Energy costs and competitiveness in Europe
Preliminary draft *

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Abstract

The upswing in energy prices recorded worldwide in the last decade has placed at the center of the European policy debate the interaction between decarbonization strategies, increasing firms' energy expenditure and countries ability to export their products. Price competitiveness is usually assessed using labor costs neglecting the role of energy cost. In order to better understand present and future of firms' energy expenditure and to assess how energy policies affects the cost structure of European industry we propose a decomposable indicator - the Unit Energy Cost (UEC). We analyse how UEC evolved in different countries/industries and what have been its main drivers (prices, energy intensity, sector composition). Using a gravity model of bilateral export we find that the UEC is negatively associated with net export, with larger effects when the analysis is limited to the Euro area countries: we interpret this as an effect of the impossibility for these block of countries to realign their exchange rates to boost their competitiveness The policy implication of our results underline the need to push forward the integration of European energy markets (as envisaged in the Energy Union and in the Winter package) in order to avoid unduly effects of the ambitious long-term European decarbonization targets on the area ability to compete worldwide.

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Contents

1 Introduction

The upswing in energy prices recorded worldwide in the last decade has placed at the centre of the policy debate the effects of an increasing energy expenditure on firms' competitiveness. Even when oil and gas prices revert towards their historical lows, in Europe energy prices paid by industrial users are sustained by the high level of taxation and by the extra-costs imposed bythe European decarbonization objectives. The EU Emission trading scheme (EU ETS) together with the renewable energy and energy efficiency targets are somehow interfering with the price signals coming from international energy markets. This trends can influence sector specialization and shift the trade structure of the European countries impacting the exports of more energy-intensive goods in the region.

The European business community has often raised the issue of a growing gap in energy prices compared with the global competitors (e.g. US and China) that could hamper the competitiveness of many industrial activities, blaming the European decarbonization strategy and an overcautious approach in harnessing unconventional hydrocarbons, that in the United States are associated with a sharp drop of energy prices (European Commission 2014b).

Also European institutions are expressing their concern for the effect that ever-increasing energy prices can have on households' energy poverty and on the competitiveness of European firms. According to the European Competitiveness Report 2014, electricity pricse for industrial use are two times higher than in the US (gas prices three times), and the cost share of energy products affects extra-EU export competitiveness (European Commission 2014a).

Nevertheless EU climate and energy policies (Europe 2020, the Energy Union and more recently the Winter package) will probably involve a further rise in energy prices (for the extra-costs implied by a full-fledged EU ETS, RES subsidization, carbon taxation, etc.) with a potential detrimental effect on European industry competitiveness.[1]

Nonetheless the relevance of this issue, European statistics on business energy costs is scant, irregular and with a very limited level of disaggregation, a situation different from the attention that devoted to labour costs (Unit Labour Cost - ULC is one of the indicator monitored in the Country Macroeconomic Imbalance Procedure - MIP - of the European Union Commission)[2]. This data gap hinders the understanding of the link between energy costs and firms' features such as sector specialization, mark-ups' and, in general, firms' ability to compete on the international markets.

In order to better understand how energy and carbon policies impact firms' competitiveness, we propose a new formulation of the Unit Energy Cost (UEC), first proposed by Skou et al. (2009). We analyse how UEC has evolved in different countries/industries and what have been its main drivers (prices, energy intensity, sector composition).

For this purpose we merge Eurostat data - at a year*country*sector level - covering production, value added and energy balances. We also use the information on energy prices paid by industrial users for gas and power (this is data are available only at a year*country level). In order to understand how UEC does influence country competitiveness, this set of data is combined with information on external trade of EA countries at the industry level.

Using a gravity model of export growth we find that negative correlation between net export and UEC, and that this relationship is stronger when we limit the analysis to the Euro Area

[1]According to the 2017 World Energy Outlook, the European Union and Japan are the Regions with the highest electricity prices, driven by high fuel costs, taxes or other costs. Over time, prices in the European Union are set to rise being among the highest globally and energy-intensive industries will face competitive challenges where they are not exempted from elements of the electricity price (see fig 6.26 of IEA, 2017).

[2]The indicators used in the MIP scoreboard to measure price and cost competitiveness are the Real Effective Exchange Rate and the nominal Unit Labour Cost with the addition of the Export Market Share that accounts for any factors of export developments other than cost and price

(EA): we interpret this as a consequence for the firms operating in the EA countries to realign their exchange rates to offset and increase in energy costs. The policy implication of our results underline the need to push forward the integration of European energy markets (as envisaged in the Energy Union and in the Winter package).

The paper is organized as follows. Section 2 recaps the main results found in the literature on the relationships between energy costs, firms' performances and their ability to sell their products and services abroad. Section 3 introduces the UEC indicator, describe its main components and reports some descriptive results. In section 4 we present a set of models in order to analyze the relationship between energy costs and competitiveness, proxied by bilateral export. Finally, Section 5 presents our conclusions.

2 The literature on energy and competitiveness

There is a large body of studies that try to assess how energy costs may affect firms' performances, focusing on how a change in these costs impacts competitiveness indicators, such as investment, profitability, exports, employment or productivity. Many of these analyses are connected to the evaluation of the side-effects of environmental (e.g. pollution constraints) and/or energy policies (e.g. ETS and carbon taxation). For example, Arlinghaus (2015) reviews the empirical literature on the effects of carbon taxes and EU ETS on various indicators of competitiveness and finds that the examined works cannot confirm any significant *ex-post* adverse effects on competitiveness indicators.

In terms of the information used, some works rely on country panel data with sectoral-level disaggregation while other use detailed microdata at the firm or plant level.

Among the studies using firms or plant microdata the results are mixed. Some find a link between energy costs changes and firms' performances. Ratti et al. (2011) exploit data on non-financial firms in 15 European countries across 25 industries over 1991–2006 and observe that a 1 per cent increase in energy prices would reduce investment by 1.2%. Abeberese (2017), focussing on India, finds a connection between the cost of electricity and firms' productivity growth and production mix. For the Italian manufacturing sector, Faiella and Mistretta (2015) impute firm-level information on energy purchases for the period 2003-2011 and observe that higher energy costs reduce the companies' ability to increase revenue, especially abroad. Rentschler and Kornejew (2017) discover that higher energy prices are correlated with reduced profit margins, though the magnitude of the effect is small and it varies with different fuels and industries. Other studies don't find such a link. Martin et al. (2014), analysing carbon taxation of the UK manufacturing sector with plant-level data, observe that taxes decrease energy intensity but with no impacts on firms' performance. On the same tone, Flues and Lutz (2015), analysing a plant-level database of the German manufacturing sector for the 1995–2005, find no correlation among changes in electricity prices (induced by a reduction in tax exemptions) firms' exports sales and other firm performance measures. Also Gerster (2017), exploiting a similar local randomization, does not find evidence for short-run effects on gross output, exports and employment (although he finds a correlation with the amount of electricity used). Rammer et al. (2017), use firm-level data for three countries (Germany, Switzerland, and Austria) featuring similar industry structures but different energy policies and their findings suggest that these policies have no relevant influence on firms' international market position (because negative cost effects have been neutralised by the adoption of more efficient technologies).

