Regulation, Acquisition and Efficiency - a study of Swedish network operators

By Jesper Ekman*

Abstract

Since the turn of the century much has happened in Sweden's electricity distribution sector. In this thesis I examine the effect of acquisition on the economic performance of network operators under two regulatory regimes using both Synthetic Control and Synthetic Difference-in-Differences. Data was provided by the Swedish regulatory authority Energimarknadsinspektionen and has been collected annually from financial and technical reports. I find no effect on labor costs nor total operating expenses but I find a strong positive effect on consumer price in the most recent regulatory period of the current regulatory regime.

Keywords: Electricity distribution, Regulation, Acquisition, Efficiency, Synthetic Control, Synthetic Difference-in-Differences

Stockholm University	Master Thesis EC9901
Department of Economics	May 19, 2020
Supervisor	Jonas Häckner

*I would first like to thank Jonas Häckner for excellent supervision. I would also like to thank Per Sonnerby and Therése Karlsson and the rest of Strukturenheten at the Swedish Ministry of Finance for inspiring discussions and much appreciated input during my thesis internship.

1 Introduction

In 1996 the Swedish electricity sector was liberalized. From having one monopolist acting across many markets the goal was to increase efficiency by introducing competition in the parts of the sector where possible. Transportation of electricity, called transmission or distribution, was considered a natural monopoly and in such a market competition is not a plausible option. The second-best alternative to improve efficiency is introducing regulation. High-voltage transportation of electricity, transmission, was put under the control of a national transmission system operator and medium- and low-voltage transportation, distribution, was put under regulation overseen by a national regulatory authority.

Regulating natural monopolies has long been practiced to mitigate market failures such as cost-inefficiency and monopoly pricing. While competition would solve both cost-inefficiency and excessive profits, regulation can in practice not do so. For that reason regulation becomes a question of preferences for which goal is to be prioritized. Cost-efficiency is achieved by encouraging firms to reduce their costs. One way to encourage firms is by threatening them of penalization if not complying with some efficiency requirements. Another is to align the regulator's goal of cost-efficiency with the firm's goal of profit maximization. Firms can improve their cost-efficiency in numerous ways, one of which is mergers and acquisitions which make it possible to utilize economies of scale and other cost-reducing synergies. In a market where prices are regulated, the rationale for mergers and acquisitions is limited, and it can be argued that potential improvements in cost-efficiency are of especially great importance.

For the regulator the connection between encouraging cost-efficiency and profitability of doing so implies a trade-off between achieving cost-efficiency and limiting excessive profits. Many researchers and public decision-makers have sought to improve this trade-off, leading to many different regulatory models or regimes being introduced throughout the years. While satisfying in theory, practical implementation is often more difficult.

The regulation of electricity distribution is no exception. The *ex post* revenue cap regulation introduced in 2003 was abandoned only six years later in 2009, in favor of the current *ex ante* revenue cap regulation first implemented in 2012. This shift meant that the amount of revenue that regulated firms are allowed to collect from their consumers are to be determined in foresight rather than hindsight.

In this thesis I examine the effect of acquisitions on economic performance under the two regulatory regimes focusing on low-voltage distribution operators. To assess economic performance I look at three variables collected from or constructed based on data from annual financial reports - labor costs, total operating expenses, and consumer price - using both Synthetic Control and Synthetic Difference-in-Differences.

To which extent regulated firms reduce their costs is dependent on the regulatory regime. Lack of support for acquisition having an effect on costs is therefore not only dependent on whether there exist cost-reducing synergies in mergers and acquisitions in the first place, but also on whether the regulation provides incentives for firms to reduce their costs. Only in the case when it does can acquisition be expected to have a downward pressure on costs.

The net effect of acquisition on consumer prices will depend on two effects. First, in the case when acquisitions do affect costs the regulatory authority likely wants a share of these synergies arising from acquisition to be passed on to consumers. This implies downward pressure on consumer prices. Second, acquisitions can be rationalized on other grounds than achieving cost synergies. There can exist other types of incentives shaped by the regulatory regime where profit maximization result in upward pressure on consumer prices. My estimated effect of acquisition would then be the net effect of these two.

Now turning to my results, I find no support for acquisition affecting labor costs nor total operating expenses under either regulatory regime. The effect of acquisition on consumer prices appear to be different for the two regulatory regimes, with no effect under the *ex post* regulation in 2003-2009 but a notable positive effect under the *ex ante* regulation implemented from 2012.

My results can have two explanations. Either there exist no incentives for cost-reduction under neither regulatory regime, or, acquisition doesn't lead to any cost synergies. In the latter case, acquisitions must be rationalized on other grounds than achieving cost synergies. While not offering a rationale for acquisitions under the first regulatory regime, my results from examining the effect on consumer price suggest that the new regulatory regime has introduced mechanisms allowing operators to increase their prices and by so increase their profitability. This may have created a new rationale for acquisitions.

My contribution relative to earlier studies lies in including more recent data making it possible to compare the effect of acquisition under two different regulatory regimes. Further, using both Synthetic Control (SC) and Synthetic Difference-in-differences (SDID) not only serves as a robustness test but also contributes to the literature of comparative research.

Previous research most closely related to this thesis include Lundin (2020) also examining the effect of acquisitions on labor costs and consumer price using Swedish data from 1998-2011 for low-voltage operators and Synthetic Control. Lundin finds that acquisition led to lower labor costs, but finds no effect on consumer prices indicating that no cost-synergies have been passed on to the consumers. Other related research includes J. E. Kwoka (2005) examining the sources of economies of scale in the US electricity distribution sector as well as the effect of mergers on a network operator's performance. Kwoka finds that economies of scale arise from increased usage of electricity or an increase in customer density, and not from the expansion of the area serviced by an individual operator. J. Kwoka and Pollitt (2010) also examine whether mergers led to any efficiency improvements in the US electricity distribution sector, but finds that mergers appear to have led to inefficiency.

This thesis proceeds as follows. In section 2 I briefly review the literature of regulation theory and relate it to both the previous and the current regulatory regime. Section 3 offers a short review of the literature around the empirical procedures used in this thesis (Synthetic Control and Synthetic Difference-in-Differences) and also describes the data used and my identification strategy. In section 4 I present my results and in section 5 I discuss my results from a policy perspective.

2 Regulation Theory and the Swedish revenue cap regulations

The ultimate goal of regulation is to achieve the same market outcome as under perfect competition - consumer prices equal to marginal cost and cost-minimization. Such an outcome would correct both cost-inefficiency and excessive profits. In practice regulation will never achieve this outcome. This leads to regulation becoming a choice between which goal is to be prioritized - cost-efficiency or limiting excessive profits.

Regulation has been practiced for a long time and many regulatory regimes have been introduced over the years. First out was rate-of-return regulation which was introduced as early as at the end of the 19th century in the US. While setting an upper limit on consumer prices, rate-of-return regulation is far from a perfect solution. Its most well-known problem with is described in Averch and Johnson (1962) showing that firms regulated under a rate of return regulation may have incentives to use a cost-inefficient input mix biased toward capital if the return on capital is higher than the return on other inputs.

