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Assessing the welfare effects of electricity tax exemptions in general equilibrium: The case of Swedish data centers

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Contents

Abstract

This paper is the first to analyze welfare impacts of data center support in a general equilibrium setting. We examine the benefits and costs of an electricity tax exemption for data centers in Sweden, effective 2017-2023. The Government motivated the exemption by competitiveness concerns and the high electricity use in such centers. We show that the net benefits of this policy are closely related to the value of a tax elasticity; it is a sufficient statistic for evaluating the policy's efficacy in *general equilibrium*. This parameter summarizes a range of economic forces such as: crowding out of existing firms, increasing profits in the electricity sector, effects on electricity tax revenue, the inability to tax profits of data centers owned by large multinational and so on and so forth.

We take our model to the data by combing panel data from the Tax Authority and several other sources on individual establishments (N=135, 2008-2020). We also use a time series on sectoral data. The time series analysis suggests a low tax elasticity, significantly lower than the threshold value of 1 in absolute value. The casual effects analysis using the panel data shows significant heterogeneity regarding the effect of the reform on electricity use. It invariably suggests that the treatment effect is positive; reducing the tax increased electricity use among those granted.

Lessons learned include the oft-repeated plea for evaluation planning: before a policy is put in place, a plan for evaluating the reform should be available. This reform is particularly difficult to evaluate because crucial data is missing that cannot be collected ex post. It would have been challenging to collect the data before the reform, because the definition of taxable subject ('a data center') has been changing after 2017. Furthermore, while a reduced energy tax on electricity is likely to increase profits, the lost tax-revenues might have been partially recoverable with a non-distortive profit tax. However, a foreign center is significantly more likely to be granted an exemption. Because such centers are typically part of an international group, profit taxes are unlikely to be effective as a way to mitigate some of the financial costs of the reform. While our evaluation does not consider employment effects, we note that data centers with no employees have been granted tax reductions.

Overall, the complexity of the reform from a legal perspective has been such that the Tax Authority has been forced to issue clarifications, in turn (essentially) reversing earlier decisions to grant exemptions. We do not explicitly take these changes into account and cannot ascertain how the net benefits of the reform were affected by these changes. Yet, the changing definition of a data center in the energy taxation code, do suggest that the implementation of the reform was rushed. This sentiment also applies to the closing of the exemption in July 2023; the reform was, it seems, closed without considering the Energy Charter, an international agreement that effectively limit governments possibilities to close down energy subsidies.

While the paucity of the data at hand forces us to be very cautious about the net benefits of the reform, we do not find strong evidence that the tax exemption granted to (certain) data centers in 2017-2023 passes a cost-benefit test. The government's decision to abolish the exemption in 2023 is thus not inconsistent with our findings.

1. Introduction

Data centers are essential in our modern world as they provide computing power for critical services such as communication, trading, and streaming. Governments worldwide have supported investments in data centers in various ways, which some economic analysis suggests may have positive impacts. Let us begin by looking at a few examples of such claims.

A report by Copenhagen Economics (2018) suggests that Google's investments in data centers in the EU have significantly impacted the EU economy, contributing an average of EUR 490 million per year between 2007 and 2017, which amounts to a total of EUR 5.4 billion over the period. This investment has, the report argues, also supported 6,600 full-time jobs, with the direct effect estimated to be between 1/6 and 1/3 of the total impact, and the multiplier effect falling somewhere between 3-6. The report also suggests that investments in data centers lead to spill-over effects, such as the transfer of know-how to domestic human capital. Finally, the report argues that data centers conserve energy due to scale economies, such as by moving email from in-house servers to cloud-based solutions at data centers. Another evaluation by SWECO (2017) contends that investments in data centers in the North of Sweden have had" significant" beneficial effects on the region and the country. The investment phase included about 400 million EUR of direct investment and 4700 full-time employees between 2012-2016. The operational phase is expected to create four hundred full-time jobs, of which 250 will be in the region. An early example of an investment in the Nordic countries is Google's investment in a data center in Hamina, Finland, 2009. Copenhagen Economics (2017) has looked closer at data centers in Finland and argues that.

> Finland reaps large economic opportunities from data center investments. Our study demonstrates that Finland's data center industry has the potential to grow from its current situation of supporting 11,200 jobs and contributing 800 million EUR to the GDP, to 33,000 jobs and EUR 2,3 billion by 2025.

The study goes on to say that *"Google's EUR 800 million investment in its data center in Hamina has on average created 1,600 jobs annually, and yielded an economic contribution of EUR 660 million EUR to Finland"*[4].

These studies do not provide a comprehensive analysis of the opportunity costs associated with investments in data centers. While data centers provide various benefits, they also bring costs, including electricity market crowding-out effects as highlighted by Benetton et al. (2021). Other crowding-out examples include the potential ban on new housing projects in west London, as new data centers have soaked up the capacity[5]. It seems to imply that new housing projects in this area have to wait until 2035, putting pressure on housing prices in other parts of London. Moreover, a Norwegian ammunition manufacturer (Nammo) argues that a nearby data center has impacted its

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[4] The study is commissioned by Google "and developed in close connection with the Finnish Prime Minister's Office and the Ministry of Economic Affairs and Employment."

[5] As reported by Financial Times, 27 July, 2022, https://www.ft.com/content/519f701f-6a05-4cf4-bc46-22cf10c7c2c0

ability to deliver ammunition to Ukraine, see The Guardian (2023). These are just two examples out of many. There are other opportunity costs that need to be taken into account when supporting data centers, e.g., the potential loss of tax revenue.

A key to understanding the economic impacts of data centers is their appetite for electricity. Estimates vary, but in total data centers around the world almost certainly use more electricity than countries like South Africa. According to some estimates, data centers used about 205 TWh in 2018, representing approximately 1% of global electricity use. A recent estimate from the IEA puts the use of electricity in the range 240-340 TWh in 2022[6]. According to The Economist (Aug 16, 2023)[7], this figure may rise to 4% by 2030. Incidentally, the Economist article also notes that about two-thirds of the electricity use in a typical data center is attributable to computing, most of the rest is for cooling.

This paper contributes to the literature in two main ways. First, we show how the welfare effects of supporting data centers can be analyzed in a general equilibrium setting. The key result suggests that a tax elasticity is a sufficient statistic for the welfare impacts of the reform. Second, we use empirical data to shed light on this elasticity. Our analysis is motivated by the decision made by Sweden in 2017 to grant data centers an exemption from the energy tax on electricity[8]. The decision was primarily driven by competitiveness concerns due to the high electricity consumption of data centers. Swedish energy taxation already included an exemption for sectors that face international competition. Thus, the decision was mainly just a matter of including one more sector into an already existing support structure. The government further motivated its proposal[9] along two main lines. First, the exemption would attract new investments in an expanding sector and secondly, the lower tax would “create jobs”, not only in the data centers. Thus, while data centers are not labor-intensive per se, they would, the Government argued, bring employment in related sectors (a multiplier of 0.6-1.3 was quoted). Our approach to evaluate the reform is tailored to handle these aspects.

The exemption significantly reduced the cost of electricity, whence a tax of about three eurocents per kWh was reduced to 0.006 eurocents per kWh (the minimum level allowed by the EU). A large data center in Sweden may use several hundred GWh per year, thus implying savings on tax liability into the hundreds of millions SEK. Large data centers are typically owned by multinationals whose profits are invariably difficult to tax. This aspect is also included in our welfare analysis.

We employ general equilibrium cost-benefit analysis techniques outlined in to systematically assess the benefits and costs of the policy measure within an equilibrium setting. This approach provides a consistent may to handle secondary market effects beyond the primary market impacted by the policy. For the empirical analysis we rely primarily on panel data. We merge data from the tax reduction application forms with firm-level accounting data. Unfortunately, key data is limited to 2017-2020 and is therefore impossible to carry out a “before-after-analysis” with the panel data. We

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[6] https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks.

[7] https://www.economist.com/science-and-technology/2023/08/16/can-computing-clean-up-its-act

[8] The exemption was removed 1 July 2023

[9] See p. 281 in Prop. 2016:17/1, which can be downloaded from www.regeringen.se, or herehttps://bit.ly/prop201617

therefore complement the panel-data analysis with sectoral time-series data 2008-2020. This allows a rough estimate of the key parameter.

The paper is structured as follows: section 2 defines the concept of a data center, section 3 discusses governmental support to data centers in selected countries, including a detailed overview of the Swedish case (see section 3.3), section 4 introduces our general equilibrium model where we derive a sufficient statistic, which summarizes the welfare effects of the tax exemption *in general equilibrium*. We begin the empirical analysis in section 5 by a descriptive overview, before turning to the estimation problem in chapter 6. A final section concludes.

2. What is a data center?

A data center is an establishment that provides various services related to data storage, processing, and management. Some common services offered include colocation services, where they rent out space, power, and cooling infrastructure to companies and organizations that need to house their own servers and networking equipment. Additionally, data centers provide cloud computing services, such as infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS) to allow customers to access and use computing resources over the internet. Managed hosting services are also offered by data centers, where they manage and maintain servers, networking equipment, and applications on behalf of their clients. Data centers provide disaster recovery services to ensure that companies can recover their data and applications in case of a disaster, such as a natural calamity, cyber-attack, or hardware failure. They also offer virtual private server (VPS) hosting services where customers can rent a virtual server and use it to host their websites, applications, or databases. In addition, data centers provide content delivery network (CDN) services to improve the performance and reliability of websites and web applications by caching content at edge locations closer to end-users. Finally, data centers offer network connectivity services that allow customers to connect to the internet or to other data centers or cloud providers. Overall, data centers play a critical role in providing a range of services to support businesses and organizations in managing and processing their data.

While this explains, at least partly, what a data center can do, it turns out to be quite difficult to define the notion more precisely. There are quite a number of different definitions. Here is an example:

> A data center – also known as a datacenter or data centre – is a facility composed of networked computers, storage systems and computing infrastructure that organizations use to assemble, process, store and disseminate large amounts of data. A business typically relies heavily on the applications, services and data contained within a data center, making it a critical asset for everyday operations.[10]

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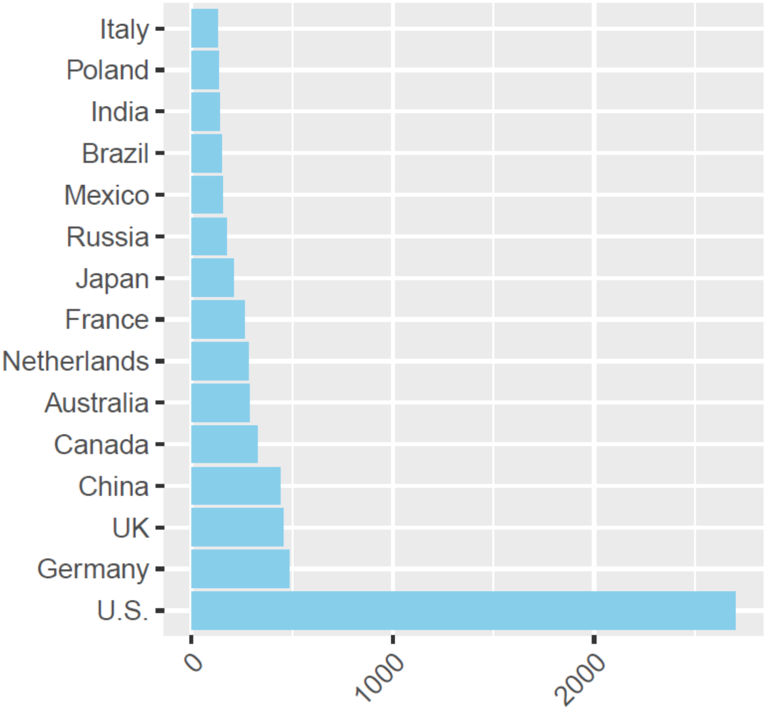
[10] https://www.techtarget.com/searchdatacenter/definition/data-center

A large data center can be loosely defined as a data center that uses electricity similar to that of a town in a developed country with about 80,000 inhabitants. A hyperscale data center is a facility that houses a large number of servers and IT equipment to support scalable applications and services. It is owned and operated by the company it supports, such as Google, Amazon, Facebook, IBM, Microsoft, and Apple. A data center is generally considered hyperscale when it exceeds 5,000 servers and 10,000 square feet.

