

2 Identifying vulnerable regions

This chapter identifies European regions that are most vulnerable to industrial transitions to climate neutrality in the key manufacturing sectors that will face the biggest transformations. These sectors refine coke and oil, and manufacture chemicals, basic metals, non-metallic minerals, paper and pulp, as well as motor vehicles. The most vulnerable regions are selected using employment shares and per capita emissions in each of the corresponding key manufacturing sectors. Regions with high employment shares and high emissions per capita face the largest transformational challenges in the transition to climate neutrality. They will have to decarbonise production assets and infrastructure whilst also protecting the workers in the key manufacturing sectors to ensure a just transition. The most vulnerable regions, spread throughout all of Europe, with a particular concentration in Central and Northern Europe, will also have to be ready to benefit from the opportunities that arise from the transition. Their distribution varies depending on the key manufacturing sector.

Towards a regionally balanced and just transition in manufacturing

This chapter identifies the regions most vulnerable to the transformation in the key manufacturing sectors in the transition to climate neutrality. The analysis is limited to regions in the 27 European Union (EU) member states (EU27), Iceland, Norway and the United Kingdom (UK), for which emissions data covered by the EU Emission Trading System (ETS) and sectoral regional employment data are available. ETS data and regional sectoral employment data are central to identifying vulnerable regions.

Vulnerable regions are identified by determining their employment and emissions in key manufacturing sectors that will need to undertake particularly profound transformations. The following section explains how the regions are identified in more detail. The chapter will then detail vulnerable regions by key sector. Regions are classified using the Nomenclature of Territorial Units for Statistics (NUTS system), which is the EU's classification regions at different level of details.

Identifying vulnerable regions in the manufacturing's transition to climate neutrality

Most EU economies only provide employment data at the two-digit Nomenclature of Economic Activities (NACE) level across large (NUTS 2) regions. To complement the employment analysis, emissions per capita in each sector across regions (NUTS 2) is used. Sectoral emissions can be computed at the three- and four-digit level as well as for small (NUTS 3) regions. As the analysis below argues, regions with both high employment shares and high emissions per capita in key manufacturing sectors are likely to be the most sensitive to the transition to climate neutrality. In the manufacturing of motor vehicles, emissions data do not serve to locate transformation challenges, as the most challenging transformations relate to the production of zero-emission vehicles rather than to the reduction of production emissions.

The identification of vulnerable regions is based on emissions per capita and shares of sectoral employment in total regional employment to assess the exposure of regional populations and workforces to the transitions sectors require to reach climate neutrality, regardless of size of region. However, the absolute amount of emissions and the total number of workers employed in a specific sector is also of interest to assess vulnerability. This information is therefore also provided below in the identification of vulnerable regions.

The analysis reveals that regions with large employment shares in the key manufacturing sectors identified in Chapter 1 are not always the same as those with high emissions per capita in these sectors. This may occur for several reasons:

- Not all sector employment is to be found at production sites hosting the installations which generate the emissions. Whilst the impact of the carbon-neutral transition is likely to be felt across the firm, workers and locations directly engaged in establishments where the emissions occur are likely to be most vulnerable. They may hold occupations with specific skills that are not always be suited to the new climate-neutral technologies. By contrast, managers and accountants working in other establishments within the firm may find it easier to transfer their skills to other sectors, including those that will benefit from the green transition.
- As demonstrated in the first chapter, there can be significant differences in the emissions intensities of three-digit NACE activities within two-digit activities. There can be significant differences in the distribution of employment across sub-sectors at the three-digit NACE level, with some regions more specialised in sub-sectors with lower emission intensities.
- Regions may also differ in how much they have advanced in adopting less emissions-intensive production. If regions continue to invest in high-emission productions, they will be more at risk of stranded assets, amplifying employment risks. Across regions, industries may also produce with different labour intensities.

Employment data used in the report are sourced from Eurostat structural business statistics (Box 2.1). Emissions data are sourced from the EU ETS. EU ETS data do not identify the NACE sector of origin. One novel contribution of this publication is to attribute regional emissions to the key NACE manufacturing sectors by identifying the companies that own the installations as well as their main sector of activity (Box 2.1).

Box 2.1. Using employment and emissions data to identify vulnerable regions

Employment data

Eurostat structural business statistics (SBS) provide employment data by two-digit NACE sectors for large (NUTS 2) regions according to the geographical location of establishments. The data are from 2018 but if some are missing then data from the latest available year are used. NUTS 2 regions are the same as Territorial Levels (TL) 2 regions, which is the OECD system for classification of regions, except in Belgium, France, Germany and the UK. For these countries, NUTS 2 regions are smaller than TL2 regions, hence allowing for more granular analysis.

Eurostat data are complemented with more granular sectoral (NACE) and geographical (NUTS) data from individual EU countries where available. Some countries provide more detailed regional employment data for employees only.

SBS employment includes employees and the self-employed. Some countries provide more detailed regional employment data for employees only. For example, Sweden provides such data for 5-digit NACE sectors at the NUTS 3 regional level, we assume the distribution of employees and the self-employed across sectors is the same as in the 2-digit sector.

Emissions data

Emissions data and matched regional and firm data are from the European Commission (EC) (2021^[1]). Emissions data are from the EU ETS as reported to the EU Transaction Log (EUTL) and provided by the EC Directorate-General for Climate Action. Not all emissions are included in the EU ETS. Inclusion criteria for installations vary. For example, only steel plants with a production capacity of over 2.5 tonnes per hour are included. Hence, when a region employs workers in a manufacturing sector but has no emissions in that sector, it may have installations below the threshold.

Emissions are attributed to large (NUTS 2) and small (NUTS 3) regions based on the location of facilities. They are attributed to two-, three- and four-digit NACE sectors according to the main sector of activity of the company that owns the installation. For this purpose, facility emissions data are matched with Orbis data on businesses. In some cases, the owner's main activity is different from the activity of the installation. Hence, the EU ETS sectoral information is used to complement the sectoral attribution to find the most suitable one. For example, a cement installation owned by a financial holding company is classified as financial services by NACE but cement production in the EU ETS. Relying solely on the EU ETS is not possible as a large part of emissions fall under the ETS activity combustion of fuels, which is the case for many installations in a wide range of manufacturing sectors. ETS activities matched with NACE codes are further described in a forthcoming working paper (Fuentes, Noels and Ventricelli, forthcoming^[2]).

Installations are in some instances owned by business whose main activity is in a different sector than the installation. EU ETS provides some sectoral information on installations and is used to complement the NACE sectors in these instances. For example, a financial holding company owns a cement-producing installation as financial services by NACE. ETS information allows to reattribute the

installation to cement production. Relying solely on the EU ETS is not possible as the sectoral classification does not follow ETS and ETS attributes many installations to the combustion of fuels, which can refer to many manufacturing NACE sectors.

Source: EC (2021^[1]), *European Emissions Trading System (ETS) – Calculations on the Regional Employment Impact of ETS Installations*, https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/reg_impact_ets_installations_en.pdf.

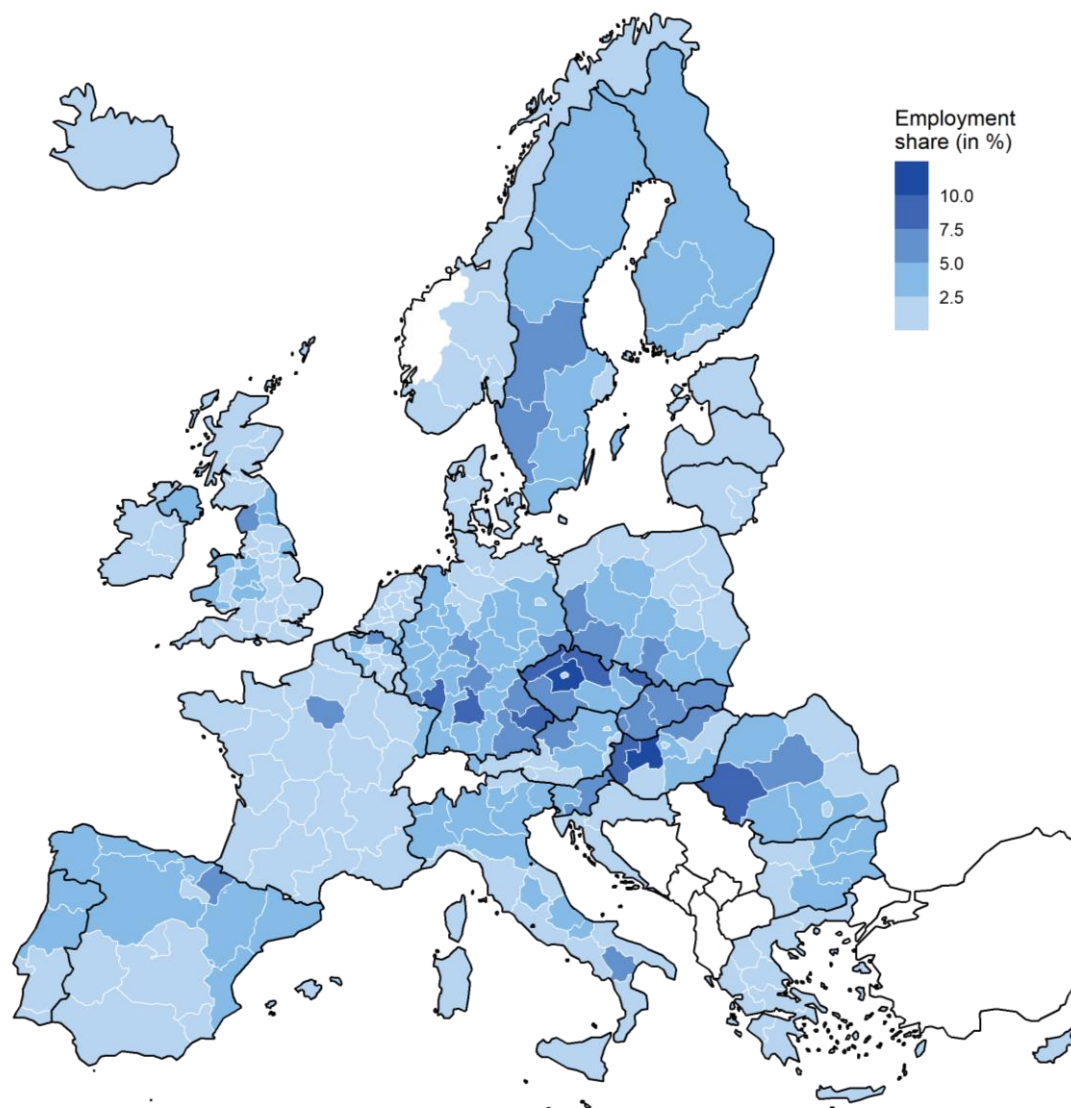
Fuentes, A., J. Noels and V. Ventricelli (forthcoming^[2]), “Regional Industrial Transitions to Climate Neutrality: Identifying vulnerable regions”, *OECD Regional Development Policy Papers*, OECD, Paris.

Regions vulnerable to transformations in the key manufacturing sectors

Employment shares across all key manufacturing sectors are high in Central and Eastern European regions (Figure 2.1). The automobile industry is the biggest employer and therefore dominates this spatial distribution of employment.

Figure 2.1. Regional employment shares in key manufacturing sectors

As a share of total employment, NUTS 2 regions, 2018



Note: The key manufacturing sectors are paper and paper products (NACE 17), coke and refined petroleum products (NACE 19), chemicals and chemical products (NACE 20), non-metallic mineral products (NACE 23), basic metals (NACE 24) and motor vehicles (NACE 29). Regional employment in these sectors is summed. In some regions, missing employment data are assumed to be zero, resulting in an underestimation of employment shares. Areas in white missing data across all sectors.

Source: Own calculations based on Eurostat.

Table 2.1 shows the regions with high employment shares and high emissions per capita in at least one of the key manufacturing sectors. For example, Asturias has high employment shares only in basic metals production as well as higher related emissions per capita. Table 2.2 lists the employment and emissions thresholds that classify regions as vulnerable.

Recognising the importance of a more granular lens, the following sections analyse the vulnerability of regions to the transformations in each key manufacturing sector.