Loeb and Magat (1979) developed a theoretical model where firms have maximal incentives for cost-efficiency and marginal cost pricing. By letting firms keep variable profits and at the same time give them a transfer equal to consumer surplus, profit-maximizing firms will charge marginal cost prices. This gives firms maximal incentives for lowering their costs. While theoretically satisfying, there are two objections to this model. First, it risks leading to excessive profits making it politically difficult to implement. Loeb and Magat suggested lump-sum taxation to overcome this problem. Second, it is very difficult for the regulator to know the demand curve a firm faces. This leads to uncertainty about how large the consumer surplus is and also how much the regulated firms can collect from the regulatory authority.

More recently Cowan (2002) outline and extend on a general framework of price cap regulation which formalizes the trade-off between excess profits and cost-efficiency. Starting with the firm, the total cost is given by three components. Θ is a random variable know to the firm but unknown to the regulator. The highest value is Θ can take on is $\bar{\Theta}$ and the expected value is $E(\Theta)$. The firm can decrease its total cost by e if employing effort equal to e, with the cost of effort being $\frac{\phi e^2}{2}$. The amount of effort put in is unknown to the regulator, which only observes the accounting cost, c. Total cost for the firm is then given by $TC = \Theta - e + \frac{\phi e^2}{2}$

and total profit is then $\Pi = p - TC$, assuming quantity sold is equal to one.

Moving on to the regulator's objective function, the trade-off between profits and cost-efficiency is captured by $W = U - TC - (1 - \alpha)\Pi$, where U is consumer utility, TC and Π as above and α is a factor reflecting the regulator's preference for consumer's relative to shareholder's interest. Because the regulator doesn't observe effort put in by the firm, minimizing both total costs and excess profits is not possible.

Instead, the regulated consumer price is set by a linear function of the accounting cost, $p(c) = a + bc$. a is a constant unaffected by costs and b is a factor reflecting what share of its accounting costs a firm is allowed to pass on to consumers. With $b = 0$ prices are decoupled from a firm's costs and incentives for cost-efficiency are maximized. This is known as a pure price cap regulation. Firms' optimal level of effort is when the marginal benefit of effort is equal to the marginal cost of effort, captured by $e^* = \frac{1-b}{\phi}$. The higher b is, the smaller incentives for cost-efficiency and the less effort is put in. If b is large, changes in the cost of effort, ϕ, have close to no effect on effort.

When maximizing its objective function, the regulator decides a and b subject to two constraints. First, firms need to be willing to participate and will only do so if able to recover their costs even in the most unfortunate case when the random factor Θ takes on its maximal value $\bar{\Theta}$. Second, the regulator always needs to take the level of effort put in by the regulated firm into account. When welfare is maximized the optimal level of cost pass-through is given by

$$b^* = (1 - \alpha)[\bar{\Theta} - E(\Theta)]\phi$$

As long as the regulator puts a larger weight on consumer's interests than shareholder's interests ($\alpha < 1$) $b^* > 0$ and a share of firms' accounting costs are passed on to consumers.

In his paper, Cowan also discusses how yardstick competition can be introduced to improve the trade-off between excessive profits and cost-efficiency. By benchmarking firms against each other and only let costs equal to the costs of the most cost-efficient firm, c^*, be passed on to consumers. Firms would then have incentives to decrease their costs since they would make no profit when $c > c^*$. In the long-run yardstick competition lead to cost-efficiency and lower consumer prices. This is generally how the Swedish network operators were regulated between 2003 and 2009. But instead of being benchmarked against other firms, operators were benchmarked against an engineered replication of their network [1]. This regulatory regime was ended in 2009 (Wallnerström & Bertling, 2010).

The *ex ante* revenue cap regulation has been in place since 2012. Instead of determining the revenue cap in hindsight by benchmarking, the revenue cap is determined in foresight

[1] Tooraj and Magnus (2010) finds that these engineered versions are a poor representation of the underlying operator, and suggests that networks should be benchmarked against real network operators instead.

according to a set of rules and laws. Figure one shows the general outline of the *ex ante* regulation. To begin with, operating costs are divided into two categories - non-controllable and controllable. Non-controllable costs are costs that the operator can't have an impact on. These costs are fully included in the revenue cap. Costs that are assumed to be under the operator's control are included less an efficiency requirement of 1-1.8 percent.

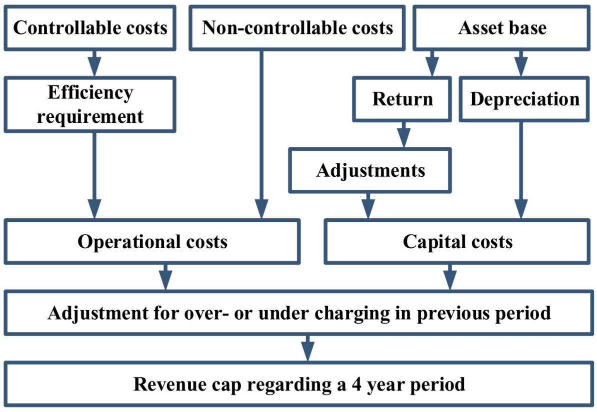

Figure 1: Outline of current revenue cap regulation
Source: Wallnerström et al. (2016)

Operators' profit is limited by the return on the asset base which is decided by the regulatory authority. The return is meant to cover the cost of raising capital and generate a fair return on investment. This resembles how a pure rate-of-return regulation work. Kuosmanen and Nguyen (2020) discuss how prevalent the Averch-Johnson effect is in the type of revenue cap regulation that is used in Sweden and other Nordic countries. Ultimately, this is a matter of whether the revenue cap is exogenous to the regulated firms, the authors point out. This is solved by separating the asset base used for calculating the revenue cap and the asset base as reported in the operators' financial statement. As long as this is guaranteed, the Averch-Johnson effect is unlikely to exist.

Also, operators can increase their profit by fulfilling certain objectives such as increased reliability in supply, reduced energy losses, and increased system utilization. If fulfilled, operators are rewarded with a 5 percent increase of the revenue cap, while failing to do so can result in a 5 percent decrease. See Wallnerström et al. (2016) for a detailed description of the regulation in place 2016-2019. These incentives create upward pressure on prices.

Going back to the framework introduced by Cowan, we know that the regulatory decides prices according to $p = a + bc$. The ex-ante regulatory regime can be interpreted as having a large b, implying a strong correlation between consumer prices and firms' costs. To mitigate cost-inefficiency the current regulation relies on the efficiency requirement.

Mergers and their anticipated synergies can also be interpreted in Cowan's framework. First, we know that the cost of effort is given by $\frac{\phi e^2}{2}$ implying that the marginal cost of effort is increasing with effort. Second, we also know that the optimal level of effort from the firm's perspective is given by $e^* = \frac{1-b}{\phi}$. Mergers and acquisitions can decrease the cost of achieving cost-saving equal to e. This decrease can arise either through that a lower level of effort is needed to achieve the same level of cost-saving which reflects economies of scale, or, through a lower cost of effort which can reflect merger specific synergies arising from hard-to-trade assets owned by the two firms involved.

In either case, cost-reducing synergies would only be passed on to consumers if firms' accounting costs decrease, which depends on how consumer prices are adjusted following a change in accounting costs[2]. This captures how incentives for acquisitions can be shaped by the regulatory regime. If the revenue cap closely follows the accounting cost, firms have small incentives for utilizing merger synergies reducing their costs since synergies would then be passed on to consumers through lower prices. This is reflected in the formula for the optimal effort above. If b is close to one, changes in the cost of effort ϕ have a very small impact on the optimal level of effort. Put in different words, when the marginal benefit of reducing their cost is very small, regulated firms can not be expected to do so. Instead, synergies lead to a decrease in the amount of effort employed, leaving costs observed by the regulator, c, largely unchanged. Lack of effect from acquisition can, therefore, be explained by two scenarios. Either the regulatory regime gives no incentives for firms to utilize merger synergies and reduce their costs, or there exist no cost synergies in the first place.