The same uncertainty characterises the analyses that rely on sectoral-level data. Costantini and Mazzanti (2012), study how environmental regulation can affect the export of the manufacturing sector using sector-level data of 14 European countries and find that carbon energy taxes are either neutral or even positively correlated with export (an evidence of a Porter effect, Porter and van der Linde,1991). Sato and Dechezleprêtre (2015), using a panel dataset with 42 countries and 62 manufacturing sectors for the period 1996–2011, observe that changes in relative energy prices have a statistically but small impact on trade. Finally Kaltenegger et al. (2017), use an input-output approach to assess total energy costs and finds that indirect energy costs - estimated using the energy embodied in intermediate inputs - are on the rise and, in many industries, they are larger than direct costs. According to these authors also this cost component should be considered in assessing how energy expenditure influences firms' performance.

Although we believe that firms' level analysis is needed for a thorough understanding of the links between energy costs and firms' performance, as in Faiella and Mistretta (2015), we also think that, without the availability of a harmonized firm-level data set that allows full comparison across countries, using sector-level full comparable data are a plus when one wishes to evaluate energy policies and trends across EU countries. For this reason in the present paper we follow the suggestions of the European Commission of using a real unit energy costs indicator, defined as energy costs as a fraction of value added (European Commission 2014b).

Finally, even if competitiveness is a multi-dimensional concept that should be assessed using a set of price- and non-price indicators, in what follows we mainly focus on the former.

3 An indicator to assess firms' energy costs

3.1 Data

Like for the Unit Labour Cost (ULC), the idea of the Unit Energy Cost (UEC) is to develop a synthetic indicator that provides ready information on the amount of expenditure that an average firm operating in a certain sector faces in order to purchase the amount of energy that, given the technological constraints and the energy mix, is necessary to produce a unit of output.

As the ULC is a combination of wages and labour productivity, the basic ingredients to design the UEC of a country is to use take the product of energy prices P_e by the energy intensity $\frac{E}{Y}$ (the inverse of energy productivity) for different energy sources and industries within the Manufacturing sector.

$UEC = P_e \frac{E}{Y}$

Every piece of information used with the purpose of calculating the UEC is based on Eurostat data and hence it is fully comparable across EU countries.

We use National Energy Balances (NEB) to collect information on the quantity of energy required by each industry sector in a given year for every EU country; the information is available at sub-industry level with details on different energy sources.[3]

Comparable information on the prices paid by the industrial consumers, released bi-annually, are only available for electricity and natural gas.[4] The information on output comes from the National Accounts. [5]

We proxy country competitiveness using Eurostat trade data among European countries. Because there is no information on export at the industry level, we use a dataset that gives information on the bilateral trade at the product level according to CN8 classification. Starting

[3]This dataset reports information on the use of total oil products, natural gas, electricity, derived heat, solid fossil fuels, renewables and waste by these sub-industries: Iron and Steel/Non-Ferrous Metals, Chemical and Petrochemical, Non-Metallic Minerals, Mining and Quarrying, Food and Tobacco, Textile and Leather, Paper Pulp and Print,Transport Equipment, Machinery, Wood and Wood Products, Construction, Non-specified (Industry).

[4]Data are collected for different consumption bands. Since we there is not information on the level of consumption in each band we use the price of the median band.

[5]Data are aggregated according to Nace rev 2. We combine these information to obtain a level of aggregation that is coherent to the one used for energy data.

from this dataset we collect data for about 18,000 different products and we map the CN8 classification mapping into the Prodcom sectorization thus obtaining trade information at the industry level according to Nace rev. 2, at two digits level, classification.[6]

3.2 The UEC and its components

As previously shown, energy costs are estimated using Eurostat data on energy use in physical terms by different industries and countries. The quantities used in manufacturing (with specific information on electricity, gas, coal, renewable and oil) is available from the NEBs while energy prices are approximated using the information on electricity and natural gas prices paid by industrial users. Since we don't have a price for each energy sources considered, we extend the contribution of gas and electricity prices to the UEC to all other sources: in details we compute the share of gas and electricity on industry final use and we employ this share in order to inflate the UEC based only on those two fuels. This probably results in an overestimation of the UEC given that it is reasonable to suppose that the sources excluded from the computation (coal, fuel oil, etc.) are cheaper than electricity and natural gas; the shrinking trend of these sources should limit the upward bias of our estimates.

The general formula for the UEC results the following:

$$UEC = \frac{EC}{VA}.$$

This indicator, that tells us what is the contribution of energy costs (EC) as a percentage of the value of production (VA), can be estimated at different levels of aggregation, allowing us to analyse it at the EU, country or industry level; moreover it can be easily decomposed in its sub-components to identify the main drivers of its dynamics.

In particular we have:

$$UEC_{EUt} = \frac{\sum_{sie} K_{siet}(P_{set}+\tau_{set})}{\sum_{si} VA_{sit}} = \sum_{si} \frac{VA_{st}}{\sum_s VA_{st}} \frac{VA_{sit}}{\sum_i VA_{sit}} \frac{\sum_e K_{siet}(P_{set}+\tau_{set})}{VA_{sit}} =$$
$$= \sum_s z_{st} \sum_i q_{sit} UEC_{sit}$$

where $q_{sit} = \frac{VA_{sit}}{\sum_i VA_{sit}}$ represents the share of sector i in state s at time t with respect to the entire manufacturing sector and $z_{st} = \frac{VA_{st}}{\sum_s VA_{st}}$ is the contribution of manufacturing of state s with respect to the total EU manufacturing.

Considering the EU UEC dynamics, computed as a difference in percentage points, we can derive the following identities:

$$\triangle_t UEC_{EU} = \underbrace{\sum_s z_{st-1} \sum_i q_{sit-1} \sum_e (\widehat{P}_{siet-1} + \widehat{\tau}_{set-1}) \triangle_t I_{ies}}_{Energy\ intenity\ effect} +$$
$$+ \underbrace{\sum_s z_{st-1} \sum_i q_{sit-1} \sum_e I_{siet} \triangle_t \widehat{P}_{sie}}_{Price\ effect} + \underbrace{\sum_s z_{st-1} \sum_i q_{sit-1} \sum_e I_{siet} \triangle_t \widehat{\tau}_{se}}_{tax\ effect} +$$

[6] Prodcom is composed by 8 digits where the first 4 are related to the correspond Nace rev. 2 classification. Using this code we are able to aggregate data at industry level. For more details see http://ec.europa.eu/eurostat/web/prodcom.

$$+ \underbrace{\sum_s z_{st-1} \sum_i UEC_{sit} \triangle_t q_{si}}_{Sectoral\ \ composition\ \ effect} + \underbrace{\sum_s UEC_{st} \triangle_t z_s}_{Country\ \ composition\ \ effect}$$

According to this decomposition, we can single out 5 drivers (more details are available in Appendix A): 1) The *Intensity effect* gives us information on how energy efficiency is evolving in time in different industries 2) The *Price effect* accounts for the developments of the unit costs of the energy sources considered (gas and electricity); 3) The *Tax effect* is similar to the Price effect but concerns taxation and levies. 4) The *Sectoral composition effect* describes how changes in industry structure influence total energy costs (e.g. because of the relative decline/increase of sector contribution to total production). 5) The *Country effect* affects the UEC according to the relative weight of different EU economies. The first three drivers can be assessed separately for electricity and gas.

3.3 Some descriptive results

Figure 1 reports the UEC trends for the EU and the EA and it shows the increasing relevance of energy costs: in the last decade a steep acceleration of this trend has materialized, and the UEC almost doubled, moving from 2.5% in 2000 to 4,0% in 2015. In the period considered, the EU UEC is greater than the EA UEC.

