University of St. Gallen

Bachelor Thesis

Bitcoin and Ether as Tax Payment Methods

A Statistical Examination of the Policy Effect of the Acceptance of Bitcoin and Ether as Tax Payment Methods on the Growth of the Local Crypto Industry

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Abstract

This research paper investigates the policy effect of the acceptance of Bitcoin and Ether as tax payment methods on the growth of the local crypto industry. Therefore, the case of the Crypto Valley within the canton of Zug in Switzerland is observed. The (augmented) synthetic control method is used to statistically determine a policy effect. No statistically significant policy effect is found.

Keywords: *Bitcoin, Ether, tax policy, Crypto Valley, Zug, augmented synthetic control.*

Contents

Acronyms

AG Argovia (Swiss canton)

AI Appenzell Innerrhoden (Swiss canton)

AR Appenzell Ausserrhoden (Swiss canton)

ASCM augmented synthetic control method

BE Berne (Swiss canton)

BL Basel-Landschaft (Swiss canton)

BS Basel-Stadt (Swiss canton)

FR Fribourg (Swiss canton)

GE Geneva (Swiss canton)

GL Glarus (Swiss canton)

GR Grisons (Swiss canton)

JU Jura (Swiss canton)

LU Lucerne (Swiss canton)

MSPE mean squared prediction error

NE Neuchâtel (Swiss canton)

NW Nidwalden (Swiss canton)

OW Obwalden (Swiss canton)

SCM synthetic control method

SG St. Gallen (Swiss canton)

SH Schaffhausen (Swiss canton)

SO Solothurn (Swiss canton)

SZ Schwyz (Swiss canton)

TG Thurgovia (Swiss canton)

TI Ticino (Swiss canton)

UR Uri (Swiss canton)

VD Vaud (Swiss canton)

VS Valais (Swiss canton)

ZH Zurich (Swiss canton)

List of Figures

List of Tables

1 Introduction

> *"You can't stop things like Bitcoin. It will be everywhere, and the world will have to readjust. World governments will have to readjust."* (McAfee in Marr, 2018)

The cybersecurity pioneer John McAfee (in Marr, 2018) predicts that governments have to adjust to the rise of cryptocurrencies (Naftulin and Canales, 2022). The cantonal government of Zug, which is one of 26 cantons in Switzerland, adjusted for the rise of cryptocurrencies by accepting Bitcoin and Ether as tax payment methods (Swiss Confederation, 2022, art. 1; Finanzdirektion Direktionssekretariat, 2020). Bitcoin and Ether are the two biggest cryptocurrencies by market capitalisation (CoinMarketCap, n.d.). Before the finance directorate of Zug published its new crypto-friendly tax policy, the head of the finance directorate and simultaneous president of the Swiss Blockchain Federation Heinz Tännler (in Vögeli, 2018) argued that the canton of Zug needs to set the right framework for the crypto industry (and the economy in general) to thrive. Many crypto firms in Switzerland cluster within the canton of Zug (Morisson and Turner, 2022, p. 917 f.). The industry cluster is also known as the Crypto Valley. Tännler (in Vögeli, 2018) recognised the potential marketing effect the policy of accepting cryptocurrencies as tax payment methods may have on the growth of the Crypto Valley.

This research paper thus examines, whether the tax policy of accepting Bitcoin and Ether as tax payment methods, led to a growth of the local crypto industry within the Crypto Valley. Therefore, the following research question is asked:

> *What effect has the acceptance of Bitcoin and Ether as tax payment methods on the growth of the local crypto industry?*

To answer the research question, the null hypothesis (H_0) and the alternative hypothesis (H_1) are formulated as follows:

> H_0: *The acceptance of Bitcoin and Ether as tax payment methods has no effect on the growth of the local crypto industry.*
> H_1: *The acceptance of Bitcoin and Ether as tax payment methods has an effect on the growth of the local crypto industry.*

To test the null hypothesis, the research paper uses a quasi-experimental research design which observes the local crypto industry of the canton of Zug as the treated unit. Thereby, the tax policy issued by the finance directorate of Zug constitutes the treatment. The crypto industries of the other 25 Swiss cantons serve as control units. The number of new registrations of crypto companies in the cantonal commercial registries serves as the instrument which observes the growth of the local crypto industries. To determine a causal effect, the (augmented) synthetic control method is used.

The research paper starts out by setting the research question into the right context. Therefore, section 2 introduces the crypto industry, the Crypto Valley and the tax policy that is the subject of this study. Section 3 then presents the methodology used to answer the research question. In said section, quasi-experimental research designs, the synthetic control method, the augmented synthetic control method and placebo studies are introduced. Section 4 on the research design thus lies out, how the research paper goes about answering the research question. Therefore, section 4 describes in detail the research question, the hypotheses, the research strategy, the used control variables and the used assumptions. Section 5 on the research data then shows how the sample data is obtained. It showcases the used data pipeline and describes the resulting sample data set both qualitatively and quantitatively. Section 6 on the data analysis then shows the process of analysing the sample data using the methodologies introduced in section 3. The findings of the data analysis are subsequently discussed and presented in section 7. At last, the research question, the conducted process to answer it and the resulting findings are again summarised in the conclusion.

2 Context

To provide the context of the research paper, this section introduces the origin of cryptocurrencies. Subsequently, the context section describes the industry founded on cryptocurrencies. A particular focus is put on the crypto industry of the Crypto Valley in the canton of Zug. The section thus introduces the tax policy issued by the cantonal government of Zug, which aims at promoting its local crypto industry. Said tax policy serves as the subject of analysis of this research paper.

In 2008, the Bitcoin white paper was published by an anonymous author under the pseudonym of Satoshi Nakamoto (2008). In the said white paper, Nakamoto (2008) proposes the notion of a fully digital, decentralised and cryptography-based currency called Bitcoin. Soon, other cryptocurrency inventors followed suit to invent more cryptocurrencies. By 2023, the online market data provider CoinMarketCap lists 22’932 available different cryptocurrencies worth a total of 1.1 trillion USD (Hicks, 2023). The two, by market capitalisation, biggest cryptocurrencies are Bitcoin and Ether (CoinMarketCap, n.d.). Around this range of different cryptocurrencies, an entire crypto industry emerged containing different companies like market exchanges, venture capital firms, banks, payment- or storage providers (Blandin et al., 2020, p. 14; Morisson and Turner, 2022, p. 919).

In 2013 and 2014, the company Bitcoin Suisse and the Ethereum foundation established themselves in the canton of Zug[1] (Morisson and Turner, 2022, p. 917 f.). This marked the beginning of the Crypto Valley, which

[1] Bitcoin Suisse is a big employer in the Crypto Valley (Bitcoin Suisse, 2023). Meanwhile, the Ethereum Foundation (2023) supports the Ethereum network, from which Ether originates (Pierro and Rocha, 2019, p. 24).

refers to the cluster of crypto companies present in the canton of Zug. Morisson and Turner (2022) report, that roughly half of all Swiss crypto companies are concentrated in the canton of Zug (p. 919). Morisson and Turner (2022) speculate, that a reason therefore might lie in the fact that Zug is known for its historically low taxes and business-friendly policies (p. 917). Indeed, the town of Zug, the capital of the equally named canton, soon started implementing a policy friendly to the crypto industry (swissinfo, 2016). In 2016, the town started a pilot project to accept Bitcoin payments for government services valued at under CHF 200 (swissinfo, 2016). Presumingly, this policy aimed to promote the Crypto Valley. A policy, which is aimed at promoting the growth of a particular industry, is known as an industrial policy (Stiglitz and Lin, 2013, p. 1). The canton of Zug followed up, by accepting both Bitcoin and Ether as payment methods for the service fees of the cantonal commercial registry (Volkswirtschaftsdirektion, 2017). In January 2021, the cantonal government of Zug doubled down on its commitment to crypto-friendly industrial policies, when the finance directorate of Zug, led by Heinz Tännler, issued a new tax policy permitting taxpayers to pay their taxes using Bitcoin or Ether (Finanzdirektion Direktionssekretariat, 2020). The implementation of the policy was conducted in cooperation with the aforementioned company Bitcoin Suisse.

The tax policy issued by the finance directorate forms the subject of analysis of this research paper. In comparison to the other two industrial policies, the tax policy deals with substantially higher amounts of cryptocurrencies, which could be used in transactions with the cantonal government. Therefore, this research paper aims to determine, if the aforementioned tax policy had its desired effect of promoting the Crypto Valley. To answer this question, statistical methods are used. The next section on the methodology introduces the statistical methods used by the paper.

3 Methodology

In the methodology section, the methods used to answer the research question are introduced. To recall, the research question asks what effect the acceptance of cryptocurrencies has on the growth of the local crypto industry. To answer the question, the methodology section first establishes how a causal effect may be observed generally. The present research paper is then designed to find such a causal effect by observing real-life data (as opposed to conducting an experiment). This type of research design is known as a quasi-experimental research design (Shadish et al., 2002, p. 14). Therefore, the methodology section goes on to describe quasi-experimental research designs in subsection 3.2. For the analysis of the real-life data, the paper uses the quasi-experimental augmented synthetic control method (ASCM). ASCM is an extension of the synthetic control method (SCM) (Ben-Michael et al., 2021, p. 1). Hence, to give an understanding of ASCM, the methodology section first introduces SCM in subsection 3.3. Then, it introduces how ASCM extends upon the original SCM in subsection 3.4. Assuming the research paper finds a causal effect in the real-life data, this effect must be tested for its significance. In (A)SCM, effects are tested for their significance using placebo studies (Abadie and Gardeazabal, 2003, p. 119; Abadie et al., 2010, p. 497). Therefore, as a last step, the methodology section introduces the concepts of placebo studies in subsection 3.5, to show how the significances of the observed effects are determined.

3.1 Finding a Causal Effect

To answer the research question, it must be established, whether the policy intervention has a causal effect on the observed instrument. A causal effect is defined by Rubin (1974) as the difference between an outcome (Y) of a treated unit (u) and its counterfactual (u^*) (p. 689). A counterfactual thereby represents a hypothetical state of the world, in which the treatment never happened (Cunningham, 2021, p. 119). Said definition of a causal effect is displayed in equation 1.

$$causal\,effect = Y(u) - Y(u^*) \tag{1}$$

Practically, the hypothetical state of the counterfactual (u^*) is impossible to obtain, as one may not simultaneously apply a treatment to one unit, while also not applying a treatment to said unit (Rubin, 1974, p. 690). This unknowability is also known as the fundamental problem of causal inference (Holland, 1986, p. 947). To work around this problem, randomised experiments are used (Shadish et al., 2002, p. 13). In a randomised experiment, a treatment is randomly assigned to a certain set of units, while the remaining units remain untreated. This randomisation results in a treatment group and in a control group, which are statistically similar[2]. By observing the difference in the expected outcomes (Y) of said two groups, the average causal effect (E) may be approximated (Holland, 1986, p. 947; Shadish et al., 2002, p. 5). The average causal effect (E) is formally described in equation 2.

$$E = E[Y(u))] - E[Y(u^*)],\ E[\cdot] = expected\,value \tag{2}$$

In the case of this study, the average causal effect of accepting cryptocurrencies as payment tax methods on the growth of the local crypto industry is investigated. It thus follows from the research question, that the observed units of this study need to be political entities[3], while the industrial policy of accepting taxes in the form of cryptocurrency marks the applied treatment. Unfortunately, a specific industrial policy is not a treatment which can be experimentally assigned to observed political entities. This marks a common practical problem when conducting economic research. To address said problem, quasi-experimental research designs were invented (Shadish et al., 2002, p. 13 f.). Therefore, in the next step, more light is shed on quasi-experimental

[2] Each unit within the two groups is different (i.e. there is variance). However, when all units are considered together as a group, the variance between the two groups is small.

[3] As only political entities can collect taxes and pass industrial policies.

research designs.

3.2 Quasi-Experimental Research Designs

In quasi-experimental research, the treatment can, for practical or ethical reasons, not be randomly assigned to the observed units (Shadish et al., 2002, p. 14). Hence, instead, the observed units self-select, whether they are treated or not. This might mean, in the context of this study, that each canton self-selects, whether it accepts Bitcoin and Ether as tax payment methods. Said performed self-selection leads to the problem, that when measuring a difference in outcomes (i.e. an effect), it is not clear, whether said difference is caused by the treatment, or by the performed self-selection (p. 14 f.). This in turn creates a threat to the internal validity of the experiment, as other variables (apart from the treatment) might be causing the observed effect. To address and control for internal validity threats, some experimental research designs use control variables, instrumental variables, propensity scores or other statistical methods (Maciejewski, 2020, p. 39).

A further problem, which arises from self-selection, is that the treatment and the comparison group might differ a lot in terms of their pre-treatment characteristics. In the context of this study, it might be, that the group of cantons which accept Bitcoin and Ether as tax payment methods, may significantly differ in terms of their population size, tax burdens, or other potentially influencing variables from the group of cantons which do not accept those cryptocurrencies as a mean to pay taxes. This problem is accentuated when there is only one unit in the treated group. E.g., in this study, the group of cantons which accept Bitcoin and Ether as tax payment methods (i.e. the treated group) consists only of the canton of Zug. Generally, a treatment group consisting of one unit might happen, when only one unit self-selects to apply a treatment. To address this problem, quasi-experimental research designs construct a comparison group, which is as similar as possible to the treatment group in terms of their pre-treatment characteristics (White and Sabarwal, 2014, p. 1). Said comparison group may then serve as an adequate counterfactual to the unit in the treatment group. To construct the comparison groups, different methods, like regression discontinuity design, propensity score matching or synthetic control were invented (White and Sabarwal, 2014, p. 1; Abadie and Gardeazabal, 2003, p. 114).