It should be noted that acquisition can still be rationalized on other grounds than cost-reducing synergies. As mentioned in the introduction there can exist incentives that are pursued because they allow for higher consumer prices. Profitability is then improved by an increase in consumer prices rather than a reduction in costs. Examples of these incentives include objectives such as increased system utilization, but also less obvious ones. For example, network operators have recently been successful in appealing the regulatory authority's decisions regarding some parts of the methodology behind determining the revenue cap. Acquisitions could then be a strategy to increase one's stake in such legal processes.

[2] Remember consumer price is decided by $p(c) = a + bc$. Cost synergies are only passed on to consumers if c decrease.

3 Empirical approach, data and identification

3.1 Empirical approach

The problem with estimating the effect of acquisition is that no control group exists. Operators that never have been acquired can't be used as a control group because they can not be assumed to be similar enough. Faced with a similar empirical problem but in a much different context, Abadie and Gardeazabal (2003) construct a synthetic control unit to estimate the effect of terrorism on economic growth in Spain's Basque region in the last decade of the 20th century. Ideally, to casually determine the effect of terrorism, the Basque region has to be compared with an identical region with the only difference that it was not struck by terrorism. Because there exists no identical region nor any region that is similar enough, Abadie and Gardeazabal construct one. After choosing some predictors for a region's economic performance, Abadie and Gardeazabal then use all other regions to create an artificial region that matches the Basque region concerning the chosen predictors. Regions more similar are given a larger weight and vice versa. The weights are then also adjusted depending on how well the constructed region matches the economic outcome of the Basque region before the onset of terrorism. The idea is then that this constructed, or as it is formally called, the synthetic region represents the outcome of the Basque region in the absence of terrorism. This Synthetic Control estimation procedure was formalized in Abadie et al. (2010) and Abadie et al. (2011). Borrowing from Doudchenko and Imbens (2016) but changing the terminology to fit my context, this estimation procedure can be written

$$\widehat{\boldsymbol{\omega}}(V) = \arg\min_{\omega} \left\{ (\mathbf{X}_t - \boldsymbol{\omega}^\top \mathbf{X}_c)^\top \boldsymbol{V} (\mathbf{X}_t - \boldsymbol{\omega}^\top \mathbf{X}_c) \right\} \tag{1}$$

$$\text{s.t.} \sum_{i=1}^{N} \omega_i = 1 \text{ and } \omega_i \geq 0 \quad \forall \quad i = 1, ..., N$$

Where $\mathbf{X}_t$ is a matrix containing the predictors of economic performance, which I have chosen, for the network operator involved in an acquisition. Subscript t indicate treatment. $\mathbf{X}_c$ contains the same predictors but for all network operators never acquired. Subscript c indicate control group. $\boldsymbol{\omega}$ is the weights assigned to each network operator in this group, which in the literature is also known as the 'donor-pool'. As explained above, the weight given to a network in the donor-pool depends both on how similar it is in terms of chosen predictors, but also on how well the synthetic unit match the outcome in the time period before the network was acquired. These outcomes are contained in $\mathbf{V}$. Solving the argument above therefor also implies simultaneously solving

$$\widehat{\boldsymbol{V}} = \arg\min_{V = diag(v_1,...,v_M)} \left\{ (\mathbf{Y}_{t,pre} - \hat{\boldsymbol{\omega}}(\boldsymbol{V})^\top \mathbf{Y}_{c,pre})^\top (\mathbf{Y}_{t,pre} - \hat{\boldsymbol{\omega}}(\boldsymbol{V})^\top \mathbf{Y}_{c,pre}) \right\} \tag{2}$$

$$\text{s.t.} \sum_{m=1}^{M} v_m = 1 \text{ and } v_m \geq 0 \quad \forall \quad m = 1, ..., M$$

Doudchenko and Imbens note that the Synthetic Control procedure does not allow controlling for systematic differences between the acquired network operators and the never-acquired operators used to construct the synthetic network operator, implicitly assuming they are equal in levels before acquisition. This is reflected by the absence of a unit-specific constant in the arguments above. While Doudchenko and Imbens do develop an alternative procedure to overcome this problem, I will use Synthetic Difference-in-Differences which was introduced in a working paper by Arkhangelsky et al. (2019) to examine what effect controlling for systematic differences has on the estimated effect if any at all.

The biggest difference between SC and SDID is that SDID doesn't use any predictor variables for estimating the counter-factual outcome, but instead estimates what would have been the outcome in absence of acquisition using only the outcome variable itself. Further, while SC uses only unit weights, SDID uses both unit and time weights. These weights are also solved in a much different way compared to how the unit weights are chosen in SC. In SDID, the procedure of minimizing the prediction errors in the pre-intervention (before acquisition) time-period is solved subject to a ridge penalization. Adding the ridge penalization means that individual weights, time or unit, are 'allowed' to be bigger only if the increase in weight results in a large enough reduction in prediction error. What 'large enough' means depends on a tuning parameter. Ridge penalization also prevents over-fitting and assigning too large weight on single network operators or specific years, which is important when collinearity is present. Robustness of the estimated effect is then achieved through jackknife resampling.

To sum up, SDID is a much more 'hands-off' procedure than SC. While SC requires the researcher to pick the economic predictors used in constructing the synthetic representation of the real operator, SDID doesn't and therefore serve as a sensitivity test to how dependent the results from SC are on the specific economic predictors chosen. For both SC and SDID I use code and packages developed and provided by the original authors.

3.2 Data and identification

All data used has been provided by the Swedish regulatory authority, Energimarknadsinspektionen. The data consists of financial data from annual reports as well as variables more specifically related to the electricity distribution market capturing both economic and technical aspects such as the number of kilometers electricity cable per customer. The data set is not complete, and data is missing for many reasons.

First, data from annual financial reports have been collected since 1998, but variables related specifically to electricity distribution have been added throughout the years. This means that some variables are only available for a limited time-period explaining some of the empty entries in the data set.

Second, some entries are empty because the regulatory authority has decided that operators should report data jointly. This only applies to neighboring concession areas owned by the same operator. When this appears to be the case, I have aggregated the data collected pre-decision and appended with data collected post-decision and treated the appended unit as one observation.

Third, data is also missing because the network operator changed name or the company was re-registered under a new company identity number. When representing the same concession area, and if no signs of changes in ownership or shifts in the data, I have treated these two operators as one observation. Checking for shifts in the data I have looked specifically at total assets, total operating expenses and total customers. A practical example of this is when network operators change suffix because of change in organizational form, for example from non-profit to for-profit.

Lastly, data is missing because of mergers and acquisitions. Post-acquisition data has often been collected only at the aggregate level. This means that data is observed at the individual operator-level up until the merger, but after the two operators have merged data is only observed jointly for both operators. To single out operators for which data is missing as a consequence of or merger or acquisition, I have used flow charts provided by Energimarknadsinspektionen illustrating changes in ownership.

