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Exploring the Economic Resilience of Low vs. High Carbon Intensity Sectors

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Abstract

This study investigates the comparative economic resilience of low carbon intensity (LCI) versus high carbon intensity (HCI) industries of the Austrian economy, examining the impact of energy price shocks on real gross value added (GVA) and employment within both LCI and HCI industries. To illustrate these dynamics, we conducted a vector autoregression (VAR) analysis to simulate the effects of various energy price shocks on key economic indicators, comparable to the price surge experienced at the start of the war in Ukraine. The results show that fossil energy price dynamics can lead to significant economic damage, such as a loss in the dimension of 6.6% in real GVA in the HCI sector one year after a gas price shock (reflecting a possible loss of EUR 10 billion) or a loss in the range of 3-4% of jobs in the HCI sector for individual years after the shock (i.e., about job 50-70 thousand jobs in certain years). We argue that LCI industries demonstrate greater resilience in the light of fossil energy price shocks, which appear to destabilise HCI industries to a higher degree at least in the short run, not accounting for other factors and considering that everything else is kept constant. In conclusion, this study underscores the necessity for policy makers to prioritise the transition to low-carbon industries.

Keywords: green transition; energy price shocks; I/O-sector-analysis; VAR; GDP; GVA; employment; climate policy

JEL classification: Q41, Q43, C22, D57, E61, O44

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Exploring the economic resilience of low vs. high Carbon intensity sectors

EXECUTIVE SUMMARY

This study investigates the comparative economic resilience of low carbon intensity (LCI) versus high carbon intensity (HCI) industries. Our analysis reveals that LCI industries demonstrate greater resilience in the light of fossil energy price shocks, which appear to destabilise HCI industries to a higher degree at least in the short run, not accounting for other factors and considering that everything else is kept constant. To illustrate these dynamics, we conducted a vector autoregression (VAR) analysis to simulate the effects of various energy price shocks on key economic indicators, comparable to the price surge experienced at the start of the war in Ukraine. Our study focused on Austria, examining the impact on real gross value added (GVA) and employment within both LCI and HCI industries.

Fossil fuel prices are inherently volatile, owing to fluctuating supply and demand, geopolitical tensions, and market speculation. This volatility disproportionately impacts HCI industries, which depend heavily on fossil fuels for their operations. In contrast, LCI industries depend less on fossil fuels and are more insulated from such price swings, leading to more stable economic performance. At times of energy or geopolitical crises, such as the onset of the war in Ukraine, fossil fuel supplies are often disrupted, leading to sharp price increases and pronounced negative impacts on HCI industries.

Our analysis indicates that a transition away from fossil fuels would enhance Austria's economic resilience. By reducing dependency on volatile fossil fuel markets, Austria could achieve more stable economic growth and foster employment opportunities. Fossil energy price dynamics can lead to significant economic damage, such as a loss in the dimension of 6.6% in real GVA in the HCI sector one year after a gas price shock (reflecting a possible loss of EUR 10 billion) or a loss in the range of 3-4% of jobs in the HCI sector for individual years after the shock (i.e., about job 50-70 thousand jobs in certain years). Significant economic damage is not reported for the LCI sector. In contrast, our results even show a significant and positive effect on employment rates in the LCI sector for certain periods after a fossil energy price shock, raising employment rates in the dimension of 3% for individual periods (representing about 90 thousand new jobs in the LCI sector for individual years).

As the price shock associated with the Ukraine conflict is not an isolated event, continued reliance on fossil fuels exposes economies to repeated cycles of instability. Historical precedents, such as the oil crises of the 1970s or the 1990 oil price shock, demonstrate the recurring nature of such disruptions. Furthermore, banning fossil fuels could also spur economic growth, increase employment, and drive innovation. Investments in renewable energy and low-carbon technologies can generate new industries and job opportunities, fostering a more robust and sustainable economic environment.

In conclusion, this study underscores the necessity for policy makers to prioritise the transition to low-carbon industries. Such a transition not only mitigates the risks associated with fossil fuel dependency but also enhances economic resilience, stability, and growth. The Austrian economy, by embracing low-

carbon energy and technologies, stands to benefit significantly from reduced exposure to global energy market volatilities and the creation of a sustainable, innovation-driven economic future.

1. INTRODUCTION

In the face of escalating environmental degradation and the imperative of mitigating climate change, the global economy stands at a critical crossroads. Central to this juncture is the exploration of economic resilience within the spectrum of low carbon intensity (LCI) versus high carbon intensity (HCI) industries. As nations grapple with the intricate interplay between economic growth and environmental sustainability, understanding the vulnerabilities and resilience of these industries emerges as a pivotal consideration.

HCI industries face a confluence of challenges, including volatile energy prices, regulatory pressures for emissions reduction, and increasing market demand for sustainable alternatives (Hepburn et al., 2020). These challenges not only threaten the economic viability of traditional industries but also exacerbate environmental degradation and contribute to climate change. The vulnerability of HCI industries lies in their dependence on finite and environmentally harmful resources, coupled with the risks posed by stringent emissions regulations, market shifts towards sustainability and geopolitical dependencies (IEA, 2021; Osvaldová, 2022). In the case of Austria, the demand for fossil fuels and an increasing dependence on Russian gas emerged with the economic recovery in the aftermath of World War II, which brought with it economic vulnerabilities and geopolitical risks that persist to the present day (Lechner, 2023). Conversely, the LCI industries are vulnerable to market uncertainties and policy fluctuations, but exhibit greater resilience to the aforementioned challenges. A swift transition to a low carbon economy promises multifaceted benefits. It would not only mitigate the risks associated with climate change, but could also foster innovation, enhance energy security, and generate employment opportunities (Stern, 2007), especially if combined with green fiscal instruments such as carbon taxation (Semmler et al., 2021; Pigato, 2019).

