Implication of Electricity Taxes and levies on Sustainable Development Goals in the European Union

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Abstract

The current high electricity prices in the European Union (EU) are in part due to the high electricity taxes. United Nations' Sustainable Development Goals (SDGs) Agenda with its global vision of attaining sustainable development especially seeks "to ensure universal access to affordable, reliable and modern energy services" (SDG 7). We investigate the synergy and trade-off effects of electricity taxes on sustainable development goals (SDGs) for the EU. Using panel data and panel vector autoregressive estimation approach, we find that higher household electricity taxes reduce both carbon emission and unemployment. Higher levels of industry electricity taxes, increase responsible production and consumption (SDG12) and reduces unemployment (SDG8). Furthermore, there is evidence for a strong synergy effect between electricity taxes, unemployment and carbon emission but a trade-off between tax and SDG9 (innovation and sustainable infrastructure). The taxes contribute more to the future variation of unemployment and responsible production and consumption in the EU, but these contributions are much larger for the industry as compared to the household sector. Our results confirm the double-dividend hypothesis, which implies that the policymakers can achieve environmental goals with higher electricity taxes, especially on household electricity. In the industrial sector, our findings suggest that there is a need for tax reform, to encourage innovation and adopt production processes that are less polluting to the environment.

Keywords: Electricity, EU, Household, Industry, Tax, Sustainable development goals

JEL Classification: H2, Q56, O13, O14, Q41, Q43

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1. Introduction

The evolution of energy taxes in Europe and later the European Union (EU) may be grouped into four phases. The first phase extends from 1917 to the first oil crisis in the early 1970s, when Nordic countries (specifically, Denmark and Sweden), implemented energy taxes with the main objective to raise revenues (Speck,1999). In the second phase of oil crisis during the 1970s, security was an important concern, thus energy taxes were designed to incentivise more efficient use of energy. During the third phase in the 1980s, energy taxes were constructed by EU-member states based on environmental principles. It was in the fourth phase during the 1990s that climate change considerations were at the centre stage of EU energy taxation. Since the 1990s, various forms of energy and carbon taxes have been implemented by numerous countries in the EU to tackle both environmental and revenue goals (Hasselknippe and Christiansen, 2003). These taxes cover a range of different fuels and different segments of the energy system, including the electricity sub-sector.

The current EU energy-tax policy goals have changed from purely revenue to a mixture of climate, revenue, and security concerns. This is largely driven by the EU energy union objectives of providing affordable energy for EU consumers (households and industry), securing energy for all EU countries, generating more renewable energy, and combating climate change. In this study, we investigate to determine the effects of electricity taxes and levies on SDGs in EU-28 and Norway. This enables us to investigate the double-dividend hypothesis, i.e., do EU electricity taxes have additional benefits over and above the objective of achieving environmental/climate targets? We further investigate and assess the heterogeneity of electricity taxation on the SDGs by analysing the households' and industrial electricity tax effects separately. In the EU, household electricity tax rates more than double that of industry rates (Eurostat, 2018). The differential rates are likely to have a direct effect on electricity prices, and an indirect effect on the various SDGs that are closely linked to electricity, such as access to affordable and clean energy, job creation, employment outcomes and the effect on emission due to the price effect of the taxes. The heterogenous analysis would provide a better assessment of the current electricity tax policy which places a higher burden on the household relative to industry in terms of achieving environmental and climate goals. The study also enables us to examine and provide guidance as to which of the SDGs goals are likely to be impacted the most in the future when electricity taxes are increased or decreased. This will also have implications on energy justice within the EU.

Most of the prior studies on electricity taxes focus on the distributional effects (Barker and KoKhler, 1998; Speck ,1999; Ekins et al., 2011; Oueslati, 2017), price effect (Trujillo-Baute et al., 2018; Borozan, 2018), emissions effect (Brännlund et al., 2014; Haites, 2018; Kettner-Marx and Kletzan-Slamanig, 2018) and barriers to the acceptability of such taxes in the EU (Carattini et al., 2017; Weishaar, 2018). None of these studies explicitly consider the following three key questions that we have investigated: Do EU electricity taxes have additional macroeconomic benefits over and above the objective of achieving the environmental/climate targets?; Do the differential tax rates between households and industry aid in achieving the environmental/climate goals and macroeconomic benefits?; and what are the implications in the changes in electricity taxes on the likely future changes of the environment (SDG13), welfare (SDG7) and the macroeconomy (SDG9, SDG8, SDG12) ?

In answering the three questions above, the study makes the following contributions. First, it provides evidence on the double-dividend hypothesis of the current EU electricity tax policy, which can be helpful to policy makers in assessing the current electricity tax policy and whether there is a need for reform. Second, the study presents the effect of the differential tax rates between households (tax rates are higher) and industry (tax rates are lower) on the climate, growth, and unemployment in the EU. And finally, it contributes by informing policy on which of the tax rate changes (household versus industry) are likely to be most effective for future changes in climate, economic growth, responsible production and consumption, unemployment, innovation and sustainable infrastructure in the EU.

Applying a panel vector autoregressive (PVAR) estimation approach, findings from the study reveals that electricity tax is a significant causal factor to some of the SDGs. Specifically, there is evidence of a double-divided electricity tax from the household sector. It promotes the reduction in both carbon emission (SDG13) and unemployment. Nevertheless, this is not the case for the industry sector since there is no evidence of a significant reduction in carbon emission. This finding reveals the implication of the current EU electricity tax policy in trying to tackle environmental concerns via higher household electricity taxes as well as promote industrial competitiveness via a relatively lower electricity tax on industry. The evidence shows that the environmental goals of EU electricity tax policy are being achieved from the household side but not from industry due to the lower tax rates for industry.

Furthermore, the finding also reveals heterogeneity of electricity tax effect across the two sectors (household and industry). Whereas household electricity tax has a significant effect on unemployment (SDG8W), innovation and sustainable infrastructure (SDG9) and climate action (SDG13), industry electricity tax has a significant effect on economic growth (SDG8G), unemployment and responsible production and consumption (SDG12), suggesting heterogeneity in the tax effect across the two sectors. Our evidence also reveals some interlinkages among some of the included SDGs in the model, and between tax and some of the SDGs.

In what follows, we present a brief review of the literature in section 2, before moving on to discuss the data and methodology in section 3, and the results in section 4. The summary and conclusions are discussed in section 5.

2. A Brief Literature Review

The concept of carbon tax-energy tax has been explored in depth by economists since the 1988 Toronto Conference, titled the International Conference of the Changing Atmosphere: Implications for Global Security conference. The concerns for human activities on the environment was formally discussed at a global level at the conference, with a suggestion to create a world atmosphere fund financed in part by a carbon/energy tax, and to reduce carbon emissions by 20 per cent in the year 2005. The research in this area, may be broadly grouped into four themes: the effect of carbon tax and energy tax on emissions; the impact of these taxes on income distribution; the price effect of such taxes and “others” (such as, barriers to effective introduction and implementation of such taxes, investment effect and influence on technology).

Table 1 summarizes some of the main studies by the type of study (theoretical, empirical, reviews), time periods studied, the geographical scope, and the main findings of the study. The summary of the reviewed literature suggests that most of the early research on carbon-energy taxes, especially in the early 1990s, focused on the carbon emission effects. Generally influenced by events during that period, especially after the 1988 Toronto conference on the changing atmosphere and the awareness thereafter about global emissions and the need to curb them. Some of the early research on the emission effect of carbon/energy tax are those from the Nordic countries as reviewed by Andersen (2004). The finding from the early studies suggest that carbon/energy tax contributed to about 3 - 5 per cent carbon emission reduction per unit of production in Sweden, about 5 per cent in Denmark and as high as 30 per cent in Norway (Andersen, 2004).

