Which impact do climate change policies have on Nordic economies, industries, and households?

An equilibrium analysis with regional detail

Methodological appendices

Appendix 1. Detailed modelling assumptions and simulations

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1. Introduction

This Appendix describes the baseline simulation for 2019 to 2030 (Section 2) and describes how we formulated the shocks, making clear the assumptions made and the data sources used (Section 3).

2. Detailed baseline simulation: 2019 to 2030

This Section describes the baseline simulation for 2019 to 2030, focusing on macro variables, output projections for industries by nation, employment projections for industries and sub-national regions, and emissions projections by nation.

CGE models can be run with different choices for the length of a period. One possibility is year-on-year simulations where the length of each period is one year. However, for this project, we are concerned with long-run effects. Consequently, we are able to simplify the simulations by having just one period of 11 years: 2019 to 2030. Each computation starts with a database for 2019. Then we apply shocks for the exogenous variables that represent their movement from 2019 to 2030. The model generates results for endogenous variables that show their implied movements from 2019 to 2030. Another way to put this is that the model starts from a picture of 2019 and generates a picture of 2030.

2.1. Baseline GDP and employment forecasts for 2019-30

Table 1 shows percentage growth in macro variables for the Nordic countries and the rest of Europe. The results are for growth over the 11 years from 2019 to 2030. They were derived in a baseline simulation.

In the baseline simulation, GDP and employment growth were set exogenously for each of the Nordic countries and Rest of Europe (RoE). In determining these variables, we started with historical GDP data from the OECD available at https://data.oecd.org/gdp/real-gdp-forecast.htm#indicator-chart. From these data, we derived GDP growth for the decades 2001-11 and 2011-21. Next, we accessed the World Bank historical data and projections for growth in population aged between 15 and 64 (working age). These are available at https://databank.worldbank.org/source/population-estimates-and-projections/preview/on#. Combining the historical data for GDP and working-age population, we derived growth in productivity for the decades 2001-11 and 2011-21 where productivity is defined as GDP divided by working-age population. For the decade 2021-31, we assumed that productivity growth in each of the five Nordic countries and RoE will be the average of the productivity growths from the two earlier decades. Finally, we assumed that employment growth in the Nordic countries and RoE in the decade 2021-31 will match the World Bank projection for growth in the working-age population. With employment growth projected in this way and our productivity assumption in place, we derived GDP growth. Our calculations are shown in Table 2.

In using the GDP and working-age population forecasts from Table 2 in our baseline simulation from 2019 to 2030, we assume that the annual growth rates implied by Table 2 for the 10-year period 2021 to 2031 apply to the 11-year period 2019 to 2030. For example, in row (9) of Table 2, the growth in GDP over 10 years for DK is given as 10.1 per cent. In Table 1, this is translated in row 6 to 11.2 per cent [= 100*($1.101^{11/10}$ – 1)].

2.2. Other baseline assumptions for 2019-2030

(1) At the sub-national regional level, real household consumption and real government consumption move by the same percentage. RoE and Iceland are single regions. Consequently, our assumption of equal growth in private and public consumption is reflected exactly at the national level for RoE and Iceland (see rows 1 and 3 in Table 1). For the other four Nordic countries, Table 1 can show small differences in C and G at the national level.

(2) Household consumption in nominal terms in each subnational region grows at the same rate as the region's nominal GDP.

(3) Rates of return on investment in all industries and all regions in 2030 are the same as in 2019.

(4) The investment to capital ratio in 2030 in all industries and all regions in 2030 is the same as in 2019.

Table 1 Baseline national forecasts: 2019-2030 (percent growth for 11 years) (Sim C21)

		DK	FI	SE	NO	IS	RoE
1	Real h'hold cons (C)	13.6	16.0	24.6	14.4	19.1	5.9
2	Real investment (I)	8.3	8.8	15.1	10.3	12.9	2.1
3	Real gov cons (G)	13.6	16.0	24.2	14.3	19.1	5.9
4	Export volumes (X)	11.8	13.8	19.0	11.2	14.7	13.0
5	Import volumes (M)	10.8	13.1	21.4	15.2	15.1	14.8
6	Real GDP	11.2	13.5	21.5	12.7	16.4	3.8
7	Aggregate employment	-1.5	-2.0	2.7	5.5	2.2	-6.5
8	Ave real wage	20.1	25.0	29.5	12.9	24.2	18.8
9	Aggregate cap stock	8.2	8.8	15.0	10.3	12.9	2.1
10	GDP price index	6.3	6.4	6.2	5.3	7.2	7.2
11	Consumer price index (CPI)	4.1	4.1	3.7	3.9	4.8	5.1
12	Export price index	3.3	3.4	3.4	1.4	3.5	4.1
13	Import price index	3.2	2.6	1.4	1.5	3.7	0.9
14	Population	3.5	0.1	5.0	8.9	5.2	-0.8

Table 2 Derivation of GDP and employment forecasts for 2021-31(%)

		DK	FI	SE	NO	IS	RoE
(1)	GDP: 2001-11	8.5	19.1	26.2	15.7	26.5	11.6
(2)	GDP: 2011-21	19.3	7.5	20.6	17.2	29.5	9.1
(3)	Working-age pop: 2001-11	1.8	2.1	6.8	12.0	14.6	2.1
(4)	Working-age pop: 2011-21	2.3	-4.0	5.0	7.3	12.9	-1.4
(5)	Working-age pop: 2021-31	-1.3	-1.8	2.5	4.9	2.0	-5.9
(6)	Productivity growth:2001-11	6.6	16.6	18.1	3.3	10.4	9.3

(7)	Productivity growth:2011-21	16.6	12.0	15.0	9.2	14.7	10.6
(8)	Productivity growth:2021-31	11.6	14.3	16.5	6.3	12.6	10.0
(9)	GDP:2021-31	10.1	12.2	19.4	11.5	14.8	3.5
(10)	Total population: 2021-31	3.2	0.1	4.5	8.0	4.8	-0.7

Notes. For RoE we used data for the Euro area even though this includes some of the Nordic countries. Rows (1) and (2) are OECD data. Rows (3) and (4) are World Bank data and row (5) is a World Bank projection. Row (6) is derived from rows (1) and (3), and row (7) is derived from rows (2) and (4). Row (8) is the average of rows (6) and (7). Row (9) is derived from rows (5) and (8). For 2021-31 we assume that employment growth is the same as growth in working-age population. Row (10) shows World Bank total populations projections and is included in this table for convenience. These projections have no role in the derivation of the GDP and employment forecasts, but they do play a minor role in the baseline simulations.

(5) Total population in each nation moves in accordance with World Bank projections given in row (10) of Table 2 translated from 10 years to 11 years. We assume the same movement in the population-to-employment ratio for all regions in a nation.

(6) Prices of imports of goods and services to the Nordic plus RoE area (that is prices of imports from China, U.S. etc) move in the same way as the average prices of goods and services produced in Nordic plus RoE nations.