Regretfully Synthetic Control doesn't allow for treatment (acquisition) at multiple time-periods or multiple treated units (operators). I have therefore merged all network operators involved in an acquisition into one observation. Further, I have assumed that this aggregated representation of all acquired operators was acquired in 2003. Choosing 2003 is motivated because during 2002-2004 a majority of the acquisitions took place. The same assumptions are maintained for SDID.

Even if the estimation procedures would allow for it, it is not always possible to keep acquired operators as individual observations . This is because post-acquisition data is most often only observed at the aggregated level. If a more recent year than 2003 is used, I risk neglecting that data collected before my chosen year are collected from operators that already were acquired. Data from these years would then wrongly be treated as representing the network operator prior to being acquired. Further, most acquisitions have been carried out by a small number of operators. Aggregating all operators involved in an acquisition at any point and assuming that this aggregated unit was acquired in 2003 is therefore both a practical and a reasonable solution.

My assumptions imply that for each year moving forward, the share of data that is generated from operators that are acquired increases. This means that if acquisition does affect any of my outcome variables, my results will indicate an increasingly strong effect as time pass. I call this the 'data effect' and will return to it where relevant.

As stated earlier, I have chosen to examine the effect of acquisition on labor costs, total

Table 1: Summary Statistics

	Acquired Operators	Standard deviation	Donor-pool Operators	Standard deviation
Labor cost	1.19	0.87	1.8	0.88
Operating expenses	3.79	1.16	4.19	1.48
Consumer price	4.55	1.3	4.48	1.36
Customers	100945	180077	16278	26139
Customer density	115.66	57.91	109.12	70.04
Under ground cable	0.048	0.018	0.05	0.023
Over ground cable	0.045	0.036	0.037	0.044
Substations	0.040	0.023	0.036	0.025
Installed apparent power	0.010	0.004	0.01	0.13
Observations	59*		132	

Table 3 shows the summary statistics for the acquired networks and the networks included in the donor-pool. Labor cost, operating expenses and consumer price are expressed in thousand SEK per customer. All variables in the second section are expressed per customer. Customer density is number of kilometers cable per customer. * Note that 59 reflects the total number of network operators that as been merged into one. Of these only 37 existed in 1998 and only 6 existed in 2018, reflecting how these operators have merged over time.

operating expenses, and consumer price. Of these three only total operating expenses are reported as an individual variable in the data set. Both labor costs and consumer price I have constructed using multiple variables from the data set. To account for both personnel and consultants I define labor costs as the sum of personnel costs and other external costs. Other external costs will include many more types of costs than consultants, for example rental of equipment, but because consultants are frequently hired, excluding these costs would severely bias my results. Consumer price is defined as the sum of revenue collected per customer. Total labor costs and total operating expenses are also divided by the number of customers. Because the total number of customers was not reported for 1998 and 1999 but only the number of low-voltage customers I have assumed that number of high-voltage customers in 1998 and 1999 is the same as in 2000. Low-voltage customers are typically households and high-voltage customers are typically industries.

For my estimations using SC I have chosen customer density defined as the number of kilometers cable per customer, number of kilometers cable above ground per customer, number of kilometers cable under ground per customer, number of substations per customer, and total installed apparent power per customer as predictor variables. Out of these five variables only customer density was collected prior to 2000.

4 Results

Throughout this section I will simultaneously present the results from SC and SDID for each outcome variable starting with labor costs, then total operating expenses, and finally consumer price. For each graph showing my main results I have illustrated both the actual outcome as well as the outcome for the synthetic representation. The synthetic representations illustrate what would have been the outcome if the networks had never been acquired. The difference between the two outcome trajectories is then the effect of acquisition.

Starting with labor costs, my results are illustrated in figure 2. The two spikes in labor costs are likely due to Sweden being hit by Gudrun and Per, two major cyclones that struck Sweden in 2005 and 2007. Post Per, both SC, and SDID tell the same story. Labor costs appear to be lower for acquired operators and have decreased gradually until the most recent years where they have risen. Worryingly, looking at the results from SC it seems that the synthetic representation is a poor representation of the acquired operators judging from the large differences in labor costs before acquisition[3]. This indicates that there are additional differences between the two than just acquisition.

If whether or not it was acquired is not the only difference between the two outcome trajectories, the difference from around 2007 and onwards can reflect other effects than that of acquisition. This failure of constructing a synthetic representation similar enough can be for two reasons. First, it could be that no combination of operators in the donor-pool produces a synthetic representation with predictor variable values that are similar to that of the acquired operators. As shown in Table 1 in the appendix, this is not the case. Second, for SC to be accurate it is required that the relation between the predictor variables and the outcome variable is linear and equal for both acquired and never-acquired operators. If this assumption fails, a weighted combination of operators in the donor-pool will not produce the outcome of the acquired operators, even if the values of the predictor variables are the same.

Further, it should be noted that my results from SC are different than those of Lundin (2020). My model shows a greater difference in the pre-acquisition time-period. Shortening the period to the same as Lundin doesn't significantly change my results. The explanation most likely lies both in the underlying data and the predictor variables used.

As suggested by Abadie and Gardeazabal (2003), a permutation test can be used to asses the robustness of the results above. This test works for both SC and SDID. The idea is that estimating the effect of acquisition on never-acquired operators should generate insignificant results if the estimation procedures are accurate.

Figure 3 illustrates the mean squared error (MSE) defined as the average of the squared

[3]Remember acquisition is assumed to have happened in 2003.

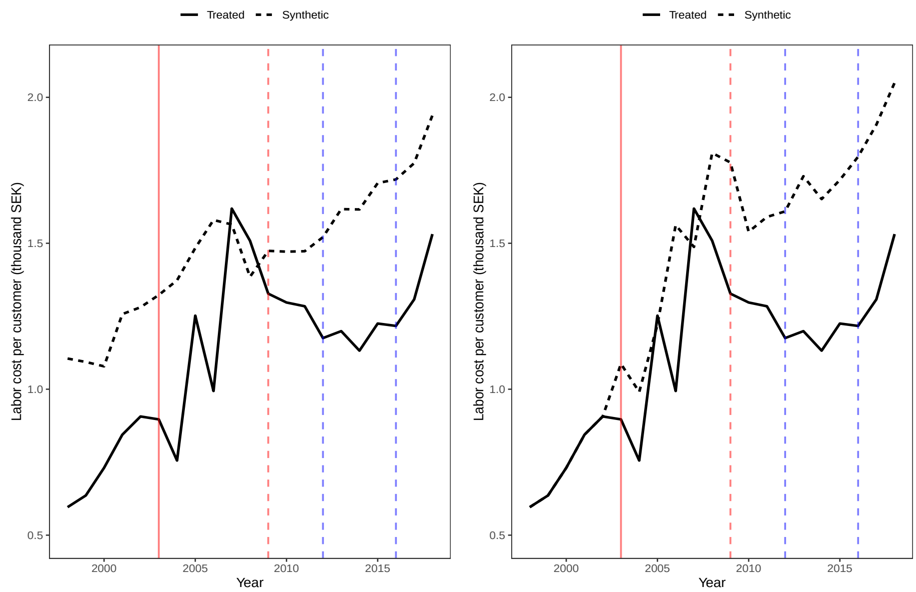

Figure 2: Labor cost estimation using SC (left) and SDID (right)

Figure 2 shows labor costs per customer for the acquired network operators (solid black line) and the estimated outcome in absence of acquisition (dotted black line). The solid red line marks the time of acquisition (2003). The vertical red lines together mark the period of the ex-post regime and the vertical blue lines mark the starting point for each regulatory period under the ex-ante regime. The left figure illustrates the results from SC and the right SDID. Both graphs show signs of differences in labor costs between acquired operators and never acquired. SC performs poorly as indicated by the large differences pre-acquisition. Figure 2 offers no visual assessment of the robustness of SDID. The synthetic network using SC has been constructed using the number of customers per km of electricity cable, number of km cable above ground, number of km cable under ground, number of transformation stations, and total installed apparent power.

difference between the actual outcome and outcome for the synthetic representation from both SC and SDID using only the post-acquisition time-period. The smaller MSE, the greater accuracy. SC and SDID perform almost equally bad with both showing low accuracy considering the rather big errors relative to the range of values labor costs take on. Knowing from figure 2 that SC performs poorly, figure 3 suggests that SDID performs equally poor.