Later research within this theme (Brännlund et al., 2014; Kuo et al., 2016; Haites, 2018; Borck and Brueckner, 2018; Kettner-Marx and Kletzan-Slamanig, 2018) found some emission reduction per unit of production from carbon/energy taxes but at magnitudes that are on the average smaller than the earlier studies. One potential reason for this maybe that the early studies were done in a period when few policy instruments (besides carbon/energy tax) were implemented to help reduce emissions. Therefore, most of the emission reduction during the early period was a result of carbon/energy taxes. In recent years, several policy instruments have been simultaneously implemented, and the emission reduction is the cumulative impact of multiple policy instruments, thereby reducing the magnitude effect of only carbon/energy tax on emission.

The studies that investigate the emission effect of such taxes at the firm and enterprises level, also find some emission reduction effect of such taxes. Brännlund et al., (2014) find carbon taxes to have improved environmental performance in Swedish industrial sectors, by reducing the energy intensity in their operations. Whereas Kuo et al., (2016) suggest that enterprises in Taiwan tend to switch to a low carbon production technology, which has a reduction effect on emissions.

Several studies examine the distributional implications of carbon/energy tax on emission, especially the incidence of such taxes on different income groups in society, and whether the tax burden is heavy on the poor, the rich or proportional. Studies within this theme (Barker and KoKhler, 1998; Speck, 1999; Ekins et al., 2011; Dissou and Siddiqui, 2014; Thomas and Flues, 2015; Levinson, 2016: Oueslati et al., 2017) generally find such taxes to be mildly regressive on average for developed countries, but progressive for developing countries. The incidence of such taxes also tends to depend on the type of energy carrier. For instance, Thomas and Flues (2015) find that taxes on transport fuels are not regressive on the average, taxes on heating fuels are mildly regressive, while taxes on electricity are more regressive relative to those on heating fuels.

Of the selected studies, four researched around the effect of carbon/energy taxes on retail prices of electricity, which is partly motivated by the rising prices of retail electricity prices in the last decade, especially in Europe even after the deregulation of the electricity sector. Findings from these studies (Apergis, 2012; Chiu et al., 2015; Trujillo-Baute et al., 2018; Borozan, 2018) are quite similar, which tend to indicate that on the average, such taxes have a positive effect on retail electricity price. Trujillo-Baute et al. (2018) study on European member countries, finds that electricity taxes in the EU has a positive effect on electricity prices and further indicate that taxes contributes more to retail electricity prices in the EU relative to renewable energy promotion cost for electricity, but less than the effect of network cost on prices.

Another European based study Borozan (2018) investigates the influence of energy taxes on electricity consumption via both the direct and indirect impacts. The indirect impact is assessed via own price elasticity, cross price elasticity and income elasticity that is induce by the energy tax. The direct impact is assessed by the author by including energy tax variable as an explanatory variable and used the coefficient estimate on that to imply the direct effect. The finding indicates that energy taxes influence electricity consumption more efficiently through the indirect effect than the direct effect in the countries studied.

The reviewed literature also includes studies (classified as "others") on diverse issues that are not directly on prices, distribution, and carbon effects. These studies focus on topics such as barriers to effective introduction and implementation of carbon/energy taxes, investment effect on energy intensity, and influence on technology etc. (Martin, 2014; Carattini et al., 2017; Weishaar, 2018). Martin (2014) focuses on assessing the impact of carbon/energy taxes on energy intensity for UK manufacturing plants based on a micro-panel data. Findings from this study reveal that carbon taxes have a strong negative impact on energy intensity and electricity use in UK manufacturing plants.

Carattini et al. (2017) and Weishaar (2018), focus on understanding the factors that affect the acceptability of such carbon-energy taxes. Carattini's study is an experimental study on the Swiss society, on voting on a large bailout of energy taxes. The finding reveals that perception of ineffectiveness, distributional and competitiveness concerns reduce the acceptability of such taxes. Weishaar (2018) on the other hand, reviews the assessment of such taxes since their implementation in the EU member states, with a focus on the Nordic countries. Findings suggest that the barriers faced by such taxes are similar across the studied countries. These barriers relate to revenue recycling, competitiveness issues and the challenge to get a large political support.

The general conclusion from this comprehensive literature survey is that none of the studies explicitly mention any of the SDGs, though in principle some of them implicitly consider them in a narrow and less focused way. For instance, the theme on emission effect of such taxes is related to SDG13 (climate action), where emission is one of the target indicators for SDG13 and the theme on the price effect may have some relation with SDG7 (access to affordable and clean energy). None of the cited studies explicitly consider the trade-offs, synergy and complementarities between SDGs and carbon-energy taxes despite their importance.

Table 1: Summary of Studies

AUTHORS / YEAR	Research type	DATA	COUNTRY	Finding	Focus of study
Nicholas Apergis (2012)	Empirical	2001 to 2014	New Zealand	Energy tax (prices) have long-run asymmetric effects on electricity prices, with only positive changes in carbon prices signaling a complete pass-through.	Tax effect on energy price
Chiu et al. (2015)	Theory & Empirical	2002 to 2013	Taiwan	Energy price effect of energy tax and emission trading are equivalent under perfect competition, but not under imperfect competition. Evidence from oil market indicate a lower price effect of energy tax relative emission trading	Tax effect on energy price
Trujillo-Baute et al. (2018)	Empirical	2007 to 2013	EU member Countries	RES support cost has positive effect on retail electricity price, but the size of the effect is smaller than that of energy only cost, taxes and levies and network cost. Differences across consumer types (residential and industrial) was observed	Tax effect on energy price
Borozan (2018)	Empirical	2005 to 2016	EU member Countries	Energy taxes influence electricity consumption more efficiently through Indirect effect than direct effect. The finding also indicates that the efficiency of energy taxes can be aided by combining changes in energy prices and policy measures that change the electricity consumption behaviour patterns.	Tax effect on energy price
Barker and KoKhler (1998)	Empirical	Survey data 1988,1992,1993	11 EU member Countries	The distribution effect of carbon /energy tax in the EU are not so regressive.	Distributional effect of energy taxes
Speck (1999)	Review of empirical studies	1990 to 1999	Developed & Developing	The review shows that energy taxes are mildly regressive for developed OECD countries and even progressive in developing countries.	Distributional effect of energy taxes
Ekins et al. (2011)	Empirical	Household spending survey data for 2005	European Countries	The results suggest that environmental taxes in Europe are generally not regressive, although the results differ by country and for different socio-economic groups. With the acceptability of such taxes depended on how the worst affected groups are mitigated.	Distributional effect of energy taxes
Dissou & Siddiqui (2014)	Theory & Empirical	SAM-2004	Canada	The relationship between carbon/energy taxes and inequality are non-monotonic (U-shaped) due to the opposing effect of carbon tax on changes in factor prices and changes in commodity prices. Carbon/energy taxes tend to reduce inequality via changes in factor prices	Distributional effect of energy taxes

				and tend to increase inequality via changes in commodity prices.	
Thomas & Flues (2015)	Empirical	Household budget surveys, 2009 to 2012	21 OECD Countries	The distributional effects of energy taxes differ by energy carrier. Taxes on transport fuels are not regressive on average but generally heterogenous across countries. In some countries, the effects of taxes on transport fuels are progressive, and others more proportional. Taxes on heating fuels are mildly regressive, whiles taxes on electricity are more regressive relative to those on heating fuels.	Distributional effect of energy taxes
Levinson (2016)	Theory & Empirical	National Household Travel Survey, 2009	USA	The theory prediction indicates that regulations targeting energy efficiency is more regressive than energy taxes under the condition of revenue-equivalence between the two. The empirical evidence in automotive fuel consumption, appliances, and residential construction all supported the theoretical prediction.	Distributional effect of energy taxes
Oueslati (2017)	Empirical	1995 to 2011	34 OECD Countries	Finding indicate that in the absence of revenue recycling mechanisms, the impact of energy tax on income inequality is moderately positive. Whereas in the case, where such mechanisms have been implemented, there is a stronger negative energy tax effect on income inequality.	Distributional effect of energy taxes
Andersen (2004)	Review of empirical studies	1990 to 2000	Nordic Countries	The review suggests that the implementation of CO2 tax in Sweden has resulted in an estimated reduction of emission by 3% to 5%. About 5 % in Denmark and 30% in Norway	Carbon/energy tax effect on emissions
Brännlund (2014)	Empirical	1990 to 2004	Sweden	Environmental performance has improved in all the sectors and that the firms' carbon intensities respond to changes in both the CO_2 tax and fossil fuel price. The emission intensity is, however, more sensitive to the tax.	Carbon/energy tax effect on emissions
				The case study indicates that the appropriate levels of tax can have a	