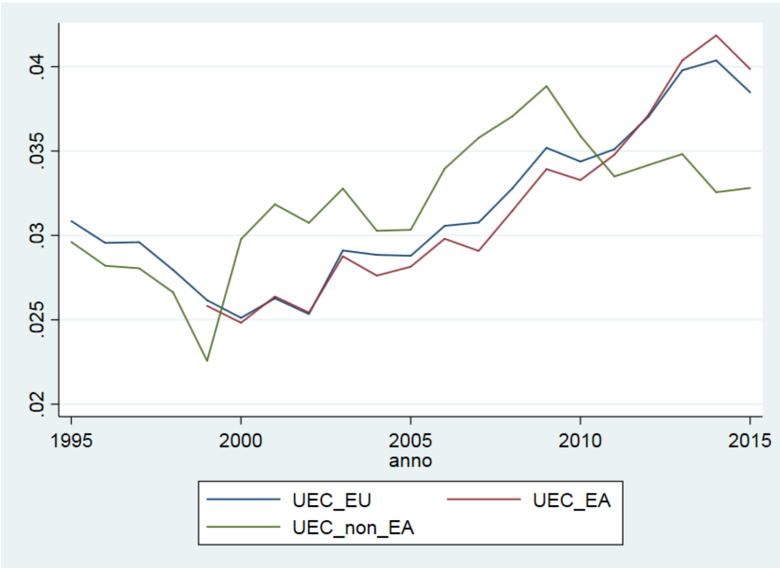

Figure 1. Comparison UEC, EU, vs EA

In order to understand what are the main drivers of EU UEC dynamics for European countries, as discussed in section 3.2, we analyse their year on year contributions (Figure 2). Until 2001 electricity prices give a negative contribution to UEC changes, while after that year they result the most important driver . The opposite is true for electricity intensity, whose contribution in UEC growth has constantly decreased (with the only exception of 2003). In more recent years, taxation, in particular on electricity that includes also the levies collected to support renewable energy, has becoming increasingly important.

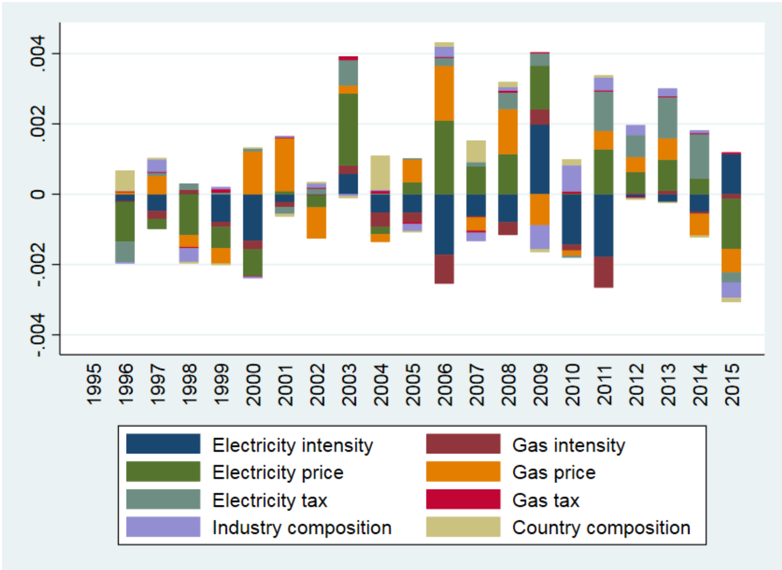

Figure 2. EU UEC dynamics, y-o-y contributions

Finally, country composition effect seems to be relevant in those years where new countries accessed the EU probably because the UEC of these countries is larger than the EU average.[7]

Another way to analyse the evolution of EU UEC is considering the cumulative growth of its components in the last 20 years. From the Fig. 3 we observe that: 1) Energy intensity (both for gas and electricity) decreased over time, suggesting a constant improvement in the level of energy efficiency (in particular for gas). 2) Price dynamics (especially for electricity) have been particularly important in defining the EU UEC. 3) Fiscal and parafiscal components have played a key role in UEC growth. The observed trends are very similar when we focus at the evolution of the UECs in the bigger EU countries (see fig. 6 and 7).

[7]From 2004 EU includes Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia; from 2007 it also includes Bulgaria and Romania.

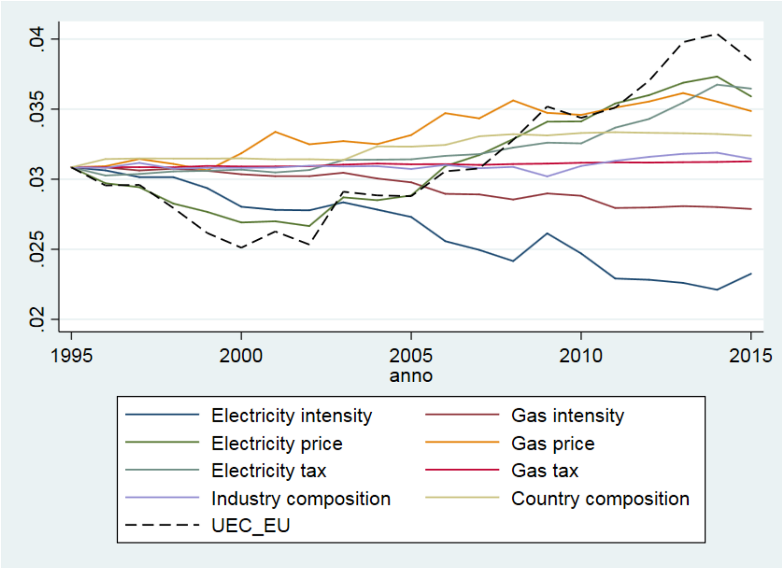

Figure 3. EU UEC, cumulative contributions

In the event that the future EU UEC changes will be governed by the same drivers, EU and National institutions should be aware of the risk that a renewed vigour in European climate policies could represent in terms of higher energy costs of the European manufacturing. Without a coordinated global action, higher energy costs could affect the price attractiveness of European goods and this in turn could hamper European competitiveness. The relationship between energy costs and trade competitiveness is the topic that we are going to investigate in the next section.

4 Econometric analysis

As section 2 showed there are various channels through which higher energy costs can hamper firms' competitiveness. We harness the detailed dataset with bilateral trade information for each EU country, described in section 3.1, exploiting a trade gravity model where information about exporter and importer are used as regressors with other covariates used to control for unobserved fixed effect that can influence the trade relationship between countries in each specific industries.

But before moving to analyze how energy costs do influence competitiveness, we briefly discuss the relationships that links renewables (RES) support schemes and the increase in UEC.

4.1 Renewable support and UEC

In the last decade there has been a growing attention to RES development as a key strategy to decarbonize the energy systems. RES deployment has become a priority since the international agreement on the Kyoto Protocol in 2005 (during the COP3). In order to achieve the decarbonization goals envisaged by the protocol, the EU devised the Europe 2020 strategy that requires a specific targets on RES deployment: in 2020 RES should contribute to about 20% to energy demand. This EU-wide objective has been translated in national targets by each country (burden sharing) .

This decarbonization process have had a significant economic impact, in particular for that group of countries (notably Italy, Germany and Spain) that invested substantially in financing RES deployment, collecting the needed resources mainly through levies on electricity.

