Industrial energy prices and the competitiveness of the Austrian business sector

Andreas Reinstaller[1,2] and Richard Sellner[2]

Office of the Austrian Productivity Board[1] and Oesterreichische Nationalbank[2]

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Abstract This study analyses the development of the energy cost-based competitiveness of the Austrian business sector with a focus on the manufacturing, construction, and transport industries. The study investigates the development of industrial end-use energy prices and the development of the energy intensity at the sector level, as both factors affect real unit energy cost. The results show that electricity and natural gas prices in Austria are closer coupled than across EU and some OECD countries. Industrial energy prices in Austria have risen steadily, with price levels close to or above the median of other EU and OECD countries. Cross-sector deviations from this pattern reflect differences in the composition of the fuel mix in energy use, with sectors heavily reliant on natural gas and electricity experiencing stronger price increases relative to their international peers. The observed reduction of aggregate energy intensity post-2014 was driven more by structural economic changes than by within-sector improvements in energy intensity. Fuel substitution plays a minor role across sectors and firms. Long-term aggregate trends show a persistent and slightly increasing use of natural gas and a gradual shift from oil to electricity. Losses in energy cost-based competitiveness are associated with a decline in the growth rates of price-cost margins, producer prices as well as productivity. Investment, employment and export growth rates are not significantly correlated to a deterioration of energy cost-based competitiveness.

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Address: c/o Oesterreichische Nationalbank
Office of the Austrian Productivity Board
Otto-Wagner-Platz 3, 1090 Vienna, Austria
PO Box 61, 1011 Vienna, Austria

Phone: +43-1-404 20 -Ext. 4780 (Author)

E-Mail: office@produktivitaetsrat.at or
Andreas.Reinstaller@produktivitaetsrat.at.

Internet: www.produktivitaetsrat.at

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Aims:

This study analyses the development of the energy cost competitiveness of the Austrian business sector with a focus on the manufacturing, construction, and transport industries. The study examines the development of industrial end-use energy prices in Austria relative to other European and OECD countries and analyses the development of the energy intensity at the sector level. Industrial energy prices and the energy intensity are then used to devise a real unit energy cost measure for the Austrian manufacturing, construction, and transport sectors, and assess its development relative to export destinations and potential economic impact. The study addresses the following research questions:

Main results:

1. Trends in Austrian industrial energy prices:
    - The development of end-use fuel prices during the 2021–2022 energy crisis differed markedly from patterns observed in other OECD countries highlighting issues in the organization of European energy markets.
    - Electricity prices co-vary more strongly with fossil fuels, and especially natural gas, than in non-EU OECD countries. This pattern is even more pronounced in Austria.
    - Austrian industry energy prices rose sharply after the 2007–2008 financial crisis, then converged back to the median price level until 2020 but rose sharply again thereafter.
    - Significant price differences across industries exist within countries, reflecting variations in fuel use. Industries with a high share of natural gas and electricity as principal fuel sources were more heavily affected by recent energy price shocks.
    - Transport sector energy prices consistently remained lower than in most other countries, suggesting potential for complementary measures alongside climate neutrality investments.
2. Drivers of changes in energy intensity:
    - Up to 2014 the development of energy intensity was characterized by an increase of energy intensity within sectors.
    - The role of structural change in influencing energy intensity has increased in Austria after 2014. Behavioral changes by firms where thus less a driver of the decline of aggregate energy intensity than changes in the composition of the economy.
    - The decline in aggregate energy intensity during the energy crisis 2022 was driven by a strong reduction of the energy intensity inside sectors pointing at efforts to counter the energy crisis through energy savings and a reduction of energy demand.
    - Only a small share of firms accounts for an energy cost share of more than 10% of total costs.
3. Energy mix and electrification:
    - Fuel substitution has played a minor role in adjustments to increasing fuel prices. The fuel use patterns show a higher long-term persistency across sectors.
    - In the short-run adjustment possibilities to counter energy shocks seem to be very limited. Austrian firms have limited possibilities in terms of the adjustment of their energy use patterns to counter sudden rises in industrial energy prices.
    - The substitution of fossil fuels in energy end use is driven – if at all – by long-term trends and technical change. A change in the fuel mix away from fossil fuels requires consistent long-term price signals and investments to change in significant ways.

4. **Relative Real Unit Energy Costs (RUEC):**
   - The relative RUEC position of most sectors worsened between 2007 and 2014, stabilized between 2015 and 2020 and worsened again after 2020.
   - An exploratory regression analysis indicates that the rate of change of price cost margins, producer prices, and productivity are negatively associated with an increase of relative real unit energy costs.

Policy implications:

1. Stable prices and decoupling from natural gas in power generation should be the primary goals of energy policy. However, an increase in the share of renewables may lead to price fluctuations induced by their availability. Hence, measures must be taken to ensure competitive and stable electricity prices.
2. The aim to achieve CO_2 reduction through electrification seems to be a hard task: There is a high persistence in the energy mix also in reaction to substantial fuel price shocks. Changes in the fuel mix occur mostly through technical change and investment. This requires investments in new technologies *and* consistent price signals. Especially in the transport sector price signals seem to be somewhat distorted. Scaling up existing measures for the adoption of more energy efficient technologies may be necessary. Due to the high concentration of energy use and energy intensity across firms, it is possible to deploy cost-effective and targeted measures.

1. Introduction

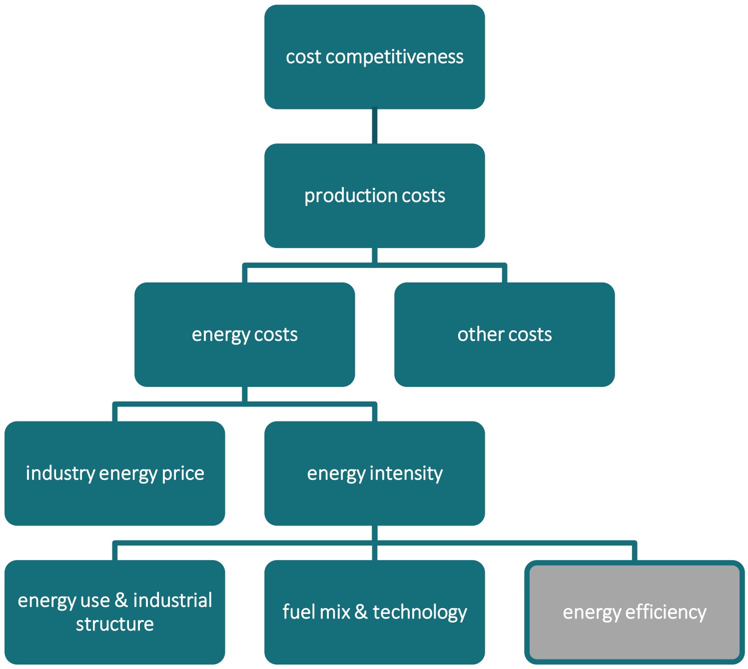
This study deals with the energy cost competitiveness of the Austrian industry. Recently, the use and cost of energy have re-emerged as an important dimension in the international cost competitiveness for several reasons. Firstly, the turmoil in the energy markets, triggered by Russia's war against Ukraine, has underscored the high dependence of European firms on geopolitically risky energy supplies. This exposure has led to asymmetric price shocks, affecting their cost position relative to international competitors. Additionally, it has long been observed that the European Union is one of the regions with the highest energy prices (European Commission, 2014; International Energy Agency, 2017, p. 51ff.). Secondly, the challenges posed by the transition to climate neutrality will significantly impact energy costs. The substantial investments required and the need to price CO_2 emissions to incentivize these investments will affect energy related costs. Considering the strong export orientation of the Austrian business sector, a thorough examination of its energy cost competitiveness is essential. Policy makers need to understand how and to what extent industrial performance reacts to changes in energy prices to ensure the effectiveness of policy measures addressing the use and cost of energy, such as compensation measures, taxes, or exemptions.

Changes in relative energy costs can affect the competitiveness of firms in many ways. Companies exhibit a broad range of responses to rising energy prices. In the short run, they may absorb these changes accepting lower profits. Alternatively, they might substitute more expensive fuel types for less expensive ones in the short run or invest in new or improved technologies to enhance overall resource efficiency. Additionally, they may pass on higher prices to consumers or adjust their overall cost structure, such as by renegotiating wages or supply contracts (Rentschler and Kornejew, 2017; cf. Fontagné et al., 2023; Mertens et al., 2022). Finally, the composition of the firm population may change depending on how flexible and adaptive firms are within this spectrum of potential responses and how persistent energy cost differentials are relative to important competitors in the medium to long term. Firms that find it difficult to adjust will face declining demand and falling profitability, eventually leading to their exit from the market. Conversely, new firms with more favorable and competitive cost structures may enter the market (Deb et al., 2023). On the other hand, higher energy prices may also boost energy efficiency and productivity if they predominantly induce investments into new, more energy efficient, technologies. Depending on the relative strengths of these effects rising energy prices can either strengthen or weaken the competitiveness of industries.

As this brief outline of important adjustment mechanisms suggests, the analysis of the development of energy cost competitiveness should not be limited to the study of energy prices but needs to also consider the use of energy and how they jointly affect business decisions. Figure 1 provides an overview on the factors affecting energy cost competitiveness. Energy costs are determined by both (effective) energy prices and the energy intensity.

For companies, the relevant cost factor are not primary energy prices but the effective end-use prices. End-use prices include various forms of costs that affect the final amount spent by end-users. Next to the primary energy price established on commodity or energy markets, they include price tax and non-tax components. The non-tax components include inter-alia distribution and network charges, as well as profit margins of energy providers. The tax component in turn includes national and subnational excise taxes, levies or subsidies (cf. International Energy Agency, 2023a). End-use prices vary across countries and across consumer categories over time. These variations are determined by country specific resource endowments, the energy market structure, energy production and transportation costs, differences in contractual terms with energy suppliers across firms, as well as trade restrictions and costs. Across countries these country specific cost components represent about two thirds of the total end-use energy prices firms pay for their energy. However, the effective end-use energy cost per unit of output depends also on the various energy sources they need in their operations. For this reason, Sato et al. (2019) have proposed an industry energy prices index to allow for better international comparison of energy prices. In this study we follow their approach which allows us to provide a comprehensive international comparison of energy costs and to assess the energy cost competitiveness of the Austrian manufacturing sector. This analysis is presented in Section 3 of the paper. The paper then analyses the fuel price fluctuations in Austria and at the industry level highlighting some idiosyncratic patterns.

Figure 1: **Energy cost components affecting cost-competitiveness at the sector and firm levels**



Source: own representation.

Next to energy prices total energy costs depend also on the final demand for energy. This is related to economic activity, but also in how energy intense economic activity is. Final energy demand per unit of value added is referred to as energy intensity. This indicator is often used as a proxy for energy consumption and the effectiveness of energy use in the provision of goods and services. Energy intensity in the business sector is determined by the industrial structure and industry specific energy use profiles, energy prices and taxes, as well as the technologies in use (Filipovic et al., 2015). It thus depends on numerous elements. Energy intensity should thus not be equated to energy efficiency. Filippini and Hunt (2015) stress that energy efficiency is strictly related to cost minimizing choices in the production of goods and services. Inefficient energy use arises when firms produce outputs without minimizing inputs which may be the case when technologies are obsolete or used inefficiently and energy prices do not correctly reflect the true (social) cost of energy use. Therefore, this paper investigates the relationship between energy intensity and both industry structure and fuel composition, as depicted in Figure 1. The development and determinants of energy efficiency will be discussed in a companion paper using Austrian firm level data.

Section 4 presents an analysis on how industry level changes in energy intensity and structural change have affected the energy intensity of the business sector. Structural change is interpreted here as shifts in the creation of value-added between industries, reflecting changes in the economy's composition. Structural change can influence the energy intensity of an economy but may not necessarily be related to changes in energy use or improvements in energy efficiency. A shift in the composition from more to less energy intensive industries will change aggregate energy intensity downwards even if the end-use energy efficiency has not improved in any part of the economy. It may be caused by a sustained lack in energy cost competitiveness but could potentially also results from a change in preferences if, for instance, customers develop a preference for less energy intensive products. However, inside industries the energy use per unit of output may change as well. Unlike structural change such changes are the result of behavioral factors, if, for instance, firms adjust their technology, or if they outsource energy intensive production activities to firms abroad. While this paper will not analyze the determinants of structural change and of changes in industry specific energy demand, it shows that the importance of these two adjustment mechanisms has changed over time potentially reflecting important changes in the underlying business fundamentals. This section also provides evidence on the development of energy intensity across sectors over time in Austria using firm level data as well as on the concentration of energy use across sectors.

The second part of Section 4 takes a closer look at the development of the fuel mix across and within industries and how this affects industrial energy prices. The fuel mix reflects firm level choices that depend on the price of fuels, technological requirements or operational considerations, the availability and supply stability of certain fuels, and environmental regulations, subsidies, or tax incentives. Fuel switching and the related elasticities of substitution are of critical importance for evaluating the economic cost both of climate policies and of insufficient energy security. Acemoglu et al. (2012), for instance, show that if clean and dirty inputs are substitutable in production, emission-reduction targets can be achieved without sacrificing long-term economic growth, whereas the availability of cheap energy source can bias the choice of the fuel mix in specific direction (Acemoglu et al., 2023). Stern (2012) argues that the harder it is to substitute renewable energy sources for fossil fuels, the more expensive climate change mitigation policy will be. The fuel mix can have an impact on energy intensity via the energy density of fuels, the energy efficiency of technologies and industrial processes or through the energy load management amongst other factors. Technical change has been found to be the most important factor (cf. Ma and Stern, 2008). The analysis in the section provides some first insight into the fuel substitution patterns and the substitutability of energy sources across sectors.

The last part of this study in Section 5 brings all the elements developed in the previous sections together by devising a real unit energy cost measure at the level of the Austrian manufacturing, construction and transport sectors.[1] It then presents an examination of the development of real unit energy costs relative to the real unit energy costs in export destinations, and the potential impact of changes in the relative real unit energy cost position on the economic performance of manufacturing industries. Several studies have already explored this link. Ratti et al. (2011), for instance, provide evidence for a negative impact of relative energy prices on firm-level investment even though the effect decreases with firm size. Sato and Dechezlepretre (2015) and Faiella and Mistretta (2020) in turn examine the impact of increased energy costs on trade and find negative but very moderate effects on exports and

[1] This measure was first proposed by Enevoldsen et al. (2009), and has been used in several studies examining the relationship between energy costs and competitiveness (cf. European Commission, 2014; Faiella and Mistretta, 2020; Reiter et al., 2023).

imports. However, Faiella and Mistretta (2020) argue that given the foreseeable increases in energy costs due to European climate policies an unit energy cost indicator should be included in the indicators of the Macroeconomic Imbalance Procedure (MIP) of the European Commission to monitor EU Member States competitiveness.

The analysis in this paper complements two recent studies on the impact of rising energy prices on the competitiveness of the Austrian industries by Hölzl et al. (2023) and Reiter et al. (2023). The study by Hölzl et al. (2023) uses a multi-sectoral and multi-regional dynamic input-output model to assess the impact of various energy price scenarios for the Austrian economy. This analysis relies also on a firm level survey. The model simulations show that persistently higher energy prices in Europe and Austria relative to international competitors would lead to a reallocation of market shares in international trade away from Austria and would dampen industrial production. Energy-intensive sectors would be particularly concerned. The firm level survey in turn reveals that companies see only a limited possibility to pass-on prices leading to a reduction in profits in the short run. This may induce the substitution of energy-intensive inputs and international reallocation of production.

The study by Reiter et al. (2023) compares the nominal energy costs, energy consumption at the industry level with important European competitors. Simulations based on a DSGE model for the Austrian economy assess the impact of various energy price scenarios on exporting industries. The simulations show that a persistent increase in natural gas prices relative to the levels of 2019 would have a negative impact ranging between 1.5 to 4 percent of the value added in energy intensive sectors. A decoupling of electricity production from natural gas as energy source would dampen this effect and impact fewer sectors. However, the study warns that a unilateral European introduction of CO_2 prices through the ETS system would have considerably more substantial negative effects especially for the iron, steel and the chemical industries.

This study offers some additional insights: The analysis of end-use fuel price variation shows that while European energy prices, particularly for electricity and natural gas, have historically been higher than in other OECD countries, the 2021-2022 energy crisis led to marked deviations in the EU and Austria. In Austria electricity and natural gas prices show a closer coupling than in other countries. Industrial energy prices in Austria have risen steadily, with significant peaks during the 2007-2008 economic crises and post-2020, generally remaining above the median of other EU and OECD countries. Cross-sector price discrepancies reflect variations in fuel usage, with sectors heavily reliant on natural gas and electricity experiencing higher price increases relative to other countries.

The results also show that the reduction in aggregate energy intensity post-2014 was influenced more by structural economic changes than by within-sector improvements and related behavioral changes. An exception is the reaction to the fuel crisis where energy intensity declined heavily due to energy savings. Fuel substitution plays a minor role, with long-term trends indicating a persistent use of natural gas and a gradual shift from oil to electricity. The impact on relative real unit energy costs varies by sector, but some important sectors such as the automotive sector have experienced a worsening of relative real unit energy costs in 2021–2022. Losses in energy cost-based competitiveness are associated with a decline in the growth rates of price-cost margins, producer prices as well as productivity, whereas investment, employment and export growth are not significantly affected.

2. Data and methodology for the construction of an industry energy price and the calculation of energy intensities

This report brings together a variety of data sources to construct an industrial energy price index and to analyze the development of energy prices in Austria with a particular focus on the manufacturing, transport, and construction sectors. These sectors cover about two-thirds of total energy end use of the business sector (see Section 4). The aim is to engage into a broad comparative exercise to analyze the development of industrial energy prices in Austria vis-à-vis EU and OECD countries. For this reason, the analysis covers a large number of countries (see Table 1). The effective number of countries included in the different analyses varies in function of the quality and availability of data. For the fuel price analysis in Section 3 the analysis includes 44 EU and OECD countries. The analyses in Sections 4 include 32 countries, whereas the sections presenting firm level evidence (4.1.2 and 4.2.2) as well as Section 5 focus on Austria. Table 2 gives a comprehensive overview on the data used in this report.

The main data source is the Energy Price Database of the International Energy Agency (International Energy Agency, 2023a). This is the most comprehensive collection of international fuel prices available. Its End-use Prices and Taxes (EPT) data cover the OECD countries and for the industrial energy prices includes all (excise) taxes, levies and subsidies but exclude VAT and are available in local currency units per terajoule (TJ) or per ton of oil equivalent (TOE).[2] For some EU countries that are not OECD members (Bulgaria, Romania) IEA's World Energy Price (WEP) data was used. Unlike the EPT, the WEP data base covers end-use consumer prices including VAT and are expressed in volumetric units or in MWh in national currency. Information on national VAT rates provided by IEA was used to calculate prices net of VAT and IEA conversion factors were used to convert prices into units of local currency per ton of oil equivalent. The data for the wide variety of fuel types included in the IEA database were subsumed into four broad categories of fuel types namely oil products, natural gas, electricity and coal using classification tables provided in the documentation of IEA's World Energy Balances (International Energy Agency, 2023b).

While the IEA Energy Price Database is the most comprehensive data source on international fuel prices the data show considerable gaps and omissions. To obtain complete and comparable time series for the calculation of an industrial energy price it is therefore necessary to impute missing values where possible. For some countries of potential interest, such as China, the fuel price series are very incomplete such that the country had to be excluded from the sample.

In the data preparation, imputation and the eventual calculation of sector specific industrial energy price indices we follow closely the methodology developed by Sato et al. (2019). We will only briefly sketch their approach in what follows. The reader is referred to this paper for more technical details. To make prices comparable across countries and years the price data in local currency units are first deflated using the national GDP deflator with base year 2015. In a second step the prices are converted into constant 2015 US-Dollars using a fixed ratio between the GDP deflator and the nominal exchange rate between the US-Dollar and the local currency unit. The USD was chosen as a reference currency as the country sample includes many non-Euro countries. These steps however ensure that the fuel prices and

[2] According to International Energy Agency (2023a, p. 55 ff.) end-use prices for Austria include the following excise taxes and subsidies: Mineralölsteuer. Pflichtnotstandsreservenabgabe, Erdgasabgabe, Kohleabgabe, Elektrizitätsabgabe, Gebrauchsabgaben, Ökostromförderbeitrag (Erneuerbaren-Förderbeitrag), Ökostrompauschale, KWK-Pauschale, Biomasseförderbeitrag, CO_2 pricing as well as network fees. General energy cost subsidies such as the Energiekostenzuschuss I & II provided to (energy intense) firms during the recent energy crisis are not included as these are not fuel specific.

the derived industrial energy prices are in real terms and show only price increases in the energy basket relative to economy-wide price changes.

Table 1: **Country coverage**

Country	2-digit code	IEA interpolated energy prices	Included in fuel price analysis: EU	Included in fuel price analysis: non-EU OECD	Industry energy prices	Country	2-digit code	IEA interpolated energy prices	Included in fuel price analysis: EU	Included in fuel price analysis: non-EU OECD	Industry energy prices
Australia	AU	x		x		Ireland	IE	x	x		x
Austria	AT	x	x		x	Israel	IL	x		x	
Belgium	BE	x	x		x	Italy	IT	x	x		x
Bulgaria	BG	x	x		x	Japan	JP	x		x	x
Brasil	BR	(x)		x		South Korea	KR	x		x	x
Canada	CA	x		x		Lithuania	LT	x	x		x
Switzerland	CH	x		x	x	Luxemburg	LU	x			x
Chile	CL	x				Latvia	LV	x	x		x
China	CN	(x)				Mexico	MX	x		x	
Czech Republic	CZ	x	x		x	Netherlands	NL	x	x		x
Germany	DE	x	x		x	Norway	NO	x		x	x
Croatia	HR	x	x		x	Poland	PL	x	x		x
Denmark	DK	x	x		x	Portugal	PT	x	x		x
Estonia	EE	x	x		x	Romania	RO	x	x		x
Spain	ES	x	x		x	Sweden	SE	x	x		x
Finland	FI	x	x		x	Slovenia	SI	x	x		x
France	FR	x	x		x	Slovakia	SK	x	x		x
Greece	GR	x	x		x	Turkey	TR	x		x	x
Hungary	HU	x	x		x	United Kingdom	UK	x		x	x
India	IN	(x)				United States	US	x		x	x

Table 2: **Data sources and sector definitions**

Source	Database	Data/Indicators	Period covered
International Energy Agency	Energy Prices	Fuel prices, aggregate price indices, wholesale prices, PPP conversion, CPI	1995-2023
	World Energy Balances	Sector fuel use	1995-2021
Eurostat	Energy Balances	Sector fuel use	1995-2022
	National accounts	Sector (NACE 2-digit) data: value-added, gross output, employment, investment	
	Short run statistics	PPI, CPI	
UNIDO	INDSTAT Rev. 4	Sector (ISIC/NACE 4-digit) data: value-added, gross output, employment, investment	1995-2020
Comtrade/BACI	CEPII	HS-2007 6-digit bilateral trade flows (values, quantities)	2007-2022
World Bank	World Development Indicators	PPP, LCU-USD conversion factors, GDP deflators, exchange rates	
Statistik Austria - AMDC	Gütereinsatzstatistik; Leistungs- und Strukturerhebung	Energy use at the firm level; firm level value added, turnover, employment	2013-2021

Sector definition

NACE	Description
B	Mining
C	Manufacturing (aggregate)
C10-C12	Food and beverages (tobacco)
C13-C15	Textile and wearing apparel
C17-C18	Pulp, paper, printing
C21 C22	Chemical, petrochemical, pharmaceutical
C22; C31_C32	Other industries
C23	Non-metalic minerals
C24	Iron and steel; basic metals*
C24.4	Non-ferrous metals*
C25-C28	Machinery; metal products; electrical equipment
C29-C30	Automotive (transport equipment)
F	Construction
H	Transport

* in most analyses collapsed into one broad sector

The IEA Energy Price Data also contain economy-level industrial price indices for each fuel type for all OECD countries as well as energy wholesale price indices for non-OECD countries. These tend to have fewer gaps than the individual fuel price series and are therefore used to impute missing values. If neither of the two indices is available in a country a regional industry or wholesale price index is calculated based on the information available in neighboring countries, assuming that neighboring countries are more likely to trade fuel at the rates observed on average across regional peers and that price developments are therefore more closely related. The imputation algorithm then uses the simple average of the leads and lags of the growth rates of these indices to obtain an estimate for the missing fuel price starting from the observations available in the data set.[3] In sample projections using the various indices for imputation are then used to assess which index shows the least deviation from the observed values and the values calculated from it are then finally used for imputation.

Fuel use data are necessary to obtain sector specific industrial energy price indices. They are used to calculate the weights of the various fuel types based on the consumption shares of each fuel type in an industry. Therefore, next to IEA Energy Price data the second most important data source are the Energy Balances by sector provided by Eurostat. This is a comprehensive data source on the total amount of energy extracted, traded, transformed, and consumed by end-users for European countries and countries associated to the EU. The energy end-use data are provided for broad end-use sectors. These sectors are aggregates of NACE-2-digit industries (see Table 2) and cannot be further disaggregated. However, in Section 4.1.2 we provide a more granular picture using Austrian firm level material input statistics accessible at the Austrian Micro Data Centre of Statistics Austria.

To combine energy use data with price data by fuel type the different amounts of energy consumed need to be aggregated into the four groups of consumption depending on the fuel type used to generate the consumed energy. In line with the end-use energy prices these four broad categories of consumption are electricity, oil products, natural gas, and coal. A fifth fuel type category, namely biofuels and waste have been omitted from the calculation of real industrial energy price as these fuels are typically the result of joint production in firm level production processes and are typically consumed internally by the producing firms without being sold on the market. Market prices for these fuels therefore are not available. This fuel type is used in the pulp and paper, wood and wood products and food and beverages industries, where it represents a substantial share of total energy use (up to 50 percent). In the chemical and petrochemical as well as non-metallic minerals industry it is used as well (Section 4.1.2). In these sectors industrial energy prices are calculated only for the energy sources firms must source externally through the market.

The Eurostat Energy Balances essentially contain the identical information as IEA's World Energy Balances but don't have their broad country coverage. However, the available Eurostat data stretch up to 2022, whereas the IEA data are provided with a greater lag (2020 for all countries and 2021 for a few). Therefore, Eurostat data were used as the principal source but were complemented with energy end-use data from IEA's World Energy Balances for some major OECD countries (USA, Japan, South Korea,

[3] More specifically, Sato et al. (2019) propose imputation according to the following formula with $NTX_{fuel,t}$ representing an industry or wholesale price index and $p_{fuel,t}$ as observed fuel price: $p^{e,i}_{c,s,t} = \frac{1}{2} p_{fuel,t-1} \left(1 + \frac{NTX_{fuel,t} - NTX_{fuel,t-1}}{NTX_{fuel,t-1}}\right) + \frac{1}{2} p_{fuel,t+1} \left(1 + \frac{NTX_{fuel,t+1} - NTX_{fuel,t}}{NTX_{fuel,t}}\right)$. $p^{e,i}_{c,s,t}$ is the imputed fuel price which will be deflated and converted into constant USD. This procedure is iterated several times to obtain complete time series conditional on the availability of at least a few observations for fuel prices.

Canada, Australia) to be able to extend the industrial energy price analysis beyond the EU and associated countries.

The industrial end-use energy prices $EPI_{c,s,t}^{realUSD}$ are constructed as a weighted average of energy prices for the four main fuel types covered in this analysis as follows:

$$EPI_{c,s,t}^{realUSD} = \sum_e p_{c,s,t}^{e,i,realUSD} * w_{c,s,t}^{e},$$

where $w_{c,s,t}^{e} = QE_{e,c,s,t} / \sum_{e,c,s,t} QE_{e,c,s,t}$, is the fuel share of fuel type *e* in total energy use of sector *s* at time *t* in country *c*, and $p_{c,s,t}^{e,i,realUSD} = \frac{p_{c,s,t}^{e,i}}{GDP\ deflator} * \frac{GDP\ deflator_{2015}}{ER_{2015}}$, corresponds to the imputed fuel prices for each fuel type *e* deflated and expressed in constant 2015 USD as explained in the previous section, with ER_{2015} representing the local currency USD exchange rate in 2015.[4] This price index thus captures changes in fuel prices and the fuel choice in a particular sector determined by its technology.

Finally, the energy use is also necessary to calculate the sectoral energy intensities that are relevant to analyze the drivers of energy use and unit energy costs. For this purpose, energy use data are combined with sector level performance data obtained from Eurostat. Eurostat provides data on value added, employment, gross investment, wages and salaries and intermediate inputs through its national accounts data (NAMA) at the NACE-2-digit level for the EU member states and associated countries. From these we have constructed a country-sector panel spanning the period 1995 to 2022. Eurostat also provides producer price indices, consumer price indices, and various production volume indices in its Short-Term Statistics (STS). To assess developments beyond the EU and associated countries we use UNIDO INDSTAT data that provide key industrial performance indicators at the ISIS-4-digit level such as value-added, gross capital formation, labor cost and employment for 114 countries. However, these data are available only up to 2020 and for many countries time series end in 2019.

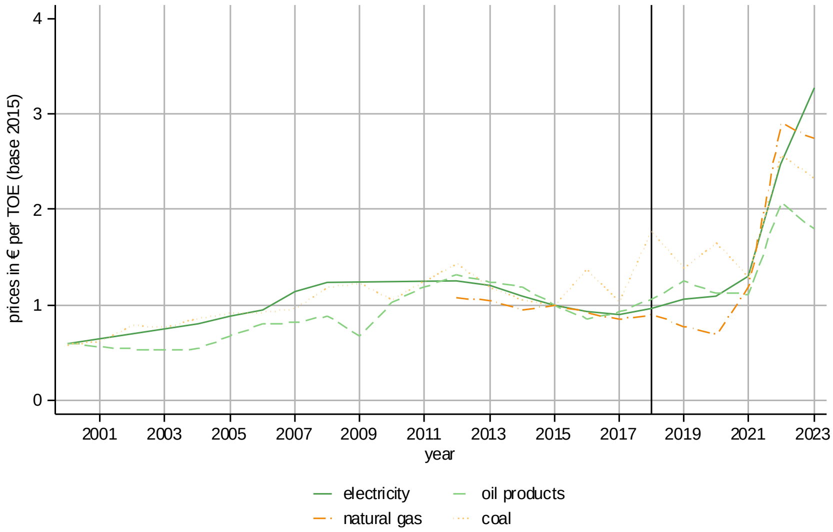
[4] Caveats apply concerning the use of waste and biofuels. The weights are calculated only for the fuel types for which market prices are paid.

3. The development of industrial end-use energy prices in Austria in international comparison

3.1 Fuel price development in Austria and major EU and OECD economies

The energy structure of an economy reflects the use of different fuel types in the generation of energy needed in the production of goods and provision of services. It determines the exposure of firms and industries to energy price shocks driven by specific fuel types, their CO_2 emission profiles, and abatement needs regarding climate goals, as well as specific fuel substitution patterns. This section analyses the development of end-use fuel prices between 2000 and 2022 in Austria in comparison to European and OECD peers.