Data centers can thus have a significant appetite for electricity, but they are not labor intensive. For example, Google owns some thirty data centers worldwide, the largest of those providing employment for some four hundred people.

In Figure 2.1 we see that the number of data centers is clearly highest in the US. The numbers are based on the definition of a data center that is provided by cloudscene.com, a global directory of data centers, co-location providers, and network fabrics. Again, there are other definitions suggesting that there are several million such centers.

Figure 2.1 The number of data centers worldwide in 2020



Source: Statista *https://www.statista.com/statistics/1228433/data-centers-worldwide-by-country/*

If a data center is in the EU/EEA and deals with personal data, it must comply with the GDPR, which is a law in the EU/EEA about data protection and privacy. This applies even if its clients or customers are located elsewhere. The GDPR requires data centers to get consent for data processing, use appropriate security measures, and give people certain rights to their data. Data centers must also report breaches to authorities and individuals. EU-based firms can use centers outside the EU/EEA, as long as the center follows GDPR requirements. But the firm must make sure the center meets these requirements before sharing personal data. Non-compliance with the GDPR can result in significant fines and damage to reputation.

3. Government support to data centers

It is common practice for countries to grant exemptions in their energy tax systems to industries that compete on world markets, such as iron ore, steel, pulp, and paper. The literature on the welfare economics of tax exemptions for data centers is limited. Some studies suggest that such tax incentives may positively impact the growth of the data center industry in certain regions. Critics argue that tax incentives for data centers may not be cost-effective as they can result in a loss of tax revenue for governments without necessarily providing significant economic benefits in return. Furthermore, some have raised environmental concerns regarding the energy consumption of data centers, arguing that tax incentives should be linked to environmental performance.

Beyond tax exemptions, there are other factors affecting localization decisions, including access to renewable energy. For example, the electricity systems in Finland and Sweden are dominated by renewable energy sources in the regional market NordPool. Furthermore, the Nordic climate is beneficial to the cooling requirements. See Sheme et al. (2018) for a detailed analysis of localizing a data center above the 60-degree northern latitude. Because photovoltaics is at a relative disadvantage at those latitudes, it has been argued that the centers still have to rely on fossil fuels, although this problem is small in Finland and even less so in Sweden.

Let us now turn to a brief overview of support to data centers in the world. Regarding Asia, there is quite active support in India[11] and Malaysia[12]. But there is also the case of Singapore, which imposed a moratorium 2019-2022 on new data centers [13]. We next consider a few examples in more detail, beginning with the USA.

3.1 USA

Tax incentives for data centers in the United States vary from state to state, and there is no comprehensive federal tax incentive program for data centers. However, several states have enacted tax policies or incentives to attract data center investments. For example, Virginia, Texas, and Washington are among the states that have implemented tax incentives for data centers. In Virginia[14] companies are eligible for sales and use tax exemptions for computer equipment, data center electrical infrastructure, and software. In Texas[15], data centers can apply for a franchise tax exemption for certain investments in the state, and in Washington[16], companies can receive a sale and use tax exemption for

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[11] "Maharashtra, Andhra Pradesh, and Telangana have announced incentives for datacenter development in the last two years."see https://www.budde.com.au/Research/India-Data-Center-Market-Investment-Analysis-and-Growth-Opportunities-2020-2025

[12] Reuters report that " Microsoft Corporation will invest $1 billion over the next five years in Malaysia as part of a new partnership program with government agencies and local companies..,", see https://asia.nikkei.com/Business/Companies/Microsoft-to-invest-1bn-in-Malaysia-to-set-up-data-centers

[13] https://www.datacenterdynamics.com/en/news/singapore-authorities-invite-applications\ \-for-new-data-centers/

[14] https://www.aligneddc.com/static/5e708bbbccb5a90a22c71f492594afe6/ALI_AshburnTaxIncentive211208-web.pdf

[15] https://comptroller.texas.gov/taxes/data-centers/

[16] https://apps.leg.wa.gov/rcw/default.aspx?cite=82.08.986

certain computer equipment and software. In addition to state-level incentives, some local governments in the United States may offer property tax abatements or other incentives to attract investments.

3.2 Europe except Sweden

A number of countries in Europe use various support measures to attract investments in data centers. Before detailing our main case of Sweden, a few examples from Europe are briefly discussed.

- Finland - The Finnish government has implemented various policies to attract data center investment, including tax incentives[17] and the establishment of dedicated data center zones. In addition, Finland has invested heavily in its digital infrastructure, including high-speed internet connectivity and a reliable power grid, which has made it an attractive location for data center operators. As a result, many large technology companies, e.g., Google as noted in the introduction.
- Ireland - According to ”Government Statement on The Role of Data Centres in Ireland’s Enterprise Strategy”, see Department of Business & Innovation (Undated), the country has established a range of policy enablers to support data centers that want to invest in the country.[18] These include supportive energy, telecoms, and data policies, as well as a streamlined strategic infrastructure process to facilitate development. Furthermore, Ireland offers incentives for capital investment in energy-efficient equipment and research and development.
- Norway - offers a tax incentive program called the ”Qualified Data Center Program” [19]. This program provides an energy tax exemption on electricity and includes a mechanism to use excess heat generated by the data centers. [20]
- Netherlands - The market in the Netherlands is one of the largest and most mature in Europe, and it is widely regarded as a key hub for data center activity in the region. The Netherlands has a relatively low cost of energy, which is a key consideration. Additionally, the country has a well-developed renewable energy sector, which is increasingly important for companies that are seeking to reduce their carbon footprint. There are several mechanisms in place in the Netherlands to attract data center investment, including tax incentives. The Dutch data center organization (2017) argues that the Dutch data center market ”is good for” nearly 13,000 jobs and an ”economic contribution” of more than EUR 1 billion. 5,000 full time employees are said to be working within existing data centers.
- Germany - There are several other country-examples and of those we mention Germany. The website https://www.germandata centers.com/en provides useful information about the German government’s support for the industry through measures such as the Digital Infrastructure Fund and tax incentives for data center construction. Let us now turn to our main case.

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[17] https://www.bergmann.fi/e/article/finland_as_a_data_center_location

[18] https://enterprise.gov.ie/en/publications/government-statement-on-role-of-data-centres-in-enterprise-strategy.html

[19] https://www.datacenterdynamics.com/en/news/norway-publishes-data-center-strategy/

[20] https://www.datacenterdynamics.com/en/news/norwegian-government-demand-data-centers-try-plugging-district-heating-systems/

3.3 Sweden

Sweden was one of the first countries to introduce a comprehensive system of energy taxation in 1957. Even though the energy taxes are high in relative terms, the country has still been able to benefit from cheap energy and abundant natural resources. High energy taxes have little or effect on competitiveness since heavy industry are exempt. Swedish Tax Authorities have ensured that energy-intensive industries do not face a significant energy tax burden, according to Ståhl (1975), p. 109. Indeed, the initial exemptions on electricity tax in Sweden was introduced to keep the country's energy-intensive industry competitive. Thus, it was straightforward, in principle, to include the exemption for data centers in the existing energy tax code, as was done in 2017. It was not straightforward in practice, as we will see.

The Swedish energy tax framework is governed by the EU Energy Tax Directive of 2003 (2003/96/EG, as of October 27, 2003) and national regulations outlined in the Energy Taxation Act (1994:1776). A unit tax on electricity is imposed on electricity producers and grid owners and a third group known as ”voluntary tax liable.” This system requires that electricity be taxed at the point of transmission to a user or at the time of consumption by the tax liability holder. If granted voluntary tax liable status, a data center pays the bill from the electricity provider without the tax. In other cases, the data center must pay the tax and then apply to the Tax Agency for reimbursement.

The energy tax on electricity in Sweden 2017 was approximately equal to the cost of the electricity itself, at around 3 eurocents per kWh. This tax thus represented a significant portion of the consumer price of electricity. The EU minimum level for energy tax is only 0.06 eurocents, so removing the tax would be a significant incentive. The proposal to widen the existing exemptions to include data centers originated with a Government Commission, SOU2015). The remit argued that energy prices are lower in neighboring countries and therefore Sweden needs to offer stronger incentives to attract investments in data centers.

The proposal that originated in the Commission was eventually approved by the Swedish Parliament and went into effect on January 1, 2017. It had a significant impact on the cost of electricity. The energy tax on electricity was 32.5 öre 2017, 33.10 öre 2018, 34.7 öre 2019, with exemptions for certain municipalities in the north. The average price of electricity on the Nordpool market in 2017-2020[21] was on average about {30,46,41,20} öre, so that the tax rebate was economically meaningful for firms that use a lot of electricity.

The exemption in 2017 thus implied that a data center would pay some three eurocents per kWh, rather than six eurocents without the exemption[22]. This incentive might have influenced some companies to direct their data center investments to Sweden. However, Facebook came to Luleå, northern Sweden before the exemptions (in 2013). Amazon Web Services established centers in Västerås 2018[23]. Microsoft opened up three data centers in Gävle, Sandviken and Staffanstorp in November 2021[24]. Google has bought land and

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[21] see urlhttps://www.elbruk.se/elpris-historik-20x, x=17,18,19,20

[22] At the time, the price differences between the 4 Swedish price areas of electricity were negligible. This has changed from about mid-2021 when the prices in the northern areas are markedly lower.

[23] https://www.vasterastidning.se/nyheter/amazon-har-startat-sina-datacenter/195826

[24] https://www.svt.se/nyheter/lokalt/gavleborg/microsofts-datacenter-oppnar-i-gavle\-och-sandviken

obtained permits to build centers in Avesta, although the process seems to have hit a snag in the summer of 2023[25].

3.3.1 Complex exemption rules

In order to unpack the energy tax legislation, we need to begin with the definition of a ”data center” in the Swedish Energy Tax Act (1994:1776).

> A data center refers to a facility where a business operator, primarily engaged in information services, information processing or rental of server space and associated services, conducts such activities and whose total installed capacity is at least 0.1 megawatts. [26]

Note that the 0.1 MW capacity limit was imposed in 2018 after the initial 0.5 MW limit was critiqued (RiR (2022), p. 27)). In this way, smaller data centers could apply for a lowered energy tax on electricity. Calculation of the installed capacity should primarily be based on the equipment's rated power. This is the power marked on the equipment by the manufacturer. If the rated power is missing or obviously deviates, the entity that wants to qualify for the lower tax rate must measure the power and document how the calculation was made. When calculating installed capacity, the power for all equipment in the facility, except for the installed power for cooling and ventilation systems, should be included.