(7) Total factor productivity movements for 2019-2030 are determined in the baseline simulation by our assumptions for GDP, employment and rates of return on capital (which ties down the growth of capital stock). Around the national total-factor-productivity movements, we introduce broad sectoral detail. We assume that productivity growth in agriculture is high relative to manufacturing, which is high relative to utilities and mining, which is high relative to services.

(8) The world demand curves for European products move out at the rate of 3.5 per cent a year, reflecting world economic growth.

2.3. Main features of the macro forecasts

While the forecasts for GDP, employment, household consumption and public consumption are set exogenously or follow in a simple way from the assumptions listed in section 2.2, the forecasts for the other variables in Table 1 are determined endogenously in the Nordic-TERM model.

Under our assumption of fixed rates of return on capital and strong productivity growth consistent with that of the last 20 years (row 8 in Table 2), Nordic-TERM implies rapid growth in real wage rates (row 8, Table 1). With real wages growing and rates of return fixed, capital/labour ratios in all countries increase (compare rows 7 and 9, Table 1). This contributes to both wage and productivity growth.

Real household and government consumption (rows 1 and 3, Table 1) grow a little quicker than real GDP. However, despite the increase in capital/labour ratios, the percentage increase in investment in all countries is less than the percentage increase in GDP (compare rows 2 and 6). With consumption growing a little quicker than GDP and investment growing slower, growth in imports approximately matches growth in exports in all countries (rows 4 and 5).

2.4. Baseline forecasts for industry outputs

Table 3 presents baseline forecasts for percentage growth in output by industry and nation. Table 4 presents the same information but as deviations from aggregate national output, measured by growth in GDP. For example, in Table 3, growth in the output of Crops in DK is -4.3 per cent. In Table 4 we deduct GDP growth for DK (11.2 per cent, Table 1) so that the DK Crop entry becomes -15.5 (= -4.3 – 11.2).

Referring to Table 4, we see for all countries that Services of dwellings (industry 53), Health and social services (52), Public administration and defence (50), Accommodation and food (39) and Fishing & aqua (4) have above average output growth. Products 53, 52, 50 and 39 are non-traded and consumption-oriented (either private or public) and have high expenditure elasticities. Their elevated output growth reflects our macro forecast that growth in C & G will exceed growth in GDP, see Table 1. In our baseline, the consumer price of Fishing & aqua (product 4) falls relative to the CPI in all regions, inducing substitution towards this product. The fall in the relative price of the product is explained by two factors. First, the Fishing & aqua industry is among those we have assumed to have high total-factor productivity growth. Second, the Fishing & aqua industry is highly capital intensive. As mentioned in the discussion of Table 1, the cost of using capital falls relative to the cost of labour. This reduces the relative price of capital-intensive products.

Table 3 Baseline forecasts for output by industry and nation (% growth, 2019-30)

	DK	FI	SE	NO	IS	RoE
1 Crops	-4.3	2.5	0.7	13.7	2.8	2.1
2 Livestock	15.5	17.1	18.8	17.1	22.3	5
3 ForestryLogs	1.7	21.3	28.5	15.7	17.2	3.1
4 FishingAqua	16.5	26.8	23.2	17.2	22.6	9.8
5 Coal	NA	4.5	9.3	5.4	NA	1.7
6 Oil	16.5	10.9	12.1	9.5	NA	7.4
7 Gas	15.7	4.6	NA	9.5	NA	3.3
8 OthMining	5.2	8	23	4	3.6	-0.6
9 FoodBevTob	14	9.1	17.6	18	35.2	5.2
10 Textiles	2	1.8	14.6	9.3	22.6	-3.5
11 Apparel	10.2	-2.9	18.7	9.2	19	-4
12 LeatherPrd	5.8	9.4	9	13.8	-1.6	-2.1
13 WoodProds	-3	20.8	27.1	10.6	8	0.9
14 PaperProds	5	22.2	27.6	11.8	23.3	0.8
15 PetrolCoalP	13.1	13.4	19.9	16.7	13.1	9
16 ChemicalPrd	18.7	16.4	37.2	11.4	16.5	3.7
17 Pharmaceutic	26.7	14.8	40.1	10.6	26	5.8
18 RubberPlas	12.9	12	27.6	11.5	16.4	-0.4
19 NonMetMinPrd	4.1	9.5	18.6	12.8	10.2	1.4
20 FeMetals	-1.9	7.8	17.2	15.6	14	-0.1
21 NonFeMetals	-4.6	12.8	13.4	16	5	1.8
22 FabriMetals	3.1	7.3	16.9	6.7	6	-0.8
23 Computer &optics	6	6.9	27.3	13	3.9	-3.2
24 ElectricEqp	5.5	8.8	19.9	13.2	11.1	-2.2
25 MachineNEC	7.8	9.8	19.4	12.7	13.2	-1.4
26 MotorVehicle	1.4	6.6	22.5	14.7	11.5	3.5
27 OthTransEqp	-6.5	1.8	29.9	8.2	-10.7	0.9
28 FurnitRepair	6.5	10.1	18.8	12.7	15.8	-0.9
29 ElecCoal	6.3	6.3	NA	NA	NA	1.7
30 ElecGas	18.3	10	10.8	22.3	NA	7.3

31 ElecOther	20.5	5	20.9	25.4	NA	8.1
32 ElecHydro	NA	0.7	11.9	13.6	12.2	-10.4
33 ElecNuc	NA	19.5	36.4	NA	NA	3
34 ElecDist	11.8	12.3	23.1	14	12.2	3.5
35 GasSupDist	15.5	NA	18.7	14.1	NA	2.9
36 Water	11	14.3	21.7	13	15.3	3.9
37 Construction	7.9	10.6	17.6	11.1	12.5	2.5
38 Wholesale & retail	10.1	12	20.2	13.2	16.3	4.3
39 AccomFood	15.2	17.5	26.8	14.4	20.8	6.9
40 LandTransprt	9.3	12.1	20.4	13.1	12.6	3.7
41 WaterTrnsprt	12.8	10.4	20.3	13.8	11.4	5.3
42 AirTransport	14.2	13.8	18.9	13.9	17.1	8.6
43 Warehousing	10.2	12.2	20.6	14.3	11.6	3.6
44 Communication	9.5	10.6	17.8	11.4	15.5	2.7
45 Finance	10.7	12.3	20.4	14.4	14.9	2.4
46 InsurPension	2.3	11.5	19.6	12.5	14.8	2.8
47 RentLease	11.6	13.1	21	12.8	16.5	4.1
48 OthBusSrv	8.6	9.6	16	10.7	15	1.6
49 Recreation &per serv	11.7	11.3	18.7	12.3	10.7	2.4
50 PubAdm & defence	12.9	15.4	23.6	13.9	17.5	5.5
51 Education	8.6	12.8	20.8	12.3	11.6	2.9
52 Health &social serv	13.3	15.7	23.6	13.7	17	5.2
53 Services of dwellings	23.6	28.3	39	18.6	30.9	11.1

NA: Output is negligible industries in these cells

Table 4 Baseline: output by industry relative to GDP (% growth, 2019-2030)