Kuo (2016)	Theory with numerical simulation	-	Taiwan	reduction effect on emission by enterprises due to the fact that it induces enterprises to alter their production processes towards a low carbon production path.	Carbon/energy tax effect on emissions
Haites (2018)	Review of empirical studies	2005 to 2015	World	Carbon/energy taxes in European countries and in British Columbia prior to 2008 reduced emissions from business-as-usual. After 2008, countries covered by the European emission tax experienced emission reduction, but largely from other mitigation than the carbon/energy taxes.	Carbon/energy tax effect on emissions
Borck & Brueckner (2018)	Theory with calibration	-	USA	It suggests that optimal taxation reduces the levels of both activities (housing consumption and commuting), which lowers the level of emissions per capita by 11.4%.	Carbon/energy tax effect on emissions
Kettner-Marx & Kletzan-Slamanig (2018)	Empirical	2004 to 2015	EU Countries	The price elasticity is –0.31 for petrol and –0.16 for diesel, which suggest an increase in prices due to energy or carbon taxation can contribute to reducing greenhouse gas emissions from the transport sector.	Carbon/energy tax effect on emissions
Martin et al. (2014)	Empirical	1993 to 2004	United Kingdom	They estimated the impact of a carbon/energy tax on manufacturing plants energy intensity. They find that carbon/energy taxes had a strong negative impact on energy intensity and electricity use.	Others-energy intensity
Carattini et al. (2017)	Empirical	2015	Switzerland	That perception of ineffectiveness, distributional and competitiveness concerns reduced the acceptability of energy taxes. Also, providing proper information on the functioning of environmental taxes reduces the gap between economists' prescriptions and preferences of the general public.	Others-acceptability of energy taxes
Weishaar (2018)	Review	1990 to 2018	EU member Countries	Impediments to the introduction of carbon/energy tax relate to revenue recycling, competitiveness issues and the challenge to get a large political support. Employing a consensus approach increases acceptability.	Others-acceptability of energy taxes

2. The Model

The theoretical underpinning of our empirical model is based on the theoretical model of the environmental tax reform (ETR)[1] and the associated double dividend hypothesis contributed by various scholars including Schöb (2003). The theoretical argument for ETR is that, by imposing a tax (carbon tax, tax on energy, tax on polluting transport, etc.) that internalize negative externalities in the production process or the consumption process by households such as pollution, it has the benefit of reducing such negative externalities, which creates some environmental benefits. Beyond correcting the negative externalities, such taxes also generate revenue for government which can be used in pursuing development objectives such as funding innovation, promoting access to clean and affordable energy sources, promote production and employment through either the reduction in the net cost of the tax system via revenue recycling or by promoting domestic resource used for public investment. In the theoretical literature, the first dividend of ETR is the pollution reduction effect on the environment and the second dividend is the production and employment effect. These two effects are directly linked to SDG 13 and 8. However, in achieving the SDG 8, especially through the government investment mechanism such as funding innovative activities (has a direct impact on SDG 9) to promote a transition to a sustainable production and consumption path (SDG12). Also, the revenues from ETR could be used to fund technology to reduce the cost of renewable energy, which has the potential to promote access to such clean energy (SDG7). Review of literature on early theoretical studies on ETR suggest that such reforms would reduce pollution sharply and increase employment, but that on output is ambiguous (Bosquet 2000; Patuelli, Nijkamp, and Pels 2005). Other studies found ETR to have a reduction effect on emission and increase both output and employment (Heady et al. 2000; Markandya 2012). The foregoing provides the theoretical underpinnings of ETR such as energy tax (electricity) tax and some selected SDGs.

The econometric model utilized in this study is the Penal Vector Autoregressive (PVAR) model. We employ PVAR approach to model the interlinkages between electricity taxes and the selected SDGs and to determine the causal impacts. In the PVAR framework, each variable in the system is explained by its own lags, lagged values of the other variables, time fixed effect and

[1] These are packages of policies that combine environmental taxes with expenditure policies, alongside various supplementary policies to protect the environment and also promote welfare through revenue recycling or expenditure on public good provision.

unobserved individual effect. The panel autoregressive distributed lag model for this study is presented compactly as

$$y_{it} = \sum_{t=1}^{n} \pi_i' y_{it-1} + \mu_{it} \quad (1)$$

where y is k*1 vector of k variables, π_i' is a k*k vector of parameters to be estimated and μ_{it} is a composite term that is made up of time fixed effects (v_t), unobserved individual effect (γ_i) and random error term (ε_{it}). In equation (1), y is a vector which is composed of electricity taxes and levies, SDG 7, SDG 8, SDG 9, SDG 12 and SDG 13. SDG7 represent affordable and clean energy, SDG8 is decent work and economic growth (decomposed into work - specifically unemployment aspects and growth), SDG9 is industry, innovation and infrastructure, SDG12 is responsible production and consumption and SDG13 is climate action. All the equations stacked in equation (1) are estimated jointly as a system, which makes it possible to trace the feedback effect from each variable on the other. Thus, we can assess the potential trade-offs or complementarity of electricity taxes directly on each of the selected SDGs and how each of the goals also influence the others. The above system of equation is estimated for the household model, where "Tax" is taxes and levies on household electricity consumption. The same system of equation is estimated for the industry model, where "Tax" is replaced with taxes and levies on industrial electricity consumption.

The PVAR approach avoids the usual problem of endogeneity due to reverse causation, given the interdependent nature of the variables that are of interest in the study. Moreover, important policy questions such as, how specific variables of interest respond to unexpected changes in other variables can also be analysed via the PVAR approach, which is panel version of the vector autoregressive (VAR) model in the time series literature. For instance, whether unexpected changes in electricity taxes to combat climate change causes a positive, negative or no reaction by SDG13, can be assessed from the PVAR approach for the countries under study.

Given the lag dependent structure, estimating a system of fixed effect model will suffer from nickel bias (where the lag dependent variable is correlated with the fixed effect) in a small sample.

The standard procedure to address such a bias, as suggested by Arellano and Bover (1995) is to use a generalized method of moment estimation procedure (GMM)[2], where lagged variables are used as instruments. The GMM approach is adopted as the estimation technique for the PVAR model, like the work by Abrigo and Love (2016).

In estimating the above model, the empirical strategy follows two steps. In the first step, the PVAR model is estimated for both household tax model and industry tax model. This step will provide estimates for each of the variables in the model and makes it possible to assess the interlinkages and causal impacts. In the second step, we provide causality test to determine the nature of interlinkages between the various variables in the model, followed by the variance decomposition analysis to account for the contribution of electricity tax to the variation of each of the SDGs for a short term (5 years ahead) and medium term (10 years ahead).