The synthetic control method (SCM) addresses both problems arising from self-selection, by constructing a comparison group with respect to not only the outcome but also the pre-treatment control variables (Abadie and Gardeazabal, 2003, p. 117). According to Courthoud (2022), SCM is especially suitable to use for quasi-experimental research, when there is only one treated unit, but many control units available, embedded in a time series data set. This also suitably describes the data of this paper, as the section 5 on the research data demonstrates. Hence, in the next step, SCM is described in further detail.

3.3 The Synthetic Control Method

The synthetic control method (SCM) was first introduced by Abadie and Gardeazabal (2003). The basic idea behind SCM is, that one may construct a comparison control group, by taking a weighted average of a set of untreated control units, which results in a synthetic control unit, which pre-treatment, is structurally very similar to the treated unit (Athey and Imbens, 2017, p. 9). In the first introduction of SCM, Abadie and Gardeazabal (2003) aim to observe the effect of the terrorist conflict in the Basque Country (a province of Spain) on the province's economy (p. 113). To do so, they construct a synthetic Basque country, using a weighted average of other Spanish provinces (p. 116). The speciality of the synthetic Basque Country is, that, unlike the actual Basque Country, it was never exposed to a terrorist conflict. Hence, the synthetic Basque Country may serve as a counterfactual, to observe the causal effect of the terrorist conflict on economic outcome variables.

Moving on, SCM is described mathematically. Therefore, let $\mathbf{Y_1}$ denote a $(T*1)$ vector, which contains all outcomes of the treated unit over all time periods (T) (Abadie and Gardeazabal, 2003, p. 117). To identify a causal effect of the treatment on the outcome, the outcome vector ($\mathbf{Y_1}$) needs to be compared to the outcome vector of the synthetic control unit ($\mathbf{Y_1^*}$). Said synthetic outcome vector ($\mathbf{Y_1^*}$) is defined, as the product of the $(T*J)$ outcome matrix ($\mathbf{Y_0}$) and the $(J*1)$ vector of the chosen weights ($\mathbf{W}^*$), where J denotes the amount of available control units. Meanwhile, the vector of the chosen weights ($\mathbf{W}^*$) represents the weights given to each control unit to form the synthetic unit, while the outcome matrix ($\mathbf{Y_0}$) contains all outcomes of all control units over the entire observed time. Said definition of $\mathbf{Y_1^*}$ is displayed mathematically in equation 3.

$$\mathbf{Y_1^*} = \mathbf{Y_0}\mathbf{W}^* \tag{3}$$

To actually obtain $\mathbf{Y_1^*}$, first, the vector of the chosen weights $\mathbf{W}^*$ needs to be derived. Therefore, let $\mathbf{W}$ denote the $(J*1)$ vector of weights, which are assigned to each control unit (Abadie and Gardeazabal, 2003, p. 116). By design, the sum of all $w \in W$ is equal to one. Further on, let $\mathbf{X_1}$ be a $(K*1)$ vector, containing K the pre-treatment values[4] of the treated unit (p. 117). Similarly, let $\mathbf{X_0}$ denote a $(K*J)$ matrix, containing the pre-treatment values belonging to the available control units. Then, let $\mathbf{V}$ be a diagonal matrix with non-negative components, which describes the relative weights of the values present in $\mathbf{X}$. The matrix $\mathbf{V}$ is chosen as such, that the pre-treatment outcome over time of the synthetic control unit resembles the control unit most closely. The vector of weights $\mathbf{W}$ is then chosen by minimising the function $f(\cdot)$, displayed in equation 4, subject to the constraints shown in equation 5.

$$min.f(\mathbf{X_0}, \mathbf{X_1}, \mathbf{V}) = (\mathbf{X_1} - \mathbf{X_0}\mathbf{W})'\mathbf{V}(\mathbf{X_1} - \mathbf{X_0}\mathbf{W}) \tag{4}$$

[4] Here, the term pre-treatment values refers to both the outcome and the control variables.

$$s.t. \sum_{j=1}^{J} w_j = 1 \wedge w_j \geq 1, j = 1, 2, ..., J \tag{5}$$

By minimising the function in equation 4, the specific weight vector $\mathbf{W}^*$ for the synthetic control unit is derived, which in turn allows for the calculation of the synthetic outcome vector $\mathbf{Y}_\mathbf{1}^*$ (Abadie and Gardeazabal, 2003, p. 117). Then, by comparing the outcome vector ($\mathbf{Y}_\mathbf{1}$) to the synthetic outcome vector ($\mathbf{Y}_\mathbf{1}^*$), the treatment effect may be identified. Originally, Abadie and Gardeazabal (2003) identify the treatment effect by qualitatively comparing $\mathbf{Y}_\mathbf{1}$ to $\mathbf{Y}_\mathbf{1}^*$ (p. 117 f.). A hypothetical example of how this may look is shown in figure 1[5]. The shaded area of figure 1 shows the effect of the treatment (assuming, that there is full internal validity). This

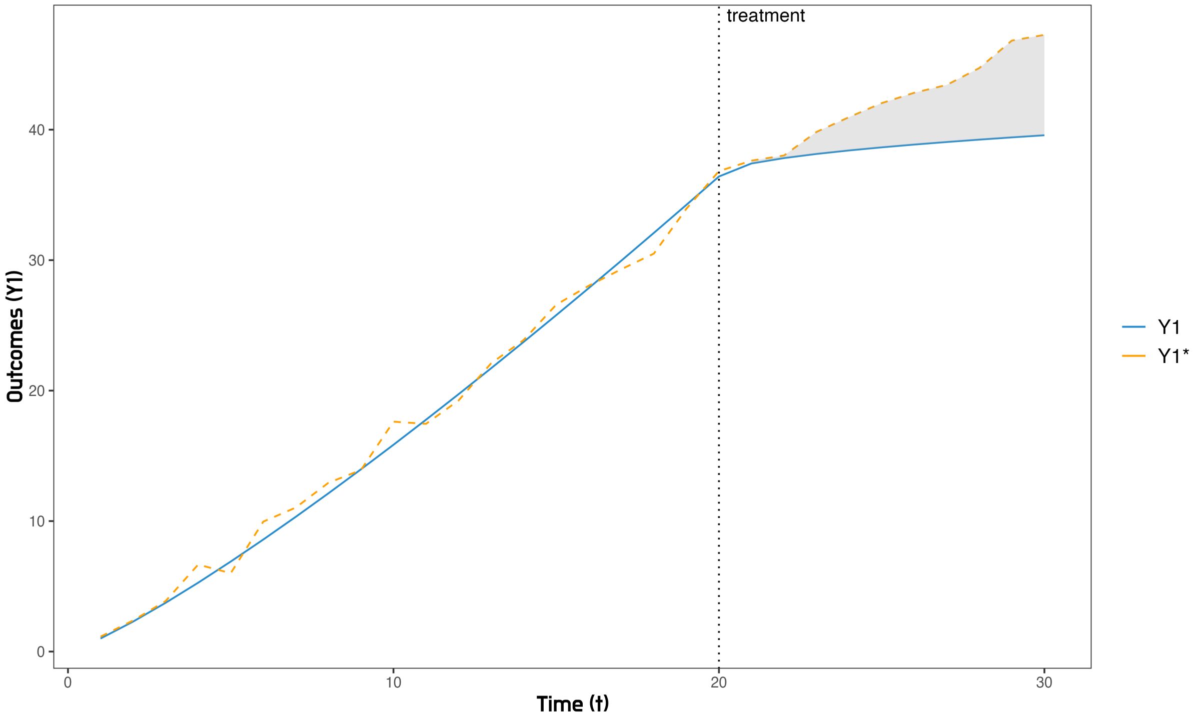

Figure 1: Example SCM

study will later go on to compare a multitude of different treatment effects under different assumptions. To be able to show how the treatment effect changes when the assumptions change, said effect needs to be quantified. Therefore, the treatment effect (E) is defined here quantitatively as the average, post-treatment ($t \geq t_0$) difference between y_t^* and y_t, where t_0 denotes the time of when the treatment is applied. The definition of E is displayed mathematically in the equation 6.

$$E = \frac{1}{(T - t_0)} \sum_{t=t_0}^{T} y_t - y_t^*, \; y_t \in \mathbf{Y}, \; y_t^* \in \mathbf{Y}^* \tag{6}$$

[5]The code to create figure 1 and all further figures of the research paper may be retrieved from GitHub from the directory called *Code/Figures and Tables/*. The retrieval of the directory from GitHub is specified in the appendix.

	actual unit	**synthetic unit**
outcome ($\bar{\mathbf{Y}}_1$)	26.93	26.79
first control variable ($\bar{x}_1$)	0.85	1.03
etc.		

Table 1: Example Goodness of Fit Comparison

According to Abadie et al. (2015), SCM should only be used when there is a good synthetic control unit fit (p. 497 f.). A good synthetic control unit fit exists, if the pre-treatment values of the variables of the synthetic unit with a significant predictive power for the outcome are similar to the pre-treatment values of the same variables of the actual unit. Rephrased differently, a good synthetic control unit fit exists, if, before the application of the treatment, the synthetic unit is similar to the actual unit. The goodness of fit is determined, by comparing an average of a set of the last values before the application of the treatment of the synthetic unit, with those same values for the actual unit (p. 502). The goodness of fit comparison thereby compares both the average outcome ($\bar{\mathbf{Y}}_1$) and the averages of any included control variables ($\bar{x}$). An example of a goodness of fit comparison is depicted in table 1.

This, so far, covers the main idea behind SCM. The next subchapter explains, how ASCM expands upon the original SCM.

3.4 The Augmented Synthetic Control Method

Since the synthetic control method (SCM) was first proposed, several theoretical and practical extensions to SCM were published, which aim at addressing certain shortcomings of the original SCM. These extensions include, among others, the generalised synthetic control method by Xu (2017) and the augmented synthetic control method (ASCM) proposed by Ben-Michael et al. (2021). In this study, ASCM is used. Therefore, it is here explained in further detail.

ASCM was developed by Ben-Michael et al. (2021) to address SCM's problem of imperfect synthetic control unit fits (p. 1). Imperfect synthetic control unit fits occur when the outcomes of the synthetic unit and those of the actual unit do not closely match in the period before the treatment is applied. In the case of an imperfect synthetic control unit fit, Abadie et al. (2015) recommend not using SCM (p. 500). An imperfect synthetic control unit fit can be improved upon by fitting the synthetic control unit using linear regression (Ben-Michael et al., 2021, p. 1). The weights resulting from the fit will likely construct a synthetic unit which matches up more closely with the actual unit in the period before the application of the treatment. However, Abadie et al. (2015) recommend against the usage of linear regression for the construction of the synthetic control unit, as the resulting weights might extrapolate certain values outside the support of the data, which would introduce bias[6] (p. 498). This reasoning justifies the restriction from equation 5, which states that only non-negative weights summing to one shall be used in the weights vector. Under the said restriction, SCM cannot be applied for certain cases. E.g., SCM cannot be applied, when the outcome of the treated unit represents an extreme value (min. or max.) within the control group, as then weights above one or weights not summing to zero would be necessary to construct a fitting synthetic control group. Therefore, Ben-Michael et al. (2021) suggest taking a middle path, where the weights shall not be restricted by the restriction displayed in equation 5, while meanwhile they should also not be unreasonably extrapolated outside the support of the data (p. 1). To achieve this, Ben-Michael et al. (2021) propose ASCM as an extension to SCM. In ASCM, the non-negativity and summing to one restriction on the weights is abolished. Instead, ASCM uses Ridge regression to construct the weights vector of the synthetic control unit. Ridge regression is a form of regression, which, besides the minimisation of the sum of the squares of the residuals also adds a penalty factor (p. 1 f.). In ASCM, the penalty factor is the distance between the weights which would be chosen by a regular linear regression and the weights which would be chosen in a classical SCM setting. The penalty factor thus restricts implausible weights that might result from an OLS regression. The resulting weights from ASCM will thereby improve the pre-treatment fit over the regular SCM, while still being controlled for bias.

The reason ASCM is chosen over the classical or other variants of SCM is the loosened restriction on the constraints on the weight vector. Given the research data, no suitable pre-treatment fit is possible using SCM, as the observed outcomes of the treated unit reside at the maximum of the outcome values of all observed units. The canton of Zug, over the observed time period between 2016 and 2022, had consistently more crypto companies than any other canton of Switzerland, as figure 5 depicts. Therefore, ASCM is used for the construction of the synthetic control unit. Besides the method of choosing the weights in the weight vector, ASCM does not introduce any further changes to SCM. Hence, the next subchapter, describing how the significance of the observed effect may be inferred using placebo studies, refers again solely to the corresponding SCM papers.

3.5 Establishing Significance Using Placebo Studies

To establish the significance of an observed effect using SCM, placebo studies are used (Abadie and Gardeazabal, 2003, p. 119; Abadie et al., 2010, p. 497). The idea behind a placebo study is to see, how the results of the analysis change, when the treated unit is changed, i.e., whether SCM also finds a treatment effect for units which were never treated in the first place (Abadie et al., 2010, p. 497). To demonstrate this idea, an example is explained. Assume, that in an observed sample data set, the treated unit is unit A. Meanwhile, the units B, C

[6] The assumption that a treated unit may be represented as a sum of high (≥ 1) or negative multiples of other control units is improbable. Therefore, Abadie et al. (2015) recommend using SCM rather conservatively, when no simple fit with non-negative weights summing to one can be used (p. 500).

and D serve as control units. When one applies SCM to the treated unit A, one obtains the synthetic outcome values of unit A. If, after the treatment is applied, the synthetic outcome values differ from the actual outcome values, one may conclude that the treatment caused a treatment effect. To test, whether said effect is significant (and not just noise), the study is repeated as a placebo study. Therefore, one applies SCM repeatedly to the untreated units B, C and D respectively, while treating those untreated units, as if they were treated[7]. Then, one observes the significance of the placebo effects of the performed placebo studies and compares them with the observed effect on the actually treated unit A. For said comparison, the notion of the mean-squared prediction error (MSPE) is introduced (Abadie et al., 2010, p. 501 f.).