	DK	FI	SE	NO	IS	RoE
1 Crops	-15.5	-11.0	-20.8	1.0	-13.6	-1.7
2 Livestock	4.3	3.6	-2.7	4.4	5.9	1.2
3 ForestryLogs	-9.5	7.8	7.0	3.0	0.8	-0.7
4 FishingAqua	5.3	13.3	1.7	4.5	6.2	6.0
5 Coal	NA	-9.0	-12.2	-7.3	NA	-2.1
6 Oil	5.3	-2.6	-9.4	-3.2	NA	3.6
7 Gas	4.5	-8.9	NA	-3.2	NA	-0.5
8 OthMining	-6.0	-5.5	1.5	-8.7	-12.8	-4.4
9 FoodBevTob	2.8	-4.4	-3.9	5.3	18.8	1.4
10 Textiles	-9.2	-11.7	-6.9	-3.4	6.2	-7.3
11 Apparel	-1.0	-16.4	-2.8	-3.5	2.6	-7.8
12 LeatherPrd	-5.4	-4.1	-12.5	1.1	-18.0	-5.9
13 WoodProds	-14.2	7.3	5.6	-2.1	-8.4	-2.9
14 PaperProds	-6.2	8.7	6.1	-0.9	6.9	-3.0
15 PetrolCoalP	1.9	-0.1	-1.6	4.0	-3.3	5.2
16 ChemicalPrd	7.5	2.9	15.7	-1.3	0.1	-0.1
17 Pharmaceutic	15.5	1.3	18.6	-2.1	9.6	2.0
18 RubberPlas	1.7	-1.5	6.1	-1.2	0.0	-4.2
19 NonMetMinPrd	-7.1	-4.0	-2.9	0.1	-6.2	-2.4
20 FeMetals	-13.1	-5.7	-4.3	2.9	-2.4	-3.9
21 NonFeMetals	-15.8	-0.7	-8.1	3.3	-11.4	-2.0
22 FabriMetals	-8.1	-6.2	-4.6	-6.0	-10.4	-4.6
23 Computer &optics	-5.2	-6.6	5.8	0.3	-12.5	-7.0
24 ElectricEqp	-5.7	-4.7	-1.6	0.5	-5.3	-6.0
25 MachineNEC	-3.4	-3.7	-2.1	0.0	-3.2	-5.2

26 MotorVehicle	-9.8	-6.9	1.0	2.0	-4.9	-0.3
27 OthTransEqp	-17.7	-11.7	8.4	-4.5	-27.1	-2.9
28 FurnitRepair	-4.7	-3.4	-2.7	0.0	-0.6	-4.7
29 ElecCoal	-4.9	-7.2	NA	NA	NA	-2.1
30 ElecGas	7.1	-3.5	-10.7	9.6	NA	3.5
31 ElecOther	9.3	-8.5	-0.6	12.7	NA	4.3
32 ElecHydro	NA	-12.8	-9.6	0.9	-4.2	-14.2
33 ElecNuc	NA	6.0	14.9	NA	NA	-0.8
34 ElecDist	0.6	-1.2	1.6	1.3	-4.2	-0.3
35 GasSupDist	4.3	NA	-2.8	1.4	NA	-0.9
36 Water	-0.2	0.8	0.2	0.3	-1.1	0.1
37 Construction	-3.3	-2.9	-3.9	-1.6	-3.9	-1.3
38 Wholesale & retail	-1.1	-1.5	-1.3	0.5	-0.1	0.5
39 AccomFood	4.0	4.0	5.3	1.7	4.4	3.1
40 LandTransprt	-1.9	-1.4	-1.1	0.4	-3.8	-0.1
41 WaterTrnsprt	1.6	-3.1	-1.2	1.1	-5.0	1.5
42 AirTransport	3.0	0.3	-2.6	1.2	0.7	4.8
43 Warehousing	-1.0	-1.3	-0.9	1.6	-4.8	-0.2
44 Communication	-1.7	-2.9	-3.7	-1.3	-0.9	-1.1
45 Finance	-0.5	-1.2	-1.1	1.7	-1.5	-1.4
46 InsurPension	-8.9	-2.0	-1.9	-0.2	-1.6	-1.0
47 RentLease	0.4	-0.4	-0.5	0.1	0.1	0.3
48 OthBusSrv	-2.6	-3.9	-5.5	-2.0	-1.4	-2.2
49 Recreation & per serv	0.5	-2.2	-2.8	-0.4	-5.7	-1.4
50 PubAdm & defence	1.7	1.9	2.1	1.2	1.1	1.7
51 Education	-2.6	-0.7	-0.7	-0.4	-4.8	-0.9
52 Health & social serv	2.1	2.2	2.1	1.0	0.6	1.4
53 Services of dwellings	12.4	14.8	17.5	5.9	14.5	7.3

NA: Output is negligible industries in these cells

All countries show below average output growth for Construction (37), Fabricated metals (22), Other business services (48), Communication (44), Education (51), Insurance and pensions (46), Electric-coal (29) and Coal (5). Construction (37), Fabricated metals (22), Other business services (48) and Communication (44) rely on investment for considerable fractions of their sales. Growth in these industries is damped because investment grows slower than GDP in all countries. In addition, the prices of Other business services and Communication rise relative to the general price level. This is mainly because these industries are among those for which we assumed low total-factor productivity growth.

Education (51) and Insurance and pensions (46) have low total-factor productivity growth. This makes them relatively expensive to consumers, inducing negative substitution effects.

Recall that the baseline includes no greenhouse policies. Consequently, the inclusion of Electric-coal (29) and Coal (5) in the list of industries with below average growth prospects in all Nordic countries is noteworthy. It implies that even without greenhouse policies, generation of electricity by coal combustion would be replaced by generation industries based on other methods. Coal electricity is labour intensive relative to other method of generating electricity. Thus, in our baseline, the cost of coal electricity rises relative to that of electricity generated by other methods.

For most products, growth prospects are above average (positive entry in Table 4) in some countries but below average (negative entry) in others. For example, Pharmaceuticals (17) has above average prospects in all Nordic countries except Norway. Ferrous metals (20) and Non-ferrous metals (21) on the other hand have above average prospects in Norway but below average prospects in all other countries. As can be seen from row 8 in Table 2, Norway has lower projected productivity growth than the other countries, leading to lower wage growth, row 8 Table 1. This means that the cost advantage enjoyed by capital-intensive industries such as Pharmaceuticals is muted in Norway compared with the other Nordic countries. Similarly, relatively labour-intensive traded-goods industries such as Ferrous metals and Non-ferrous metals gain an advantage in Norway relative to these industries in other Nordic countries.

Apart from labour and capital costs, differences in trade orientation can explain differences across the Nordic countries in baseline prospects for a given industry. Consider for example Wood products (13). This industry has above average prospects in Finland and Sweden. Both these countries have significant exports of Wood products to fast growing economies outside Europe. This is not the case for the Wood products industries in other Nordic countries.