3. Data

The analysis is based on the Eurostat data base, where both the energy price components and SDGs are obtained. Key variables extracted from the Eurostat data are: electricity taxes and levies, key SDGs that are closely associated with energy and their associated target indicator variables. The period of data coverage is determined by data availability in the data set. The data on disaggregated price data for electricity into its components such as production cost, network charges, taxes and levies are only available on consistent basis starting from 2007, whiles that for SDGs start from 2000. However, Some of the SDGs have missing data for the years 2017 and 2018. Due to that the data coverage was restricted to the period from 2007 to 2016 for EU-28 countries plus Norway. There are

[2] This is not a difference or system GMM model as usually done for dynamic panel models but rather an estimation technique that utilized similar idea of using internal instruments and applying method of moments approach in the estimation of the model presented in equation (1).

few missing data for some of variables, particularly R&D personnel by sector, patent application, share of transport modes in passenger land transport, therefore we have an unbalance panel. The industry tax data also have several missing data which result in having a much smaller sample than that for the households.

The key variables of interest include electricity taxes and levies (both households and industrial customers) and indicators for selected SDGs. The electricity taxes and levies variable are sourced from Eurostat for both consumers and the industry. The tax and levies data is quoted in Euros per kWh for the two end-user groups (households and industry). Further, the data is classified based on annual consumption bands from very small band (annual consumption below 1 000 kWh) to very large band (annual consumption above 15000 kWh) for the household end-users, and a very small band (annual consumption below 20 MWh) to very large band (annual consumption above 150 000 MWh) for industrial end-users[3]. For this study we rely on the taxes and levies from the medium consumption bands for both households and industry as most households and industries fall within this band. Thus, Band-DC (Medium): annual consumption between 2500 and 5000 kWh for household, and Band-IC: annual consumption between 500 and 2000 MWh for industry. The choice of consumption band is consistent with previous studies such as Trujillo-Baute (2018).

The tax and levies for the two end-users is presented in Figure 1, which shows the averages for each country over the period 2007 to 2016. Denmark has the highest taxes and levies on households (0.180 Euros /kWh) followed by Germany (0.121 Euros /kWh). Malta, on the other hand, has the least average electricity taxes on households (0.007 Euros /kWh). The top five countries with

[3] Details of the methodology used by Eurostat for the data collection can be found via their website (https://ec.europa.eu/eurostat/data/database).

the highest household electricity taxes in the region in order of ranking are: Denmark, Germany, Portugal, Italy and Sweden. In the case of industrial electricity taxes and levies, Italy has the highest taxes and levies over the period (0.052 Euros /kWh) followed by Germany (0.041 Euros /kWh), and Malta has the least in the region, with approximately zero taxes. The highest average household tax on electricity is about 246 per cent higher than the highest industrial average tax in the region, suggesting the policy direction of these taxes in the region within the context of competitiveness concerns versus environmental motives of the policy maker. The distribution of the tax data is presented in figure A1 in the appendix, which present the entire distribution of the tax data for each country over the study period. The figure highlights significant variability in taxes for both households and firms within countries depicted by the size of the boxes (inter-quartile range) and across countries depicted by variation in the median value of the taxes (depicted by the white inline in the boxes).

The next set of variables are the SDGs. Our focus is not on all the SDGs but rather those that are directly connected to energy use. Specifically, we are interested in SDGs 7, 8, 9, 12 and 13, guided by Swain and Karimu (2020) study. The indicators used to capture each of these SDGs are presented in Table A1 in the Appendix. The indicators for SDG7 include primary energy consumption, final energy consumption, final energy consumption in households per capita, share of renewable energy in gross final energy consumption by sector, energy dependence by product, and greenhouse gas emissions intensity of energy consumption.

Indicators for SDG 8 are divided into two components. An unemployment component (8W) and a growth component (8G) of SDG8. Indicators for SDG8W are young people neither in employment nor in education and training by sex, long-term unemployment rate by sex and inactive population due to caring responsibilities by sex. Indicators for SDG8G are real GDP per capita, resource productivity and domestic material consumption.

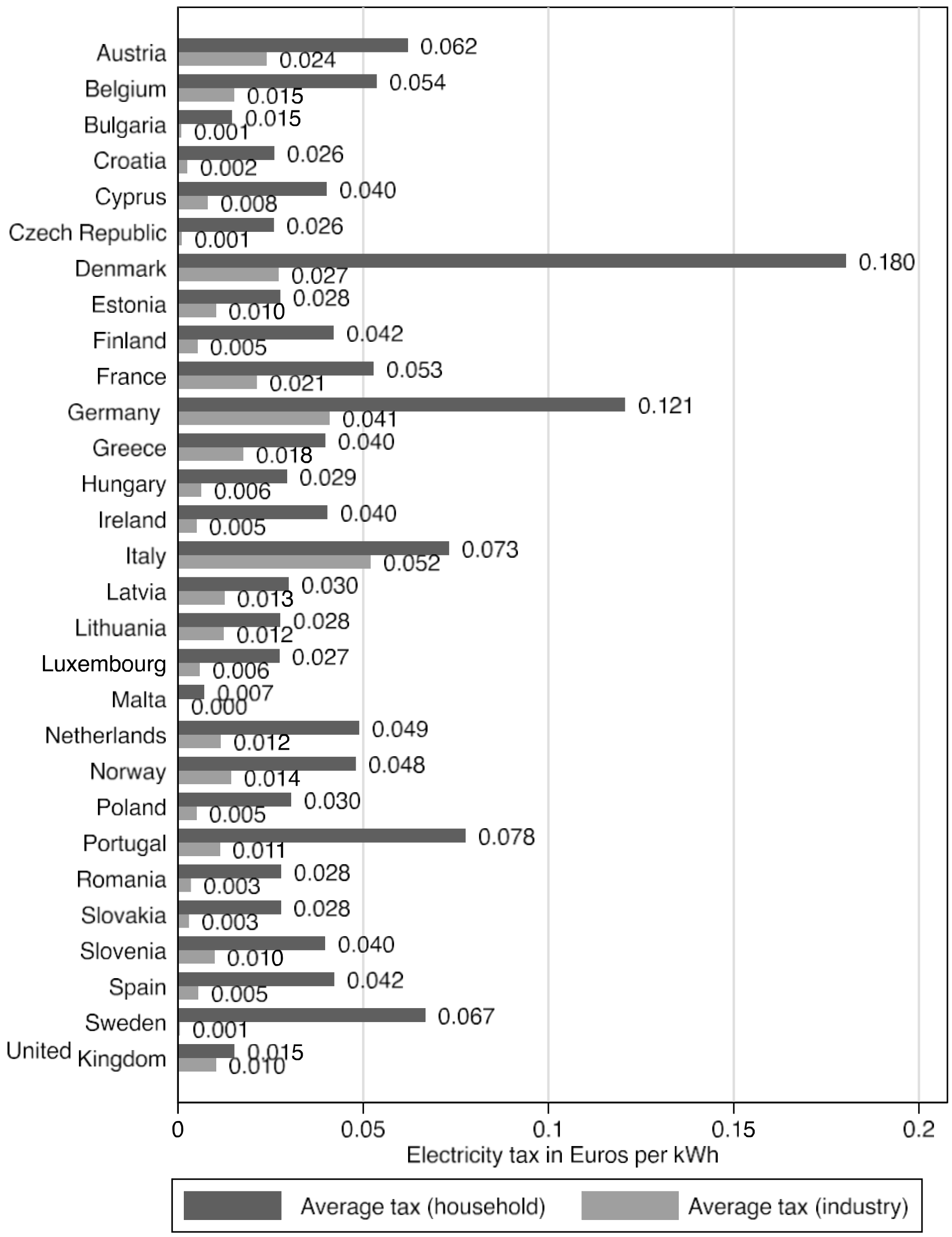

Figure 1: Electricity taxes and levies for EU-28 countries and Norway (2007–2016).