Figure 2: **Fuel price increases in Austria relative to 2015**



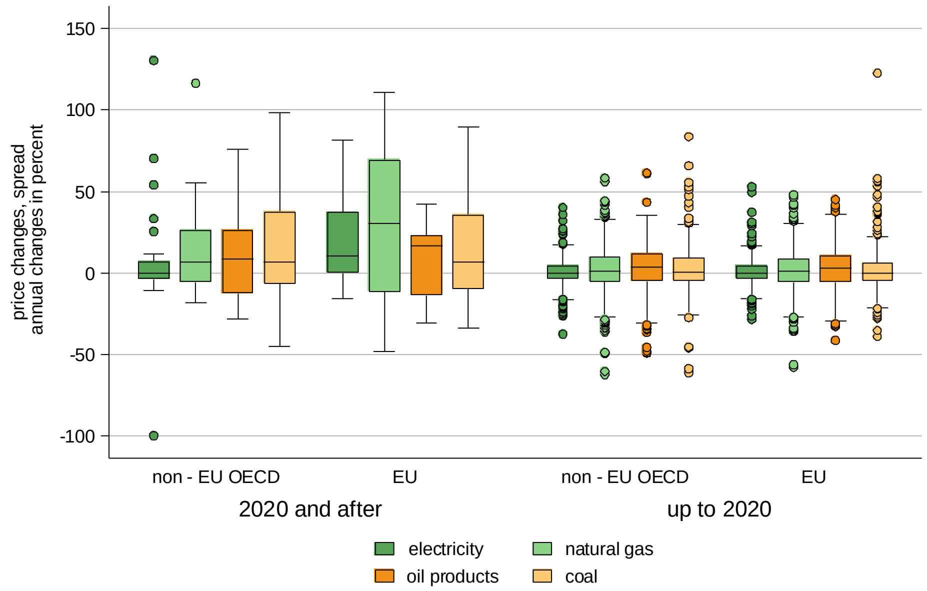
Source: IEA Energy Prices; April 2024. Own calculations based on raw data without imputations. End use prices for business incl. excise taxes and subsidies (excl. VAT).

Especially in Europe energy prices have experienced a sharp increase. This development started in the period running up to the start of Russia's attack on Ukraine in February 2021 and persisted for about a year. Austria was no exception as Figure **2** shows. The end use energy prices for industry of all four fuel types have increased sharply between 2021 and 2023 relative to the chosen base year 2015. This development was stronger for electricity and natural gas. In 2023 electricity prices have increased further whereas prices for all other fuel types have started to decline. Another potential source of variation especially for electricity prices in Austria may have been the splitting of the German-Austrian power price zone in 2018 marked by the vertical line. The data show here some mild increase of electricity prices around the date of the split (October 2018). The observed increase may however have been caused by other developments. The development merits however further study, as it is of particular importance for the integration of European energy markets.

The variation of fuel prices was stronger especially for electricity and natural gas in Europe after 2020 than in the non-EU OECD countries in the sample (USA, UK, Japan, South Korea, Mexico, Turkey, Canada). Figure **3** shows this with a box plot of the fuel price changes observed across countries in the two country groups before and after 2020. While the variation of fuel prices has increased after 2020 in both country groups, the variation was larger especially for natural gas and electricity in the EU countries.

This indicates that changes in these two fuel types were driven by EU specific factors. Before 2020 the variation between the two country groups did not differ substantially.

Figure 3: **Dispersion of fuel prices across EU and non-EU OECD countries before and after 2020**



Source: IEA Energy Prices; April 2024. Own calculations based on imputed prices in constant 2015 USD.

To better understand the variation observed in the price data an exploratory principal components analysis (PCA) of year-on-year end use price changes of the four fuel types has been executed. The PCA decomposes the covariance matrix of the fuel price changes into components (eigenvectors) that are linear combinations of the initial data. The method compresses most of the information on the variation in the first components that are independent from one another but capture the increasingly smaller shares of the total variation in the original data captured by associated eigenvalues (see Box 1 for a more comprehensive explanation). The results are shown in Figure **4** and Figure **5** as well as Table **10** and Table **11** in the Appendix.

These principal components typically capture some common but latent factor that jointly influences the fuel price variation. Table **3** provides an interpretation of the components reported in Figure **4** and the tables in the appendix.[5] The reported component loads capture the correlation between the original data and the identified principal components. A higher load thus indicates a higher correlation and fuel types with similar loads also correlate more strongly with one another. Negative signs in turn indicate a negative co-variation. It can be shown that the squared component loading also captures the proportion of the variation in the fuel price changes explained by a component.

[5] Table 11 (p. 69) presents the decomposition of the long-term fuel price variation between 2000 and 2022. The interpretation of the PCs in Table **3** is also applicable for the pre-2020 period reported in the upper half of Table **10** (p. 68). The lower half of Table **10** in turn presents the variance decomposition for the post-2020 period. While the overall interpretation of the PCs identified for this period holds as well, the loadings and the variance explained by the various PCs changes in some cases drastically.

Table 3: **Interpretation of identified principal components (PC) in fuel price variation**

2000–2022 for EU and non-EU OECD countries in Figure 4 (PC1, PC2), see also Table 11 (p. 69)

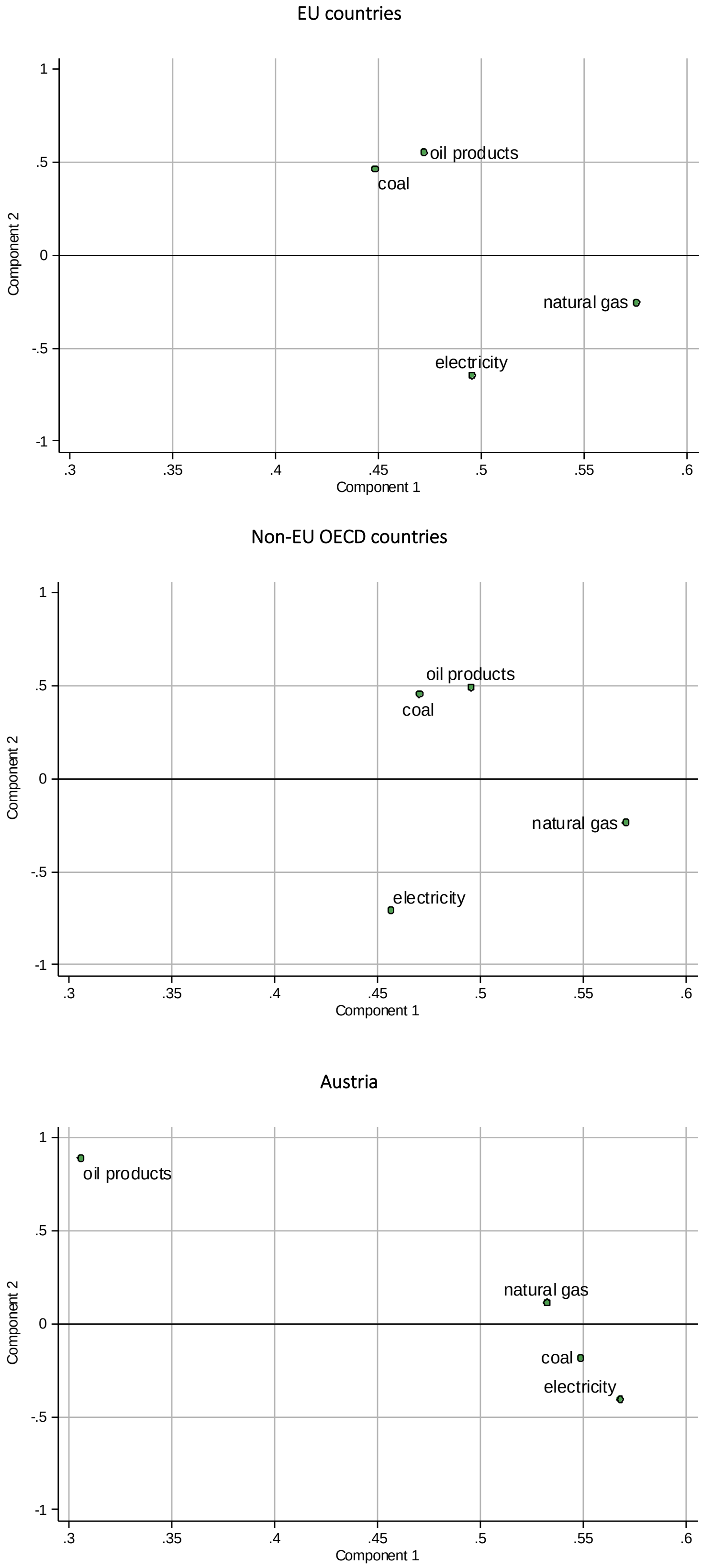
PC (explained variance in %)	Loading	Interpretation
PC 1 (40-80%)	Positive on all fuel types; load more on natural gas and oil prices	Common trend across fuels driven by natural gas and oil prices
PC 2 (15-25%)	Opposing signs between coal/oil products on the one hand and natural gas/ electricity on the other hand	Relative changes in the slope of fuel price developments between coal and oil as well as natural gas and electricity. Potentially reflects dynamics induced by natural gas use in electricity generation.
PC 3 (7-20%)	Opposing signs between coal/electricity and natural gas/oil products	Relative changes in fuel use patterns possibly related to coal use in electricity generation affecting the curvature of fuel price development

Figure **4** compares the results for the decomposition of the covariance of fuel price changes over the period 2000-2022 across all European countries and non-EU OECD countries in the sample, as well as for Austrian price data only. The figure plots the loadings of the first two principal components for each fuel type. The first component loads the fossil fuels most heavily indicating that the first principal component captures mainly fossil fuel induced price variation (Table **3**). The fact that electricity shows a positive covariation and significant factor load captures the fact that electricity prices are also determined by fossil fuel prices which is related to the merit-order based pricing in European energy markets.

In the EU countries the first component loads electricity more than in the non-EU OECD countries pointing at a higher correlation with fossil fuel price changes in the EU. In Austria this aspect is even more accentuated than in the EU. Table **11** (Appendix, p. 69) shows that the first component explains about 75 percent of the variance of natural gas both in the EU and the non-EU OECD countries but only about 55% in Austria. On the other hand, for electricity the explained variance by the first component lies at 48% for non-EU OECD countries, at close to 56% for EU countries and at more than 63% for Austria. At the same time also the proportion of the variation of coal prices explained by the first component is higher in Austria. This suggests that the general trend of fuel price development in Austria is mostly driven by electricity, natural gas and coal with electricity being the dominant source of variation. In the EU and non-EU OECD countries the trend is in turn more strongly determined by natural gas. In the non-EU OECD countries oil products also play a greater role.

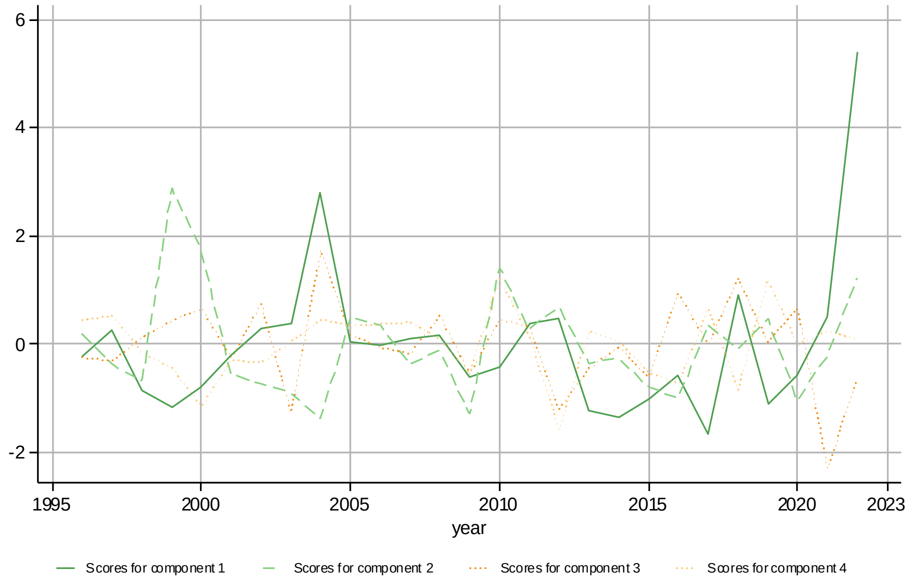
Figure 4: **Loadings for the first two principal components calculated for the fuel price changes across EU countries, non-EU OECD countries, and Austria**

2000–2022



Source: IEA Energy Prices; own calculations based on imputed prices in constant 2015 USD. Loadings lie in the interval [-1,1]. Positive loadings indicate positive covariation of fuel prices. Larger values indicate that the principal component explains a larger share of the variation associated with a specific fuel price.

Figure 5: **Predicted price changes by principal component in terms of standard deviations of the rate of change for Austria**



Source: IEA Energy Prices; own calculations based on imputed prices in constant 2015 USD.

Figure **4** also shows some Austrian specifics in the development of prices for oil products. Unlike in the EU and non-EU OECD countries their price dynamics is less correlated to the overall trend of development in fuel prices. This points at a very specific national price dynamics that is somewhat detached from the development across the larger country groups. This shows in the second component. Whereas for the EU and non-EU OECD countries the second component reflects a contrast, i.e., a negative co-variation between different fuel types lying above and below the black reference line and explains a significant part of the price variation for electricity, in Austria it shows a contrast between all other fuel sources and oil products and explains about 75 percent of the variation in the prices of oil products. Austrian fuel price developments therefore stand out relative to the fuel price variation patterns observed across two large country groups due to the higher association of electricity prices with both natural gas and coal, and the rather idiosyncratic development pattern for oil products.

Figure **5** shows the contribution of the various principal components to fuel price co-variation over time for Austria using the PCA calculated over the period 2000 to 2022 (see Table 11, Appendix). As outlined earlier, the first component that for Austria captures close to 50 percent of the total variation, can be interpreted as reflecting fossil fuel induced price fluctuations also on prices for electricity. This component was the most important driver of the price development in Austria between 2020 and 2022. Referring back to the Boxplots in Figure **3** the PCA analysis for this subperiod (see Table **10**, p. 68) shows that also in the EU the first component did not only drive the observed variation to a more significant extent (total variation explained in the EU: 78.2% vs. non-EU OECD 65.8%) but the proportion of total variation of natural gas and electricity explained by the first component increased significantly in comparison to the pre-crisis period. This indicates that European fuel markets were somewhat less stable relative to those on non-EU countries if we take the lower variation in prices in the latter as measure for stability.

To summarize, this first exploration of the development of end-use fuel prices over time shows that the 2021-2022 energy crisis is a distinct European phenomenon and highlights issues in the organization of European energy markets and the organization of the supply of these fuels. For Austria the data show a distinct pattern especially concerning the impact of fossil fuels on end use electricity prices for commercial use, which warrants further investigations into the causes and potential remedies.

Box 1: **Principal components analysis of fuel prices**

For the exploratory principal component analysis (PCA) the covariance matrix of year-on-year fuel price changes has been used. A PCA involves computing the covariance matrix to understand relationships between fuel prices across the observed time series, and then decomposing this covariance matrix into eigenvectors and eigenvalues (see e.g. Jolliffe 2002). The eigenvectors represent the directions of maximum variance whereas the eigenvalues indicate the magnitude of variance for each eigenvector. A PCA thus splits the covariance matrix into scaling factors (eigenvalues) and directions (eigenvectors). The analysis has been carried out using the covariance matrix of fuel price changes. Using the correlation matrix instead leads to qualitatively largely identical results.

The eigenvector (principal component) associated with the largest eigenvalue reflects the linear combination of fuel price changes explaining the largest part of the variance in the data. By ordering principal components according to the magnitude of the associated eigenvalues we obtain the principal components capturing decreasing amounts of the variation in the data. This is shown in the tables in the appendix (see Table 10 and Table 11, p. 68). By projecting the original price data onto principal components, it is possible to reduce the dimensionality of the data and allows to highlight the most influential fluctuations in the fuel price time series.

Figure 4 on page 17 shows the loadings for the first two principal components. Loadings capture the correlation between an extracted principal component and the data. They are defined as the eigenvector element of a particular fuel type in a PC times the square root of the associated eigenvalue. Directional information of the eigenvector is thus combined with scaling information from the eigenvalue. Higher loadings for any fuel type on a component specific axis indicate that the component explains a larger share of the variation observed for this fuel type. This points at a common (latent) source of variation for the fuel types with a high score (e.g., jointly increasing demand and related impact on the fuel types with high loads). Loadings with a negative sign indicate that the underlying fuel price varies in the opposite direction of fuel prices with loadings with a positive sign.

Figure 5 in turn presents the eigenvector scores which are linear combinations of the data that are determined by the coefficients for each principal component. They indicate the direction of a principal component in each period given the values the various fuel types take in that period. The eigenvector scores thus show in which direction a component affects the variation observed in the data.

Technically, a PCA finds a linear combination of the data vectors x that explains the maximum amount of variation:

$$z_{1t} = b_{11}x_{1t} + b_{11}x_{1t} + \cdots + b_{n1}x_{nt}; t = 1, .., T$$

In matrix form: $z_1 = Xb_1$. In this analysis the data matrix X is matrix of the log first-difference of the fuel price series. The principal components are now given by z_1. To obtain a linear combination that maximizes the amount of explained variance, the following maximization problem, starting with the first component:

$$\max z_1' z_1 \; = \; b_1' X' \; X b_1$$

$$\text{s.t. } b_1' b_1 = 1$$

and for the second component

$$\max z_2' z_2 \; = \; b_2' X' \; X b_2$$

$$\text{s.t. } b_2' b_2 = 1; \; b_1' b_2 = 0$$

The first constraint is an imposed normalization of the coefficients b such that their sum of squares equals one and the second constraint for the second component imposes orthogonality. The execution of this optimization problem for all components using the Lagrangian leads to

$$z = XB$$

$$B'B = I$$

$$z'z = \Lambda$$

where B are the eigenvectors of X and Λ is a diagonal matrix with elements λ_i as eigenvalues for which holds $VAR(z_i) = z_i' z_i = \sum_i \lambda_i$ which corresponds to the total variation in the data. The contribution of the principal component z_i to total variation in the data equals then $\lambda_i / \sum_i \lambda_i$. The correlation between data X_i and component z_j is furthermore given by

$$r(X_i, z_j \;) = \frac{cov(X_i, z_j \;)}{\sqrt{var(x_i)}\sqrt{var(z_j)}} = \frac{X' \; X b_j}{\sqrt{var(x_i)}\sqrt{var(z_j)}} \rightarrow \frac{\lambda_j b_{ij}}{\sqrt{var(x_i)}\sqrt{\lambda_j}} = \frac{\sqrt{\lambda_j} b_{ij}}{\sqrt{var(x_i)}}$$

, where $\sqrt{\lambda_j} b_{ij}$ corresponds to the loadings of component z_j for fuel type *i*. The squared correlation, $r(X_i, z_j \;)^2$, is then equal to the proportion of the variation in X_i explained by component z_j . The tables in the Appendix show for each component the share of total variation explained, $\lambda_i / \sum_i \lambda_i$, the eigenvectors b_j, the loadings $\sqrt{\lambda_j} b_{ij}$ and the proportion of variation of a fuel price *i* explained by a component *j*, which is equal to the squared correlation between a fuel price and a component: $\left(\frac{\sqrt{\lambda_j} b_{ij}}{\sqrt{var(x_i)}}\right)^2 = \frac{\lambda_j b_{ij}^2}{var(x_i)}$.

3.2 Industry energy prices: General trends and sources of variation

This section establishes some stylized facts on the development of industry energy prices for Austria. As outlined in Section 2, industry level end-use energy prices represent a weighted price index build from the fuel prices and the share of each fuel type in total energy use of that industry according to Eurostat and IEA Energy Balance data. Hence, the industry energy price is determined by both the fuel prices and the energy mix firms use in each sector.

Figure 6 shows the development of industry energy prices for the total economy, industry (which comprises in the Eurostat energy balances including manufacturing, construction, and part of the mining sectors), and the transport sector across 32 EU and OECD countries between 1995 and 2022.[6] The dashed line captures the average industry energy price for Austria. The industry energy price has steadily increased across countries from about 600 USD at constant 2015 US Dollars at market exchange rates for the median country (solid line) to levels above 1000 USD in 2010 for the total economy and industry. Around 2012 a slow decline started which lasted until 2020. In the aftermath the data show a strong energy price increase across countries. The transport sector shows a similar development pattern even though the price increase was stronger during the period 1995-2012 starting from lower levels in 1995 and peeking out at higher levels in 2012. Price dispersion on the other hand seems to have been relatively stable across countries over time. The data do not show a systematic widening or narrowing of the distribution over time.

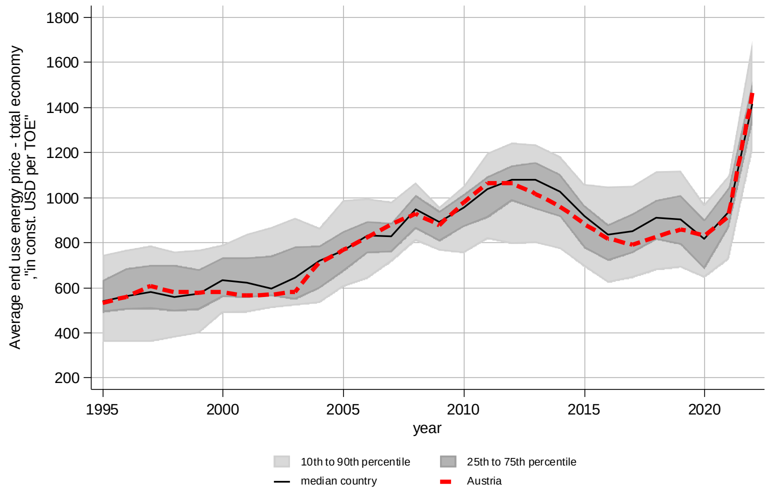
Austrian industry energy prices were close to the level of the median country in 1995 but rose more sharply than in other EU and OECD countries in the aftermath of the financial and economic crises 2007-2008. After 2011 they converged back to the median price level until 2016. Between 2016 and 2020 they were below the median, but after 2020 they rose more sharply than in many other countries moving into the upper quartile of the countries in the sample. In the transport sector in turn energy prices were consistently lower than in most other countries lying consistently in the lower quartile of the price distribution. Given that the Austrian government has started investing heavily into the climate neutrality of the transport sector this evidence suggests that there is still room to complement these measures with adjustments of the energy price signals.

[6] The analysis in this section follows Sato et al. (2019).

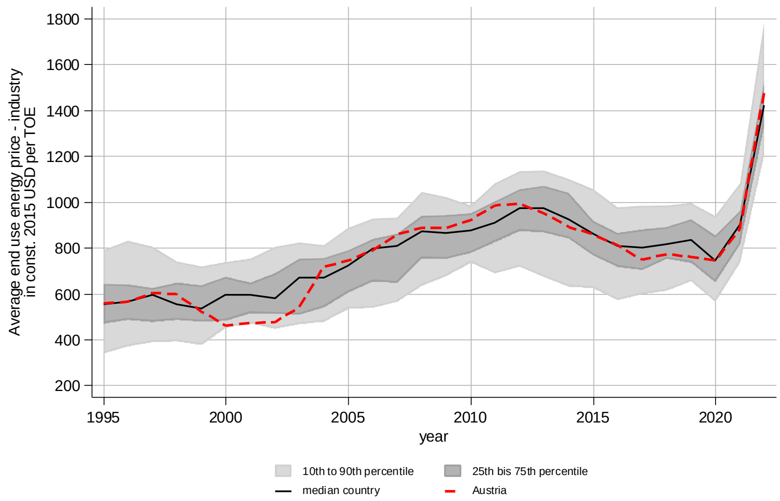
Figure 6: **End use prices industry: total economy; manufacturing, construction and mining sectors, transport sector**

Const. 2015 USD per TOE, 1995–2022

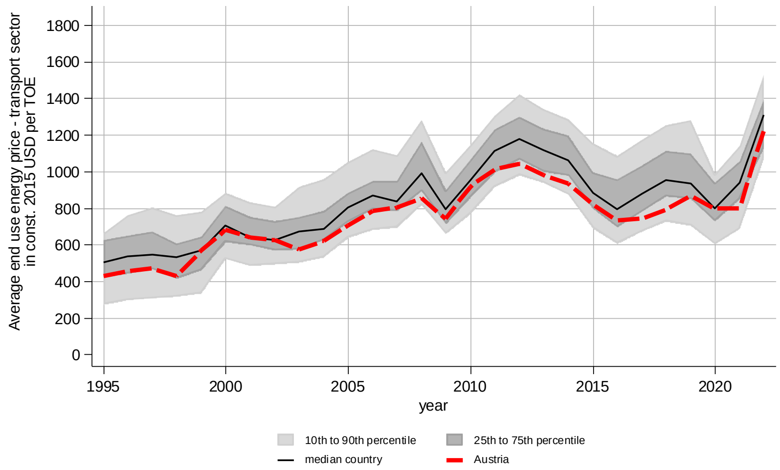
Total economy



Manufacturing and construction; mining



Transport sector

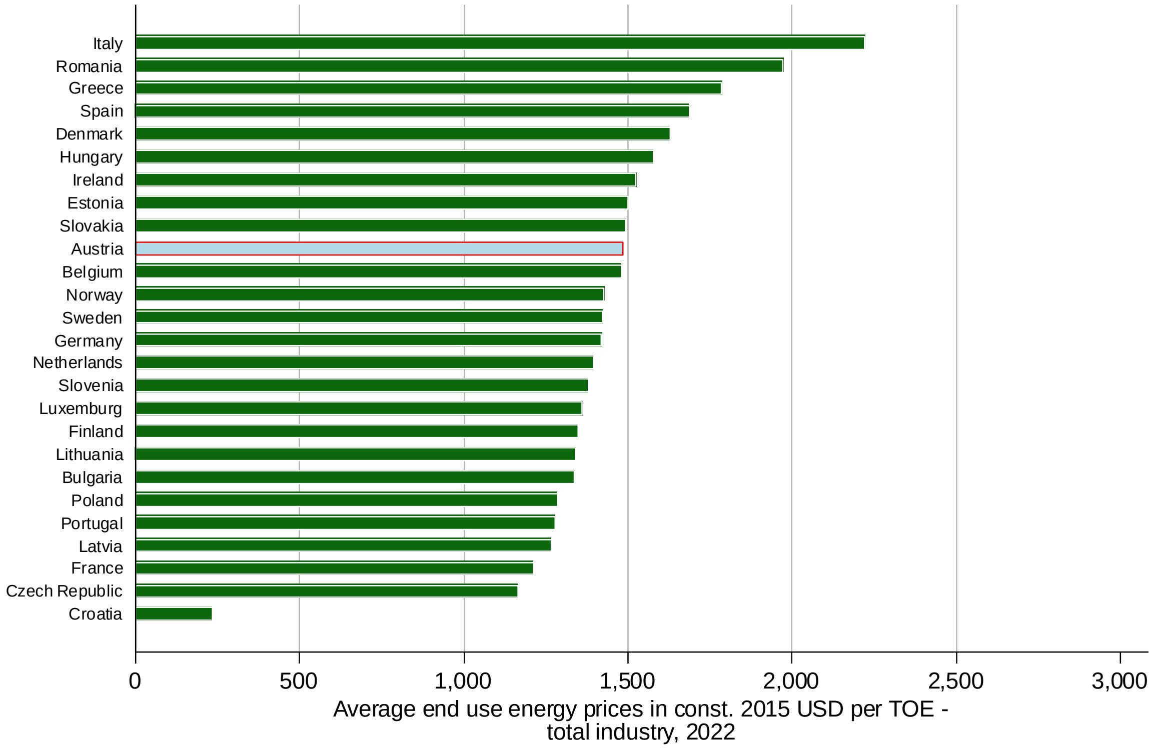


Source: IEA Energy Prices and World Energy Balances; Eurostat Energy Balances, own calculation.

Figure **7** shows that in 2022 industry energy prices for the total economy in Austria figured on the 10th position in the EU. Looking at Austria's most important trade partners inside the EU, Germany and Italy, price levels in Germany were below Austria whereas prices where highest in Italy. Keeping all else equal this development implies a slight worsening of the cost position of Austrian exporters vis-à-vis competitors in Germany and an improvement relative to Italian competitors. The development of overall energy cost-based competitiveness is examined more thoroughly in Section 5 of this paper.

Figure 7: **Average end use energy prices in total industry across EU countries**

Const. 2015 USD per TOE, 2022



Source: IEA Energy Prices and World Energy Balances; Eurostat Energy Balances, own calculation.

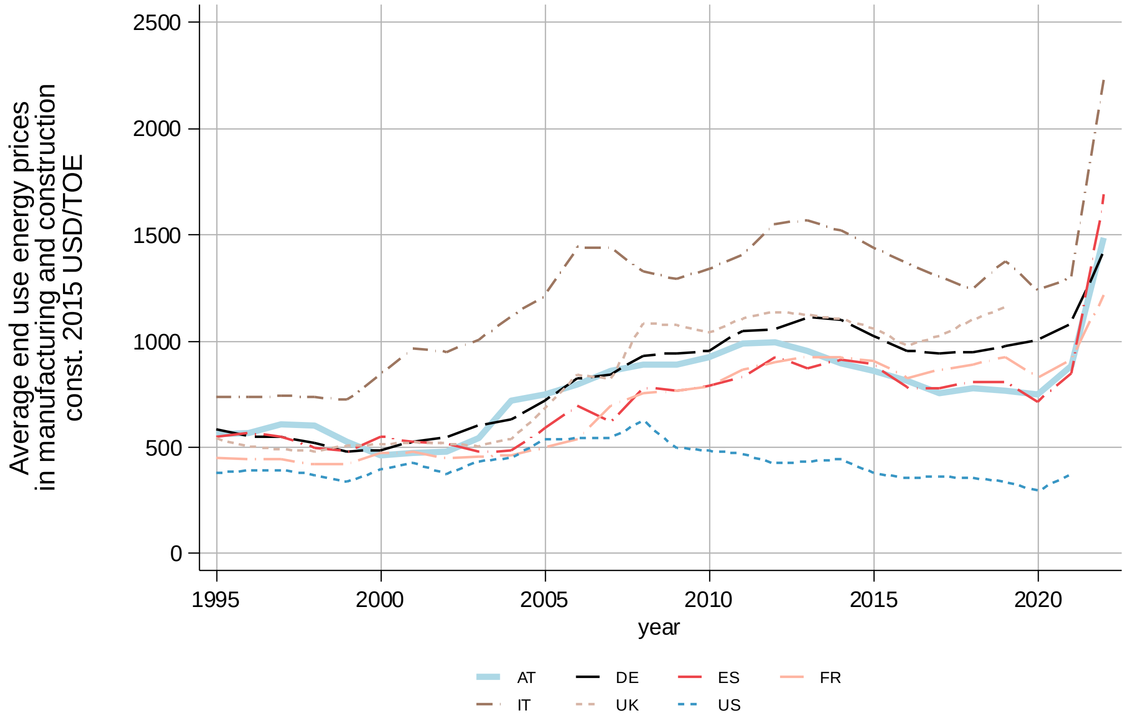
Figure 8 shows that the development of industry energy prices in the USA followed a completely different pattern than in Austria or the big EU economies.[7] They are considerably lower and have remained also much more stable over time than for the European counterparts. This suggests that European exporters face systematic energy costs-related disadvantages vis-à-vis their US trading partners and competitors which must be compensated either through other competitive factors. These considerable price gaps relative to the US present a strong incentive for European firms to serve the US market through direct investments and production in the USA rather than exports. Current US industrial policies such as the Inflation Reduction Act (IRA) provide further strong incentives in this direction. Given that the USA are the most important trading partner for Austrian companies outside the EU these developments are significant especially if the divergence in industry energy prices is persistent. Figure **31** and Figure **32** in the Appendix (page 70) underscore these differences both in the price levels and in price variation. They

[7] Figure **33** on p. 72 provides additional evidence on the development of industry energy prices in comparison with den BENESCAND countries. Witt the exception of Belgium prices in Austria were mostly higher after 2007. As an oil producing country Norway presents an idiosyncratic price development, similar to what is observed for the US.

become even more accentuated if the comparison is carried out based on purchasing power parities instead of market exchange rate.