Table 2.1. Employment shares and emissions per capita in key manufacturing sectors for the most vulnerable regions

Large (NUTS 2) regions with high employment shares and emissions per capita in at least one of the key manufacturing sectors, 2018

Region name	Oil		Chemicals		Basic Metals		Other non-metallic minerals		Paper		Cars	
	Employment share	CO ₂ /capita	Employment share	CO ₂ /capita	Employment share	CO ₂ /capita	Employment share	CO ₂ /capita	Employment share	CO ₂ /capita	Employment share	CO ₂ /capita
AT22 Styria	0.00	0.00	0.19	0.00	1.70	2.57	0.76	0.34	0.69	0.63	0.69	1.64
AT31 Upper Austria	0.01	0.00	0.98	0.73	1.69	5.65	0.74	0.41	0.47	0.09	0.47	1.45
BE21 Antwerp	0.39	3.32	2.37	3.82	0.80	0.02	0.47	0.00	0.25	0.02	0.25	0.80
BE23 East Flanders	0.04	0.03	0.95	0.65	0.94	2.95	0.50	0.00	0.16	0.21	0.16	1.77
BE34 Luxembourg (Belgium)	0.00	0.00	0.67	0.03	0.09	0.00	0.46	1.48	0.69	0.42	0.69	0.24
CZ02 Central Bohemian Region	0.08	0.01	0.83	0.21	0.33	0.04	1.19	0.67	0.38	0.00	0.38	7.61
CZ04 Northwest	NA	0.36	1.42	3.88	0.76	0.02	2.32	0.39	0.57	0.31	0.57	2.79
CZ05 Northeast	NA	0.02	0.66	0.27	0.66	0.00	1.76	0.38	0.67	0.02	0.67	5.89
CZ08 Moravia-Silesia	NA	0.10	0.39	0.00	3.41	2.33	0.49	0.00	0.43	0.01	0.43	4.46
DE11 Stuttgart	NA	0.00	0.52	0.00	0.24	0.00	0.26	0.13	0.49	0.05	0.49	7.06
DE22 Niederbayern	0.11	0.69	0.39	0.21	0.40	0.00	1.12	0.26	0.23	0.06	0.23	5.62
DE91 Braunschweig	0.00	0.00	0.50	0.02	1.25	2.86	0.45	0.24	0.32	0.06	0.32	NA
DEA1 Düsseldorf	0.04	0.41	1.71	0.42	1.80	3.42	0.30	0.05	0.21	0.04	0.21	0.70
DEA3 Münster	NA	1.40	1.47	1.01	0.30	0.16	0.62	0.95	0.25	0.03	0.25	0.70
DEB3 Rheinhessen-Pfalz	NA	0.00	4.75	3.75	0.33	0.00	0.79	0.33	0.34	0.06	0.34	1.66
DEC0 Saarland	NA	0.68	0.17	0.00	2.87	6.07	0.64	0.00	0.03	0.00	0.03	3.89
DEE0 Sachsen-Anhalt	0.15	1.17	1.62	1.80	0.87	0.10	0.98	1.13	0.33	0.09	0.33	0.46
DK05 Northern Jutland	0.00	0.00	0.16	0.00	0.34	0.00	1.01	3.72	0.10	0.00	0.10	0.15
EL65 Peloponnese	0.45	3.75	0.05	0.00	0.02	0.00	0.37	0.03	0.11	0.00	0.11	0.02
ES12 Asturias	NA	0.02	0.44	0.12	2.28	5.63	0.66	1.20	0.16	0.06	0.16	0.22
FI19 Western Finland	0.01	0.00	0.34	0.00	0.61	0.00	0.59	0.00	1.18	0.34	1.18	0.53
FI18 Helsinki-Uusimaa	0.24	1.64	0.67	0.49	0.08	0.00	0.28	0.00	0.28	0.00	0.28	0.03
FI1C Southern Finland	0.11	0.17	0.56	0.11	0.50	0.12	0.86	0.77	1.47	0.66	1.47	1.08
FI1D Eastern and Northern Finland	0.01	0.00	0.31	0.02	1.28	3.67	0.54	0.00	0.92	0.61	0.92	0.21
HU21 Central Transdanubia	0.09	0.25	0.62	0.82	2.24	0.80	1.24	0.11	0.67	0.34	0.67	5.93
HU22 Western Transdanubia	0.14	0.00	0.12	0.02	0.22	0.00	0.64	0.00	0.17	0.00	0.17	7.47
HU31 Northern Hungary	0.49	0.00	1.03	1.38	0.48	0.03	0.62	0.00	0.30	0.00	0.30	3.83
IT14 Friuli-Venezia Giulia	0.01	0.00	0.23	0.00	1.10	1.24	0.70	0.34	0.42	0.39	0.42	0.29
IT12 Umbria	0.02	0.00	0.30	0.00	0.90	0.42	1.07	1.49	0.44	0.02	0.44	0.34
NL33 South Holland	0.22	2.37	0.49	0.83	NA	0.01	0.12	0.00	0.08	0.00	0.08	0.09
NL34 Zeeland	NA	4.27	1.87	20.82	NA	0.19	0.26	0.39	NA	0.00	NA	0.13
PL22 Silesia	0.17	0.27	0.46	0.01	1.22	1.20	1.07	1.10	0.22	0.01	0.22	3.41
PL52 Opole region	0.00	0.00	0.82	1.48	0.41	1.13	1.20	3.61	0.60	0.06	0.60	1.72
PL72 Świętokrzyskie	0.01	0.00	0.13	0.00	0.70	0.07	1.77	4.16	0.32	0.00	0.32	1.40
RO42 West	0.01	0.00	0.28	0.00	0.29	0.05	0.54	0.32	0.13	0.00	0.13	7.35
SE32 Central Norrland	NA	0.00	0.61	0.11	1.92	0.69	0.34	0.00	1.74	0.45	1.74	0.13
SE33 Upper Norrland	NA	0.00	0.27	0.00	0.03	2.04	0.17	0.17	0.77	0.12	0.77	1.33
SK01 Bratislava Region	NA	3.39	0.18	0.00	0.03	0.00	0.88	1.35	0.06	0.00	0.06	5.42
SK02 West Slovakia	NA	0.00	0.67	0.72	0.45	0.00	0.87	0.46	0.24	0.00	0.24	3.27
UKD6 Cheshire	0.22	2.03	0.86	0.80	1.12	0.05	0.32	0.00	0.34	0.00	0.34	1.37
UKE1 East Yorkshire and Northern Lincolnshire	0.33	3.85	0.97	0.71	1.03	5.47	0.69	0.32	0.37	0.00	0.37	0.89

Note: Regions are identified as the most vulnerable regions by having high employment share and high emissions per capita in at least one of the key sectors. Employment shares relate to the key sectors at the two-digit NACE level. The sectors are NACE 19: manufacture of coke and refined petroleum products with an employment share of at least 0.2%; NACE 20: manufacture of chemicals and chemical products with an employment share of at least 1%; NACE 24: manufacture of basic metals with an employment share of at least 1%; NACE 23: manufacture of non-metallic mineral products with an employment share of at least 1%; NACE 17: manufacture of paper and paper products with an employment share of at least 0.65%; NACE 29: manufacture of vehicles, trailers and semi-trailers with an employment share of at least 5%.

Emissions (in CO₂e) per capita relate to the key sectors at the two-, three- or four-digit level. The sectors are NACE 19: manufacture of coke and refined petroleum products with at least 1 tCO₂e/capita; NACE 20: manufacture of chemicals and chemical products with at least 1 tCO₂e/capita; NACE 241: manufacture of basic iron and steel and ferroalloys; NACE 2442: aluminium production with at least 1 tCO₂e/capita combined; NACE 235: manufacture of cement, lime and plaster with at least 1 tCO₂e/capita; and NACE 171: manufacture of pulp, paper and paperboard with at least 0.25 tCO₂e/capita.

Source: Authors' calculations based on Eurostat and EU ETS.

Table 2.2. Thresholds that classify regions as vulnerable

Sector	Employment share (%)	Emissions per capita (tCO ₂ /capita)
Paper and pulp	0.65	0.25
Coke and refined petroleum	0.20	1.00
Chemicals	1.00	1.00
Non-metallic minerals/cement	1.00	1.00
Basic metals/steel and aluminum	1.00	1.00

Note: For non-metallic minerals, employment shares refer to non-metallic minerals but emissions per capita refer to cement emissions. For basic metals, employment shares refer to basic metals but emissions per capita refer to steel and aluminium emissions.

Regions with employment and emissions in the manufacture of coke and refined petroleum products
























Most petroleum refineries will become obsolete as the EU moves towards climate neutrality. Regional employment shares in the manufacture of coke and refined petroleum products are low across the EU. There is little employment in coke production in the EU, so this sector will be referred to as oil refining. No large (NUTS 2) region employs more than 0.5% of workers in this sector. Still, in some regions, it can reach several thousands of workers. One outlier is Île-de-France with over 15 000 employees in 2017, but very low emissions, likely reflecting the presence of headquarters or other managerial functions in the Paris region, with managerial or administrative occupations.

A few large (NUTS 2) regions, spread across West, North and South Europe, have both relatively high employment shares and high emissions per capita in oil refining (Figures 2.2 and 2.3). These regions and their workers will likely be most vulnerable to the gradual phase-out of oil products. Moreover, their employment is concentrated in relatively few establishments. The regions with the highest absolute emissions covered by the EU ETS are in Germany, Italy, the Netherlands and Poland.

Transition risks of moving to climate neutrality are further concentrated in small (NUTS 3) regions (Annex Figure 2.A.1).

Figure 2.2. Regions with high employment shares in oil refining

Regions with employment shares in the manufacture of coke and refined petroleum products exceeding 0.15%, 2018

Nuts ID	Region name	Employment share	Emissions/capita	Employment	Emissions
HU31	Northern Hungary	0.49 	0.00	1 916	0
EL65	Peloponnese	0.45 	3.75	1 079	2 161 611
BE21	Antwerp	0.39 	3.36	3 263	6 210 089
UKE1	East Yorkshire and Northern Lincolnshire	0.33 	3.85	1 342	3 586 379
HU12	Pest	0.32 	0.00	1 511	0
HR04	Continental Croatia	0.31 	0.11	3 491	312 088
FR10	Île-de-France	0.30 	0.06	19 244	764 142
DE60	Hamburg	0.30 	0.48	3 790	873 772
EL30	Attica	0.29 	0.54	5 033	2 012 220
HU33	Southern Great Plain	0.25 	0.00	1 180	0
FI1B	Helsinki-Uusimaa	0.24 	1.64	2 202	2 709 561
UKD6	Cheshire	0.22 	2.03	1 109	1 880 351
NL33	South Holland	0.22 	2.37	4 201	8 717 532
HU23	Southern Transdanubia	0.20 	0.00	657	0
HR03	Adriatic Croatia	0.20 	0.73	1 056	1 004 631
EE00	Estonia	0.20 	1.33	1 293	1 751 336
ITC3	Liguria	0.19 	0.25	1 277	391 425
BG31	Severozapaden	0.19 	0.00	559	3 322
ITG1	Sicily	0.19 	1.56	2 815	7 822 051
PT18	Alentejo	0.18 	3.31	574	2 359 050
PL22	Silesia	0.17 	0.27	3 215	1 235 980
ES42	Castile-La Mancha	0.15 	0.73	1 109	1 485 092
DEE0	Sachsen-Anhalt	0.15 	1.17	1 497	2 600 136

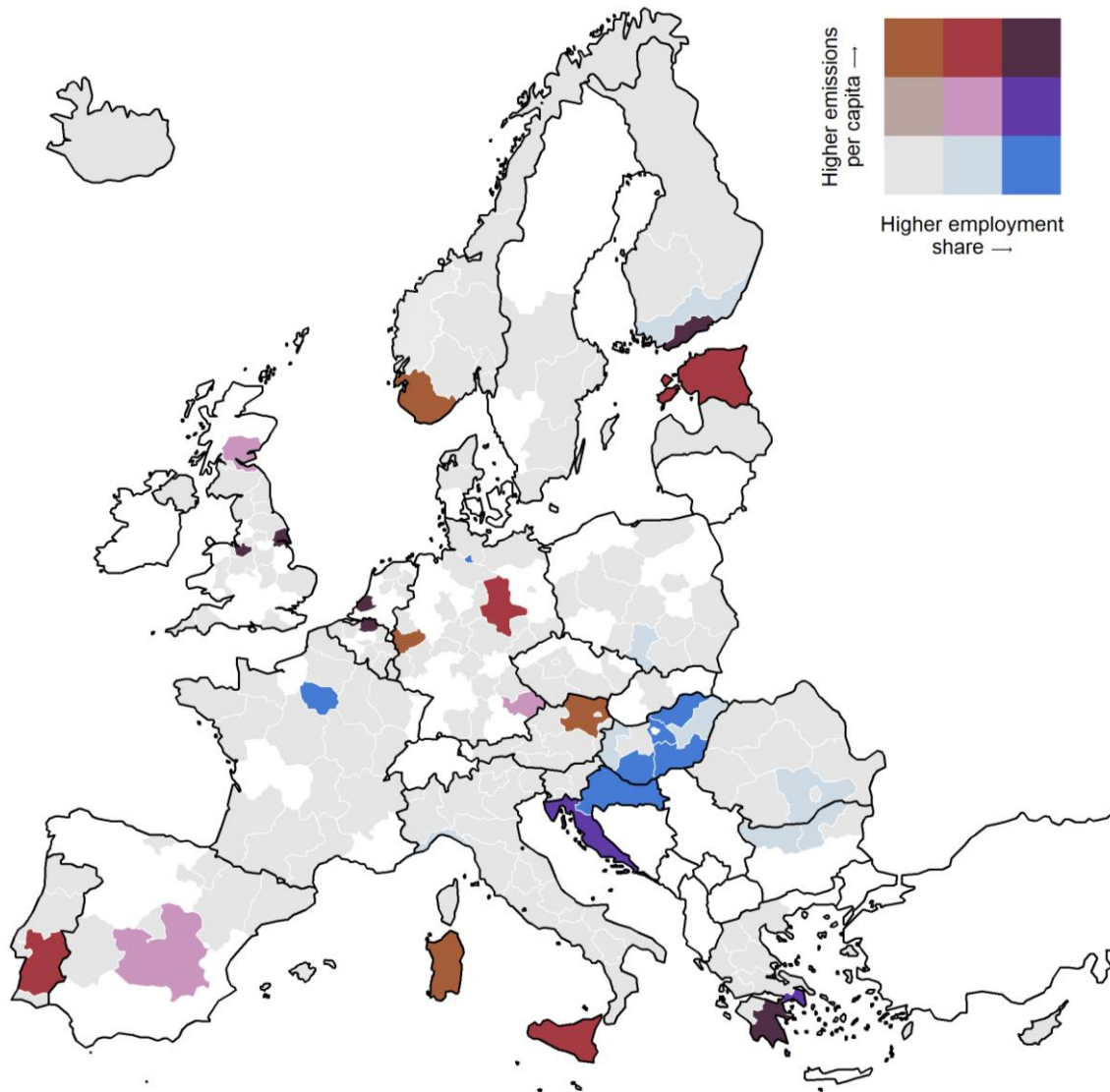
Note: Emissions in tCO_{2e}.