Other transport equipment (27) is an industry in which both differences in primary-factor inputs and trade orientation are important in explaining differences in prospects across the Nordic countries. In Sweden, the industry has above average prospects, whereas it has below average prospects in the other countries. For Sweden, nearly half the industry's output is exported to countries outside Europe. The corresponding exports shares for the other Nordic countries are much lower. At the same time, the Swedish industry is capital intensive relative to its counterparts in the other Nordic countries.

2.5. Baseline forecasts for industry employment

Table 5 shows baseline employment growth from 2019 to 2030 by industry and nation. These employment projections follow in a mechanical way from the output projections in Table 3 and from our baseline sectoral productivity assumptions. For each of the five Nordic countries, very good fits are obtained in regression equations of the form

$$\text{emp(i,n)} = \alpha_0 + \alpha_1 * \text{output(i,n)} - \alpha_2 * \text{productivity(i)}, \; i \in \text{IND(n)} \qquad (2.1)$$

where

emp(i,n) is the baseline employment growth projection from Table 5 for industry i in nation n;

output(i,n) is the baseline output growth projection from Table 3 for industry i in nation n;

productivity(i) is productivity growth relative to aggregate productivity growth assumed for industry i, see point (7) in section 2.2;

IND(n) is the set of industries in nation n that have non-negligible output (we exclude the industries marked *NA* in Table 3 and Table 5; and

α_0, α_1 and α_2 are regression coefficients.

For the five Nordic countries, regression equation (2.1) gives R^2 values of between 0.89 and 0.96.

2.6. Baseline forecasts for employment by nation and region

The first row in each panel of Table 6 shows baseline employment forecasts. The national forecasts are taken from Table 1. In Table 6, national employment forecasts are disaggregated to NUTS2 regions. These regions are defined under the table and can be identified in the map. No disaggregation is given for Iceland. In Iceland there is only one NUTS2 region.

Table 5 Baseline forecasts for employment by industry and nation (% growth, 2019-30)*

	DK	FI	SE	NO	IS	RoE
1 Crops	-29.2	-25.6	-28.9	-9.2	-24.2	-21.1
2 Livestock	-12.0	-13.1	-13.9	-6.0	-6.9	-19.0
3 ForestryLogs	-24.1	-12.7	-9.9	-9.1	-11.3	-21.3
4 FishingAqua	-16.6	-8.9	-15.4	-10.1	-13.5	-20.8
5 Coal	NA	-21.0	-17.0	-8.7	NA	-13.5
6 Oil	-2.3	-11.7	NA	-3.2	NA	-9.5
7 Gas	-3.1	-21.3	NA	-3.2	NA	-13.7
8 OthMining	-10.7	-12.4	-3.1	-6.8	-12.8	-14.8
9 FoodBevTob	-6.4	-13.4	-9.2	0.7	5.6	-12.9
10 Textiles	-15.8	-18.5	-10.6	-6.5	-2.9	-19.4
11 Apparel	-9.8	-22.7	-8.5	-7.5	-8.2	-19.7
12 LeatherPrd	-12.5	-13.3	-11.5	-3.5	-22.0	-18.3
13 WoodProds	-19.6	-2.7	-1.0	-4.6	-12.5	-15.5
14 PaperProds	-13.5	-3.5	-2.0	-3.9	-4.5	-15.9
15 PetrolCoalP	-10.2	-12.4	-11.2	-1.9	NA	-11.2
16 ChemicalPrd	-5.5	-9.7	2.2	-6.0	-8.8	-14.5
17 Pharmaceutic	-0.2	-12.0	3.1	-7.4	-2.9	-13.4
18 RubberPlas	-8.0	-10.8	-2.1	-4.5	-7.3	-16.2
19 NonMetMinPrd	-13.7	-12.3	-7.8	-3.6	-9.9	-15.3
20 FeMetals	-18.3	-13.4	-9.2	-1.6	-9.1	-16.7
21 NonFeMetals	-20.3	-11.9	-12.1	-1.4	-16.8	-15.4
22 FabriMetals	-14.4	-13.8	-9.1	-8.1	-12.9	-16.5
23 Computer &optics	-13.5	-16.0	-3.4	-3.7	-15.9	-19.0
24 ElectricEqp	-13.4	-13.9	-8.1	-3.2	-11.1	-18.0
25 MachineNEC	-11.3	-12.9	-8.2	-3.5	-9.4	-17.1
26 MotorVehicle	-16.6	-14.4	-6.3	-1.5	-11.0	-13.6
27 OthTransEqp	-23.1	-17.7	-1.1	-6.3	-25.9	-15.2
28 FurnitRepair	-11.9	-12.9	-8.6	-3.0	-7.6	-16.9
29 ElecCoal	-10.2	-12.6	NA	NA	NA	-11.3
30 ElecGas	-1.6	-11.2	-13.6	7.4	NA	-7.6
31 ElecOther	0.3	-14.6	2.2	9.9	NA	-6.9
32 ElecHydro	NA	-17.8	-12.0	0.2	-6.4	-21.5
33 ElecNuc	NA	-4.2	5.3	0.0	NA	-11.5
34 ElecDist	-6.5	-8.8	-3.6	0.3	-7.1	-10.2
35 GasSupDist	-4.2	NA	-5.9	0.8	NA	-11.3
36 Water	-3.1	-2.8	1.5	2.3	-0.6	-7.9
37 Construction	-5.5	-6.2	-3.0	0.4	-2.3	-9.7
38 Wholesale & retail	1.0	-0.4	4.1	8.5	4.0	-3.5
39 AccomFood	6.6	5.7	11.4	10.2	9.4	-0.1
40 LandTransprt	0.6	0.3	3.8	7.4	2.9	-3.5
41 WaterTrnsprt	-0.1	-1.3	5.0	7.2	3.7	-3.7
42 AirTransport	4.6	-0.1	3.2	9.7	2.7	0.8
43 Warehousing	-0.1	-1.5	1.6	7.5	0.1	-4.6
44 Communication	-1.0	-2.9	0.4	5.5	0.8	-5.3
45 Finance	-0.3	0.5	3.4	6.9	1.2	-4.8
46 InsurPension	-4.8	-2.2	1.1	6.2	0.6	-5.1
47 RentLease	-1.2	-3.1	0.3	5.4	-0.1	-5.9
48 OthBusSrv	-0.5	-2.4	0.6	5.7	1.6	-5.2