The rules for exemptions (spring 2023) are as follows:

> For the electricity you have consumed before July 1, 2023, you may be entitled to a deduction or refund of the difference between the applicable tax rate and 0.6 öre per kilowatt-hour. For the electricity you have consumed before January 1, 2021, you may be entitled to a deduction or refund of the difference between the applicable tax rate and 0.5 öre per kilowatt-hour. If you apply for a refund, you are only entitled to the part of the refund amount that exceeds 8,000 SEK per calendar year [27]

Thus, as noted, a firm either deduct in a tax declaration what they are entitled to or applies for a refund. The voluntary taxable is defined by:

> If you have consumed more than ten gigawatt-hours of electricity in certain areas of use, such as in a data center, you can apply to be approved as a voluntary taxpayer. As a voluntary taxpayer, you cannot apply for a refund, but you can deduct the tax in the declaration that you receive when you are approved. From July 1, 2023, it will no longer be possible to apply as a voluntary taxpayer for energy tax on electricity consumed in a data center [28].

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[25] see https://www.avestatidning.com/2023-06-01/darfor-overklagar-de-googles-marklov-vi-saknar-helheten

[26] translated from https://skatteverket.se/foretag/skatterochavdrag/punktskatter/energiskatter.4.18e1b10334ebe8bc8000843.html

[27] translated from https://skatteverket.se/foretag/skatterochavdrag/punktskatter/energiskatter.4.18e1b10334ebe8bc8000843.html

[28] translated from https://skatteverket.se/foretag/skatterochavdrag/punktskatter/energiskatter.4.18e1b10334ebe8bc8000843.html

An entity that wants to enjoy a lower electricity tax thus submits one of two different forms to the Tax Authority. These two forms are a key part of our panel data-set, and we will analyze them in some detail later on. To enjoy exemption of energy tax for electricity consumed in a data center, the applicant must have *control over* the equipment that consumed the electricity. In addition, the equipment must be located in a data center. By ”control over”, the Swedish Tax Agency refers to legal control, such as ownership, leasing or renting of the equipment[29].

3.3.2 Co-location providers and the 2018 change

Before 2018, all data centers were considered eligible for a reduced energy-tax, following the 2017 imposition of the new exemption. In September 2018, the Swedish Tax Authority published a clarification 30, stating that it is the user of electricity that should be the recipient of the state support. Previously, a co-location provider generating at least 75% of its revenue from data center services could claim tax incentives on the energy used by the entire facility. The clarification was subsequently heavily critiqued by representatives of Swedish-owned data centers. A number of them were of the co-location type and lost the exemptions, because they did not have ”control” over the equipment31. According to some critics, the tax exemption benefitted large foreign companies, but had little or no effect on the domestic data centers32.

3.3.3 The decision to remove the exemption in 2023

The social-democrat government that proposed the electricity tax exemption in 2017, initiated a process to remove it in the autumn of 2022 33. The government argued that the Russian invasion of Ukraine drastically changed the electricity market and created unprecedented electricity prices for Swedish households in the winter of 2022-2023. Therefore, computer centers should be subject to the same incentives as other companies in the service sector to save on electricity; existing exemptions for other companies (typically energy intensive industry) are not discussed. Furthermore, the government anticipated a ”green revolution” and an electrification of society that will require substantially more electricity than what is currently generated domestically. Electricity generation should therefore, the government argued, not be geared towards data centers via a lower electricity tax.

3.3.4 The Energy Charter Treaty

It is uncertain whether revoking the tax break for data centers will come at a cost due to a possible breaching of agreements. As many data centers are owned by foreign firms, Investor-State-Dispute-Settlement (ISDS) and The Energy Charter Treaty (ECT) could come into play. ISDS (Investor-State-Dispute-Settlement) is a mechanism that allows foreign investors to bring claims against host states for alleged violations of investment protections under international treaties, such as bilateral investment treaties or free trade agreements. The ETC (Energy Charter Treaty) is a multilateral treaty that provides

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[29] See www4.skatteverket.se/rattsligvagledning/371124.html?date=2018-09-19&q=datorhall.

[30] See https://www4.skatteverket.se/rattsligvagledning/371124.html?date=2018-09-19

[31] See e.g. https://www.breakit.se/artikel/18812/serverhallar-riskerar-skattesmall //-det-rader-upprorsstamning.

[32] See e.g. https://www.sweclockers.com/nyhet/33545-bahnhof-slopa-skattefri-el-for//-amerikanska-teknikjattar.

[33] See Fi (2022) ”Avskaffad avfallsförbränningsskatt och slopad energiskattenedsättning för datahallar”, Ministry of Finance, 2022-09-09, Fi2022/02588.

investment protection and guarantees for energy-related investments. Both mechanisms have been used by investors in the past to challenge changes in government policies that they believe have harmed their investments.

For example, in the case of Eiser Infrastructure Limited and Energía Solar Luxembourg S.à.r.l. v. Kingdom of Spain ( ), the investors claimed that Spain had violated the Energy Charter Treaty by enacting a series of measures that drastically scaled back and ultimately withdrew the incentives, which the investors had a reasonable and legitimate expectation would remain unchanged during the lifetime of their plants. This case is too complex to discuss here, suffice it to say that it was decided in favor of the investor involving a payment of some 140 mill EUR, a decision that was later annulled, a decision that, in turn, was contested [34]. This is not the only case involving Spain. The "Spanish renewables saga" involves arbitration proceedings totaling 10,000 million EUR, according to http://www.qil-qdi.org/renewable-energy-investment-cases-against-spain-and-the-quest-for-regulatory-consistency/. The same source indicates that Spain has paid 825 million EUR as of June 2020 in ECT settlements. The root of the matter is cancelled subsidy programs for renewable energy generation.

Another high-profile case involved the Swedish energy company Vattenfall and the German government[35], regarding compensation for the German nuclear phase-out decision that affected Vattenfall's investment in the German power sector.

Whether ISDS or the ETC will be invoked in this case will depend on several factors, including the specific language of the investment agreements and the treaties that are in place, as well as the extent to which the change in policy is seen as discriminatory or arbitrary. Sweden has signed and ratified the ETC, which provides foreign investors with protections for their energy-related investments. However, the treaty also allows states to take measures to protect the environment and promote sustainable development, which may provide a basis for Sweden's decision to remove the energy tax exemption for data centers.

Thus, it is not obvious that a removal of the tax exemption for data centers in Sweden will be without cost for the Swedish government. Additionally, removing a tax break could harm Sweden's credibility regarding foreign investments in Sweden. We do not explicitly consider the ISDS costs. They may be considered a transfer payment and thus would not affect the real costs and benefits. The potential negative effect on future foreign investments has real effects, however, but are very hard, if not impossible, to estimate. It should be noted that the EU has (in 2023) formally initiated a process of leaving the ETC [36].

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[34] see https://www.italaw.com/cases/5721, https://www.ibanet.org/article/C3481397-686D-49E6-A324-61A399DBB2D8, https://www.bilaterals.org/?eiser-infrastructure-limited-and and https://investmentpolicy.unctad.org/investment-dispute-settlement/cases/535/eiser-and-energ-a-solar-v-spain for details about this case.

[35] see https://www.dw.com/en/vattenfall-wins-case-against-german-nuclear-phaseout/a-55572736 for details

[36] https://www.euronews.com/my-europe/2023/07/07/brussels-tables-eu-wide-exit-from-the-energy-charter-treaty-considered-at-odds-with-the-gr

4. General equilibrium cost-benefit rules

While many governments view data centers as economically viable investments, there are several economic questions that need to be carefully examined. For example, how will data centers affect electricity use in existing companies? How many new jobs will be ''created''? What will be the impact on tax revenues? Before turning to our theoretical model, we discuss some examples of studies that have shed some light on these questions.[37]

Benetton et al. (2021) analyzed the localization of crypto mining to determine whether the benefits of investments in certain Chinese and New York state municipalities outweigh the costs. They found that while crypto mining substantially increased business tax revenues relative to GDP in Chinese locations, it had a negative impact on local wages and value-added taxes. In New York State, they found substantially higher electricity prices for businesses and commercial operations. Small businesses (households) in Upstate NY paid an extra 90 (189) million annually due to increased electricity consumption from crypto miners.

Scharnowski & Shi (2021) discusses the impact of Bitcoin mining on the electricity market. Bitcoin miners tend to gravitate towards regions with cheap electricity. This can lead to higher electricity costs for households and small businesses in those regions. The paper also submits that Bitcoin mining is related to increasing volatility levels in the electricity spot market. According to research by Lee et al. (2023), for every GW of cryptocurrency mining load on the ERCOT (Electric Reliability Council of Texas) grid, the wholesale price of electricity increases by 2%. The cryptocurrency mining load on the ERCOT grid is around 1 GW, which suggests that wholesale prices have already risen by this amount. The authors claim that there is 27 GW of mining load not yet connected to the grid, which thus can increase wholesale prices markedly. For an overview of energy consumption in data centers, see the review in Dayarathna et al. (2016). Let us now turn to our model.

4.1 A model

Let the (representative) data center be producing good 1 at price p_1. The good is exported and profits are assumed to be fully dissipated, so that the income from the data center does not affect the utility of domestic households. This assumption is based on the idea that multinational companies like Google have the ability to shift profits between different subsidiaries and jurisdictions. This can be done through various mechanisms such as transfer pricing, where companies adjust the prices of goods and services traded between different subsidiaries in order to shift profits to low-tax jurisdictions. However, there are regulations in place to prevent companies from engaging in aggressive tax planning and profit shifting. For example, the Organization for Economic Co-operation and Development (OECD) has developed a framework called the Base Erosion and Profit

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[37] See also Johansson, P.-O. & Kriström, B. (2021).

Shifting (BEPS) project (https://www.oecd.org/tax/beps/), which aims to prevent companies from shifting profits to low-tax jurisdictions [38].

To simplify further, we only consider efficiency issues, so that the indirect utility function of the representative household introduced below is the social welfare function.

4.1.1 Small changes

The profit function for the data center is denoted $\pi_1(p_1, p_e(1+t_1))$, where p_e is the price of electricity and t_1 a tax on electricity. We suppress other inputs to production in the data center, whence the results below are unaffected as long as these markets are competitive.

Let $V(p_2, p_e, \pi_2 + T) = v(p_2) + p_e \cdot E + \pi_2(p_2, p_e(1+t_2)) + T - p_2 \cdot x_2(p_2)$ be a quasi-linear utility function, where p_2 is the price of a Hicksian composite good, E is electricity, π_2 a profit function for the production of good 2, T tax revenue, $v(p_2)$ a strictly convex function with negative first-derivative, t_2 a tax on sector 2s electricity input and x_2^d demand for good 2, and the right-hand side terms $in\ \ V(.)$, except $v(p2)$, sum to the demand for the numéraire.