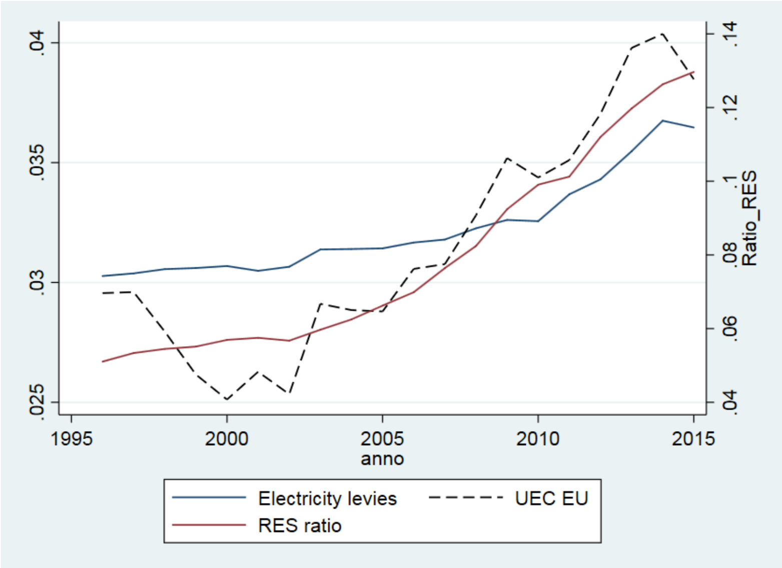

Figure 4. EU UEC, RES deployment and financing

As it is shown in Fig. 4, it is clear that RES financing seriously affected electricity levies and consequently the EU UEC. To better understand the nature of this link we run a set of regressions that explain the UEC changes with the indirect impact of RES on firms electricity consumption, using different specifications: our results show a strong effect of RES[8] deployment on EU UEC (see columns 1 and 5 in Table 1).

$$RES_{ist} = \frac{Electricity_{ist}}{TotalEnergy_{ist}} \frac{RES_{st}}{ElectricityProduced_{st}}$$

However, these results could be affected by a reverse causality problem (e.g. the share of RES could be industry-specific according to their different deployment costs). To avoid this we adopt the follow IV strategy. As said, the RES deployment in EU countries is related to the enforcement of the *Europe 2020* strategy. This should be exogenous with respect to the single industry of a particular country. If RES deployment influences energy costs (and therefore the country UEC), probably these additional costs should be related not only with the county target but also with the relative effort of the country in order to achieve it.

For this reason we define a variable $effort_{it}$ that is informative on the endeavour of each country s at time t in order to achieve the national $target_t$

$$effort_{st} = \frac{RESshare_{st}}{target_s}$$

Following the approach proposed by Abeberese (2017), that uses the generation power mix as an instrument for electricity price, we employ as instrument for RES dynamics (ΔRES_{ist}) the progression towards the effort $\Delta effort_{st}$ interacted with a dummy for the period in which Europe 2020 has become compulsory (columns 2 and 6 in Table 1) and, additionally, the level of the national RES target (see columns 3-4 and 7-8 in Table 1).

Our estimates finds a causality link between RES deployment and industries' energy cost for European countries; in particular RES deployment caused an average raise the UEC that ranges

[8]We consider the RES share as the product of the share of electricity in the firm energy mix by the RES contribution to the national power energy mix.

between 0.29 and 0.48 percentage points. This average effect reflects a large heterogeneity among EU countries. It is possible that countries use different policies: for example one country decides to subsidy RES mainly shifting the costs on firms while the other decides to put the financial burden on households (as happened in Germany). These differences might change how UEC does affect countries' competitiveness, that is the topic of the next section.

4.2 UEC and export competitiveness

In order to explore how UEC does influence trade, we estimate a gravity model using European data. In the last 40 years, gravity models have been extensively used in the trade literature for their empirical robustness and explanatory power (Kepaptsoglou, Karlaftis, and Tsamboulas 2010); in the last years this class of models has become the main tool for estimating bilateral trade (Egger and Pfaffermayr 2003).

Since the seminal paper by Santos Silva and Tenreyro (2006), the empirical literature suggests to adopt the Poisson quasi maximum likelihood (PQML) in order to estimate gravity models. This estimation procedure allows to deal with a large number of zero values and with the presence of a high level of heteroscedasticity, and the resulting estimator performs better than the alternatives in term of bias.

According to the literature, to avoid biased estimators (Baldwin and Taglioni 2006), besides considering bilateral trade, uni-directional bilateral flows should be considered;[9] additionally all trade information should be considered in nominal terms. In this type of models, bilateral export is modeled using a specification in which demand and supply factors are use as controls: typically among the regressors are included GDP, population size and other variables deemed relevant (e.g. the distance between countries is included to proxy the barriers to trade).[10]

The specification of our model is the following:

$$Exp_{spit} = \alpha X_{sit} + \omega W_{pt} + \beta UEC_{sit} + t + \lambda_{spi} + \epsilon_{spit}.$$

where Exp_{spit} is the uni-directional bilateral trade flowing from country s to country p of goods produced by industry i at time t; additionally, X_{sit} includes controls for the exporter country (s) and W_{pt} for the commercial counterpart (p); controls are the GDP and per capita GDP. Moreover, since the UEC includes only information on electricity and natural gas, we also include the share of other energy sources that are consumed at the industry level not included in the UEC and the industry-country specific Unit Labor Cost (ULC). Finally we include a fixed effect λ_{spi} at industry-country-partner level.

According to our estimates we observe a negative relation, statistically different from zero, between the UEC and exports.

INSERT HERE TABLE 2

These results are robust under different specifications of the model and using various strategies to compute standard errors. Our estimates support the hypothesis that industries/countries with an higher UEC have a lower level of export, i.e. energy costs are important for country competitiveness, and they are coherent with the existing literature (see for example Sato at al. 2015).[11]

[9] Meaning export: the previous literature used an average between import and export but this might lead to biased estimators.

[10] There is an intense debate regarding the inclusion of fixed effects in panel data analyses: according to Egger and Pfaffermayr (2003), models including bilateral effects dominate those with main effects and a selection of observable time-invariant variables; however, the inclusion of fixed bilateral effects makes it impossible to directly estimate the coefficients of time-invariant observables (like distance).

[11] The coefficients reported in Table 2 and following are parameters estimated witha a PQML and as such they can be interpreted as elasticities. See Gourieroux, 2000.

This result appear to be larger when only European partners are considered (see columns (3)-(5)).[12]

As a robustness check, we collapse the data in two years pair and we estimate the same specification, obtaining similar results (col (1)-(3), Tab 3).

We are aware that our estimator could be affected by a problem of reverse causality: for instance firms more exposed on the internationals markets may decide to invest more in energy efficiency changing also their energy mix (and therefore their energy cost structure).

We try to deal with this problem including lags of the UEC among the regressors (one-lag, col (4)-(6), and two-lags, col (7)-(9) of Tab 3). Since we are using a bi-annual dataset we are assessing the impact of the UEC in a 4-years time span.

Also this specification confirms that energy costs matter for competitiveness, and even in this case UEC plays a more important role when we limit the analysis to EU countries.

4.3 The adoption of the Euro as a natural experiment

To better grasp the link between energy costs and competitiveness we use the adoption of the Euro as a specific event who constrained the pricing strategy of the EA members manufacturing firms (see for example Bayoumi et al., 2011).

Because EA members cannot modify their exchange rate to improve their terms of trade, a persistent rise in the euro-wide UEC can advantage countries with lower energy costs (because they are endowed with domestic energy inputs or they have less ambitious climate and energy policies - relying on the cheaper fuels disregarding their effects on the environment - or they shield industrial users from taxation on energy products).