To quantify the significance of an observed treatment effect mathematically, the ratio of the pre- and post-treatment MSPE of the actually treated unit is compared with the MSPE ratios of the placebo studies (Abadie et al., 2010, p. 503). To define the MSPE, first, let U denote the set of all actual and placebo-treated units. Then, the MSPE for each $u \in U$ is defined as the mean squared difference of the actual outcome values ($\mathbf{Y_1^u}$) and the synthetic outcome values ($\mathbf{Y_1^u}^*$) (p. 501). In fact, the MSPE is defined twice. Once, as the pre-treatment MSPE ($MSPE^u_{pre}$), considering the pre-treatment values of $t \in [1, t_0 - 1]$, and once as the post-treatment MSPE ($MSPE^u_{post}$), considering the post-treatment values of $t \in [t_0, T]$ (p. 503). The definition of the pre-treatment MSPE is displayed in equation 7, while the post-treatment MSPE is displayed in equation 8.

$$MSPE^u_{pre} = \frac{1}{t_0 - 1} \sum_{t=1}^{t_0-1} (y_t - y_t^*)^2,\ y_t \in \mathbf{Y_1^u},\ y_t^* \in \mathbf{Y_1^{u*}},\ \forall u \in U \tag{7}$$

$$MSPE^u_{post} = \frac{1}{T - t_0} \sum_{t=t_0}^{T} (y_t - y_t^*)^2,\ y_t \in \mathbf{Y_1^u},\ {y_t^u}^* \in \mathbf{Y_1^*},\ \forall u \in U \tag{8}$$

To make this relationship more graspable, an example of the outcome differences between $\mathbf{Y_1^u}$ and $\mathbf{Y_1^u}^*$ is displayed in figure 2 for $\forall\, u \in U$. In said exemplary figure 2, it becomes evident, that the post-treatment difference in the actual and synthetic outcome is much higher for the actually treated unit A than it is for the other, untreated units B, C and D. Hence, the MSPE captures the idea, of mathematically quantifying the outcome differences shown in figure 2. To analyse the significance of the proposed treatment effect on unit A, the distribution of the ratios of the pre- and post-treatment MSPEs is observed (Abadie et al., 2010, p. 503). Therefore, the ratio (R) of the pre- vs. post-treatment MSPE is defined for each $u \in U$, as equation 9 displays.

$$R_u = \frac{MSPE^u_{post}}{MSPE^u_{pre}},\ \forall u \in U \tag{9}$$

Then, the significance of the actual treatment effect can be established, by comparing the MSPE ratio (R_{u_A})

[7]Another method of performing placebo studies is by varying the date of the applied treatment, and observing how the results change (Abadie et al., 2015, p. 499).

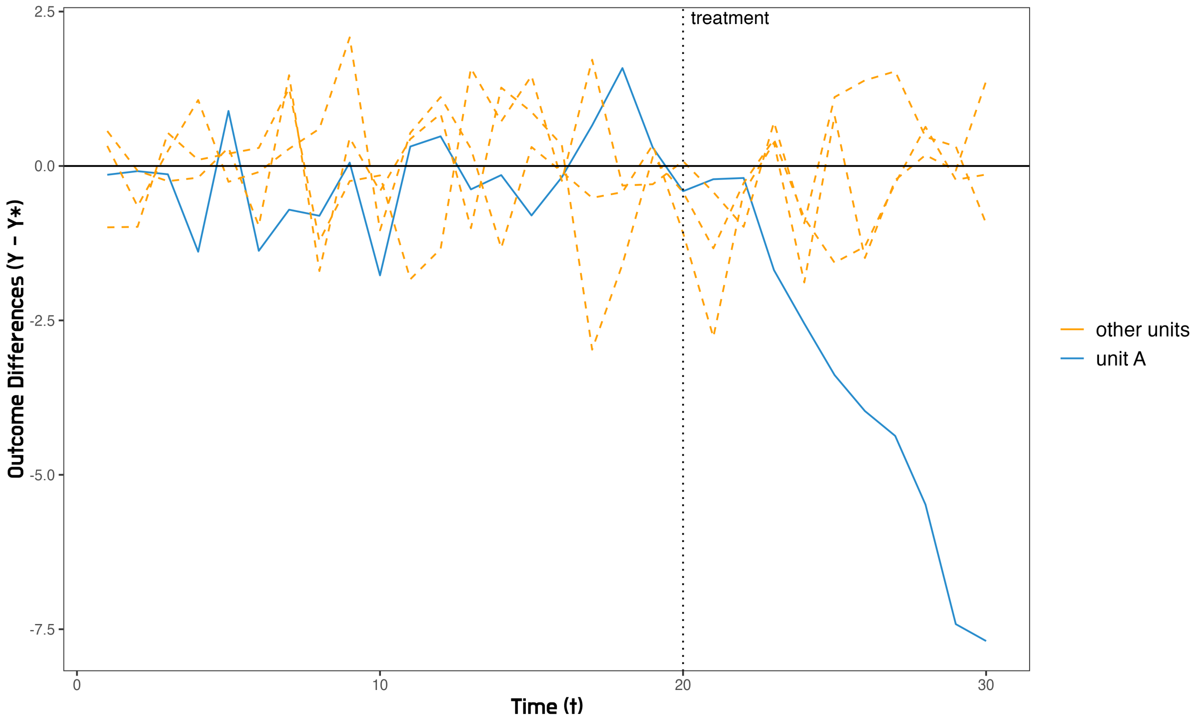

Figure 2: Example Outcome Differences

of the actual treated unit (u_A) with the MSPE ratios (R_u) resulting from the placebo studies, i.e. from $u \in U \setminus \{u_A\}$ (Abadie et al., 2010, p. 503). In the given example of the units A, B, C and D (as shown previously in figure 2), it results, that the MSPE ratio (R_{u_A}) of the actually treated unit (u_A) is much higher than it is for the other control units. This relationship is graphically exemplified in figure 3. To break down the disparity between the MSPE ratios (R_u) of the treated and the untreated units into a single-number (p-value), Abadie et al. (2010) ask what would be the probability (P) of obtaining an MSPE ratio (R_u) equal or greater than the one of the treated unit (u_A), if one were to choose a unit (u) at random from the set of units (U) (p. 503). The resulting probability can be interpreted as a p-value, which here forth shall be denoted as p_{syn} (Abadie et al., 2015, p. 500). The formulation of p_{syn} is again expressed mathematically in equation 10.

$$p_{syn} = P(R_u \geq R_{u_A}) = \frac{|H|}{|U|},\ H = \{u \in U | R(u) \geq R(u_A)\} \tag{10}$$

In the example case demonstrated in figure 3, the probability (p_{syn}) of getting an MSPE equal or greater than the one of unit A is one-fourth, i.e. $p_{syn} = \frac{1}{4}$. To get a smaller p-value (p_{syn}), a greater sample size is necessary. This forms a relevant restriction when testing and interpreting the results of a significance test using placebo studies, as the p-value can't be smaller than one over the sample size ($\frac{1}{|U|}$). This definition of the p-value (p_{syn}) is used later on to establish the significance of the results of the observed effects in the research data.

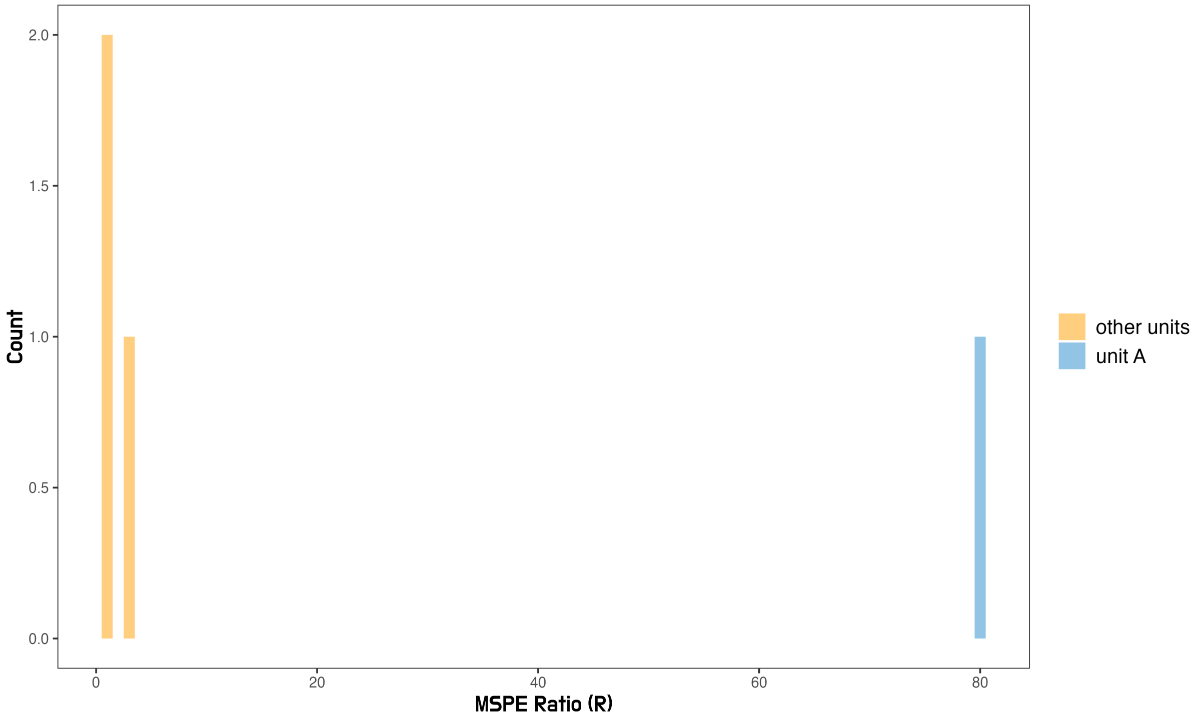

Figure 3: Example MSPE Ratios

To summarise, the paper examines whether a causal effect of the acceptance of cryptocurrencies as tax payment methods can be found on the growth of the local crypto industry. To find a causal effect, the difference of the actual outcomes of the canton of Zug and the outcomes of a constructed synthetic control unit is determined. Therefore, the synthetic control unit is constructed using ASCM. Then, the significance of the effect is measured using placebo studies. How this works in practice is shown in the section, which introduces the research design.

4 Research Design

The research design chapter explains, how the paper answers the research question. Therefore, subsection 4.1 describes again the research question, the null hypothesis and the alternative hypothesis. Then, subsection 4.2 introduces the research strategy, describing how the paper tests the null hypothesis to answer the research question. The research strategy shows how (A)SCM is used, to obtain an answer to the research question. To test the robustness of this answer (i.e. of the results), the research strategy includes the use of control variables. Subsection 4.3 hence introduces the included control variables. Further on, the control variables and the chosen research strategy give rise to various assumptions. Therefore, the last subsection 4.4 describes these assumptions in detail.

4.1 Research Question and Hypotheses

To recall, this study aims to examine the policy effect of accepting cryptocurrencies as tax payment methods. Therefore, the paper asks the following research question:

> *What effect has the acceptance of Bitcoin and Ether as tax payment methods on the growth of the local crypto industry?*

To answer the research question, at first, the null hypothesis (H_0) is formulated:

> H_0*: The acceptance of Bitcoin and Ether as tax payment methods has no effect on the growth of the local crypto industry.*

Based on said null-hypothesis (H_0), the alternative hypothesis (H_1) is formulated:

> H_1*: The acceptance of Bitcoin and Ether as tax payment methods has an effect on the growth of the local crypto industry.*

The alternative hypothesis (H_1) is openly formulated, meaning, that the study examines both negative and positive effects, which may result from the research question. To answer the research question and test the null hypothesis (H_0), the research strategy, as described in the next subchapter, is followed.

4.2 Research Strategy

Here, the research strategy is described, which is followed to answer the research question. Hence, to answer the research question, the case of the canton of Zug in Switzerland is studied, which introduced the policy of accepting Bitcoin and Ether as tax payment methods in January 2021 (Finanzdirektion Direktionssekretariat, 2020). Here, said policy is also referred to as the treatment. To estimate the treatment effect of this policy, the number of new crypto companies registered in the commercial registry of the canton is used as the instrument to estimate the growth of the local crypto industry. For the purpose of simplicity, the paper refers to the instrument simply as the number of crypto companies, or as the outcome (Y). The sample data on the instrument is obtained by feeding a set of crypto companies into the central business name index of Switzerland called Zefix. Zefix stores the data of all cantonal commercial registries (Swiss Confederation, n.d.). By web-scraping LinkedIn, the set of crypto companies used therefore is constructed ("LinkedIn", 2023). On the resulting master sample data set, the data analysis is performed. As a first step of the data analysis, the augmented synthetic control method (ASCM) is used to get an untreated counterfactual to the canton of Zug, by constructing a synthetic canton of Zug out of a set of other cantons of Switzerland which did not introduce the treatment. The cantons included in the set are varied to check for the robustness of the observed treatment effect. The observed treatment effect is defined as the difference in the outcomes (Y) of the actual canton Zug and the synthetic canton Zug. To see whether the null hypothesis (H_0) can be rejected, placebo studies are used to test for the significance of the observed treatment effect. To further test the robustness of the result, the analysis is repeated using different sets of control variables. To perform the analysis, a sample data set is constructed. The construction of said sample data set is described in chapter 5. Meanwhile, the next subchapter describes the included control variables in further detail.