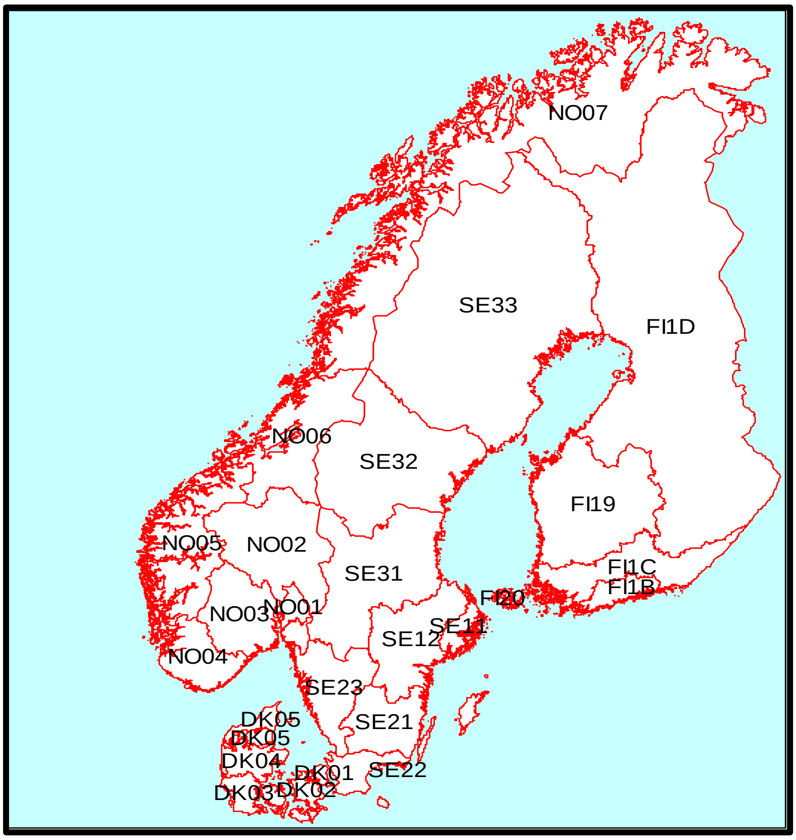
49 Recreation &per serv	1.4	-1.2	2.3	6.9	-0.5	-4.5
50 PubAdm & defence	4.4	4.0	9.4	9.2	7.5	-0.7
51 Education	1.7	3.3	8.8	8.7	3.8	-1.7
52 Health &social serv	6.1	5.9	11.3	10.1	8.7	0.4
53 Services of dwellings	6.6	7.1	11.8	9.1	11.1	-1.1

(1) *NA*: Output is negligible industries in these cells.

* The industries in Nordic-TERM are based on those used in the GTAP model, defined in https://www.gtap.agecon.purdue.edu/databases/contribute/detailedsector57.asp. However, we have made a few aggregations. For example. our industry 1, Crops, is an aggregation of the first 8 GTAP industries. We have also disaggregated the GTAP electricity generation industry into 5 generating industries (our industries 29-34).

Table 6 Baseline forecasts for employment, nations & regions: 2019-2030 (percent growth)

	Denmark	DK01	DK02	DK03	DK04	DK05			
Employment	-1.5	-0.8	-1.6	-1.9	-1.9	-2.0			
Dev from nation		0.7	-0.1	-0.4	-0.4	-0.5			
Ind. mix		1.1	0.0	-0.7	-0.7	-0.8			
Ind. growth		-0.4	-0.1	0.3	0.3	0.2			
	Finland	FI19	FI1B	FI1C	FI1D	FI20			
Employment	-2.0	-2.3	-1.5	-2.1	-2.3	-3.4			
Dev from nation		-0.3	0.5	-0.1	-0.3	-1.4			
Ind. mix		-0.6	0.6	-0.2	0.1	-0.6			
Ind. growth		0.3	-0.1	0.1	-0.4	-0.8			
	Sweden	SE11	SE12	SE21	SE22	SE23	SE31	SE32	SE33
Employment	2.7	2.8	2.5	2.0	2.3	4.0	2.2	1.6	1.8
Dev from nation		0.1	-0.2	-0.8	-0.4	1.3	-0.6	-1.1	-0.9
Ind. mix		0.4	0.2	-0.9	0.0	-0.1	-0.3	-0.4	-0.1
Ind. growth		-0.4	-0.5	0.2	-0.3	1.4	-0.2	-0.7	-0.8
	Norway	NO01	NO02	NO03	NO04	NO05	NO06	NO07	
Employment	5.5	6.0	5.1	5.2	4.4	6.1	5.2	5.3	
Dev from nation		0.6	-0.4	-0.2	-1.1	0.6	-0.2	-0.1	
Ind. mix		1.0	-0.3	-0.3	-1.1	-0.4	-0.1	0.6	
Ind. growth		-0.4	-0.1	0.1	0.1	1.0	-0.2	-0.8	



DK01	Hovedstaden
DK02	Sjælland
DK03	Syddanmark
DK04	Midtjylland
DK05	Nordjylland
FI19	West Finland
FI1B	Helsinki-Uusimaa
FI1C	South Finland
FI1D	North and East Finland
FI20	Åland
NO01	Oslo og Akershus
NO02	Hedmark og Oppland
NO03	Sør-Østlandet
NO04	Agder og RogÅland
NO05	Vestlandet
NO06	Trøndelag
NO07	Nord-Norge
SE11	Stockholm
SE12	Östra Mellansverige
SE21	Småland med öarna
SE22	Sydsverige
SE23	Västsverige
SE31	Norra Mellansverige
SE32	Mellersta Norrland
SE33	Övre Norrlan

The employment growth forecast for a region within a nation can differ from the national employment growth forecast for two reasons:

(1) the industrial composition of employment in the region differs from that in the nation; and

(2) growth rates for industries in the region differ from those for the corresponding industries at the national level.

We refer to (1) as the industry-mix effect. In calculating this effect, we assume that the growth rate for each industry at the regional level is the same as the industry's growth at the national level. Thus, a region has a positive industry-mix effect if it has relatively large shares of its employment in industries with strong employment growth at the national level and relatively low shares of its employment in industries with weak employment growth at the national level. By relative shares, we mean regional shares relative to national shares.

We refer to (2) as the industry-growth effect. In calculating this effect, we compare the employment growth forecast for a region with what it would have been if regional employment growth in each industry had been the same as the industry's national employment growth.

Mathematically, we can write the two effects for region r as:

$$\text{Ind-mix effect(r)} = \sum_{j \in \text{Ind}} \left[SR(j,r) - SN(j,n(r)) \right] * en(j,n(r)) \qquad (2.2)$$

and

$$\text{Ind-growth effect(r)} = \sum_{j \in \text{Ind}} SR(j,r) * \left[er(j,r) - en(j,n(r)) \right] \qquad (2.3)$$

where

SR(j,r) is the share of region r's employment accounted for by industry j;

SN(j,n(r)) is the share of employment in the nation to which r belongs accounted for by industry j;

er(j,r) is the percentage growth in employment in industry j in region r; and

en(j,n(r)) is the percentage employment growth in industry j in the nation to which r belongs.

The two effects are a complete decomposition of the deviation between the growth rate of employment in region r and the growth rate in employment in the nation to which r belongs:

$$\begin{aligned}
&\text{Ind-growth effect(r)} + \text{Ind-mix effect(r)} \\
&= \sum_{j\in Ind} SR(j,r) * [er(j,r) - en(j,n(r))] + \sum_{j\in Ind} [SR(j,r) - SN(j,n(r))] * en(j,n(r)) \\
&= \sum_{j\in Ind} SR(j,r) * er(j,r) - \sum_{j\in Ind} SN(j,n(r) * en(j,n(r)) \\
&= ertot(r) - entot(n(r))
\end{aligned} \tag{2.4}$$

where

ertot(r) is total employment growth for region r; and

entot(n(r)) is total employment growth in the nation to which r belongs.