Within a currency area the rebalancing of countries with current account deficits requires deflationary adjustment such as fiscal contraction and/or internal devaluation. The literature on internal devaluation usually considers differences in ULCs and it finds that countries with lower labor costs exhibit an higher degree of competitiveness. In particular, Myant et al. (2016) observe that during the double-dip recession internal devaluation has been used in order to reduce current account imbalances; Angelini et al. (2015) compare the experiences of internal devaluation in Germany and Spain and find that lower wage and price mark-ups led to an increase in competitiveness; Stockhammer and Sotiropoulos (2014) estimate the effect on current account of domestic demand and ULC in order to assess the costs of internal devaluation.

In line with this literature, we want to examine if low-UEC countries have a competitive edge over the others. Since our data coverage starts from 1995, we can analyse how (and if) the adoption of the common currency has changed the relationship between UEC and export dynamics (in practice we test if the adoption of Euro caused a change in the elasticity of export to UEC).

As in section 4.2 we maintain the structure of our gravity model using socio-economic characteristics of both exporter and importer countries and bilateral fixed effects that absorb time invariant unobserved variables.

Before studying if different energy costs affect trade differently for countries belonging to the EA, it is interesting to analyse if adopting the Euro has boosted *per se* the trade opportunities within the common currency area.

[12]For comparability we decide to use Eurostat data; this prevent us to have information for some counterparts like China, U.S. and the Rest of the World. For this reason in the first column of Table 2 we don't have counterparts' information as control variables. To disentangle how much our results depends on the sample composition or the controls considered, in col (3) we exclude trade flows to China, U.S. and the Rest of the World.

The hypothesis that EMU has no effect on trade/exports does not seem consistent with the literature. Since Glick and Rose (2002) a large body of literature has investigated this issue. Most of the studies has found a large and positive effect on trade; more recently, Glick and Rose (2016) downward revised their results. Rose (2017) provides a short review of the papers on the EMU effect on trade:[13] he finds that there are about 45 papers on this topic and only six of them report negative effects, while all the others are positive. According to the author, the extent of the estimates of the EMU on trade (that according to most of the studies boosted trade by about 20%) is different because different countries and years are selected to define the sample. Camarero et al. (2018) find that the effect of the euro on trade has been positive and significant also on foreign direct investment (that have also contributed to increase trade). A different voice comes from Mika and Zymek (2017) that, focussing on the experience of countries that recently joined the EA, revise the trade benefits of euro membership arguing that *estimates from an appropriately specified and estimated gravity equation do not support the notion of a euro effect on trade flows based on the experience of euro adopters to date.*

To test how the effect of joining the EA is related to the UEC, following Santos Silva and Tenreyro (2010), we use a diff-in-diff approach in a gravity model framework where the treated is the group of countries that joined the EA while the control group is composed by the EU countries that didn't join (e.g. the UK, Denmark, Sweden etc...), since these countries are subject to the same institutional setting (the EU trade framework).

In Figure 5 we compare the export of countries that join the EA with the export of those that are only in the EU; the trends between the two groups diverges clearly since 1999, when Euro was adopted. The same happens when focusing only on countries that belonged to the EU in 1995 and joined the EA in 1999 (labelled as "EU1995-EA1999 countries" in Fig. 5).

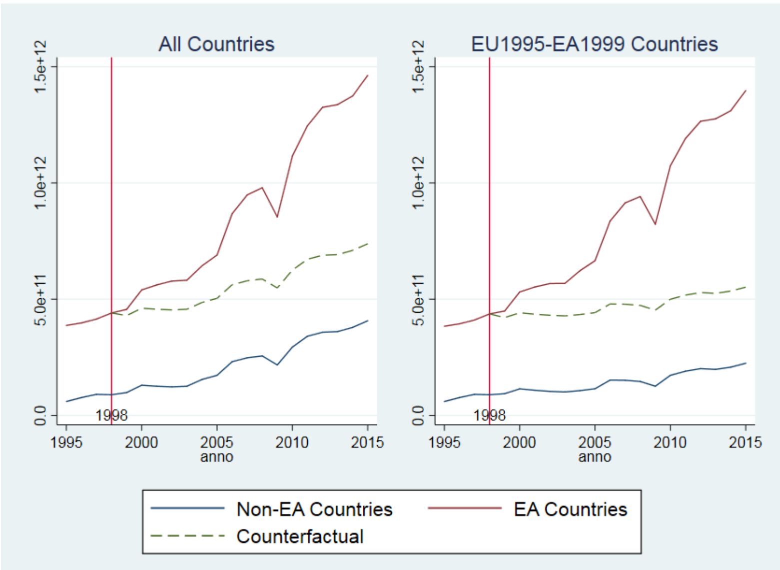

Figure 5. Export, in levels

In line with the empirical literature, in the model we use as controls also a set of interactions of time-dummies together with the bilateral fixed effects, in order to take into account that not

[13] There are several papers that review this literature like Rose (2005) and Havranek (2010).

all countries joined the EA (the treatment) in the same year.[14]

We estimate the following model:

$$Exp_{spit} = \alpha X_{sit} + \omega W_{pt} + \beta UEC_{sit} + \nu EU_{st} + \theta EU_{pt} + \varphi EA_{st} + \psi EA_{pt} + t + \lambda_{spi} + \epsilon_{spit}.$$

where EA_{st}/EA_{pt} is a dummy equal to one if country s/partner p joined the EA at time t (the same representation is used for the EU dummy). According to this specification φ represents the causal effect on export of belonging to EA. Results presented in Table 4 confirms that joining the EA has a positive effect on trade, in line with most of the studies available in the literature: this effect is larger when only intra-EU trade is considered (see col (3)-(6)). Moreover our estimates confirm that belonging to the EA has a positive effect on trade whatever the counterpart.

As previously explained, our main interest is related to the heterogeneous effect of joining the EA according to different level of UEC or, from another point of view, how does the relevance of energy costs for price-competitiveness change when a country lose control on its exchange rate. To better understand this mechanisms we add to the previous diff-in-diff model the interaction between UEC and the treatment dummy variables. This new specification is the following:

$$Exp_{spit} = \alpha X_{sit} + \omega W_{pt} + \beta UEC_{sit} + \nu EU_{st} + \theta EU_{pt} + \varphi EA_{st} + \psi EA_{pt} + \psi EA_{s} * UEC_{sit} + \\ \varrho EU_{st} * UEC_{sit} + \rho EU_{pt} * UEC_{sit} + \phi EA_{st} * UEC_{sit} + \pi EA_{pt} * UEC_{sit} + t + \lambda_{spi} + \epsilon_{spit}.$$

where the parameters we are interested in ϕ.

Table 5 shows the parameters of this model and the results confirm that UEC effect on trade has been heterogeneous among countries that adopted the Euro or not: those that joined the EA show a larger (and negative) elasticity of UEC to trade. This is further amplified when we limit the analysis to intra-EA trade (cols (4)-(5)). Additionally, to avoid the risk that our results are somehow influenced by a trend that links UEC and trade, we include a common time trend ($t * UEC_{sit}$; see cols (2), (3) and (5)); also this specification corroborate that UECs matter for international competitiveness.[15]

5 Conclusions and future research

The EU is the world biggest trader, accounting for 16.5% of the world imports and exports and free trade among its members is one of the EU founding principles. The Economic and Monetary Union took the EU one step further in its process of economic integration with clear benefits in terms of lower transaction costs for firms and consumers, greater price transparency and encouraging inward investments. At the same time the EA members lost the possibility to depreciate their currency in case they need to rebalance their price competitiveness.