Source: Authors' calculations based on Eurostat and EU ETS.

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Figure 2.3. Regional employment and emissions in oil refining

Emissions per capita and employment share of manufacture of coke and refined petroleum products, NUTS 2 regions, 2018



Note: Breaks in employment shares are at 0.1% and 0.2%. Breaks in emissions per capita are at 0.5 and 1 tCO₂e/capita. White areas represent missing data. Emissions per capita are calculated as emissions from EU ETS installations of businesses whose main activity is the manufacture of coke and refined petroleum products (NACE 19) divided by the population in NUTS 2 regions. Employment shares are calculated as employment in the manufacture of coke and refined petroleum products (NACE 19) as a share of total employment in NUTS 2 regions.
 Source: Author's calculations based on Eurostat and ETS-Orbis.

Regions with employment and emissions in the manufacture of chemicals and chemical products

Regions with high employment shares in the manufacture of chemicals and chemical products are mostly in Central and Western Europe. In some cases, high employment in this sector overlaps with high employment in oil refining as they are often closely related. However, employment is much higher in the chemicals sector. Regions with high levels of employment in this sector employ several tens of thousands of workers. Once again, the Île-de-France region in France is an outlier with over 100 000 workers in this sector in 2018, likely also reflecting a headquarters effect, as Île-de-France has almost 3 000 establishments but only 3 emitting installations in chemical production.

Regions with the highest employment shares are located in Belgium, Germany and the Netherlands (Figure 2.4). Regions with high employment shares and high emissions per capita tend to overlap (Figure 2.5). The most emission-intensive sub-sector is the manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms (NACE 201), where transformation challenges are also likely to be particularly deep.


Figure 2.4. Regions with high employment shares in chemicals

Regions with employment shares in the manufacture of chemicals and chemical products exceeding 1%, 2018

Nuts ID	Region name	Employment share	Emissions/capita	Employment	Emissions
DEB3	Rheinessen-Pfalz	4.75	3.75	48 224	7 695 111
BE21	Antwerp	2.37	3.82	19 809	7 057 306
NL34	Zeeland	1.87	20.52	3 508	7 845 417
DEA1	Düsseldorf	1.71	0.42	47 949	2 208 716
FR10	Île-de-France	1.63	0.05	105 126	623 516
DEE0	Sachsen-Anhalt	1.62	1.80	16 229	4 008 005
DE71	Darmstadt	1.54	0.02	35 692	75 867
DEA3	Münster	1.47	1.01	19 400	2 652 811
CZ04	Northwest	1.42	3.68	7 247	4 105 686
DE21	Oberbayern	1.35	0.15	39 192	704 259
DEA2	Köln	1.25	0.78	30 611	3 488 582
BE22	Limburg (BE)	1.08	0.46	3 821	405 266
NL42	Limburg (NL)	1.07	0.00	6 281	0
DE92	Hannover	1.04	0.05	11 962	109 269
HU31	Northern Hungary	1.03	1.38	4 021	1 571 453
ES51	Catalonia	1.03	0.38	36 459	2 867 029
BE32	Hainaut	1.00	0.72	4 431	969 843

Note: Emissions in tCO_{2e}.

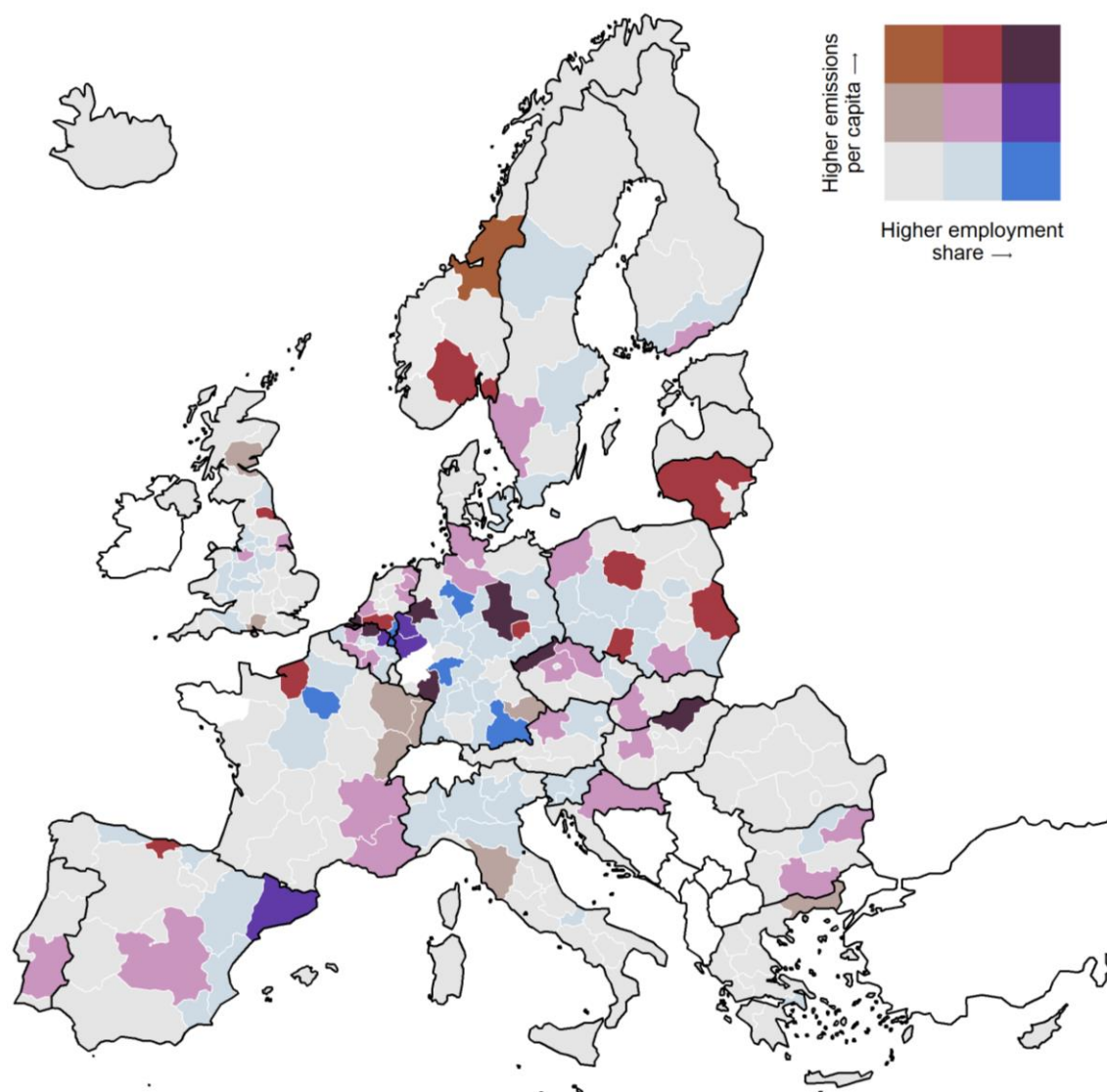
Source: Authors' calculations based on Eurostat and EU ETS.

StatLink  <https://stat.link/28cgst>

The emissions of the large (NUTS 2) regions with the highest employment shares and the highest level of emissions tend to be concentrated in just one small (NUTS 3) region (Annex Figure 2.A.2).

Figure 2.5. Regional employment and emissions in chemical production

Emissions per capita and employment shares of manufacture of chemicals and chemical products, NUTS 2 regions, 2018



Note: Breaks in employment shares are at 0.4% and 1%. Breaks in emissions per capita are at 0.2 and 1 tCO₂e/capita. White areas are missing data. Emissions per capita are calculated as emissions from EU ETS installations of businesses whose main activity is in the manufacture of chemicals and chemical products (NACE 20) divided by the population in NUTS 2 regions. Employment shares are calculated as employment in the manufacture of chemicals and chemical products (NACE 20) as a share of total employment in NUTS 2 regions.

Source: Author's calculations based on Eurostat and ETS-Orbis.

Regions with employment and emissions in the manufacture of basic metals

Many regions have thousands or even tens of thousands of workers in basic metals manufacturing, with Arnsberg, Germany, having over 50 000. Two sub-sectors stand out as particularly emissions-intensive and hard to abate, namely the manufacture of basic iron, steel and ferroalloys (NACE 241) and aluminium production (NACE 2442). Therefore, EU ETS emissions related to these two sub-sectors are shown.

Employment shares in the manufacture of basic metals can reach several percentage points. Regional employment shares in basic metals manufacturing exceed 1% in 26 large (NUTS 2) regions. Regions with higher shares are mainly in Central and Northern Europe, especially in the Czech Republic, Sweden and the UK (Figure 2.6).

Thirteen large (NUTS 2) regions have both an employment share in basic metals exceeding 1% and emissions per capita for steel and aluminium over 1 tCO_{2e} per capita (Figure 2.7). They are spread across Austria, the Czech Republic, Finland, Germany, Italy, Poland, the Slovak Republic, Spain, Sweden and the UK, with a particular concentration in Central and Northern Europe. These regions may find it more challenging to move to climate neutrality as they need to convert current infrastructure, reskill or find employees with skills suitable to the production of green steel and aluminium.

In some large regions with high employment shares, emissions per capita in steel and aluminium production are relatively low, as is the case for Arnsberg. These regions could have jobs in less emission-intensive sub-sectors or employ workers in managerial or administrative tasks rather than in production processes. Conversely, a few large regions have high emissions from steel and aluminium plants but do not stand out on employment shares. Still, they may employ thousands of workers. As Box 2.2 illustrates for Sweden, data at the three-digit NACE level allow for the identification of employment in sectors where transformation challenges are likely to be less deep, such as in the production of tubes and pipes.

Both steel and aluminium production emissions are concentrated within their respective large (NUTS 2) regions. In both cases, large regions with the highest emissions have over 85% of their emissions in just 1 small region (Annex Figures 2.A.3 and 2.A.4).