Figure 4 illustrates the trajectories of the estimated effect of acquisition for both the acquired operators and each individual operator in the donor-pool. The estimated effect of acquisition from the results shown in figure 2, here illustrated with a green line, is not significantly different than those from the permutation test.

As mentioned in the data section in section 2, because of my processing of the data an increasing share of the aggregation of acquired operators is generated by operators that are

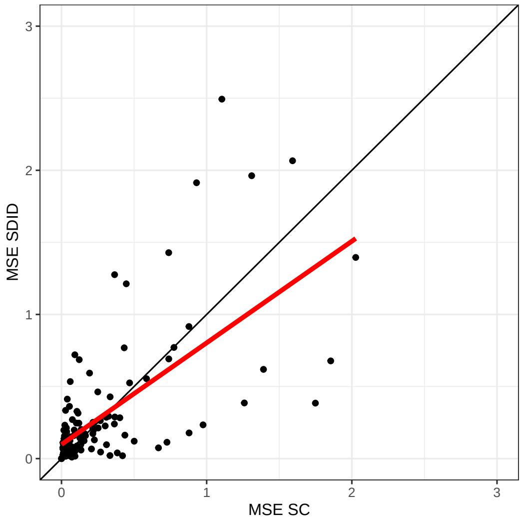

Figure 3: Placebo Acquisition - Comparison of mean squared error of SC and SDID

Figure 3 shows a comparison of MSE between SC and SDID. Each network in the donor-pool has sequentially been treated as if acquired and then SC and SDID have been used to estimate the effect of acquisition on labor costs. Since not acquired, an accurate model and estimation technique would have a low MSE. Each dot represents one network operator in the donor-pool. The black line is drawn at a 45-degree angle. Proximity to axis indicates accuracy and the closer to an axis the lower accuracy relative to the other method. The red line is linearly fitted. Eight operators are estimated with an MSE greater than three and are for illustrative reasons excluded.

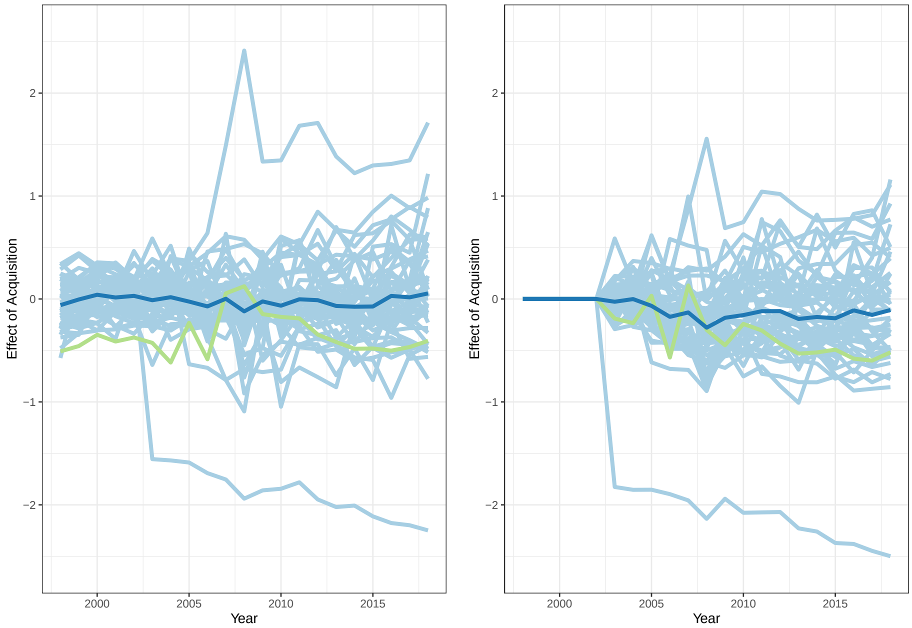

Figure 4: Placebo Acquisition - Trajectory of estimated effect on labor costs from SC (left) and SDID (right)

Figure 4 shows the difference in labor costs between the synthetic network operator and the real operator. Again each operator in the donor-pool has been sequentially treated as if acquired and then using all other operators left in the original donor-pool, a synthetic operator has been created. Light blue color indicates the estimated effect for operators in the original donor-pool. Dark blue color represents the average effect on all operators in the donor-pool. Green color represents the acquired networks. The upper graph illustrates the results from SC and the lower graph illustrates the results from SDID. The illustrations serve as a robustness test to evaluate the estimated effect of acquisition. Poor goodness of fit in SC and great variance in estimated effect in SDID means little support for acquisition affecting labor costs.

acquired. This means that in the case acquisition do affect, it's likely that my results indicate an increasingly strong effect. Although figure 4 and the results from SDID illustrate an effect with this exact pattern, I do not find my results convincing enough to conclude that acquisitions do affect labor costs.

Given the uncertainty regarding the effect on labor costs, examining the effect on total operating expenses serve as an exercise to find out if any synergies that may arise from acquisition are large enough to have a meaningful impact. Further, looking at specific cost types may only tell one side of the story, and while one cost type decrease, another can increase. Thus, by looking at total operating expenses I would capture the net effect of acquisition on operating expenses.

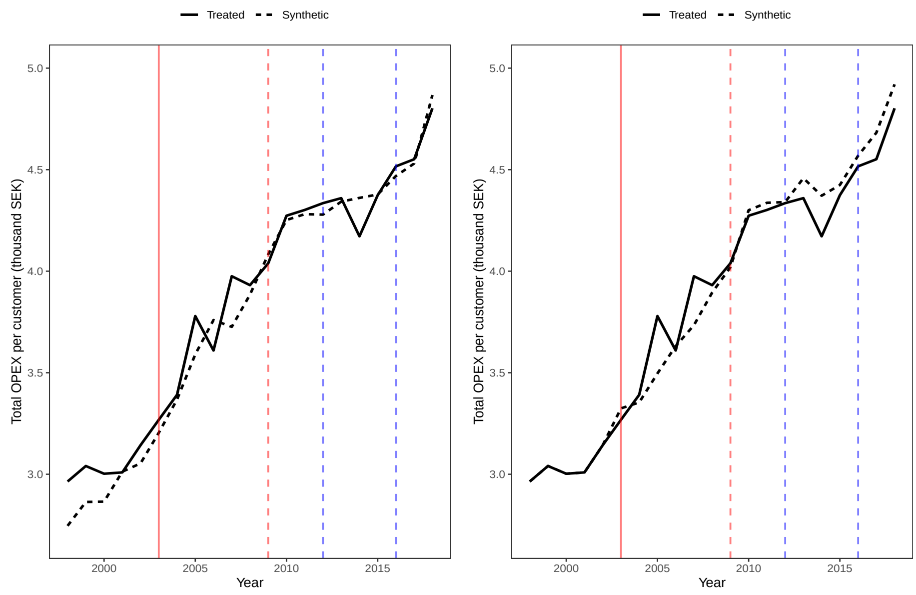

Figure 5: Total operating expenses per customer using SC (left) and SDID (right)