The profit functions can be written as

$$\pi_i = p_i \cdot x_i(p_i, p_e(1+t_i)) - p_e \cdot (1+t_i) \cdot x_{ie}(p_i, p_e(1+t_i)), i = 1,2. \tag{4.1}$$

Tax revenues equals:

$$T = \sum_i t_i \cdot p_e \cdot x_{ie}(p_i, p_e \cdot (1+t_i)) \tag{4.2}$$

Consider now a small change of the tax faced by the first sector. The resulting change in monetary welfare equals:[39]

$$\begin{aligned} dV = \ & [x_2 - x_2^d]dp_2 + [E - x_{2e}]dp_e + t_2 \cdot p_e \frac{\partial x_{2e}}{\partial p_2} dp_2 + t_2 \cdot p_e \frac{\partial x_{2e}}{\partial p_e} dp_e + x_{1e} \cdot [p_e dt_1 + t_1 dp_e] + \\ & t_1 \cdot p_e \frac{\partial x_{1e}}{\partial p_{1e}^T} dp_{1e}^T \end{aligned} \tag{4.3}$$

where $p_{1e}^T = (1+t_1) \cdot p_e$. Provided the market for the composite commodity is in equilibrium, the first term on the right-hand side of equation 4.4 vanishes. Using the fact that $E - x_{2e} = x_{1e}$ in equilibrium, equation 4.4 can be simplified to read:

$$dV = t_2 \cdot p_e \frac{\partial x_{2e}}{\partial p_2} dp_2 + t_2 \cdot p_e \frac{\partial x_{2e}}{\partial p_e} dp_e + x_{1e} \cdot \left[1 + \frac{t_1 \cdot p_e}{x_{1e}} \frac{\partial x_{1e}}{\partial p_{1e}^T}\right] dp_{1e}^T \tag{4.4}$$

It seems reasonable to assume that the price of the composite commodity remains more or less unchanged, and that the increase in electricity demand induced by $dt_1 < 0$ causes the producer price of electricity p_e to increase. The end-user price of electricity faced by

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[38] For example, a Swedish subsidiary of a foreign company is in conflict with the Swedish Tax Agency over excessive royalty payments to the foreign parent company (see https://bit.ly/3KLM8Y8 for details). The Tax Agency argued that the payments did not reflect arm's length pricing, resulting in adjustments to the taxpayer's tax assessment and additional taxes owed.

[39] The marginal utility of income equals unity for the considered quasi-linear social welfare function.

the first sector, i.e., p_{1e}^T, is affected by opposing forces; the tax paid by the sector is reduced while the producer price increases. However, the end-user price will, reasonably, decrease, i.e., $dp_{1e}^T < 0$. At least this is the aim of the tax reduction.

Given these assumptions, the middle term on the right-hand side of equation 4.5 has a negative sign, while the sign of the final term depends on the magnitude of the elasticity $\varepsilon = [t_1 \cdot p_e / x_{1e}][\partial x_{1e} / \partial p_{1e}^T]$. A sufficient (but not necessary) condition for welfare to decrease is that $\varepsilon \geq -1$. Thus, the more price insensitive (sensitive) the sector's electricity demand, the more likely it is that the considered tax reform is welfare decreasing (increasing).

4.1.2 Discrete changes

Let us now consider a discrete change in the tax rate from t_1^0 to t_1^1. Suppose that we can use the market equilibria for the Hicks' composite commodity and electricity to solve for the associated equilibrium prices as functions of the tax rate, i.e., $p_2 = p_2(t_1)$ and $p_e = p_e(t_1)$, suppressing any other exogenous parameters. For simplicity, we continue to ignore any change in p_2. Integrating equation 4.4 with $dp_2 = 0$, one obtains:[40]

$$\Delta V = \quad V^1 - V^0 = \int_{t_1^0}^{t_1^1} \frac{\partial V(t_1)}{\partial t_1} dt_1 =$$

$$t_2 \cdot \int_{t_1^0}^{t_1^1} p_e\,(t_1) \frac{\partial x_{2e}(t_1)}{\partial p_e} \frac{\partial p_e}{\partial t_1} dt_1 + \int_{t_1^0}^{t_1^1} x_{1e}\,(p_1, t_1) \cdot \left[1 + \frac{t_1 \cdot p_e(.)}{x_{1e}(.)} \frac{\partial x_{1e}(.)}{\partial p_{1e}^T}\right] \frac{\partial p_{1e}^T}{\partial t_1} dt_1 \qquad 4.5$$

where V^1 (V^0) denotes final (initial) welfare, and the integral is a definite one, in sharp contrast to the line integral stated in equation 4.6. A kind of watershed for the sign of ΔV is provided by the price elasticity ε. If the tax reduction under evaluation causes p_e to remain unchanged or increase and p_{1e}^T to decrease, then a sufficient condition for $\Delta V < 0$ is that $\varepsilon > -1 \; \forall t \in [t_1^0, t_1^1]$ in equation 4.6. If x_{1e} goes to zero as t_1 approaches t_2, then equation 4.6 captures the domestic welfare effect of a data center.

Given econometric estimates of the relevant functions it is straightforward to estimate ΔV. Even with incomplete information, an approximation might be possible. Suppose that we somehow have approximated $x_{je}(t_1^i)$ and p_e^i for $j = 1{,}2, i = 0{,}1$. Then, one could draw on the Rule of Half, see, for example, de Rus (2021) and Johansson (2021, eq. (6)). To illustrate, the first term on the right-hand side of equation 4.6 could be approximated as $(1/2) \cdot t_2 \cdot (p_e^0 + p_e^1) \cdot (x_{2e}^1 - x_{2e}^0)$.[41] Proceeding in this way provides the investigator with an approximation of ΔV.

4.1.3 An alternative approach

An alternative approach to the estimation of ΔV exploits that equilibrium prices are changed from (p_2^0, p_e^0) to (p_2^1, p_e^1), where it will be assumed that $p_2^0 = p_2^1$. This approach yields a line integral because both p_e and t_1 change. Drawing on equation 4.4, changing the producer price of electricity, holding $t_1 = t_1^0$, and then changing the tax rate, holding the price at its final level, $p_{1e} = p_{1e}^1$, one obtains:

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[40] If $dp_2 = 0$, then the integral of $(t_2 \cdot p_e(t_1) \cdot \partial x_{2e}[p_2(t_1), p_e(t_1)] / \partial t_1) dt_1$ reduces to the first term on the right-hand side of equation [eq:46].

[41] Recall that the integral in equation [eq:46] of $\partial x_{2e} / \partial p_e$ equals $x_{2e}^1 - x_{2e}^0$.

$$
\begin{aligned}
\Delta V = \quad & V^1 - V^0 = \int_{p_e^0}^{p_e^1} \left[\left(E - x_{2e}(.)\right) + t_2 \cdot p_e \frac{\partial x_{2e}(.)}{\partial p_e} \right] dp_e + \\
& t_1^0 \cdot \int_{p_e^0}^{p_e^1} \left[x_{1e}\left(p_e \cdot (1 + t_1^0)\right) + p_e \cdot \frac{\partial x_{1e}(.)}{\partial p_e} \cdot (1 + t_1^0) \right] dp_e + \\
& p_e^1 \cdot \int_{t_1^0}^{t_1^1} \left[x_{1e}\left(p_e^1 \cdot (1 + t_1)\right) + t_1 \cdot \frac{\partial x_{1e}(.)}{\partial t_1} \cdot p_e^1 \right] dt_1
\end{aligned}
$$

4.6

where the critical factors for the data center's demand for electricity are indicated. Reversing the order of integration or choosing some other allowed path would result in ΔV; recall that the line integral is path-independent. For details on the equivalent approaches used in equations 4.5 and 4.6, the reader is referred to Johansson (2021).

4.2 Relations to the sufficient statistics literature

Our results can be seen in the light of some recent result on ”sufficient statistics” in the welfare evaluation of policy reform. The basic idea can be traced back to Harberger (1964), valid for small changes. In a widely cited paper, Chetty (2009) argues that there are two basic approaches to welfare evaluation: the structural approach and the reduced-form approach. He develops ”sufficient statistics” in a general framework, which combines these two approaches. Table 1 in Chetty (2009) summarizes studies on taxes, social insurance, and behavioral models, which uses structural and reduced forms. In some cases ”sufficient statistics” are derived. Chetty gives the example of Feldstein (1999) who shows

> ..how the marginal welfare gain from raising the income-tax rate can be expressed purely as a function of the elasticity of taxable income even though taxable income may be a complex function of choices such as hours, training, and effort.

The ”sufficient statistics” approach has many applications in a number of economic fields, such as development economics, industrial organization, international trade, macroeconomics, labor economics and political economy; see the references and the discussion in Jacquet & Lehmann (2021). An interesting example from the literature on international trade has been proposed by Arkolakis et al. (2012). Two parameters can summarize much of the welfare economics of trade (i) the share of expenditure on domestic goods and (ii) the elasticity of imports with respect to variable trade costs. The change in real income attributable to ”any foreign shock” is a simple function of these two parameters. This is quite surprising given the complexity of large-scale trade models. Finally, Chetty (2009) obtains formulas that provide simple ways to compute deadweight loss of taxation allowing for optimization errors.

Hendren (2016) introduces a somewhat similar idea, based on observed behavior:

> .., the present analysis shows that the causal impact of the behavioral response on the government budget (e.g., tax revenue) as opposed to the tax base (e.g., taxable income) remains sufficient even in cases where the behavioral response by individuals occurs on multiple tax margins. This

> suggests focusing on the tax revenue impacts, as opposed to taxable income, may be the most general empirical approach for welfare analysis

Our analysis will provide some support to these ideas, although Hendren's ”policy elasticities” are a kind of compromise between Hicksian and Marshallian elasticities, whence they are based on observed behavior (so that neither utility nor nominal income is necessarily constant).

A fundamental assumption of the ”sufficient statistics” approach is that the change is marginal. For non-marginal changes, it seems difficult to obtain simple formulas. For a critical review of the approach and some alternatives and generalizations, see Kleven (2021).

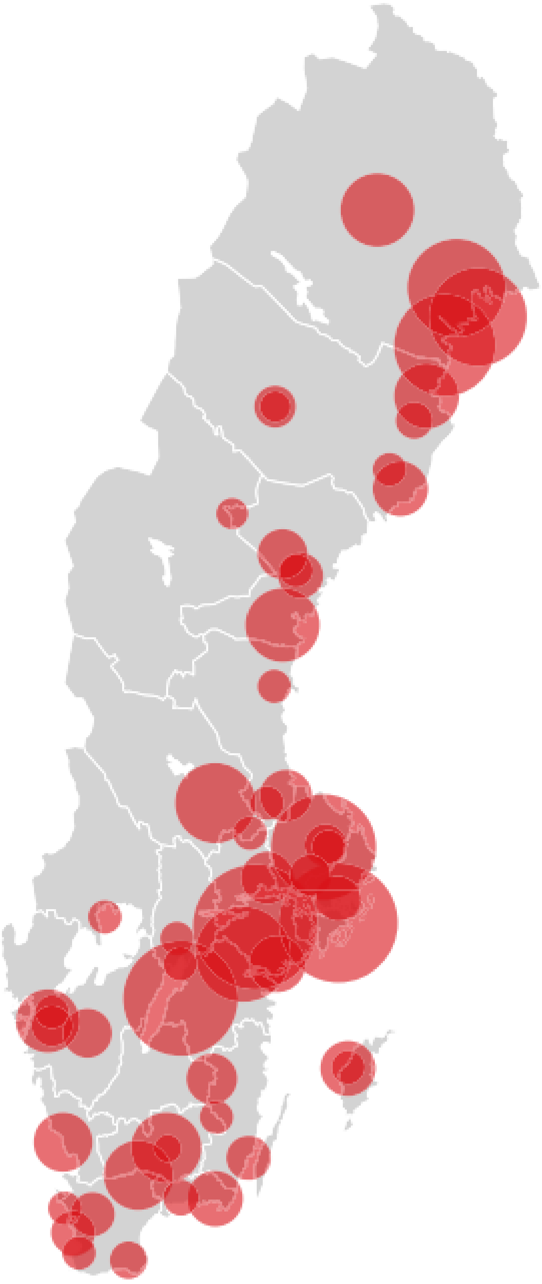
5. Descriptive analysis

This and the next chapter present our empirical analysis. We begin by looking at aggregate data, showing where the data centers are primarily located in Sweden. We then turn to our panel data-set. As noted, our panel consists of entities that have applied for a lower energy tax on electricity in a data center, which might be an entity with another main activity.