4.3 Control Variables

To control for influences which, besides the treatment, might affect the outcome, four control variables are introduced. The definition of the control variables, and the reasons they were chosen, are listed below.

1. **Tax Burden** (TX): The tax burden is chosen as a control variable, as it is assumed, that companies prefer to do business in a low-tax than in a high-tax canton. To estimate the tax burden for each canton, the total tax burden[8] of a company limited by shares[9] located in the cantonal capital and earning a taxable profit of CHF 20'000 a year is observed.

2. **Working population** (WP): The working population is chosen as a control variable, as it is assumed, that cantons with a higher working population contain and grow more companies in general. Therefrom, it is deduced that cantons with a higher working population also contain and grow more crypto companies. The working population is thereby defined as all people in a canton aged 20 to 64.

3. **Share of the financial sector in the local crypto industry** (f): The share of the financial sector in the local crypto industry is chosen as the first control variable aiming at modelling the structure of the local crypto industry. In this paper, a sector is understood as a subclassification of companies within the crypto industry itself, as it is assumed, that the observed policy effect has a different impact on differently structured industries.

4. **Share of the IT sector in the local crypto industry** (it): The share of the IT sector in the local crypto industry is chosen as a second control variable aiming at modelling the structure of the local crypto industry. The idea behind it is the same as for variable f.

In the performed data analysis, the given control variables are added cumulatively and step-by-step to the data, to see how the effect changes with the amount of included control variables.

4.4 Assumptions

At last, the assumptions resulting from the research strategy are discussed. In the end, there are three assumptions which result from the research strategy. To account for the flexibility employed in the research strategy,

[8] The total tax burden is defined as the sum of the communal, cantonal and federal taxes.
[9] A company limited by shares refers to the *Aktiengesellschaft* as defined by the Swiss code of obligations (Swiss Confederation, 1911, art. 620 ff.).

assumption	qualitative description	formal description
$A_{1.0}$	The sample outcome (Y) is representative of the true outcome (Y_{true}).	$E(x_1\|Y) = E(x_2\|Y_{true}), x_1 \in Y, x_2 \in Y_{true}$
$A_{1.1}$	The sample tax burden (TX) is representative of the true tax burden (TX_{true}) and $A_{1.0}$ holds true.	$E(x_1\|TX) = E(x\|TX_{true}) \wedge A_{1.0}, x_1 \in TX, x_2 \in TX_{true}$
$A_{1.2}$	The sample working population (WP) is representative of the true working population (WP_{true}) and $A_{1.1}$ holds true.	$E(x_1\|WP) = E(x_2\|WP_{true}) \wedge A_{1.1}, x_1 \in WP, x_2 \in WP_{true}$
$A_{1.3}$	The sample share of the financial sector (f) is representative of the true share of the financial sector (f_{true}) and $A_{1.2}$ holds true.	$E(x_1\|f) = E(x_2\|f_{true}) \wedge A_{1.2}, x_1 \in f, x_2 \in f_{true}$
$A_{1.4}$	The sample share of the IT sector (it) is representative of the true share of the IT sector (it_{true}) and $A_{1.3}$ holds true.	$E(x_1\|it) = E(x_2\|it_{true}) \wedge A_{1.3}, x_1 \in it, x_2 \in it_{true}$

Table 2: Assumption of a Representative Sample Data

the assumptions are formulated for the different sets of included cantons and control variables. The first assumption, which results from the research strategy, concerns the construction of the sample data set. For the construction of the sample data set, it must be assumed, that the observed variables in the data sample are representative of the actual values of the variables. This assumption is described in detail and for all control variables, in table 2. The second assumption, which the research strategy requires, concerns the correlation of the outcome (Y) with the treatment (t). It is assumed, that the outcome (Y), controlled for the different control variables, correlates with the applied treatment (t). This assumption is described in detail, for all control variables, in table 4. The last assumption, which needs to be made for an analysis using synthetic control, is that the canton of Zug (u_{zug}) can be represented as a linear combination of cantons (u) from the set of cantons (U). This assumption is needed, as this linear representation of the canton of Zug (i.e. the synthetic Zug) is the counterfactual, against which the treatment effect is measured. However, of the other 25 observed cantons, some contain only very few or even no crypto companies. Therefore, a cut-off (c) is defined, which states the minimal number of crypto companies a canton needs to have, to be included in the linear representation of the canton of Zug. As a result, the assumption is defined 21 times, for 21 different values of the cut-off (c).

To summarise, the research question asks whether the canton of Zug's implemented industrial policy has an effect on the growth of its crypto industry. To test the null hypothesis of the research question, the number of newly registered crypto companies in the cantonal commercial registries is used as an instrument. The sample data on the instrument is obtained by web-scraping Linked and Zefix. Further on, (A)SCM is used to analyse the resulting data and look for a treatment effect. To examine the robustness of the results, four control variables are included step-by-step in the data analysis. A set of assumptions is added, which describes the different scenarios of the analysis by in- or excluding different cantons and/or control variables. In the next section on the

assumption	**qualitative description**	**formal description**
$A_{2.0}$	The outcome (Y) correlates with the treatment (t).	$Cov(Y,t) \neq 0$
$A_{2.1}$	The outcome (Y), controlled for the tax burden (TX), correlates with the treatment (t).	$Cov(Y,t\|TX) \neq 0$
$A_{2.2}$	The outcome (Y), controlled for the tax burden (TX) and the working population (WP), correlates with the treatment (t).	$Cov(Y,t\|TX,WP) \neq 0$
$A_{2.3}$	The outcome (Y), controlled for the tax burden (TX), the working population (WP) and the share of the financial sector (f), correlates with the treatment (t).	$Cov(Y,t\|TX,WP,f) \neq 0$
$A_{2.3}$	The outcome (Y), controlled for the tax burden (TX), the working population (WP) as well as the share of the financial (f) and IT (it) sector, correlates with the treatment (t).	$Cov(Y,t\|TX,WP,f,it) \neq 0$

Table 3: Assumption of a Treatment Correlation

assumption	**qualitative Description**	**formal description**
$A_{3.c}$	The canton of Zug (u_{zug}) can be represented as a linear combination of the cantons ($u \in U$), that have a higher outcome (Y) than the cut-off (c).	$u_{zug} \approx \sum_{j=1}^{\|U_c\|} w_j u_j, w \in W, U_c = \{u \in U\|Y(u) \geq c\}, c \in [0,20]$

Table 4: Assumption of a Linear Representation of Zug

research data, the construction of the master sample data set upon which the analysis is conducted is described in detail.

5 Research Data

The section on the research data explains, how the master sample data set upon which the data analysis is conducted is obtained. Therefore, the section showcases the data pipeline used to derive the master sample data set. In the second step, said master data set, and its properties are examined, analysed and visualised in further detail, to give an adequate understanding of the data used in the analysis. Hence, the data section starts with a subchapter on the data pipeline showing the construction of the master data set and concludes with a subchapter on the properties of the master data set.

5.1 Data Pipeline

To obtain the data needed for the analysis, the process, as depicted in the data pipeline in figure 4 is followed. The data pipeline is logically structured into four stages and contains four data sources. Namely, the data sources are LinkedIn, Zefix, the Federal Statistical Office and the Federal Tax Administration of Switzerland. In the first stage of the data pipeline, LinkedIn is used to gather a data set of companies in Switzerland which are active in the crypto industry. In the second stage, the crypto companies are looked up in the respective cantonal commercial registries using Zefix, to retrieve their respective founding dates. The resulting data set of individual crypto companies is then aggregated into a time series data set, which contains inter alia the number of crypto companies within a canton on each given month. In the third stage, macroeconomic variables as retrieved from the Federal Statistical Office and the Federal Tax Administration are added to the data set as control variables. In the last stage, the treatment period for the canton of Zug is set. This in turn forms the master sample data set, which is used for further analysis. Going forward, the execution of the data pipeline is described in detail.

5.2 Execution of the Data Pipeline

The subsection on the execution of the data pipeline shows how the four stages of the data pipeline are executed. It starts with the first stage of the gathering of the companies and ends with the fourth and last stage of setting the treatment variable.

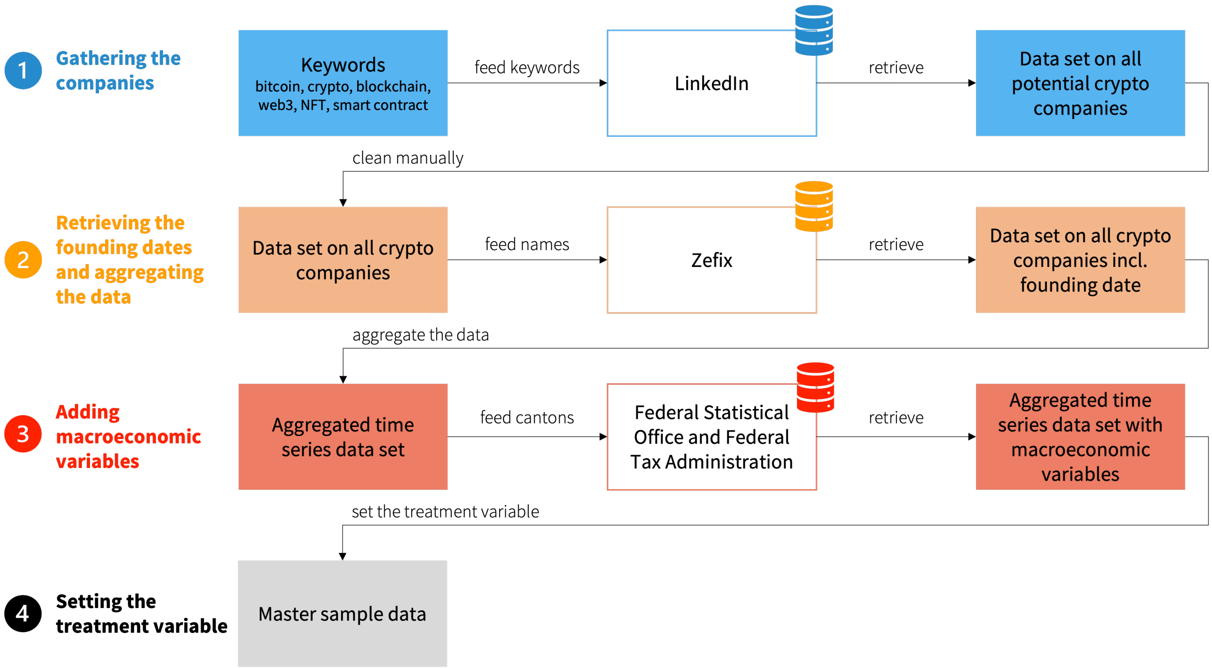

Figure 4: Data Pipeline

5.2.1 Gathering the Companies

The first stage of the data pipeline involves the gathering of all crypto companies. To achieve this task, the LinkedIn (2023) search is used. Preliminarily, the search is restricted to companies which are based in Switzerland. Next, individual searches are conducted for each keyword in a set of keywords, which relate to the crypto industry. Therefore, the following keywords are chosen:

- **Bitcoin:** Bitcoin is the first cryptocurrency to ever be conceived (Nakamoto, 2008).
- **Crypto:** Crypto is short for cryptocurrency and refers to all cryptographically secured currencies (Merriam-Webster, n.d.-a).
- **Blockchain:** The blockchain is one of the underlying technologies used in cryptocurrencies (Wamba et al., 2020, p. 4).
- **Web3:** Web3 is an umbrella term, which inter alia encompasses the idea of using blockchain technology and decentralisation in a new form of the web (Sheridan et al., 2022, p. 1).
- **NFT:** An NFT is a non-fungible token, which is stored on a blockchain (Merriam-Webster, n.d.-b).
- **Smart Contract:** A smart contract is a program, which runs on a blockchain (Alharby and van Moorsel, 2017, p. 125).

It is assumed that a LinkedIn search for the selected set of keywords returns a representative sample of companies in the Swiss crypto industry. This assumption is described formally as assumption $A_{1.0}$ in table 2 in section

	name	sector
0	Tabet Advisory	Investment Advice
...	...	...
403	dotcom Ventures Holding AG	Venture Capital and Private Equity Principals
404	SignorCrypto	Technology, Information and Internet
405	GRNGrid	Technology, Information and Internet
406	Bitu DAO	Civic and Social Organizations
...	...	...
809	ATMChain Foundation	Research

Table 5: Sample Data from LinkedIn

4 on the research design.

To actually conduct the retrieval of the sample of companies from LinkedIn, web scraping techniques are used. To perform the web scraping, Python in combination with the Selenium package is used[10] (Muthukadan, n.d.). The Python code programmatically feeds the keywords into the LinkedIn search, while restricting the search area to Switzerland. The LinkedIn search, in turn, yields an HTML file, whose contained semi-structured data is read and parsed into a table format using the Beautiful Soup package ("Beautiful Soup Documentation", n.d.). From the results of these LinkedIn search queries, a data set of potential crypto companies containing 1'125 rows is obtained. However, some potential crypto companies are not actually based in Switzerland or are not actual crypto companies. These false positives are manually removed, which reduces the size of the table to 810 crypto companies. A small sample from the said data set is depicted in table 5. This data set on all crypto companies forms the basis for the second stage of the data pipeline, i.e. the retrieval of the founding dates and the aggregation of the data.