Figure 5 shows total operating expenses per customer for the acquired network operators (solid black line) and the estimated outcome in the absence of acquisition (dotted black line). The solid red line marks the time of acquisition (2003). The vertical red lines together mark the period of the ex-post regime and the vertical blue lines mark the starting point for each regulatory period under the ex-ante regime. The left figure illustrates the results from SC and the right SDID. Both figures illustrate that acquisition did not affect total operating expenses. SC also performs much better and the prediction error pre-acquisition is smaller than in the results in figure 2. The synthetic network using SC has been constructed using the number of customers per km of electricity cable, number of km cable above ground, number of km cable under ground, number of transformation stations, and total installed apparent power. Robustness tests are shown in the appendix.

Figure 5 illustrates the effect of acquisition on total operating expenses. First, the goodness of fit in the pre-acquisition period for SC is better than before suggesting that SC performs better than when examining the effect on labor costs. Secondly, no effect of acquisition can be observed using either estimation procedure.

To summarize, I find no support for acquisition affecting neither labor costs nor total operating expenses under either regulatory regime using either estimation procedure. Using Cowan's framework[4], the lack of effect on costs can be interpreted in two ways. As discussed before, either no synergies are arising from acquisition and ϕ is unchanged which leads to the

[4]Remember a firm's optimal level of effort is given by $e^* = \frac{1-b}{\phi}$

cost of achieving cost-saving e remaining unchanged, or the operators have no incentives for utilizing synergies reducing their costs. The latter is the case when b is close to 1, implying that the revenue cap closely follows accounting costs[5]. If b is close to 1, the optimal level of effort is largely unaffected by changes in the cost of effort, ϕ.

Moving on to consumer prices my results are illustrated in figure 6. The results from SC and SDID are very similar. Both show a very small effect up until 2015. Comparing SC and SDID it seems that accounting for systematic differences, as is done in SDID, between the two further decreases the effect. No downward effect on consumer prices can be observed. Given the lack of support for acquisition affecting costs this is not surprising. Again using Cowan's framework, if c is unchanged so are prices.

From the onset of the second regulatory period of the ex-ante revenue cap in 2016 and onwards it seems like acquisition has led to a much higher consumer price. In attempting to determine the source for this increase it is necessary to remember that operational *costs* as used in the general outline of the revenue cap shown in figure 1, and total operating *expenses* as defined by the structure of financial reports and as used in my estimations, differ from each other. Total operating expenses include, using the terminology from figure 1, controllable costs, non-controllable costs, and depreciation. Because depreciation is accounted for, any differences in the size of the asset base are also captured but indirectly through depreciation, assuming that the same depreciation method is used. Though, note that depreciation included in my cost variable is different from the depreciation included in the revenue cap since the asset bases are different, as mentioned earlier.

Since no effect from acquisition was found on operating expenses, what gives rise to the difference in consumer prices must, therefore, be explained by the other components in the revenue cap; the efficiency requirement, the return which is applied to the asset base, or adjustments to the return. While it is beyond the scope of this thesis to determine the exact source for the difference, I will nonetheless in the next section discuss whether any of the three components is a plausible source.

5 Discussion and concluding remarks

The reasons and motives for horizontal mergers and acquisitions are numerous. In this thesis I have examined the effect of acquisitions on labor costs, total operating expenses, and consumer price under two regulatory regimes. I find no support for acquisitions affecting neither labor costs nor total operating expenses. The scope of my findings is limited specifically to the

[5]Remember consumer prices are set according to $p(c) = a + bc$

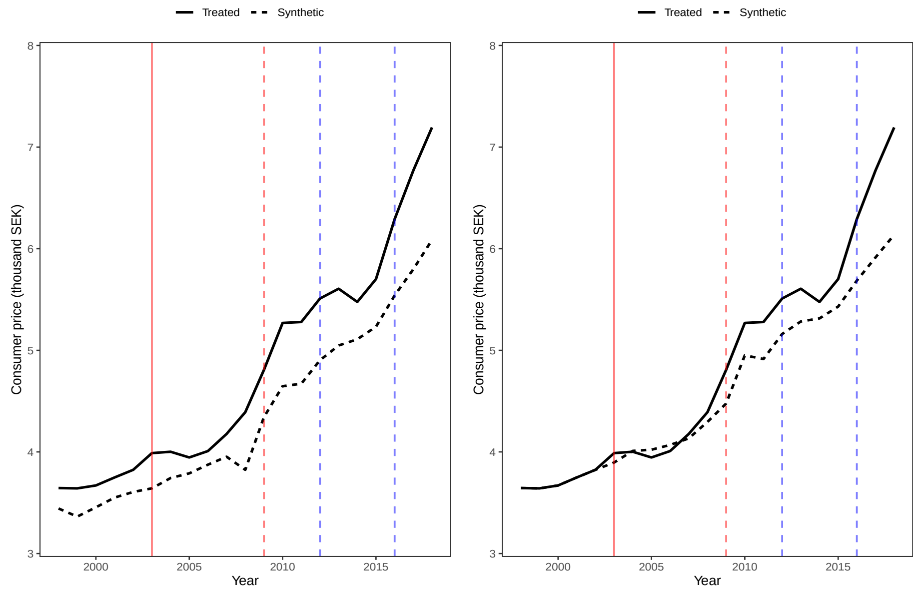

Figure 6: Consumer price estimation using SC (left) and SDID (right)

Figure 6 shows consumer prices for the acquired network operators (solid black line) and the estimated outcome in absence of acquisition (dotted black line). The solid red line marks the time of acquisition (2003). The vertical red lines together mark the period of the ex-post regime and the vertical blue lines mark the starting point for each regulatory period under the ex-ante regime. The left figure illustrates the results from SC and the right SDID. Both graphs illustrate that acquisition led to an increase in consumer prices from 2016 and onward, with small differences before 2016. The synthetic network using SC has been constructed using the number of customers per km of electricity cable, number of km cable above ground, number of km cable under ground, number of transformation stations and total installed apparent power. Robustness tests are shown in the appendix.

Swedish electricity distribution market from 1998 until 2018 and is therefore constrained by the regulatory regimes during this period. If operators never have had any incentives for reducing their costs, they would have no incentives for utilizing cost synergies arising from acquisitions, even if such synergies exist. It appears that under the current regulatory regime where the cost pass-through factor b is close to one, incentives for cost-reduction are limited. Whether incentives for cost-reduction have existed under the previous regulatory regime I leave for others with more in-depth knowledge to discuss.

Moving on to the effect on consumer prices, my results indicate that during the second regulatory period of the *ex ante* revenue cap regulation, acquisition led to higher consumer prices. Knowing from figure 5 that no similar effect is seen on operating expenses it seems that the profitability increased significantly during these years.