Figure 2.6. Regions with high employment shares in basic metals

Regions with employment shares in the manufacture of basic metals exceeding 1%, 2018

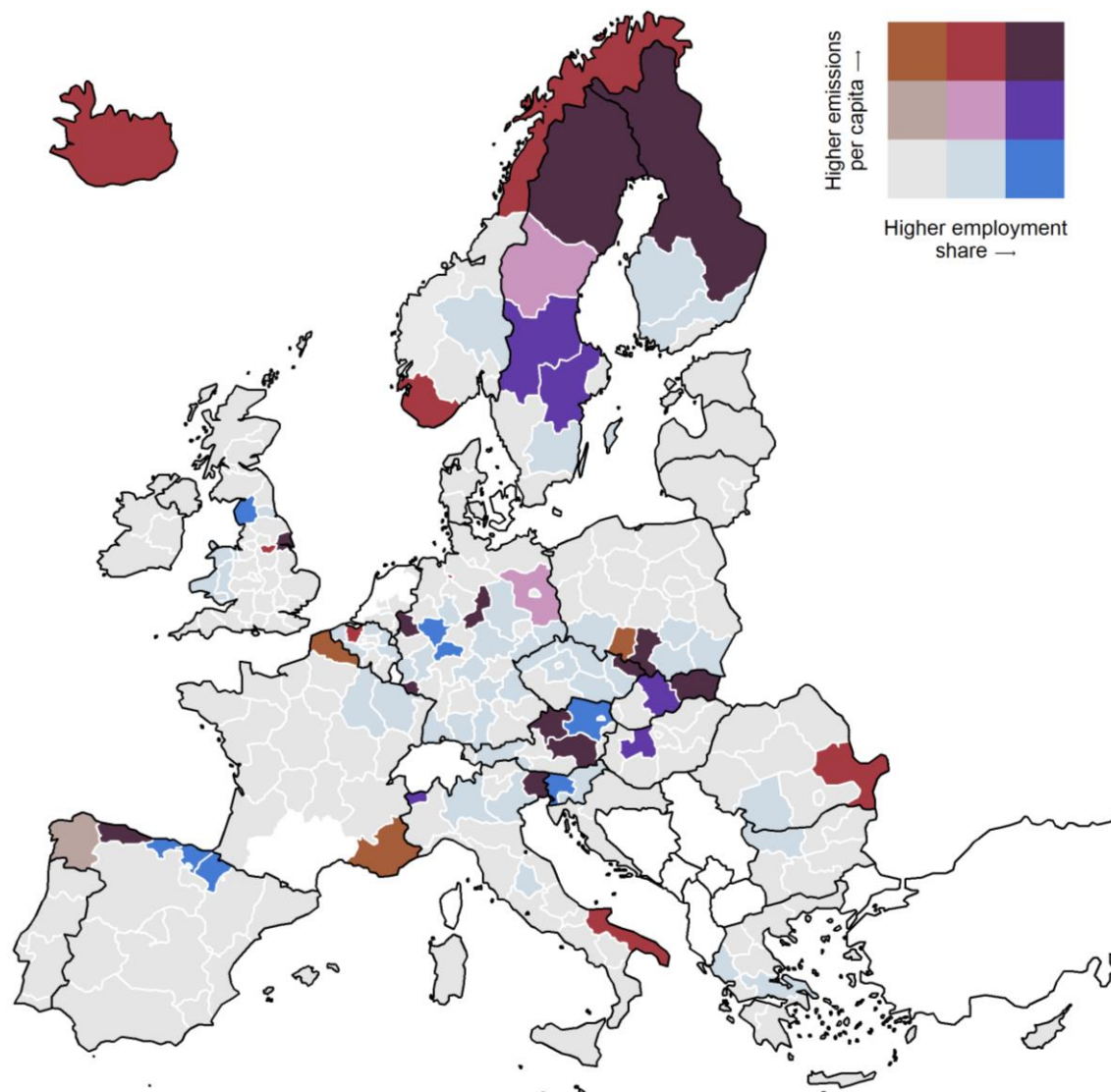
Nuts ID	Region name	Employment share	Emissions/capita	Employment in basic metals	Emissions in steel and aluminium	Emissions ratio
UKD1	Cumbria	4.03	0.00	10 134	0	
SE31	North Middle Sweden	3.68	0.75	14 067	642 166	
CZ08	Moravia-Silesia	3.41	2.33	19 465	2 808 083	
DEC0	Saarland	2.87	6.07	15 323	6 038 045	
DEA5	Arnsberg	2.80	0.16	52 024	565 753	
ES12	Asturias	2.28	5.63	9 000	5 788 321	
HU21	Central Transdanubia	2.24	0.80	10 552	843 977	
SK04	East Slovakia	2.07	3.68	11 856	5 969 066	
ITC2	Aosta Valley	2.06	0.85	1 268	107 236	
SE33	Upper Norrland	1.92	2.04	4 868	1 058 183	
DE72	Gießen	1.87	0.13	9 797	139 981	
DEA1	Düsseldorf	1.80	3.42	50 597	17 782 968	
AT22	Styria	1.70	2.57	10 757	3 191 868	
AT31	Upper Austria	1.69	5.56	13 027	8 188 526	
ES21	Basque Country	1.67	0.28	17 279	598 525	
SE12	East Middle Sweden	1.44	0.91	11 427	1 542 102	
SK03	Central Slovakia	1.38	0.51	7 859	686 339	
FI1D	Eastern and Northern Finland	1.28	3.67	7 071	4 730 587	
DE91	Braunschweig	1.25	2.86	10 419	4 564 932	
PL22	Silesia	1.22	1.20	22 773	5 392 646	
AT12	Lower Austria	1.20	0.00	8 746	0	
ITH4	Friuli-Venezia Giulia	1.10	1.24	6 004	1 502 802	
SI04	Western Slovenia	1.10	0.11	5 933	108 454	
UKE1	East Yorkshire and Northern Lincolnshire	1.03	5.47	4 176	5 093 365	
ES13	Cantabria	1.03	0.41	2 345	238 152	
ES22	Navarra	1.00	0.10	3 067	66 473	

Note: The ratio of emissions represents the combined emissions from the manufacture of basic iron and steel and of ferroalloys (NACE 241) and aluminium production (NACE 2442) as a share of total emissions across all manufacture of basic metals (NACE 24). Niederösterreich has no emissions in NACE 24. Emissions in tCO₂e.

Source: Authors' calculations based on Eurostat and EU ETS .

Figure 2.7. Regional employment and emissions in the manufacture of basic metals

Emissions per capita from the manufacture of basic iron and steel and of ferroalloys and aluminium production, and employment shares in the manufacture of basic metals, NUTS 2 regions, 2018



Note: Breaks in employment shares are at 0.5% and 1%. Breaks in emissions per capita are at 0.5 and 1 tCO₂e/capita. White areas have missing data. North Holland has high emissions but does not provide employment data. Emissions per capita are calculated as emissions from EU ETS installations of businesses whose main activity is in the manufacture of basic iron and steel and ferroalloys (NACE 241) and aluminium production (NACE 2442) divided by the population in NUTS 2 regions. Employment shares are calculated as employment in the manufacture of basic metals (NACE 24) as a share of total employment in NUTS 2 regions.

Source: Author's calculations based on Eurostat and ETS-Orbis.

Box 2.2 Basic metals employment in Swedish regions

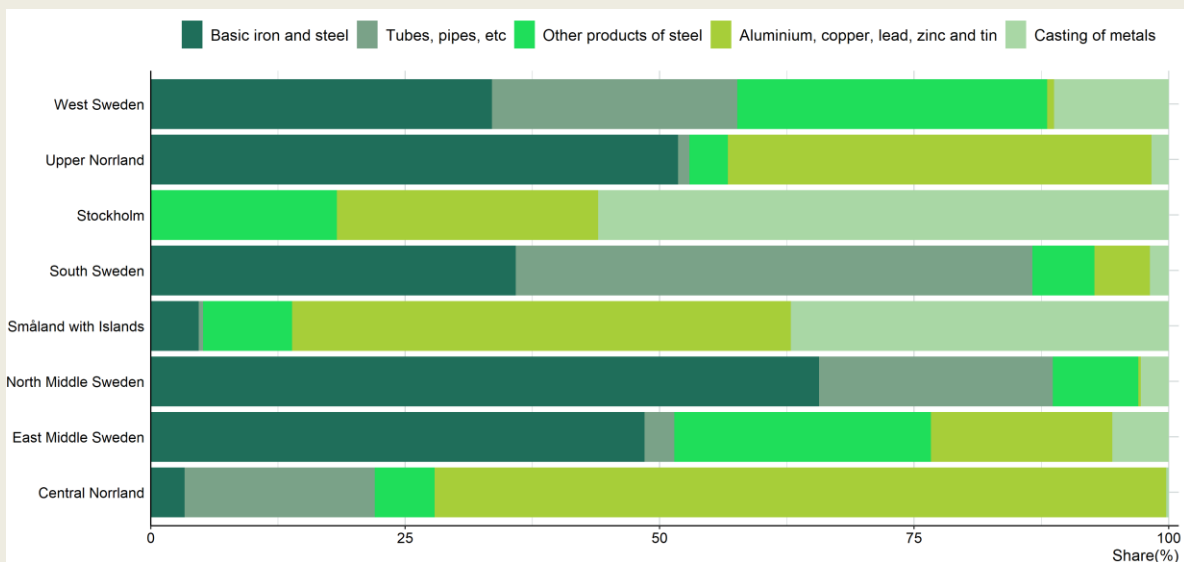
Activities within the manufacturing of basic metals (NACE 24) are affected to different degrees by the transformations to reach climate neutrality, as highlighted in Chapter 1. Workers will therefore also be differently affected depending on which sub-sector they work in. Workers and businesses in the manufacture of basic iron and steel and ferroalloys (NACE 241) and aluminium production (NACE 2442) may be particularly impacted, more so than in the manufacture of other basic metals. Moreover, transformation challenges differ across sub-sectors: indeed, they are not the same in steel and aluminium production. A fine sectoral breakdown for regional employment data, therefore, allows for better identification of regional development challenges. Sweden is one of few countries providing such a breakdown and has vulnerable regions in basic metals production.

The relative importance of employment in these basic metal manufacturing sub-sectors varies substantially across Swedish regions. Moreover, the concentration of EU ETS-related emissions from basic metals in steel production can give an indication of how strongly steel-related employment directly relates to activities generating high emissions.

High emissions from steel or aluminium production do not imply that all workers employed in basic metals are affected. For example, in Upper Norrland, 100% of emissions from basic metals are in steel production but only 52% of employment and in East Middle Sweden, 96% of emissions for only 49% of employment. Hence, the more granular three-digit data allow better identification of the challenges for employment. Emissions data cannot fill this gap.

Figure 2.8. Contribution of three-digit employment to employment in basic metals

Employees in three-digit NACE sub-sectors as a share of employees in the manufacture of basic metals in large (NUTS 2) regions, 2018



Note: The three-digit manufacturing sectors are basic iron and steel and of ferroalloys (NACE 241), tubes, pipes, hollow profiles and related fittings, of steel (NACE 242), other products of first processing of steel (NACE 243), basic precious and other non-ferrous metals (NACE 244) which includes aluminium production and casting of metals (NACE 245)

Source: Swedish Agency for Economic and Regional Growth.

Regions with employment and emissions in the manufacture of non-metallic mineral products

The output of the manufacture of non-metallic mineral products is diverse. Cement production has been identified as particularly difficult to move to climate neutrality. Hence, employment in this sub-sector may be more at risk. While employment in cement production cannot be distinguished from other non-metallic mineral production in most countries, emissions from the EU ETS can identify regions producing cement, lime and plaster (NACE 235). Large (NUTS 2) regions with high employment shares in the manufacture of non-metallic mineral products are especially numerous in Central Europe (Figure 2.9). The regions with the highest shares are located in the Czech Republic, Germany, Poland and Portugal. However, high employment shares can also reflect employment in other sub-sectors.

In Italy, employment in cement production can be distinguished from employment in non-metallic minerals (Box 2.3). The example of Italy shows that high cement-related emissions per capita combined with high employment in non-metallic minerals can provide some indication of which regions face more cement-related transformation challenges.

Beyond Italy, there are several large (NUTS 2) regions with employment in non-metallic minerals above 1% and where at least half of emissions in the sector are cement-related. These are located in Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Germany, Hungary and Poland. Many of these large regions have high emissions per capita in cement production (Figure 2.10). Some particularly large (NUTS 2) regions with low emissions per capita and employment shares still stand out for high absolute cement-related emissions and employ thousands of workers, especially in Germany and Spain.

As in other key manufacturing sectors, cement-related activity is further concentrated within small (NUTS 3) regions (Annex Figure 2.A.5). For example, in the large region Opole, Poland, all cement-related emissions are emitted in the small region Opolski. Hence, this Polish community may be especially vulnerable to employment losses.