Since 2007, the EU started to pursue a common climate and, de facto, energy policy taking the leadership in the climate arena establishing targets (for climate, renewable energy and energy efficiency) and setting up the biggest cap-and-trade system in the world. Since then these policies, although lately with less political emphasis, have been reiterated and extended to 2030 (with the Energy Union and the Winter package). We are now waiting for the definition of the EU long-term policies that should give substance to the vision of the 2050 roadmap.

[14] The majority of EA countries adopted the euro in 1999 and we model this circumstance using a common time trend instead of a standard pre/post treatment dummy.

[15] Shang et al. (2017) , following Puhani (2012), argue that in case of non-linear models (in particular with a Poisson link function), the interaction parameters cannot be considered as the difference in semi-elasticity and propose a solution to fix this issue; in the bottom of Table 5 we propose estimates for the interactions that use the same kind of adjustment.

How these different strategies interact is not completely understood. On one side the adoption of the Euro has been beneficial for those country, like Italy, that are purchasing most of their energy abroad. Euro revaluation against the dollar, has shielded the country from the price spike happened in the last decade of the 2000. On the other hand, EU climate and energy policies are putting upward pressure on energy prices (for the extra-costs implied by a full-fledged EU ETS, RES subsidization and carbon taxation) with a potential detrimental effect on European industry competitiveness. Our estimates finds a causality link between RES deployment and industries' energy cost for European countries; in particular RES deployment caused an average raise the UEC that ranges between 0.29 and 0.48 percentage points. This average effect reflects a large heterogeneity among EU countries. If the effects of these policies on the UEC and hence on competitiveness will be similar of what happened in the past we can expect that EU manufacturing sector will be seriously impacted unless similar policies are adopted across the board at the global level.

In order to better understand how energy and carbon policies impact firms' competitiveness, we propose a new formulation of the Unit Energy Cost (UEC) - merging Eurostat data at a year*country*sector level that cover production, value added and energy balances - and we analyse how UEC has evolved in different countries/industries and what have been its main drivers (prices, energy intensity, sector composition).

Using a gravity model of export growth we find that negative correlation between net export and UEC, and that this relationship is stronger when we limit the analysis to the EA: we interpret this as a consequence for the firms operating in the EA countries to realign their exchange rates to offset and increase in energy costs.

The policy implication of our results underline the need to push forward the integration of European energy markets (as envisaged in the Energy Union and in the Winter package).

Finally, as it happens for the ULC, we suggest to use a energy cost indicator in monitoring country competitiveness: a possibility is to add the UEC in the Countries' MIP prepared by the European Commission. This would add information compared with the current analyses that only asses differences in energy prices (that have no information neither on the quantity nor on the level or the evolution of energy intensity). Filling this data gap would improve the understanding of the link between energy and climate policies, firms' costs and firms' features such as sector specialization, mark-ups' and, in general, EU firms' ability to compete on the international markets.

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A Appendix: UEC decomposition

$\triangle_t UEC_{si} = UEC_{sit} - UEC_{sit-1} =$

$= \frac{\sum_e K_{siet}(P_{set}+\tau_{set})}{VA_{tis}} - \frac{\sum_e K_{siet-1}(P_{set-1}+\tau_{set-1})}{VA_{sit-1}} = \frac{\frac{\sum_e K_{siet}(P_{set}+\tau_{set})}{defl_{sit}}}{\frac{VA_{sit}}{defl_{sit}}} - \frac{\frac{\sum_e K_{siet-1}(P_{set-1}+\tau_{set-1})}{defl_{sit-1}}}{\frac{VA_{sit-1}}{defl_{sit-1}}} =$

$= \frac{\sum_e K_{siet}(\widehat{P}_{siet}+\widehat{\tau}_{siet})}{\widehat{VA}_{tis}} - \frac{\sum_e K_{siet-1}(\widehat{P}_{siet-1}+\widehat{\tau}_{siet-1})}{\widehat{VA}_{sit-1}}$

where $\widehat{P}_{siet} = \frac{P_{set}}{defl_{sit}}; \widehat{P}_{siet} = \widehat{P}_{siet-1} + \triangle_t \widehat{P}_{sie}$;
$\widehat{\tau}_{siet} = \widehat{\tau}_{siet-1} + \triangle_t \widehat{\tau}_{sie}$ and $\widehat{VA}_{sit} = \frac{VA_{sit}}{defl_{sit}}$

we define energy intensity as $I_{sit} = \frac{\sum_e K_{siet}}{\widehat{VA}_{tis}}$

$= \sum_e I_{siet}(\widehat{P}_{siet-1} + \triangle_t \widehat{P}_{sie} + \widehat{\tau}_{siet-1} + \triangle_t \widehat{\tau}_{sie}) - \sum_e I_{siet-1}(\widehat{P}_{siet-1} + \widehat{\tau}_{siet-1}) = \sum_e (\widehat{P}_{siet-1} + \widehat{\tau}_{siet-1})(I_{siet} - I_{siet-1}) + \sum_e I_{siet}(\triangle_t \widehat{P}_{sie} + \triangle_t \widehat{\tau}_{siet}) = \underbrace{\sum_e (\widehat{P}_{siet-1} + \widehat{\tau}_{siet-1}) \triangle_t I_{ies}}_{Energy\ \ intensity\ \ effect} +$

$\underbrace{\sum_e I_{siet} \triangle_t \widehat{P}_{sie}}_{price\ \ effect} + \underbrace{\sum_e I_{siet} \triangle_t \widehat{\tau}_{sie}}_{tax\ \ effect} = \triangle_t UEC_{si}$

$\triangle_t UEC_s = \sum_i q_{sit} UEC_{sit} - \sum_i q_{sit-1} UEC_{sit-1} =$

$= \sum_i q_{sit} UEC_{sit} + \sum_i q_{sit-1} UEC_{sit} - \sum_i q_{sit-1} UEC_{sit} - \sum_i q_{sit-1} UEC_{sit-1} == \sum_i q_{sit-1}(UEC_{sit} - UEC_{sit-1}) + \sum_i UEC_{sit}(q_{sit} - q_{sit-1}) =$

$= \sum_i q_{sit-1} \triangle_t UEC_{si} + \sum_i UEC_{sit} \triangle_t q_{si} = \triangle_t UEC_s$

$\triangle_t UEC_{EUt} = \sum_s z_{st} UEC_{st} - \sum_s z_{st-1} UEC_{st-1} =$

$= \sum_s z_{st} UEC_{st} + \sum_s z_{st-1} UEC_{st} - \sum_s z_{st-1} UEC_{st} - \sum_s z_{st-1} UEC_{st-1} == \sum_s z_{st-1}(UEC_{st} - UEC_{st-1}) + \sum_s UEC_{st}(z_{st} - z_{st-1}) =$

$= \sum_s z_{st-1} \triangle_t UEC_s + \sum_s UEC_{st} \triangle_t z_s = \triangle_t UEC_{EU}$

plugging in the previous results, we obtain

$== \underbrace{\sum_s z_{st-1} \sum_i q_{sit-1} \sum_e (\widehat{P}_{siet-1} + \widehat{\tau}_{set-1}) \triangle_t I_{ies}}_{Energy\ \ intenity\ \ effect} +$