5.2.2 Retrieving the Founding Dates and Aggregating the Data

So far, in the first stage of the data pipeline, the data set on all crypto companies is assembled. Said data set contains the sector and the name of each crypto company. Hence, in the second stage of the data pipeline, more data on those crypto companies is collected using Zefix (Swiss Confederation, n.d.). With the help of Python and Selenium, the name of each company is fed into the commercial registry's website (Muthukadan, n.d.). Then, the HTML returned by the server is parsed into a table data format, again using Python and the Beautiful Soup package ("Beautiful Soup Documentation", n.d.). Some companies present in the prior data set were not found based on their name on Zefix, which further reduces the data set of available companies to 275. For the 275 remaining companies, two further columns containing the founding date and the canton of the location of the

[10] The specific Python scripts used can be found in the *Code/Data Pipeline* directory on GitHub. The retrieval of the scripts from GitHub is specified in the appendix.

	name	canton	founding date	sector
0	Tech Bureau Europe SA	ZG	2017-12-29	IT Services and IT Consulting
...	...	...	...	...
133	Block0 SA	VD	2018-05-03	Venture Capital and Private Equity Principals
134	RACE-CAP AG	SG	2018-06-22	Financial Services
135	Digital Asset Solutions AG	ZG	2022-06-24	Financial Services
136	MOONCHAIN CAPITAL SA	GE	2018-04-24	Financial Services
...	...	...	...	...
269	Disruptr GmbH	ZH	2019-12-18	Software Development

Table 6: Sample Data from LinkedIn with Zefix Data

company's headquarters are added to the data set[11]. To get a clean timespan on which the time series is defined, a cutoff is set on the founding date, to only include companies founded between 01.01.2016 and 31.12.2022[12]. This cutoff eliminates five companies, which thus results in a data set of 270 companies. A small sample of this data set is displayed in table 6. The derived data, as displayed in table 6, is still in the wrong shape for the analysis. Then, to answer the research question, the data on the individual companies must be aggregated into a data set which describes the industry as a whole for each specific canton at all points in time. This data aggregation is performed with the help of a Python script. In this aggregation, the granularity of the founding dates is reduced from a daily to a monthly basis. Additionally, the values in the sector column are reduced to merely indicate, whether a company is active in the financial, IT- or another (crypto) sector[13]. Therefrom, the control variables aimed at modelling the structure of the industry, i.e. the shares of IT- and financial crypto companies, are added to the aggregated rows. As a result, each data row in the aggregated data set shows the number of crypto companies (Y) as well as the share of the IT- (it) and the finance (f) crypto sector for a given canton in a given month between the 01.01.2016 and the 31.12.2022. This aggregated data set contains data on 26 cantons for 7 years on a monthly basis, which hence results in 2'184 table rows. A small sample of the said data set is shown in table 7. In the next stage of the data pipeline, two macroeconomic variables are added to said aggregated, per canton data set, to serve as control variables in the analysis later.

5.2.3 Adding Macroeconomic Variables

In the third stage of the data pipeline, macroeconomic variables are added to the aggregated data set. Specifically, the control variables on the working population (WP) and on the tax burden (TX) per canton are added.

[11] The data on all the companies can be found on GitHub in the table called *Data/All Companies of the Master Sample Data Set.csv*. The retrieval of the data from GitHub is specified in the appendix.

[12] The time series is cut to observe the data during exactly seven years as thereby potential annual seasonal components are included in full, i.e. there is no observation of merely a fraction of a season.

[13] The classification of sectors into financial, IT and other sectors is detailed on GitHub in the file *Code/Data Pipeline/Adding Macroeconomic Variables/sector_classification.txt*. The retrieval of the file from GitHub is specified in the appendix.

	month	canton	Y	f	it
0	2016-01-31	ZG	0	NaN	NaN
...	...	...	...	...	...
1090	2019-06-30	GE	10	0.50	0.20
1091	2019-06-30	JU	0	NaN	NaN
1092	2019-07-31	ZG	70	0.41	0.43
1093	2019-07-31	ZH	27	0.48	0.37
...	...	...	...	...	...
2183	2022-12-31	JU	1	0.00	0.00

$Y = outcome\ (number\ of\ companies), f = fin.\ sector\ (\%), it = IT\ sector\ (\%)$

Table 7: Sample of the Aggregated Data

	month	canton	Y	TX	WP	f	it
0	2016-01-31	ZG	0	2361.00	78376.0	NaN	NaN
...	...	...	...	...	...	...	...
1090	2019-06-30	GE	10	4893.55	315296.0	0.50	0.20
1091	2019-06-30	JU	0	4372.45	42605.0	NaN	NaN
1092	2019-07-31	ZG	70	2338.50	79665.0	0.41	0.43
1093	2019-07-31	ZH	27	4356.00	972784.0	0.48	0.37
...	...	...	...	...	...	...	...
2183	2022-12-31	JU	1	NaN	NaN	0.00	0.00

$Y = outcome\ (number\ of\ companies), TX = tax\ burden, WP = working\ population, f = fin.\ sector\ (\%), it = IT\ sector\ (\%)$

Table 8: Sample of the Aggregated Data with Macroeconomic Variables

The data needed is obtained from the Federal Statistical Office (n.d.) and the Federal Tax Administration (n.d.) of Switzerland. The working population, as obtained from the Federal Statistical Office (n.d.), is defined as the number of inhabitants of a canton aged between 20 and 64. Data on the working population is available for the years 2016 – 2021, which in turn means, that for the last year of the collected aggregated data (i.e. 2022), no data is available for the working population. To record the data on the tax burden per canton, due to the complexity of local tax codes, an estimator for the tax burden has to be chosen. Therefore, the total tax burden[14] of a company limited by shares[15], located in the cantonal capital and earning a taxable profit of CHF 20'000 a year, is chosen as an estimator for the tax burden in each canton. The data for this estimator is obtained from the Federal Tax Administration (n.d.). Like with the working population, no data on the tax burden is available for the year 2022. A sample of the aggregated data set with the two macroeconomic variables added is shown in table 8. In the next and final stage of the data pipeline, the treatment variable is defined and added to the data set.

[14] The total tax burden is the sum of the communal, cantonal and federal taxes.

[15] A company limited by shares refers to the *Aktiengesellschaft* as defined by the Swiss code of obligations (Swiss Confederation, 1911, art. 620 ff.).

	month	canton	Y	TX	WP	f	it	t
0	2016-01-31	ZG	0	78376.0	2361.0	NaN	NaN	0.0
...	...	...	...	...	...	...	...	...
1896	2022-01-31	GE	16	NaN	NaN	0.44	0.25	0.0
1897	2022-01-31	JU	0	NaN	NaN	NaN	NaN	0.0
1898	2022-02-28	ZG	110	NaN	NaN	0.41	0.39	1.0
1899	2022-02-28	ZH	52	NaN	NaN	0.42	0.38	0.0
1900	2022-02-28	BE	4	NaN	NaN	0.25	0.00	0.0
1901	2022-02-28	LU	4	NaN	NaN	0.50	0.25	0.0
...	...	...	...	...	...	...	...	...
2183	2022-12-31	JU	1	NaN	NaN	0.00	0.00	0.0

$Y = outcome\ (number\ of\ companies), TX = tax\ burden, WP = working\ population, f = fin.\ sector\ (\%), it = IT\ sector\ (\%), t = treatment$

Table 9: Sample of the Master Sample Data Set

5.2.4 Setting the Treatment Variable

In the fourth and last stage of the data pipeline, the treatment variable is set. Since January 2021, the canton of Zug is accepting Bitcoin and Ether as tax payment methods (Finanzdirektion Direktionssekretariat, 2020). This policy intervention is regarded as the assumed treatment. Therefore, a binary treatment variable (t) is introduced to the data set. Said treatment variable is set to 1 for all rows where the value in the canton column is Zug and the value in the month column is at least as recent as January 2021. In all other rows, the treatment variable is set to 0. Said setting of the treatment variable represents the final step in the data pipeline, and hence yields the final data set needed for the analysis, called the master sample data set. A sample of the said master sample data set is depicted in table 9. In the next subchapter, the characteristics and summary statistics of the master sample data set are examined in closer detail.

5.3 Master Sample Data

The subsection on the master sample data set further examines the master sample data as displayed in table 9. Here, the master sample data is simply referred to as the data. Said data is a multivariate time series set, containing 84 monthly rows for each of the 26 cantons. The main variable of interest of the time series is the outcome (Y), i.e. the number of existing crypto companies in a canton. To showcase an overview of the data, the time series of the outcome variable is plotted in figure 5. The graph in figure 5 further indicates the month in which the treatment begins (i.e. January 2021) with a dotted line. When analysing the data in figure 5, it is visible that only five out of the 26 cantons harbour ten or more crypto companies. Therefore, it is decided to summarise the other cantons in a constructed "average other canton"[16].

[16] The entire master sample data set can be found on GitHub in the table called *Data/Master Sample Data Set.csv*. The retrieval of the data from GitHub is specified in the appendix.

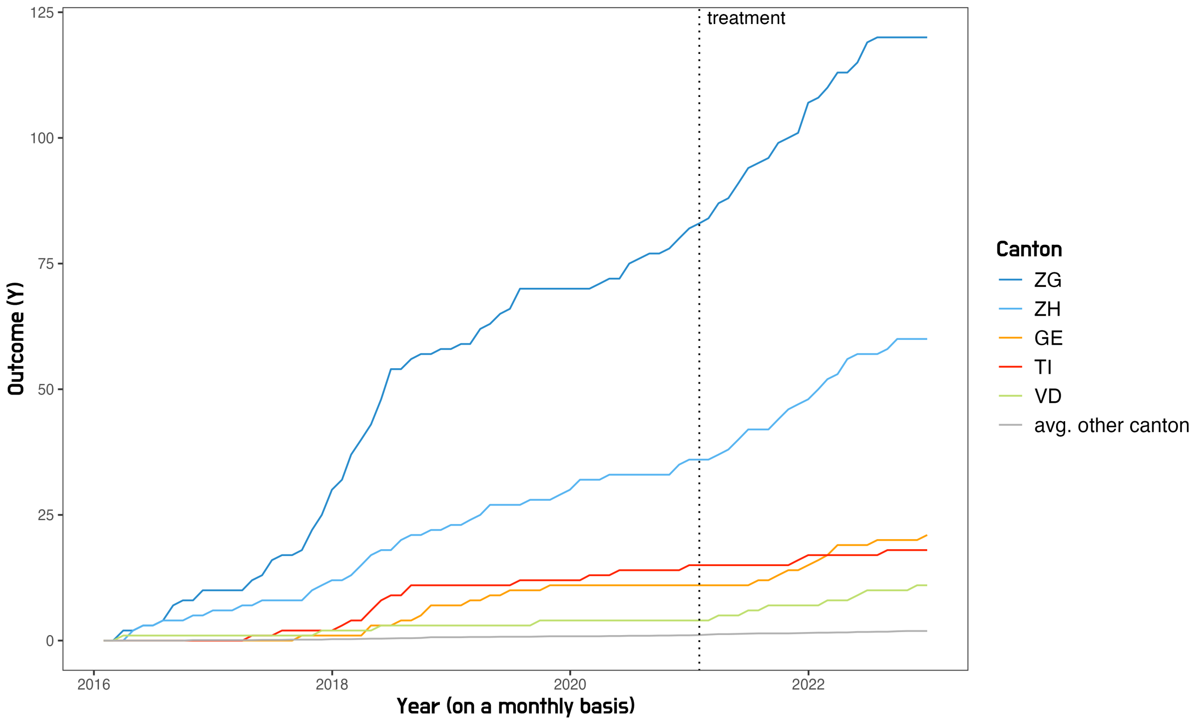

Figure 5: Time Series of the Companies

canton	count December 2022	count January 2016	$\bar{Y}$	s_Y	Q_1	Q_2	Q_3
ZG	120.0	0	60.33	37.76	21.00	68.00	87.25
ZH	60.0	0	26.86	17.75	9.50	27.00	37.25
GE	21.0	0	8.00	6.63	1.00	10.00	11.00
TI	18.0	0	9.61	6.45	2.00	11.50	15.00
VD	11.0	0	3.88	2.83	1.00	3.00	5.00
avg. other canton	1.9	0	0.78	0.59	0.19	0.76	1.29

Table 10: Summary Statistics on the Outcomes

Further on, summary statistics are constructed for the outcome and control variables and displayed in table 10 and 11. Table 10 shows the count of the outcome variable (Y) at the beginning of the data (January 2016), the count of Y at the end of the data (December 2022), the sample mean of Y ($\bar{Y}$), the sample standard deviation of Y (s_Y), as well as the 25th- (Q_1), 50th- (Q_2) and 75th-percentile (Q_3) for the values of Y. Table 11 shows the sample mean ($\bar{x}$) and the in sample standard deviation (s_x) for each control variable (x).