This report examines the comparative resilience of LCI versus HCI industries of the Austrian economy, regarding key economic indicators in light of energy price shocks of the magnitude of those which followed the onset of war in Ukraine. The study is structured as follows: Section 2 gives a description of the data and methodology (without technical details); Section 3 presents and discusses the results obtained; and Section 4 sets out our conclusions.

2. DATA AND METHODOLOGY

This study analyses the effects of energy price shocks on HCI and LCI industries of the Austrian economy. The approach is motivated by a study by Mittnik and Semmler (2022), who explored the impacts on a high and low carbon intensive sector for the German economy. Our analysis applies a vector autoregression model (VAR) to the Austrian economy and uses data for key economic indicators from Eurostat, CO_2 emission data from Yamano and Guilhoto (2020), and energy price data from Statistik Austria (2024).

Key economic indicators that are to be analysed are the growth rate of real gross value added (GVA) and the growth rate of employment, which are computed based on a chain-linked volume measure of GVA (base year 2015; Eurostat, 2024a) and total domestic employment (Eurostat, 2024b) between 1995 and 2022. The Eurostat database provides data on national accounts aggregates by industry (up to

NACE A*64) but not on the fossil energy intensity of individual industries. Therefore, we refer to Yamano and Guilhoto (2020) for CO_2 emissions data on an industrial level for 2019. The economic and emissions data do not exactly match regarding their industry classifications, but the degree of disaggregation of national account data from Eurostat data has been harmonized, based on the highest possible degree of granularity that is shared by the different datasets.

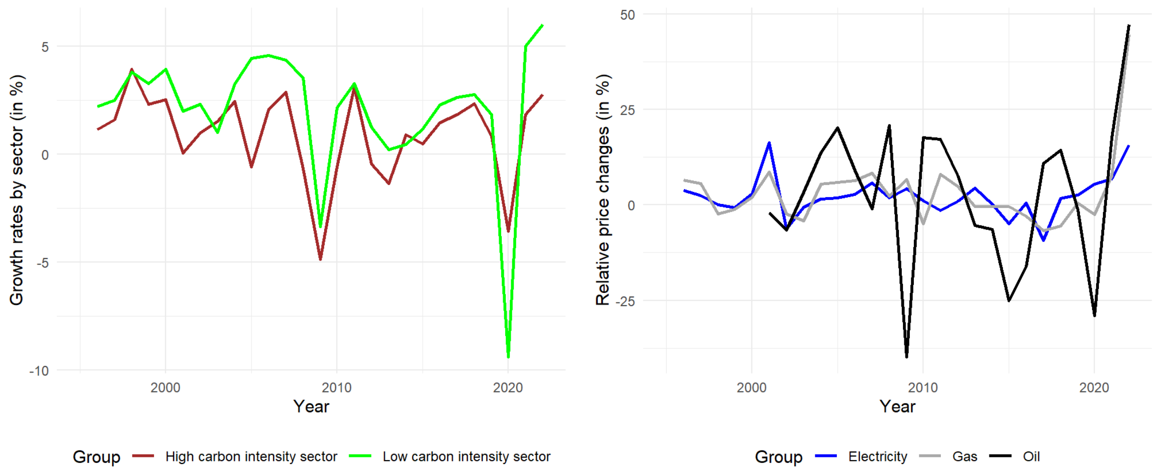
Our analysis distinguishes between an aggregated HCI and LCI sector. Based on CO_2 emissions data and real GVA we calculate the industry specific CO_2 intensities. The measure used is CO_2 emissions (in million tons) per million euros of real GVA (in 2015 chain-linked volumes) for 2019. Following Mittnik and Semmler (2022), we assign the individual industries to the HCI and LCI sector according to their CO_2 intensity and aggregate the amounts of the real GVA and employment respectively. Industries whose CO_2 intensity per unit of production is above (below) the median are assigned to the sector with high (low) CO_2 intensity (lists with details about the specific NACE codes and labels that are assigned to either the HCI or LCI group can be found in the appendix in Table A1 and Table A2). Real GVA growth for the HCI and LCI sector are depicted in Figure 1a below.

Statistik Austria (2024) reports information on various energy goods in the form of average consumer prices by year. Available information includes data on natural gas (in EUR per 100 kWh; data available between 1987 and 2023), on extra light heating oil (in EUR per 3,000 l; data available between 2000 and 2023), and on daytime electricity (in EUR per 100 kWh; data available between 1987 and 2023). The study therefore analyses the energy price shocks based on these three energy commodities. Relative price changes are depicted in Figure 1b below.

Figure 1 / Real GVA growth for the HCI and LCI sector and energy price shocks, % change, year on year

a) Real GVA by sector

b) Energy prices by energy type



Sources: Eurostat (2024a); Statistik Austria (2024).

Sources: Yamano and Guilhoto (2020).

Similar to Mittnik and Semmler (2022), our analysis models the impact of energy shocks on economic key variables by utilising VAR modelling. Conventional VAR models represent a linear approximation of dynamic processes. VAR models provide a useful tool to policymakers as they enable the computation of impulse response functions (IRFs), the main purpose of which is to describe the evolution of a model's variables in reaction to a shock in one or more variables. This feature allows us to trace the transmission of a single shock within an otherwise noisy system of equations. The shocks that are applied to the time series data of the key economic indicator variables are constituted by the magnitude of the energy price shocks that were observed between 2021 and 2022 and coincide with price spikes that are associated with the war in Ukraine. Based on consumer price data for the selected energy commodities we detect price shocks between 2021 and 2022 for natural gas in the order of 80.1% (from EUR 6.36 to EUR 11.51 per 100 kWh), for extra-light heating oil in the order of 89.7% (from EUR 2,233.75 to EUR 4,237.37 per 3,000 l), and for daytime electricity in the order of 18.5% (from EUR 17.94 to EUR 21.26 per 100 kWh). Importantly, results of the VAR are to be interpreted with the assumption that only effects of the shock variable are considered while everything else is kept constant and no other factors are accounted for. In addition, outcomes of IRFs only reflect short-run effects for individual periods after the shock and should not be taken as long-run outcomes.