Figure 2.9. Regions with high employment shares in non-metallic mineral products

Regions with employment shares in the manufacture of other non-metallic mineral products exceeding 1%, 2018

Nuts ID	Region name	Employment share	Emissions/capita	Employment in non-metallic minerals	Emissions in cement	Emissions ratio
PT16	Central Portugal	2.46	0.71	24 672	1 588 032	
CZ04	Northwest	2.32	0.39	11 807	429 958	
DE24	Oberfranken	1.89	0.00	11 259	0	
PL72	Swietokrzyskie	1.77	4.16	8 986	5 130 059	
CZ05	Northeast	1.76	0.38	12 634	567 456	
DE23	Oberpfalz	1.71	0.80	11 160	887 234	
BG33	Severozitochen	1.49	0.95	6 437	882 410	
ES52	Valencia	1.35	0.40	26 229	1 956 508	
DEB1	Koblenz	1.33	0.00	10 060	0	
PL82	Podkarpacia	1.31	0.00	10 965	4 733	
ITH5	Emilia-Romagna	1.30	0.18	28 080	810 781	
PL71	Lodzkie	1.25	0.63	14 202	1 548 287	
PL51	Lower Silesia	1.25	0.01	15 243	22 497	
HU21	Central Transdanubia	1.24	0.11	5 834	120 377	
PL52	Opole region	1.20	3.61	4 695	3 428 969	
CZ02	Central Bohemian Region	1.19	0.67	7 358	905 923	
PL43	Lubusz	1.18	0.00	4 853	0	
UKG2	Shropshire and Staffordshire	1.16	0.00	8 604	0	
BE22	Limburg (BE)	1.13	0.00	3 996	0	
DE22	Niederbayern	1.12	0.26	7 669	317 966	
DEG0	Thüringen	1.12	0.47	11 714	1 010 775	
AT21	Carinthia	1.09	0.80	2 890	449 914	
IT12	Umbria	1.07	1.49	3 983	1 314 225	
BE32	Hainaut	1.07	2.03	4 754	2 722 515	
PL22	Silesia	1.07	0.10	19 917	462 000	
BE35	Namur	1.06	0.00	1 868	0	
CZ03	Southwest	1.06	0.00	6 288	0	
AT33	Tyrol	1.03	0.28	4 231	211 612	
SI03	Eastern Slovenia	1.03	0.05	4 954	58 496	
DK05	Northern Jutland	1.01	3.72	2 895	2 190 706	
ITF1	Abruzzo	1.01	0.13	5 270	169 808	

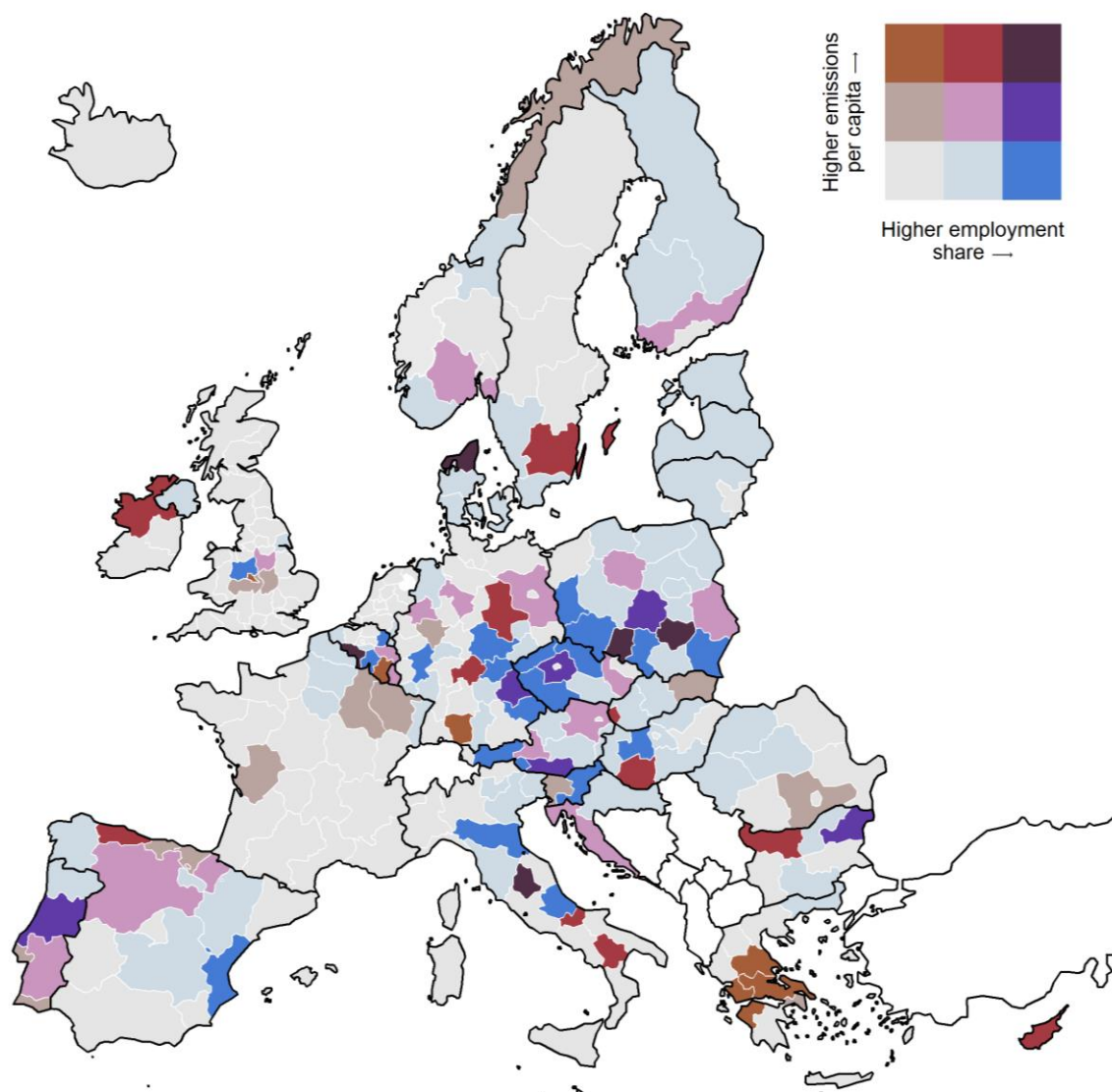
Note: The ratio of emissions represents the combined emissions from the manufacture of cement, lime, and plaster (NACE 235) as a share of total emissions across all manufacture of other non-metallic mineral products (NACE 23). Emissions in tCO_{2e}.

Source: Authors' calculations based on Eurostat and EU ETS.

StatLink <https://stat.link/5cwn3>

Figure 2.10. Regional employment and emissions in the manufacture of non-metallic mineral products

Emissions per capita from the manufacture of cement, lime and plaster and employment shares of the manufacture of non-metallic mineral products, NUTS 2 regions, 2018



Note: Breaks in employment shares are at 0.5% and 1%. Breaks in emissions per capita are at 0.5 and 1 tCO₂e/capita. White areas have missing data. Emissions per capita are calculated as emissions from EU ETS installations of businesses whose main activity is in the manufacture of cement, lime and plaster (NACE 235) divided by the population in NUTS 2 regions. Employment shares are calculated as employment in the manufacture of non-metallic mineral products (NACE 23) as a share of total employment in NUTS 2 regions.

Source: Author's calculations based on Eurostat and ETS-Orbis.

Box 2.3. The manufacture of cement in Italy

Three-digit data allows for identifying employment in the manufacture of cement, lime and plaster (NACE 235). The only country with data providing a breakdown of employment in non-metallic minerals, including in cement production, and that has high employment shares in the manufacture of other non-metallic mineral products is Italy. It also provides these data at a finer regional breakdown, for NUTS 3 regions.

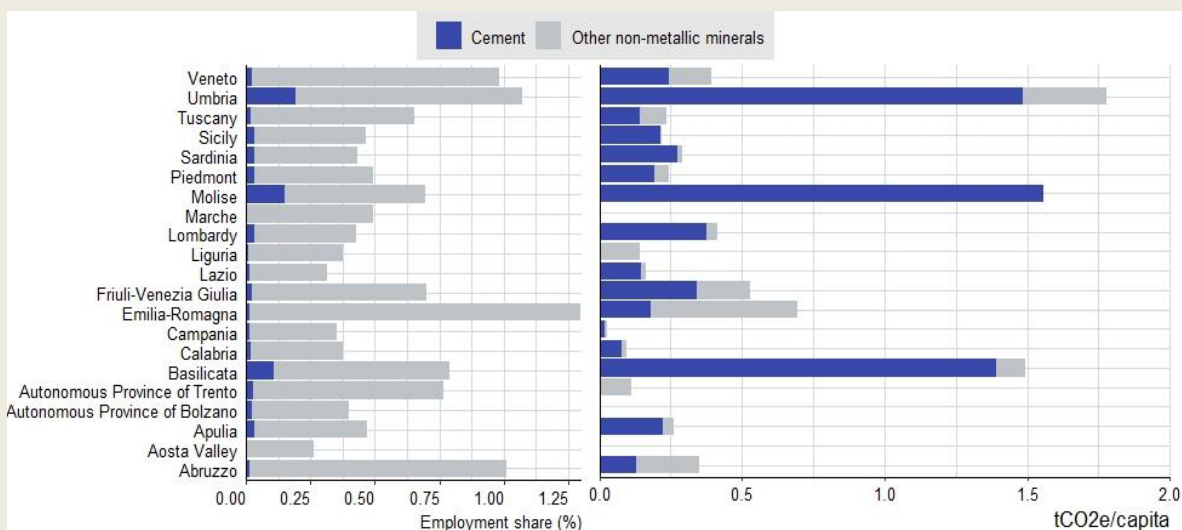
The regions of Abruzzo and Emilia-Romagna have high employment shares in the manufacture of non-metallic mineral products (NACE 23) but not in the manufacture of cement, lime and plaster (Figure 2.11).

Regions with high cement-related emissions and high employment shares in non-metallic mineral products tend to have higher shares of employment in cement production. Figure 2.10 identifies Umbria for its high employment share in non-metallic mineral products and high emissions per capita in cement. In the manufacture of cement, lime and plaster (NACE 235), Umbria has the highest employment share of the Italian regions. The emissions of the manufacture of cement, lime and plaster (NACE 235) represent 84% of regional emissions from the manufacture of non-metallic mineral products (NACE 23).


Employment risks are more concentrated than large (NUTS 2) regions data allow to identify. The small (NUTS 3) region of Perugia, a part of Umbria, employs almost all cement workers of Umbria. It hosts 8 establishments and emits 87% of Umbrian emissions.

Figure 2.11. Contribution of cement within non-metallic mineral products

Contribution of manufacture of cement, lime and plaster to employment shares and emissions per capita in the manufacture of non-metallic mineral products, large (NUTS 2) regions, 2018



Source: Italian National Institute of Statistics, Eurostat and ETS-Orbis.

StatLink  <https://stat.link/47x2a9>

Regions with employment and emissions in the manufacture of paper and paper products

Among the key sectors, emissions are relatively low in the manufacture of paper and paper products. Even so, the transformations needed are still great in the manufacture of pulp, paper and paperboard (NACE 171), which is the most emissions intensive. Therefore, emissions from this sub-sector are considered.

While employment shares exceed 1% in only a few large (NUTS 2) regions, regional employment can still reach thousands of workers (Figure 2.12). Large regions with higher employment shares in the manufacture of paper and paper products are mostly in Northern Europe. Swedish regions lead the sector. Their high employment shares rely on a relatively small number of establishments.


Figure 2.12. Regions with high employment shares in paper

Regions with employment shares in the manufacture of paper and paper products exceeding 0.65%, 2018

Nuts ID	Region name	Employment share	Emissions/capita	Employment in paper paper products	Emissions in paper and pulp	Emission ratio
SE31	North Middle Sweden	2.02	0.22	7 723	187 191	
SE32	Central Norrland	1.74	0.45	3 105	169 161	
FI1C	Southern Finland	1.47	0.96	7 483	1 116 447	
FI19	Western Finland	1.18	0.34	7 357	469 470	
PL61	Kuyavian-Pomerania	1.11	0.05	9 664	112 943	
FRF1	Alsace	1.09	0.13	8 516	251 624	
DEB2	Trier	1.01	0.00	2 644	0	
SE21	Småland with Islands	0.92	0.04	3 963	30 371	
PL43	Lubusz	0.83	0.22	3 422	220 993	
DEB1	Koblenz	0.81	0.17	6 134	260 965	
SE33	Upper Norrland	0.77	0.12	1 965	62 686	
HU12	Pest	0.75	0.00	3 549	0	
ES22	Navarra	0.75	0.21	2 291	137 460	
PL41	Greater Poland	0.72	0.01	11 573	48 513	
AT34	Vorarlberg	0.69	0.06	1 372	23 889	
BE34	Luxembourg (Belgium)	0.69	0.42	683	119 393	
AT22	Styria	0.69	0.68	4 353	837 297	
SE23	West Sweden	0.69	0.07	7 080	139 249	
HU21	Central Transdanubia	0.67	0.34	3 155	355 311	
CZ05	Northeast	0.67	0.02	4 800	36 887	
SE12	East Middle Sweden	0.66	0.07	5 264	120 203	

Note: The ratio of emissions represents the combined emissions from the manufacture of pulp, paper, and paperboard (NACE 171) as a share of total emissions across all manufacture of paper and paper products (NACE 17). Trier and Pest have no emissions in NACE 17. Emissions in tCO_{2e}.