Next, the master sample data is described on a qualitative level. It results from the data, that the Swiss crypto industry is very much concentrated within the Crypto Valley (i.e. in Zug). Besides Zug, merely the cantons of Zürich (ZH), Geneva (GE), Ticino (TI) and Vaud (VD) contain a significant number of crypto companies. The major part of Swiss cantons has a very small to non-existing crypto industry. The data also supports Moris-

canton	$\bar{x}_{TX}$	s_{TX}	$\bar{x}_{WP}$	s_{WP}	$\bar{x}$	s_f	$\bar{x}_{it}$	s_{it}
ZG	2516.26	229.17	79600.00	741.28	0.40	0.05	0.42	0.05
ZH	4308.67	106.58	965984.67	14978.86	0.39	0.10	0.48	0.15
GE	4206.23	977.38	312826.00	4462.51	0.58	0.23	0.16	0.09
TI	4188.57	231.20	208873.00	1480.39	0.06	0.04	0.52	0.13
VD	3560.55	765.45	494795.17	7713.98	0.51	0.30	0.45	0.32
avg. other canton	3126.06	168.21	152821.66	896.66	0.49	0.09	0.06	0.05

$TX = tax\ burden, WP = working\ population, f = fin.\ sector\ (\%), it = IT\ sector\ (\%)$

Table 11: Summary Statistics on the Control Variables

son and Turner's (2022) claim, that Zug is historically known for its low taxes (p. 917). In fact, Zug has the lowest tax burden amongst all cantons in the sample data. This might be a contributing factor, as to why the Crypto Valley formed itself in Zug. The second observed macroeconomic variable is the working population. The cantons with the highest outcomes have, besides Zug, all rather high working populations. The rather large canton of Berne is notably absent in the list of cantons with many crypto companies, despite being Switzerland's second-biggest canton in terms of its working population (Federal Statistical Office, n.d.). Compared to the canton of Berne, Zug's working population is tiny. It seems that the population size of a canton alone is not a good indicator of the size of its crypto industry. The two control variables f and it are intended to model the structure of the local crypto industries of the cantons. While some cantons' crypto industries are structured significantly differently from others, no noticeable patterns of the economic structures can be recognised from a qualitative assessment. At last, no radical change seems to be induced by the treatment on the growth of the crypto industry in Zug.

To summarise, the section on the research data describes the data pipeline and the resulting master sample data set. The data pipeline, which shows the derivation of the master sample data set, consists of four stages. In the first stage, the names of Swiss crypto companies are gathered using the LinkedIn search function. In the second stage, the companies' names are fed into Zefix to obtain their founding dates. The resulting data is hence aggregated into a per canton time series data set. The two control variables on the structure of the crypto industry are constructed using the sector description of the companies on LinkedIn and are subsequently added to the time series data set as well. In the third stage, the two macroeconomic control variables are retrieved from the Federal Statistical Office (n.d.) and the Federal Tax Administration (n.d.) and added to the data as well. The last stage of the data pipeline is the addition of the binary treatment variable. By executing the steps in the data pipeline, one gets the master sample data set. The master sample data shows, that the Swiss crypto industry is indeed clustered within the Crypto Valley. In the next section, the obtained master sample data is analysed.

canton	$w_j^* \in \mathbf{W}^*$	*etc.*		*etc.*	
AG	-1.03	**GR**	1.15	**SZ**	-1.79
AI	-0.96	**JU**	-0.96	**TG**	-0.96
AR	-0.96	**LU**	1.68	**TI**	2.04
BE	0.05	**NE**	-0.86	**UR**	4.76
BL	-0.96	**NW**	-0.96	**VD**	1.28
BS	-0.30	**OW**	0.92	**VS**	-0.96
FR	-0.96	**SG**	-0.18	**ZH**	1.10
GE	0.83	**SH**	0.92		
GL	-0.96	**SO**	-0.96		

Table 12: Chosen Weights Vector under Basic Assumptions

6 Data Analysis

The section on data analysis shows the process of finding a treatment effect of the examined tax policy and determining the significance of the said effect. The section starts out by showing the complete analysis of the master sample data under basic assumptions. Basic assumptions mean here, that no control variables are included, and no cantons are excluded. To test the robustness of the results obtained under basic assumptions, it is shown how the results change when the assumptions change. The results obtained from the data analysis are explained and discussed in detail in the subsequent section 7 on the findings.

6.1 Data Analysis under Basic Assumptions

At first, the master sample data set is analysed under basic assumptions, i.e. without the inclusion of any control variables and without the exclusion of any cantons. Formally, the basic assumptions mean the assumptions $A_{1.0}$, $A_{2.0}$ and $A_{3.0}$. The analysis of the master sample data is conducted using (A)SCM. Thus, the synthetic counterfactual of the canton of Zug is constructed first. Then, a treatment effect is determined, by comparing the outcomes of the synthetic canton with those of the actual canton of Zug. The significance of the obtained treatment effect is found by comparing the MSPE ratio (R) of the actual unit with the MSPE ratios resulting from the placebo studies.

6.1.1 Construction of Synthetic Zug

The synthetic canton of Zug is constructed using ASCM. Therefore, the R-package *augsynth* is used[17] (Ben-Michael, 2021). To recall, the synthetic canton of Zug is a linear combination of the control cantons, as shown in equation 3. A weight vector ($\mathbf{W}$) contains the weights of each canton of the linear combination making up the synthetic canton of Zug. In casu, the weights vector chosen by ASCM ($\mathbf{W}^*$) is displayed in table 12. The chosen

[17] The specific R-scripts used can be found in the *Code/Data Analysis* directory on GitHub. The retrieval of the scripts from GitHub is specified in the appendix.

	ZG	synthetic ZG
$\bar{Y}_{2020}$	75.00	76.06

Average values for the months in 2020

Table 13: Goodness of Fit Comparison under the Basic Assumptions

weight vector ($\mathbf{W}^*$), and the data on the control cantons, are sufficient to completely define the synthetic canton of Zug[18]. The outcomes of the synthetic canton of Zug are thus compared with those of the actual canton of Zug in figure 6. To recall, SCM may only be used, if there is a good synthetic control unit fit (Abadie et al., 2015,

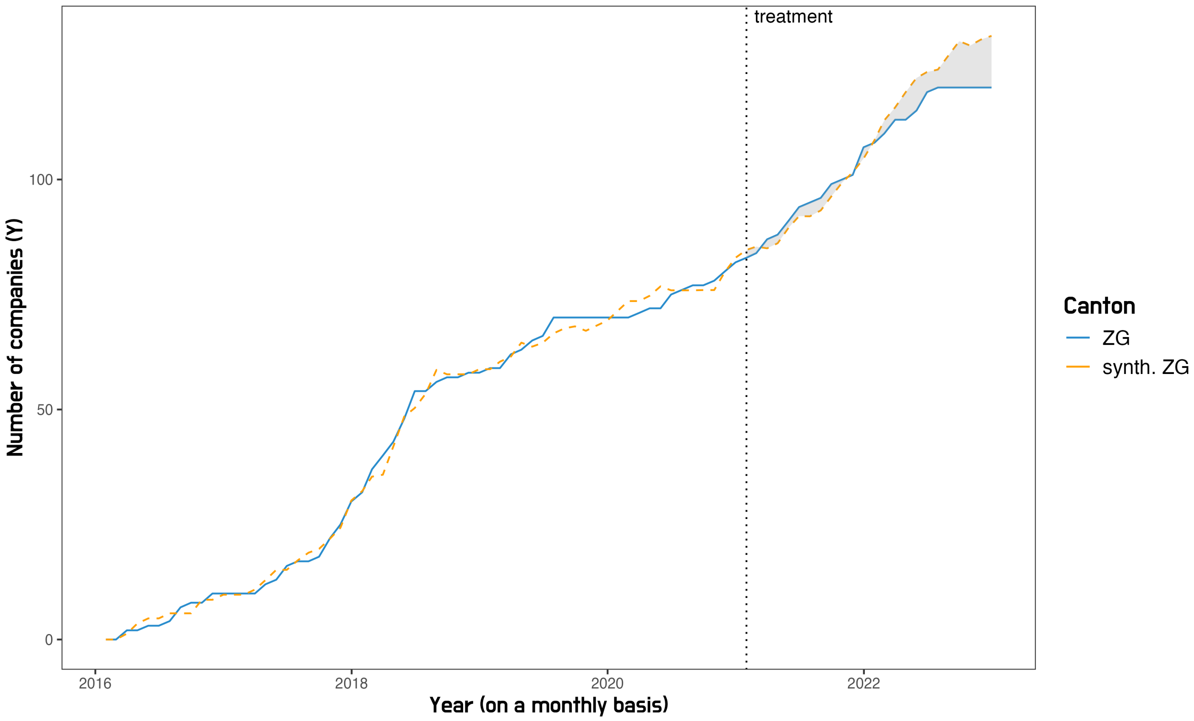

Figure 6: Outcomes of the Actual versus the Synthetic Canton of Zug

p. 497 f.). A goodness of fit comparison with the average outcome values of the year 2020 (the last year before the treatment) is depicted in table 13. After the assessment of the goodness of fit, the treatment effect can be determined.

6.1.2 Determining a Treatment Effect

Abadie and Gardeazabal (2003) determine the treatment effect only qualitatively by looking at the outcome differences between the actual and the synthetic outcome (p. 117 f.). In casu, the qualitative assessment can be conducted by looking at figure 7, which depicts the outcome difference between the actual and the syn-

[18] See in equation 3.

thetic canton of Zug. Alternatively, the treatment effect can also be quantified by using the formula depicted

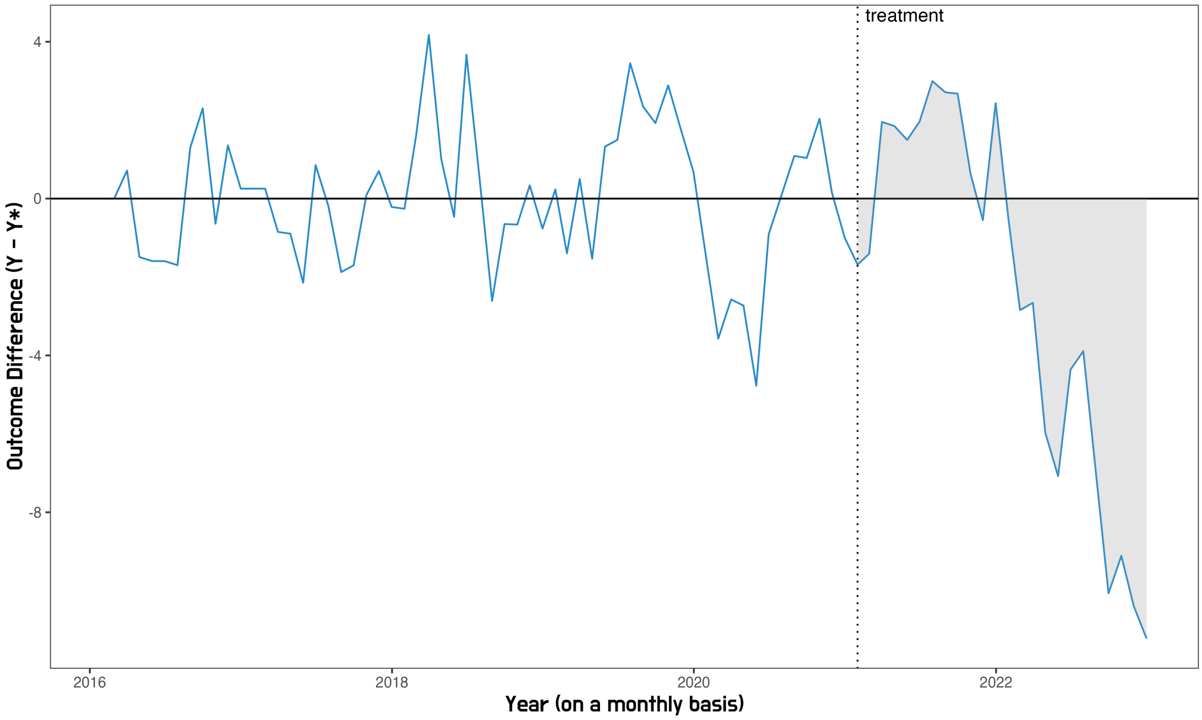

Figure 7: Outcome Differences Between the Actual and the Synthetic Canton of Zug

in equation 2, which calculates the average post-treatment outcome difference. Applying said formula to the data displayed in figure 7, a treatment effect of -2.50 is found.

6.1.3 Determining the Significance of the Treatment Effect

To check whether the treatment effect found in subsubsection 6.1.2 is significant, placebo studies are conducted. It is hence observed, whether treatment effects can also be found for the non-treated control cantons. This is done, by comparing the mean-squared prediction error (MSPE) ratios (R) of each control canton to the actually treated unit of Zug. Then, a p-value (p_{syn}) is determined, which measures the significance of the treatment effect by looking at the probability of the treated ratio (R_{ZG}) occurring in the data. Therefore, the formula for p_{syn} as depicted in equation 10 is used.

To obtain the MSPE ratios ($R_u \forall u, u \in U$), the outcome differences ($\mathbf{Y} - \mathbf{Y}^*$) are calculated for all control cantons. The resulting outcome differences are depicted in figure 8 over the entirety of the observed timespan[19]. Then, based on the outcome differences ($\mathbf{Y} - \mathbf{Y}^*$), the MSPE ratio ($R$) is calculated for each canton following the equations 7, 8 and 9. The results are depicted in figure 9. Based on the results depicted in figure

[19]As all lines for all other 25 cantons are coloured in orange, the visualisation is a bit dense for the other cantons.