3. RESULTS: THE IMPACT OF ENERGY PRICE SHOCKS ON THE HCI AND LCI SECTORS

3.1. The impact on real GVA growth rates

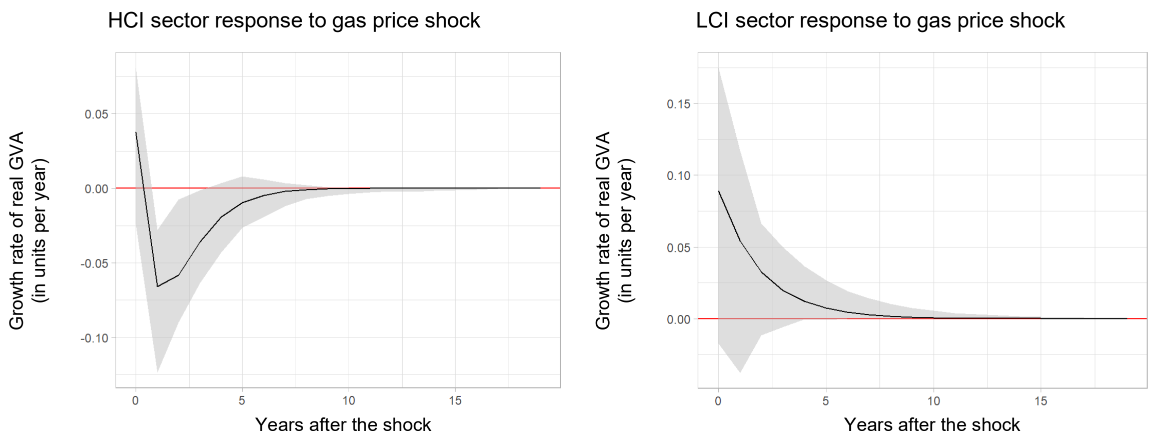
The first analysis explores the impact of energy price shocks on the growth rate of real GVA and finds that GVA growth rates in the HCI sector are more vulnerable to energy price shocks than those in the LCI sector. Although results for the different energy commodity prices reflect different sizes and periods of significant effects, the general appearance of a less vulnerable LCI sector remains the same. Positive energy price shocks applied to the LCI and HCI sector yield higher output growth rates in the former than in the latter, at least in the short run and assuming everything else is kept constant. While heating oil price shocks show a significantly higher output growth rate for the LCI sector than for the HCI one, positive gas price shocks indicate negative GVA growth rates for the HCI sector for at least two consecutive years. Most significant effects disappear about three years after the shocks are applied. Positive electricity price shocks do not yield significant differences between the HCI and LCI sectors, which promotes the argument that the HCI sector is especially vulnerable to fossil energy price volatilities. As results for the natural gas price shock appeared as the most pronounced, we discuss these results below (see Figures 2 and 3) and have placed charts on heating fuel and electricity price shocks in the Annex (see Figures A2 and A3).

Results of the short-run effects of a gas price shock are based on the depicted IRFs (see Figure 2 below) which report significant drops in real GVA growth rate for two consecutive years after the shock hits the economy (long-run effects are discussed in the paragraph above Figure 3 below). One year after the occurrence of an 80.1% gas price shock the real GVA growth rate in the HCI sector is expected to drop significantly by 6.6%. This recessionary territory also remains significant in the second year after the shock, represented by a real GVA growth rate of -5.8%. Although the average effect still appears negative three years after the shock, the confidence bands turn the effect insignificant by then. In 2022 real GVA amounts to EUR 152.7 billion in the HCI sector and EUR 186.7 billion in the LCI sector. Referring to 2022 as the base year, a drop of 6.6% in real GVA is therefore equivalent to a loss of EUR 10.1 billion, followed by a subsequent loss of 5.8%, equivalent to EUR 8.3 billion, which, if added up and everything else is kept constant, implies a significant loss of EUR 18.3 billion in total.

Conversely, a gas price shock of the same magnitude does not imply a significant reduction in real GVA growth rates in the LCI sector. The average effect ranges consistently though insignificantly above zero. This indicates that positive GVA growth for some time after the shock is not guaranteed for the LCI sector but more likely than in the case of the HCI sector. The convergence of the IRF towards the horizontal axis, slowly approaching zero, indicates the diminishing effect of the initial shock over time. This decrease in impact is due to various factors such as adjustments in the economy, reversion to long-term trends, and the dissipation of the initial disturbance.

Although it might appear counterintuitive that the energy shocks initially impact GVA growth rates positively (as shown by the black curves above the horizontal axis in year zero when the shock hits), it should be noted that in the raw data positive GVA growth rates coincide with energy price increases in 2021 and 2022 (see Figures 1a and 1b). If the analysis is carried out with modified time series data, with observations for 2021 and 2022 excluded, positive values for the median curve (i.e. the black line) disappear for the HCI and decrease for LCI sector.[1] However, including the fully available time range reflects dynamics of the post-pandemic recovery as well as energy price dynamics related to the Ukraine conflict. It is also noteworthy that the initial real GVA growth rate response in the period of the shock tends to be more positive for the LCI sector (reporting a value of 8.89% in year zero) than for the HCI one (at 3.75% in year zero). While observations of these point estimates are not significant, the trends relate to the real GVA growth rates which are also higher for the LCI than the HCI sector for recent time periods. Possible explanations for these tendencies could be stronger growth rates in LCI industries compared to HCI industries over time in correspondence to structural issues as well as a stronger push towards a green transition and low carbon industries in recent years.