5.1 Location of data centers in Sweden

The following figure displays the location of data centers in Sweden 2020, the circles in the figure being proportional to installed power (total installed 642 MW 2020, according to RiR (2022), p. 17). Figure 5.1 shows the geographical distribution of data centers in Sweden.

Figure 5.2 The geographical distribution of data centers in Sweden 2020 (RiR (2022)). The circles are proportional installed power (642 MW)



Source: RiR (2022), p. 17)

There is a cluster of data centers in the Stockholm area and another cluster up north. An important location factor is electricity price. Contrary to many other countries connected to the regional electricity market Nordpool, Sweden splits into four price areas; "SE1" is the northernmost and the southmost price area is called "SE4". After 2020 the electricity prices have become markedly higher in the south compared to the north. Unfortunately, we do not have data to analyze any events at the establishment level past 2020.

While electricity-cost is a significant share of the cost of running a data center, there are several other factors that influence the location decision. According to an ex-post analysis

(SWECO (2017)) of Facebook's investment in Luleå 2013, the localization decision was based on the following parameters.

- A robust electricity system
- Availability of ”green” electricity
- A well-developed fibre-infrastructure for internet connectivity
- A cold climate, reducing cooling costs (a major component)
- A low risk for natural disasters
- A supply of qualified personnel in the IT-sector
- A technical university in the region
- State support

To this some might add the proximity to renewable energy: Luleå, a university town in the north of Sweden, is located near abundant sources of hydroelectric power. Its location also helps ensuring low-latency connections to users in Europe and North America. The undersea fiber-optic cables provide low-latency[42] connections that are crucial for the performance of the data center.

5.2 The panel

We have compiled an unbalanced panel data-set ($N = 135, t = 2008 - 2020$) by merging records from the Swedish Tax Agency with information extracted from annual reports. This data-set specifically pertains to data centers that have applied for a reduction in electricity taxation during the period 2017-2020. In general terms, an establishment is an organization that has a legal identity identifier, typically a private firm, but the equipment could also be controlled by e.g., a municipality. While the panel covers 2008-2020, we focus the period 2017-2020, because the key data are generated after the reform came into effect 1 Jan 2017. As explained above, the data on electricity consumption and energy tax payments are generated via the submitted forms. Such data are not available in data based on accounting information. While databases covering the establishments in the industrial sector might include energy costs, this is not the case here. The fact that we do not have access to data on electricity usage before the reform makes an assessment of the effects of the reform more difficult.

The application procedure puts the data centers into two distinct categories:

1. **Voluntarily Tax Liable:** This category encompasses data centers with an annual electricity consumption of at least 10 GWh. These entities are subject to tax liability and are required to submit an energy declaration as part of their compliance.
2. **Requesting Tax Reimbursement:** The second category consists of data centers that seek a refund of the tax through a separate form, typically because they use less than 10 GWh per year and are not required to submit an energy declaration.

There may not exist a one-to-one correspondence between electricity usage in a given year and the energy tax paid net in the same year, as the firm may receive the tax reduction in a subsequent year. Additionally, a form for tax reduction can be submitted

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[42] ”We are expecting this datacenter to continue to help us reduce latency for our users in Europe and beyond”, Facebook spokesman Michael Kirkland, https://www.datacenterknowledge.com/archives/2011/10/27/facebook-goes-global-with-data-center-in-sweden

up to three years after the year when the tax was due. Consequently, our data might not encompass all entities eligible for tax reduction, although as of the time of data collection (spring 2023), it included all establishments that had applied for an energy tax reduction on electricity utilized in a data center.

5.3 Descriptive statistics

We now describe the data along a number of dimensions. The data were cleaned, so that errors and inconsistencies were removed. See the appendix.

5.3.1 Electricity use and tax liability

We begin with a description of basic panel data on electricity use and tax liability before exemption. Table 5.1 presents these statistics for raw and cleaned data. The differences are minor. Total electricity use is roughly 3 TWh and total tax liability 2017-2020 about 1 billion SEK. This is also what we expect, given that the tax is about thirty öre per kWh during this period. There are no obvious trends in the data, but we see a marked increase the year after the reform was in place. Activity is then reduced in 2019.

Table 5.1 Electricity use and tax revenues without exemption. The processes of cleaning (”Clean” vs ”Raw”) the data is described in the appendix

Year	MWh	mSEK	N	Data-type
2017	791906.28	223.26	59	Clean
2018	979646.21	302.39	74	Clean
2019	755470.12	252.51	66	Clean
2020	780852.26	263.86	49	Clean
Total	3307874.86	1042.02	248	Clean
2017	791906.28	229.72	135	Raw
2018	986636.66	302.44	135	Raw
2019	755470.12	252.52	135	Raw
2020	786056.86	267.76	135	Raw
Total	3320069.92	1052.45	540	Raw

To obtain insights into the distributions of electricity use, consider the statistics reported in table 5.2. The differences between the median and the mean suggest that the distribution is skewed. Indeed, about 40% of the total electricity use can be attributed to four data centers. Overall, there has been various technological developments (e.g., regarding cooling and so-called virtualization) that have affected electricity use

Table 5.2 Descriptive statistics on electricity use in the sample

Year	sum_MWh	mean_MWh	median_MWh	sd_MWh	N
2017	791906.28	13422.14	2432.43	41686.61	59
2018	979646.21	13238.46	1920.62	42574.58	74
2019	755470.12	11446.52	1339.52	46608.86	66
2020	780852.26	15935.76	2085.40	54952.81	49

5.3.2 Number of approved and rejected applications

We expect to find that the means and other characteristics of the distribution of tax liabilities is a mirror image of electricity use, since the tax system is linear. However, not all applicants are granted an exemption. A unique feature of the dataset is information about whether or not an application to enjoy a lower electricity tax is granted. As we have discussed above, the Tax Authority issued a clarification in the autumn of 2018, which had a significant impact on co-located centers, whence they were no longer considered to be the users of electricity. Only the entity ”in control” of the equipment was granted the deduction.

Table 5.3 shows the number of approved and rejected applications 2017 to 2020. Each year has a number of units that have no decision, because they might not yet have applied, or the decision is prepared. The majority of the applications that have a decision are granted the tax reduction.

Table 5.3 Rejected and approved applications for a lower tax rate on electricity in the data-set

Year	Rejected	Approved	Total
2017	18	41	59
2018	17	57	74
2019	16	50	66
2020	8	41	49
Total	59	189	248

We will return to factors that are correlated with the decision to grant or deny tax reduction, i.e., whether or not the center is owned by a foreign entity. Next, we take a look at how the reduced tax-rate have affected tax-revenues.

5.3.3 A comparison with the National Audit Office estimates

We next compare our estimates with those given by National Audit Office (RiR) and its report 2022:18. RiR uses the same data-source from the National Tax Office, but their data were extracted at an earlier date. The numbers are expected to be similar, subject to corrections not available to the Audit office. A comparison is in table 5.4, where we collect tax exemption data and number of firms that have been granted a reduction.

Table 5.4 Comparing RiR (2022) and our panel data on tax before reduction (MSEK)

Year	RiR_SEK	RiR_N	Raw_SEK	Raw_N	Clean_SEK	Clean_N
2017	222.40	39.00	229.72	48	223.26	41
2018	330.10	55.00	302.44	60	302.39	57
2019	269.50	41.00	252.52	52	252.51	50
2020	228.60	33.00	267.76	44	263.86	41

The differences are small and are presumably thus due to the fact that the data we use are newer. The numbers are reasonably similar and reflects the fact that an establishment can submit a request to the Tax authority several years after the year of interest. Thus, the database is expanding over time, as companies submit their forms.

5.3.4 The effect of the reform on electricity tax revenue

We estimate the static effect of the reform on tax-revenues during 2017-2020. We do this by imputing tax revenue for firms that have reported electricity use but has not reported a tax payment. These estimates are thus slightly different from the ones reported above, because we used only complete applications. There are two key factors that affect tax payments, the price, and the tax rate, neither of which is necessarily the same geographically.

Regarding electricity price, as noted above, the Swedish electricity markets has been divided into four prices areas since 1 November 2011. While the prices were initially rather similar, the electricity prices started to diverge in the 2020s, when the ”south” (area SE3 and SE44) has faced significantly higher prices compared to the ”north”(SE1 and SE2). Furthermore, the electricity tax varies across the country, being about 30% lower in the ”north”. More precisely, certain municipalities (mostly in the north, but there are a few in the south-west) enjoy a lower electricity tax. The price areas do not align perfectly with these municipalities. The differences are, however, likely to be small (see the map in 5.1).

Because the firms who were denied a reduction pays the same tax (per unit) as they would have before the reform, we may reasonably argue that the reform had no effect on tax-revenues in that group. There could be indirect effects, if the reform crowded out electricity use among those denied a lower tax. Crowding out effects may also impact other users, as discussed in the literature review. But the main effect on tax revenues will be found among the exempted data centers. Consider table 5.5 in which we display tax revenues before and after for the firms that were granted an exemption.

Table 5.5 Imputed tax revenues before and after the reform in (mSEK). Missing values on tax payments have been imputed by using tax rates by price area 2017-2020

Year	Decision	Before	After	N
2017	Rejected	14.15	14.15	18
2017	Approved	223.26	3.72	41
2018	Rejected	14.35	14.35	17
2018	Approved	302.39	4.65	57
2019	Rejected	5.49	5.49	16
2019	Approved	252.51	3.70	50
2020	Rejected	7.58	7.58	8
2020	Approved	263.86	3.79	41
Total		1083.60	57.44	248

The tax reform meant, in a static sense that does not take into account adjustments in the rest of the economy, a loss of about 1 billion SEK. The imputation of revenues makes little difference.

5.3.5 Foreign ownership

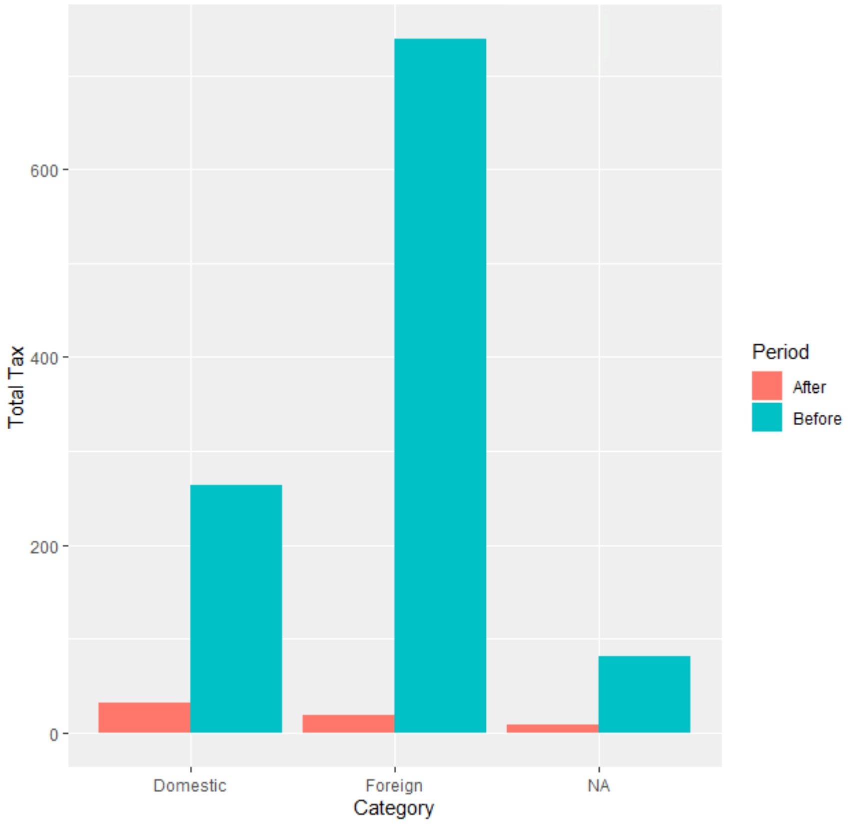
As we noted above, owners of Swedish data centers have argued that the reform benefitted large foreign multinationals. There are five owner categories in the data, see table 5.6.