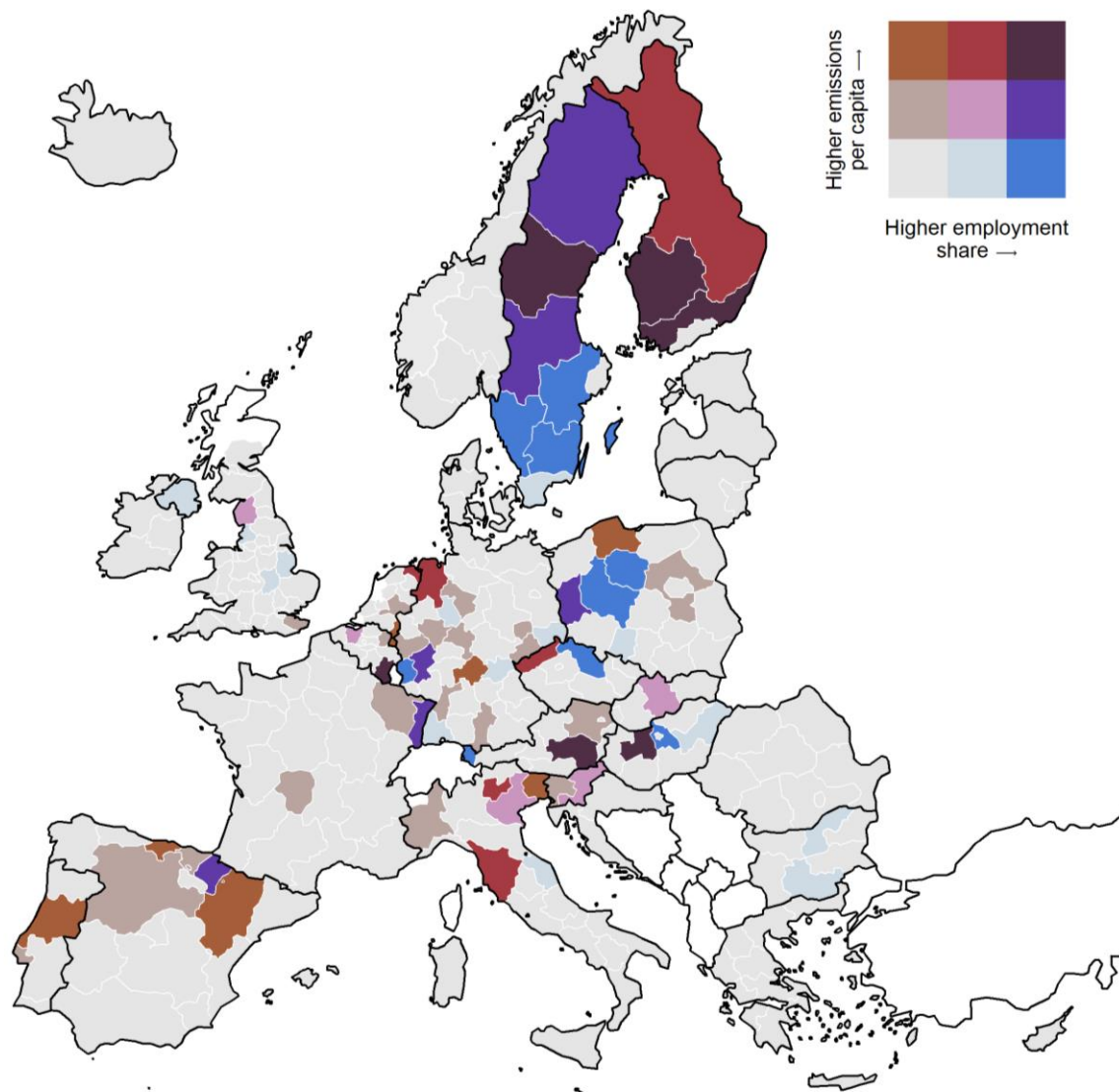
Source: Authors' calculations based on Eurostat and EU ETS.

StatLink  <https://stat.link/h7u0b1>

Regions with high employment shares and high emissions per capita are mainly located in Finland and Sweden (Figure 2.13). Few other sectors have such consistent overlap in regions scoring high on both. Finnish regions also have among the highest absolute emissions.

Figure 2.13. Regional employment and emissions in the manufacture of paper and paper products

Emissions per capita from the manufacture of pulp, paper and paperboard and employment shares of the manufacture of paper and paper products, NUTS 2 regions, 2018



Note: Breaks in employment shares are at 0.5% and 0.65%. Breaks in emissions per capita are at 0.1 and 0.25 tCO₂e/capita. White areas have missing data. Emissions per capita are calculated as emissions from EU ETS installations of businesses whose main activity is in the manufacture of pulp, paper and paperboard (NACE 171) divided by the population in NUTS 2 regions. Employment shares are calculated as employment in the manufacture of paper and paper products (NACE 17) as a share of total employment in NUTS 2 regions.

Source: Author's calculations based on Eurostat and ETS-Orbis.

Box 2.4. Manufacturing of paper and paper products in Swedish regions

Figure 2.13 shows that Swedish regions have very high employment shares and some also have high emissions per capita in the manufacture of paper and paper products (NACE 17). Two Swedish regions, North Middle Sweden and Central Norrland, lead on employment shares. However, emissions in these Swedish regions are low. This may be due to Sweden's reliance on biomass as 41% of energy use in industry comes from bioenergy and the pulp and paper industry accounts for more than 50% of industrial energy use (Swedish Energy Agency, 2021^[3]). Following the rules of the EU ETS, the burning of biomass is considered carbon neutral as it is assumed that emissions have been saved during the growth phase and will be compensated by the growth of new biomass (Transport & Environment, 2015^[4]). They may nevertheless face some transition risks from competing demands on biomass.

Using three-digit employment data illustrates that most of the employment in Sweden's most vulnerable regions is concentrated in the manufacture of pulp, paper and paperboard (NACE 171), which is likely to be more vulnerable to the transition to climate neutrality than the production of paper products (NACE172). This sub-sector accounts for 92% of North Middle Sweden's and 97% of Central Norrland's employment in the manufacture of paper and paper products. Similarly, the sub-sector represents 85% and 100% respectively of regional emissions in the manufacture of paper and paper products. In the case of Central Norrland, transition risk is further concentrated in Västernorrland as 100% of employment in the three-digit sub-sector is in this small (NUTS 3) region.

Note: As described in Box 2.1, the three-digit employment data refer to employees only.

Source: Swedish Agency for Economic and Regional Growth, Eurostat and ETS-Orbis (2018); Swedish Energy Agency (2021^[3]), *Energy in Sweden 2021 - An Overview*, <https://energimyndigheten.a-w2m.se/Home.mvc?ResourceId=198022>; Transport & Environment (2015^[4]), *Reasons to Change the Zero-rated Criteria for Biomass in the EU ETS*, https://www.transportenvironment.org/wp-content/uploads/2021/07/2015%2001%20biomass%20ets_rating_FINAL.pdf.

Regions with employment and emissions in the manufacture of motor vehicles, trailers and semi-trailers

Regional employment shares in the manufacturing of motor vehicles, trailers and semi-trailers (NACE 29) across the EU are the highest among the key sectors. Almost a third of EU large (NUTS 2) regions have a regional employment share greater than 1% in this sector, indicating that a great share of regions and their workers will be at risk.

The regions that have high employment shares are mainly concentrated in Central and Eastern Europe (Figure 2.14). Four large regions, employing over 300 000 workers combined, in the Czech Republic, Germany, Hungary and Romania have regional employment shares greater than 7%. Regions with the highest employment shares in the EU do not report data for three-digit vehicle manufacturing sub-sectors. Box 2.5 focuses on Romania, where more than half of large (NUTS 2) regions have employment shares above the EU average.

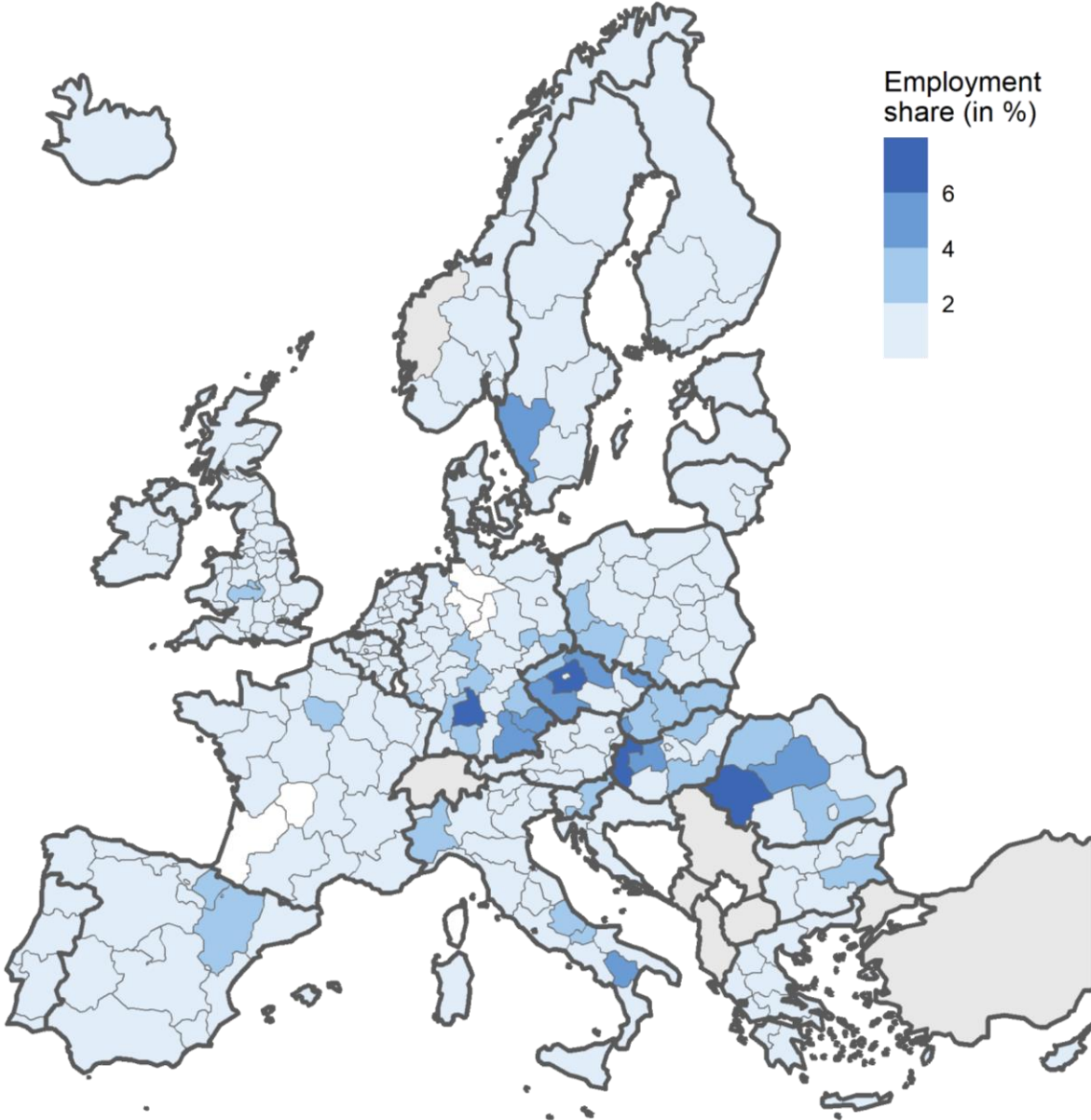
Some large (NUTS 2) regions are more dependent on fewer establishments. For example, while the Central Bohemian region in the Czech Republic has a similar number of workers compared to West Romania, it has more than double the number of establishments. Central Bohemia may be better able to absorb firm-specific employment shocks when a single establishment closes.

Transformation challenges in this sector do not mainly relate to emissions, so emissions are not shown. Moreover, only 52% of sectoral emissions are represented in the EU ETS, as many installations fall below the threshold to be included in the EU ETS. Île-de-France, France, and Stuttgart, Germany, have the

highest and second-highest absolute employment respectively. There may be a stronger headquarters effect in Paris, where workers may have more transferable skills.

Figure 2.14. Regional employment shares in the manufacture of motor vehicles, trailers and semi-trailers

Employment in the manufacture of motor vehicles, trailers and semi-trailers as a share of total employment in NUTS 2 regions, 2018



Note: White areas have missing data.
Source: Eurostat.

Box 2.5. Manufacture of motor vehicles, trailers and semi-trailers in Romania

Romanian regions with employment shares above the EU average in the manufacture of motor vehicles, trailers and semi-trailers are the West (7.36%), the Centre (4.78%), South-Muntenia (3.19%), the North-West (2.18%) and South-West Oltenia (1.65%).

Most employment in Romanian regions is concentrated in the manufacture of parts and accessories for motor vehicles (NACE 293), which will be affected by the transition to producing electric vehicles. The employment shares in the West (5.62%), the Centre (3.49%), South-Muntenia (2.27%) and the North-West (1.62%) are particularly large.