The second row of results for each country in Table 6 shows the deviations between the regional and national growth rates in employment, and the third and fourth rows show the decompositions of these deviations into the industry-mix effects and industry-growth effects. For example, DK01 (Hovedstaden) has employment forecast growth that is 0.7 percentage points above that for Denmark as a whole [=(-0.8) – (-1.5)]. The deviation in DK01's forecast from the national forecast is decomposed into an industry-mix effect of 1.1 percentage points and an industry-growth effect of -0.4 percentage points. What this means is that from the point of view of employment, DK01 has a favourable mix of industries, but that DK01's industries have on average slightly lower employment growth rates than the corresponding industries at the national level.

From the Nordic-TERM database, we find that DK01 has a relatively high share of its employment in public administration and relatively low shares in manufacturing and agriculture. This produces a positive industry-mix effect (1.1 percentage points) because baseline employment growth in public administration is high for Denmark whereas baseline employment in manufacturing and agriculture is low. In the case of public administration, output grows broadly in line with Denmark's GDP, but measured productivity growth is low, giving the industry high employment growth. In the cases of manufacturing and agriculture, baseline output growth in Denmark is below that of GDP and productivity growth is relatively high, giving these two sectors low employment growth.

We traced the negative industry-growth effect for DK01 (-0.4 percentage points) to wage rates. Baseline wage rates in DK01 rise slightly faster than in the other regions of Denmark. This reflects DK01's relatively favourable employment situation (-0.8 per cent compared with growth between -1.6 and -2.0 per cent in the rest of Denmark). Higher wage growth in DK01 reduces the competitiveness of DK01's industries, giving them on average lower growth rates than the corresponding industries in other Danish regions.

While for DK01, the industry-mix effect is the dominant contributor to the gap between the region's employment growth and that of the nation (1.1 compared with -0.4), for other regions the industry growth effect is dominant. For example, in SE23 (Västsverige) the industry-growth effect is large (1.4 percentage points) whereas the industry-mix effect is small (-0.1 percentage points). We found that exports of commodities to the rest of the world leaving Sweden from ports in SE23 are nearly half the size of SE23's economy. This is a much larger fraction than for any other Nordic region. In our baseline, non-European trade partners have high rates of growth relative to Europe. This gives enhanced growth prospects to industries in regions such as SE23 that rely directly or indirectly on trade with non-European partners.

Among all the Nordic regions, FI20 (Åland) has the lowest baseline employment growth (-3.4 per cent) and the largest absolute gap between its employment growth and that of its nation (1.4 percentage points). Both the industry-mix effect and the industry-growth effect are negative for FI20 (-0.6 and -0.8).

FI20 scores a negative industry-mix effect because it has low employment shares for Public administration & defence (ind 50) and Health &social services (ind 52), both of which have strong employment growth at the national level. At the same time FI20 has high employment shares for Construction (ind 37) and various manufacturing industries such as Food & beverages (ind 9) and Other transport equipment (ind 27), all of which have strongly negative employment growth at the national level.

Most industries in FI20 exhibit less growth than the corresponding industries in the rest of Finland, giving FI20 a negative industry-growth effect. Industry growth in FI20 is negatively affected by weak private and public consumption associated with the region's unfavourable industry-mix. As we have seen in the discussion of SE23, an unfavourable industry-mix effect does not guarantee a negative industry-growth effect. However, unlike the situation for SE23, in the case of FI20 trade links are not sufficient to overcome the negative effects of damped local consumption demand.

2.7. Baseline forecasts for CO2 emissions

Table 7 gives data on CO2eq emissions in Nordic countries in 2019. In all these countries, combustion of Petroleum & coal products, mainly in truck and car transport, accounts for an important part of total emissions. This justifies the focus of the Nordic countries on de-carbonizing the road transport sector.

In 2019, burning coal was still a significant source of emissions for Nordic countries. In FI and DK, coal was burnt primarily in the generation of electricity (ind 29, ElecCoal). In the other countries coal was used in various industrial processes such as metals production.

Burning gas is important in electricity generation for FI and IS. In NO and SE, gas is an input to industries such as chemicals, metals production and production of petroleum and coal products. In DK, gas is burnt by households and in industrial processes.

FI, SE and NO use forests for carbon sequestration, giving them negative entries in Table 7 in the forestry & land row. For DK and IS the entries in this row are positive indicating carbon-releasing changes in forestry activities and land use. The "other" row in Table 7 refers to emissions from non-combustion activities such as: emissions produced in agriculture by livestock and soil disturbance; fugitive emissions, such as methane emissions from open-cut coal mines; emissions produced from manufacturing processes, e.g. manufacture of cement; and waste emissions, including methane from the breakdown of solid wastes.

In our modelling, we calculate input emission coefficients (emissions per unit of use of coal, gas, petroleum & coal products) and output emission coefficients (emissions from output activities by industries). This gives us a basis for projecting effects on emissions of growth in output by industries and consumption by households. We also use emission coefficients for estimating the effects on emissions of policies that change the composition of inputs to industries and the commodity composition of consumption e.g. substitution of bio-materials for fossil materials in production of motor fuels, and the substitution of electricity for motor fuels by households.

The source for our emissions data and the technicalities of our emission modelling are set out in Appendix 3.

Table 8 projects Table 7 forward to 2030 under baseline assumptions. These include the assumption that there are no greenhouse policies beyond those already in place in 2019. As can be seen from Table 7 and Table 8, we assume no change in emissions from forestry and land use. However, emissions from other sources increase with output and consumption activities. Baseline percentage increases in emissions between 2019 and 2030 deduced from the "Total" rows of Table 7 and Table 8 are shown in Table 9.

The "Total" rows in Table 7 and Table 8 and the percentage changes in Table 9 refer to emissions including those from forestry and land use, somewhat confusingly called net emissions. When emissions from forestry and land use are excluded, the resulting measure is referred to as gross emissions. Table 10 shows baseline percentage growth in both net and gross emissions and compares these projections with baseline GDP growth.

With no new greenhouse policies included in the baseline, growth in gross emissions is broadly in line with GDP growth in all Nordic countries. However, when emissions from forestry and land use are included (net emissions), we see that baseline CO2eq net emission growth for SE far exceeds baseline GDP growth. For IS the reverse is true.

SE has large negative CO2eq emissions from its Forestry activities (see Table 7). We assume no change in these emissions. SE's emissions from other sources grow approximately at the rate of GDP. With no change in the large negative contributor to SE's total emissions and positive growth in the other contributors, SE's net CO2 emissions show a very large positive percentage increase.

In the case of IS, most of the emissions are from land use. We assume in the baseline that this is constant. Emissions from other sources grow approximately in line with GDP, leaving net emissions for IS with low growth relative to GDP.