Table 5.6 Owner categories

Owner	N
State-controlled entities	4
Municipally-controlled entities	4
County council-controlled entities	0
Privately Swedish-controlled entities without group affiliation	74
Privately Swedish-controlled entities with group affiliation	89
Foreign-controlled entities	66

Although there are quite a few foreign-controlled data centers, a significant majority is controlled by Swedish entities. For simplicity, we merge the categories into two, ”Domestic” and ”Foreign”. Figure 5.2 displays electricity use and tax reimbursement claims for these two groups. It should be noted that there are a number of firms that have no classification, i.e., the information about ownership category is missing.

Figure 5.2 Estimated tax revenue before and after the tax reform, 2017–2020



The results show that foreign-owned entities have a significantly higher electricity consumption and pay higher electricity taxes compared to domestic owners. These results suggest that the tax exemption benefitted large consumers of electricity, of which many are controlled by foreign entities.

6. Estimating economic consequences of the reform

We next estimate the effects of the tax-exemption on the use of electricity in data centers, using time series and panel data. Of key interest is the tax elasticity, $\varepsilon = [t_1 \cdot p_e/x_{1e}][\partial x_{1e}/\partial p_{1e}^T]$. Recall that t_1 is the tax on electricity, p_e the price of electricity, $p_{el}^T = (1 + t_1) \cdot p_e$ the gross price and x_{1e} electricity demanded.

The literature on the price-sensitivity we are focused on is sparse. Price-elasticities have been reported to be in the interval 0.1%-0.4%, which seem plausible in the short-run. According to , the total electricity costs is 30-50% of the total operating cost of a data center. There is limited scope for substituting electricity in a data center in the short run, since they are built to specific energy efficiency standards; any immediate reduction in electricity usage could compromise performance. One area where there might be some flexibility is in cooling systems. ”Free cooling” methods discussed above use ambient air or water for cooling instead of traditional air conditioning, which consumes a lot of electricity.

In the medium term, investing in more energy-efficient servers that provide the same computing power but consume less electricity is a possibility. Load shifting to times when electricity is cheaper is more of a timing adjustment than a substitution. The elasticity of substitution for electricity in a data center is therefore likely to be relatively low, especially in the short term, due to the critical role electricity plays in both computing and cooling. Consequently, the short-run price elasticity is likely to be small, even though the cost-share of electricity is high.

As noted, we cannot base our general strategy on comparing ”before-after” data for ”treated” (and ”untreated”) units. What is more, we do not have access to the prices of electricity that the firms in our panel paid. Consequently, the lack of data is a major challenge when evaluating the reform with our approach. We proceed in two different ways. In section 6.1 we collect time-series on electricity use at sector-level and apply time-series methods. Section 6.2 then turns to panel-data methods, using the data-set previously described.

6.1 Time series data

In the time-series analysis, we limit our study to key sectors, even though there are data centers that belong to firms in sectors that do not have IT as a main activity. We use sector J62 and J63 according to the NACE classification[43], i.e., computer programming, consultancy, and information service activities. J62 is ’Computer programming, consultancy and related activities’, while J63 contains ’Information service activities’. To motivate our use of these sectors for the time-series analysis, consider the use of electricity in the panel-data set across 2-level sector classification. See table 6.1.

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[43] https://bit.ly/NACE_EU

Figure 6.1 Electricity Use and Sector Share in the panel-data

Industry Code & Description (sni2007 2) _	Electricity Use (MWh)	Share (%) (shr1)
63 Information Services	1,714,632	51.8
62 Software Programming, Data Consulting, etc.	1,107,842	33.5
68 Real Estate Operations	328,961	9.94
61 Telecommunications	54,432	1.64
Other sectors	103,275	3.12

Thus, sectors 62 and 63 is 51.8+33.5=85.5% of total electricity use in the panel-data set. There have been some re-classifications of the sector-belongings, whence a firm self-report its classification. These changes are not important. We thus argue that the tax-reform essentially affected the entities in J62 and J63 sectors.

For the econometric time-series analysis, we use data from different sources: SCB, Sweden energy and The Swedish Agency for Growth Policy Analysis. These sources give us price and quantity data for chosen sectors. A plot of the data we will use for our regression model is in figure 6.1.

According to these data, value added and electricity use increases roughly along a trend. To further explore how the tax-reduction in 2017 may have affected electricity use in J62-J63, we turn to a series of regression models. They are exploratory in nature.

Our basic regression model is

$$\log El_t \quad = \alpha + \beta_1 \cdot \log\tau + \beta_2 \cdot \mathtt{logVA} + \epsilon_t$$

where El_t is the use of electricity in sector J62-J63 at time t (in MWh), τ is the tax-rate (in SEK/100 per kWh) and VA is value-added in the sector (in 2019 MSEK)[44].

There are at least two challenges. First, we need to deal with the possibility that the regressions are spurious. Second, VA is not necessarily exogenous. We deal with these issues by using ARIMAX models and various instrumental variable approaches. The result of estimating the ARIMAX models are displayed in table 6.2.

Across all models, the coefficient on logtax is negative, suggesting a consistent inverse relationship between the electricity tax and consumption. In the baseline ARIMAX(0,0,0) model, a 1% increase in the electricity tax corresponds to a 0.125% decrease in consumption. This effect diminishes slightly when considering a trend or differencing the data, with coefficients of -0.077 and -0.051, respectively. These results are congenial to intuition.

The logVA coefficient captures the elasticity of electricity consumption to value added in the sector. In the baseline model, the elasticity is estimated to be 0.604, indicating that a 1% increase in value addition is associated with a 0.604% increase in electricity consumption. This relationship strengthens in the models with a trend or using

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[44] There is official data on electricity use and electricity tax revenue in this sector, but the data is of too low quality. It is being revised by the Central Bureau of Statistics (SCB).

differenced data, with elasticities of 1.139 and 1.081, respectively. This suggests that as the sector's productivity or economic contribution grows, its electricity consumption also rises, possibly at an increasing rate. We will deal with the potential endogenity issues shortly.

Figure 6.1 A plot of the data for our regression model. Scaled (mean=0 and sd=1) of electricity consumption in J62-J62 sectors (El), Value added (2019 prices, VA) and the tax on electricity in data centers

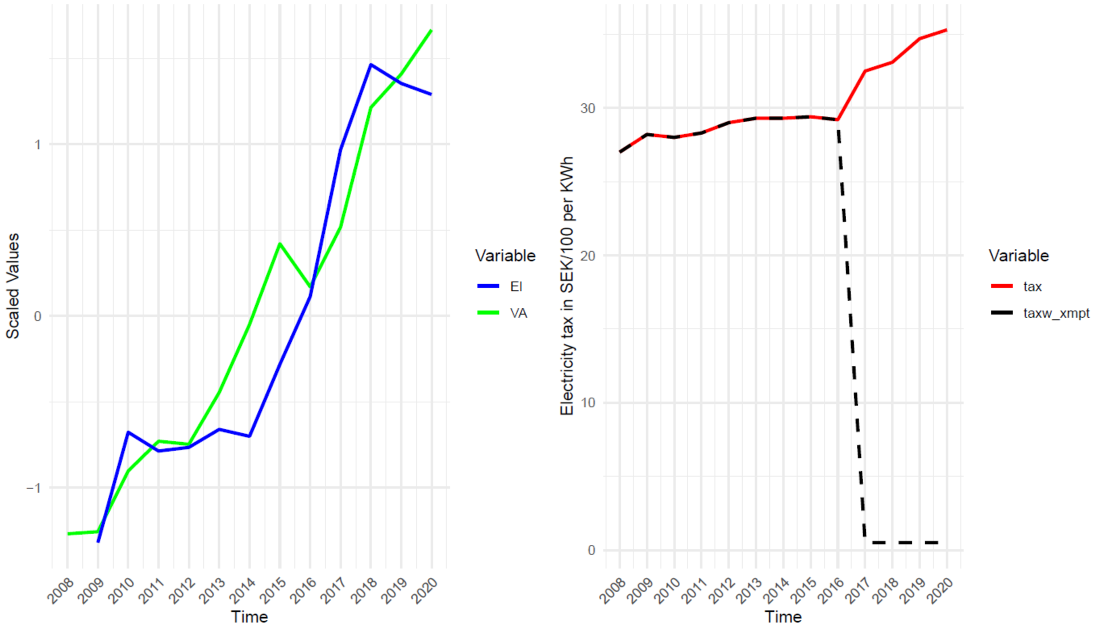


Table 6.2 Estimated ARIMAX models for electricity consumption in sectors J62-J63 2009-2020

	ARIMAX(0,0,0)	ARIMAX trend(0,0,0)	ARIMA DYDX
logtax	-0.125	-0.077	-0.051
	(0.018)	(0.026)	(0.036)
logVA	0.604	1.139	1.081
	(0.004)	(0.234)	(0.481)
year		-0.003	
		(0.001)	
Num.Obs.	12	12	11
AIC	-11.2	-13.5	-7.1
BIC	-9.7	-11.6	-5.9
RMSE	0.12	0.10	0.13

Note: Model selection using the forecast package in R. The package provides a range of functions for au-tomatic model selection, we have used the auto.arima function, which selects the best ARIMA model. Model ARIMAX (0,0,0) is based on levels, Model ARIMAX trend (0,0,0) includes a trend, model ARIMAX DYDX uses differenced data.

The ARIMAX model with a trend captures potential underlying linear trends in electricity consumption that are not explained by the included regressors. The negative coefficient of -0.003 indicates a slight declining trend in consumption over the period, independent of changes in logtax and logVA. The Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) favor the ARIMAX with a trend, with values of -13.5 and -11.6, respectively. Moreover, this model also exhibits the lowest Root Mean Square Error (RMSE) of 0.10, indicating superior predictive accuracy.

Furthermore, an examination of stationarity was carried out on the data series using the Augmented Dickey-Fuller (ADF) test. Preliminary findings on the original data hinted at non-stationarity across all series. logtax, even after differencing, did not exhibit stationarity. logEl, surprisingly, became even less stationary after differencing, suggesting the possibility that the series might have an underlying structural break or a more complex form of non-stationarity. logVA moved closer to stationarity after differencing. We acknowledge these issues, suggesting that the results must be interpreted with care. The correlations could be spurious, although it is still interesting to see that the elasticity is estimated to be rather small.

One might argue that VA is endogenous and depends on the tax-rate and other exogenous variables, such as time. We explore versions of models that can take into account such endogeneity, using 2SLS and a control approach. In the latter case, the residuals from the first stage in the 2SLS regression is used as a variable in a quantile regression. The basic idea is to first estimate the reduced form equation for the endogenous variable, and then use the residuals from this equation as a control variable in the quantile regression model. This helps to control for the endogeneity of the endogenous variable and obtain unbiased estimates of the quantile regression coefficients. The control function approach has been used to study a variety of topics in economics, including the impact of education on earnings, the effects of government programs on labor market outcomes, and the relationship between health and income, see e.g., Chernozhukov & Hansen (2006). For completeness, we also include a quantile regression without catering for endogeneity. We thus estimate the models described in table 6.3.