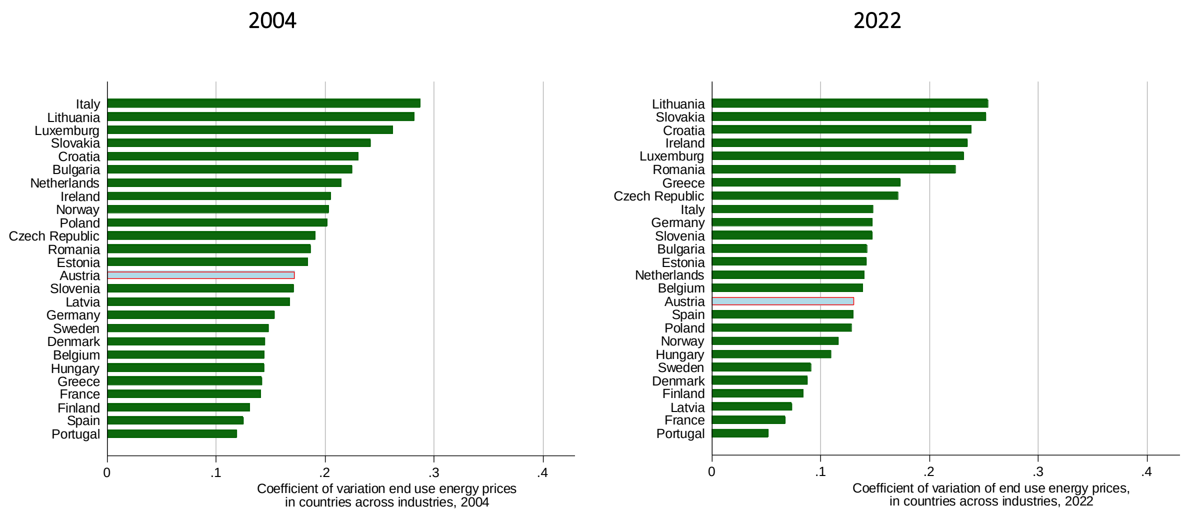
Figure 8: **End use energy prices in the manufacturing, construction, and mining sectors for selected countries**

Const. 2015 USD per TOE, 1995-2022



Source: IEA Energy Prices and World Energy Balances; Eurostat Energy Balances, own calculation.

Figure 9: **Variation of industry energy prices in EU countries across industries**

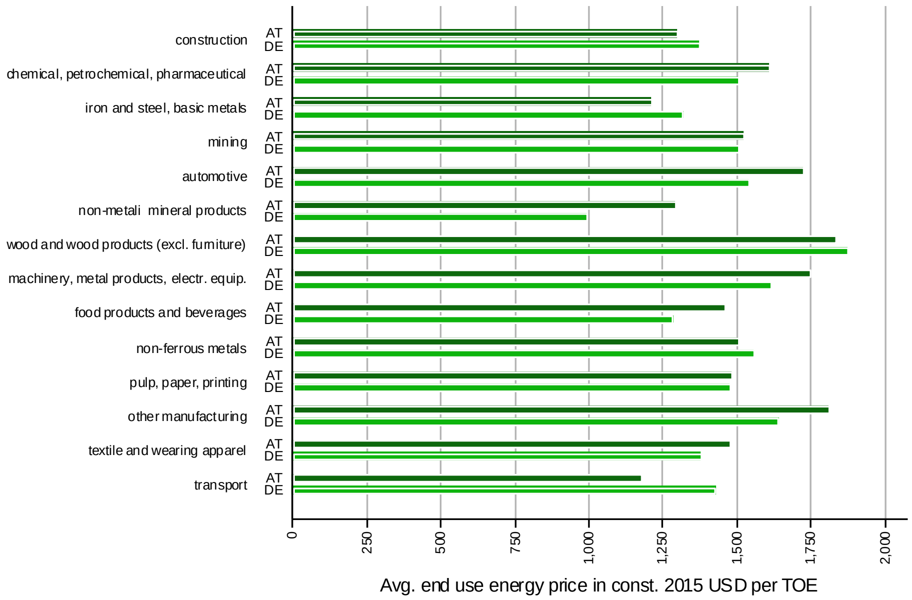


Source: IEA Energy Prices and World Energy Balances; Eurostat Energy Balances, own calculation.

Despite the significant price shock in 2022 the variation of industry energy prices across sectors in the EU countries has decreased if compared to 2004, a period of economic stability and expansion prior to both the financial and economic crisis 2007-2008 and the crises after 2020. Figure 9 shows this by means of the coefficient of variation that captures the extent of variability of energy prices in relation to the mean industry price in a country. This evidence suggests that the price shock propagated in a homogenous way across sectors in each country. Yet, there are significant differences across countries. They reflect different industry structures, as well as differences in national energy markets and policies.[8] The cross-sector variation in energy prices has decreased in Austria relative to 2004 and it was low compared to other EU countries which suggests a more homogeneous response of firms across sectors.

Figure 10: **Average end use energy prices in broad sectors in Austria and Germany**

Const. 2015 USD per TOE, 2022



Source: IEA Energy Prices and World Energy Balances; Eurostat Energy Balances, own calculation. Broad sectors according to the sector classification used in the IEA and Eurostat energy balances.

These aggregate industrial energy price figures hide that there are significant price differences across industries inside countries that reflect variations in the use of different fuel types. Figure 10 shows the measured industry energy prices based on the fuel prices and fuel use across broad sectors in Austria and Germany in 2022. In a longer-term perspective (see Figure 34 through Figure 36 in the Appendix, p. 67ff), sectors with a higher share of electricity and natural gas use face also higher industrial energy prices. Industrial energy prices in 2022 reflect this to a large extent but show also some variation given differences in substitution possibilities between fuel types and energy saving potentials across sectors. For instance, in both Germany and Austria, the share of electricity in total energy use in the wood and wood products industry is close to 90%.[9] The share of electricity is also high in the machinery and equipment or automotive industries. On the other end of the scale, the iron and steel industry use coal to

[8] Figure **37** in the Appendix (p. 76) shows that more than 60 percent of the price dispersion in industry energy prices between 2004 and 2022 can be explained by price variation across countries which indicates that national price components determine end use prices in industry to a larger extent. Our results however indicate a lower share than the one reported by Sato et al (2019), who reported values closer to 80 percent. In the transport sector the country specific price component is lower (about 50 percent).

[9] As mentioned earlier these shares refer to the energy consumption firms have to buy over the market. The factual energy share of electricity, considering the use of waste and biofuels is lower in the sectors where the latter are used intensively.

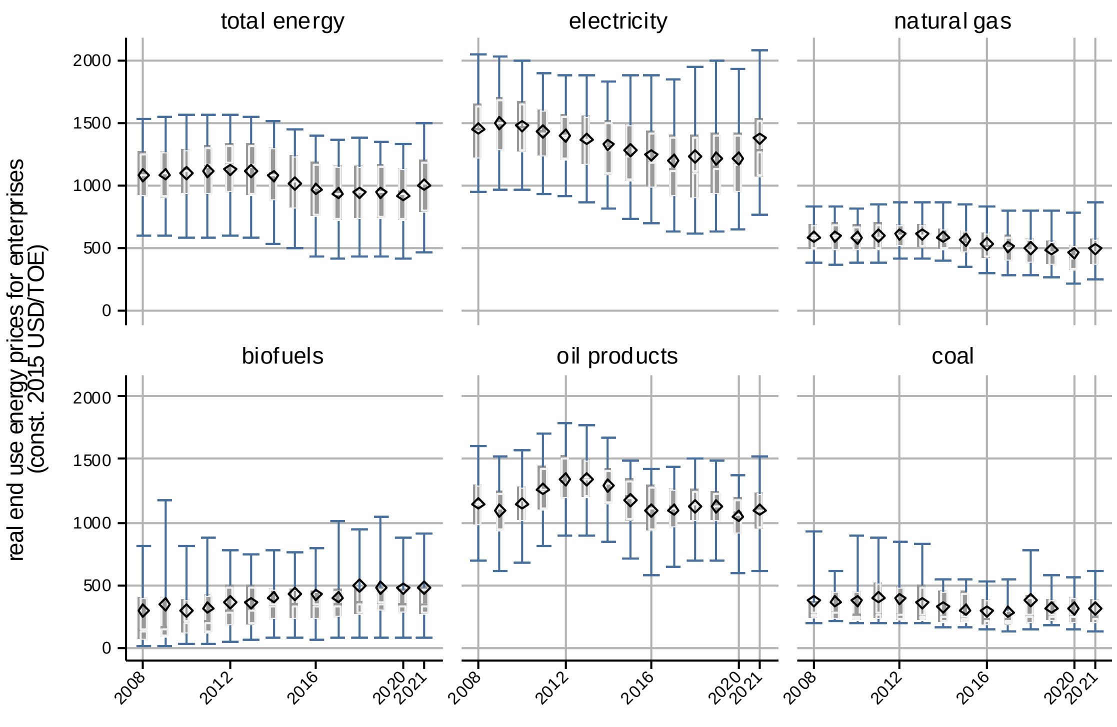
generate heat; to a lesser extent this is also the case for the non-metallic mineral products industry. Other industries again, such as the food products and beverages or the textile industry use higher shares of natural gas than electricity and were also able (mildly) adjust the fuel mix, for instance by increasing the use of oil products. The adjustment of the fuel-mix over time and in response to the price shocks after 2020 will be discussed in greater detail in Section 4.2 of the paper.

3.3 Firm level evidence on the distribution and determinants of fuel prices

The analysis of end use energy price variations at the company level shows that in addition to the strong dispersion of energy prices between countries, a strong dispersion can also be observed at the company level. Figure 11 shows this for Austrian firm level data between 2008 and 2021. It displays the price variations by fuel type at the company level. The total energy price shown in the upper left panel corresponds to the firm level total energy expenditures across fuel types per ton of oil equivalent. The dispersion varies little over time across fuel types. The development of the median total energy prices shown in the figure matches the development shown in Figure 8 for the period 2008 - 2021. The dispersion is largest for electricity prices. In 2021 prices started to increase markedly especially for electricity. Changes in natural gas were still more moderate. The figure also shows biofuels as a comparatively competitive energy source.

Figure 11: **Dispersion of energy end prices at company level**

2008–2021



Source: Statistik Austria material use statistics, AMDC. Own calculations.

Note: The chart shows the price dispersion across all companies included in the goods input statistics. The lower and upper limits of the gray box show the 25th and 75th percentiles respectively. In contrast to conventional box plots, the end values of the hairlines show the 5th and 95th percentiles. This means that 90% of all observations lie between these two limits. The diamond represents the unweighted average.

Table 4: **Exploratory regression analysis of factors influencing energy prices at the firm level**

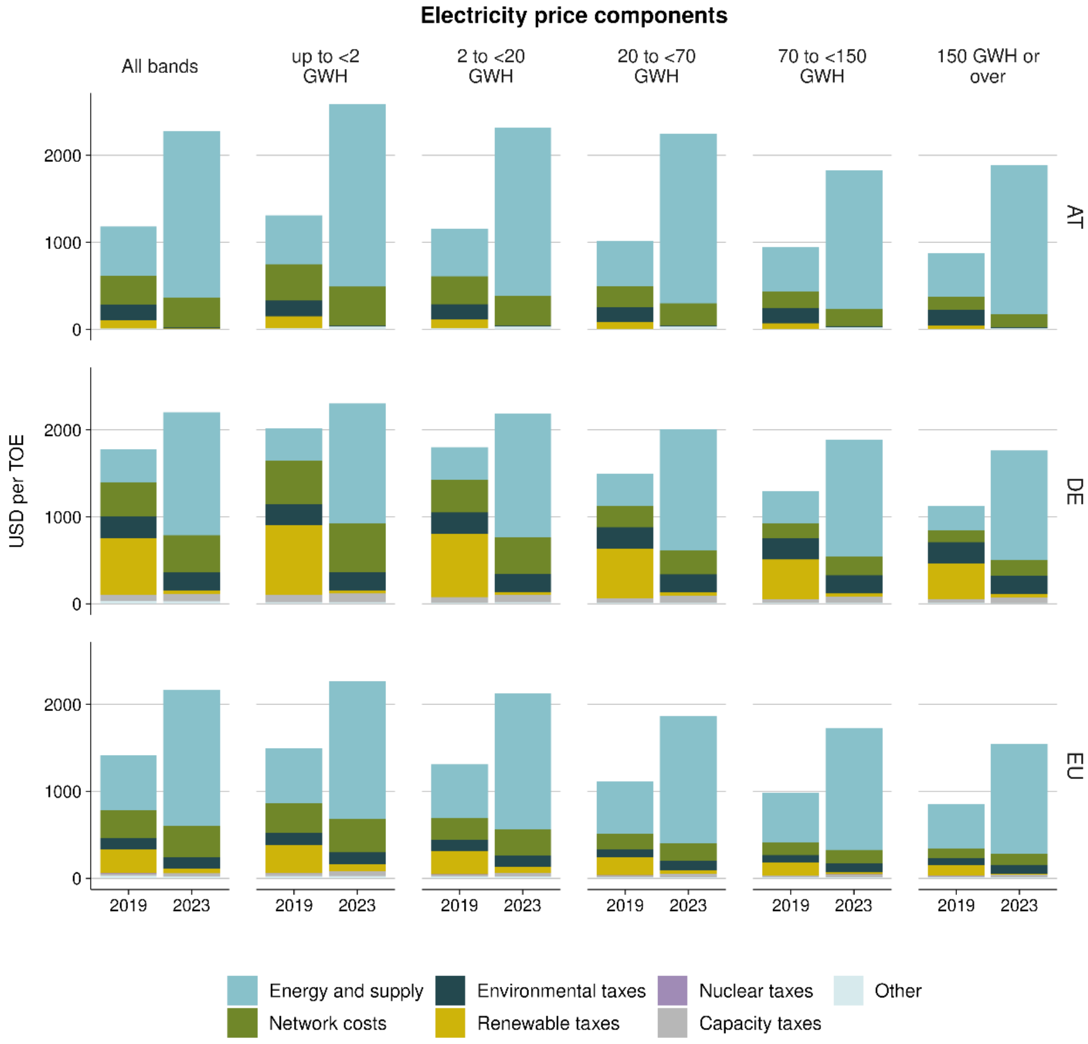
Dependent var: total end use energy price	OLS	OLS	OLS	FE	FE	FE
energy consumption - 2nd quantile	-0.0463***		-0.0493***	-0.0574***		-0.0543***
	(0.0085)		(0.0075)	(0.0105)		(0.0099)
energy consumption - 3rd quantile	-0.0785***		-0.0799***	-0.1194***		-0.1115***
	(0.0101)		(0.0086)	(0.0142)		(0.0138)
energy consumption - 4th quantile	-0.1708***		-0.1454***	-0.1939***		-0.1746***
	(0.0123)		(0.0104)	(0.0179)		(0.0178)
energy consumption - 5th quantile	-0.2994***		-0.2463***	-0.2910***		-0.2600***
	(0.0161)		(0.0129)	(0.0219)		(0.0220)
Renewable energy user	-0.0913***	-0.0901***	-0.0848***	-0.0585***	-0.0561***	-0.0596***
	(0.0116)	(0.0115)	(0.0101)	(0.0112)	(0.0111)	(0.0100)
ETS Account holder	-0.1366***	-0.0868*	-0.0903**			
	(0.0504)	(0.0494)	(0.0415)			
turnover - 2nd quantile	0.0132*		0.0088	0.0098		0.0086
	(0.0079)		(0.0060)	(0.0066)		(0.0060)
turnover - 3rd quantile	0.0410***		0.0271***	0.0273***		0.0269***
	(0.0098)		(0.0079)	(0.0097)		(0.0089)
turnover - 4th quantile	0.0538***		0.0417***	0.0367***		0.0365***
	(0.0112)		(0.0089)	(0.0121)		(0.0115)
turnover - 5th quantile	0.0976***		0.0719***	0.0414***		0.0371**
	(0.0141)		(0.0111)	(0.0155)		(0.0149)
log energy consumption		-0.0825***			-0.1184***	
		(0.0043)			(0.0103)	
log sales		0.0447***			0.0474***	
		(0.0053)			(0.0095)	
share gas in total energy consumption			-0.0045***			-0.0045***
			(0.0002)			(0.0003)
share oil products in total energy consumption			0.0002			-0.0002
			(0.0001)			(0.0003)
share natural gas in total energy consumption			-0.0058***			0.0062
			(0.0006)			(0.0075)
share biofuels in total energy consumption			-0.0065***			-0.0066***
			(0.0003)			(0.0009)
average labor productivity - 2nd quantile			0.0014			-0.0072*
			(0.0052)			(0.0038)
average labor productivity - 3rd quantile			0.0004			-0.0121***
			(0.0062)			(0.0047)
average labor productivity - 4th quantile			-0.0068			-0.0177***
			(0.0068)			(0.0052)
average labor productivity - 5th quantile			-0.0079			-0.0183***
			(0.0079)			(0.0062)
intercept	3.1235***	3.3872***	3.2200***	3.1257***	3.6827***	3.2310***
	(0.0077)	(0.0397)	(0.0110)	(0.0141)	(0.0993)	(0.0196)
year dummies	Y	Y	Y	Y	Y	Y
observations	17192	17192	17192	17192	17192	17192
number of clusters	2628	2628	2628	2628	2628	2628
absorbed	350	350	350			
Adj. R^2	0.3890	0.3924	0.5727	0.1387	0.1612	0.2165
R^2 overall				0.2623	0.2654	0.4998
R^2 within				0.1398	0.1620	0.2178
R^2 between				0.3371	0.3074	0.6062

Source: Statistik Austria structural business statistics, material use statistics - AMDC. Own calculations. Sector dummies included in the OLS regressions.

The exploratory regression analysis in Table 12 reveals that the price differences across firms strongly correlate with the energy intensity of the companies. We don't observe a significant relationship between energy prices and firm size captured by firms' turnover. Results are consistent across OLS and fixed effects (FE) specifications. Electricity prices for companies in the top quintile of the energy intensity distribution are on average between 25 and 30% lower than for companies in the lowest quintile. For natural gas, the difference is between 20 and 30% (see fuel type specific regressions in the Appendix, Table 12). The additional price discount for companies with installations in the EU ETS is in the order of 10% on average after taking their energy intensity into account. Renewable energy users and companies using higher shares of natural gas, and coal pay also lower average energy prices. In the FE specification controlling for unobserved firm level heterogeneity energy prices also decrease for more productive firms.

Figure 12: **Components of the real electricity end price for industry according to the level of annual energy consumption (consumption bands)**

Const. 2015 USD (excl. value added tax)/TOE



Source: Eurostat, energy statistics [Label: nrg_pc_205_c]. "Other" includes (where applicable) renewable energy tax subsidy, capacity tax subsidy, environmental tax subsidy, nuclear tax subsidy and the residual category 'Other'.

Lower end use energy prices in industry for more energy intensive firms result from different price discounts for large customers and regressive grid costs. Figure 12 shows this for the electricity prices in Austria and Germany. Most EU countries, including Austria and Germany, have responded to the price increases on the energy markets by reducing various taxes, which has reduced the share of taxes in final energy prices. In Austria environmental taxes and taxes on renewable energies have been suspended. In Germany, the abolition of the EEG levy to finance the expansion of renewable energies has significantly reduced end prices. The public expenditure previously financed in this way was passed on to the general budget with corresponding redistribution effects. It should be noted that in 2023, the end use prices for electricity were higher in Austria than in Germany or the EU average. This is particularly true for companies in the lower consumption bands (small and medium-sized consumers). In the consumption bands for large consumers, on the other hand, they were only just above those in Germany or the EU average. However, this represents a deterioration compared to the period before the energy crisis. At that time, electricity prices were below those in Germany across all consumer bands and were at a similar level to the EU average.[10]

[10] Inspection of the development of natural gas prices reported by Eurostat not reported here show a different trend. In all but the highest consumption band, they were below those of Germany and the EU average in 2023. For 2023, this means a higher cost burden for Austrian companies compared to German competitors in the consumption of electricity and natural gas in the highest consumption band.

4. The development of energy intensity and its influencing factors

Final energy demand per unit of value added or unit of output is referred to as energy intensity. It provides insights into the use of energy for economic activity even though it is not directly a measure for energy efficiency. Energy intensity in the business sector is determined by overall energy demand induced by any level of economic activity, the industrial structure, energy prices and taxes, the supply chain structure, as well as the technologies in use. As the development of fuel prices and industry energy prices have been discussed in the previous section, this section focuses on characterizing the development of energy intensity in the business sectors that are responsible for about 60% of total end use of energy in Austria (manufacturing, construction, and transport). Energy intensity and energy prices jointly determine unit energy costs that are analyzed in Section 5.

Section 4.1 analyses the impact of industry structure and structural change on the development of the economy wide energy intensity. It also presents evidence on the micro-economic factors underlying the observed sectoral patterns of energy intensity relying on firm level data. Section 4.2 in turn examines the energy mix at aggregate and sector levels, and its development over time. This allows to develop an understanding of the impact of the underlying technologies and substitution potentials of firms in the face of rising energy costs.

4.1 The development of energy intensity in the business sector and its determinants

4.1.1 The development of energy intensity in manufacturing, construction, and transport

The analysis of the development of energy intensity in the business sector focuses on the broad sectors manufacturing, construction, and transport, which jointly are responsible for more than 60 percent of total end use of energy in Austria. Figure 13 presents the development of energy end use in Austria between 1995 and 2022. In 2022 total energy end use amounted to 1065 TJ of which close to 32 percent were assigned to the transport sector, about 30 percent to manufacturing and construction, and the remaining 38 percent to households, public and private services, and agriculture. The most recent preliminary energy balance data published by Statistics Austria[11] show that in 2023 energy end use has slightly declined to 1022 TJ with end-use in manufacturing and construction declining by 9.4 percent, the transport sector increasing by 1.4 percent and other sectors also declining by 4.5 percent relative to 2022.

Looking at the long-run picture of the development of the end use of energy the figure shows a steady increase in energy use between 1995 and 2022 with an average annual growth rate of 1.4 percent each year in the manufacturing and construction sectors, by 1.2 percent in the transport sector and by 0.2 percent in all other sectors. Splitting the sample in sub-periods shows that there was a period of stronger expansion of energy end-use between 1995 and 2010 where annual growth rates averaged 2.4 and 2.8 percent in the manufacturing and construction sectors and the transport sector respectively. These rates declined to 0.1 percent for manufacturing and construction and to 0.7 percent for transport during the period 2011 und 2022, where especially the years after 2019 had a particularly strong dampening effect.

Figure 14 relates these energy end use now to the level of economic activity by showing the development of aggregate energy intensity for the sectors manufacturing, construction, and transport over time

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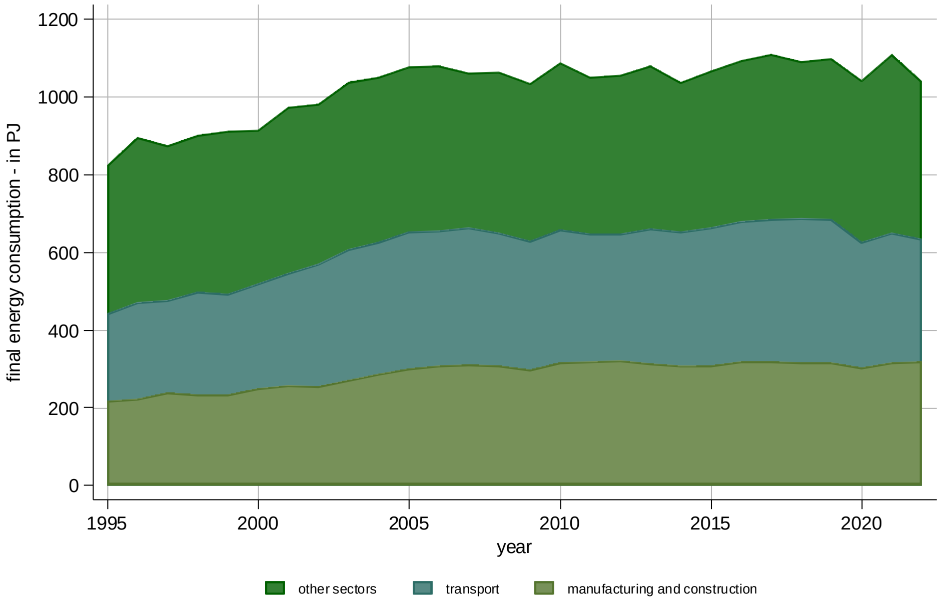
[11] Published May 25th 2024: https://www.statistik.at/statistiken/energie-und-umwelt/energie/energiebilanzen.

in comparison to the developments in Germany over the same period. The figure shows energy intensity as calculated from the data as well as two counterfactual development paths, one time holding the industry structure and one time holding the energy intensity underlying these aggregates constant at the year 2000.

Figure 13: **Energy end use in Austria**

1995–2022



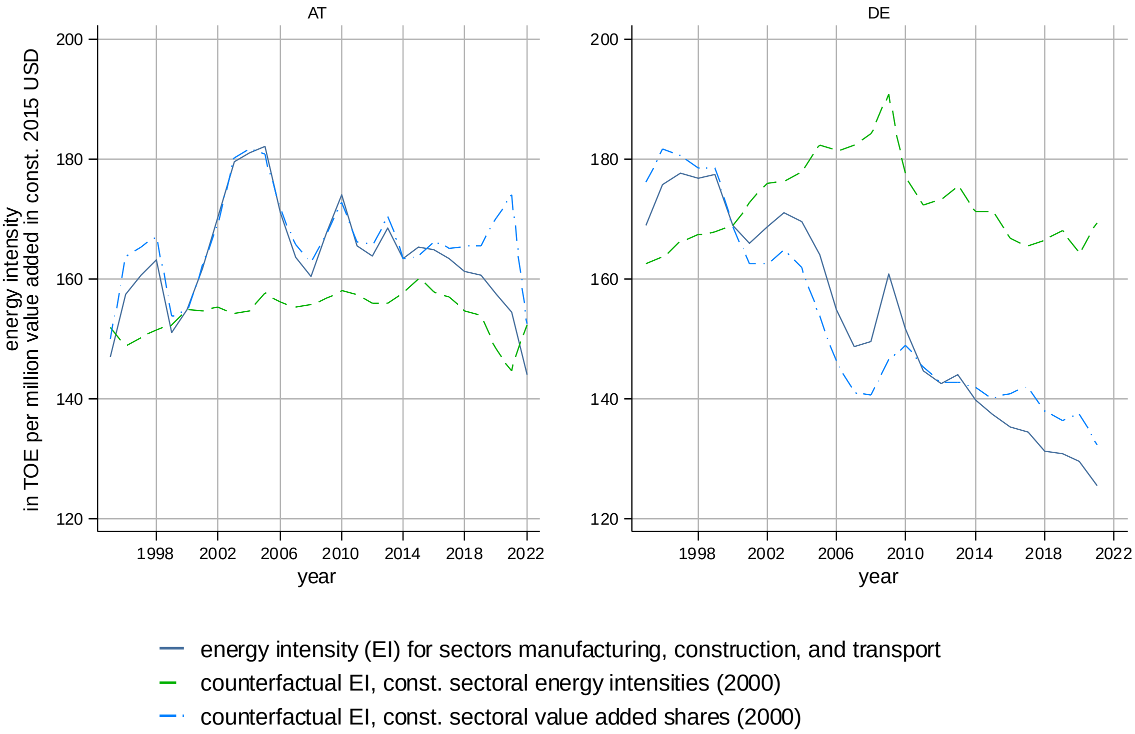
Source: Eurostat energy balances, own calculation.

Figure 14 clearly shows an expansion of the energy intensity in the Austrian sectors between 1995 and 2005 followed by a sharp decline during the financial and economic crisis 2007-2008 followed by a recovery to peak pre-crisis levels in 2010 and a steady decline henceforth. Energy intensity in German sectors in turn peaked in 1999 and declined steadily, with some temporary rebounds between 2001 and 2003 as well as 2008 and 2009. Relative to Germany Austria therefore followed a distinct path of expansion of its energy intensity up until 2010 which is in line with the observed increase in end-use energy over the period 1995-2010 observed earlier.

The counterfactual scenarios Figure 14 allow a first assessment on whether the observed development paths of energy intensity were driven by structural change towards energy intense industries, of by an increase or decrease of sectoral energy intensities. Keeping the energy intensity at a constant level (in our case for the year 2000) provides insights into the impact of structural change on the development of aggregate energy intensity. In this case an increase of the counterfactual energy intensity would point at structural change towards sectors that were more energy intense in the year 2000. Conversely, if sectoral value-added weights are kept constant the resulting counterfactual aggregate energy intensity provides insights into changes in sectoral energy intensities. An increase then indicates that energy consumption per unit of value-added has increased which may be related to inefficiencies, changes in relative energy prices and associated substitution effects or technical change.

Figure 14: **Development of energy intensity of sectors industry, transport, and construction**

1995–2022



Source: Eurostat energy balances, national accounts statistics, own calculations.

For Austria the counterfactual evidence in Figure 14 indicates that between 1998 and 2015 the industrial structure has remained stable but sectoral energy intensities have increased. Indeed, the counterfactual with constant industry structure (blue dashed line) closely matches the observed development (continuous line). This indicates that industry structure in terms of value-added shares has remained stable (green dashed line), but that energy demand of these sectors has increased. After 2015 in turn, we observe an increasing impact of structural change on aggregate energy intensity. If the industry structure (in terms of shares in total value added) had not changed since 2000, energy intensity (blue dashed line) would have been significantly higher. The value-added share of sectors with higher energy intensity in 2000 has declined (green dashed line). In Germany the development was very different. Up to 2009 the value-added share of sectors with higher energy intensity in 2000 have increased, thereafter is has decreased again. This implies that the energy intensity of energy intense sectors (2000) declined up to 2009. Afterwards structural change towards sectors with lower energy intensity has set in.

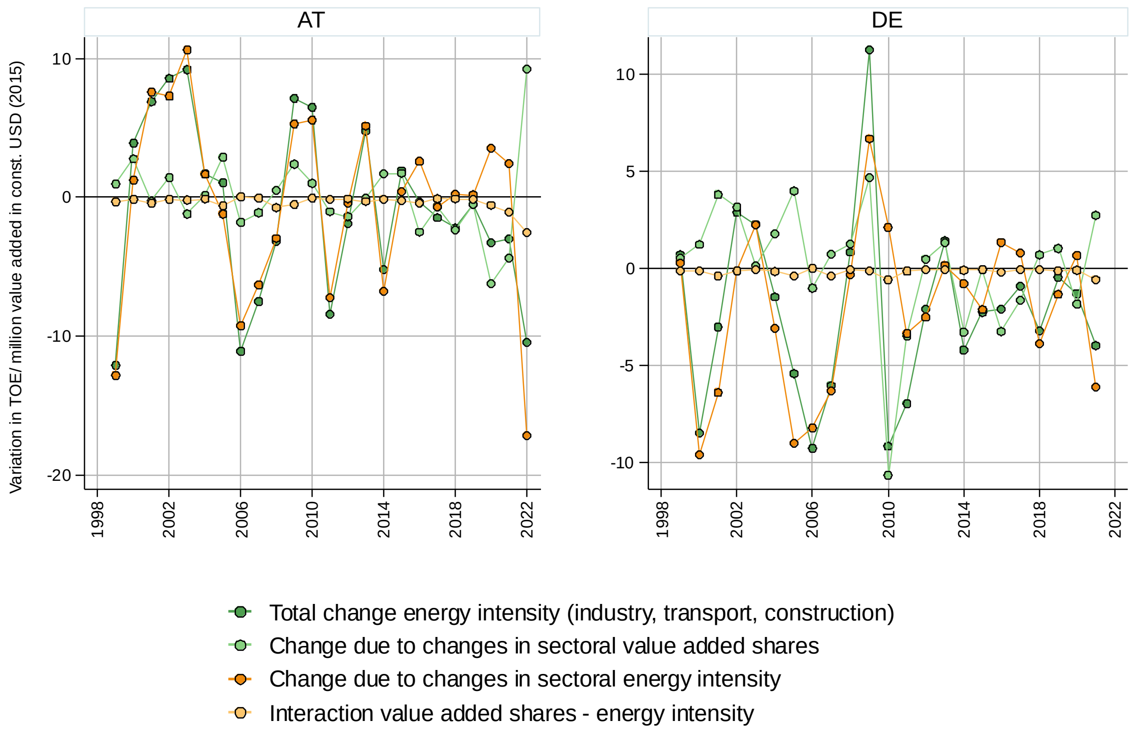
To better understand these pattern Figure 15 and Table 5 present the results of a shift-share analysis. A shift-share analysis decomposes year-on-year aggregate changes in energy efficiency, $\Delta EI_{c,t}$, at time t in country c into changes of the value-added share of a sector s, $\omega_{c,s,t}$, (structural change), and changes in energy efficiency, $EI_{c,s,t}$ of each sector as follows:

$$\Delta EI_{c,t} = \sum_s EI_{c,s,t-1} * \Delta\omega_{c,s,t} + \sum_s \Delta EI_{c,s,t} * \omega_{c,s,t-1} + \sum_s \Delta EI_{c,s,t} * \Delta\omega_{c,s,t}$$

The first sum in equation (1) captures the aggregate effects of structural change, the second sum the aggregate effects of changes in energy intensity, and the third sum the so-called interaction effect, i.e., the effect of simultaneous changes in value-added shares and energy intensities of sectors. An interaction effect with positive sign indicates that the co-movements were predominantly in the same direction. The reverse holds for negative signs.