As mentioned in the data section, data for the aggregation of acquired operators are increasingly generated from operators that have been acquired. In the case when acquisitions do have an effect, my results would show an increasingly strong effect. While it is true that the effect on consumer price is increasing over time, the data effect can not explain the sharp increase in 2016 as no acquisition of the magnitude that is necessary to generate such an effect on the aggregate outcome took place around that year. For that reason it seems likely that changes made to the regulatory regime is at least a part of the explanation to the sudden increase starting in 2016.

As discussed earlier, there are three possible sources for the increase in consumer prices under the new regulatory regime that is not captured in any of my results. These are the efficiency requirement, the percentage return on the asset base, and adjustments made to the return. First, the efficiency requirement on controllable costs means that an operator may only count controllable costs less the efficiency requirement toward the revenue cap. For this to be a valid source, the efficiency requirement on acquired operators would have to be substantially smaller than for all other operators. I have not found this to be the case. Second, the allowed return on investments is set by the regulatory authority following methodology determined by the law and is equally applied to all operators. Unless the acquired operators for some reason is granted a higher percentage return on the asset base, the explanation for differences in consumer prices is unlikely to be found here.

The only possible source left is adjustments made to the return. Adjustments are designed to give operators incentives to comply with three goals determined by the regulator; increase reliability, reduce energy losses, and increase system utilization (Wallnerström et al., 2016) . The maximal reward for complying is a 5 percent increase of the revenue cap and the maximal penalty is a reduction of 5 percent. The divergence in consumer prices from 2016 and onward could then be explained by acquired operators responding relatively stronger to financial incentives. Noting that a large share of operators that never were acquired has remained in the ownership of municipalities, my results are also in line with the findings of Tooraj and

Magnus (2010), that private operators respond more strongly to financial incentives than non-private. The relative increase in consumer prices is perhaps then not surprising considering that existing financial incentives appear to exclusively have an upward pressure on consumer prices and incentives for cost reduction appears to be limited.

As stated earlier, determining the exact source for the effect on consumer prices is beyond the scope of this thesis. More research is needed before concluding that adjustments made to the revenue cap are what give rise to the differences in consumer price. Another potential explanation is differences in the degree of utilization of the revenue cap meaning that operators might choose to collect less revenue than what the revenue cap maximally allows. It is also unclear to what extent my results are affected by the outcomes of the legal processes mentioned earlier.

Whatever the source for the estimated effects it it clear that the profitability has increased in recent years. With these newly arisen and seemingly strong financial incentives in combination with low interest rates and difficult budgetary situation for many Swedish municipalities, the strong acquisition trend seen in the early days of the liberalization may have found new momentum. While an industry that reacts strongly to incentives created by the regulator implies more swift compliance with the regulator's goals, it also increases the stakes and risks in designing the regulatory regime and the incentive structure. For example, as the market's aggregated response to financial incentives increase, the consequences of financial incentives that are not on par with markets competing for the same production inputs as electricity distribution grows larger. Since investments are directed toward markets most profitable, markets less profitable than electricity distribution would see increased difficulties in raising necessary funds. How large of a problem this would be dependent on the relative market size of electricity distribution and the competing markets.

Adjustments have been made to the regulatory regime going into the third regulatory period of the ex-ante revenue cap 2020 to 2023 and we will have to wait and see what effects these will have on the economic performance of the network operators. The difficulties of designing a *ex ante* regulatory regime due to information asymmetry and the uncertainty around the consequence of changes made to it, are not unique for the Swedish electricity distribution market. Recently the UK's regulatory authority Ofgem has decided to introduce a return adjustment mechanism that works as a backstop against excessive profits. While multiple different adjustment mechanisms were discussed in the preparatory work (Ofgem, 2018), Ofgem decided to introduce what is called a 'sharing factor (Ofgem, 2020). The sharing factor works by having firms pass some of the revenue arising from the incentive structure back to consumers. Important to note is that the sharing factor would not be applied to the baseline return of the revenue cap that is designed to cover the cost of raising capital and to give a reasonable return on investments. Ofgem has also considered sculpting this sharing factor to further decrease the possibility of excessive profits, but no decision has yet been taken regarding exactly how the sharing factor will be designed. If introduced in Sweden this mechanism could be applied to the adjustments made to the return and would result in a share of the revenue that arises from the adjustments to be passed back to consumers. The design would be of great importance and determines whether firms face increasing, decreasing, or constant marginal benefits of pursuing the objectives set by the regulatory authority.

References

Abadie, A., Diamond, A., & Hainmueller, J. (2010). Synthetic control methods for comparative case studies: Estimating the effect of california's tobacco control program. *Journal of the American Statistical Association*, *105*(490), 493. https://ezp.sub.su.se/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=edsjsr&AN=edsjsr.29747059&site=eds-live&scope=site

Abadie, A., Diamond, A., & Hainmueller, J. (2011). Synth: An r package for synthetic control methods in comparative case studies. *Journal of Statistical Software, Articles*, *42*(13), 1–17. https://doi.org/10.18637/jss.v042.i13

Abadie, A., & Gardeazabal, J. (2003). The economic costs of conflict: A case study of the basque country. *The American Economic Review*, *93*(1), 113. https://ezp.sub.su.se/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=edsjsr&AN=edsjsr.3132164&site=eds-live&scope=site

Arkhangelsky, D., Athey, S., Hirshberg, D. A., Imbens, G. W., & Wager, S. (2019). *Synthetic Difference in Differences* (Working Papers No. 25532). NBER. http://papers.nber.org/tmp/47755-w25532.pdf

Averch, H., & Johnson, L. L. (1962). Behavior of the firm under regulatory constraint. *The American Economic Review*, *52*(5), 1052–1069. http://www.jstor.org/stable/1812181

Cowan, S. (2002). Price-cap regulation. *Swedish Economic Policy Review*, (9), 167–188.

Doudchenko, N., & Imbens, G. W. (2016). Balancing, regression, difference-in-differences and synthetic control methods: A synthesis. https://ezp.sub.su.se/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=edsarx&AN=edsarx.1610.07748&site=eds-live&scope=site

Kuosmanen, T., & Nguyen, T. (2020). Capital bias in the nordic revenue cap regulation: Averch-johnson critique revisited. *Energy Policy*, *139*. https://ezp.sub.su.se/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=edselc&AN=edselc.2-52.0-85079519863&site=eds-live&scope=site

Kwoka, J., & Pollitt, M. (2010). Do mergers improve efficiency? evidence from restructuring the us electric power sector. *International Journal of Industrial Organization*, (6), 645. https://ezp.sub.su.se/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=edsbl&AN=RN311814252&site=eds-live&scope=site

Kwoka, J. E. (2005). Electric power distribution: Economies of scale, mergers, and restructuring. *Applied Economics*, *37*(20), 2373–2386. https://ezp.sub.su.se/login?url=http:

//search.ebscohost.com/login.aspx?direct=true&db=buh&AN=19031713&site=eds-live&scope=site

Loeb, M., & Magat, W. A. (1979). A decentralized method for utility regulation. *The Journal of Law Economics*, *22*(2), 399. https://ezp.sub.su.se/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=edsjsr&AN=edsjsr.725125&site=eds-live&scope=site

Lundin, E. (2020). Effects of privatization on price and labor efficiency: The swedish electricity distribution sector. *Energy Journal*, *41*(2), 247–273. https://ezp.sub.su.se/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=141952955&site=eds-live&scope=site

Ofgem. (2018). Riio-2 framework consultation - our approach to setting price controls for gb gas and electricity networks. https://www.ofgem.gov.uk/system/files/docs/2018/03/riio2_march_consultation_document_final_v1.pdf

Ofgem. (2020). Riio-ed2 framework decision. https://www.ofgem.gov.uk/system/files/docs/2020/01/riio-ed2_framework_decision_jan_2020.pdf

Tooraj, J., & Magnus, S. (2010). The effects of average norm model regulation: The case of electricity distribution in sweden. *Review of Industrial Organization*, *36*(3), 249. https://ezp.sub.su.se/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=edsjsr&AN=edsjsr.41799465&site=eds-live&scope=site

Wallnerström, C. J., & Bertling, L. (2010). Laws and regulations of swedish power distribution systems 1996-2012 : Learning from novel approaches such as less good experiences.

