but with less statistical significance. The low p values indicate a statistically significant difference in the ATT. These significant changes can also be observed by looking at the figure 4. Especially in the third year after treatment, we observe a strong negative ATT.

In table 2 we have the averaged ATT over all periods. The ATT over all periods is -2.174 that is statistically significant with a p value of 0.004. So we see on average indeed an impact on the suicide rate among the treated regions.

Table 1: ATT by period (GSC)

	ATT	S.E.	CI.lower	CI.upper	p.value	n.Treated
1	0.169	0.692	-1.538	1.272	0.974	0
2	-0.603	0.684	-2.149	0.539	0.272	0
3	0.318	0.736	-1.188	1.680	0.704	0
4	0.511	0.726	-0.894	2.004	0.408	0
5	-0.006	0.637	-1.038	1.428	0.840	0
6	-0.025	0.816	-1.541	1.725	0.914	0
7	0.031	0.723	-1.412	1.485	0.894	0
8	-0.048	0.741	-1.209	1.739	0.798	0
9	-1.404	1.137	-3.482	0.927	0.294	12
10	-1.482	1.073	-3.444	0.834	0.234	12
11	-4.180	1.202	-6.026	-1.408	0.004	12
12	-1.762	1.037	-3.772	0.404	0.130	12
13	-0.935	1.127	-2.863	1.541	0.576	12
14	-2.891	1.218	-5.029	-0.342	0.026	12
15	-2.599	1.334	-4.883	0.052	0.056	12
16	-2.534	1.148	-4.534	-0.101	0.040	12
17	-1.779	1.320	-4.066	1.086	0.276	12

Table 2: ATT averaged over all periods (GSC)

ATT.avg	S.E.	CI.lower	CI.upper	p.value
-2.174	0.804	-3.551	-0.513	0.004

5.3 Results Comparison

For comparison, we also use OLS DiD and two-way fixed effects DiD to estimate ATT averaged over all periods. In table 3, the estimated ATT averaged is negative on both regressions but it is not significant in OLS estimation but significant in two-way fixed effects estimation. From column (1) to column (2), we see a decrease in standard errors since we control for unit-specific and time-specific effects at the same time in two-way fixed effects regression. Such an impact is smaller than the one we estimated by using GSC. The reason is that: in the two-way FE model, we use all potential control units as comparison for estimation but clearly not all control units are good comparisons; however, in GSC with two-way fixed effects, we give more weights to those control units that are good comparisons[6].

[6]How to choose control units and determine optimal weights? Please refer to **Methodology**.

Table 3: ATT averaged without using GSC

	suicide rate	
	OLS	*panel linear*
	pooling	two-way FE
	(1)	(2)
ATT.avg	−0.894 (1.705)	−0.894* (0.511)
Observations	1,734	1,734
Note:	*p<0.1; **p<0.05; ***p<0.01	

6 Discussion

The discussion of our results is divided into two subsections. In section 6.1, we discuss the causal channel that causes a negative impact on the suicide rates among the elderly. In section 6.2, we explain the limitations our study has and what should be taken into account for future work.

6.1 Causal Channel

We observed a negative impact of euthanasia on regional suicide rates among elderly. We now turn to the discussion of the causal channel for our finding.

People commit suicide mainly for two reasons. One reason is that they suffer physically due to illnesses or accidents so they commit suicide to end their physical pains. Another reason is that they suffer mentally due to stress, depression, or loneliness so they commit suicide to end their mental pains. If we focus on a certain age group of people, elderly in particular, we can easily infer that physical suffering is the main cause of suicide among elderly. Why is it the case? On the one hand, elderly people are more vulnerable to age-related diseases so they are more likely to suffer physically due to illnesses. On the other hand, elderly people are more mature so they are less likely to commit suicide impulsively due to mental suffering (caused by stress, depression, loneliness, etc.). Therefore, we can conclude that physical suffering is the main cause of suicide among elderly.

We next turn to euthanasia. Euthanasia is mainly available for patients experiencing unbearable physical suffering. It is inaccessible to people who are experiencing mental suffering caused by stress, depression, loneliness, etc. Euthanasia only has an impact on patients who are experiencing physical suffering and would have committed suicide if euthanasia were not legalized. Therefore, we know that the availability of euthanasia will keep patients who suffer physically from attempting suicide.

With the above reasoning, we know that the legalization of euthanasia affects the elderly most. At the individual level, the legalization of euthanasia makes it possible for elderly patients to request professional assistance in suicide so they do not have to do it themselves. At the regional level, the legalization of euthanasia can somehow reduce suicide rates among elderly. It is worth noting that the legalization of euthanasia does not reduce death rates and it only reduces suicide rates. People still die but not from suicide. They die with dignity (and with less pain).

6.2 Limitations

Of course, we can not completely exclude other potential confounders that may have an impact on the suicide rates. In our project, we mainly focused on how to construct a good control group by applying the generalized synthetic control method. In order to investigate further the causalities, an extension to this work would be to include other control variables to see if such a causal effect on suicide rates is still statistically different from zero. A problem would be to find such variables we can control meaning that they are unlikely to be observable (e.g., general opinion on euthanasia, religious beliefs, habits, inculcated values, etc.). But from previous work such as [5, 7, 8, 9], we can say that there are also other policies and programs that had an impact on suicide rates. With a more detailed literature review, it should be possible to find some measurable variables to control.

Although we view our findings as empirical evidence about the causal effect of euthanasia on suicide rates among elderly, our study may suffer threats to external validity [7]. We only provide empirical evidence from certain European countries. However, we are not sure whether we can apply the findings of our study to a broader context. To answer this question, it will be necessary to further investigate and test such an impact in different settings.

7 Conclusion

We have investigated the impact of the legalization of euthanasia on regional suicide rates. Exploiting the generalized synthetic control method, we have estimated the treatment effects over periods on regional suicide rates among elderly.

Using the panel data extracted from European Statistics Database [1] and generalized synthetic control method [12], we found a negative effect of euthanasia on regional suicide rates among elderly. The option of euthanasia would help elderly patients (with physical suffering) wait for professional assistance in suicide and refrain from doing it themselves.

[7] External validity is the extent to which we can generalize the findings of our study to other settings.

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