These shift-share components have rather different economic interpretations. The structural change components reflect changes in the economic importance of certain sectors because their value creation progresses at a slower pace relative to other sectors, e.g., through different dynamics in the demand for their products or a general loss of competitiveness where energy costs may be playing a role. The components capturing changes in energy intensity at the sector level however reflect more strongly behavioral components of the actors inside the sectors related to energy use in the production and provision of services and goods in terms of energy saving through increases in energy efficiency, changes in the fuel mix and related technical adjustments and technical change, or rearrangements of the distributed production process across companies and countries, which may give rise to carbon leakage.[12]

Figure 15: **Shift-share analysis of aggregate energy intensity of the sectors industry, transport and construction for Austria and Germany**



Source: Eurostat energy balances, national accounts statistics, own calculations.

Figure 15 plots the three shift-share components for Austria (left panel) and Germany (right panel). The co-movement of a component with the aggregate change in energy intensity points at its contribution

[12] A recent review finds however that aggregate emission transfers from developed to developing countries peaked around 2006 and declined since. It also summarizes research that does not support the hypothesis that climate policies induce substantial carbon leakage (Grubb et al., 2022). A recent firm level study on the impact of the EU-ETS system finds also little evidence on carbon leakage (Colmer et al., 2024).

into the direction of change of the aggregate outcome. It confirms that in Austria changes in energy use at the sector level determined aggregate development of energy intensity up until 2014. The component capturing changes due to sectoral energy intensity closely matches the observed variation in aggregate energy intensity in this period. Drops in aggregate energy intensity were also followed by recoveries the years after. This is remarkable given that industry energy prices increased and were higher than in many other EU and non-EU OECD countries especially between 2006 and 2014 (see Figure 6). In 2014 finally a large decrease in sectoral energy intensity was offset by an increase in the value-added share of energy intense industries. After 2014 the pattern starts to change and aggregate energy intensity starts to fall. This goes along with falling value-added shares which capture the structural change away from energy intense sectors, but also sectoral energy intensities decline. This development lasted until 2020.

The first years of the pandemic resulted in increases in energy intensity at the sector level that were offset by falling value-added shares of energy intense industries. This is also evident from the interaction effects that in 2020 start to move into the direction of aggregate energy intensity. In 2022 finally, with the start of the war in Ukraine and the energy crisis in Europe, sees a very distinctive pattern that can be observed also for Germany. Due to the industry energy price shocks sectoral energy intensities drop sharply indicating that firms have started to save energy where possible, however, this was partly offset by an increase in the value-added share of energy intensive sectors.

Table 5 summarizes the results of the shift-share analysis for the EU and non-EU OECD countries. The sample includes countries and periods for which data in sufficient quality were available in terms of the average contribution of changes in sectoral energy intensity to the aggregate variation in energy intensity in percent. It is sorted by the contribution of sectoral energy intensity over the period 2004-2022[13] and some relevant subperiods related to the major economic crises of the past two decades. The table shows for Austria that structural change has played an increasingly important role for the development of aggregate energy intensity in Austria after 2014 whereas in earlier years the development was largely determined by an increasing energy use at the sector level relative to the level of economic activity. The table also shows a wide variety of country specific determinants for the development of aggregate energy intensity. In countries like the UK, Belgium, or the Czech Republic changes in energy use at a given level of economic activity were the main driver, whereas on the other end of the spectrum in countries like Norway, Latvia or Sweden structural change had the dominant impact.

The final column shows that not all countries have reduced the aggregate energy intensity. In countries like Norway (NO), Ireland (IE), Greece (GR) or Hungary (HU) between 2004 and 2019 it has increased (shorter time interval due to the high fluctuations in the years 2020-2022). While reductions in energy intensity were considerable in some cases such as Switzerland (CH) or Slovakia (SK) most countries experienced reduction in the range between 10 and 30 percent. For Austria the reduction in aggregate energy intensity was on the lower end of the scale with -6 percent. There is no significant correlation between the share of the aggregate change in energy intensity explained by changes in sectoral energy intensity between 2004 and 2019 and reductions in aggregate energy intensity. While a simple correlation analysis is not conclusive the absence of a significant association suggests that the shift-share analysis does not reveal any dominant driver of aggregate reductions in energy intensity.

[13] The shorter period for this shift-share analysis with broader country coverage is due to data availability for several countries.

Table 5: **Shift-share analysis: Contribution of changes in sectoral energy intensities to changes in aggregate energy intensity ΔEI (M, T, C) across countries**

Manufacturing (M), transport (T), and construction (C)

Country	2004-2007	2008-2013	2014-2019	2020-2022	2004-2022	ΔEI (M, T, C) 2004-2019 %
			In %			
UK	34.7	75.7	87.5*	n.a.	69.6	n.a.
CZ	72.2	76.6	64.7	63.1	68.4	-48.0
CH	50.2	74.8	82.8	20.4	65.3	-50.0
RO	76.9	44.3	53.1	57.6	65.2	-23.5
BE	69.7	56.6	70.3	47.0	65.2	-12.8
SI	61.2	50.3	69.8	61.5	64.7	-18.9
HU	45.7	78.1	57.3	76.2	63.5	26.6
EE	45.3	61.4	61.8	49.5	62.3	-20.4
LU	57.5	53.4	57.8	75.0	62.2	-28.4
ES	76.9	50.1	66.1	31.5	61.5	-9.3
FR	55.1	61.0	67.7	35.6	61.2	-14.8
LT	62.2	55.5	60.6	40.7	60.6	-13.5
AT	70.1	69.9	36.8	41.4	60.0	-11.3
IT	45.8	61.2	68.9	27.5	59.4	-18.9
NL	68.7	57.5	49.0	63.6	58.7	-19.5
PL	59.3	45.7	71.3	43.9	57.1	-33.0
HR	53.4	58.9	50.9	58.3	55.7	4.5
BG	62.6	37.1	54.8	54.3	54.7	-31.5
GR	26.9	59.2	66.3	49.3	54.5	35.8
DK	47.6	55.7	59.3	45.2	54.0	-23.7
SK	71.2	31.8	66.3	54.9	53.0	-56.4
SE	62.4	77.6	45.7	36.7	52.9	-25.7
DE	75.6	39.1	51.7	31.4	50.9	-22.9
PT	49.2	51.0	47.8	32.1	50.5	-15.1
LV	57.4	39.3	59.6	38.5	50.4	-8.7
FI	31.8	51.6	57.9	48.5	48.6	-11.8
CY	64.7	36.4	40.4	29.8	46.8	-25.6
IE	39.3	41.2	53.7	43.9	44.9	38.6
NO	47.2	41.4	33.1	27.0	38.3	13.3

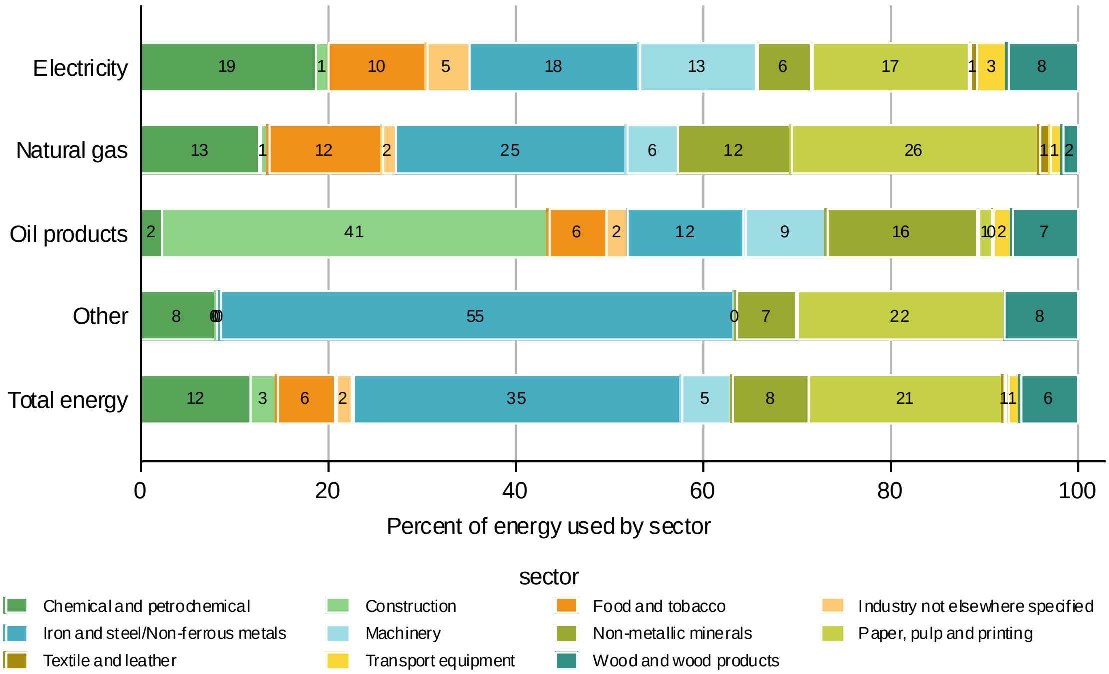
Source: own calculations, Eurostat, IEA Energy Prices. Country abbreviations follow the ISO3166 standard. * 2018 for UK.

4.1.2 Firm level evidence of sectoral patterns of energy consumption and intensity in Austria

The analysis of firm level data allows developing a more granular perspective on energy use. Using data for manufacturing and construction companies, Figure 16 presents evidence on the energy use by fuel type and for total energy use across sectors using firm level data for the most recent year available in the data. It shows the share of each sector in the use of a particular fuel type in percent.

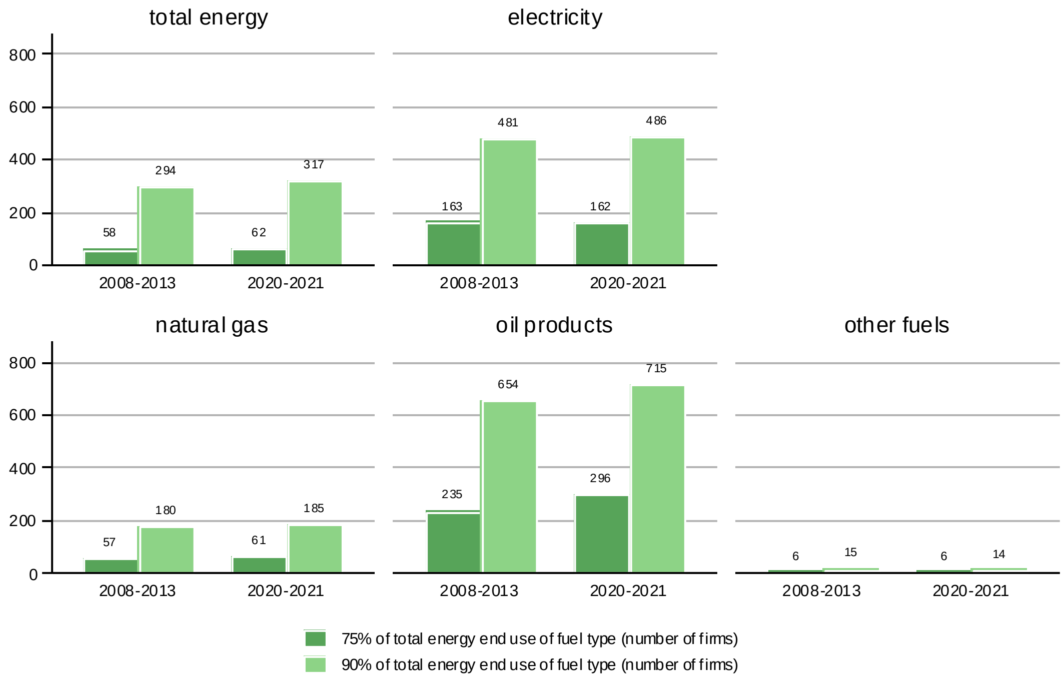
Looking at total energy consumption, the figure shows a very high sectoral concentration of final energy use. The four major sectors that account for more than 75 percent of the total energy used in manufacturing and construction are the iron and steel/basic metals sector, the pulp, paper, and printing sector, the chemical, petrochemical, and pharmaceutical sector, and the non-metallic mineral sector. The iron and steel/basic metals sector accounted for 35 percent of total energy used in manufacturing and construction in 2021. This sector consumed 25 percent of total natural gas, 18 percent of electricity, and 55 percent of other fuels. This last category combines coal, waste, and biofuels into one category for confidentiality reasons. However, the data show that the iron and steel sector will still be a heavy user of coal in 2021. The second most important sector in terms of total energy consumption is the pulp, paper and printing sector, which was responsible for 21 percent of total consumption. This sector was also the largest user of natural gas and the second largest user of electricity and other fuels. However, unlike the iron and steel sector, the pulp, paper and printing sector is the largest user of waste and biofuels. Finally, the chemical sector consumed 12 percent of the final energy demand in manufacturing and construction, relying mainly on electricity and natural gas.

Figure 16: **Energy use by fuel type across sectors for the year 2021**



Source: Statistik Austria structural business statistics, material use statistics - AMDC. Own calculations.

Figure 17: **Concentration of energy use in the Austrian corporate sector for total energy consumption and different energy sources**

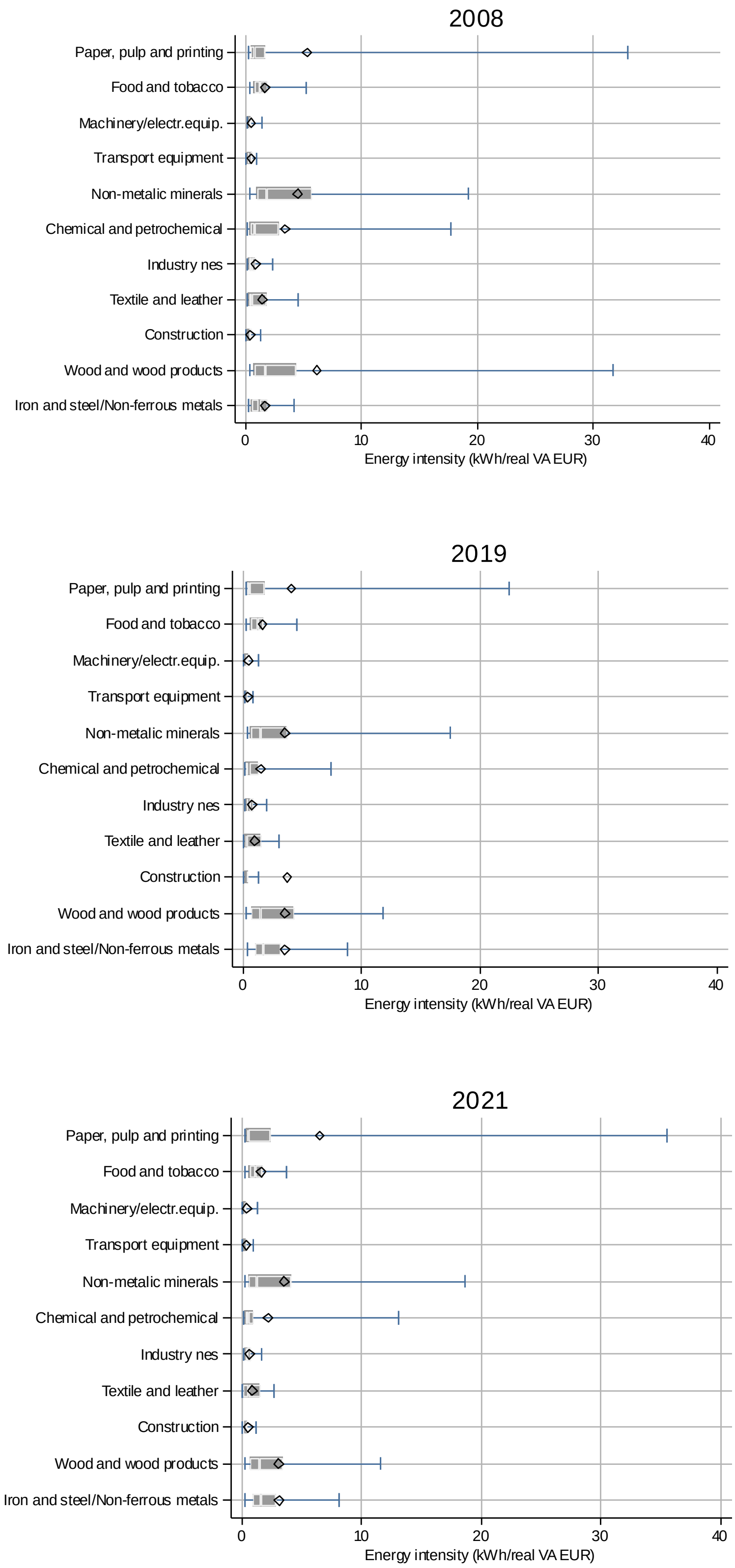


Source: Statistik Austria structural business statistics, material use statistics - AMDC. Own calculations.

Looking at the concentration of energy consumption across firms Figure 17 shows that a very small number of firms accounts for a very high share of total energy consumed. This is especially true when moving form total energy use to specific energy sources like coal and coal products and biofuels. The concentration varies across the different fuel types. Between 2009 and 2013, an average of 58 companies accounted for 75% of total final energy consumption in manufacturing. Between 2020 and 2021, the figure rose slightly to 62 companies. In the same period, 317 companies were responsible for 90% of total final energy consumption in manufacturing. This concentration varies across different energy sources. The concentration is higher for final energy consumption from natural gas and other energy sources (coal, utilization of waste products) and lower for final energy consumption from electricity. In both cases, however, fewer than 200 companies are responsible for 75% of total final energy consumption. Concentration is lowest in the use of petroleum products, but here too around 90% of consumption was accounted for by 715 companies in 2020-2021.

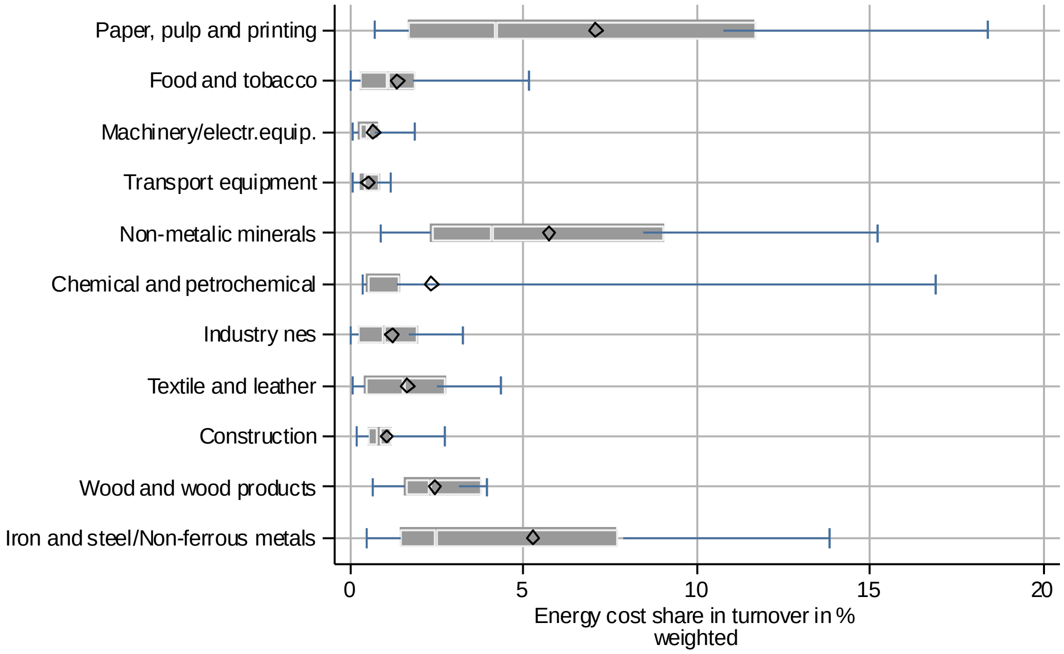
Looking at the relationship between energy consumption and value added Figure 18 shows that in terms of median energy intensity (here measured as kWh per real value added in EUR at 2015 prices), the paper, pulp and printing sector tops the sectors, followed by the non-metallic minerals and chemical/petrochemical/pharmaceutical sectors and the iron and steel sector. With the exception of the wood and wood products sector the energy intensity seems to have remained largely stable over time across sectors. The wood and wood products sector is an exception insofar as it has experienced a strong reduction in both the median energy intensity as well as the dispersion of energy intensities across companies in this sector.

Figure 18: **The distribution of firm level energy intensity (energy use relative to value added) across sectors for the years 2008, 2019 and 2021**



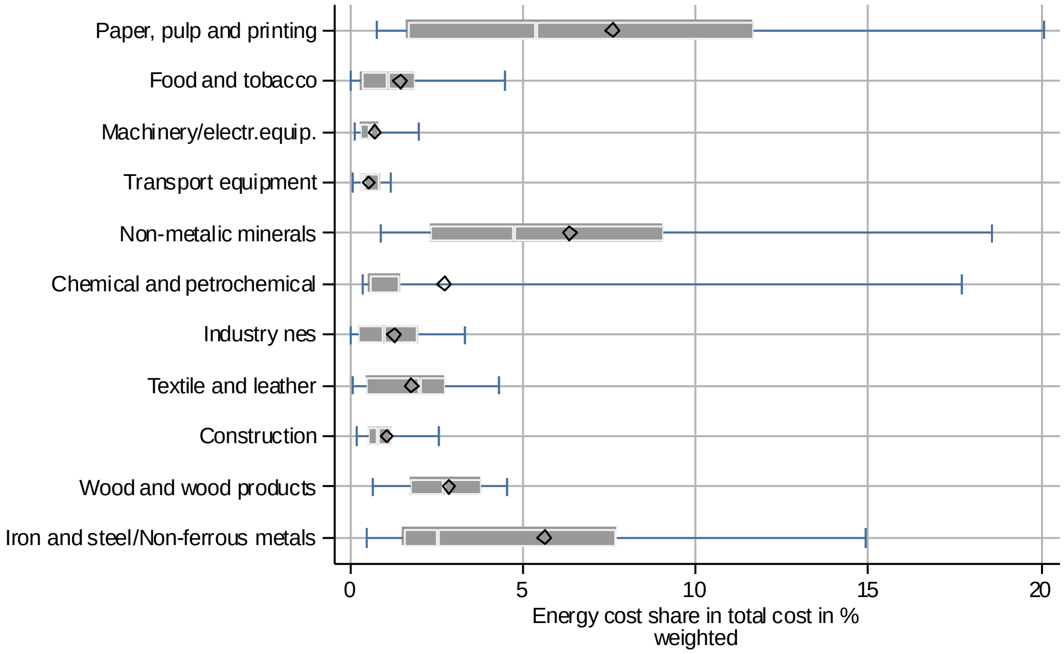
Source: Statistik Austria structural business statistics, material use statistics - AMDC. Own calculations. The lower and upper limits of the gray box show the 25th and 75th percentiles respectively. The end values of the hairlines show the 5th and 95th percentiles. This means that 90% of all observations lie between these two limits. The diamond represents the unweighted average.

Figure 19: **The distribution of firm level turnover based energy intensity across sectors for the year 2021**



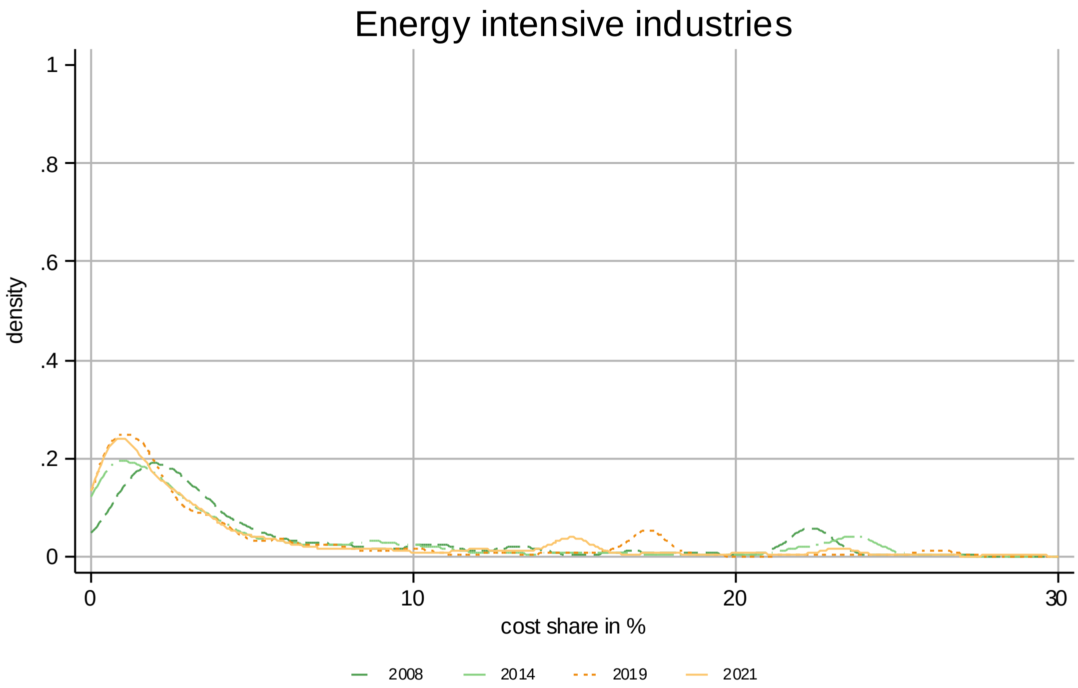
Source: Statistik Austria structural business statistics, material use statistics - AMDC. Own calculations. The lower and upper limits of the gray box show the 25th and 75th percentiles respectively. The end values of the hairlines show the 5th and 95th percentiles. This means that 90% of all observations lie between these two limits. The diamond represents the unweighted average.

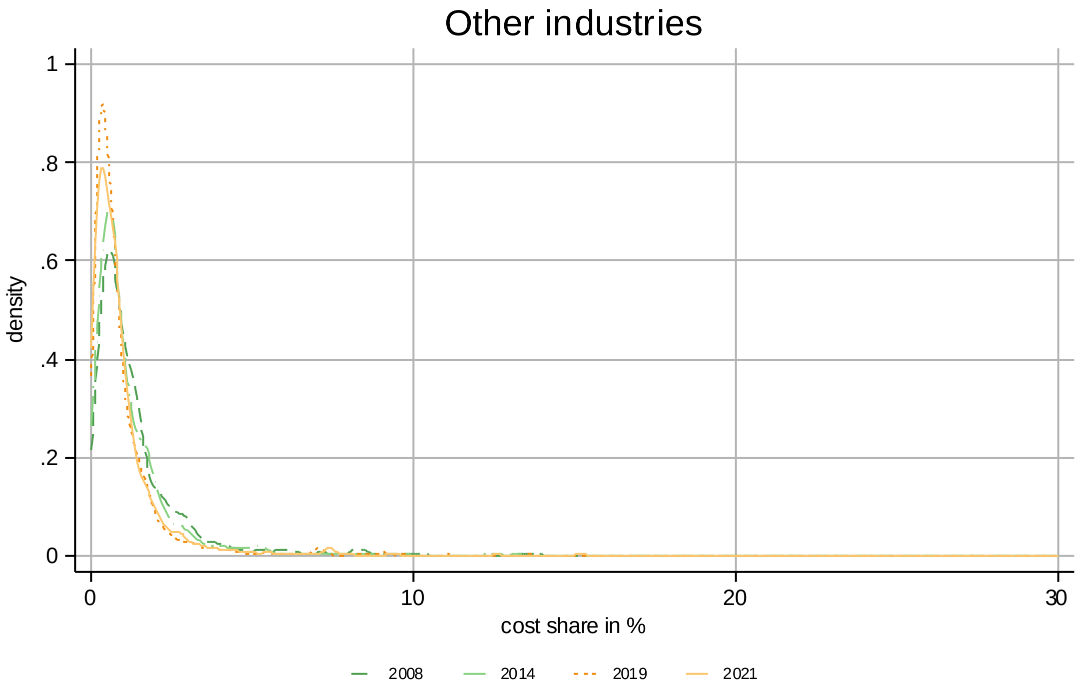
Figure 20: **The distribution of firm level energy cost shares across sectors for the year 2021**



Source: Statistik Austria structural business statistics, material use statistics - AMDC. Own calculations. The lower and upper limits of the gray box show the 25th and 75th percentiles respectively. The end values of the hairlines show the 5th and 95th percentiles. This means that 90% of all observations lie between these two limits. The diamond represents the unweighted average.

Figure 21: **Distribution of energy costs in total costs in energy-intensive and other industries in Austria (kernel density estimator) for the years 2008, 2014, 2019 and 2021**





Source: Statistik Austria structural business statistics, material use statistics - AMDC. Own calculations.

Calculating energy intensity based as share of energy costs in total operating costs or turnover (Figure 19 and Figure 20) largely mirrors the results for the energy intensity based on value added but shows some stronger dispersion in the iron and steel sector. The significance of energy costs for companies is best captured by the share of energy costs in total operating costs. In energy-intensive sectors, the median and average values are significantly higher than those of other industries and show a much wider spread. The chemical industry is an exception insofar as the majority of companies have a comparatively low energy cost share, but there is a small proportion of companies with very high energy intensity. Overall, the data shows a high degree of heterogeneity in the energy cost share not only between the industry groups, but also within the industry groups.

The heterogeneity is particularly evident when looking at the overall distribution of energy cost shares for energy-intensive and other industries (Figure 21). The mode of the share of energy costs in operating costs is 1 percent; in energy-intensive industries it is between 2 and 3 percent. However, the distribution of energy costs in energy-intensive sectors is skewed to the right. This means that the energy cost share of the majority of companies in these sectors is above these values. In a right-skewed distribution, the energy cost share of the median company is higher than in the point of the distribution with the highest density (mode) and the average value is in turn higher than the median value. This implies that there are few companies with a very high share of energy costs and very many with a low share of energy costs. Hence, not all companies in energy-intensive sectors are also energy-intensive. In the case of a skewed distribution of energy cost shares, policies to subsidize energy cost should be very targeted, as the majority of companies even in energy intense sectors do not need significant subsidies to maintain their competitiveness in the face of an adverse energy price shocks. However, the few firms with very high energy cost shares may need significant support. A cost-effective policy should focus on these companies. The figure also shows that in the energy-intensive sectors the distribution has shifted to the left over time. This means that the share of energy costs has decreased over time across the entire distribution and lost importance compared to other operating costs.