Table 7 CO2eq. emissions (Kt) for 2019

	DK	FI	SE	NO	IS
Combustion of					
Coal	3588	15250	8098	4085	685
Gas	6012	4314	1775	13707	0
PetrolCoalPrds	20146	19267	24545	15953	996
Activity in					
Forestry & land	2893	-13590	-36736	-16436	9020
Other	14491	13905	16393	17330	3031
Total (net)	47130	39146	14075	34639	13732

Table 8 CO2eq. emissions (Kt) for 2030 without new policies: baseline

	DK	FI	SE	NO	IS
Combustion of					
Coal	3819	16660	9751	4649	781
Gas	6964	4830	2239	15664	0
PetrolCoalPrds	22685	21796	29872	18206	1145
Activity in					
Forestry & land	2893	-13589	-36737	-16438	9020
Other	15729	15534	19437	19748	3364
Total (net)	52090	45231	24562	41829	14310

Table 9 Percentage change in net CO2eq. emissions between 2019 and 2030: baseline

	DK	FI	SE	NO	IS
%change 2019-30	10.5	15.5	74.5	20.8	4.2

Table 10 Baseline forecasts for CO2eq. emissions and Real GDP (%, 2019-2030)

	Net co2 eq.*	Gross co2 eq**	Real GDP
DK	10.5	11.2	11.2
FI	15.5	11.5	13.5
SE	74.5	20.6	21.5
NO	20.8	14.1	12.7
IS	4.2	12.3	16.4

* Includes forestry and land use

** Excludes forestry and land use

3. Detailed modelling to facilitate the setting of policy shocks

3.1. Introduction

This section describes how we formulated the policy shocks, making clear the assumptions we have made and identifying the data sources on which we have relied.

The main information sources for modelling climate policies in the Nordic countries are national reports (referenced at the foot of Table 11). Policy targets and some of the measures Nordic countries are adopting are reported in a broadly comparable fashion by their governments' progress reports and action plans to the EU. These reports are updated every three years. We used data from the reports for 2019. These were the most recent reports when we started this project. The national reports differ in level of detail. For example, the Danish report contains a very detailed annex covering economic and energy assumptions, as does the Finnish report, which however relies more on referring to research reports. What is common to the reports is that the detail on policy targets is richer than the detail on policy measures.

3.2. Biofuels

3.2.1. Biofuel targets in diesel blends

This section describes the assumptions and calculation methods used to estimate the biofuel targets for diesel fuels, as well as the effects of biofuel targets on costs of motor fuels reported on Table 11 below, also included in the Main Report.

The first two columns in Table 11 show the actual share of biofuels in motor fuels in 2020 (column 1), and the target for 2030 (column 2), as it was defined in 2020. The formulation of the blending target varies between the Nordic countries. For most of them, the biofuel blending target was expressed in terms of biofuel share in motor fuels. One exception was Sweden, where the target was expressed separately for petrol and diesel in the 2018 law.

As explained in Section 3.2.4 below, we calculated implied biofuel targets for diesel fuels, assuming no increase in bio-shares in gasoline for all countries except Sweden, for which we increased the gasoline bio share from 12 per cent to 28 per cent. The results of these calculations are in columns (3) and (4) of Table 11. The 2020 shares and the targets for 2030 expressed in terms of bio shares for diesel are not much different from the bio shares expressed in terms of motor fuels, that is, columns (3) and (4) are similar to columns (1) and (2).

Table 11 Calculation of % increases in Motor fuel costs in 2030

	Bio fuels % in motor fuels		Bio fuels % in diesel		Cost of diesel blend in 2030		Diesel blend	Diesel share in passenger-car motor fuel use	Car fuels used by H'hlds	Average over all motor fuels
	2020	Target 2030	2020	Target 2030	with baseline shares	with target shares	% price rise, 2030		% price rise, 2030	% price rise, 2030
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Denmark	6	7	5.39	6.49	0.675	0.688	1.961	0.29	0.49	1.77
Finland	11.7	30	11.66	32.16	0.750	0.996	32.803	0.29	8.89	29.19
Sweden	23	63	23.88	66.00	0.897	1.402	56.404	0.38	36.53	54.02
Norway	20	30	20.30	30.69	0.854	0.978	14.592	0.56	8.29	14.07
Iceland	7.6	8	7.02	7.47	0.694	0.700	0.783	0.33	0.23	0.69

Biofuel percentages in 2020 and targets for 2030

Denmark: Denmark's Integrated National Energy and Climate Plan under the Regulation of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action. Denmark's Ministry of Climate, Energy and Utilities, December 2019. Rapport (kefm.dk)

Finland: Integrated Energy and Climate Plan. Publications of the Ministry of Economic Affairs and Employment Energy 2019:66. Finland's Integrated Energy and Climate Plan (europa.eu)

Norway: National Plan related to the Decision of the EEA Joint Committee No. 269/2019 of 25. Norwegian Ministry of Climate and Environment, October 2019. national-plan-2030_version19_desember.pdf (regjeringen.no) and Climate Action Plan for 2021–2030. Norwegian Ministry of Climate and Environment, Meld St. 13 (2020–2021) (regjeringen.no)

Sweden: Integrated National Energy and Climate Plan. The Ministry of Infrastructure, 2020. se_final_necp_main_en_0.pdf (europa.eu)

Iceland: 2020 Climate Action Plan. Ministry for the Environment and Natural Resources. 201004 Umhverfisraduneytid Adgerdaaaetlun EN V2.pdf (government.is).

3.2.2. Effect of biofuel targets on costs of motor fuels

Biofuels cost more than energy-equivalent quantities of fossil fuels. We assume that the cost in 2030 of bio-diesel per litre is 1.81 euro and the cost of an equivalent amount of fossil diesel is 0.61 euro[1]. Thus, the adoption of higher bio shares in diesel fuels will increase their costs in 2030 relative to what these costs would have been if the bio shares remained at their 2020 levels. We calculate the percentage cost increase in 2030 resulting from the bio targets according to:

$$\%\text{ increase in cost of blended diesel in 2030 } = 100 * \left[\frac{(1-s_{2r})*0.61 + s_{2r}*1.81}{(1-s_{1r})*0.61 + s_{1r}*1.81} - 1 \right] \qquad \text{(A1.3.1)}$$

where

s1r is the *baseline* biofuel share in diesel in country r [0.0539 in Denmark, for example, see col (3), Table 11];

s2r is the *target* or policy biofuel share in diesel in country r [0.0649 in Denmark, see col (4), Table 11]; and

1.81 and 0.61 are the assumed costs of bio-diesel per litre and an equivalent amount of fossil diesel.

The calculation of the prices of blended diesel with the initial and target shares are shown in columns (5) and (6) of Table 11. The percentage price increases for blended diesel in 2030 calculated according to (A1.3.1) are shown in column (7) of Table 11. These price increases apply to all motor fuel used by the transport sector in each country.