Figure 2 / Impulse response function of a gas price shock to growth rates of real GVA in the HCI sector (left) and LCI sector (right)[2]



Source: Authors' computations, based on Eurostat (2024a), Yamano and Guilhoto (2020) and Statistik Austria (2024).

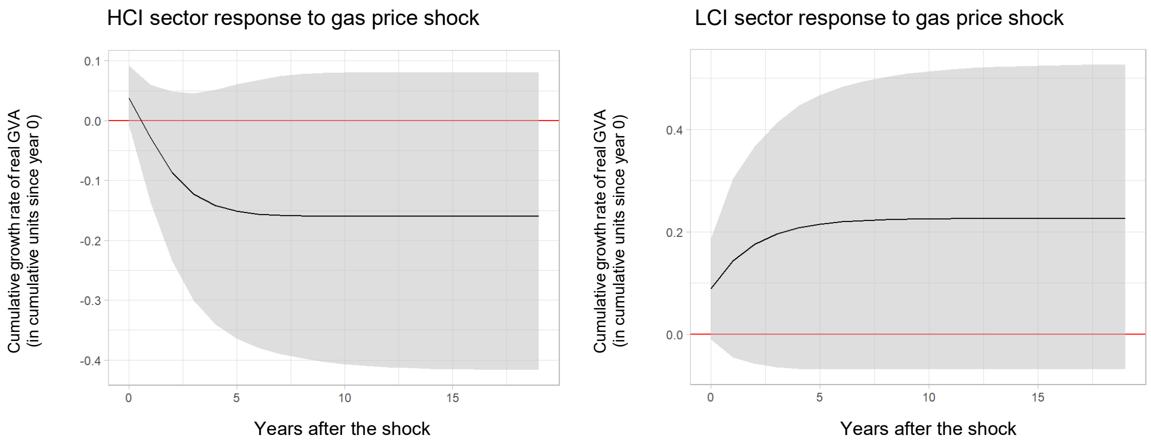
1 Results are available upon request.

2 The black line shows the point estimate for the amount the real GVA growth rate is expected to change rates (y-axis) for years 0 to 20 (x-axis) in the aftermath of an energy price shock to the extent of an 80.1% increase in gas prices in year 0. The shaded area indicates the 95% statistical confidence band. A significant effect is detected if the black line and the grey shaded area are jointly located below or above the horizontal axis.

Looking at state-based statistics it becomes evident that Upper Austria, Lower Austria, and Styria are the three states with the highest emission intensities (see Figure A1 in the Annex and Umweltbundesamt, 2020). Certain levels of GVA in these states coincide with higher amounts of greenhouse gas emissions than it is the case for other states. While a more fine-grained analysis would be needed, it could be argued that economic structures and stakeholders in these states would be affected most by energy price shocks.

In addition to the standard IRFs, we also add the cumulative IRFs, which do not track the single-year effects, but as the name implies, the cumulative effects of each year added together. Results in Figure 3 below indicate that summing up the effects over all years would report a negative effect for the HCI sector and positive effect for the LCI sector. However, the confidence bands cover the zero line in each case, which indicates that the effect is not a significant one. Even though we do find significant effects for individual years after the event of an energy price shock (as shown in Figure 2), the cumulated responses over all post-shock years do not indicate significant effects. From this, it follows that, although there is no evidence of a sustained long-term impact of an energy price shock, there is a clear and measurable negative impact on economic growth in the short-term.

Figure 3 / Cumulative impulse response function of a gas price shock to growth rates of real GVA in the HCI sector (left) and LCI sector (right)[3]



Source: Authors' computations, based on Eurostat (2024a), Yamano and Guilhoto (2020) and Statistik Austria (2024).

[3] The black line shows the point estimate for the cumulative amount the real GVA growth rate is expected to change (y-axis) for years 0 to 20 (x-axis) in the aftermath of an energy price shock to the extent of an 80.1% increase in gas prices in year 0. The shaded area indicates the 95% statistical confidence band. A significant effect is detected if the black line and the grey shaded area are jointly located below or above the horizontal axis.

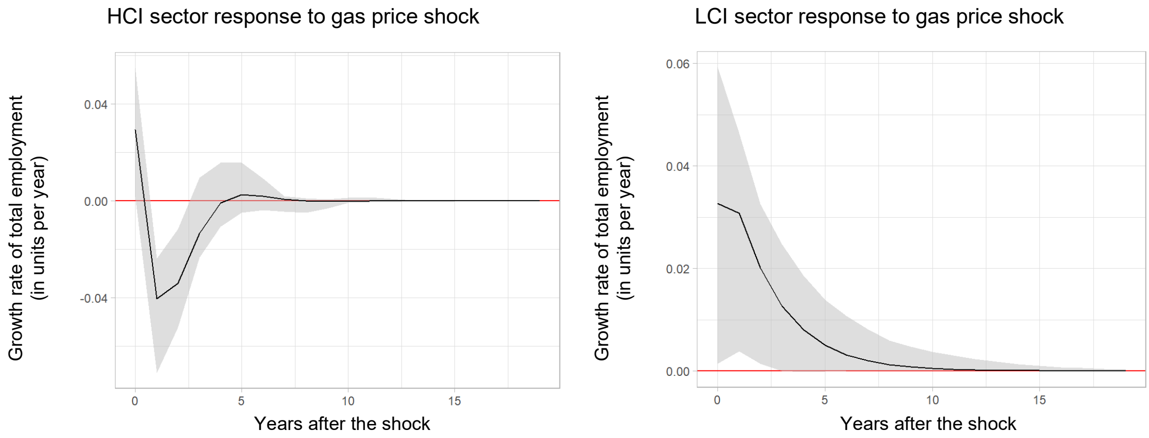
3.2. The impact on employment growth rates

The results on employment growth rates generally mirror the effects of real GVA growth values for the HCI and LCI sectors respectively. In the case of a gas price shock, we find that employment growth rates become significantly negative for the HCI sector in individual years and remain significantly positive for some periods after the gas price shock in case of the LCI sector. These results emphasise the general effects already obtained before for real GVA growth rates. Figure 4 depicts short-run effects based on the standard IRFs and Figure 5 the cumulative IRF results. Effects of other energy shocks are similar to those for gas price shocks, although less pronounced. Results on their IRFs can be found in the Annex (see Figures A4 and A5).