To conclude, the analysis in this section using firm level data shows a high concentration of energy consumption both across sectors and firms. Similarly, also energy intensity or energy cost shares are also very concentrated. When it comes to energy use there is only a small number of firms that actually are critically exposed to strong energy price shocks both in terms of energy consumption and the share of energy costs in total cost. Public interventions to support firms exposed to such shocks can thus be very well targeted.

4.2 The development of the fuel mix and fuel switching at the level of sectors and firms

The fuel or energy mix in energy end use in an industry is affected by the technology, energy costs, the availability of certain energy sources in a particular location, regulations, taxes and subsidies, as well as considerations about energy security or logistics. It thus reflects behavioral adaptations at the firm level to balance these constraints and ensure cost-effective production and operational efficiency. The fuel mix is of particular importance for the economic performance and cost-competitiveness of firms as it determines the adjustment needed to meet CO_2 emission goals, potential additional costs firms face through emission trading schemes or carbon taxes and the exposure to geopolitical risk of firms.

Changes in the fuel mix may reduce the energy intensity in the provision of goods and service, through various adjustment channels such as using fuels with higher conversion efficiency, the adaptation of more energy-efficient technologies, process optimization, or the reorganization of production and supply chains. The levels of investment needed in turn will to a large extent depend on the substitution potentials and technological alternatives that would allow carbon neutral and cost-effective operations. Section 4.2.1 will provide cross-country sector level analysis and compares developments in Austria with international peer countries. Section 4.2.2 provides firm level evidence for Austria on the development of the fuel mix at the sector level. Both sections provide an analysis on how fuel price changes and fuel substitution have affected industry energy prices in the past.

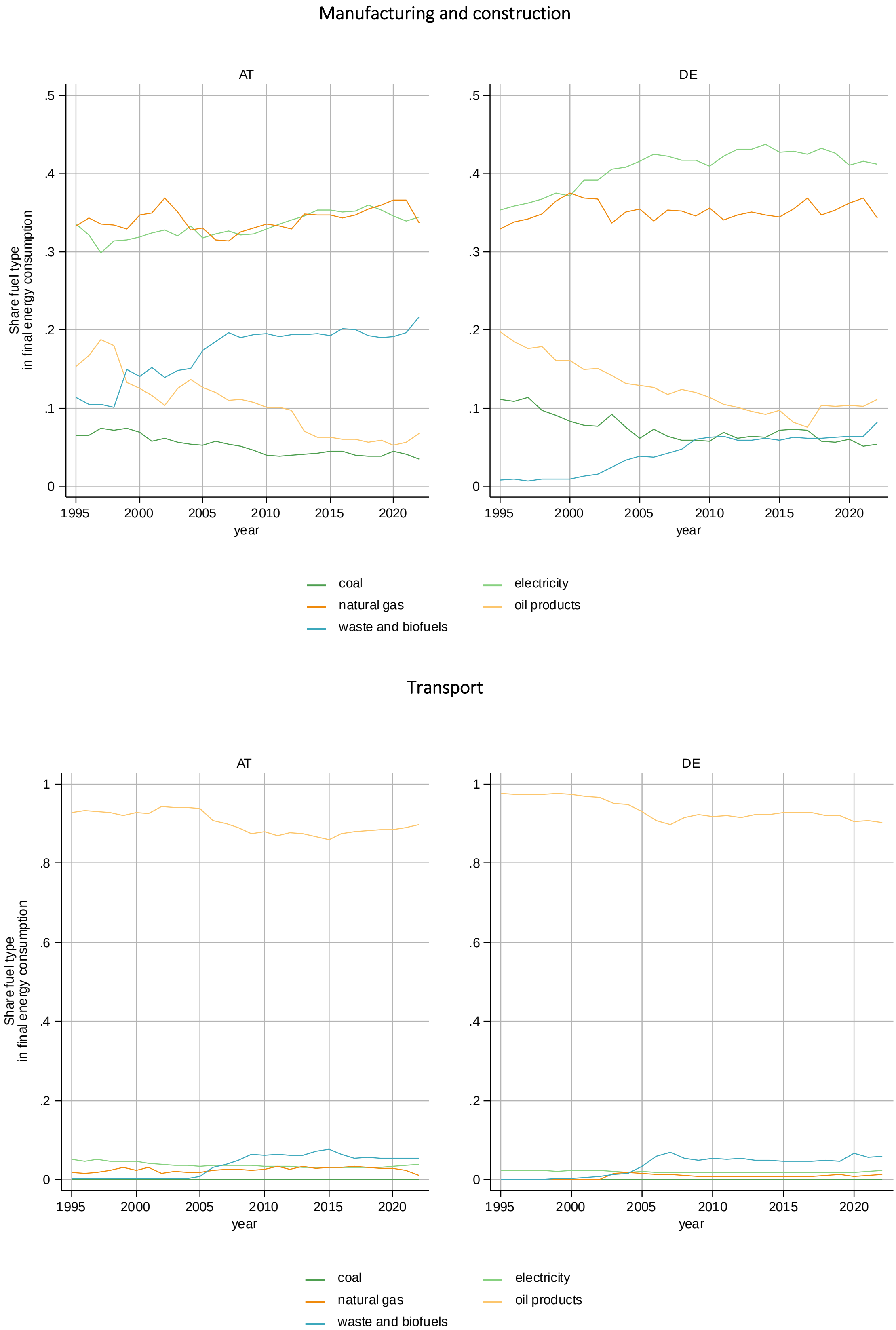
4.2.1 Cross-country aggregate and sector level evidence

The aggregate fuel mix in Austrian manufacturing and the construction sector is dominated by electricity that covers more than 50% of total end use of energy (Figure **22**). The use of electricity has increased steadily over time. It has experienced a phase of acceleration between 1995 and 2007, after that the share has increased at a more moderate rate. Over the entire period of observation spanning from 1995 to 2022 the use of oil products has declined steadily. This holds also at a somewhat lower rate for the use of coal. The end use energy share of natural gas in turn has remained relatively stable over time even though it has experienced some up- and downswings related to the major economic crises witnessed during the past twenty years. This overall picture suggests that in the past electricity has been substituted for oil products and coal but not so much for natural gas. The share of biofuels and waste in turn is low and was below 5 percent of total end use energy use all the time. The energy crisis in 2021-2022 following the Russian invasion of Ukraine led to downward adjustments in natural gas use that was compensated by higher use of electricity and oil products. The transport sector shows a different pattern of energy use. Oil products are the dominant source of energy. Between 2005 and 2010 the data show some decline, but the shares stabilize afterwards. After 2020 the data show a slight increase in the use of oil products again. Similar patterns of development can be observed for Germany as well.[14]

[14] A comparison of energy use especially with Sweden or Finland (see Appendix Figure 38, p. 80) shows that the degree of electrification of manufacturing and construction in these countries is more advanced. The energy mix in these countries has evolved to considerably higher shares of electricity use after 2005. This is particularly marked for the transport sector in which oil products are being replaced with electricity. Both countries generate most electricity consumed from nuclear, hydroelectric and wind power plants. Sweden is also a net exporter of electric energy (IEA 2022).

Figure 22: **Development of the fuel mix in manufacturing and construction, and the transport sector in Austria and Germany**

1995–2022



Source: Eurostat energy balances, own calculations.

To analyze to what extent the observed patterns of development of the fuel mix are related to changes in fuel prices we decompose the observed changes in industry energy prices presented in Section 3 into changes related to fuel switching and thus (short-run) substitution processes between fuel types and changes related to increases in the fuel prices. This provides insights into substitution potentials and the persistence of the observed energy use patterns. For this purpose, changes in industry energy prices, $\Delta EPI_{c,s,t}^{realUSD}$, are decomposed in a similar fashion as was done in the shift-share analysis of the development of energy intensity:

$$\Delta EPI_{c,s,t}^{realUSD} = \sum_{e} p_{c,s,t-1}^{e,i,realUSD} * \Delta w_{c,s,t}^{e} + \sum_{e} \Delta p_{c,s,t}^{e,i,realUSD} * w_{c,s,t-1}^{e} + \sum_{e} \Delta p_{c,s,t}^{e,i,realUSD} * \Delta w_{c,s,t}^{e}$$

where $p_{c,s,t-1}^{e,i,realUSD}$ and $w_{c,s,t}^{e}$ are the prices of fuel type *e* in constant 2015 USD and fuel weights respectively as described in Section 2. The first sum captures the aggregate industry price effects related to fuel switching, the second changes due to fuel price changes and the third terms is as earlier the interaction effect capturing change of prices and weights in the same or opposite directions. A negative interaction term thus captures fuel adjustments to counter aggregate price increases.

Figure 23 shows that the price component in the decomposition explains the largest share of aggregate industry energy price variation in most countries shown in the figure, in an apparently independent fashion of the observed energy mix.[15] It closely matches the changes in the aggregate industry price. Changes in the fuel mix play a relatively subordinate role over most of the observation period spanning 2004-2022. This is also true for Finland and Sweden where the fuel mix has steadily changed over time, but the price component closely mirrors aggregate industry level price changes. An exception is the US, where the substitution component has a stronger effect. Table 6 extends this evidence to all European countries. In the long run the price component explains between 64.5 and 88 percent of total industry level price variation. The energy crisis 2021-2022 has not substantially affected this relationship across countries. Figure 23 shows that changes in the fuel mix had a stronger impact after in Austria and Germany in 2022, but this change did little to dampen the aggregate price increase as the fuel switch positively affected the aggregate price level.

This evidence does not come as a surprise given the results from sector level (cf. Nikolaos and Vlachou, 2005) or firm level studies (cf. Hyland and Haller, 2015) on interfuel substitution elasticities.[16] They show that the demand for electricity is highly insensitive to own-price changes as well as changes in the prices of other fuels (see also Stern, 2012). The responsiveness of natural gas prices depends on whether firms or sector use other fossil fuels. In this case the demand for natural gas is more responsive to own-price changes and changes in the prices of substitutes. This may explain to some extent the higher importance of fuel switching in the US or Sweden and Finland, as shown in the Figure 23. In the US as the fuel share of fossil fuels is above 70 percent (2022). In Sweden or Finland where the share of electricity in end use is high, substitution possibilities are more limited, hence the price component has a stronger effect relative to the US.

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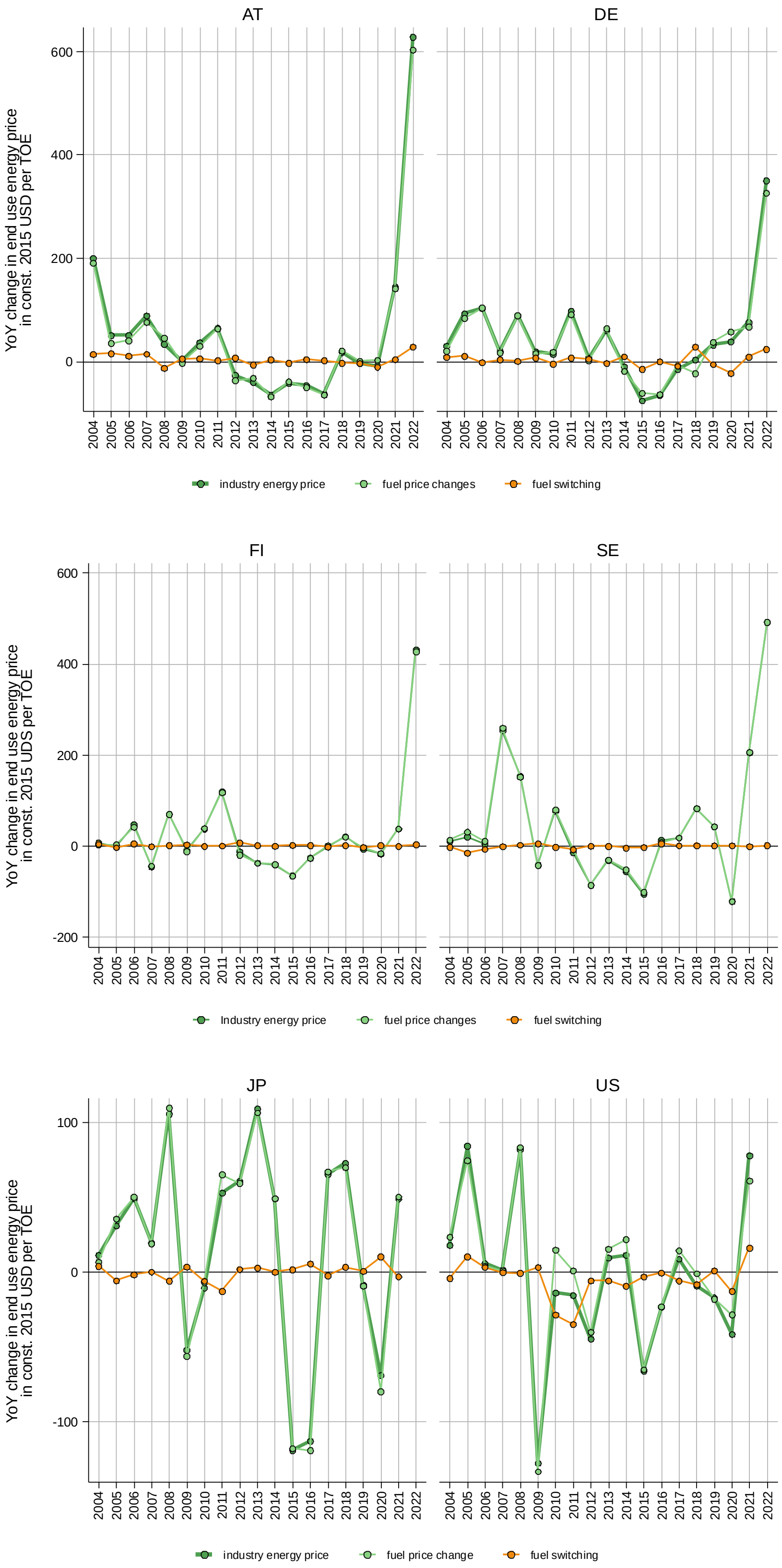
[15] The interaction terms have been omitted from this figure. Their impact on the industry level price is generally close to zero.

[16] Interfuel substitution elasticities for Austrian firms will be estimated and discussed in a companion paper.

Figure 23: **Decomposition of industry energy price changes into a fuel switching and pure price component in Austria and Germany**

2004–2022



Source: IEA Energy Prices; IEA and Eurostat Energy Balances. Own calculations.

Table 6: **Average YoY changes in end use industry energy prices explained by changes in fuel prices in percent, all countries**

2004–2022

Country	2004-2007	2008-2013	2014-2019	2020-2022	2004-2022
			In %		
JP	84.1	84.7	95.8	90.0	88.8
FI	79.2	88.0	86.0	95.3	86.7
SE	75.7	85.5	82.8	98.8	84.7
NO	81.9	81.1	80.8	96.6	83.6
DK	84.4	76.4	83.4	96.1	83.4
BE	84.1	76.1	84.8	94.0	83.4
SI	92.0	70.9	92.1	77.8	83.1
LU	82.5	80.4	84.6	83.8	82.7
UK	83.3	76.5	86.8	n.a.	82.1
HU	91.1	57.4	89.3	95.7	80.6
NL	87.4	76.7	75.4	79.7	79.0
FR	72.1	75.0	79.5	94.0	78.8
AT	83.7	64.7	88.2	74.5	77.7
PL	69.1	76.2	77.1	86.4	76.6
DE	87.9	71.7	67.9	82.8	75.7
ES	70.8	75.5	67.8	96.1	75.4
HR	59.0	68.1	81.7	92.3	74.3
CH	52.9	83.0	66.4	95.7	72.2
IT	47.2	68.5	86.2	78.3	71.2
IE	71.5	69.1	70.1	75.6	71.0
RO	58.7	58.0	86.9	79.8	70.7
GR	83.5	81.0	46.7	78.0	70.2
SK	63.8	62.4	76.1	80.2	69.9
US	64.0	64.6	72.2	73.5	68.0
PT	53.1	78.0	56.7	78.4	66.1
EE	53.8	67.1	65.4	81.2	66.0
BG	70.0	52.0	63.8	89.3	65.4
LV	64.0	52.3	64.2	84.8	63.7
LT	41.4	65.1	61.9	91.5	63.3
CZ	58.3	47.9	73.4	71.4	61.9
KR	48.1	66.0	63.5	57.2	60.2

Source: IEA Energy Prices; IEA and Eurostat Energy Balances. Own calculations.

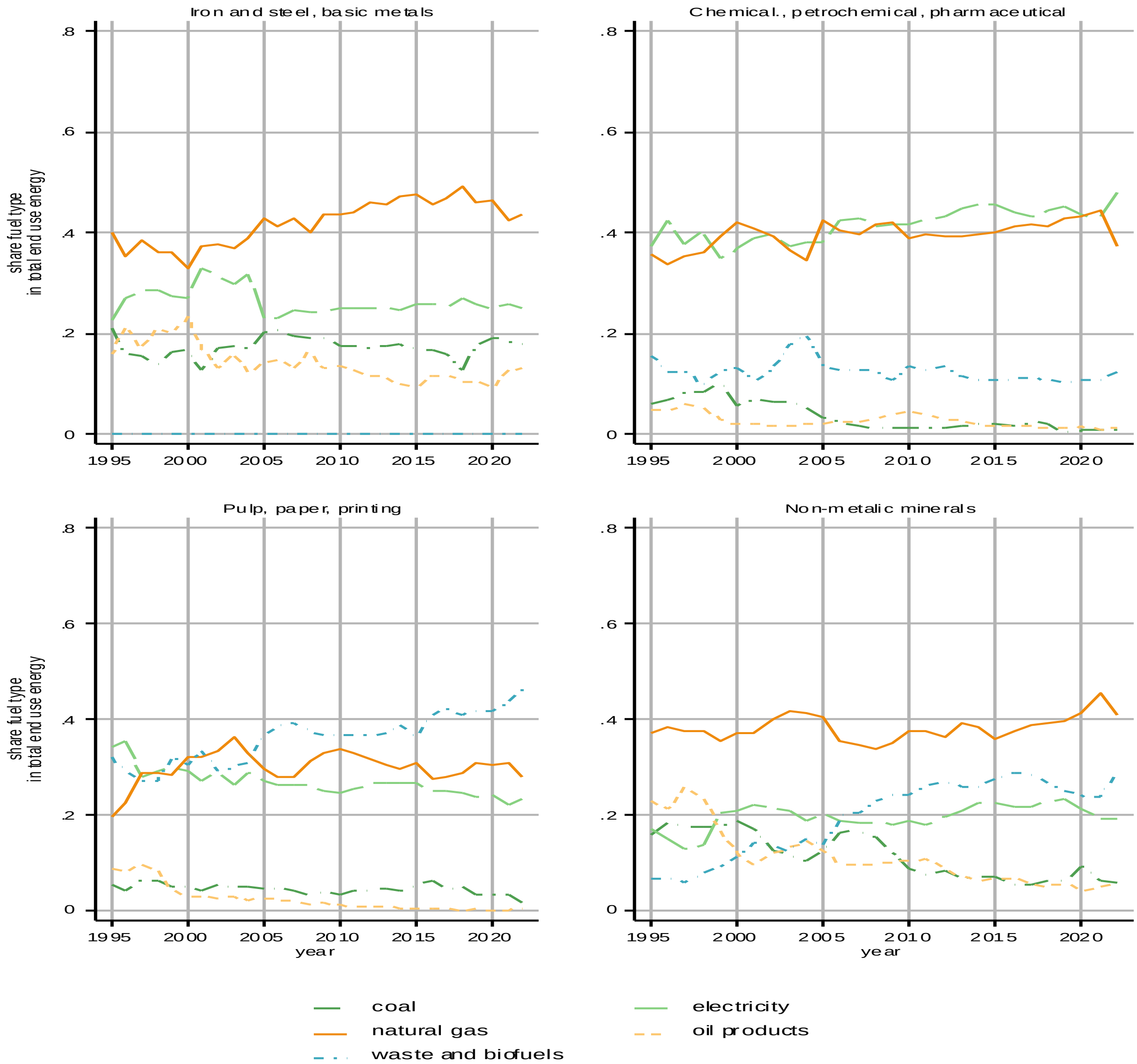
The evidence on fuel switching and industry energy prices is largely consistent with evidence for single sectors. Figure 25 shows the development of the fuel mix and the decomposition exercise of the industry level prices for energy intensive sectors in Austria (pulp and paper; non-metallic minerals, iron and steel, and the chemical, petrochemical and pharmaceutical sector).[17] Industrial energy prices are mostly determined by the price component. During the energy crisis the pulp and paper industry, the chemical industry and the non-metal minerals industry have countered increasing natural gas prices by increasing

[17] The pulp and paper sector and the chemical sector make extensive use of waste and biofuels resulting as a joint product in their production process (see Section 4.2.2) and are not acquired on energy markets and for which therefore no price data are available. The figure shows only the shares for electricity, oil products, natural gas and coal.

their demand for electricity. This is also evident from Table 7. The iron and steel industry instead countered increasing natural gas prices well before the energy crisis by increasing its demand for coal and oil products. Table 7 confirms that across sector in Austria industry level energy prices are largely driven by fuel price changes.

Figure 24: **Development of the fuel mix in energy intensive sectors in Austria**

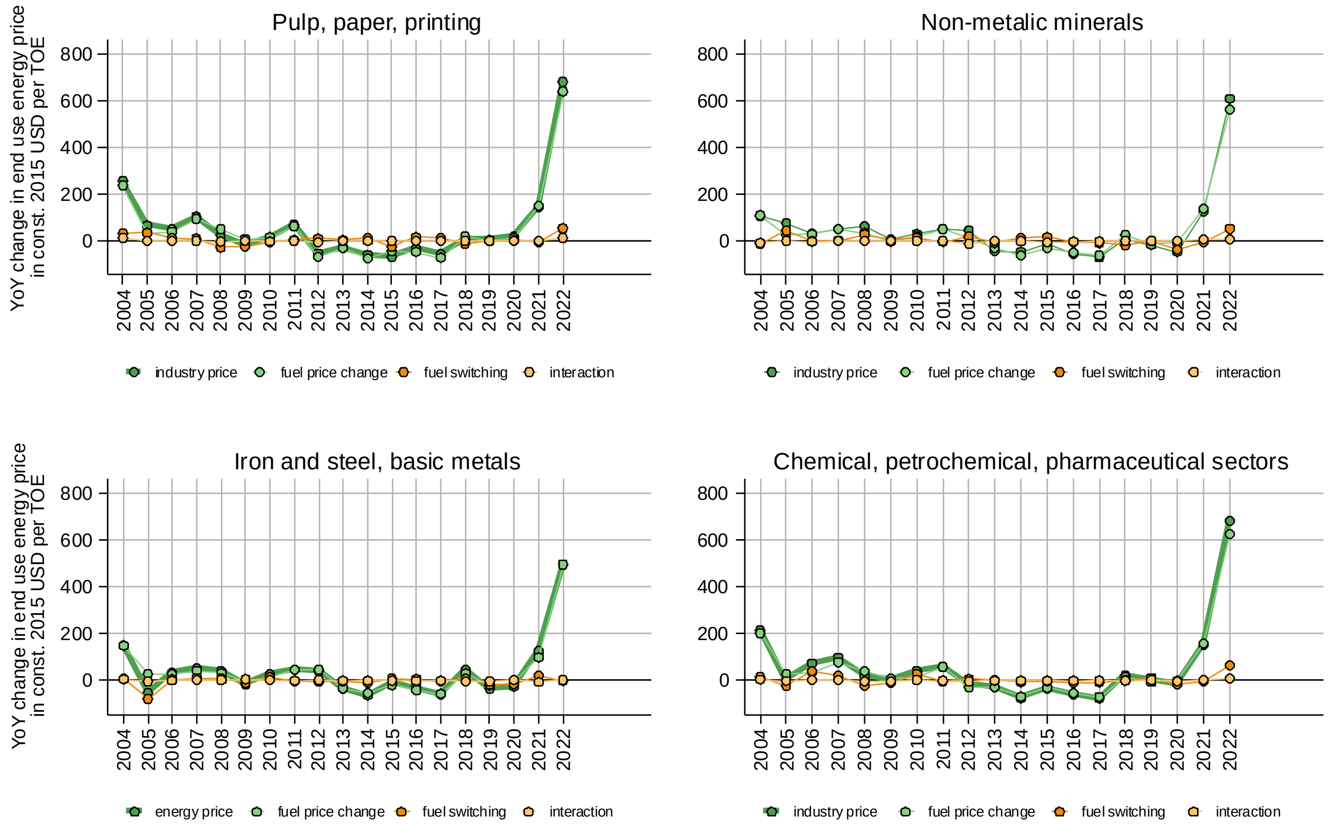
1995–2022



Source: Eurostat energy balances, own calculations.

Figure 25: **Decomposition of industry energy price changes into a fuel switching and pure price component in energy intensive sectors in Austria**

2004–2022



Source: IEA Energy Prices, Eurostat energy balances, own calculations.

Table 7: **YoY changes in end use industry energy prices explained by changes in fuel prices, Austrian sectors**

2004–2022

Sector	2004–2007	2008–2013	2014–2019	2020–2022	2004–2022
			In %		
Chemical, petrochemical, pharmaceutical	65,9	68,3	80,6	64,8	71,1
Construction	91,5	88,3	78,6	89,0	86,0
Food products and beverages	78,7	63,5	74,7	75,9	72,2
Other industries	94,4	75,7	82,0	90,4	84,0
Iron and steel, basic metals	68,4	68,7	76,0	73,9	71,7
Machinery, metal products, electr. equip.	83,8	66,0	84,4	78,1	77,5
Mining	78,4	60,6	66,8	70,7	67,9
Non-ferrous metals	85,4	55,0	69,1	80,0	69,8
Non-metallic minerals	79,4	63,9	84,2	68,4	74,3
Pulp, paper, printing	83,6	52,2	76,5	67,5	68,9
Textile and wearing apparel	79,4	55,5	59,6	73,2	64,6
Automotive	89,7	54,5	73,4	92,2	73,8
Wood and wood products (excl. furniture)	64,8	78,0	83,5	84,3	78,0

Source: IEA Energy Prices, Eurostat energy balances; own calculations.

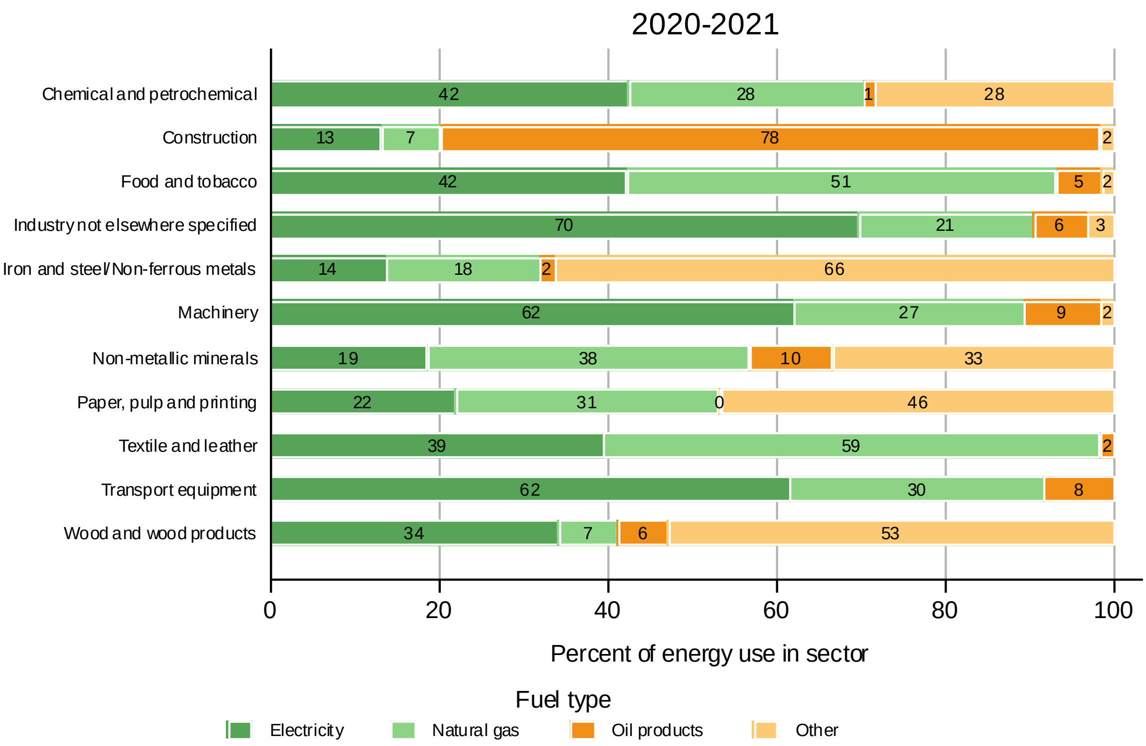
To summarize, the data on the energy mix and fuel switching in the end-use of energy in the manufacturing, construction and transport sectors do not show a very encouraging picture as to what concerns the electrification or more generally the de-fossilization of production in Austria. This is despite the introduction of the EU emission trading system (ETS) in 2005 which should guide long-term expectations of firms on the development of (relative) energy costs despite low initial CO_2 price levels and free allowances, and impact on the long-term development trend of fuel shares. The degree of electrification is low if compared to countries like Sweden or Finland both in the manufacturing and the transport sectors where end-use industrial energy prices tend also to be lower than in Austria (cf. Figure 33). The use of natural gas in turn was very stable and has fallen only slightly relative especially to electricity. With this the dependency of overall energy end-use in a large part of the business sector on his fuel remains with a continued exposure to geopolitical risk.

The analysis of the substitution patterns supports prior scientific evidence on inter-fuel substitution. Fuel substitution plays generally a minor role. Energy demand is largely determined by underlying technologies. Short run price fluctuations exert relatively little impact on the fuel mix. Fuel mixes thus change only slowly over time and require both consistent long-run price signals related to specific fuel types but most importantly investments into new technologies relying on a different energy mix. To accelerate changes in the energy mix to meet net-zero goals or to decrease strategic dependence related to specific fuel types requires substantial investments. If the aim is to achieve these goals through electrification this will decrease the adaptability to electricity specific price shocks as the demand of electricity is highly insensitive to changes in its own prices due to even more limited substitution possibilities.

4.2.2 Firm level evidence on the fuel mix and energy price adjustments

Firm level analysis of the fuel mix indicates that it is relatively stable over time. Figure 25 shows the average fuel mix across industries for the years 2020 and 2021. With few exceptions for most industries electricity and natural gas are the principal sources of energy. In the pulp, paper and printing sector as well as in the wood and wood products industry waste and biofuels (included in the category of other fuels) are an important energy source, whereas in the iron and steel and the non-metalic minerals sectors coal still plays an important role. For the construction sector oil products dominate energy consumption.

Figure 26: **Decomposition of industry energy price changes into a fuel switching and pure price component in energy intensive sectors in Austria**



Source: Statistik Austria structural business statistics, material use statistics - AMDC. Own calculations.

To analyze how this fuel mix and interfuel substitution has affected the industry-level energy end-use price over time, we decompose the aggregate energy price index per manufacturing industry (23 2-digit NACE) into a component reflecting the pure price changes of the energy sources used and a component reflecting the composition of the energy sources used using the log mean divisia index decomposition (LMDI). Box 2 provides a more detailed discussion of this decomposition method.