Table 6.3 Models used in the time-series analysis

Model name	**Model specification**	**Note**
OLS	$\log(El_t) = \alpha + \beta_1 \cdot \log(\tau) + \beta_2 \cdot \log(VA) + \epsilon_t$	Ordinary least squares
rq 1_	$\log(El_t) = \alpha + \beta_1 \cdot \log(\tau) + \beta_2 \cdot \log(VA) + \epsilon_t$	Quantile regression, $\tau = 0.5$
ivreg	$\log(El) = a + b_{11} \cdot \log(VA) + b_{12} \cdot \log(\text{tax}) + \beta_{11} \cdot \text{year} + \beta_{12}\, \text{year}^2 + \beta_3 \cdot \log(\text{tax})_t + \epsilon_1$	2SLS with logVA endog
Control	$\log(El) = a + b_{11} \cdot \bar{\log}(VA) + b_{12} \cdot \log(\text{tax}) + \gamma \cdot \varepsilon \vert \beta_{11} \cdot \text{year} + \beta_{12}\, \text{year}^2 + \beta_3 \cdot \log(\text{tax})_t + \epsilon_1$	Control function using quantile regression, $\tau = 0.5$

The results, presented as a graph in figure 6.2, shows that the elasticity w.r.t. VA is significant in all four specifications, note that the control function approach is using the estimated value logVA.hat. The estimates are rather similar. Comparing the coefficients, the coefficient of logVA is smaller in the 2SLS model than in the OLS model (0.87 vs 1.10), while the coefficient of logtax is similar in both models (-0.098 vs -0.076). This suggests that the endogeneity of logVA may have biased the OLS estimate upwards, and the 2SLS estimate is more reliable. At any rate, the tax elasticity is low (and thus somewhat consistent with the meagre literature on the subject). The estimated coefficients for logtax are $(-0.0760, -0.0959, -0.0713, -0.0888)$,for OLS, quantile, ivreg and control function approach, respectively.

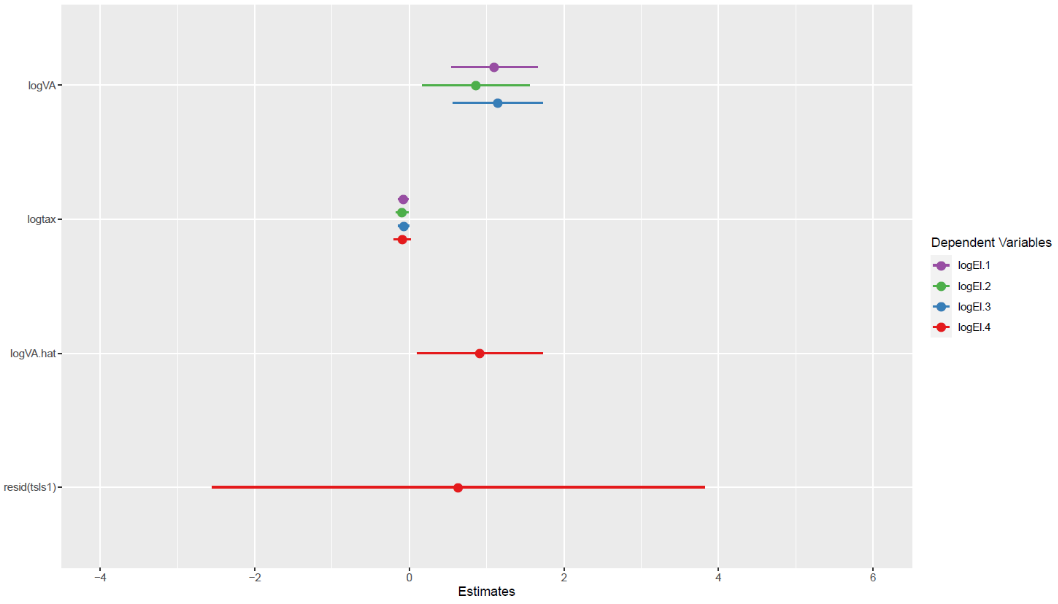
The performance of the models is displayed in table [tab:63]. The Akaike criteria (AIC and BIC) suggest that the quantile regression model fits the data best (these criteria include a penalty for adding explanatory variables), but overall, the fit is rather similar across models and quite satisfactory. Regarding the IV-regression, the result appears satisfactory. The Wald test is highly significant (210.2,2), which suggests that the endogenous regressor has a significant effect on the outcome variable. The weak instruments test is also significant (p=2.46e-05), but this is not necessarily a problem. The weak instruments test is only a test of the strength of the instruments, not the validity of the model. The Wu-Hausman test (p=0.475) and the Sargan test (p= 0.246) are both non-significant, which suggests that the IVreg model is valid. The Wu-Hausman test tests for the consistency of the OLS estimator under the assumption that the IVreg estimator is consistent. The Sargan test tests overidentification restrictions.

The Durbin-Watson statistics for all four models are close to 2 (1.74-1.78), which suggests that there is no significant autocorrelation in the residuals. The Ljung-Box statistics (0.165-0.587) for all four models are also below the critical value; there is no significant non-normality in the residuals. Overall, the residual tests suggest that all four models are valid.

Table 6.4 Performance measures for the four models

	OLS	**Quantile regression**	**IVreg**	**Control approach**
AIC	-13.61	-17.00	-13.56	-15.03
BIC	-11.67	-15.55	-11.62	-13.09
RMSE	0.10	0.10	0.10	0.10
R2	0.93	0.93	0.93	0.93

Figure 6.2 Coefficients for four models plotted together with their confidence intervals. MOdel1=OLS, Model2=Quantile regression, Model3=IV regression, Model4=Control function approach using quantile regression in step 2



In summary, the regression models fit the data satisfactorily. The weak instrument test suggests that the 2SLS estimates may still be subject to some degree of bias. Given this caveat, these results support our intuition that the tax-elasticity is rather low. Again, we caution that these results are based on a limited number of observations. We next turn to our panel-data.

6.2 Panel data

As noted, we cannot use a ”before-after” comparison, because the panel only tells us about ”within-period” changes. However, we have information about the Tax authority decision to grant or deny the application. We use this information to create a ”treatment” and ”control” group. It stands to reason that the firms in these two categories are quite similar across many dimensions, a key difference being the outcome of their application. Recall the Tax Authority’s decision to make a clarification in September 2018, in which only the entity in control of the equipment was considered to be a user of electricity and hence eligible to apply for a tax exemption.

A main challenge is to estimate the causal effect, rather than a correlation between the tax change and the use of electricity in data centers. The literature on causal inference is extensive and rapidly advancing, especially when estimating causal effects in dynamic panels. The gold-standard is the randomly assigned treatment and control, before and after, but we will have to do with the data at hand.

Inspired by the medicine literature, we begin by describing the data across the treatment and control groups to check the similarity between the treatment and control groups. This is usually denoted an analysis of the balance of covariates, see table 6.5.

Table 6.4 A comparison between treatment (granted) and control groups (denied tax exemption) for a set of covariates

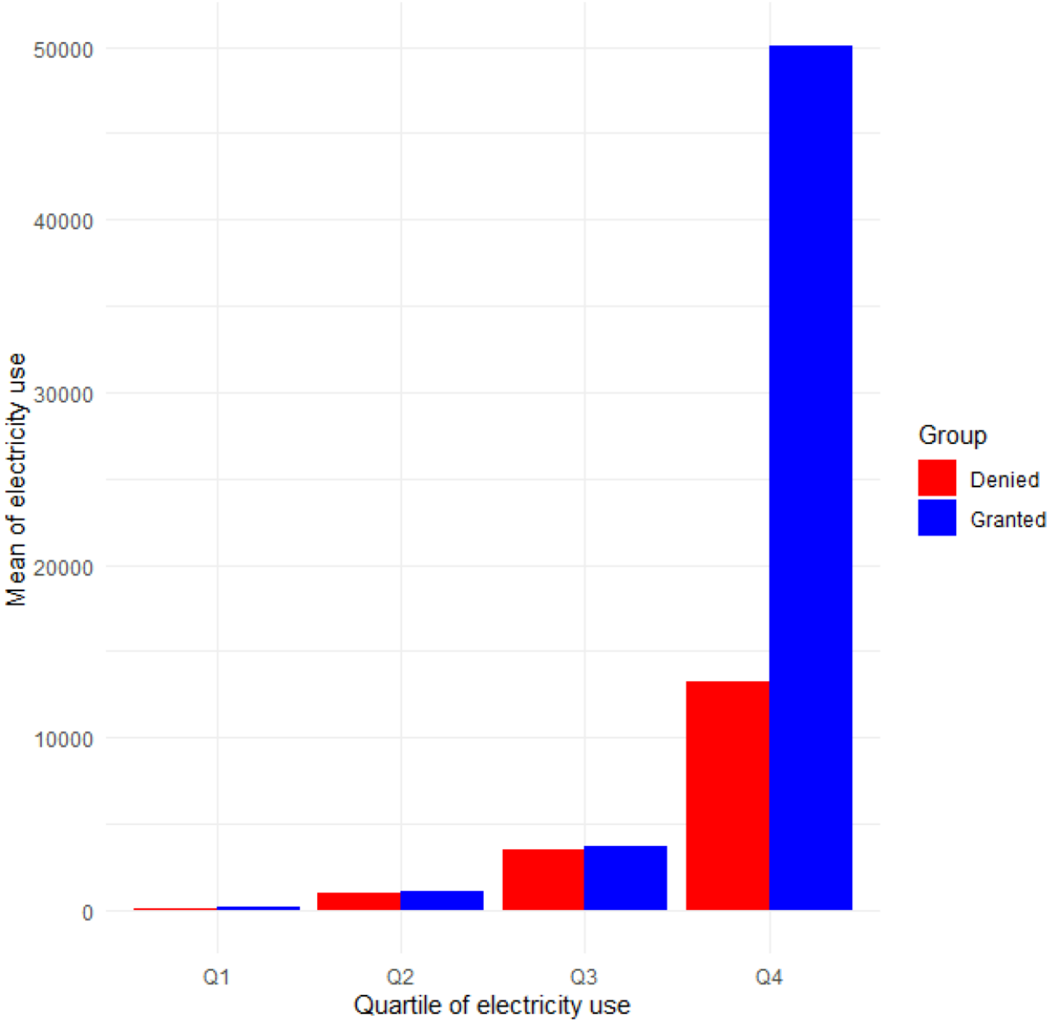
	Rejected (N=56)	**Granted (N=177)**	**Total (N=233)**	**p-value**
Domestic - Foreign				< 0.001 (1)
- Domestic	51 (91.1%)	120 (67.8%)	171 (73.4%)	
- Foreign	5 (8.9%)	57 (32.2%)	62 (26.6%)	
Electricity (MWh)				0.048 (2)
- Mean (SD)	1987.301 (3510.348)	15910.066 (52409.992)	12563.822 (46067.888)	
- Range	39.475 - 18493.661	7.397 - 371500.194	7.397 - 371500.194	
# Employed				0.010 (2)
- Mean (SD)	670.696 (1861.446)	207.249 (820.418)	318.635 (1171.085)	
- Range	0.000 - 7990.000	0.000 - 8027.000	0.000 - 8027.000	
Group mother country				0.004 (1)
- Other	25 (44.6%)	94 (53.1%)	119 (51.1%)	
- SE group mother	31 (55.4%)	63 (35.6%)	94 (40.3%)	
- US group mother	0 (0.0%)	20 (11.3%)	20 (8.6%)	
Equity				0.009 (2)
- Mean (SD)	2251876.411 (7703358.864)	576567.090 (1949868.989)	979216.541 (4179353.603)	
- Range	-477.000 - 47699763.000	-165311.000 - 11305854.000	-165311.000 - 47699763.000	
El Price Area				0.373 (2)
- Mean (SD)	2.982 (0.618)	2.881 (0.771)	2.906 (0.737)	
- Range	1.000 - 4.000	1.000 - 4.000	1.000 - 4.000	

Beginning with domestic vs foreign firms, the p-value of < 0.001 indicates a significant difference between the denied and granted centers concerning their domestic or foreign status. Of those N=56 that were denied, 51 were domestic. 32.2% of the granted centers were foreign, but only 8.9% of those denied were foreign. Furthermore, it appears that the granted centers used significantly more electricity (p=0.048). We also see that there are significant differences between number of employees (p=0.010) and equity (p=0.09). It is noteworthy that centers with no employees, presumably because a holding company submitted the application, received tax exemptions. Comparing group mother country reveals a p-value of 0.004. Denied centers predominantly represent SE group mothers, whereas US group mothers are exclusively seen in granted centers. Conversely, the electricity price area, serving as a location indicator, does not exhibit a substantial difference between denied and granted centers (p=0.373). This implies that the location may not play a crucial role in the determination of tax reduction approvals or denials.