If everything else is considered constant, employment rates within the HCI sector drop significantly by 4.1% one year after the gas price shock and by 3.4% two years after the gas price shock (see Figure 4). Similar to the impulse response dynamics of real GVA rates, the point estimate of employment rates in the third year after the shock remains negative, though becomes insignificant. Total employment values in 2022 amount to 1.8 million in the HCI sector and 2.8 million in the LCI sector. Therefore, a significantly negative employment rate of 4.1% in the HCI sector could be seen as equivalent to a loss of 74 thousand jobs, which is followed by another significant drop of 3.4% in the HCI sector in the year afterwards, amounting to a loss of 59 thousand jobs. In the short run, a gas price shock to the extent of the one experienced between 2021 and 2022 is associated with a significant risk for of losing in total 133 thousand employment opportunities in the HCI sector within three years after the shock if everything else is assumed to stay constant.

Compared to the HCI sector, employed persons in the LCI sector do not face the same risk of losing their jobs (see Figure 4). In contrast, employment rates in the LCI sector significantly grow by 3.3% in the same year of the gas price shock, by 3.1% one year after the shock, by 2.0% two years after the shock, and by 1.3% three years after the shock. These significant effects regarding LCI-employment rates imply a job creation of 94 thousand in the year of the shock, 90 thousand one year after the shock, 58 thousand two years after the shock, and 37 thousand three years after the shock. If added up, these dynamics imply an increase of 279 thousand employment opportunities in the short run up to three years after the gas price shock if everything else is kept constant. Similar to the dynamics of real GVA rates, total employment rates in the LCI sector appear to be positive though insignificant in the years afterwards.

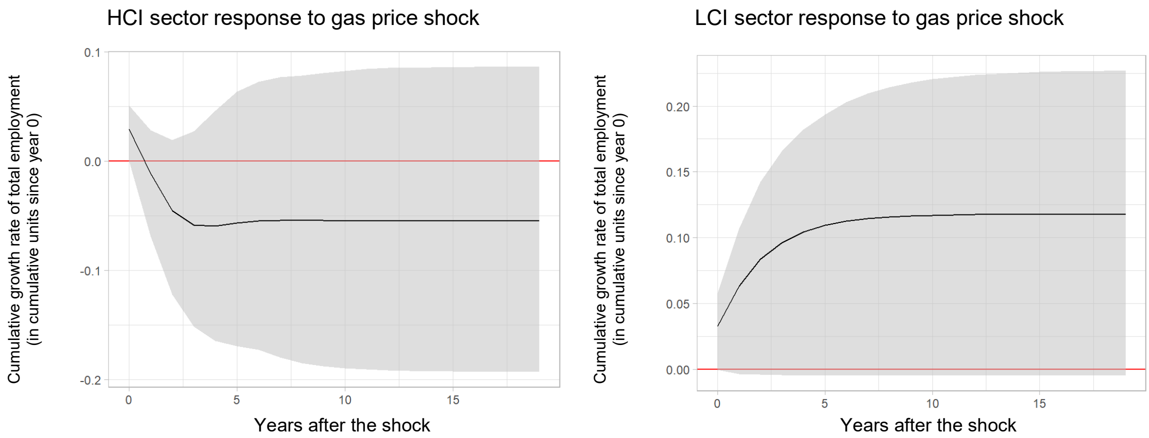
Figure 4 / Impulse response function of a gas price shock to employment growth rates in the HCI sector (left) and LCI sector (right)[4]



Source: Authors' computations, based on Eurostat (2024b), Yamano and Guilhoto (2020) and Statistik Austria (2024).

Importantly, the discussed impacts represent effects that are specific to these individual periods for the HCI and LCI sector and do not necessarily reflect a sustained impact. This is also indicated by cumulative IRF in Figure 5, which underscores that the short-term effects do not translate into a significant long-term impact.

Figure 5 / Cumulative impulse response function of a gas price shock to employment growth rates in the HCI sector (left) and LCI sector (right)[5]



Source: Authors' computations, based on Eurostat (2024b), Yamano and Guilhoto (2020) and Statistik Austria (2024).

4 The black line shows the point estimate for the amount the total employment growth rate is expected to change (y-axis) for years 0 to 20 (x-axis) in the aftermath of an energy price shock to the extent of an 80.1% increase in gas prices in year 0. The shaded area indicates the 95% statistical confidence band. A significant effect is detected if the black line and the grey shaded area are jointly located below or above the horizontal axis.

5 The black line shows the point estimate for the cumulative amount the total employment growth rate is expected to change (y-axis) for years 0 to 20 (x-axis) in the aftermath of an energy price shock to the extent of an 80.1% increase in gas prices in year 0. The shaded area indicates the 95% statistical confidence band. A significant effect is detected if the black line and the grey shaded area are jointly located below or above the horizontal axis.

4. CONCLUSIONS AND POLICY IMPLICATIONS

This study investigates the effects of energy price shocks on the HCI and LCI sectors for the Austrian economy by utilising a VAR approach. The initial hypothesis that an HCI sector is more vulnerable to (fossil) energy price shocks is validated by results of the study, at least in the short run. Based on the analysis of key economic indicator variables (real GVA and total employment), we find that (fossil) energy price shocks of the magnitude of those that followed the onset of the Ukraine war led to a sharper decrease in the HCI sector than in the LCI one in the short run for individual post-shock years, if everything else is assumed to remain constant.