Box 2: **Aggregate energy price decomposition using the Log Mean Divisia Index (LMDI) approach**

The LMDI is a widely used method for decomposition analysis, particularly in energy and environmental studies. Below is the derivation for both **additive** and **multiplicative** index decomposition of an aggregate industry price index $EPI_{k,t}$ for energy in industry *k* and fuel types *j*, *j = 1..m*, having prices $p_{j,t}$ and shares $w_{j,k,t}$ in total energy consumption $QE_{k,t}$ at the industry level:

As earlier in the report aggregate industry energy prices are calculated as

$$EPI_{k,t} = \sum_j p_{j,t} * w_{j,k,t},$$

where $w_{j,k,t} = QE_{j,k,t} / \sum_{e,c,s,t} QE_{k,t}$. These shares have been obtained from individual fuel type consumption data across firms in sector k. As in the standard shift share approach the aggregate industry price index can be decomposed into effects due to changes in prices $p_{j,t}$ and shares $w_{j,k,t}$.

Following Ang (2005) the **multiplicative decomposition** starts from the ratio of aggregate price indices over time and decomposes the effects in a multiplicative fashion:

$$\frac{EPI_{k,t}}{EPI_{k,t-1}} = \text{price effect} * \text{structural effect}.$$

Taking natural logarithms the **price effect** can be written as:

$$ln(\text{price effect}) = \sum_{j=1}^{m} L(w_{j,k,t-1}, w_{j,k,t}) * \ln\left(\frac{p_{j,t}}{p_{j,t-1}}\right),$$

and the structural effect as:

$$ln(\text{structural effect}) = \sum_{j=1}^{m} L(p_{j,t-1}, P_{j,t}) * \ln\left(\frac{w_{j,k,t}}{w_{j,k,t-1}}\right).$$

Total change can then be expressed as

$$ln\left(\frac{EPI_{k,t}}{EPI_{k,t-1}}\right) = \sum_{j=1}^{m} L(w_{j,k,t-1}, w_{j,k,t}) * \ln\left(\frac{p_{j,t}}{p_{j,t-1}}\right) + \sum_{j=1}^{m} L(p_{j,t-1}, p_{j,t}) * \ln\left(\frac{w_{j,k,t}}{w_{j,k,t-1}}\right),$$

which by exponentiating both sides recovers the multiplicative decomposition:

$$\frac{EPI_{k,t}}{EPI_{k,t-1}} = \prod_{j=1}^{m} \left(\frac{p_{j,t}}{p_{j,t-1}}\right)^{L(w_{j,k,t-1}, w_{j,k,t})} * \prod_{j=1}^{m} \left(\frac{w_{j,k,t}}{w_{j,k,t-1}}\right)^{L(p_{j,t-1}, p_{j,t})}.$$

Note that $L(w_{j,k,t-1}, w_{j,k,t})$ is the logarithmic mean $L(w_{j,k,t-1}, w_{j,k,t}) = \frac{w_{j,k,t} - w_{j,k,t-1}}{\ln(w_{j,k,t}) - \ln(w_{j,k,t-1})}$.

The term $L(p_{j,t-1}, p_{j,t})$ is defined in an analogous way.

The **additive decomposition** is obtained by decomposing the total change in $EPI_{k,t}$ over time:

$$\Delta EPI_{k,t} = \Delta \mathrm{P}_k + \Delta \mathrm{W}_k,$$

where $\Delta \mathrm{P}_k$ and $\Delta \mathrm{W}_k$ are changes due to price effects and changes due to structural change respectively.

In the case of an additive decomposition the price effect is defined as

$$\Delta \mathrm{P}_k = \sum_{j=1}^{m} L(w_{j,k,t-1}, w_{j,k,t}) * (p_{j,t} - p_{j,t-1}),$$

and the structural effect is then defined as

$$\Delta \mathrm{W}_k = \sum_{j=1}^{m} L\left(p_{j,t-1}, p_{j,t}\right) * \left(w_{j,k,t} - w_{j,k,t-1}\right).$$

The tables in this paper show the total effect over the time period indicated in the header of the table as well as the price and the structural effect in the following columns. In the multiplicative decomposition an effect >1 indicates that the component has contributed to an increase of the aggregate price, whereas an effect <1 points at a contribution to decrease the aggregate index.

The results for the multiplicative decomposition are presented in Table 8 below, whereas the results for the additive decomposition are presented in Table 13 in the Appendix. The analysis using firm level energy use data supports the analysis in the previous section. The results indicate that between 2013 and 2019 the aggregate energy price index declined in all manufacturing industries except for manufacturing of wood products. The declines were driven by the price change component in all industries. For the wood industry the energy source composition effect more than compensated for the price decrease, resulting in an overall energy price index increase in this industry. Overall, in 13 out of 23 industries, energy source composition effects contributed positively to overall price changes even though the price component is the most important factor of aggregate prices changes in all industries. In the most recent period covered by the data (2020 to 2021) shows increases in all but one industry (basic metals). In all but this one industry the price component drove the aggregate price increase. Changes in the energy source composition only slightly dampened the industry price increases in 15 out of 23 industries.

Table 8: **Firm-level multiplicative Log Mean Divisia Index decomposition of industry energy price per manufacturing industry for the periods 2013–2019 and 2020–2021**

		LMDI multiplicative, 2013–2019			LMDI multiplicative, 2020–2021		
NACE	division	rEPI	lmdi_mul_price	lmdi_mul_struc	rEPI	lmdi_mul_price	lmdi_mul_struc
C11	Manufacture of beverages	0.823	0.796	1,035	1,073	1,098	0.978
C14	Manufacture of wearing apparel	0.849	0.873	0.972	1,037	1,063	0.975
C18	Printing and reproduction of recorded media	0.976	0.986	0.990	1,014	1,020	0.994
C26	Manufacture of computer, electronic and optical products	0.697	0.692	1,008	1,186	1,181	1,005
C23	Manufacture of other non-metallic mineral products	0.863	0.822	1,049	1,336	1,315	1,016
C22	Manufacture of rubber and plastic products	0.934	0.917	1,019	1,250	1,265	0.988
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	1,049	0.869	1,206	1,216	1,265	0.961
C29	Manufacture of motor vehicles, trailers and semi-trailers	0.831	0.804	1,033	1,292	1,294	0.998
C15	Manufacture of leather and related products	0.960	0.942	1,019	1,638	1,673	0.979
C25	Manufacture of fabricated metal products, except machinery and equipment	0.811	0.807	1,005	1,190	1,187	1,003
C31	Manufacture of furniture	0.899	0.913	0.984	1,110	1,109	1,002
C10	Manufacture of food products	0.807	0.773	1,044	1,099	1,077	1,021
C17	Manufacture of paper and paper products	0.749	0.771	0.971	1,992	1,886	1,056
C13	Manufacture of textiles	0.731	0.824	0.887	1,330	1,334	0.997
C20	Manufacture of chemicals and chemical products	0.782	0.768	1,019	1,498	1,512	0.991
C27	Manufacture of electrical equipment	0.898	0.872	1,030	1,131	1,131	0.999
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	0.820	0.830	0.989	1,344	1,341	1,002
C32	Other manufacturing	0.895	0.883	1,014	1,052	1,076	0.977
C19	Manufacture of coke and refined petroleum products	0.690	0.696	0.992	1,305	1,310	0.997
C28	Manufacture of machineryand equipment n.e.c.	0.921	0.897	1,027	1,117	1,127	0.991
C24	Manufacture of basic metals	0.876	0.902	0.972	0.986	0.986	1,000
C33	Repair and installation of machinery and equipment	0.962	0.979	0.982	1,224	1,229	0.995
C30	Manufacture of other transport equipment	0.823	0.860	0.958	1153	1154	0.999

Source: Statistics Austria, Austria Microdata Centre; own calculations on the basis of the Material Use Statistics (Gütereinsatzstatistik).

5. Real unit energy costs and the international costs competitiveness of Austrian industries

Energy is a key input in the provision of goods and services. For this reason, energy costs constitute an important part of the cost structure of firms and represent an important competitiveness factor. Energy costs impact the international competitiveness of firms if energy costs per unit of output are unfavorable relative to relevant international competitors. This is determined by the energy price and by the energy intensity of the production process. Based on these two factors it is possible to define a unit energy cost measure that can capture this often-neglected aspect of international cost-competitiveness. This brings together the elements discussed in Section 3 and 4 of this paper. Real unit energy costs, $RUEC_{AT,s,t}$, are defined as the ratio of energy costs $EC_{AT,s,t}$ in Austria in sector s at time t and the value added, $VA_{AT,s,t}$, generated in this sector as follows (European Commission, 2014; cf. Faiella and Mistretta, 2020):

$$RUEC_{AT,s,t} = \frac{EC_{AT,s,t}}{VA_{AT,s,t}} = EPI_{AT,s,t}^{realUSD} * \frac{QE_{AT,s,t}}{VA_{AT,s,t}^{real}} = EPI_{AT,s,t}^{realUSD} * EI_{AT,s,t}$$

As can be seen from the formula, by splitting up energy costs in the energy quantity, $QE_{AT,s,t}$, and industry energy prices $EPI_{AT,s,t}^{realUSD}$ it is possible to define $RUEC_{AT,s,t}$ as the product of industry energy prices and energy intensity (both in constant terms).[18,19] In real unit energy costs the price the deflators of nominal energy cost and value added cancel out. As in the remaineder of this paper the real industrial energy price, $EPI_{AT,s,t}^{realUSD}$, can be interpreted as the calorific unit of energy used relative to the deflator. It thus measures energy inflation over the inflation of produced goods and services in the economy. The $EI_{AT,s,t}$ in turn defines the technical relationship between value creation and energy consumption. Nominal unit energy costs is obtained by multiplying $RUEC_{AT,s,t}$ with the GDP deflator, $P_{VA,t}$, and the nominal exchange rate (in our case the EUR/USD rate) with regards to its export destinations. With these factors we introduce a nominal effect.

$$NUEC_{AT,s,t} = RUEC_{AT,s,t} * E_{€/\$,t} * P_{VA,t}$$

Nominal unit energy cost therefore also captures adjustment mechanisms such as exchange rates and changes in domestic producer prices.

Figure 27 compares the development of nominal and real unit energy costs with that of industry-specific nominal unit labor costs for the period 2008-2022.[20] Real unit energy costs have risen noticeably in most industry groups since 2021. This price shock followed a phase in which they had been declining. Nominal unit energy costs have followed this trend. Nominal effects play a subordinate role in the longer-term

[18] Some authors argue that this measure of unit energy cost is too simple and should also include next to the direct energy intensity also the indirect energy embodied in the inputs of a sector (cf. Löschel et al., 2015; Kaltenegger et al., 2017). For the present purpose the simpler measure is however preferable because we are interested in the direct energy cost incurred by domestic firms, and potential carbon leakage would already be reflected in both the observed energy intensity through both the direct energy use as well as the value added.

[19] Energy quantity excludes the use of biofuels and waste that represent a significant share of total energy use in some sectors, to get a correct RUEC measure.

[20] The sectoral nominal unit labor cost index shown was calculated from the ratio of employee compensation at current prices and real gross value added at sector level.

view. Compared to 2015, real unit energy costs rose the most in vehicle construction (+106%), in the "Other" industry group with the plastics and furniture industry (+102%), in the glassware and ceramics industry (+90%) and in the textile industry (+82%). The average increase across all sectors was just under 65% by 2022; in the energy-intensive sectors, the average increase was 67.5%. Wholesale prices for electricity and gas have been falling again since 2023. However, in the upper consumption levels for both energy sources, they are above the European average and in some cases at the top of the range.

With the exception of the paper industry (+0.6%), nominal unit labor costs rose in all industry groups between 2015 and 2022. The increase was highest in vehicle construction at 59.5%. This was followed by the "Other" industry group with the plastics and furniture industry (31.7%), the glassware and ceramics industry (29.9%) and the chemical industry (19.8%). This means that the sectors with the highest increase in real unit energy costs were also those with the highest increase in unit labor costs. The extent to which these increases in unit energy costs and unit labor costs will also be reflected in a deterioration of the competitive position depends on developments at European and international competitors.

In order to gain insight into the possible effects of unit energy costs on the price competitiveness of Austrian industry, a relative multilateral unit energy cost index, $rRUEC^{ex}_{AT,s,t}$, is constructed, which enables a comparison of energy price developments in industry with trading partners. For this purpose, the energy unit costs in the export markets *j* are determined at industry level. The calculated unit energy costs are normalized with the value of the base year 2015 to enable a better comparison of changes over time. The relative real unit energy cost index is calculated as a weighted geometric mean of the real unit energy costs for all export destination countries *j* with export share $g_{j,t}$ as follows:

$$rRUEC^{ex}_{AT,s,t} = \prod_{j=1}^{n-1} \left(\frac{RUEC_{AT,s,t}}{RUEC_{AT,s,t=2015}} \Big/ \frac{RUEC_{j,s,t}}{RUEC_{j,s,t=2015}} \right)^{g_{j,t}}$$

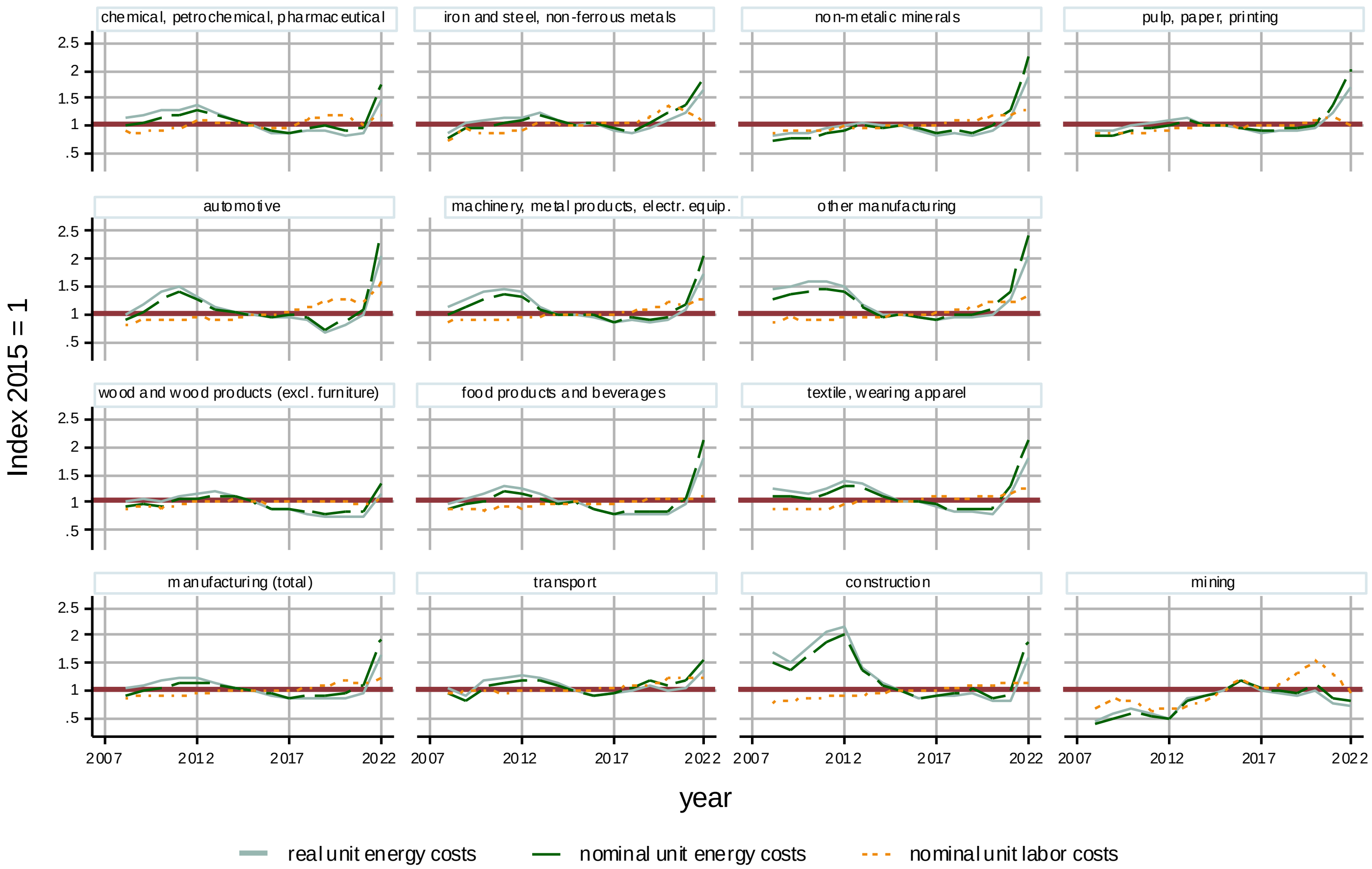
An increase in this index corresponds to a relative increase in the domestic energy prices per unit of energy required to generate one € of real gross value added in an industry group *s* compared to the same industry group of EU trading partners. An analogous calculation was carried out for imports from countries of origin.[21] The trade weights are obtained from granular trade data for commodities and products. The index thus captures only the relative energy-based cost position in the trade of goods. The index was also calculated for all global trading partners. Here, however, industry data is only available up to 2020. The related figures are shown in the Appendix (Figure 39).

Figure 28 and Figure 29 show that with the exception of the wood processing industry and mining, the relative energy cost position has deteriorated since 2020 in most industry groups. In some industries, this trend can already be observed from 2017 onwards. In 2022 the automotive sector, other manufacturing that comprises the plastics industry, the non-metalic minerals as well as the pulp, paper and printing sector were particularly affected. To a lesser extent, energy price increases have impacted the price competitiveness of the chemical and food industries. In contrast, the unit labor cost position improved in most industries in 2022. However, for 2023 and the following years forecasts by the European Commission and the major economic research institutes show a deterioration of unit labor costs.

[21] Reiter et al. (2023) present a similar exercise using physical energy flow accounts and European input-output tables and the BACI data to calculate a summary competitiveness index relative to European peers. Unlike the exercise here the study distinguishes between direct and indirect energy unit costs but does not assess the impact on economic performance indicators at the sector level.

Figure 27: **Nominal and real unit energy cost index and nominal unit labor cost index (base 2015) for Austrian manufacturing industries, construction, and the transport sector**

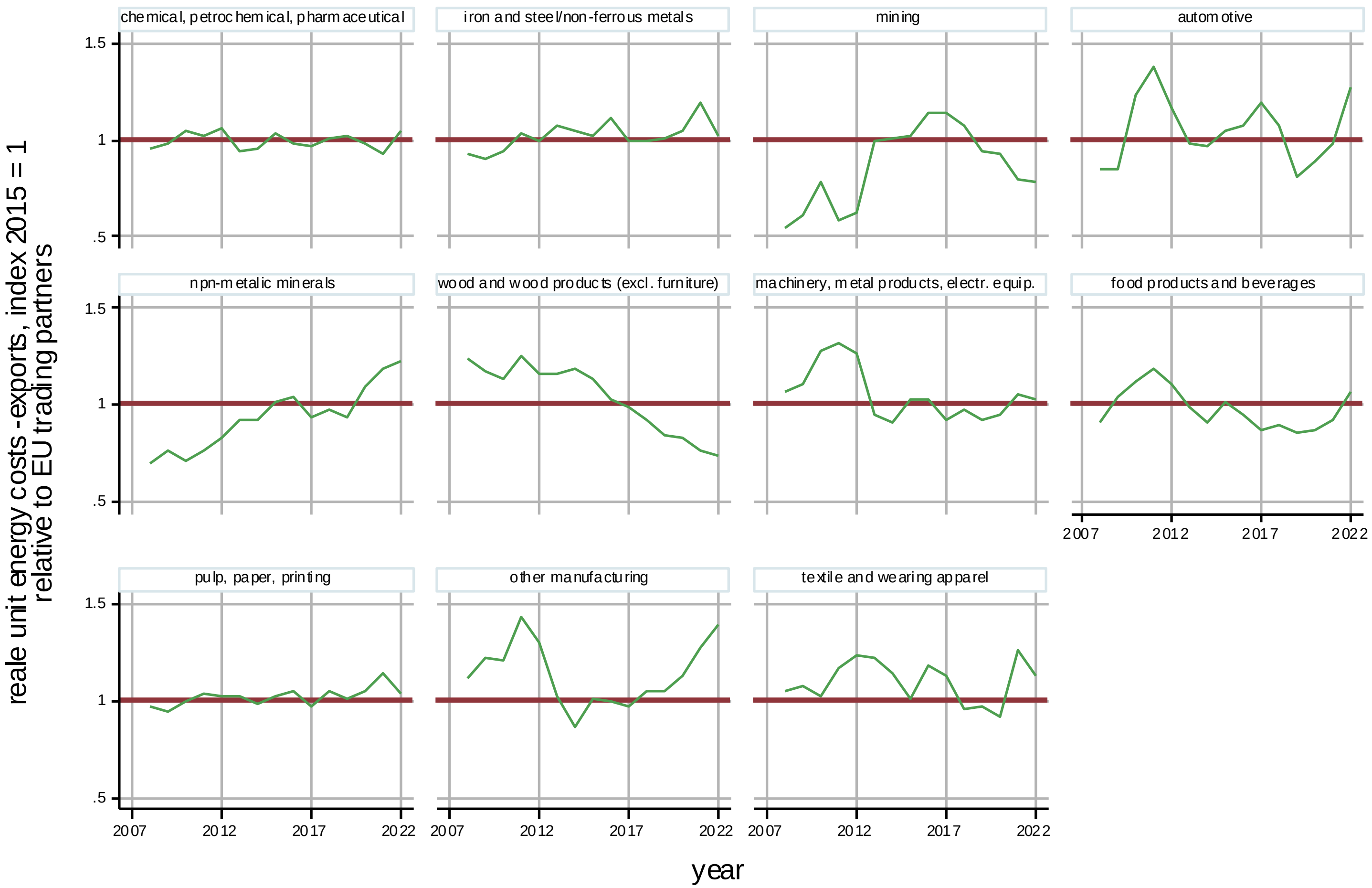
2008–2022



Source: Eurostat national accounts, energy balances, IEA Energy Price Data, CEPII-BACI data (Gaulier and Zignago, 2010); own calculations.

Figure 28: **Relative unit energy cost index (base 2015) for exports relative to EU trading partners**

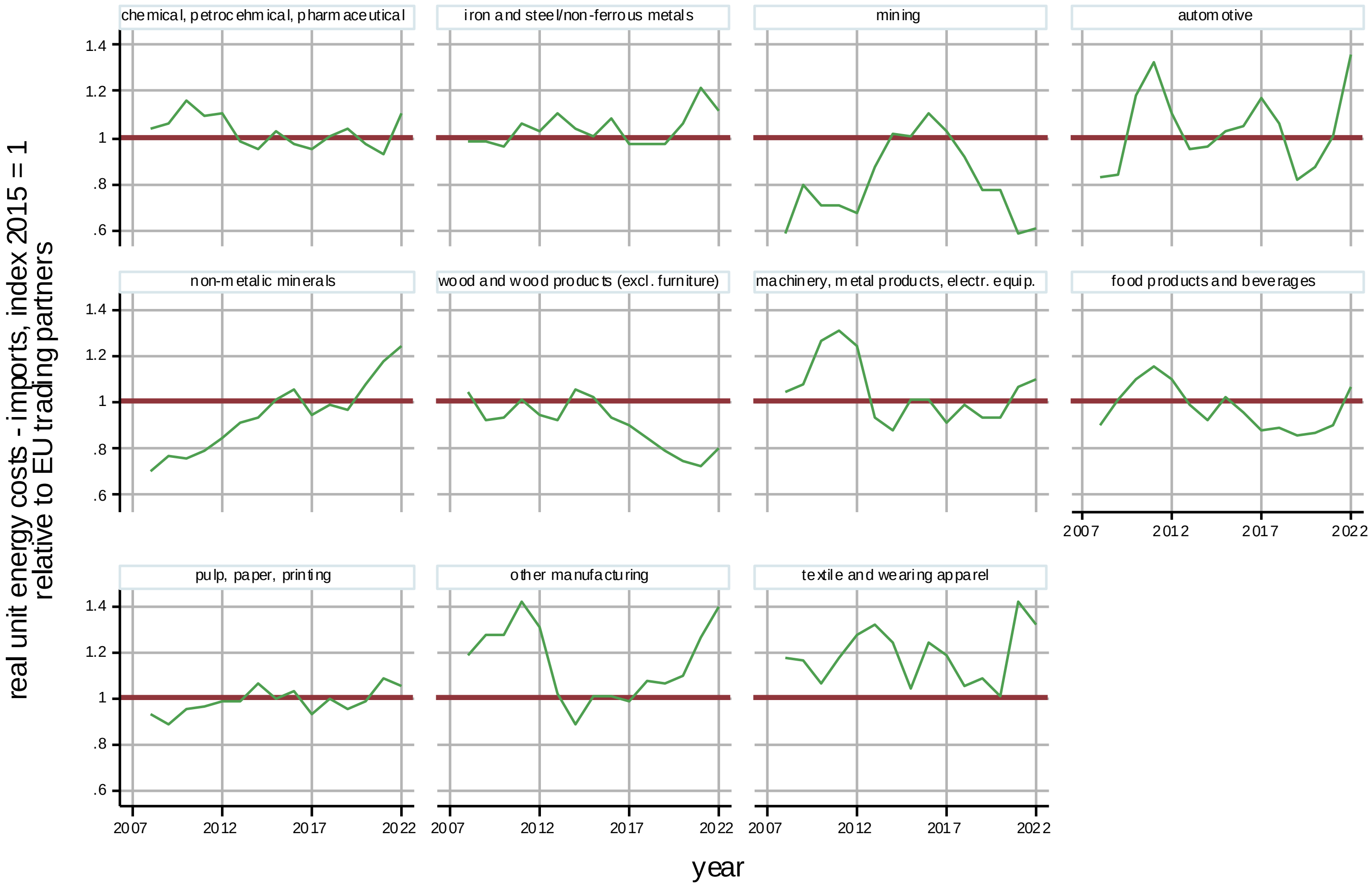
2008–2022



Source: Eurostat national accounts, energy balances, IEA Energy Price Data, CEPII-BACI data (Gaulier and Zignago, 2010); own calculations.

Figure 29: **Relative unit energy cost index (base 2015) for imports relative to EU trading partners**

2008–2022



Source: Eurostat national accounts, energy balances, IEA Energy Price Data, CEPII-BACI data (Gaulier and Zignago, 2010); own calculations.

It is difficult to assess whether the deterioration in relative unit energy costs will have an impact on competitiveness. Energy prices fluctuate procyclically, as an upswing in economic activity is associated with higher energy demand. Hence, a deterioriation of relative unit energy costs may be associated with differentials in the business cycle or reflect sustained growth differentials between a country and its trading partners when it expands faster vis-a-vis other countries. Such a development is typically positively associated with other economic performance indicators.

To assess to what extent a worsening, i.e. and increase of $rRUEC^{ex}_{AT,s,t}$, impacts the economic performance of Austrian industries it is therefore also necessary to control for domestic industry energy prices. For this purpose, a first difference (FD) panel model of the form

$$\Delta y_{s,t} = \delta_0 + \beta_1 \Delta rRUEC^{ex}_{s,t} + \beta_2 \Delta FEPI_{s,t} + \beta_3 \Delta rRUEC^{ex}_{s,t}\, x\, \Delta FEPI_{s,t} + \gamma_t + \Delta u_{s,t}$$

was estimated. Preference was given to a first difference approach over a fixed effects (FE) model as rate of changes are better able to capture reactions to changes in the relative real unit energy costs. Changes in levels which would be used in an FE model are likely to come to effect only slowly. From an econometric point of view the FD transformation provides consistent estimators equivalent to the FE transformation insofar as both eliminate the unobserved individual (in our case sectoral) effects that are fixed. Both use the time variation within each cross-section to estimate the coefficients, but FD estimators are less efficient. To account for variation in the data related to unobserved events that took place and that may have influenced the dependent variables each model includes time dummies γ_t. The model includes a constant δ_0 which controls for potential deterministic time trends in the dependent variable.

The dependent variables $\Delta y_{s,t}$ in the estimated models are the log-difference of investment, employment, and energy demand, price-cost margins[22], sector specific producer prices, sector specific export prices; real wages[23], and finally productivity[24] and export values. These variables have been selected as firms adjust to changes in energy prices through multiple adjustment channels (cf. Fontagné et al., 2023). The variable of interest is $\Delta rRUEC^{ex}_{s,t}$ which is the first difference of the indicator discussed in the first part of this chapter. To control for domestic industry end use energy price changes, we use a fixed fuel-weight version of the industry level energy price $\Delta FEPI_{s,t}$ that captures the variation of fuel prices including policies and taxation only and corrects for the effects of domestic industry energy price adjustments through adjustments of the fuel mix. The interaction term allows assessing the impact on the outcome variables when the relative unit energy costs and domestic industry energy prices change in the same or opposite direction. These interactions may dampen or increase the observed relationship between the dependent variables and either relative unit energy costs or domestic industry level energy prices.

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[22] Price-cost margins are calculated as $PCM_{s,t} = (VA_{s,t} - LC_{s,t})/GPV_{s,t}$ with $VA_{s,t}$ representing the value-added of sector s at time t, $LC_{s,t}$ its total labor cost and $GPV_{s,t}$ its gross production value. All indicators are available from Eurostat national accounts data. This version of price-cost margins is a proxy for short-run profits. It does not account for capital costs.

[23] Real wages have been calculated from the sum of wages and salaries deflated by the CPI.

[24] Productivity has been calculated from gross value-added deflated by the GDP-deflator and employment.

Table 9: **The relationship between changes in relative real unit energy costs in export markets and various adjustment channels at the sector level in Austria**

First difference and first difference models, 2008–2022

Dep. Variable (Δ ln)	investment	employment	energy use	price-cost margins	PPI	PREN	real wages (CPI deflated)	productivity	exports
Δ rRUECI (t)	.11	-.013	.65***	-.43***	-.053*	-.061**	-.019	-.3***	-.071
	(0.58)	(0.43)	(0.00)	(0.00)	(0.08)	(0.01)	(0.55)	(0.00)	(0.36)
Δ FEPI (t)	.39	-.022	-.58*	.42**	.14*	-.018	-.038	.33***	.29
	(0.30)	(0.67)	(0.05)	(0.04)	(0.08)	(0.66)	(0.57)	(0.00)	(0.29)
Δ FEPI (t) x Δ rRUECI (t)	-.65	.13	-.86**	-1.3**	-.53**	-.21	.082	-1.1**	-.65
	(0.29)	(0.11)	(0.02)	(0.04)	(0.04)	(0.15)	(0.23)	(0.02)	(0.39)
constant	-.035	-.01	.005	-.12***	.028**	.033*	-.00025	-.036	.041
	(0.48)	(0.32)	(0.88)	(0.00)	(0.02)	(0.07)	(0.98)	(0.16)	(0.27)
time FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	165	165	165	165	165	165	165	165	165
adj. R^2	0.1	0.45	0.41	0.33	0.45	0.34	0.27	0.33	0.22

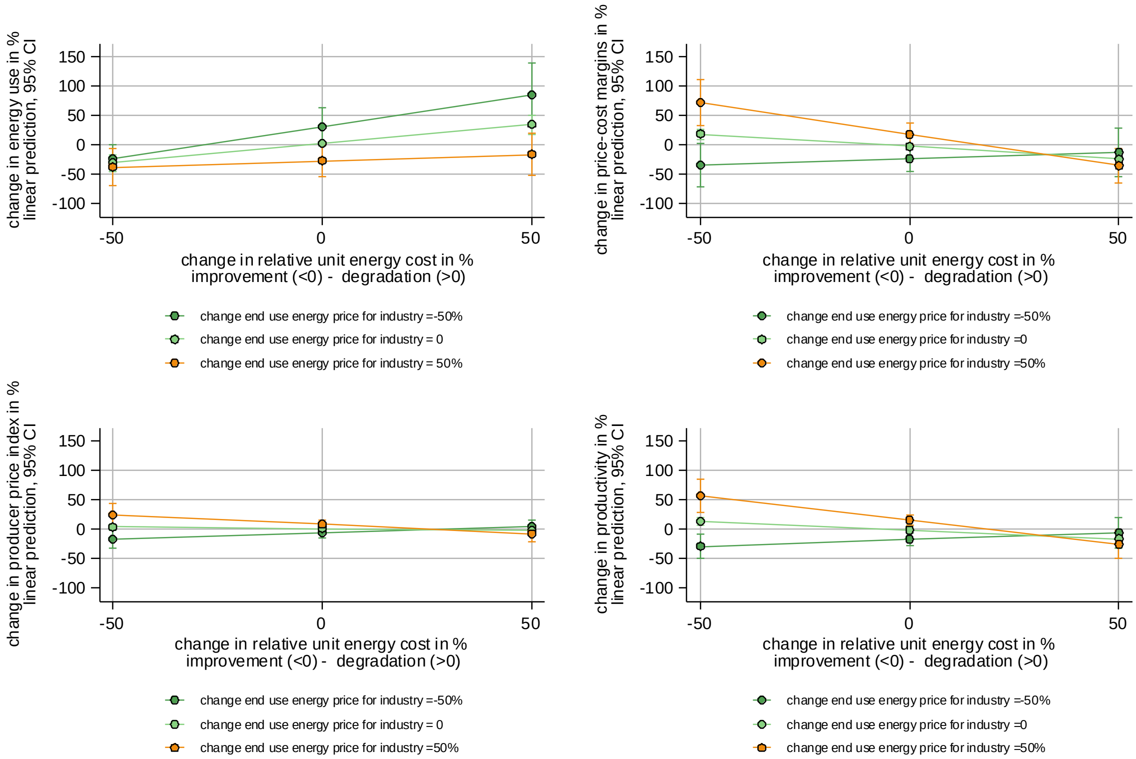
p-values in parentheses

* p<0.1, ** p<0.05, *** p<0.01

Clustered standard errors at the sector level.