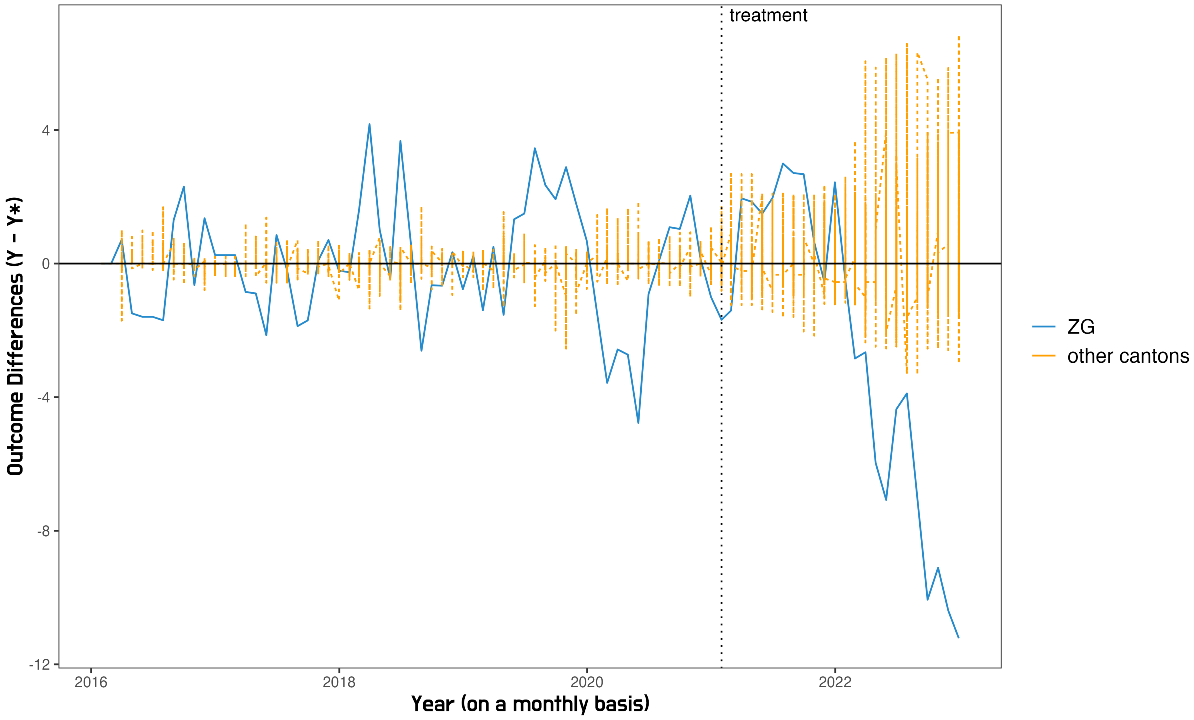

Figure 8: All Outcome Differences for the Synthetic versus the Actual Values

9, the p-value (p_{syn}) may be calculated by using the formula displayed in equation 10. Applying the formula results in a p-value of $p_{syn} = \frac{24}{26} = 0.92$.

Having shown how the data is analysed under the basic assumptions, the next subchapter shows how the results change when these basic assumptions are changed.

6.2 Change of Results with a Change of Assumptions

The analysis conducted in the previous subsection is conducted under the basic assumptions, i.e. under the assumptions $A_{1.0}$, $A_{2.0}$ and $A_{3.0}$. To test the robustness of the previously obtained results, this subsection changes these assumptions. Therefore, subsection 6.2 defines the following five cases:

- **Case 0** (C_0): This is the case under the basic assumptions. The assumptions $A_{1.0}$ and $A_{2.0}$ are assumed to hold true[20].
- **Case 1** (C_1): This is the case with the inclusion of the tax burden as a control variable. The assumptions $A_{1.1}$ and $A_{2.1}$ hold true.
- **Case 2** (C_2): This is the case with the inclusion of the tax burden and the working population as control variables. The assumptions $A_{1.2}$ and $A_{2.2}$ hold true.

[20]The assumption $A_{3.0}$, which is assumed to hold true in the previous subsection, is discussed later on.

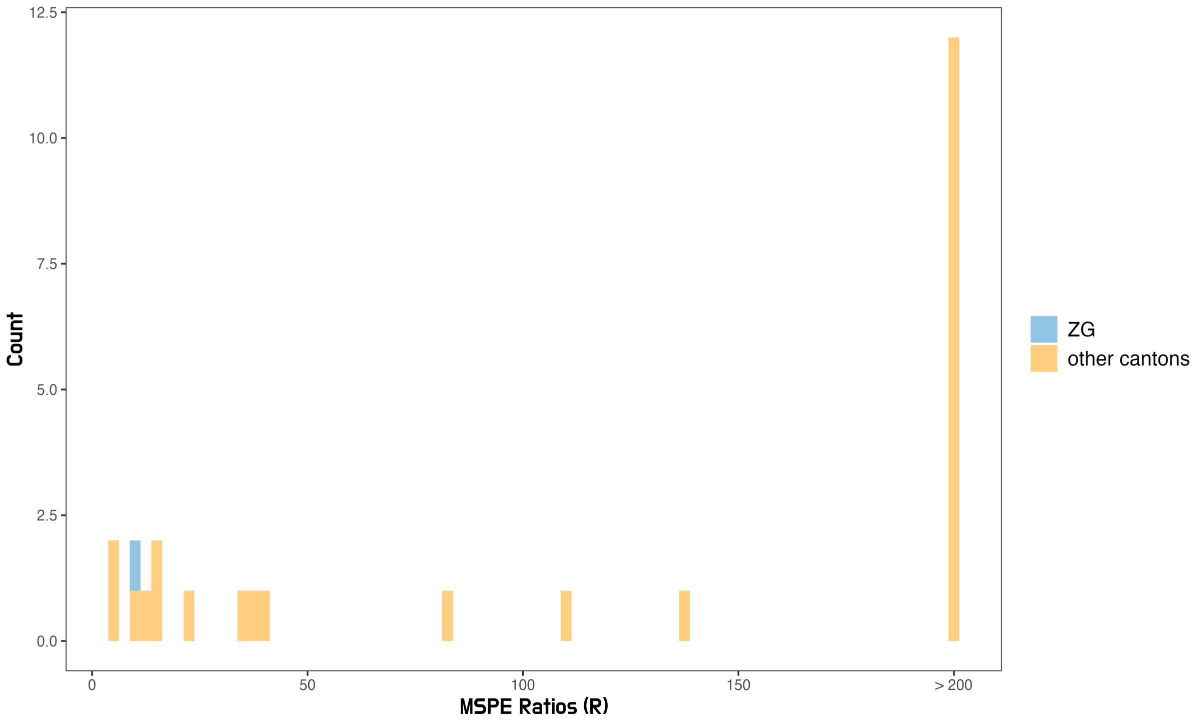

Figure 9: All MSPE Ratios

- **Case 3** (C_3): This is the case with the inclusion of the tax burden, the working population and the share of the financial sector as control variables. The assumptions $A_{1.3}$ and $A_{2.3}$ hold true.
- **Case 4** (C_4): This is the case with the inclusion of the tax burden, the working population, the share of the financial and the share of the IT sector as control variables. The assumptions $A_{1.4}$ and $A_{2.4}$ hold true.

These five cases manage the in- or exclusion of the different control variables. The assumption $A_{3.c}$ manages the in- or exclusion of different cantons. The assumption $A_{3.c}$ is defined 21 times for 21 different values of the cutoff ($c \in [0, 20]$). The cutoff (c) governs which cantons are in or excluded. This adds a second dimension to the robustness test of the results. The combination of all cases and all cutoff values is thus here defined as a two-dimensional robustness matrix ($\mathbf{RM}$). The robustness matrix ($\mathbf{RM}$) is depicted in equation 11.

$$\mathbf{RM} = \begin{bmatrix} C_0(A_{3.0}) & C_1(A_{3.0}) & C_2(A_{3.0}) & C_3(A_{3.0}) & C_4(A_{3.0}) \\ C_0(A_{3.1}) & C_1(A_{3.1}) & C_2(A_{3.1}) & C_3(A_{3.1}) & C_4(A_{3.1}) \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ C_0(A_{3.20}) & C_1(A_{3.20}) & C_2(A_{3.20}) & C_3(A_{3.20}) & C_4(A_{3.20}) \end{bmatrix} \tag{11}$$

Going forward, a synthetic canton of Zug is constructed for all cases in the robustness matrix. The goodness of fit of the synthetic control canton is checked in a goodness of fit comparison. Subsequently, the treatment effect is determined for all cases in the robustness matrix. Additionally, the significances of the treatment effects

	ZG	synth. (C_0)	ZG	synth. (C_1)	ZG	synth. (C_2)	ZG	synth. (C_3)	ZG	synth. (C_4)	ZG
$\bar{Y}_{2020}$	75.00	76.06		76.08		76.10		76.08		76.08	
$\bar{x}_{TX_{2020}}$	2848.80	-		1173.29		824.43		1173.29		1173.29	
$\bar{x}_{WP_{2020}}$	80234.00	-		-		103230.21		1326113.83		1326113.83	
$\bar{x}_{f_{2020}}$	0.42	-		-		-		4.75		4.75	
$\bar{x}_{it_{2020}}$	0.42	-		-		-		-		0.67	

Average values for the months in 2020, if $A_{3.0}$ holds true.

Table 14: Goodness of Fit Comparison for all Cases

are determined.

Thus, to start, the synthetic canton of Zug is constructed for all elements of the robustness matrix. Table 14 shows a goodness of fit comparison for the first row of the $\mathbf{RM}$ matrix, i.e. for all cases under the assumption $A_{3.0}$[21]. After having constructed the synthetic cantons and evaluated their respective goodness of fit, the treatment effects are determined. The treatment effects for all cases in the robustness matrix are calculated using equation 6. The resulting treatment effects are depicted in figure 10. The significance of the treatment

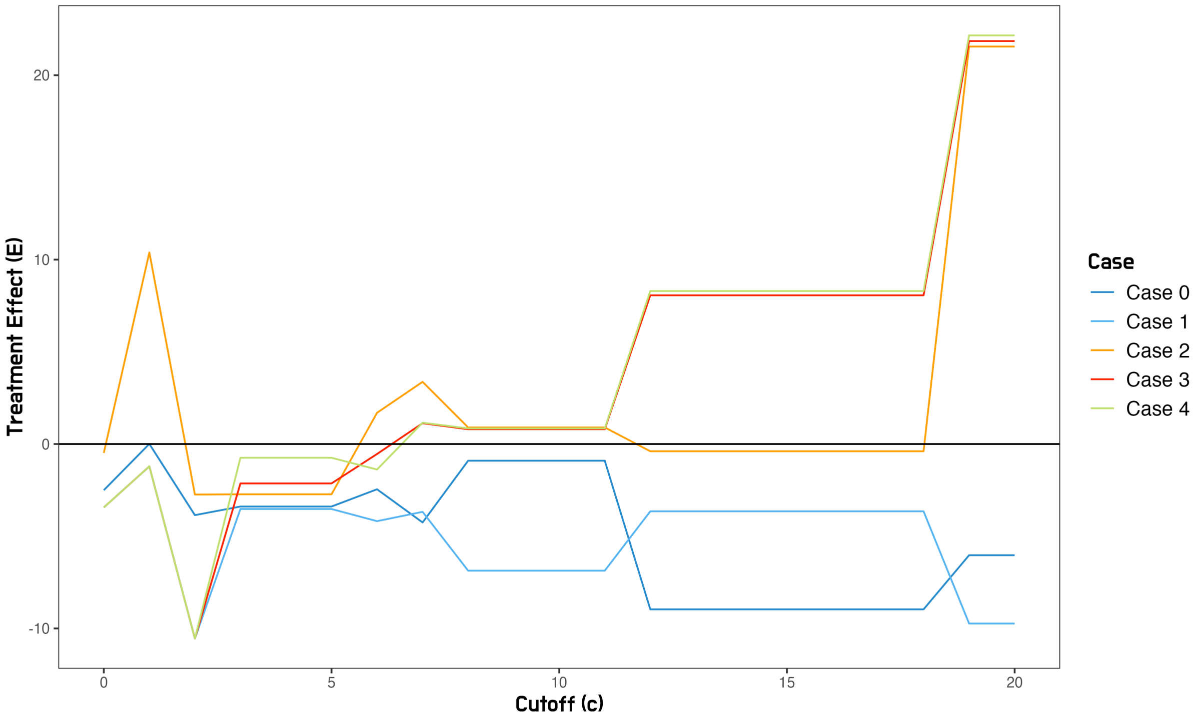

Figure 10: Treatment Effects in the Robustness Matrix

[21]The data for a goodness of fit comparison for all cases of the robustness matrix can be found on GitHub in the table called *Data/Goodness of Fit for all Cases in the Robustness Matrix.csv*. The retrieval of the data from GitHub is specified in the appendix.

effects can be determined by calculating their respective p-values (p_{syn}). The p-values are calculated based on the ratio of the pre- and post-treatment MSPEs (R) using the formula depicted in equation 10. The p-values of each case in the robustness matrix are depicted in figure 11[22]. To recall, by the definition of p_{syn} in equation 10, the minimal possible p-value for a given set of observed units (U) cannot be smaller than $\frac{1}{|U|}$. Therefore, a dashed line is drawn into figure 11, which depicts the minimal possible p-value for each cutoff.