Our results reflect that a fossil energy price shock as in the form of an increase of natural gas price spikes can significantly reduce real GVA in the HCI sector a year after the shock by 6.6% (possible loss of EUR 10bn) or reduce employment rates in the HCI sector a year after the shock by 3.4% (potential loss of 59 thousand jobs). While we do not find significant economic damage regarding the impact of a fossil energy price shock to the LCI sector, our results even show a significant and positive effect on employment rates in the LCI sector following a fossil energy price shock. In the aftermath of a gas price shock employment rates in the LCI sector grow for individual periods up to 3.3 % (amounting to about 90 thousand jobs in one year).

Although effects differ in their size and significance over time for different origins of energy price increases (natural gas, extra-light heating oil, or daytime electricity prices) the overall conclusion of a more volatile HCI sector generally holds. The least differences regarding HCI and LCI dynamics are observed in case of electricity price shocks, which promotes the argument that fostering economic resilience is most effective by reducing vulnerabilities to fossil energy price volatilities. Additionally, significant observations are only made for individual periods, which underscores that short-term effects do not necessarily translate into a long-term significant impact.

While further research is needed to investigate the robustness of the detected effects in terms of methodology and data specification the observations made so far should nevertheless encourage policy makers to accelerate the green transition and diversify energy sources to mitigate economic and geopolitical vulnerabilities. Austria is still highly dependent on Russian gas and further geopolitical disruptions in the future are likely to lead to higher energy prices than in other economies that have diversified their energy sources much more quickly. Although a complete ban on fossil fuels is a desirable goal in the long run, a diversification of energy sources is a more realistic strategy regarding energy security and risk reduction to the domestic economy in the short run. Historical precedents, such as the oil crises of the 1970s or natural disasters that can disrupt energy supply chains and cause sudden price increases demonstrate the recurring nature of such disruptions, which can and will happen again. Therefore, policy makers should anchor energy efficiency and seek to increase the share of renewable energy as part of a risk reduction strategy (Lechner, 2023).

REFERENCES

Eurostat (2024a), National accounts aggregates by industry (up to NACE A*64). Data code nama_10_a64. Doi: 10.2908/NAMA_10_A64_E Retrieved from: https://ec.europa.eu/eurostat/databrowser/bookmark/f18a6509-c29f-4b01-917b-85270cd099c4?lang=en

Eurostat (2024b), National accounts employment data by industry (up to NACE A*64). Data code nama_10_a64_e. Doi: 10.2908/nama_10_a64_e Retrieved from: https://ec.europa.eu/eurostat/databrowser/bookmark/a4ae86e8-842f-41be-bf55-78e612875383?lang=en

Hepburn, C., B. O'Callaghan, N. Stern, J. Stiglitz, and D. Zenghelis (2020), 'Will COVID-19 fiscal recovery packages accelerate or retard progress on climate change?', Smith School Working Paper 20-02.

International Energy Agency (IEA) (2021), 'Net Zero by 2050: A roadmap for the global energy sector'. https://www.iea.org/reports/net-zero-by-2050 [accessed on 21.9.2022].

Lechner, H. (2023), 'An der Gasleine. Zur Geschichte der Abhängigkeit Österreichs von Russischem Gas', Austrian Energy Agency, Vienna.

Mittnik, S., and W. Semmler (2022), 'Die Substitution fossiler Energieträger – die Analyse wirtschaftlicher Kurz- und Langfristwirkungen', *Vierteljahrshefte zur Wirtschaftsforschung*, Vol. 91(3), pp. 11–44. Doi: 10.3790/vjh.91.3.11.

Osvaldová, D. (2022), 'The climate crisis and the war in Ukraine's common denominator: fossil fuels dependence', *Heinrich Böll Stiftung Kommentar No. 14*. https://eu.boell.org/en/2022/04/14/slovakia-fossil-fuelsdependence [accessed on 21.9. 2022].

Pigato, M. A. (2019), 'Fiscal policies for development and climate action. International development in focus', World Bank, Washington, D.C. Doi:10.1596/978-1-4648-1358-0.

Semmler, W., J.P. Braga, A. Lichtenberger, M. Toure, and E. Hayde (2021), 'Fiscal policies for a low-carbon economy'. World Bank, Washington, D.C.

Statistik Austria (2024), 'VPI-Durchschnittspreise ab 1987', Direktion Volkswirtschaft, Preisstatistik.Stern, N. (2007), *The Economics of Climate Change: The Stern Review*, Cambridge University Press.Umweltbundesamt (2020), 'Bundesländer Luftschadstoff-Inventur 1990-2018'. Report, Rep-0746.

Yamano, N., and Guilhoto, J. (2020), 'CO2 emissions embodied in international trade and domestic final demand: Methodology and results using the OECD Inter-Country Input-Output Database', OECD, Paris. Doi: 10.1787/8f2963b8-en.

ANNEX: COMPLEMENTARY TABLES AND OUTPUTS

1) Tables on the industrial composition of the HCI and LCI sectors

The final specification of HCI and LCI sectors is based on carbon emissions per unit of economic output (measured by real gross value added). This approach follows the method utilised by Mittnik and Semmler (2022), and yields the following list of industry compositions:

Table A1 / Industry compostion of the HCI sector

#	NACE code	NACE label
1	A	Agriculture, forestry and fishing
2	B	Mining and quarrying
3	C10-12	Manufacture of food products; beverages and tobacco products
4	C13-15	Manufacture of textiles, wearing apparel, leather and related products
5	C16-18	Manufacture of wood, paper, printing and reproduction
6	C19	Manufacture of coke and refined petroleum products
7	C20	Manufacture of chemicals and chemical products
8	C22-23	Manufacture of rubber and plastic products and other non-metallic mineral products
9	C24-25	Manufacture of basic metals and fabricated metal products, except machinery and equipment
10	D	Electricity, gas, steam and air conditioning supply
11	E	Water supply; sewerage, waste management and remediation activities
12	F	Construction
13	G	Wholesale and retail trade; repair of motor vehicles and motorcycles
14	H49	Land transport and transport via pipelines
15	H50	Water transport
16	H51	Air transport
17	H53	Postal and courier activities
18	L	Real estate activities
19	T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use

Source: Authors' compilations, based on Eurostat (2024a) and Yamano and Guilhoto (2020).