Source: Eurostat national accounts, energy balances, IEA Energy Price Data, CEPII-BACI data (Gaulier and Zignago, 2010); own calculations.

Figure 30: **Interaction effects in the regression model. Linear predictions for combinations of domestic end use energy price changes and relative real unit energy costs**



Source: Eurostat national accounts, energy balances, IEA Energy Price Data, CEPII-BACI data (Gaulier and Zignago, 2010); own calculations.

Table 9 presents the results of this explorative regression analysis examining the association of changes in relative unit energy costs with changes in factor use (investment, employment, energy use), income (price cost margins, industry producer prices, industry export prices, real wages), and economic performance (productivity, exports). The coefficients β_1 for $\Delta rRUEC_{s,t}^{ex}$ can be interpreted as a percentage point change of the growth rate of the dependent variable if the $\Delta rRUEC_{s,t}^{ex}$ changes by one percent, ceteris paribus ($\Delta FEPI_{s,t} = 0$). The table reports also standard errors in brackets below the coefficients. They have been clustered at the sector level to allow for intragroup correlation, implying that the observations are independent across groups but not necessarily within groups.

Using Austrian industry level data at the NACE 2-digit level over the period 2007-2022 the table shows a negative statistical correlation between changes in relative unit energy costs driven by rising energy end prices and the development of profit margins, the industrial price and export price indices and productivity growth at industry level. This implies that a deterioration (an increase of $\Delta rRUEC_{s,t}^{ex}$) of relative unit energy costs is ceteris paribus negatively associated with these economic performance indicators. No significant associations are observed for industry level investment, employment, real wages, and export growth. Linear predictions of the interaction effects for different combinations of changes in $\Delta rRUEC_{s,t}^{ex}$ and$\Delta FEPI_{s,t}$ for energy use, price-cost margins, producer prices and productivity are shown in Figure 30.

The regression result for energy use suggests that a worsening of relative unit energy costs often is indeed associated with phases of differential economic expansion between the domestic sectors and the trade partners as conjectured at the beginning of this section. This is captured by the positive and both economically and statistically significant coefficient for $\Delta rRUEC_t$. Increases in industry level energy prices on the other hand are, ceteris paribus, associated with a reduction of energy use, as expected. The prediction of the interaction effects shows that these price effects outweigh changes in relative unit energy costs and negatively correlate with energy use, also for substantial deteriorations of the energy-based cost-competitiveness. Productivity growth is negatively associated with relative unit energy costs. This statistical correlation is reinforced when final energy prices rise (Figure 30). If on the other hand $\Delta rRUEC_t$ does not change an increase in energy prices is positively associated with increases in productivity again hinting at a positive association between increases in energy prices and increases in economic activity. An essentially identical pattern is observed for the association of changes in price-cost margins with changes in both energy prices and energy-based cost-competitiveness. The association between our indicators of interest and producer price indices is statistically not as significant. Changes in producer prices are positively associated with energy prices and negatively associated with changes in relative unit energy costs. The economic significance captured by the estimated elasticity is considerably higher for energy prices. Hence, producer prices are only weakly affected by changes in cost-based price-competitiveness.

6. Summary and conclusions

This study analyses the development of the energy cost competitiveness of the Austrian business sector with a focus on the manufacturing, construction, and transport industries. These sectors are responsible for about two thirds of the energy end use in the Austrian economy. To develop a measure of energy cost competitiveness the study investigates the development of industrial end-use energy prices and analyses the development of the energy intensity at the sector level in Austria relative to other European and OECD countries. The industrial energy prices and the energy intensity are then used to devise a real unit energy cost measure for the Austrian manufacturing, construction, and transport sectors, assessing its development relative to export destinations and potential economic impact.

The analysis reveals a notable trend in the development of end-use fuel prices in Europe and Austria. While it is well known that energy prices are higher in Europe (and Japan) than in most other OECD countries, the fuel prices tended to show a similar variation. This changed however during the 2021-2022 energy crisis as fuel price fluctuations especially for electricity and natural gas deviated markedly from the pattern observed in other OECD countries highlighting issues in the organization of European energy markets and the organization of the supply of these fuels. The analysis also reveals that in the EU electricity prices co-vary more strongly with fossil fuels and especially natural gas than in non-EU OECD countries. This pattern is even more pronounced in Austria, electricity and natural gas prices are more closely coupled. End-use industrial fuel prices have a strong country specific cost component from taxes, network charges and other levies, which would generally allow to dampen sudden price shocks. Interestingly, fuel prices for oil products are more detached from the price development of other fuel sources.

Industrial energy prices show a steady increase over time with peaks during the economic crises 2007-2008 and after 2020. Industrial energy prices in Austria followed this pattern. For most of the time the price level was either close to or above the price level of the median country, especially in the manufacturing sector. Industrial energy prices rose sharply across countries after 2020, but the increase was more sustained in Austria than in the majority of other EU and OECD countries. The data point at a uniform response to increasing energy prices insofar as the cross-sector variation has decreased relative to earlier periods. However, price discrepancies across industries within the country reflect differences in the industry specific fuel mix. For instance, the iron and steel sector was less affected by recent energy price increases due to the relatively high share of coal as energy source, whereas sectors with a high share of natural gas and electricity as principal fuel sources were typically more heavily affected. Energy prices in the Austrian transport sector in turn have developed consistently below the levels of other countries.

In terms of the development of energy intensity the results show that a change in the composition of the business sector away from energy intense sectors has played an increasingly important role in more recent years. Up to 2014 the development of energy intensity was characterized by an increase of energy intensity within sectors. This indicates that the observed reduction in aggregate energy intensity after 2014 was more heavily influenced by structural adjustments of the economy rather than changes in the energy use inside industries. The response to the energy crisis and the observed strong decline in aggregate energy intensity in 2022 was however driven by a strong reduction of the energy intensity inside sectors pointing at efforts to counter the energy crisis through energy savings and a reduction of energy demand. The analysis of firm level data shows that only a very small number of companies account for a large share of the total energy consumption, and that relative to the years before the crisis in 2021 the dispersion of energy intensities has declined.

Moreover, the analysis highlights that fuel substitution has played a minor role in adjustments to increasing fuel prices. The fuel use patterns show a higher long-term persistency across sectors. An important long-term trend is the substitution of electricity for oil products and to a lesser extent coal. The share of natural gas has slightly increased over time. The transport sector has experienced some replacement of oil products with electricity between 2005 and 2010, but fuel shares have remained stable ever since. Overall, the analysis of changes in the fuel mix suggests that the substitution of fossil fuels in energy end use is driven – if at all – by long-term trends and technical change. In the short-run adjustment possibilities to counter energy shocks seem to be very limited, which indicates on the one hand, that Austrian firms have limited possibilities in terms of the adjustment of their energy use patterns to counter sudden rises in industrial energy prices. On the other hand, it indicates that a change in the fuel mix away from fossil fuels requires consistent long-term price signals and investments to change in significant ways.

Lastly, the impact of these developments on relative real unit energy costs (RUEC) has been heterogeneous. While relative real unit energy costs show a relatively stable development for the chemical, the iron and steel and the machinery and equipment sectors, they have worsened in recent years for the automotive, the non-metallic minerals or the pulp and paper industries. The wood sector in turn has improved its relative unit energy cost position over time. The energy crisis in 2022 has contributed to worsen the energy cost-based competitiveness in some important manufacturing sectors such as the automotive, the non-metallic minerals or other manufacturing that also includes the rubber and plastic industry. An exploratory regression analysis indicates that the rate of change of price cost margins, producer prices, and productivity are negatively associated with an increase of relative real unit energy costs.

These results come with a number of policy implications. Firstly, they suggest that in the face of serious energy price shocks the government could provide some relief by adjusting the country specific institutional price components in the end-use industrial energy price. However, such a strategy would also present important trade-off as on the one hand, it would distort price signals for CO_2 reduction and on the other hand, it could have a negative effect on the financing of the energy infrastructure which is based on revenues from network charges. Increases in energy prices have a negative impact on energy use and thus on CO_2 emissions.

Secondly, the results suggest that electricity prices and natural gas prices should be more strongly decoupled as the latter contribute to the level and the volatility of the former. Stable energy prices should be a primary goal of national policy. However, this is also a European challenge. The investments into an energy infrastructure that the same time ensures high energy security and stable prices requires substantial national and EU-wide efforts as well as coordination with European partners. Strong involvement in the EU energy policy is therefore needed to enhance the internal energy market and address disadvantages from exclusion from the common electricity trading zone with Germany.

Thirdly, the results suggest that achieving CO_2 reduction through electrification as it is the goal of the government, might turn out to be more difficult than expected. The low fuel substitution rates in reaction to fuel price changes and the high persistence in the use of specific fuel mixes, indicate that changes in the energy mix predominantly result from and require technical change and investments. While the Austrian government has put in place measures to support the development and adoption of new more energy efficient technologies, it may be necessary to scale up the support focusing on cost-effective and targeted measures, given that only a small share of companies account for a large share in total energy consumption, making broad undifferentiated measures unnecessary.

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8. Appendices

Table 10: **Principal components analysis of year-on-year fuel price changes for periods 2000 to 2019 and 2020-2022 EU countries and non-EU OECD countries**

						EU countries before 2020						
		Comp 1			Comp 2			Comp 3			Comp 4	
Eigenvalue		1.628			1.039			0.843			0.490	
Explained variance		40.71%			25.98%			21.07%			12.25%	
Cumulated explained variance		40.71%			66.68%			87.75%			100.00%	
rate of change:	Eigenvector	Comp. Load	proportion of variation explained by PC	Eigenvector	Comp. Load	proportion of variation explained by PC	Eigenvector	Comp. Load	proportion of variation explained by PC	Eigenvector	Comp. Load	proportion of variation explained by PC
Coal	0.441	0.563	31.7%	-0.315	-0.321	10.3%	0.814	0.748	55.9%	-0.207	-0.145	2.1%
Electricity	0.318	0.406	16.5%	0.824	0.840	70.6%	0.248	0.227	5.2%	0.397	0.278	7.7%
Natural gas	0.612	0.781	61.1%	0.198	0.202	4.1%	-0.418	-0.384	14.7%	-0.641	-0.449	20.1%
Oil products	0.574	0.732	53.6%	-0.426	-0.435	18.9%	-0.318	-0.291	8.5%	0.623	0.436	19.0%
						non-EU OECD countries before 2020						
		Comp 1			Comp 2			Comp 3			Comp 4	
Eigenvalue		2.067			0.916			0.641			0.376	
Explained Variance		51.68%			22.90%			16.03%			9.39%	
Cumulated Variance		51.68%			74.58%			90.61%			100.00%	
rate of change:	Eigenvector	Comp. Load	proportion of variation explained by PC	Eigenvector	Comp. Load	proportion of variation explained by PC	Eigenvector	Comp. Load	proportion of variation explained by PC	Eigenvector	Comp. Load	proportion of variation explained by PC
Coal	0.454	0.653	42.6%	-0.542	-0.519	26.9%	0.662	0.530	28.1%	-0.247	-0.151	2.3%
Electricity	0.425	0.611	37.3%	0.708	0.677	45.9%	0.426	0.341	11.6%	0.370	0.227	5.1%
Natural gas	0.565	0.813	66.1%	0.259	0.248	6.2%	-0.422	-0.338	11.4%	-0.660	-0.404	16.4%
Oil products	0.542	0.779	60.6%	-0.371	-0.355	12.6%	-0.450	-0.360	13.0%	0.606	0.371	13.8%
						EU countries after 2020						
		Comp 1			Comp 2			Comp 3			Comp 4	
Eigenvalue		3.130			0.444			0.308			0.118	
Explained Variance		78.24%			11.10%			7.70%			2.95%	
Cumulated Variance		78.24%			89.34%			97.05%			100.00%	
rate of change:	Eigenvector	Comp. Load	proportion of variation explained by PC	Eigenvector	Comp. Load	proportion of variation explained by PC	Eigenvector	Comp. Load	proportion of variation explained by PC	Eigenvector	Comp. Load	proportion of variation explained by PC
Coal	0.479	0.848	71.9%	0.631	0.420	17.7%	0.564	0.313	9.8%	-0.234	-0.080	0.6%
Electricity	0.487	0.862	74.3%	-0.627	-0.418	17.5%	0.454	0.252	6.4%	0.404	0.139	1.9%
Natural gas	0.522	0.924	85.4%	-0.316	-0.211	4.4%	-0.378	-0.210	4.4%	-0.696	-0.239	5.7%
Oil products	0.510	0.902	81.4%	0.330	0.220	4.8%	-0.577	-0.320	10.2%	0.546	0.188	3.5%
						non-EU OECD countries after 2020						
		Comp 1			Comp 2			Comp 3			Comp 4	
Eigenvalue		2.634			0.852			0.425			0.089	
Explained Variance		65.85%			21.29%			10.63%			2.23%	
Cumulated Variance		65.85%			87.14%			97.77%			100.00%	
rate of change:	Eigenvector	Comp. Load	proportion of variation explained by PC	Eigenvector	Comp. Load	proportion of variation explained by PC	Eigenvector	Comp. Load	proportion of variation explained by PC	Eigenvector	Comp. Load	proportion of variation explained by PC
Coal	0.463	0.751	56.4%	0.491	0.453	20.5%	0.736	0.480	23.1%	-0.051	-0.015	0.0%
Electricity	0.466	0.757	57.3%	-0.673	-0.621	38.5%	0.193	0.126	1.6%	0.541	0.162	2.6%
Natural gas	0.574	0.932	86.9%	-0.263	-0.243	5.9%	-0.236	-0.154	2.4%	-0.738	-0.221	4.9%
Oil products	0.489	0.793	62.9%	0.487	0.449	20.2%	-0.604	-0.394	15.5%	0.399	0.119	1.4%

Source: IEA Energy Prices; own calculation. The explained proportion variation in fuel prices explained by a component is equivalent to the squared correlation between the eigenvector and the data.

Table 11: **Principal components analysis of year-on-year fuel price changes for period 2000-2022, Austria, EU countries and non-EU OECD countries**

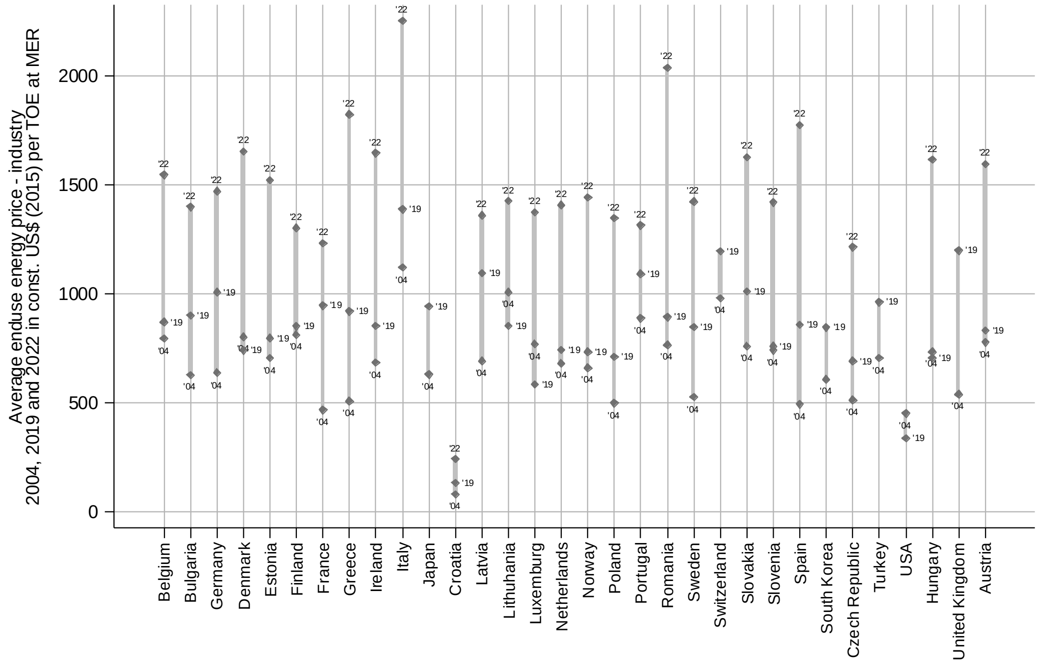
Austria 2000-2022												
		Comp 1			Comp 2			Comp 3			Comp 4	
Eigenvalue		1.960			0.960			0.672			0.408	
Explained Variance		49.01%			24.00%			16.79%			10.19%	
Cumulated Variance		49.01%			73.02%			89.81%			100.00%	
rate of change:	Eigenvector	Comp. Load	explained proportion of fuel price variation	Eigenvector	Comp. Load	explained proportion of fuel price variation	Eigenvector	Comp. Load	explained proportion of fuel price variation	Eigenvector	Comp. Load	explained proportion of fuel price variation
Coal	0.549	0.768	59.0%	-0.183	-0.180	3.2%	0.635	0.521	27.1%	-0.512	-0.327	10.7%
Electricity	0.568	0.795	63.2%	-0.407	-0.398	15.9%	-0.032	-0.026	0.1%	0.715	0.457	20.8%
Natural gas	0.532	0.745	55.5%	0.113	0.111	1.2%	-0.742	-0.608	37.0%	-0.391	-0.250	6.2%
Oil products	0.306	0.428	18.3%	0.888	0.870	75.7%	0.211	0.173	3.0%	0.272	0.173	3.0%
EU countries 2000-2022												
		Comp 1			Comp 2			Comp 3			Comp 4	
Eigenvalue		2.277			0.807			0.637			0.279	
Explained Variance		56.93%			20.18%			15.92%			6.97%	
Cumulated Variance		56.93%			77.11%			93.03%			100.00%	
rate of change:	Eigenvector	Comp. Load	explained proportion of fuel price variation	Eigenvector	Comp. Load	explained proportion of fuel price variation	Eigenvector	Comp. Load	explained proportion of fuel price variation	Eigenvector	Comp. Load	explained proportion of fuel price variation
Coal	0.448	0.676	45.7%	0.462	0.415	17.2%	0.760	0.607	36.8%	-0.087	-0.046	0.2%
Electricity	0.495	0.748	55.9%	-0.647	-0.581	33.8%	0.165	0.131	1.7%	0.556	0.294	8.6%
Natural gas	0.575	0.868	75.4%	-0.255	-0.229	5.2%	-0.267	-0.213	4.6%	-0.730	-0.385	14.8%
Oil products	0.472	0.712	50.7%	0.551	0.495	24.5%	-0.569	-0.454	20.6%	0.388	0.205	4.2%
non-EU OECD countries 2000-2022												
		Comp 1			Comp 2			Comp 3			Comp 4	
Eigenvalue		2.314			0.851			0.549			0.285	
Explained Variance		57.86%			21.28%			13.73%			7.13%	
Cumulated Variance		57.86%			79.14%			92.87%			100.00%	
rate of change:	Eigenvector	Comp. Load	explained proportion of fuel price variation	Eigenvector	Comp. Load	explained proportion of fuel price variation	Eigenvector	Comp. Load	explained proportion of fuel price variation	Eigenvector	Comp. Load	explained proportion of fuel price variation
Coal	0.470	0.715	51.2%	0.454	0.419	17.6%	0.752	0.557	31.1%	-0.084	-0.045	0.2%
Electricity	0.456	0.694	48.2%	-0.706	-0.651	42.4%	0.198	0.147	2.2%	0.504	0.269	7.3%
Natural gas	0.570	0.868	75.3%	-0.235	-0.217	4.7%	-0.296	-0.220	4.8%	-0.729	-0.389	15.2%
Oil products	0.495	0.753	56.8%	0.490	0.452	20.4%	-0.555	-0.411	16.9%	0.455	0.243	5.9%

Source: IEA Energy Prices, own calculation. The explained proportion variation in fuel prices explained by a component is equivalent to the squared correlation between the eigenvector and the data.

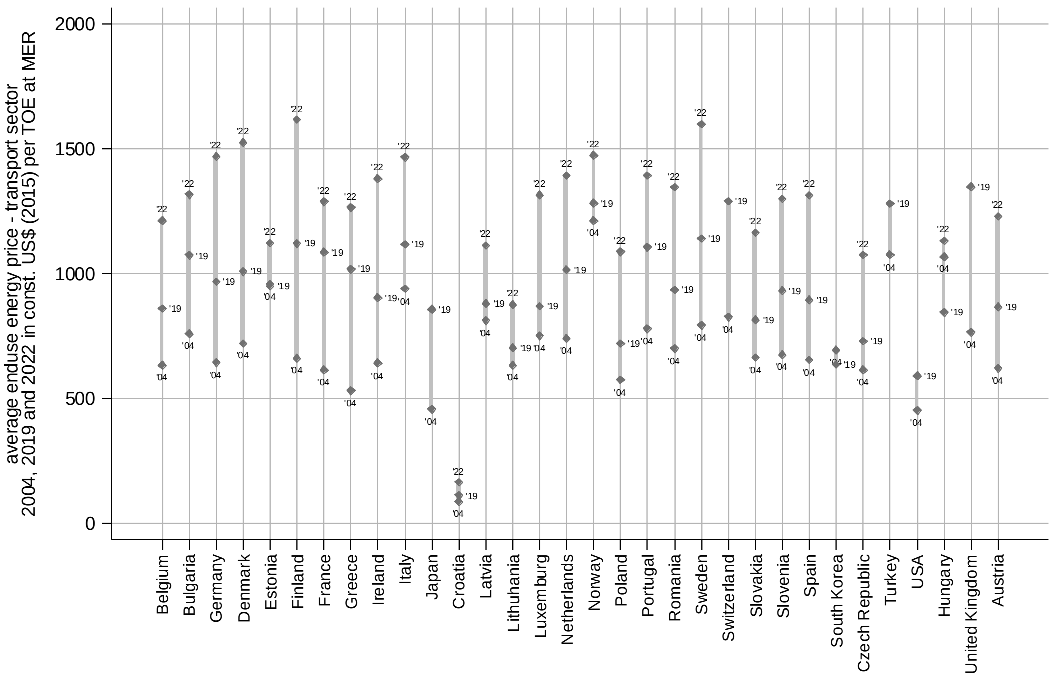
Figure 31: **Cross-country variation of end use energy prices at market exchange rates**

Const. 2015 USD, 2004, 2019, 2022

Manufacturing and construction; mining



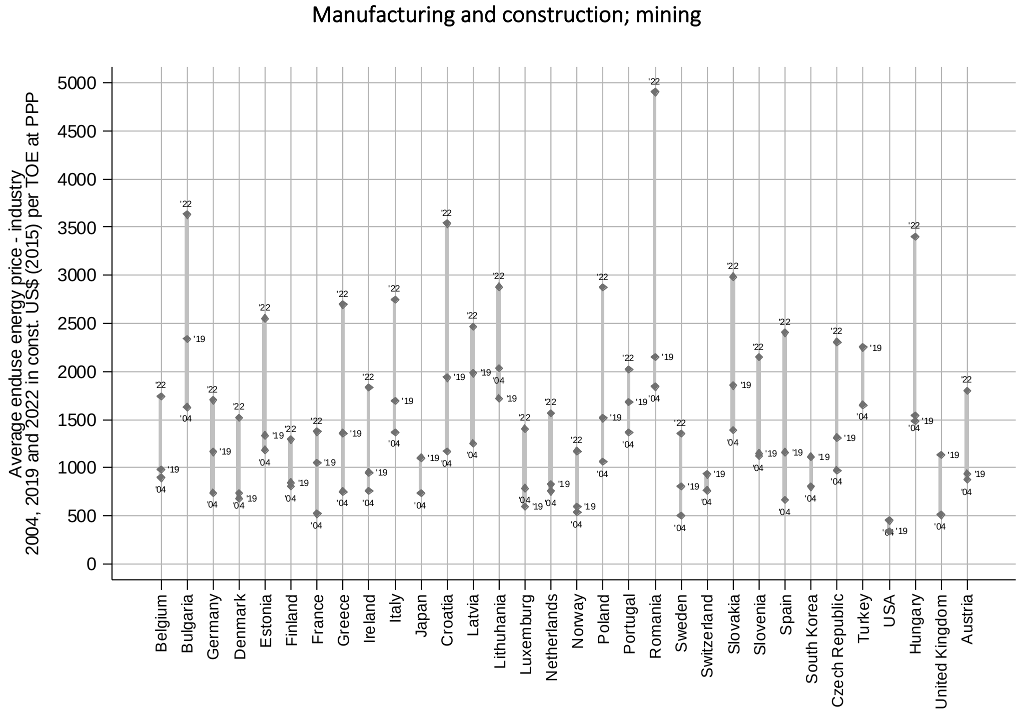
Transport

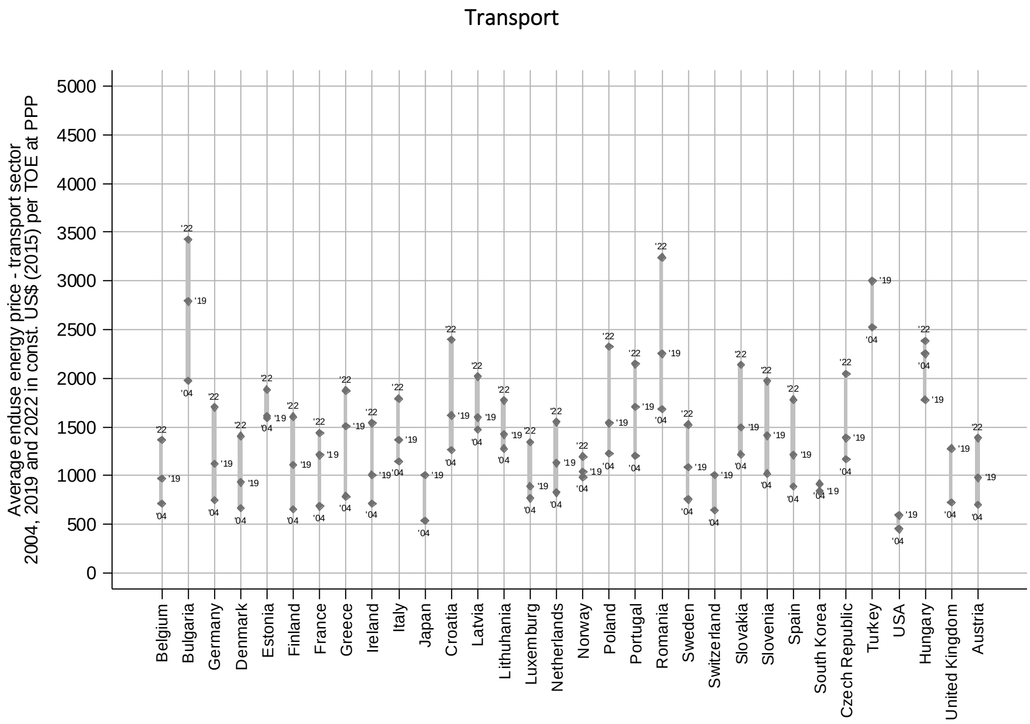


Source: IEA Energy Prices and World Energy Balances; Eurostat Energy Balances, own calculation.

Figure 32: **Cross-country variation of end use energy prices at purchasing power parities**

Const. 2015 USD, 2004, 2019, 2022

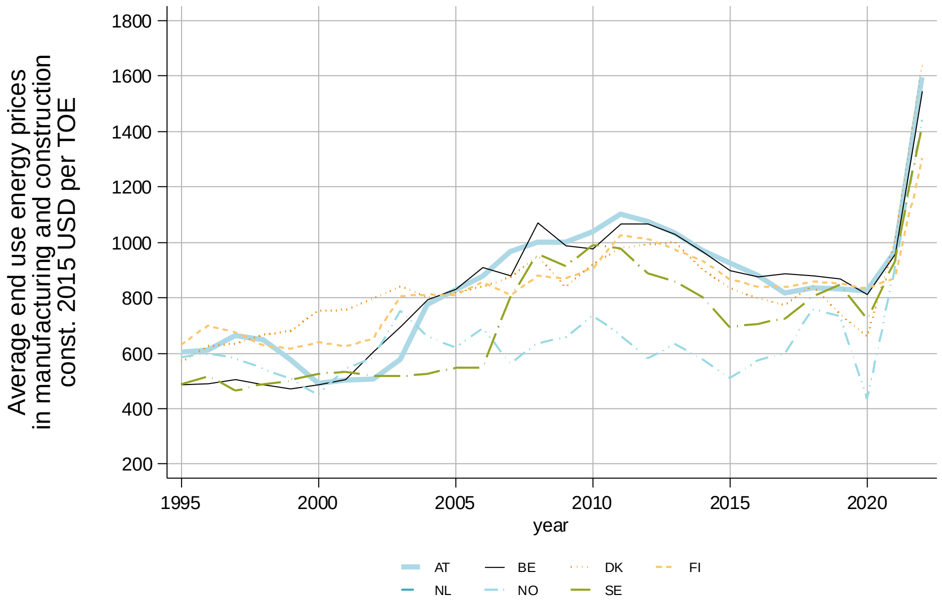




Source: IEA Energy Prices and World Energy Balances; Eurostat Energy Balances, own calculation.