In the case of SDG9, the indicators used are gross domestic expenditure on research and development by sector, employment in high and medium-high technology manufacturing sectors and knowledge- intensive service sectors, research and development personnel by sector, patent applications to the European Patent Office, share of collective transport modes in total passenger land transport by vehicle, share of rail and inland waterways activity in total freight transport.

For SDG12, the indicators comprise consumption of toxic chemicals by hazardousness, resource productivity and domestic material consumption, average CO_2 emissions per km from new passenger cars, volume of freight transport relative to GDP, primary energy consumption, final energy consumption, energy productivity, and share of renewable energy in gross final energy consumption by sector.

Another directly connected SDGs to energy is SDG13, under which we use greenhouse gas emissions per capita (CO_2) from WDI. We use CO_2 emissions to represent SDG13 because it is a major climate concern globally, has reliable data information and furthermore, is a major reason used by policy makers to promote renewable electricity and justification of carbon-based taxation. Each SDG is captured by several indicators that are listed, which complicate any meaningful econometric analysis due to overlapping of some of the target variables across some of the SDGs. For instance, we have final energy consumption as one of the indicators for both SDG7 and SDG12. We combine each of the target variables under each SDG into one index via principal component analysis (PCA) approach. The PCA approach utilises the correlation between the variables that constitute each of the SDGs in the data to construct an index that adequately capture the features of the original variables for each of the SDGs in the data. By doing so, it reduces the many variable indicators for a particular SDG into one index, which retain a greater proportion of the original information from the indicators used to construct the index.

The summary statistics for the variables for the study is reported in Table A1 in the Appendix, which reveals a strong heterogeneity among countries in terms of primary energy consumption, final energy consumption, tax on industry electricity and patent application, as their respective standard deviations are of larger magnitude than their means. A variable with a larger standard deviation relative to its mean, suggests high variability in the variable and therefore a strong heterogeneity. Furthermore, Table A1 shows more variation of the variables between countries than within countries, which will be utilized in the econometric analysis of the data.

4. Results and Discussion

We first present the results based on step one, followed by step two in that order as outlined in the empirical strategy. Before discussing the step 1 results of the PVAR approach, it is important to first discuss the time series properties of the data, the model fit and stability of the model.

Time series properties of the data are examined via panel unit root test and panel cointegration test. Though the time dimension is too short for any reliable test to be performed to establish the time series properties (Pesaran, M. H., 2012), for the purpose of completeness, such tests are provided with a caution that these test results are not robust due to the limited time dimension of the data (time dimension of 10 years on annual frequency). Using the Pesaran's(2007) unit root test, which controls for both heterogeneity and cross-sectional dependence in the testing procedure, the results indicate that all variables are stationary at level except SDG8(Unemployment) and SDG12 (responsible production and consumption), which failed to reject the null hypothesis of a unit root. This implies that all the included variables are stationary at the level, thus, $I(0)$ except SDG8(Unemployment) and SDG12 (responsible production and consumption), which are $I(1)$ since it is only after the first difference of these two variables that the null of a unit root is rejected at the 5% significance level.

These results are reported in Table A2 in the appendix. Given the mix integration, where some of the variables are stationary, whiles others follow a unit root process, regression results from equation 1 could be spurious if the variables in the model are not cointegrated. Applying the Pedroni panel cointegration test, the test results generally rejected the null hypothesis of no cointegration at the 5% level for five out of the seven different test statistics, as reported in Table A3 in the appendix. Results reported in Table 1 and 2 are therefore generally not spurious based on this evidence.

More importantly since we are interested in establishing causal effects to determine the nature of interlinkages of electricity taxes and the selected SDGs, the stability of the model is very important. Moreover, given the interest in assessing how each of the SDG's variance is explained by electricity taxes and levies, the model stability is again an important requirement. It is also important to establish whether the model fits the data generation process (DGP) before discussing the results.

First, regarding the model fit, since the model estimation approach is based on generalized method of moment (GMM), we perform the Hansen-J test for over-identification, which is more of a specification test to determine if the over-identifying restrictions are valid. The test results reported in Tables 2 and 3 for household and industry respectively, suggest that our models fit the data generation process.

The model stability is checked by calculating the modulus of each eigenvalue of the estimated PVAR model. If all moduli of the companion matrix are strictly less than 1, the VAR model is stable (Hamilton, 1994; Lutkepohl, 2005). The results reported in Table A4 in the Appendix, suggest that both models (household and industry tax model) are stable. Our estimated models therefore satisfy both the model fit test and the model stability test.

a. PVAR results for the household model

First, the household model estimates are presented followed by the discussion on the model estimates. The results as reported in Table 2 is presented by first considering the tax equation (1) to determine how household electricity taxes respond to each of the selected SDGs. Next, we focus on how each of the SDGs respond to household electricity taxes (column 2 to 7).

Considering the results based on the tax equation (equation 1), previous level of taxes and each of the SDGs (except SDG7 and SDG 9) are significant causal factors to household electricity taxes in the EU-28 countries and Norway. Specifically, goal8W and goal12 had positive impact on taxes with elasticity values of 0.08, 0.92, respectively. Whereas goal8G and goal13 had negative impact on household electricity taxes with respective elasticity values of -0.86 and -0.24.

The results from SDG 7 (column 2) suggest that all the SDGs (except SDG9) are significant causal factors. Specifically, SDG 7 responded positively to its previous level, SDG8W, SDG12 and SDG13 with respective elasticity values of 0.81, 0.05, 0.32 and 0.19. It also responded negatively to SDG8G with elasticity value of -0.16.

Furthermore, finding from SDG8G (column 3) indicates that each of the SDGs (except SDG13) are significant causal factors for SDG8G. Whereas in the case of the unemployment equation (SDG8W), all variables are significant causal factors, except SDG9.

Results based on SDG9 (innovation and sustainable infrastructure) equation also revealed that taxes and each of the SDGs are significant causal factors at any of the conversional significance level. Whilst from the SDG12 (responsible production and consumption) equation, SDG8G (economic growth), SDG8W (unemployment) and SDG13 (climate action) are the significant causal factors. The finding further showed that all the variables are significant causal factors except SDG9 in influencing SDG13.

Table 2: PVAR Household electricity taxes estimates

Response of:	Response to Tax_{t-1}	$SDG7_{t-1}$	$SDG8G_{t-1}$	$SDG8W_{t-1}$	$SDG9_{t-1}$	$SDG12_{t-1}$	$SDG13_{t-1}$
Tax_t	0.318^{***}	0.133	-0.861^{***}	0.075^{*}	0.092	0.916^{***}	-0.236^{***}
	(5.83)	(0.86)	(-5.54)	(1.82)	(1.55)	(6.04)	(-3.62)
$SDG7_t$	-0.028	0.807^{***}	-0.164^{***}	0.046^{***}	-0.034	0.319^{***}	0.186^{***}
	(-1.64)	(11.71)	(-4.50)	(3.25)	(-1.62)	(5.94)	(5.23)
$SDG8G_t$	-0.033	-0.130^{**}	0.091^{**}	0.042^{**}	-0.156^{***}	0.666^{***}	0.006
	(-1.37)	(-2.42)	(2.44)	(2.50)	(-6.43)	(12.31)	(0.19)
$SDG8W_t$	-0.367^{***}	2.059^{***}	-0.394^{***}	0.973^{***}	0.141	-0.770^{***}	0.977^{***}
	(-4.56)	(8.81)	(-2.59)	(16.70)	(1.60)	(-3.40)	(7.27)
$SDG9_t$	-0.252^{***}	-1.060^{***}	-0.664^{***}	0.134^{***}	0.521^{***}	1.247^{***}	-0.647^{***}
	(-4.36)	(-5.30)	(-3.80)	(3.54)	(6.38)	(4.91)	(-7.17)
$SDG12_t$	0.027	-0.013	-0.365^{***}	0.052^{***}	-0.005	1.147^{***}	0.104^{***}
	(1.26)	(-0.23)	(-7.62)	(3.19)	(-0.22)	(19.03)	(2.91)
$SDG13_t$	-0.141^{***}	-1.317^{***}	0.506^{***}	-0.169^{***}	-0.027	-0.184^{*}	-0.972^{***}
	(-3.15)	(-8.55)	(6.04)	(-4.93)	(-0.53)	(-1.66)	(-11.84)
Observation	202						
J-Stats	155.219						
P-value	[0.305]						