Table A2 / Industry compostion of the LCI sector

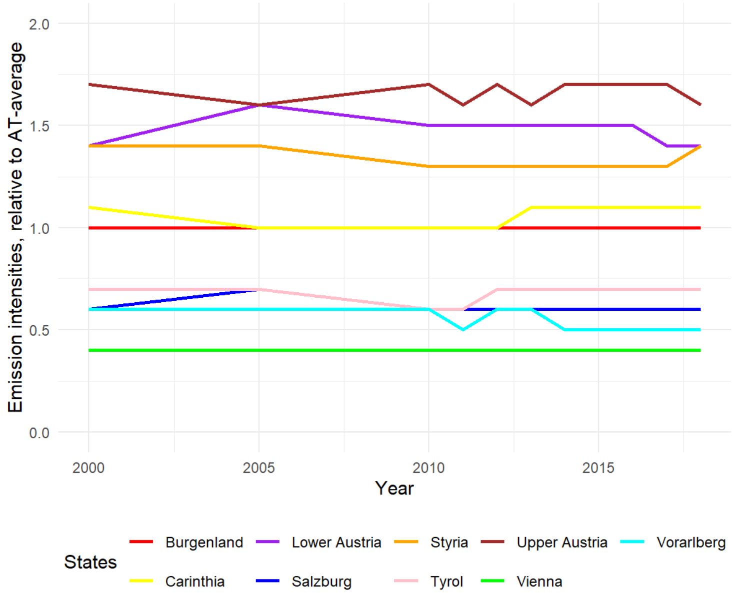
#	NACE code	NACE label
1	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
2	C26	Manufacture of computer, electronic and optical products
3	C27	Manufacture of electrical equipment
4	C28	Manufacture of machinery and equipment n.e.c.
5	C29-30	Manufacture of motor vehicles, trailers, semi-trailers and of other transport equipment
6	C31-33	Manufacture of furniture; jewellery, musical instruments, toys; repair and installation of machinery and equipment
7	H52	Warehousing and support activities for transportation
8	I	Accommodation and food service activities
9	J58-60	Publishing, motion picture, video, television programme production; sound recording, programming and broadcasting activities
10	J61	Telecommunications
11	J62-63	Computer programming, consultancy, and information service activities
12	K	Financial and insurance activities
13	M	Professional, scientific and technical activities
14	N	Administrative and support service activities
15	O	Public administration and defence; compulsory social security
16	P	Education
17	Q	Human health and social work activities
18	R	Arts, entertainment and recreation
19	S	Other service activities

Source: Authors' compilations, based on Eurostat (2024a) and Yamano and Guilhoto (2020).

2) Emission intensities by Austrian states

The nine Austrian states show very different emission profiles. A very detailed report on the inventory of greenhouse gas emissions on a subnational level is provided by Umweltbundesamt (2020). Their analysis reports different indicators on emission intensities for each Austrian state. Based on that, Figure A1 below shows the emission intensities for the nine states in relation to the Austrian average emission intensity. Values for emission intensities of a state s (EI_s) are computed as relative greenhouse gas emissions (GHG) for state s (GHG_s) in relation to total Austrian GHG emissions (GHG_{AT}) divided by GVA of the respective state s (GVA_s) in relation to total Austrian GVA (GVA_{AT}), i.e. $EI_s = \frac{GHG_s / GHG_{AT}}{GVA_s / GVA_{AT}}$.

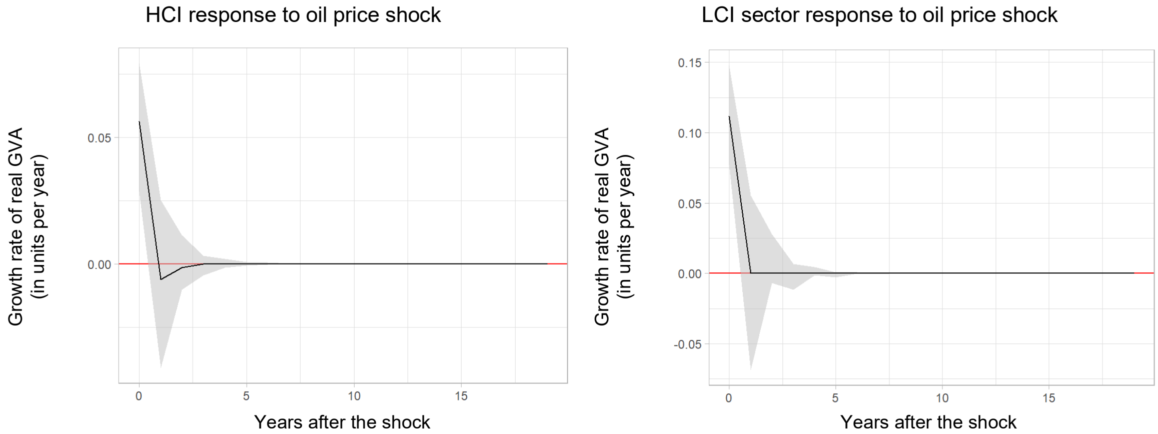
Figure A1 / Emission intensities for the nine Austrian states, relative to the Austrian average



Source: Authors' depiction, based on Umweltbundesamt (2020).