The NUTS 3 regional breakdown can further identify the regions with high employment and that may face greater risks. This would be especially useful for the Czech Republic, Germany and Hungary. In Romania, four NUTS 3 regions employ over 10 000 people in the manufacture of parts and accessories for motor vehicles. They are Timis in West, Arges in South-Muntenia, and Brasov and Sibiu in the Centre.

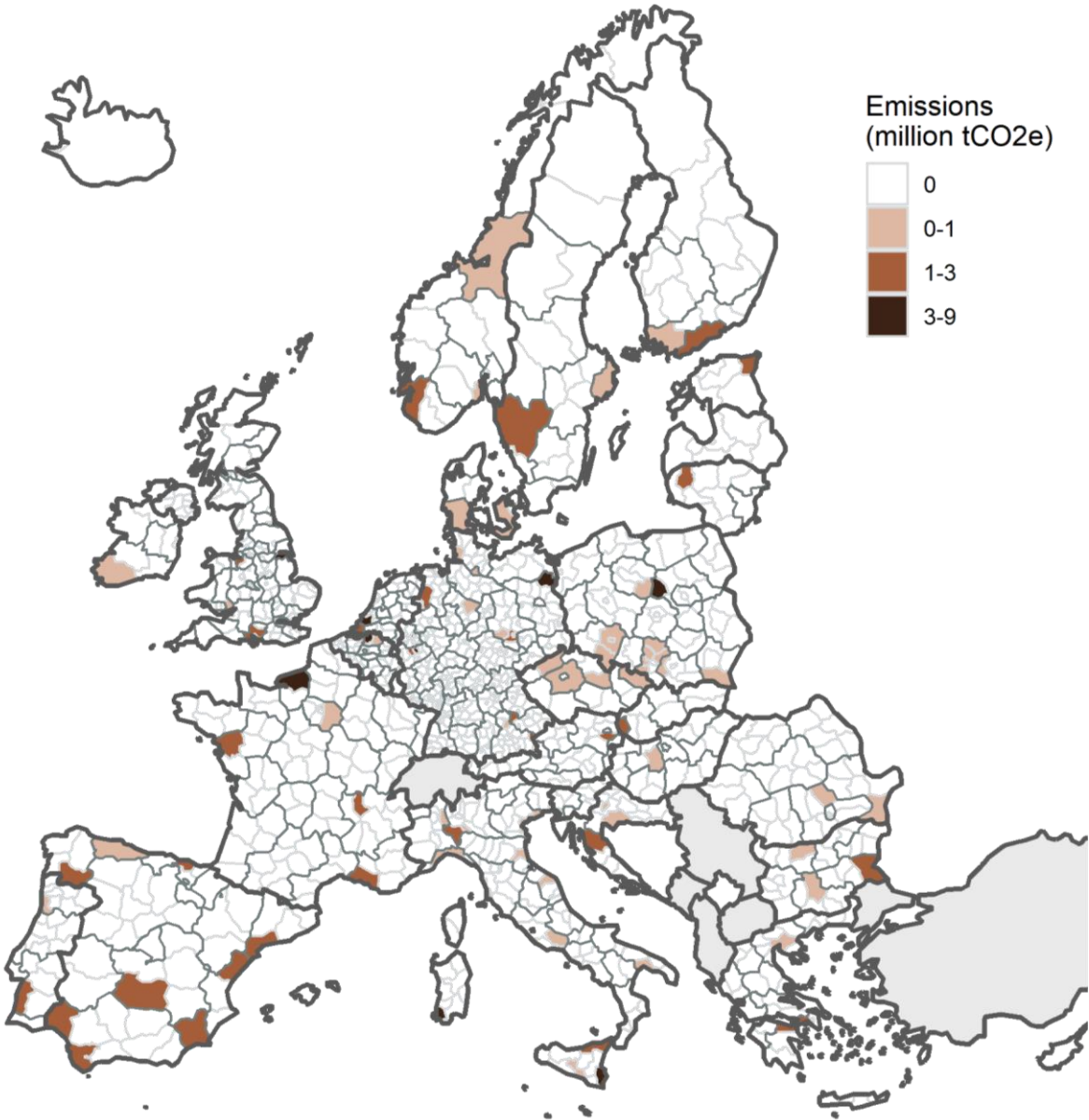
Note: There is no emissions data available for any Romanian regions in this sector on the ETS database.

Source: Romanian Ministry of Public Works, Development and Administration and Eurostat (2018).

Annex 2.A.

Annex Figure 2.A.1. Regional emissions in coke and petroleum

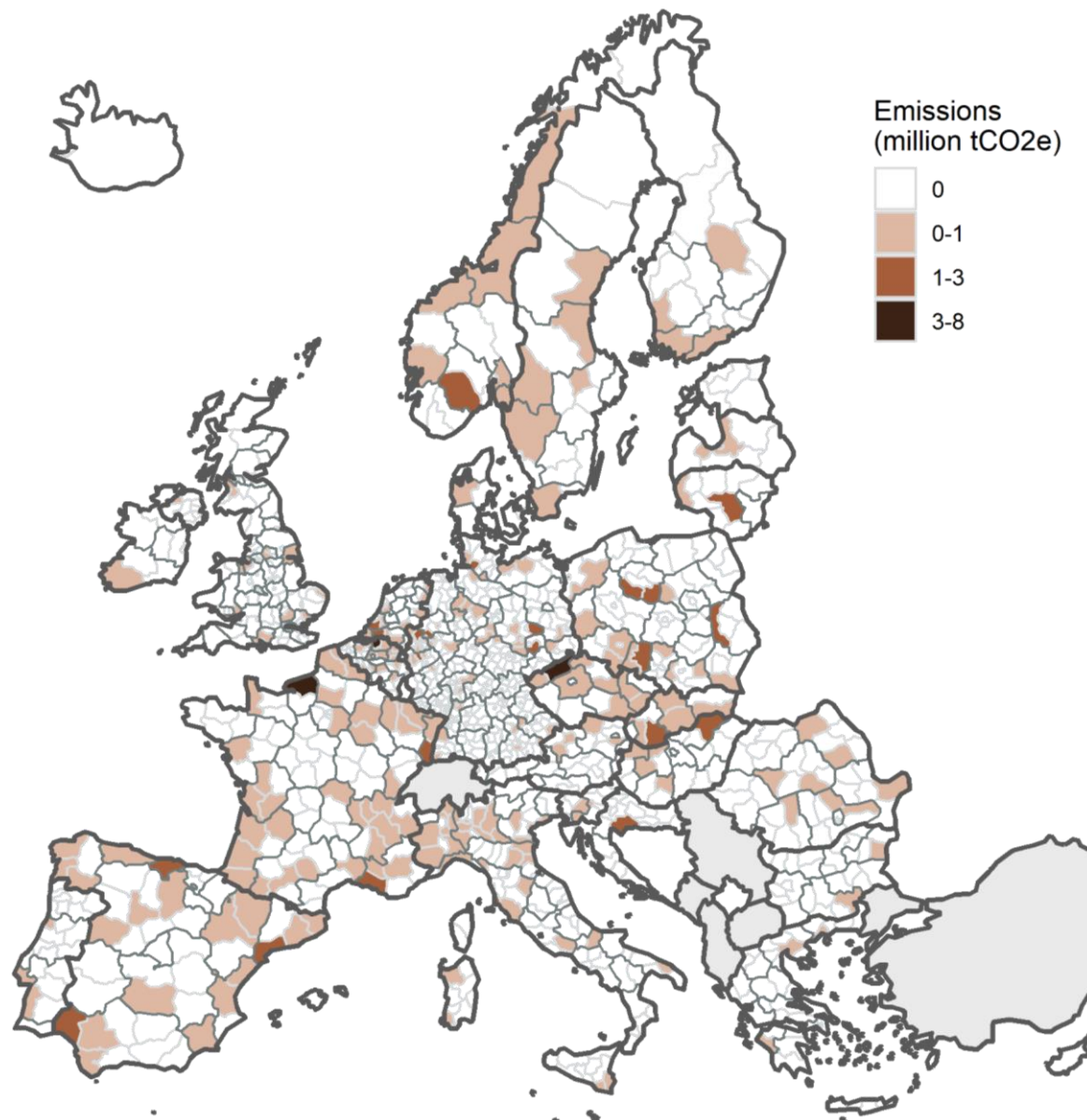
Emissions from EU ETS installations of businesses whose main activity is in the manufacture of coke and refined petroleum products (NACE 19), NUTS 3 regions, 2018



Source: Authors' calculations based on ETS-Orbis and Eurostat.

Annex Figure 2.A.2. Regional emissions in chemicals

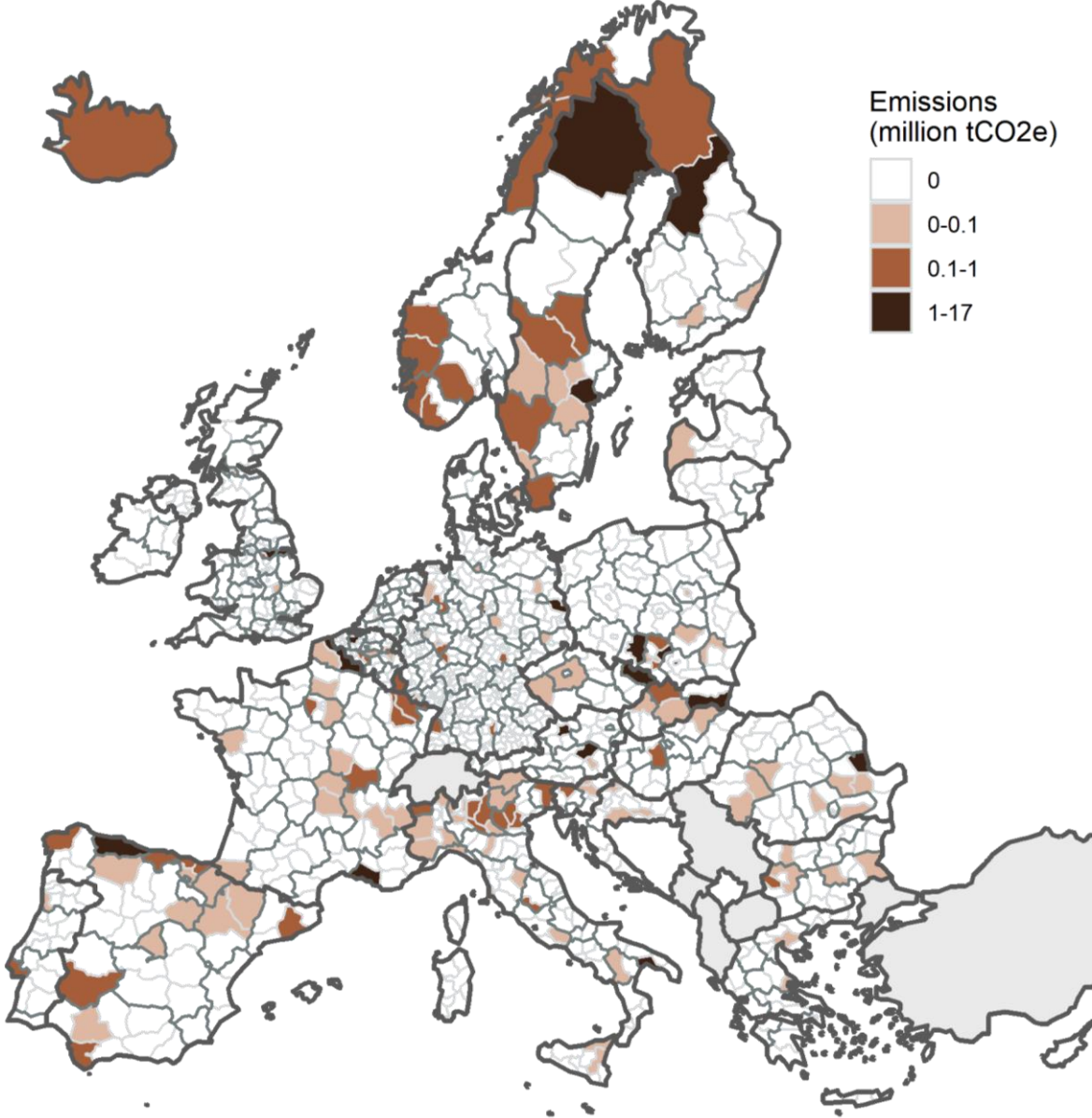
Emissions from EU ETS installations of businesses whose main activity is in the manufacture of chemicals and chemical products (NACE 20), NUTS 3 regions, 2018



Source: Authors' calculations based on ETS-Orbis and Eurostat.