$+ \underbrace{\sum_s z_{st-1} \sum_i q_{sit-1} \sum_e I_{siet} \triangle_t \widehat{P}_{sie}}_{Price\ \ effect} + \underbrace{\sum_s z_{st-1} \sum_i q_{sit-1} \sum_e I_{siet} \triangle_t \widehat{\tau}_{se}}_{tax\ \ effect} +$

$$+\underbrace{\sum_s z_{st-1}\sum_i UEC_{sit}\triangle_t q_{si}}_{Sectoral\ \ composition\ \ effect}+\underbrace{\sum_s UEC_{st}\triangle_t z_s}_{Country\ \ composition\ \ effect}=\triangle_t UEC_{EU}$$

B Figures

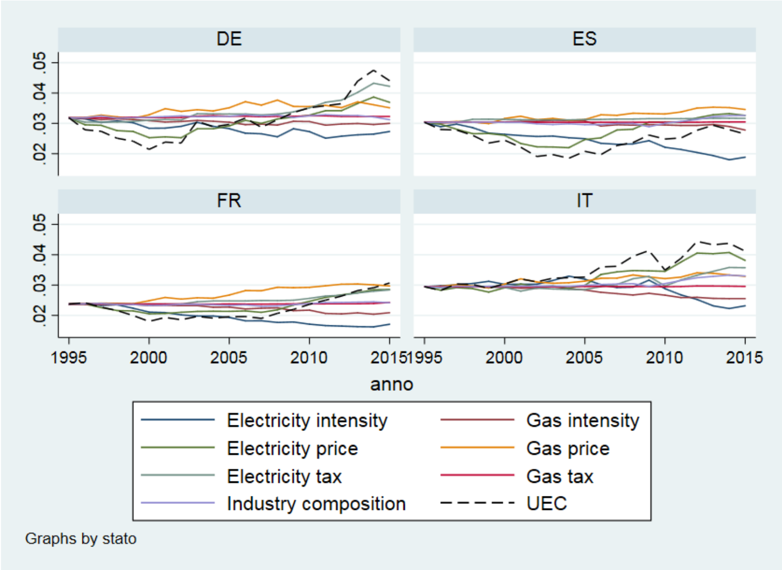

Figure 6. UEC cumulative contributions. Germany, France, Italy and Spain.

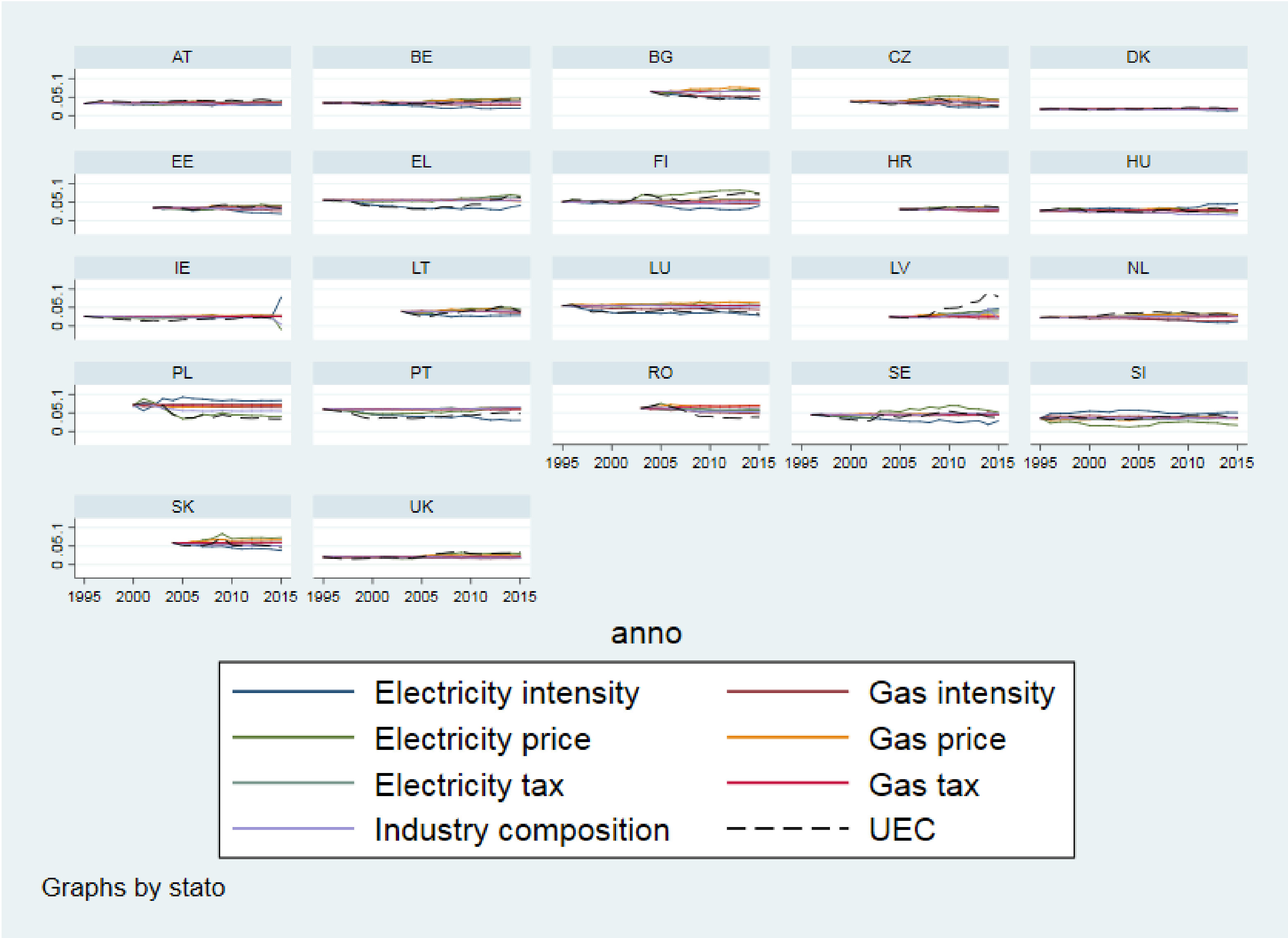

Figure 7. UEC cumulative contributions. EU Countries.

C Table

Table 1. EU UEC and RES

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Res	.0479***	.0437***	.0334***	.0293***	.0479	.0437*	.0334*	.0293*
	(0.005)	(0.000)	(0.000)	(0.000)	(0.127)	(0.053)	(0.051)	(0.068)
N	10,903	10,903	10,903	10,903	10,903	10,903	10,903	10,903
r2	.063	.0342	.0329	.0607	.063	.0342	.0329	.0607
fe	yes	no	no	yes	yes	no	no	yes
method	OLS	2SLS	2SLS	2SLS	OLS	2SLS	2SLS	2SLS
SE	cluster id	cluster id	cluster id	cluster id	cl country	cl country	cl country	cl country

p-values in parentheses
Dependent variable is the ΔUEC in percetage points. All regressions include a country-specific quadratic trend as a FE. Cols (1) and (5) report OLS estimates. Cols (2)-(4) and (6)-(8) show IV 2SLS estimates. Models (2) and (6) use the share of RES at time t over the share of RES 2020 target as an instrument; models (3), (4), (7)-(8) add as an instrument the share of 2020 RES target. In all specification weak instrument hypothesis is rejected.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2. EU Export and UEC: estimate in levels