3) Additional charts regarding effects of heating oil and electricity price shocks on real GVA growth rates:

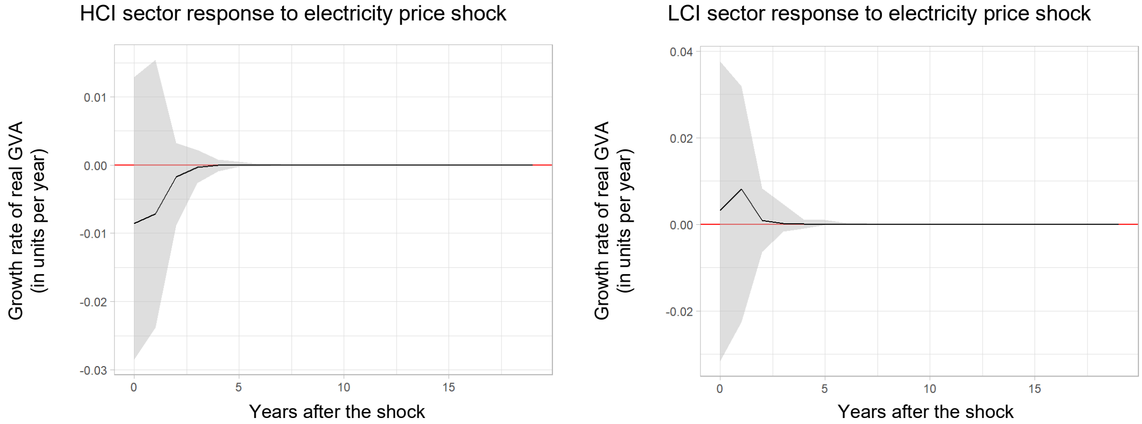
Figure A2 / Impulse response function of a heating oil price shock to growth rates of real GVA in the HCI sector (left) and LCI sector (right)[6]



Source: Authors' computations, based on Eurostat (2024a), Yamano and Guilhoto (2020) and Statistik Austria (2024).

6 The black line shows the point estimate for the amount the real GVA growth rate is expected to change rates (y-axis) for years 0 to 20 (x-axis) in the aftermath of an energy price shock to the extent of an 89.7% increase in extra light heating oil prices in year 0. The shaded area indicates the 95% statistical confidence band. A significant effect is detected if the black line and the grey shaded area are jointly located below or above the horizontal axis.

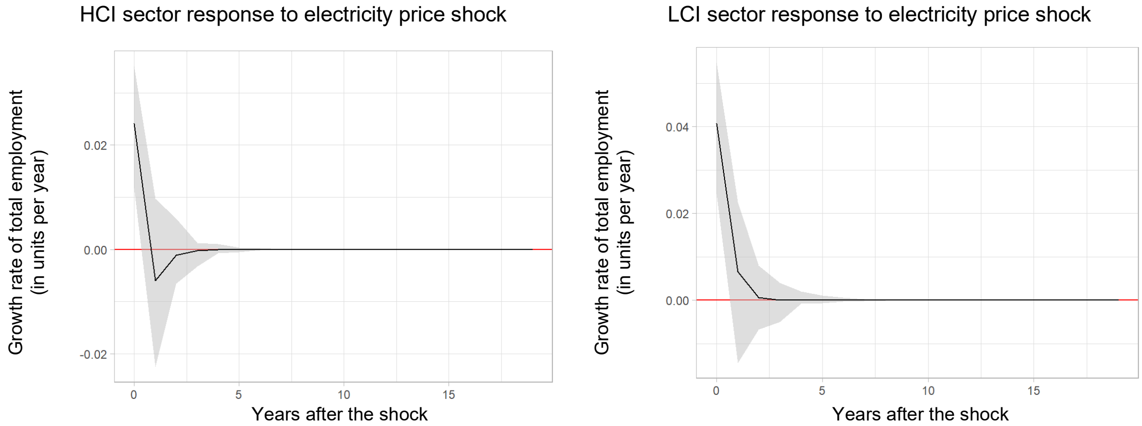
Figure A3 / Impulse response function of an electricity price shock to growth rates of real GVA in the HCI sector (left) and LCI sector (right)[7]



Source: Authors' computations, based on Eurostat (2024a), Yamano and Guilhoto (2020) and Statistik Austria (2024).

4) Additional charts regarding effects of heating oil and electricity price shocks on total employment growth rates:

Figure A4 / Impulse response function of a heating oil price shock to growth rates of total employment in the HCI sector (left) and LCI sector (right)[8]



Source: Authors' computations, based on Eurostat (2024b), Yamano and Guilhoto (2020) and Statistik Austria (2024).

7 The black line shows the point estimate for the amount the real GVA growth rate is expected to change rates (y-axis) for years 0 to 20 (x-axis) in the aftermath of an energy price shock to the extent of an 18.5% increase in daytime electricity prices in year 0. The shaded area indicates the 95% statistical confidence band. A significant effect is detected if the black line and the grey shaded area are jointly located below or above the horizontal axis.

8 The black line shows the point estimate for the amount the total employment growth rate is expected to change rates (y-axis) for years 0 to 20 (x-axis) in the aftermath of an energy price shock to the extent of an 89.7% increase in extra light heating oil prices in year 0. The shaded area indicates the 95% statistical confidence band. A significant effect is detected if the black line and the grey shaded area are jointly located below or above the horizontal axis.

Figure A5 / Impulse response function of an electricity price shock to growth rates of total employment in the HCI sector (left) and LCI sector (right)[9]

Source: Authors' computations, based on Eurostat (2024b), Yamano and Guilhoto (2020) and Statistik Austria (2024).

9 The black line shows the point estimate for the amount the total employment growth rate is expected to change rates (y-axis) for years 0 to 20 (x-axis) in the aftermath of an energy price shock to the extent of an 18.5% increase in daytime electricity prices in year 0. The shaded area indicates the 95% statistical confidence band. A significant effect is detected if the black line and the grey shaded area are jointly located below or above the horizontal axis.

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