These differences complicate matching. For instance, there are no firms with a US group mother that were denied; all such data centers were granted a lower tax. This complicates the estimation of the treatment effect. Furthermore, numerous instances present minimal or no overlap in the data.

The distribution of electricity use is notably skewed, an important feature to consider in our analysis. It is thus useful to look at the differences in electricity consumption across treatment/controls by quartiles. See figure 6.3. Companies with granted applications generally demonstrate higher electricity consumption, especially in the fourth quartile, where the mean consumption is significantly higher compared to rejected applications. Because the methods we are considering typically focus on the ATE (Average Treatment Effect) or ATT (Average treatment effect among the treated), we need to keep the skewness of the distribution in mind when interpreting the results.

Figure 6.3 Mean electricity use by treatment (granted)/control(denied) and quartile in the panel data 2017–2020



6.2.1 Propensity score matching without panel structure

We begin using a propensity score model, where we do not take into account of the panel structure. To investigate the (causal) relationship between electricity use (elfb_mwh) and the treatment variable denied/approved (typ1), a weighted linear regression model was implemented. Propensity score weighting was conducted using the `WeightIt` package in R to balance the treated and control groups on the covariates. The `method = ”ps”` argument was used for propensity score weighting, and the `stabil = TRUE` argument was used to obtain stabilized weights.

The summary of the weight model showed a coefficient of variation of 0.747 for the treated group and 0.901 for the control group, with no zeros in either group. The effective sample sizes were 32.81 for the control and 120.93 for the treated group, post-weighting, compared to 59 and 188 pre-weighting, respectively. The balance of covariates was checked using the `cobalt` package in R. The standardized mean differences were reduced for all covariates post-weighting, with the largest absolute standardized mean difference reduced to below 0.04.

A weighted linear model was fitted using the weights obtained from the propensity score model to analyze the effect of the decision to grant a tax-reduction on the use of electricity.

The weighted linear model provided the following estimates:

$$\begin{aligned} \text{Intercept} &: 3373 \text{ (Std. Error} = 5549\text{)}, p = 0.544 \\ \text{typ1} &: 9811 \text{ (Std. Error} = 6306\text{)}, p = 0.121 \end{aligned}$$

The model explained 0.009783 of the variance in `elfb_mwh`, adjusted $R^2 = 0.005741$, and did not find a statistically significant effect of `typ1` on `elfb_mwh` ($p = 0.121$). While the propensity score weighting improved the balance on the covariates between the treated and control groups, the effect of `typ1` on `elfb_mwh` was not found to be statistically significant in the weighted linear model. The average treatment effect (ATE) was found to be 9811 MWh. To explore further we used quantile regression with quantiles set at {0.1, 0.25, 0.5, 0.75, 0.9}. The results are in table 6.6.

Table 6.6 Results of a quantile regression for the casual effects model

	$\tau=0.1$	**$\tau=0.25$**	**$\tau=0.5$**	**$\tau=0.75$**	**$\tau=0.9$**
Intercept	53.34	123.01	624.27	2026.17	6992.35
typ1	96.33	589.47	1899.05	7405.74	28598.72
Lower_Intercept	43.05	92.64	345.35	1358.29	4431.47
Upper_Intercept	33.71	379.56	1258.41	5479.23	19911.81
Lower_typ1	85.93	204.36	1040.37	3619.75	11752.79
Upper_typ1	224.00	766.98	2304.61	10010.25	33516.16

Each column represents a different quantile, and each row delineates a coefficient, either the intercept or *typ1*, with 95% wide confidence intervals indicated. The table suggests that the estimated effect of `typ1` on `elfb_mwh` varies across different quantiles. For instance, at the 0.1 quantile, the estimated effect is 96.33, while at the 0.9 quantile, it is 28598.72 MWh, indicating a higher effect at the upper quantiles of the response variable. In brief, the results strongly suggest heterogeneity, larger users are affected more strongly by the reform. This is also intuitively plausible.

Our models so far thus suggest an ATE of 9811 MWh. At the median of the distribution, the effect is estimated to be 1899 MWH, underlining the asymmetry.

So far, we have not exploited the dynamic nature of the panel, in which we have repeated measurements over time. As noted, this literature is rapidly evolving, see Imai et al. (2023).

6.2.2 Propensity score matching with panel structure

We employ the `PanelMatch` package in R to discern the causal impact of obtaining or being refused a tax deduction on the electricity consumption within data centers. This package is designed for longitudinal data settings. The `PanelMatch` function operates by initially matching each treated unit with a corresponding control unit, utilizing the specified matching method and covariates. The execution of this function rests on several assumptions that are crucial for the validity of the inferred causal relationships:

1. **Exogeneity of Treatment:** The treatment variable, in this case being granted or denied a tax deduction, is assumed to be exogenous. This assumption implies that the assignment of the treatment is independent of the potential outcomes and is not influenced by any unobserved factors. One could argue that it is a strong assumption in this context, in the sense that the individual firm can affect its chances for being treated (e.g., by not applying).
2. **Conditional Independence:** Given the outcome variable, the matching variables are assumed to be conditionally independent of the treatment variable. This assumption posits that, conditioned on the observed covariates, there are no unobserved variables that simultaneously influence the treatment assignment and the potential outcomes.
3. **Common Support Condition:** This assumption ensures that there is sufficient overlap in the covariate distributions between the treatment and control groups, allowing for meaningful comparisons to be drawn between the two groups. This assumption has been discussed above and will be discussed further below.

It was difficult to find a reasonably sized matched panel data-set, which cater for the dynamics and the differences between the treated and control groups. The result of the matching was generally a very small set of matched pairs. This outcome is not very surprising, given the differences we found between the treated and control groups above. Notice that the matching algorithm is different from we used when we ignored the dynamic panel structure of the data. In the `PanelMatch` case, we must impose a treatment dynamic. This means that we must specify how the treatment is expected to affect the outcome over time. This is necessary because `PanelMatch` uses a matching algorithm to match treated and untreated units based on their pre-treatment outcomes and covariates. The treatment dynamic is used to ensure that the matched treated and untreated units have similar pre-treatment trends in their outcomes, so that we can be confident that any differences in their post-treatment outcomes are due to the treatment. This has significant impact on the robustness of the results. We therefore leave this approach for future research.

7. Conclusions

This paper presents a cost-benefit analysis of supporting data centers through electricity tax exemptions, using an example from Sweden. We show, using the theory of welfare measurement in general equilibrium, that the net benefits of the support measure are related to a tax elasticity. This parameter integrates a range of economic forces, such as crowding out of existing firms, increasing profits in the electricity sector, and the inability to tax profits of data centers owned by large multinationals. Our empirical analysis of a Swedish tax reform 2017-2023 suggests that the reform did affect electricity use in data centers. The tax elasticity is estimated to be negative and significantly less than one. This suggests that the net benefits of the support measure are likely to be negative, because the tax elasticity is a sufficient statistic.

Our empirical analysis is based on a unique panel from the Swedish Tax Authority, detailing applications from data centers to be exempted from electricity tax in the period 2017-2020. We combined this panel with several other data-sets, resulting in a panel 2008-2020 with N=135. In addition, we complement this dataset with sectoral data for a time series analysis. The panel data analysis suggests that the reform increased electricity use, but the effect is not statistically significant in the preferred specification (using standard methods from casual inference in observational studies).

Whether or not the decision to end the exemption in 2023 comes with additional costs is unknown, given the potential costs associated with the Energy Charter Treaty (ECT), a charter EU has signed. A main objective of the treaty is to create a predictable and stable investment climate for energy companies; the treaty includes a provision that allows foreign investors to sue governments for changes to energy policies that they believe harm their investments. Indeed, the Swedish Government explicitly encouraged companies like Amazon, Facebook, and Google to invest in Sweden to enjoy the lower tax. Therefore, the decision to cut the reform short may have ramifications for the credibility of future Swedish industrial policy. We do not include these potential costs in our analysis.

With the tax reform being a thing of the past, our CBA can only buttress the decision. Still, there are some more generic lessons to be learned. An important lesson that applies to many policy areas, is to create mechanisms ex ante such that the policy can be effectively evaluated ex post. In the case under consideration, it is not possible (except at extraordinary cost) to know the electricity use in data centers before the reform at the establishment level. The lack of detailed data raises questions about the economic analysis that was used to support the decision. The official remit (SOU 2015:87) does not include a detailed economic analysis of how the reform would affect the economy. Since the definition of the beneficiary has changed after the reform, this analysis would not have been complete. The Tax Authority clarified the lawmaker's intention 18 months into the reform, perhaps suggesting that the reform was rushed.

Our empirical analysis shows that a foreign center is significantly more likely to be granted an exemption. Because such centers are typically part of an international group, profit taxes are unlikely to be effective as a way to mitigate some of the financial costs of the reform. It is likely that the public acceptance of reforms, such as what effectively is a tax-break for large multinationals, is not invariant to the way the profit of a reform is distributed. Such an outcome would have been easily predictable ex ante. True, we have not studied public acceptance, but it seems like a useful lesson learned for future reforms.

We note that centers with no employees have been granted tax reductions (most likely because a holding company has filed). We assume in our theoretical model that the labor market of interest is competitive, so there are no net benefits to be added to ”jobs created”. It is not unusual that evaluations include the benefits of ”new jobs”, without considering the opportunity costs; after all, the personnel must come from somewhere.

Our study is a first step in understanding the economic impact of support measures for data centers; there is widespread use of data center support around the world. While our application is to the case of Sweden, the methodology has general applicability.

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Appendix: Data cleaning

We have cleaned the data and removed some inconsistencies and errors. First, there are some observations in the sample where the tax rate is outside of the interval 0.2 - 0.4 SEK per kWh, which is outside of the statutory energy tax in effect during 2017-2020. Second, there are some instances where the reported tax is zero, even though the electricity usage is positive. In these, all involving cases where the tax reduction has been granted, we impute the tax that should have been paid. For completeness, we initially display the data before and after cleaning. The econometric analysis in the next section will be based on the cleaned data set.

På vilket sätt statens insatser bidrar till svensk tillväxt och näringslivsutveckling står i fokus för våra rapporter.

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