	(1)	(2)	(3)	(4)	(5)
UEC	-.0573***	-.0573**	-.0829***	-.0798***	-.0798***
	(0.00)	(0.03)	(0.00)	(0.00)	(0.00)
ULC	-.407***	-.407***	-.403***	-.407***	-.407***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Gdp per capita	2.63***	2.63***	2.91***	2.66***	2.66***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Gdp	-1.87***	-1.87***	-2.04***	-1.83***	-1.83***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Gdp per capita partners				1.15***	1.15**
				(0.00)	(0.03)
Gdp partners				-.508***	-.508
				(0.00)	(0.36)
N	309,587	309,587	246,724	246,724	246,724
r2					
SE	robust	cluster id	cluster id	robust	cluster id

p-values in parentheses
The dependent variable is the level of the uni-directional bilateral trade flow (export) for European countries vs the other European countries, USA, China and the rest of the world. Cols (3)-(5) exclude flow to USA, China and the rest of the world. Al estimates include fixed and year effects and are estimated using PQML procedure.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3. EU UEC: estimate in log-levels with lags

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
UEC	-.0911***	-.143***	-.139***	-.0925***	-.128***	-.124***	-.0993***	-.119***	-.118***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
CLUP	-.401***	-.359***	-.363***	-.345***	-.284***	-.288***	-.32***	-.262***	-.26***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Gdp per capita	2.7***	3.11***	2.85***	2.81***	3.25***	2.97***	2.71***	3.08***	2.8***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Gdp	-1.93***	-2.23***	-2.01***	-2.1***	-2.33***	-2.09***	-2.18***	-2.3***	-2.05***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Gdp per capita partners			1.19**			1.27**			1.32**
			(0.02)			(0.02)			(0.01)
Gdp partners			-.512			-.57			-.602
			(0.34)			(0.29)			(0.27)
N	168,860	136,521	136,521	148,867	123,100	123,100	130,426	110,421	110,421
r2									
SE	robust	robust	cluster id	robust	robust	cluster id	robust	robust	cluster id

p-values in parentheses
The dependent variable is the level of the uni-directional bilateral trade flow (export) for European countries vs the other European countries, USA, China and the rest of the world. Cols (2), (3), (5), (6), (8) and (9) exclude flow to USA, China and the rest of the world. Regressors are the log transformation of the biannual average. Regressions (1)-(3) consider contemporaneus regressors; regressions (4)-(6) consider one lag regressors; (7)-(9) consider the second lag for the reressors. In all regressions we controll for the industries' energy mix and we include time dummies and FE.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4. EA diff in diff

	(1)	(2)	(3)	(4)	(5)	(6)
EA_{st}	.158***	.157***	.187***	.19***	.187***	.191***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
EA_{pt}		-.0973***			.0528	.043
		(0.01)			(0.12)	(0.19)
EU_{st}	.113*	.0853	.0478	.054	.0386	.0538
	(0.06)	(0.16)	(0.42)	(0.37)	(0.51)	(0.37)
EU_{pt}		.323***			.267***	.0296
		(0.00)			(0.00)	(0.50)
UEC	-.0535**	-.0552**	-.0804***	-.0773***	-.0822***	-.0774***
	(0.04)	(0.03)	(0.00)	(0.01)	(0.00)	(0.01)
ULC	-.384***	-.38***	-.381***	-.385***	-.378***	-.386***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Gdp per capita	2.43***	2.32***	2.74***	2.49***	2.65***	2.48***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Gdp	-1.72***	-1.6***	-1.92***	-1.7***	-1.82***	-1.69***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.01)
Gdp per capita partners				1.11**		1.04*
				(0.04)		(0.07)
Gdp partners				-.46		-.414
				(0.40)		(0.47)
N	309,587	309,587	246,724	246,724	246,724	246,724
r2						
fe	yes	yes	yes	yes	yes	yes
method	PQML	PQML	PQML	PQML	PQML	PQML
SE	cluster id	cluster id	cluster id	cluster id	cluster id	cluster id

p-values in parentheses
Dependent variable is the level of uni-directional bilateral trade flow (export) for European countries vs the other European countries, USA, China and the Rest of the World. All regressions include fe as time dummy. Cols (3)-(6) exclude flows to USA, China and the rest of the world; col (7) considers only flow to country that belong to EA in 2016. EA_{st} (EA_{pt}) and EU_{st} (EU_{pt}) are dummy for exporter (importer) countries that belong to EA and EU respectively.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5. heterogeneus EA diff in diff

	(1)	(2)	(3)	(4)	(5)
$EA_{st} * UEC$	-.0717***	-.107***	-.0927***	-.105***	-.0952***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$EA_{pt} * UEC$	-.0679***	-.0306	-.0253	-.0304	-.0267
	(0.01)	(0.22)	(0.42)	(0.21)	(0.38)
$EU_{st} * UEC$	-.156***	-.08*	-.00918	-.0818*	-.00937
	(0.00)	(0.07)	(0.86)	(0.07)	(0.86)
$EU_{pt} * UEC$	-.102***	-.0165	.0465	-.00806	.0575
	(0.01)	(0.56)	(0.22)	(0.78)	(0.14)
UEC	.203***	.0478	-.0362	.0377	-.0564
	(0.00)	(0.45)	(0.67)	(0.56)	(0.51)
ULC	-.409***	-.393***	-.448***	-.404***	-.459***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Gdp per capita	2.37***	2.76***	3***	2.57***	2.81***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Gdp	-1.67***	-1.95***	-2.18***	-1.8***	-2.03***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
EU_{st}	-.517***	-.281*	-.0139	-.269	.00362
	(0.01)	(0.09)	(0.94)	(0.10)	(0.98)
EU_{pt}	-.0741	.197*	.45***	-.00501	.253*
	(0.62)	(0.08)	(0.00)	(0.97)	(0.07)
EA_{st}	-.119	-.225*	-.178	-.217*	-.187*
	(0.24)	(0.05)	(0.10)	(0.06)	(0.09)
EA_{pt}	-.339***	-.0586	-.0371	-.0675	-.0525
	(0.00)	(0.56)	(0.77)	(0.49)	(0.67)
$EA_{s} * UEC$	.0218	.0488	.0128	.0628	.0305
	(0.70)	(0.23)	(0.79)	(0.12)	(0.52)
Gdp per capita partners				1.03*	1.05*
				(0.07)	(0.06)
Gdp partners				-.405	-.413
				(0.48)	(0.45)
EAxUEC: EA as base	-.0614***	-.081***	-.0741***	-.0805***	-.0753***
EAxUEC: UEC as base	-.0848***	-.106***	-.0854***	-.104***	-.0858***
N	309,587	246,724	246,724	246,724	246,724
r2					
Effects					
UECXyear	no	no	yes	no	yes
method	PQML	PQML	PQML	PQML	PQML
SE	cluster id	cluster id	cluster id	cluster id	cluster id

p-values in parentheses
The dependent variable is the level of uni-directional bilateral trade flow (export) for European countries vs the other European countries, USA, China and the Rest of the World. All regressions include fe as time dummy. Cols (2), (3) and (5) exclude flow to USA, China and the rest of the world. Cols (3) and (5) also consider a common time trend in UEC's elasticity. EA_{st} (EA_{pt}) and EU_{st} (EU_{pt}) are dummy for exporter (importer) countries that belong to EA and EU respectively. *EAxUEC: EA as base* and *EAxUEC: UEC as base* are the interaction effects computed according Shang (2017).
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$