Annex Figure 2.A.3. Regions with high-emitting steel production installations

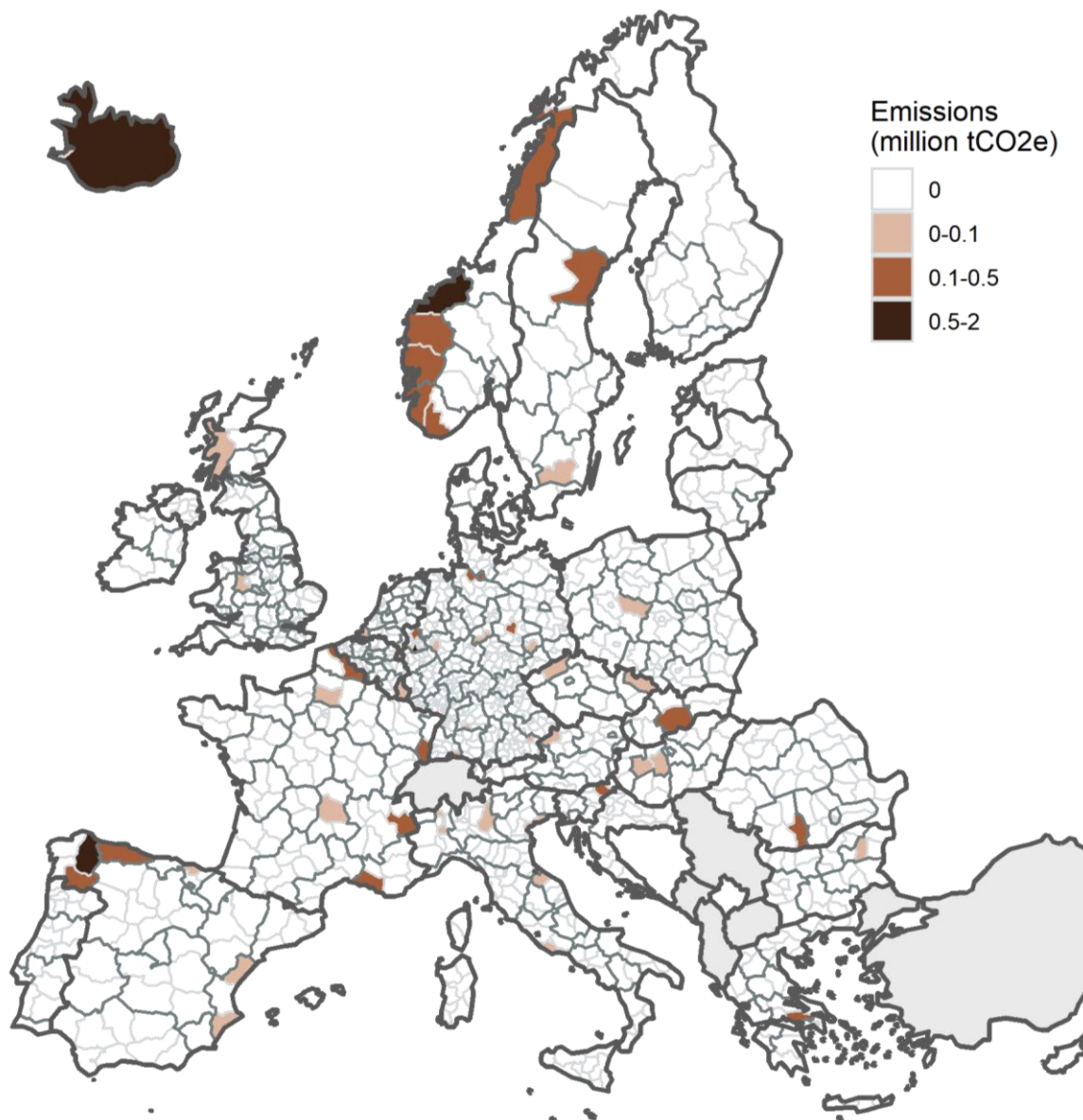
Emissions from EU ETS installations of businesses whose main activity is in the manufacture of basic iron and steel and ferroalloys (NACE 241), NUTS 3 regions, 2018



Source: Authors' calculations based on ETS-Orbis and Eurostat.

Annex Figure 2.A.4. Regions with high-emitting aluminium production installations

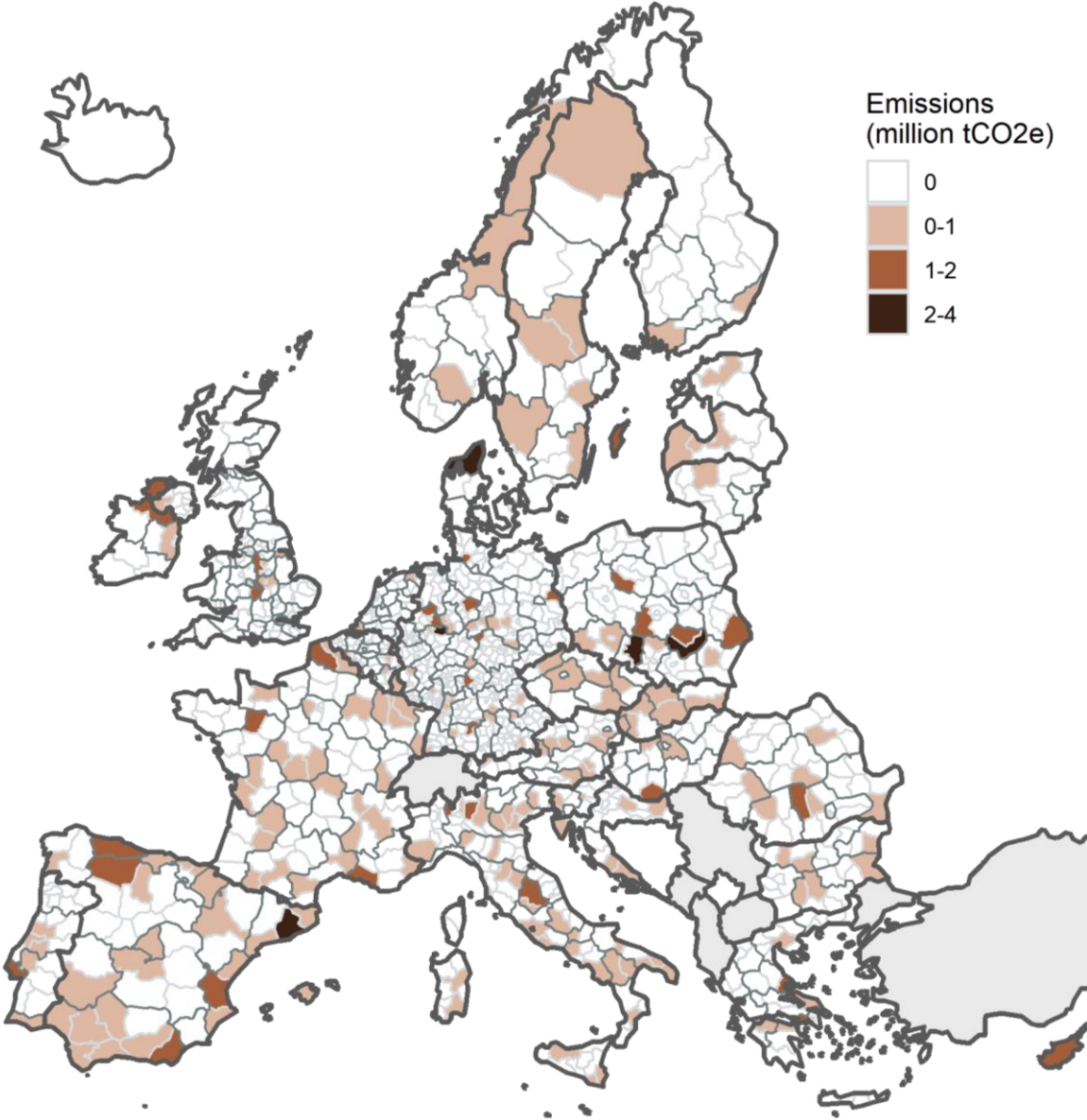
Emissions from EU ETS installations of businesses whose main activity is in the manufacture of aluminium (NACE 2442), NUTS 3 regions, 2018



Source: Authors' calculations based on ETS-Orbis and Eurostat.

Annex Figure 2.A.5. Regions with high-emitting cement production installations

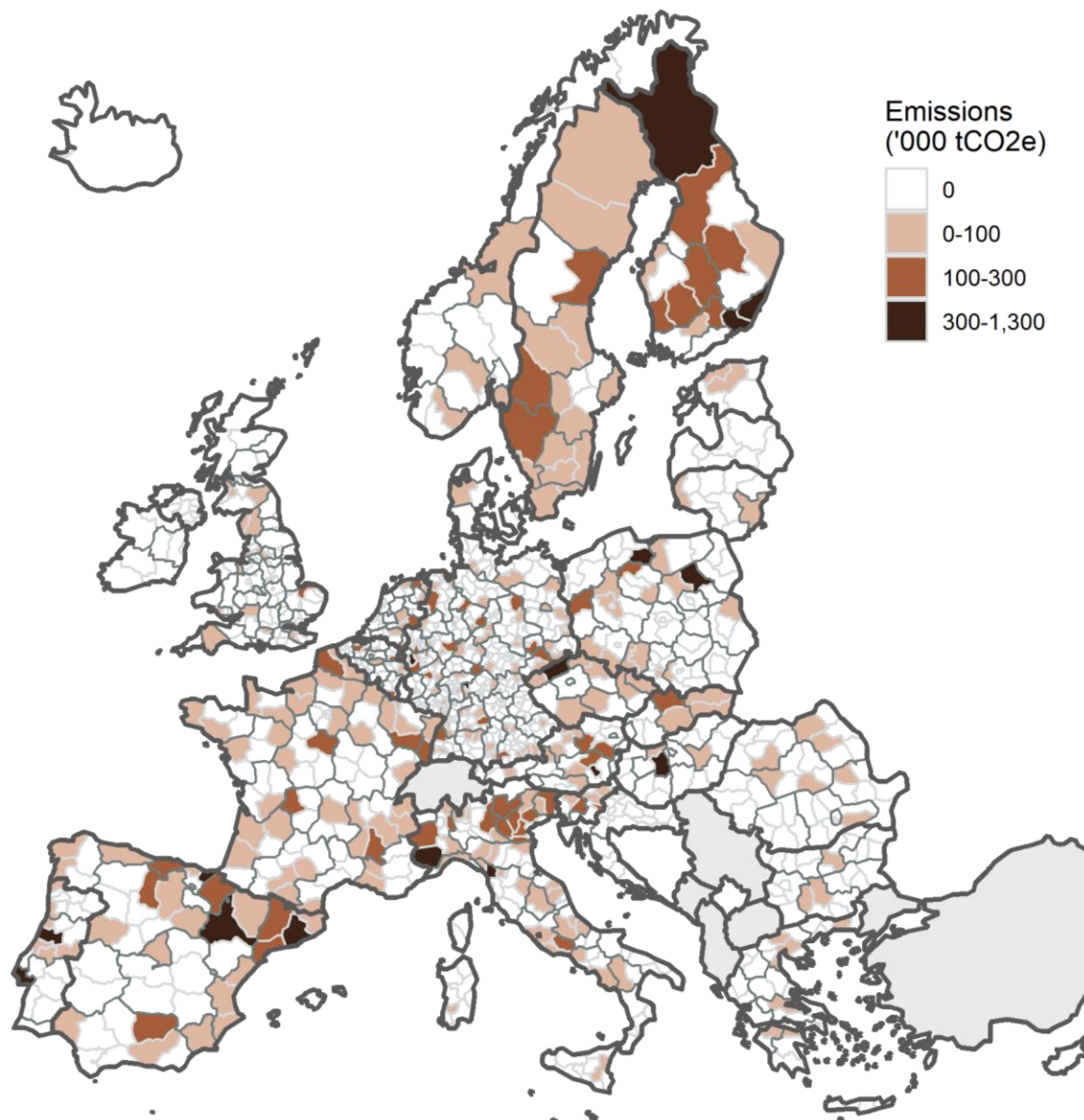
Emissions from EU ETS installations of businesses whose main activity is in the manufacture of cement, lime and plaster (NACE 235), NUTS 3 regions, 2018



Source: Authors' calculations based on ETS-Orbis and Eurostat.

Annex Figure 2.A.6. Regional emissions in paper

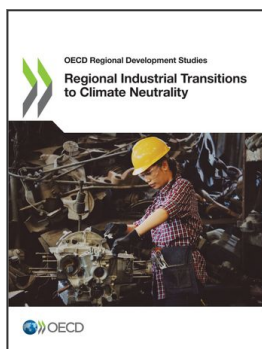
Emissions from EU ETS installations of businesses whose main activity is in the manufacture of pulp, paper and paperboard (NACE 171), NUTS 3 regions, 2018



Source: Authors' calculations based on ETS-Orbis and Eurostat.

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