Note: Lags up to a maximum of 4 of each of the variables in the model was used as valid instruments in the estimation to resolve potential endogeneity problems based on GMM style of instrumentation. Robust standard errors are used to correct for potential heteroskedasticity. T-statistics are in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 2 presents the variance decomposition of each of the variables in the household model to a tax shock. Accordingly, the contribution of household electricity tax shock to the variance of economic growth (SDG8G) is about 18 per cent at a 5-year horizon, which increases to about 22 per cent at the 10-year horizon. Correspondingly, tax shock contribution to the variance of SDG 9, 12 and 13 are 8 per cent, 9 per cent, and 6 per cent, respectively at the 10-year horizon. At the 5 -years horizon, tax shock accounted for about 1 per cent, 13 per cent and 5 per cent of the variation in SDG9, SDG12 and SDG13, respectively.

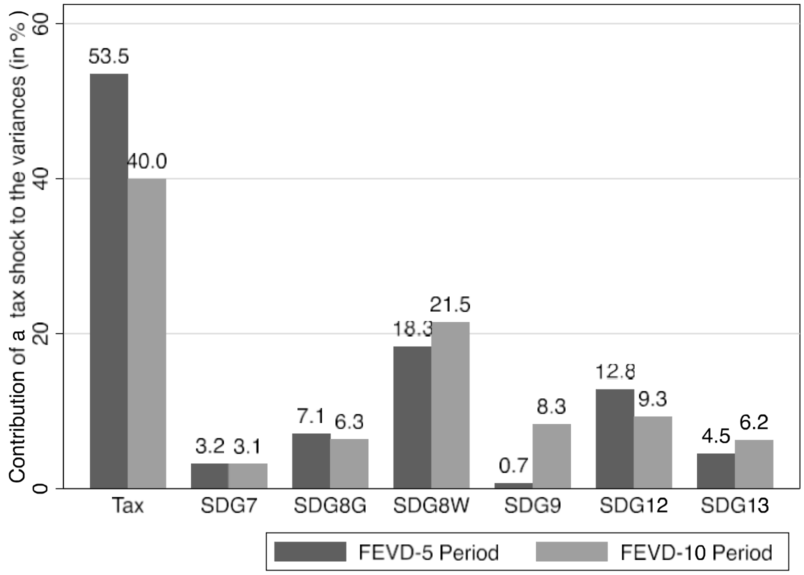

Figure 2: Forecast error variance decomposition for a tax shock in the household model

b. Discussion of household's electricity tax model results

Clearly, Table 2 showed that household electricity tax in the EU28 and Norway has a significant influence on only three of the selected SDGs (SDG8W-unemployment, SDG9-innovation and sustainable infrastructure, and SDG13-climate action) even at the conservative 1 per cent significance level.

Specifically, the negative significant effect of electricity tax on unemployment (SDG8W) can be explained by the theory of double-divided associated with environmental/energy tax reform (ETR) policy (e.g., Goulder, 1995). Theoretical work on the double-dividend of ETR suggest that in a case of involuntary unemployment, taxes on energy can provide both environmental and employment benefits as long as the revenues from such taxes are recycled in a manner that replaces some of the distortionary taxes on labour (e.g., income tax, social security tax). With the recycling targeted at reducing the labour cost for employers, labour demand increases, thereby reducing the level of unemployment. This finding is consistent with finding from the broader literature on the environment and macroeconomic effect of ERT such as Capros et al. (1997), Bayar (1998), Jansen and Klaassen (2000). These studies found consistently, a positive effect of ERT on employment, which can be interpreted to mean a reduction in unemployment.

The negative effect of household electricity taxes on SDG9 is in line with findings from studies on taxation and innovation such as Akcigit et al. (2018), they showed that taxes generally have a negative effect on innovation. Additionally, Akcigit et al. (2018) showed that the negative effect is particularly pronounced in the case of taxes on personal income and corporate taxes. This implies that as the returns to innovation are lowered by these taxes, it reduces individuals and firms' incentive to invest in innovation.

Also, a negative effect of electricity tax on carbon emission is consistent with prior literature on ERT (Wendner, 2001; Patuelli et al., 2005; Andersen and Skou, 2010; Haites 2018). This can be explained via the price effect of taxes on final retail electricity price. As prices of electricity become expensive due to the taxes, consumers respond to that either through conservation measures or efficient use of electricity or both.

Furthermore, findings also revealed that some of the SDGs are interlinked. For instance, SDG13 showed bi-causal relationship with SDG7, SDG8W and SDG12. SDG12 has a bi-causal relationship with SDG8W, SDG8G, SDG13. Economic growth (SDG8G) has a bi-causal relationship with SDG7, SDG8W, SDG9 and SDG12. These casual relations can be inferred from the causality test reported in Table A3 in the appendix, where the null hypothesis of no causality is tested using a chi-square test statistic, rejecting the null suggest causality.

In brief, we conclude that the household electricity tax is a causal factor to SDG8W, SDG9 and SDG13, whereas SDG8G, SDG8W, SDG12 and SDG13 are significant causal factors for household electricity taxes in the EU and Norway. Moreover, the results further show that increases in taxes on household electricity consumption can help achieve SDG8 via reduction in unemployment and help achieve SDG13 via reduction in CO_2, suggesting a synergy between tax and these SDGs (SDG8 and 13). Nonetheless, in the case of SDG9, the finding revealed a trade-off relationship with household electricity tax.

Regarding the nature of causal relationship between household electricity tax and SDGs, only SDG8W and SDG13 show bi-causal interlinkages with household electricity tax. Whereas in the case of SDG9 there is no evidence of interlinkages but rather a unit-directional causation from SDG9 to household electricity tax. Moreover, the variance decomposition suggests that household taxes accounts for a significant variation of the selected SDGs, which range from 3.1 per cent (SDG7) to 22 per cent (SDG8W) at the 10-year horizon.

a. PVAR results for the industry model

The industrial model results are reported in Table 3 and revealed that previous level of industrial electricity tax, SDG8W and SDG9 are the significant causal factors for industrial electricity tax (equation 1), with respective elasticity values of 0.85, 0.27 and -0.19. From the SDG7 equation, the estimated tax effect is not significant at any of the conventional significance level, suggesting that industrial electricity tax is not a significant causal factor for SDG7 in the EU-28 and Norway.

Results further reveal that industrial electricity tax has a significant negative effect on both SDG8G and SDG8W, with elasticity values of -0.06 and -0.64, respectively, suggesting a negative tax effect on each of these goals. Whereas from the SDG9 equation, tax is not a significant causal factor. The industrial electricity effect on SGD12 is positive (0.12) and significant, whiles in the case of SDG13, tax is not a significant causal factor.