Figure 33: **End use prices industry in the manufacturing, construction, and mining sectors in Austria and the BENESCAND countries**

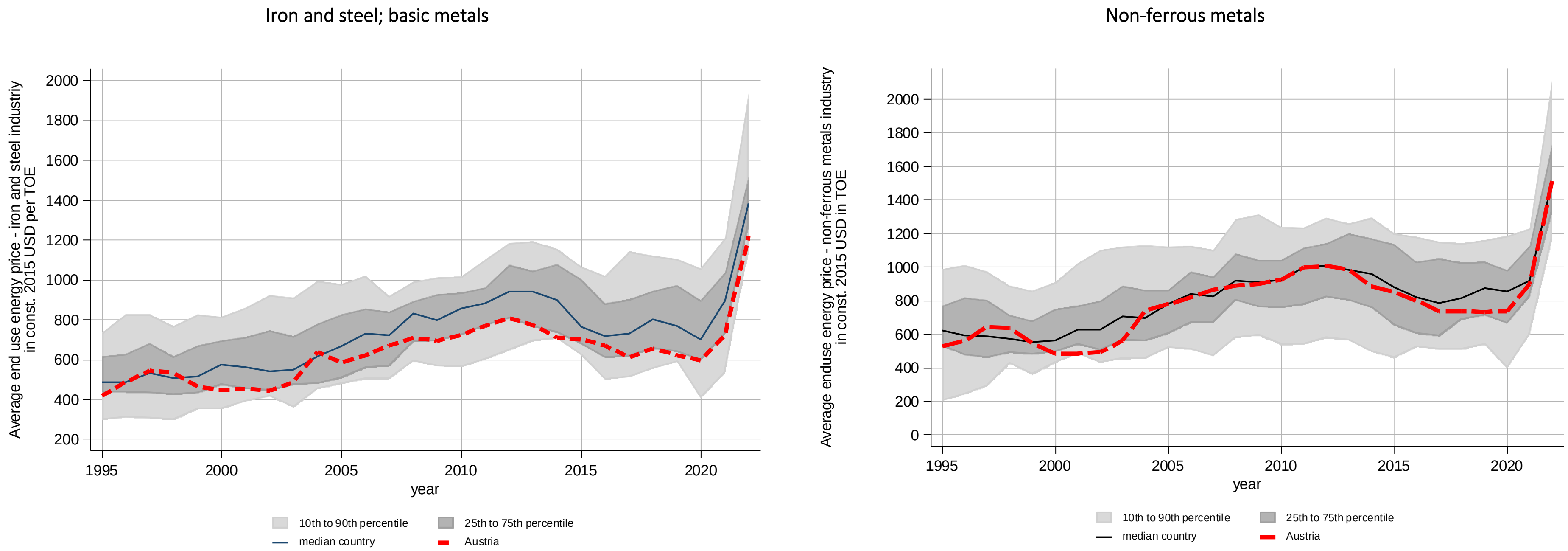
Const. 2015 USD per TOE, 1995–2022



Source: IEA Energy Prices and World Energy Balances; Eurostat Energy Balances, own calculation.

Figure 34: End use prices industry (share of electric energy and natural gas below 50%): Iron and steel, basic metals; non-ferrous metals

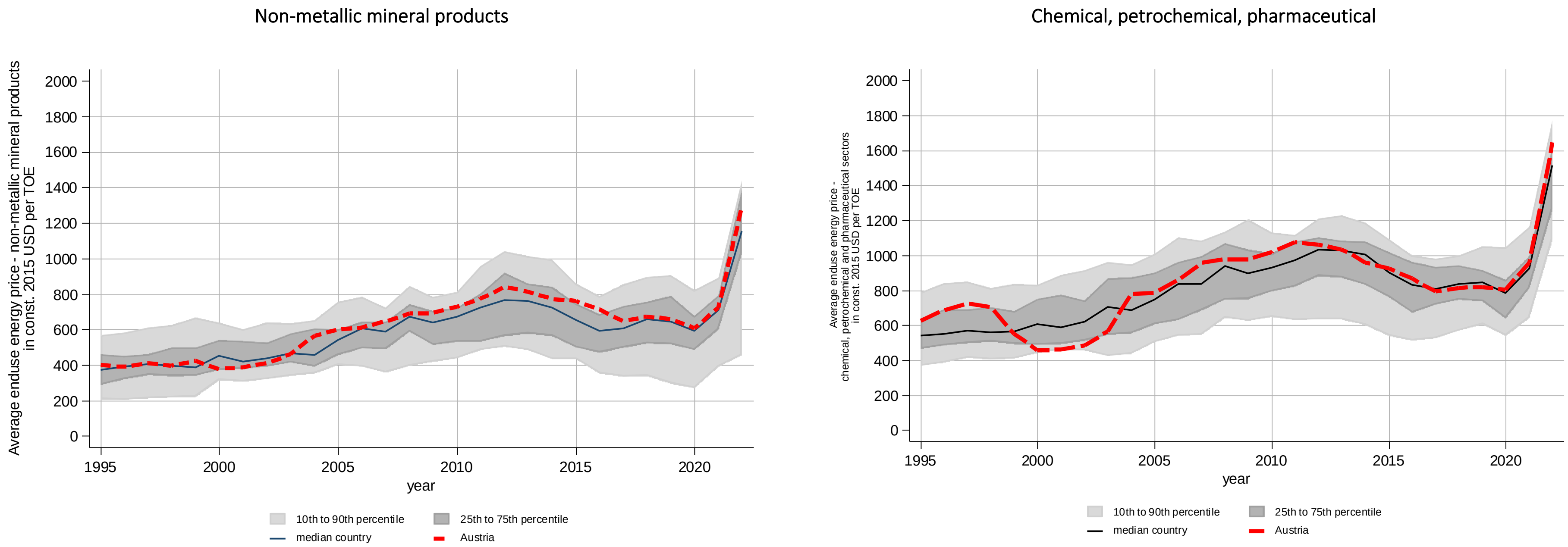
1995–2022



Source: IEA Energy Prices and World Energy Balances; Eurostat Energy Balances, own calculation. Reference to energy share: Average energy mix between 2016 and 2018 for Austria, from Figure 38.

Figure 35: **End use prices industry (share of electric energy and natural gas above 50%): non-metallic minerals; chemical, petrochemical, pharmaceutical**

1995–2022



Source: IEA Energy Prices and World Energy Balances; Eurostat Energy Balances, own calculation. Reference to energy share: Average energy mix between 2016 and 2018 for Austria, from Figure 38.

Figure 36: **End use prices industry (share of electric energy above 50%): machinery, metal products, electric equipment; automotive**

1995–2022

Source: IEA Energy Prices and World Energy Balances; Eurostat Energy Balances, own calculation. Reference to energy share: Average energy mix between 2016 and 2018 for Austria, from Figure 38.

Table 12: **Exploratory regression analysis of factors influencing energy prices at the firm level: Tables for natural gas, electricity, and oil products**

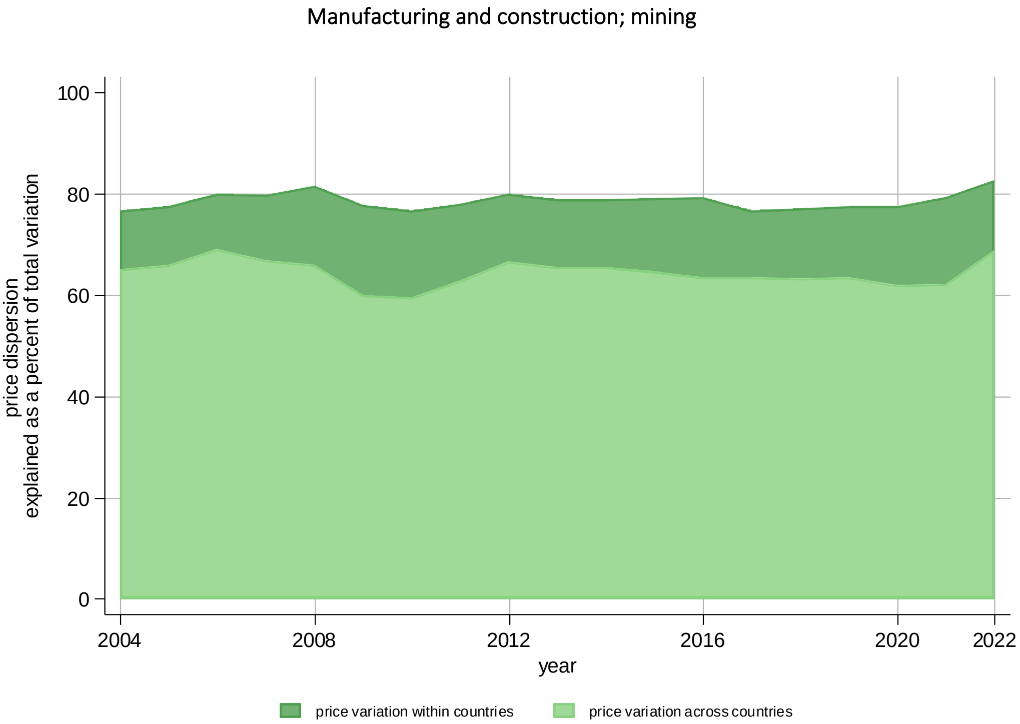
Dependent var: end use prices for natural gas	OLS	OLS	OLS	FE	FE	FE
energy consumption - 2nd quantile	-0.0811***		-0.0824***	-0.0689***		-0.0704***
	(0.0131)		(0.0131)	(0.0159)		(0.0158)
energy consumption - 3rd quantile	-0.1342***		-0.1362***	-0.0983***		-0.1000***
	(0.0140)		(0.0141)	(0.0205)		(0.0206)
energy consumption - 4th quantile	-0.1813***		-0.1833***	-0.1413***		-0.1435***
	(0.0154)		(0.0156)	(0.0251)		(0.0251)
energy consumption - 5th quantile	-0.2762***		-0.2782***	-0.1911***		-0.1925***
	(0.0186)		(0.0186)	(0.0354)		(0.0355)
Renewable energy user	-0.0181	-0.0173	-0.0183	-0.0022	-0.0054	-0.0017
	(0.0133)	(0.0136)	(0.0132)	(0.0197)	(0.0197)	(0.0195)
ETS Account holder	-0.1051***	-0.0612**	-0.1036***			
	(0.0268)	(0.0262)	(0.0266)			
turnover - 2nd quantile	0.0109		0.0113	0.0099		0.0147
	(0.0101)		(0.0101)	(0.0097)		(0.0097)
turnover - 3rd quantile	-0.0011		0.0006	0.0043		0.0131
	(0.0114)		(0.0116)	(0.0138)		(0.0139)
turnover - 4th quantile	0.0222*		0.0254**	0.0119		0.0253
	(0.0126)		(0.0129)	(0.0174)		(0.0180)
turnover - 5th quantile	0.0203		0.0253*	0.0041		0.0222
	(0.0143)		(0.0150)	(0.0225)		(0.0232)
log energy consumption		-0.0514***			-0.0520***	
		(0.0034)			(0.0084)	
log sales		0.0122**			0.0082	
		(0.0049)			(0.0114)	
average labor productivity - 2nd quantile			-0.0041			-0.0164**
			(0.0085)			(0.0072)
average labor productivity - 3rd quantile			0.0008			-0.0203**
			(0.0092)			(0.0083)
average labor productivity - 4th quantile			-0.0135			-0.0301***
			(0.0098)			(0.0088)
average labor productivity - 5th quantile			-0.0139			-0.0371***
			(0.0110)			(0.0109)
intercept	2.5202***	2.7137***	2.5258***	2.5041***	2.7752***	2.5182***
	(0.0108)	(0.0415)	(0.0122)	(0.0216)	(0.1318)	(0.0220)
year dummies	Y	Y	Y	Y	Y	Y
observations	7906	7906	7906	7906	7906	7906
number of clusters	1468	1468	1468	1468	1468	1468
absorbed	348	348	348			
Adj. R^2	0.3514	0.3556	0.3517	0.0972	0.1025	0.0996
R^2 overall				0.2660	0.2776	0.2656
R^2 within				0.0997	0.1043	0.1026
R^2 between				0.3814	0.3972	0.3826

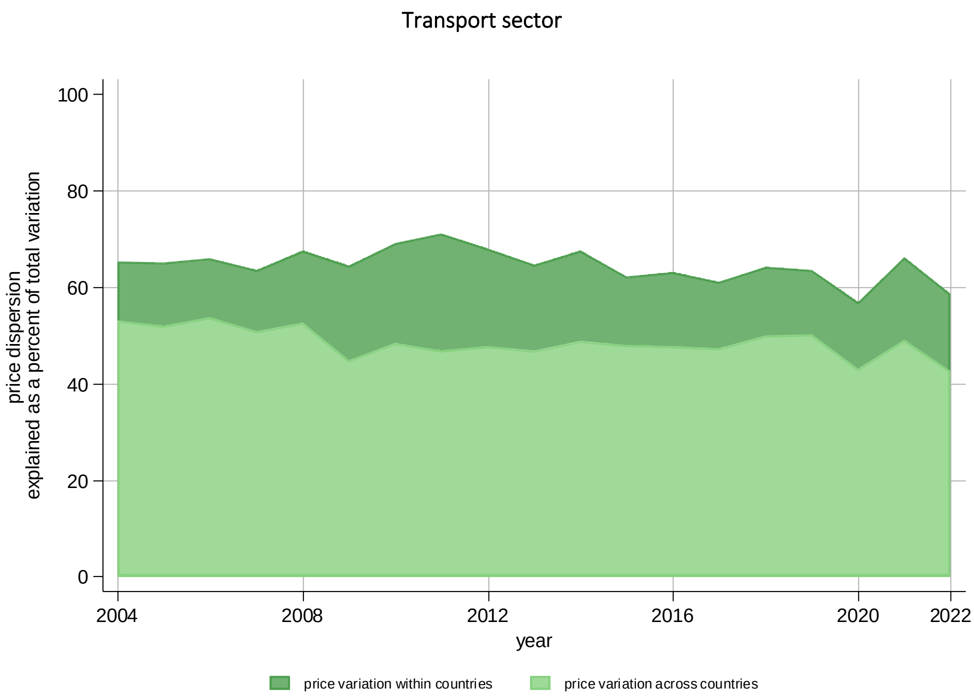
Dependent var: end use prices for electricity	OLS	OLS	OLS	FE	FE	FE
energy consumption - 2nd quantile	-0.0398***		-0.0418***	-0.0338***		-0.0340***
	(0.0091)		(0.0091)	(0.0114)		(0.0114)
energy consumption - 3rd quantile	-0.1166***		-0.1191***	-0.0962***		-0.0964***
	(0.0107)		(0.0107)	(0.0158)		(0.0159)
energy consumption - 4th quantile	-0.1851***		-0.1876***	-0.1715***		-0.1714***
	(0.0118)		(0.0119)	(0.0191)		(0.0191)
energy consumption - 5th quantile	-0.3014***		-0.3034***	-0.2519***		-0.2519***
	(0.0140)		(0.0140)	(0.0234)		(0.0234)
Renewable energy user	-0.0938***	-0.0888***	-0.0936***	-0.0991***	-0.0988***	-0.0991***
	(0.0103)	(0.0100)	(0.0102)	(0.0111)	(0.0110)	(0.0111)
ETS Account holder	-0.0681*	-0.0557	-0.0661*			
	(0.0397)	(0.0357)	(0.0395)			
turnover - 2nd quantile	0.0011		0.0022	0.0030		0.0033
	(0.0067)		(0.0067)	(0.0058)		(0.0058)
turnover - 3rd quantile	-0.0003		0.0018	0.0146*		0.0154*
	(0.0078)		(0.0078)	(0.0082)		(0.0083)
turnover - 4th quantile	0.0229***		0.0263***	0.0242**		0.0252**
	(0.0086)		(0.0087)	(0.0107)		(0.0110)
turnover - 5th quantile	0.0427***		0.0482***	0.0158		0.0168
	(0.0098)		(0.0100)	(0.0137)		(0.0141)
log energy consumption		-0.0669***			-0.0717***	
		(0.0029)			(0.0077)	
log sales		0.0239***			0.0198***	
		(0.0038)			(0.0072)	
average labor productivity - 2nd quantile			-0.0109**			-0.0057
			(0.0055)			(0.0041)
average labor productivity - 3rd quantile			-0.0080			-0.0057
			(0.0063)			(0.0048)
average labor productivity - 4th quantile			-0.0199***			-0.0064
			(0.0069)			(0.0054)
average labor productivity - 5th quantile			-0.0212***			-0.0014
			(0.0076)			(0.0061)
intercept	3.3926***	3.6098***	3.4040***	3.3753***	3.6915***	3.3784***
	(0.0081)	(0.0302)	(0.0092)	(0.0144)	(0.0808)	(0.0145)
year dummies	Y	Y	Y	Y	Y	Y
observations	16789	16789	16789	16789	16789	16789
number of clusters	2568	2568	2568	2568	2568	2568
absorbed	350	350	350			
Adj. R^2	0.4092	0.4117	0.4100	0.1699	0.1743	0.1699
R^2 overall				0.3477	0.3661	0.3480
R^2 within				0.1710	0.1751	0.1712
R^2 between				0.4441	0.4505	0.4447

Dependent var: end use prices for oil products	OLS	OLS	OLS	FE	FE	FE
energy consumption - 2nd quantile	-0.0204***		-0.0196***	-0.0136*		-0.0139*
	(0.0064)		(0.0065)	(0.0080)		(0.0080)
energy consumption - 3rd quantile	-0.0357***		-0.0349***	-0.0311***		-0.0317***
	(0.0068)		(0.0069)	(0.0109)		(0.0109)
energy consumption - 4th quantile	-0.0661***		-0.0650***	-0.0700***		-0.0708***
	(0.0076)		(0.0077)	(0.0130)		(0.0130)
energy consumption - 5th quantile	-0.0847***		-0.0833***	-0.0965***		-0.0977***
	(0.0082)		(0.0082)	(0.0159)		(0.0158)
Renewable energy user	-0.0131**	-0.0133**	-0.0134**	-0.0095	-0.0091	-0.0094
	(0.0062)	(0.0062)	(0.0062)	(0.0081)	(0.0081)	(0.0081)
ETS Account holder	0.0158	0.0053	0.0135			
	(0.0181)	(0.0178)	(0.0180)			
turnover - 2nd quantile	0.0092*		0.0093*	0.0061		0.0070
	(0.0055)		(0.0055)	(0.0055)		(0.0055)
turnover - 3rd quantile	0.0190***		0.0186***	0.0189**		0.0208**
	(0.0060)		(0.0060)	(0.0081)		(0.0083)
turnover - 4th quantile	0.0306***		0.0302***	0.0351***		0.0383***
	(0.0064)		(0.0064)	(0.0101)		(0.0104)
turnover - 5th quantile	0.0450***		0.0435***	0.0304**		0.0348**
	(0.0077)		(0.0079)	(0.0137)		(0.0142)
log energy consumption		-0.0218***			-0.0275***	
		(0.0020)			(0.0053)	
log sales		0.0179***			0.0191***	
		(0.0029)			(0.0073)	
average labor productivity - 2nd quantile			-0.0005			0.0003
			(0.0046)			(0.0040)
average labor productivity - 3rd quantile			-0.0073			-0.0055
			(0.0053)			(0.0045)
average labor productivity - 4th quantile			0.0038			-0.0069
			(0.0056)			(0.0051)
average labor productivity - 5th quantile			0.0064			-0.0093
			(0.0063)			(0.0062)
intercept	3.2380***	3.2088***	3.2372***	3.1280***	3.1324***	3.1313***
	(0.0060)	(0.0263)	(0.0068)	(0.0133)	(0.0765)	(0.0136)
year dummies	Y	Y	Y	Y	Y	Y
observations	12147	12147	12147	12147	12147	12147
number of clusters	2245	2245	2245	2245	2245	2245
absorbed	347	347	347			
Adj. R^2	0.3980	0.3992	0.3984	0.1971	0.1965	0.1973
R^2 overall				0.2498	0.2348	0.2500
R^2 within				0.1985	0.1976	0.1990
R^2 between				0.3553	0.3159	0.3527

Figure 37: **Industry energy price dispersion: variation within and across countries, manufacturing and construction as well as transport sectors**

2004–2022



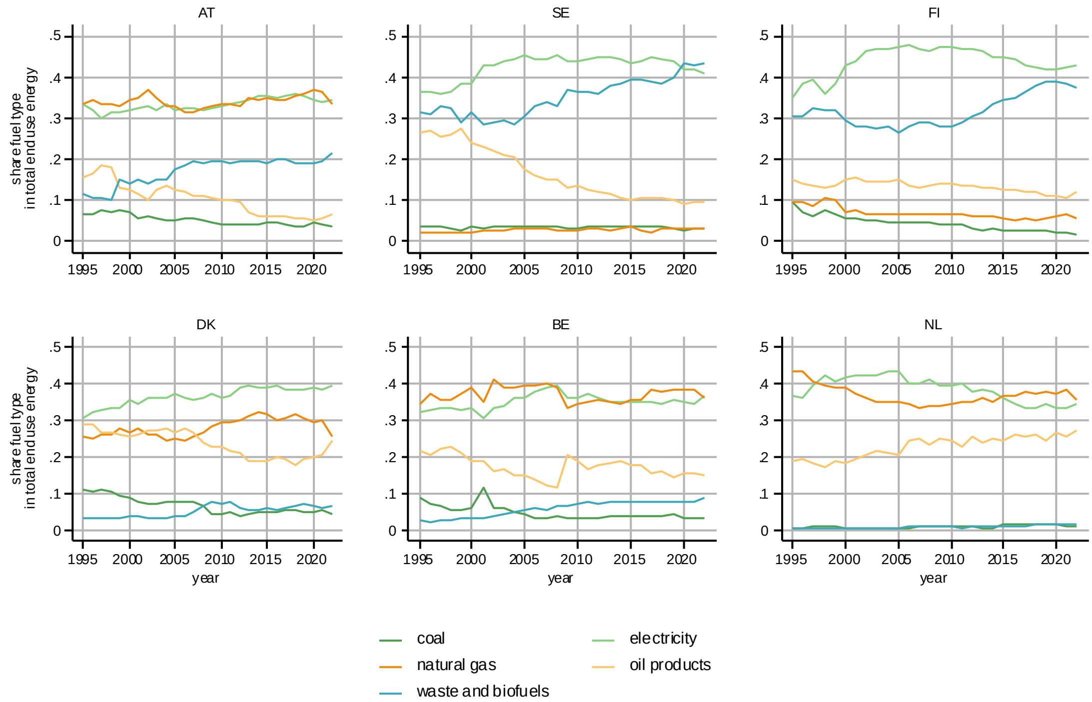


Source: IEA Energy Prices and World Energy Balances; Eurostat Energy Balances, own calculation. Results from an ANOVA analysis of share of total variation explained by country and sector dummies.

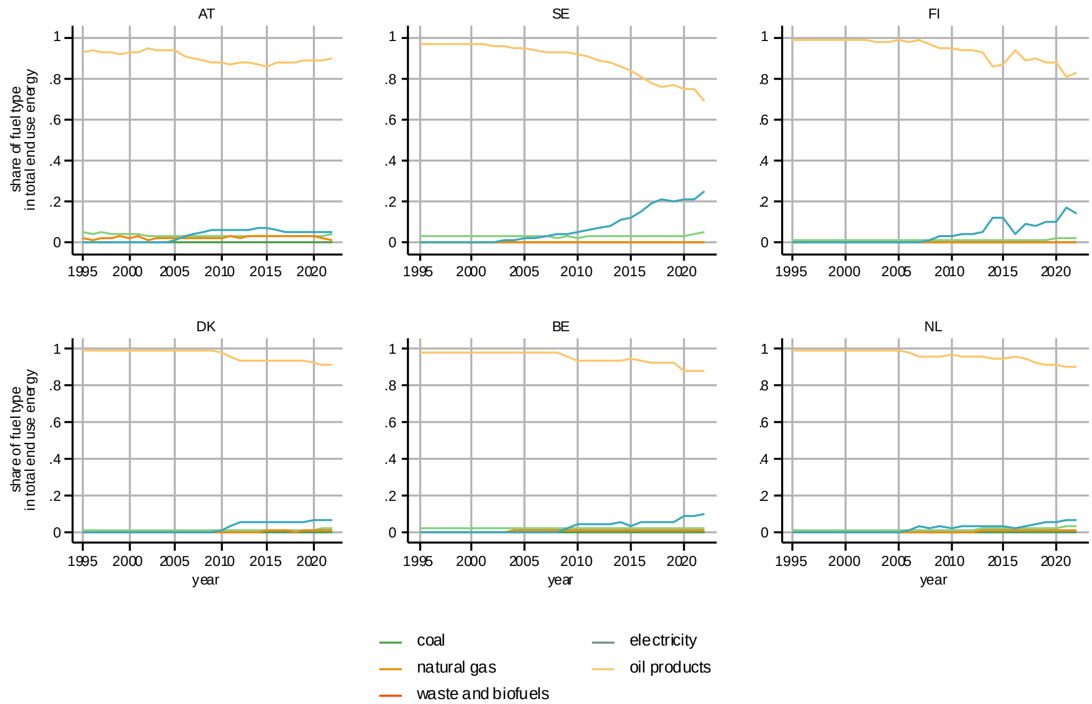
Figure 38: **Energy mix in manufacturing, construction, and transport in Austria and the BENESCAND countries**

1995–2022

Manufacturing and construction; mining



Transport



Source: IEA Energy Prices and World Energy Balances; Eurostat Energy Balances, own calculations.

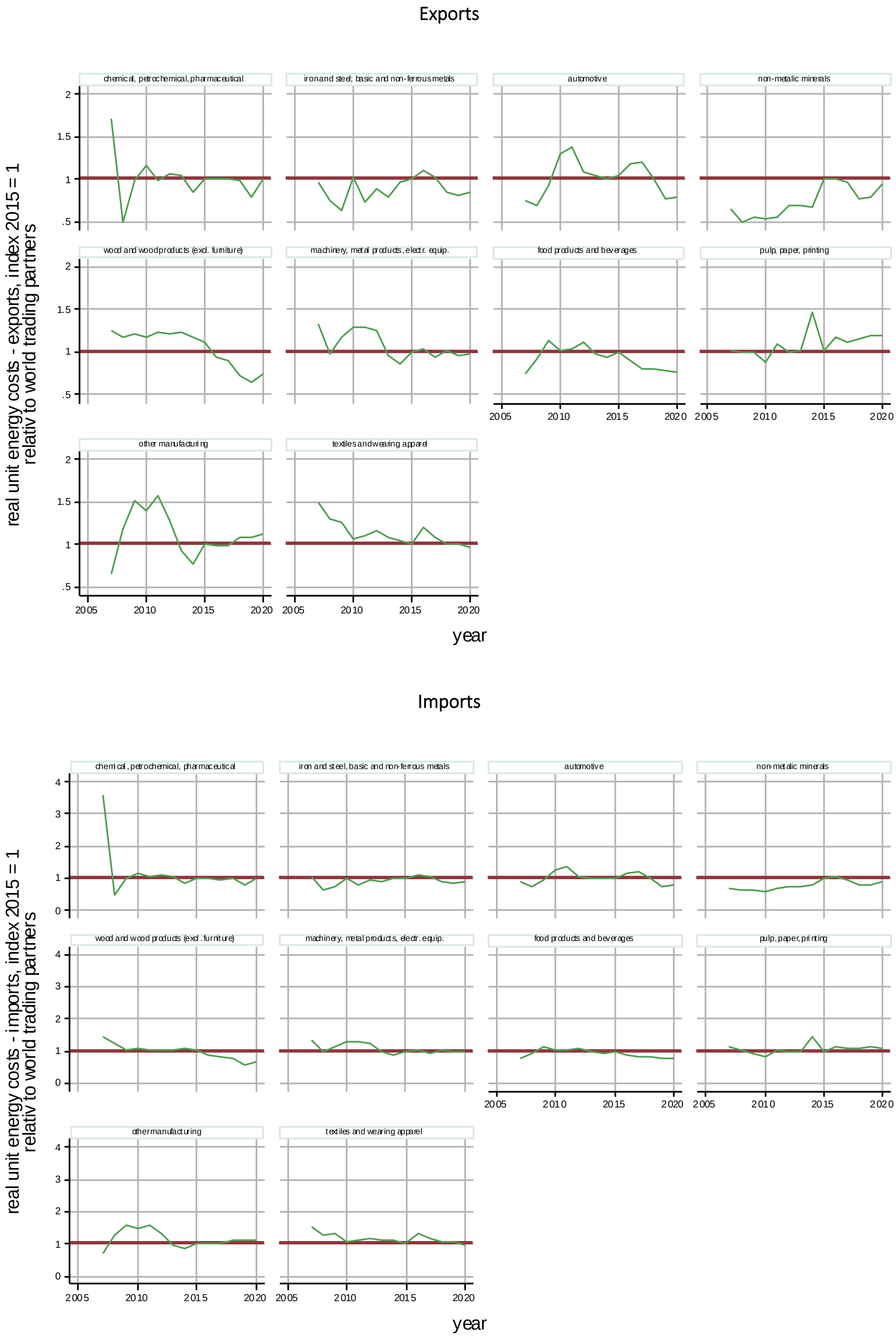
Table 13: **Firm-level additive Log Mean Divisia Index decomposition of industry energy price per manufacturing industry for the periods 2013–2019 and 2020–2021**

		LMDI additive, 2013–2019			LMDI additive, 2020–2021		
NACE	division	dEPI	lmdi_add_price	lmdi_add_struc	dEPI	lmdi_add_price	lmdi_add_struc
C11	Manufacture of beverages	-3,080	-3,619	0.540	1,055	1,394	-0.340
C14	Manufacture of wearing apparel	-3,304	-2,731	-0.573	0.659	1,116	-0.457
C18	Printing and reproduction of recorded media	-0.491	-0.289	-0.202	0.263	0.371	-0.108
C26	Manufacture of computer, electronic and optical products	-6,652	-6,798	0.146	2,916	2,836	0.079
C23	Manufacture of other non-metallic mineral products	-1,601	-2,124	0.523	3,231	3,059	0.172
C22	Manufacture of rubber and plastic products	-1,252	-1,592	0.340	4,522	4,759	-0.237
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	0.461	-1,360	1,822	2,045	2,458	-0.413
C29	Manufacture of motor vehicles, trailers and semi-trailers	-3,255	-3,822	0.567	4,758	4,792	-0.034
C15	Manufacture of leather and related products	-0.563	-0.826	0.263	7,339	7,650	-0.310
C25	Manufacture of fabricated metal products, except machinery and equipment	-3,661	-3,752	0.091	2,697	2,920	0.047
C31	Manufacture of furniture	-2,109	-1,794	-0.315	1,947	1,918	0.030
C10	Manufacture of food products	-2,876	-3,447	0.571	1,202	0.940	0.262
C17	Manufacture of paper and paper products	-1,634	-1,469	-0.164	4,224	3,888	0.336
C13	Manufacture of textiles	-4,608	-2,848	-1,760	4,155	4,200	-0.045
C20	Manufacture of chemicals and chemical products	-1,767	-1,901	0.134	3,348	3,432	-0.075
C27	Manufacture of electrical equipment	-1,995	-2,547	0.552	2,324	2,338	-0.014
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	-2,716	-2,561	-0.156	4,081	4,056	0.025
C32	Other manufacturing	-2,541	-2,851	0.309	1,192	1,744	-0.552
C19	Manufacture of coke and refined petroleum products	-2,627	-2,568	-0.058	1,508	1,527	-0.020
C28	Manufacture of machineryand equipment n.e.c.	-1,669	-2,202	0.533	2,244	2,434	-0.190
C24	Manufacture of basic metals	-1,129	-0.884	-0.245	-0.103	-0.102	0.000
C33	Repair and installation of machinery and equipment	-0.872	-0.462	-0.410	4,567	4,670	-0.103
C30	Manufacture of other transport equipment	-3,866	-3,004	-0.862	2,979	2,996	-0.018

Source: Statistics Austria, Austria Microdata Centre; own calculations on the basis of the Material Use Statistics (Gütereinsatzstatistik).

Figure 39: **Relative unit energy cost index (base 2015) for exports and imports relative to global trading partners**

2008–2020



Source: UNIDO Industry data, energy balances, IEA Energy Price Data, CEPII-BACI data (Gaulier and Zignago, 2010); own calculations.