Wallnerström, C. J., Gragn, E., Wigenborg, G., Öhling, L., Robles, H., Alvehag, K., & Johansson, T. (2016). The regulation of electricity network tariffs in sweden from 2016. https://ei.se/Documents/Nyheter/Nyheter%202016/Artikel%20Ei%20till%20SAEE2016%20final%20version.pdf

Appendix

Tables

Table A1: Predictor Balance in Synthetic Control

	Labor Cost	Operating Expenses	Consumer Price
Customer density	188	188	188
Under ground cable	44	44	44
Over ground cable	37	37	37
Substations	36	36	36
Installed apparent power	9	9	10

Table one show the predictor values for the estimated synthetic network operator using Synthetic Control.

Table A2: Predictor Weights in Synthetic Control

	Labor Cost	Operating Expenses	Consumer Price
Customer density	0.572	0.004	0.007
Under ground cable	0.127	0.27	0.192
Over ground cable	0.033	0.553	0.241
Substations	0.209	0.168	0.558
Installed apparent power	0.059	0.005	0.001

Table 2 shows the parameter values associated with each predictor variable for each output variable.

Figures

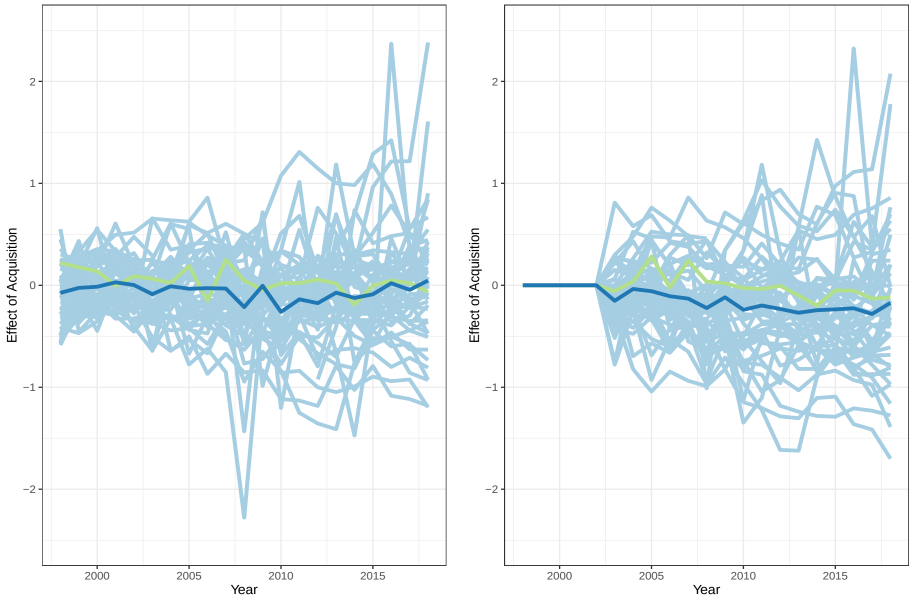

Figure A1: Placebo Acquisition - Trajectory of estimated effect on total operation expenses using SC (left) and SDID (right)

Figure A1 shows the difference in total operation expenses per customer between the synthetic network operator and the real operator. Again each operator in the donor-pool has been sequentially treated as if acquired and then using all other operators left in the original donor-pool a synthetic operator has been created. Light blue color indicates the estimated effect for operators in the original donor-pool. Dark blue color represents the average effect on all operators in the donor-pool. Green color represents the acquired networks. The upper graph illustrate the results from SC and the lower graph illustrates the results from SDID. The illustrations serves as a robustness test to evaluate the estimated effect of acquisition. As can be observed, the estimated effect on operators that actually were acquired is not distinguishable from the placebo estimates in terms of magnitude. No support for acquisition having an effect on total operating expenses is found.

Figure A2: Placebo Acquisition - Trajectory of estimated effect on consumer prices using SC (left) and SDID (right)

Figure A2 shows the difference in consumer prices between the synthetic network operator and the real operator. Again each operator in the donor-pool has been sequentially treated as if acquired and then using all other operators left in the original donor-pool a synthetic operator has been created. Light blue color indicates the estimated effect for operators in the original donor-pool. Dark blue color represents the average effect on operators in the donor-pool. Green color represents the acquired networks. The upper graph illustrates the results from SC and the lower graph illustrates the results from SDID. The illustrations serve as a robustness test to evaluate the estimated effect of acquisition. While SC offer little support for concluding acquisition to affect consumer prices, SDID illustrates that acquired network operators appear to have reacted more strongly to the changes that came with the second regulatory period of the *ex post* revenue cap.

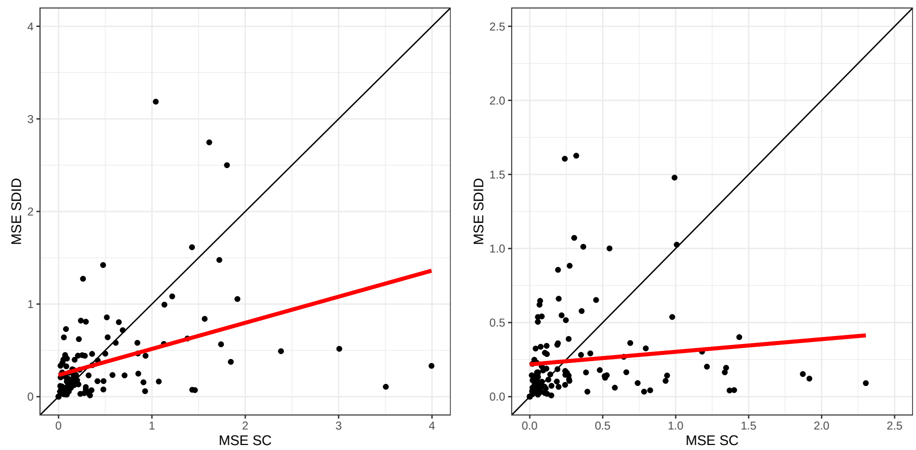

Figure A3: Placebo Acquisition - Comparison of mean squared error of OPEX (left) and consumer price (right) using SC and SDID

Figure A3 shows a comparison of MSE between SC and SDID. Each network in the donor-pool has sequentially been treated as if acquired and then SC and SDID have been used to estimate the effect of acquisition on operating expenses and consumer price respectively. Since not actually acquired, an accurate model and estimation technique would have a low MSE. Each dot represents one network operator in the donor-pool. The black line is drawn at 45 degree angle. Distance from a dot to an axis indicates relative accuracy, and the closer to an axis, the lower relative accuracy. The red line is a linearly fitted line. For illustrative reasons operators with relatively large MSE have been excluded. The excluded operators are almost exclusively placed below the black line for both SC and SDID.