Table 3: PVAR Industry electricity taxes estimates

Response of:	Response to Tax_{t-1}	$SDG7_{t-1}$	$SDG8G_{t-1}$	$SDG8W_{t-1}$	$SDG9_{t-1}$	$SDG12_{t-1}$	$SDG13_{t-1}$
Tax_t	0.851^{***}	-0.254	0.078	0.274^{***}	-0.188^{**}	0.211	-0.237
	(7.04)	(-0.78)	(0.74)	(4.64)	(-2.12)	(0.71)	(-1.59)
$SDG7_t$	0.039	0.658^{***}	0.298^{***}	0.021	0.006	-0.039	0.105^{**}
	(1.10)	(8.01)	(4.84)	(1.01)	(0.18)	(-0.39)	(2.00)
$SDG8G_t$	-0.056^{**}	0.152	-0.285^{***}	0.007	0.043	0.827^{***}	0.265^{***}
	(-2.01)	(1.64)	(-5.09)	(0.25)	(1.44)	(7.09)	(5.95)
$SDG8W_t$	-0.642^{***}	1.581^{***}	-2.201^{***}	0.906^{***}	0.014	1.232^{***}	0.626^{***}
	(-5.56)	(5.68)	(-6.56)	(10.02)	(0.10)	(3.20)	(4.05)
$SDG9_t$	0.047	-0.277	-1.680^{***}	0.001	0.480^{***}	1.620^{***}	0.055
	(0.49)	(-1.05)	(-6.51)	(0.02)	(4.81)	(4.12)	(0.40)
$SDG12_t$	0.117^{***}	-0.001	-0.518^{***}	0.009	-0.032	0.887^{***}	0.044
	(3.74)	(-0.01)	(-8.98)	(0.39)	(-0.91)	(7.26)	(0.96)
$SDG13_t$	0.064	-1.001^{***}	-0.680^{***}	-0.116^{**}	0.012	0.262	-0.067
	(0.76)	(-5.52)	(-4.96)	(-2.46)	(0.15)	(1.07)	(-0.60)
Observation	167						
J-Stats	102.436						
P-value	[0.360]						

Note: Lags up to a maximum of 4 of each of the variables in the model was used as valid instruments in the estimation to resolve potential endogeneity problems based on GMM style of instrumentation. Robust standard errors are used to correct for potential heteroskedasticity. *T*-statistics are in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Furthermore, the variance decomposition of each of the variables to the industry model to tax shock is presented in Figure 3. Admittedly, industry electricity tax shock accounts for a significant variation of each of the SDGs in the model, irrespective of the time horizon (5 or 10 years) presented. Specifically, industry electricity tax shock accounts for about 48.1 per cent of the variation in unemployment (SDG8W) at the 10-year horizon. It also accounts for about 28.9 per cent, 48 per cent and 9.7 per cent variation in SDG9, SDG12 and SDG13, respectively. Certainly, the contribution of industry electricity taxes to future variation of each of the SDGs are much significant in magnitude relative to those from the household electricity tax model. This among other things suggest that increases in the level of taxes on industry electricity consumption is likely to have the greatest impact on the future direction of the selected SDGs within the EU, relative to increases in household electricity taxes.

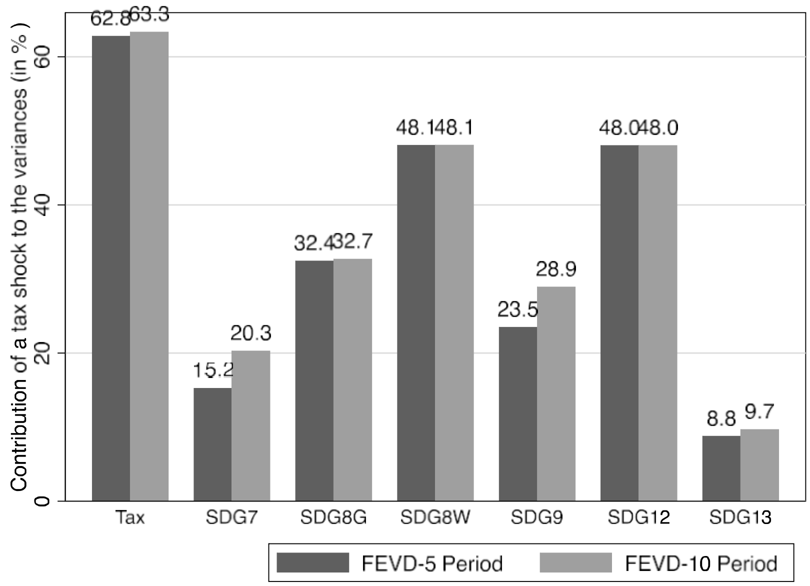

Figure 3: Forecast error variance decomposition for a tax shock in the industry mode

b. Discussion of industry electricity tax model results

Similarly, the industry tax model reveals that tax is a significant causal factor for only three of the SDGS (SDG8G, SDG8W and SDG12). Conversely, two of the SDGs (SDG8G and SDG12) that industrial electricity tax has a significant influence on are different from those found in the household tax model, suggesting the heterogeneity of electricity tax effect across the two sectors (household and industry).

The negative effect of tax on economic growth (SDG8G) is in line with some of the studies on Europe as documented in a meta-analysis by Patuelli et al. (2005) and for energy intensive industries by Andersen and Skou (2010). Our finding is however contradictory to some of the previous studies on EU Environmental/Energy Tax Reform (ETR) policy (e.g., Cambridge Econometrics,1998; Capros et al., 1997; Bayar, 1998; Jansen and Klaassen, 2000), especially when recycling of tax revenue is incorporated into the analysis. We argue that the negative tax effect on economic growth may be explained via the recycling effect and the inability to shift cost from labour-intensive sectors to energy-intensive sectors in the region. Out of the 28 countries in our sample, only nine countries[4] have an explicit environmental tax and revenue recycling policy (in line with the ETR policy). Out of the nine, only six countries focus on recycling such tax revenues to reduce pension contributions by employers, a channel that produces the most gains both for employment and economic growth, as documented in meta study by Patuelli et al. (2005).

Furthermore, the negative impact of unemployment (SDG8W) is partially (since there was no significant effect on climate, satisfying only one aspect of the double divided hypothesis) in line with the theory of double divided of such taxes (e.g., Goulder, 1995), which is also consistent with previous empirical studies (Cambridge Econometrics,1998; Capros et al., 1997; Bayar, 1998; Patuelli et al., 2005; Anderson, 2010).

On the other hand, tax is not a significant causal factor for SDG9. A possible explanation for this may be due to the low rates of electricity taxes for industry. In the EU, electricity taxes on industry are very low relative to the household sector. In most of the countries, average household electricity taxes over the period of the analysis are more than twice that of industrial taxes, making industries' innovation component of SDG9 less responsive to electricity taxes. Moreover, given government support policy such as tax deductibles on investment in innovation by industry, taxes tend to have little effect on the marginal benefit of innovation by industry.

Conversely, the positive effect of industrial electricity on SGD12 may be explained via the cost of production channel. Cost of production increases with higher electricity tax, especially in electricity- intensive industries (EII) such as chemical, machinery, paper, food and steel, given that electricity is the major energy carrier in these industries (Åhman and Nilsson, 2015). The cost restriction

[4] Belgium, Denmark, Finland, Germany, Italy, Netherlands, Sweden, United Kingdom and Norway.

of a higher electricity tax will force EII either to produce and consume responsibly or relocate. If the cost of relocation is higher relative to being innovative, they will adopt more responsible production and consumption processes.

On the other hand, industry electricity tax has no significant effect on carbon emission (SDG13) at any of the conventional significance levels. This may be explained by the watered-down regulation, soft tax deals and preferential pricing that they are benefitting from (Climate Action Network Europe, 2018).