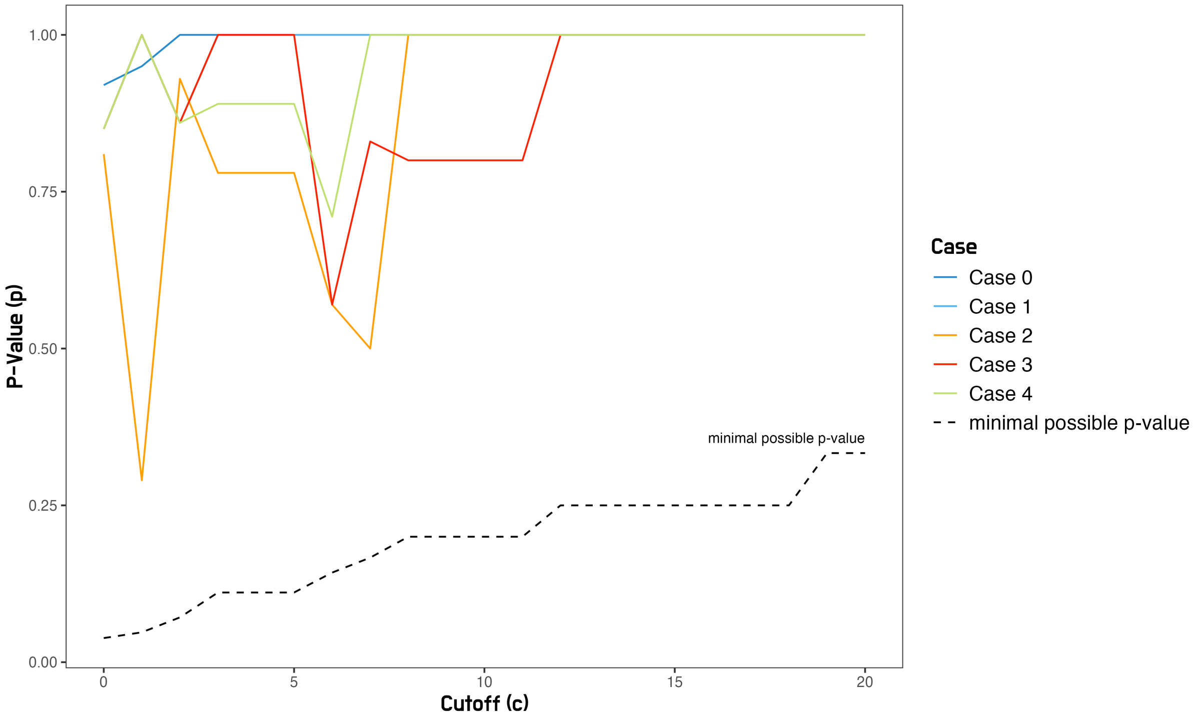

Figure 11: P-Values in the Robustness Matrix

To summarise, the data analysis section shows the determination of the treatment effects and their significances. First, the treatment effect and its significance are displayed under the case of basic assumptions. Then, these basic assumptions are changed. A $(5 * 21)$ robustness matrix is defined, which contains all reasonable combinations of assumptions under which the analysis is conducted again. At last, all treatment effects and their significances are established for every case in the robustness matrix.

7 Findings

The findings section describes and interprets the findings made from the data analysis. Thus, the findings section provides the answer to the posed research question. At first, the section discusses and interprets the goodness of fit of the constructed synthetic control cantons in section 6. Then, the section displays the treatment

[22] A complete numerical summary of the treatment effects and their respective p-values is provided on GitHub in the table called *Data/Effects and P-Values for the entire Robustness Matrix.csv*. The retrieval of the data from GitHub is specified in the appendix.

case	$\bar{x}_E$	s_E	$LCL_{95\%}$	$UCL_{95\%}$	$min.\,p_{syn}$	$max.\,p_{syn}$
case 0 (C_0)	-4.84	3.36	-6.28	-3.40	0.92	1.0
case 1 (C_1)	-5.05	2.53	-6.13	-3.97	0.85	1.0
case 2 (C_2)	2.29	6.99	-0.70	5.27	0.29	1.0
case 3 (C_3)	3.92	7.84	0.57	7.27	0.57	1.0
case 4 (C_4)	4.20	7.83	0.85	7.55	0.71	1.0
all cases	0.10	7.35	-1.30	1.51	0.29	1.0

Table 15: Summary Statistics on the Treatment Effect

effects and their significances quantitatively in table format. These results are subsequently interpreted to deduce an answer to the research question. At last, the limitations of the finding are discussed.

7.1 Goodness of Fit

The goodness of fit is assessed qualitatively based on the goodness of fit comparison in table 14. It results, that for the outcome value (Y), the synthetic control unit fit is good in all cases. The highest deviation of $\bar{Y}_{2020}$ observed in all cases is less than 1.5% from the actual value. However, while the outcome is fitted well, the control variables are generally fitted quite poorly. E.g., the average working population ($\bar{x}_{WP_{2020}}$) and the average share of the financial sector ($\bar{x}_{f_{2020}}$) in the cases C_3 and C_4 are more than ten times above the actual value. Also, the values of $\bar{x}_{TX_{2020}}$ and $\bar{x}_{it_{2020}}$ do not match up particularly well. To conclude, the outcome variable is fitted well, while the control variables are fitted poorly. In total, this is described as a mediocre fit[23].

7.2 Treatment Effect

The treatment effect (E) is assessed based on the data used to create figure 10 which shows the treatment effect (E) for all cases in the robustness matrix. To examine the significance of the treatment effects, the p-values (p_{syn}), as displayed in figure 11, are assessed. The summary statistics on the treatment effects and the p-values are displayed in table 15. Table 15 shows the average treatment effect ($\bar{x}_E$) found for each case when averaging out the 21 different cutoff values (c). Additionally, table 15 shows the lowest ($min.$) and the highest ($max.$) p-value measured of the individual treatment effects for each case. At last, table 15 displays the standard deviation (s_E) of each measured treatment effect (E) and the thereby resulting lower and upper 95%-confidence levels ($LCL_{95\%}$ and $UCL_{95\%}$) for the average treatment effect ($\bar{x}_E$).

For an effect to be significant, the corresponding p-value to the effect must lie below a certain threshold

[23] One could analyse the fit further in-depth, by evaluating the weights of the fit. Therefore, one could have a look at the chosen weight vector ($\mathbf{W}^*$) depicted in table 12. The weight vector contains weights which are negative, and the elements of the weight vector do not sum to one. Abadie et al. (2015) discourage using SCM under these conditions (p. 500). This further deteriorates the quality of the fit.

(Fisher in Dahiru, 2008, p. 21). The established and commonly accepted p-value threshold for the significance of an effect lies at 0.05. No single treatment effect (E) shown in table 15 has a p-value lower than 0.05. The lowest observed p-value (p_{syn}) lies at 0.29, for the case C_2 and the assumption $A_{3.1}$. This leads to the conclusion, that the treatment effects (E) observed in the data are pure noise and not significant. This conclusion is further supported when looking at the average treatment effect ($\bar{x}_E$) for all cases. The measured average treatment effect ($\bar{x}_E$) for all cases, as shown in table 15, lies at 0.10. Thus, the average treatment effect is close to zero. Meanwhile, the 95% confidence interval of the average treatment effect (i.e. $[-1.30, 1.51]$) encompasses zero nearly in its middle. This further supports, that the treatment (E) has no effect on the outcome (Y). To conclude, the null hypothesis (H_0) cannot be rejected at any reasonable confidence level. No proof can be found, that the acceptance of Bitcoin and Ether as tax payment methods in the canton of Zug has an effect on the growth of its local crypto industry.

7.3 Limitations

The finding, that the null hypothesis (H_0) cannot be rejected, is subject to various limitations. The null hypothesis (H_0) is tested, by observing the number of newly registered crypto companies in the cantonal commercial registries. It might be, that the instrument of observing crypto companies in the commercial registry is not a good instrument to begin with, as it does not correlate with the growth of the crypto industry[24]. Alternatively, it is possible, that the instrument is not granular enough to detect a possible treatment effect. Also, it is possible, that the retrieved sample data on the instrument and/or on the control variables are not representative of the true values (implying that the assumptions $A_{1.0} - A_{1.4}$ might be false). However, it is assessed that the most likely source of error for the analysis originates from the goodness of fit.

The synthetic canton of Zug fits the actual canton of Zug only mediocrely in all observed cases. This indicates, that the assumption $A_{3.c}$, which states that the canton of Zug can be represented as a linear combination of the control cantons, might be false. The reason, why Zug may not be represented as a linear combination of the control cantons, may lay in the fact that the canton is a true outlier within the sample data. Despite its small population, the canton of Zug contains by far the most crypto companies within its territory, as figure 5 depicts. Meanwhile, Zug is among the cantons with the smallest working populations and the lowest tax burdens, as shown in table 11. All these extreme values make it difficult to find an adequate synthetic fit for the canton of Zug. In addition, the data availability for crypto companies in other cantons is rather sparse. While the cantons of Zürich, Geneva, Ticino, and Vaud still contain a reasonable number of crypto companies within their territories, other cantons have next to none (see table 10). This sparseness of data adds further difficulty to finding a

[24] It is possible, that with the growth of the industry, companies consolidate into larger companies, and the creation of new companies might not play a significant role in the growth of the industry.

treatment effect. To conclude, the lack of granularity of the instrument, the sparse availability of data on the instrument, and the particularity of the data related to the canton of Zug are identified by this paper as limiting factors on the findings. It is possible, that there are further limiting factors not mentioned here.

To summarise, only a mediocre synthetic control unit fit can be constructed. Despite (or because) of that, no significant treatment effect can be found. There are several limitations, which might explain why this research paper cannot find a significant effect.

8 Conclusion

The canton of Zug is home to the Crypto Valley, which is the biggest cluster of crypto companies within Switzerland (Morisson and Turner, 2022, p. 917 f.). In January 2021, the finance directorate of the canton of Zug implemented a new industrial policy which introduced the acceptance of Bitcoin and Ether as tax payment methods (Finanzdirektion Direktionssekretariat, 2020). This research paper asks whether the introduction of said tax policy had an effect on the growth of the local crypto industry in the Crypto Valley.

To answer the research question, the number of newly registered crypto companies in the commercial registry of Zug is observed as an instrument to track the growth of the crypto industry. To see, how the crypto industry in the canton of Zug had developed without the examined tax policy, a synthetic canton of Zug is constructed as a counterfactual to the actual canton of Zug using the augmented synthetic control method. The synthetic canton of Zug is constructed as a linear combination of the other 25 Swiss cantons, which did not introduce the tax policy of accepting Bitcoin and Ether as tax payment methods. Thus, by web-scraping LinkedIn and Zefix, a sample data set is constructed that contains the number of in-the-commercial-registry registered crypto companies for every Swiss canton for the years between 2016 and 2022. Based on the sample data, the synthetic control canton of Zug is constructed. The construction is repeated several times for different cases with different control variables and different assumptions. For each case, a treatment effect is determined by measuring the average difference between the actual and the synthetic number of registered crypto companies in the period after the tax policy was implemented. The significances of the treatment effects are thus determined using placebo studies. It results, that the average observed treatment effect is close to zero. The null hypothesis, which states that there is no effect, is well within the 95%-confidence bounds of the average treatment effect. Additionally, no observed treatment effect is statistically significant[25]. To conclude, the null hypothesis cannot be rejected at a reasonable confidence level. No evidence is found that the policy of Zug's finance directorate of accepting Bitcoin and Ether as tax payment methods impacted the growth of the crypto

[25] The lowest observed p-value of a treatment effect lies at 0.29.

industry in the Crypto Valley.

The finding is limited by a range of limitations. The granularity of the instrument and the goodness of fit are assessed to be the biggest limiting factors. Thus, the research paper might fail to find a policy effect, because the number of newly registered crypto companies has a low variance, and thus the instrument is unsuitable to pick up on small changes. Alternatively, the research paper might fail to detect an effect, as the fit of the synthetic control unit is mediocre. The mediocre fit may invalidate the use of the synthetic control unit as a counterfactual for the determination of a policy effect.

To conclude, no policy effect on the growth of the crypto industry in the Crypto Valley is found to result from the tax policy issued by the finance directorate of the canton of Zug to accept Bitcoin and Ether as tax payment methods.

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Appendix

This research paper has an accompanying GitHub repository called *BenNorsk/Bitcoin-and-Ether-as-Tax-Payment-Methods*, which contains all the scripts and tables of the appendix. The GitHub repository is located here:

https://github.com/BenNorsk/Bitcoin-and-Ether-as-Tax-Payment-Methods.

The GitHub repository is structured into a *Data* and a *Code* directory. The *Data* directory contains the master sample data set, the data on all the crypto companies included in the master sample data set, as well as the data on all the different analyses and outcomes of the analyses of all the cases within the robustness matrix. The data present in the *Data* directory is sufficient to replicate the research paper. The *Code* directory contains all the code which is used for the execution of the data pipeline, the analysis of the data and the creation of the figures and tables. Intermediate tables which are used during the process of executing the data pipeline are removed from the *Code* directory. The structure of the GitHub repository is shown in figure 12. Thus, the

```
├── Data/
│   ├── Master Sample Data Set.csv
│   ├── All Companies of the Master Sample Data Set.csv
│   ├── Effects and P-Values for the entire Robustness Matrix.csv
│   ├── Goodness of Fit for all Cases in the Robustness Matrix.csv
│   ├── MSPE Ratios (Case 0).csv
│   └── All Weights for All Cases/
├── Code/
│   ├── Data Analysis/
│   ├── Data Pipeline/
│   ├── Figures and Tables/
│   ├── bin/
│   ├── lib/
│   └── pyvenv.cfg
├── README.md
└── Bachelor Bitcoin Logo.png
```

Figure 12: Structure of the GitHub Repository

GitHub repository as shown in figure 12 may be used to obtain all the data and code belonging to the appendix.

Declaration of Authorship

I hereby declare,

- that I have written this thesis independently,
- that I have written the thesis using only the aids specified in the index;
- that all parts of the thesis produced with the help of aids have been precisely declared;
- that I have mentioned all sources used and cited them correctly according to established academic citation rules;
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Benjamin L. Brückner