Additionally, the findings also reveal that some of the SDGs are interlinked. For instance, SDG7 shows bi-causal relationship with SDG13. SDG8G has a bi-causal relationship with SDG12 and SDG13. Whereas SDG12 has a bi-causal relationship with only SDG8G. On the other hand, SDG13 has a bi-causal relationship with SDG8G and SDG8W. Electricity tax is only interlinked with SDG8W (bi-causal relationship). These casual relations can be inferred from the causality test reported in Table A3 in the appendix.

In summary, industrial electricity tax influence SDG8 via economic growth and unemployment components of this goal; it also influences responsible production and consumption (SDG12) in the EU-28 and Norway. In all, the effect of industrial electricity tax on the economy via SDG8 and SDG12 lend support to the macroeconomic benefits of such energy taxes in a narrow sense of the broader environmental tax reform policy.

5. Conclusion and Policy Implications

The aim of this study is to investigate the impact of electricity taxes within the EU on selected SDGs that are closely connected to the energy sector. The goal is assessing the current EU electricity tax policy in terms of environmental/climate impact and macroeconomic impacts based on the double-divided hypothesis. Specifically, we are interested in determining the potential interlinkages and trade-offs between the electricity tax policy and selected SDGs. Moreover, given the current differential rates in electricity tax between the household sector and industry, we examine the potential heterogeneity of the impacts of these taxes on the SDGs across the two sectors. Using the PVAR approach for a panel of 28 EU countries and Norway, we estimate the electricity tax effect on SDGs, utilising the differences in the tax rates between industry and the household sectors.

Several interesting findings emerge. First, in general, increase in electricity taxes within the EU has a significant effect on some of the SDGs. Second, the effect of electricity taxes on SDGs differs depending on whether the tax is on households or industry. Household electricity taxes influence unemployment (SDG8W), innovation and sustainable infrastructure (SDG9), and climate action (SDG13), whereas in the case of industry, it influences economic growth (SDG8G), unemployment (SDG8W), and responsible production and consumption (SDG12). This suggests evidence of the double-dividend hypothesis for the household sector regarding such taxes but not in the case of industry, possibly due to the relatively low electricity taxes on industry driven by competitiveness concerns and the fact that the EU emission trading system is operational, which among other things may suggest the relatively low electricity taxes on industries.

Third, there is evidence of interlinkages between electricity tax and some of the SDGs, and trade-offs with others (for instance SDG9 with industry electricity tax). Finally, tax increases will have a significant impact on future variation of some of the SDGs, particularly unemployment, economic growth, carbon emission, responsible production and consumption. The future variation effect of electricity tax on SDGs is more pronounced with industry taxes relative to household taxes. Furthermore, the evidence from the variance decomposition reveals that electricity taxes account for close to 50 per cent of the future variation in unemployment (SDG8W) and responsible production and consumption (SDG12) from the industrial sector, whereas it accounts for close to 18 to 22 per cent of the future variation of SDG8W and close to 9 to 13 per cent of the future variations of SDG12 from the household sector.

Our results have important policy implications. The double-dividend proposition of ETR with a specific reference to electricity taxation is a reality within the EU. Policy makers can achieve environmental goals such as reducing carbon emission with higher electricity taxes, especially on household electricity, which also has the added benefit of reducing unemployment if there is a strong revenue recycling policy that will reduce the labour cost of employers via a reduction in social security contribution or government investment spending in areas that will promote productivity. Correspondingly, the finding from the meta-analysis by Patuelli et al. (2005), which suggests that the employment benefits of such taxes are greatest when the generated revenue from such taxes are recycled into reducing social security contribution, provide the policy direction of such recycling policy.

Nonetheless, in the industrial sector, the electricity tax policy within the overall EU energy policy, based on our finding, implies that there is a need to reform the taxes, especially the electricity tax component, if the environmental benefit of such taxes is to be realised. The current EUETS policy and industry electricity tax policy does not encourage industry, especially electricity-intensive industries, to innovate and adopt production processes that are less polluting to the environment. Accordingly, the industry tax policy needs to be revised upwards if the overriding interest of EU policy makers is more on achieving environmental benefit relative to industry competitiveness.

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Appendix

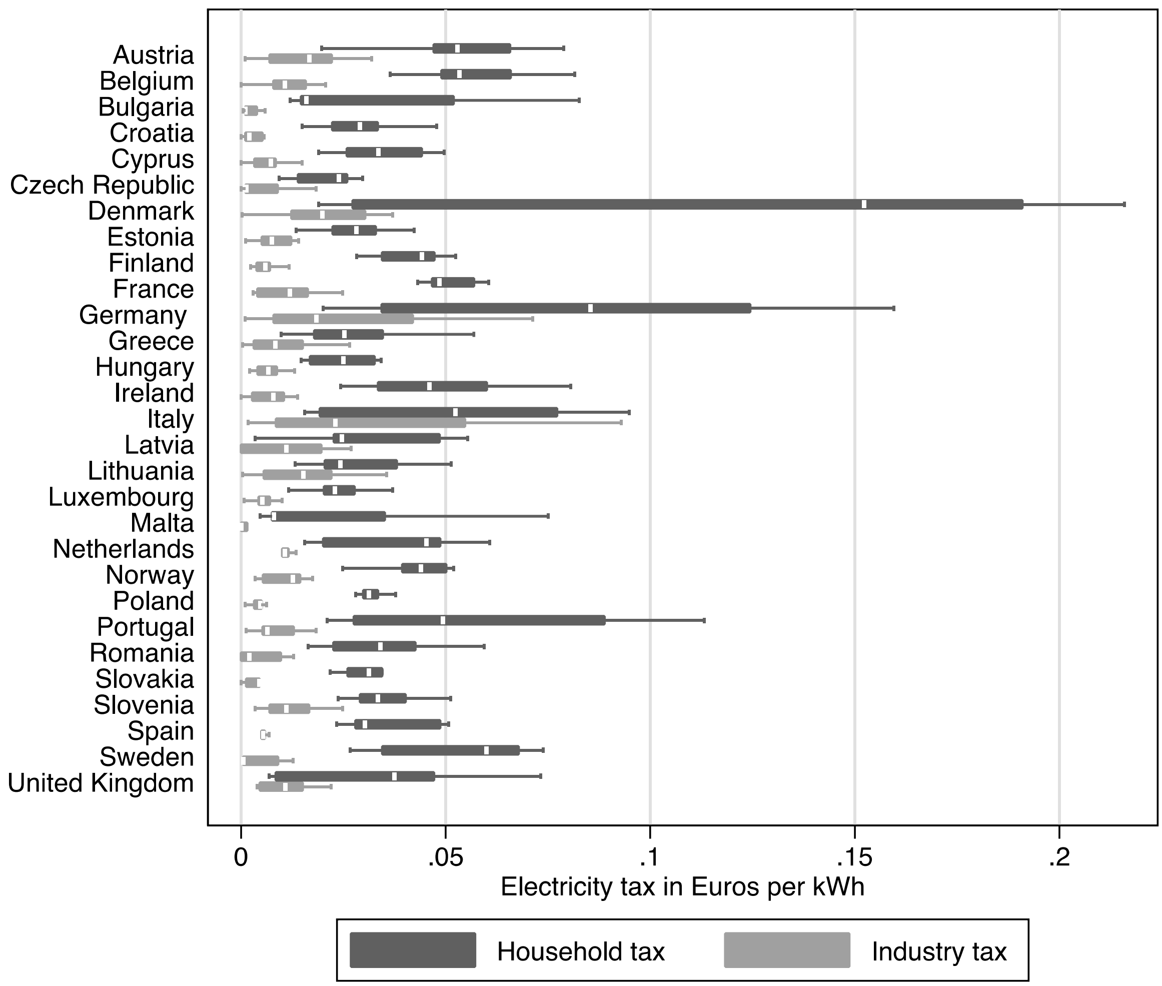

Figure A1: Distribution of EU-28 and Norway tax data for both households and firms