Increases in the cost of *blended diesel fuels* will also affect the average cost of motor fuels to households in each of the Nordic countries. In calculating the percentage effect on fuel prices for the passenger-car fleet, we assume that the cost of *petroleum blends* in 2030 will be 0.82 euro per litre, the same as its cost in 2020. We calculate the percentage increase in fuel cost for passenger cars as:

$$\%\text{ increase in ave cost of motor fuel to households in country r}$$

$$= 100 * \left[\frac{(1-h_r)*0.82 + h_r * \text{pdiesel}(2030)}{(1-h_r)*0.82 + h_r * \text{pdiesel}(2020)} - 1 \right] \quad \text{for } r \neq \text{SE} \qquad \text{(A1.3.2a)}$$

and

[1] Costs of biofuels are estimated on the basis of a recent study by AFRY: Esa Sipilä, Henna Poikolainen, Anna Lilja, Taneli Rautio and Nils-Olof Nylund (2021): Increasing the level of distribution obligation in road transport. Prime Minister's Office, VN/13807/2021. (in Finnish, but including a summary in English) Liikenteen_jakeluvelvoitetason_nosto (valtioneuvosto.fi).

% increase in ave cost of motor fuel to households in Sweden

$$=100*\left[\frac{(1-h_{SE})*1.01+h_{SE}*\text{pdiesel}(2030)}{(1-h_{SE})*0.82+h_{SE}*\text{pdiesel}(2020)}-1\right] \qquad \text{(A1.3.2b)}$$

where

h_r is the share of country r's internal-combustion passenger-car fleet accounted for by diesel cars, assumed to be the same in 2020 and 2030, see column (8) of Table 11;

0.82 is the cost of blended petroleum used in passenger vehicles for all countries in 2020 and in all countries except Sweden in 2030;

1.01 is the cost of blended petroleum used in passenger vehicles in Sweden in 2030, taking account of Sweden's increased bio-blending target for 2030[2];

pdiesel(2020) is the price of blended diesel in 2020 (same as the baseline price in 2030);

and

pdiesel(2030) the price of blended diesel in 2030 with increased bio shares.

The two diesel prices are calculated in columns (5) and (6) of Table 11.

Column (9) of Table 11 shows the percentage increases in the average cost of motor fuels to households in each country calculated according to (A1.3.2a&b). We assume that the national percentage cost increase applies to the regions within a country.

Column (10) of Table 11 shows the cost increase for motor fuels in 2030, averaged across industries and households, caused by the adoption of the bio fuel targets. In calculating these averages, we applied shares from the Nordic-TERM database to the price increases in columns (7) and (9) in Table 11.

We assume that all motor fuels (fossil-based and renewable) are produced in a single Nordic-TERM industry, Petroleum and coal products. The coal component of this industry is negligible – we will refer to the industry simply as Motor fuels. We impose the price increases for Motor fuels from column (10) of Table 11 on the Motor fuels industry through a "technological deterioration" that causes an increase in inputs per unit of output. Then we introduce the different price increases for industries and households [columns (7) and (9)] through phantom taxes/subsidies.

3.2.3. Inputs to the Motor fuels industry

Here we describe the shocks that we applied in Nordic-TERM to simulate the switch from Oil to renewable materials in the Motor fuels industry.

With a switch towards biofuels, the Oil input to Motor fuels per unit of output will fall and the input of materials from agriculture and forestry will rise. We assume that with the achievement of the biofuel targets in columns (1) and (2) of Table 11, the percentage reductions in oil input per unit of output in motor fuels will be in line with the percentage reduction in the non-bio shares of motor fuels. Our calculations are shown in Table 12. For DK, for example, the reduction is 1.1 per cent [= 100*((1-7/100)/(1-6/100)-1)].

[2] We calculated the cost of blended petrol for Sweden in 2020 as $1.01 = 0.82 + (0.28 - 0.12)*(1.81 - 0.61)$.

Table 12 Calculating the % change in oil per unit of output of motor fuels

	Bio fuels % in motor fuels (see col 1&2, Table 11) 2020	Target 2030	% change in oil content
Denmark	6	7	-1.1
Finland	11.7	30	-20.7
Sweden	23	63	-51.9
Norway	20	30	-12.5
Iceland	7.6	8	-0.4

For Denmark, we assume that Oil displaced by biofuels in 2030 is replaced by products from the Crops industry. For the other Nordic countries, we assume that the replacement materials are supplied from the Forestry industry. Initially, we assumed that the replacement of Oil per unit of output of motor fuels was with biomaterials of equal value. But this caused difficulties in simulating the cost increases for Motor fuel implied by Table 11: too much cost increase concentrated on too small a share (the non-oil, non-bio share) of Motor fuel inputs. This led us to assume that replacement of Oil was with biomaterials worth 1.5 times the value of the replaced Oil. With substantial increases in demands for the products of the Crops and Forestry industries, Nordic-TERM generates increases in the prices of these products. The model then indicates that part of the demand increases will be satisfied by increased imports and diversion of exports back onto the domestic market.

3.2.4. Translating bio shares for motor fuels into bio shares for diesel

The motor-fuel bio share (MFBioSh) for each country is given by

$$\begin{aligned}\mathrm{MFBioSh} = {} & \mathrm{SS_I} * \mathrm{DieselBioSh} \\ & + \mathrm{SS_H} * \mathrm{DieselCarSh} * \mathrm{DieselBioSh} \\ & + \mathrm{SS_H} * (1 - \mathrm{DieselCarSh}) * \mathrm{GasolineBioSh}\end{aligned} \qquad \text{(A1.3.3)}$$

where

SS_I and SS_H are the shares of the sales of Motor fuels that go to industries (mainly the transport industries) and households;

DieselBioSh is the renewable share in diesel fuels;

DieselCarSh is the share of the combustion-engine passenger fleet that uses diesel fuel; and

GasolineBioSh is the renewable share in gasoline fuels.

In (A1.3.3), we assume that motor fuels supplied to industries are entirely diesel, whereas households use both diesel and gasoline in the passenger-car fleet.

Rearranging (A1.3.3) we obtain:

$$\text{DieselBioSh} = \frac{\text{MFBioSh} - \text{SS}_H * (1 - \text{DieselCarSh}) * \text{GasolineBioSh}}{\text{SS}_I + \text{SS}_H * \text{DieselCarSh}} \quad \text{(A1.3.4)}$$

Values for SS_I and SS_H can be deduced from the Nordic-TERM database. For DieselCarSh, we use the values shown in column (8) of Table 11 for both 2020 and 2030. For GasolineBioSh, we use 0.12 for all countries in 2020 and 2030, except Sweden in 2030 for which we assume 0.28. Then, we evaluate the right-hand side of (A1.3.4) with MFBioSh set according to the numbers in columns (1) and (2) of Table 11. This reveals DieselBioSh for each country in 2020 (column 3) and the targets for 2030 (column 4).

3.3. Electric vehicles (EV)

3.3.1. EV targets

The approximate targets for increasing the share of electric vehicles (EVs) in passenger car fleets are given in Table 13. There is an explicit target for growth in the number of EVs in only two of the Nordic countries. The Danish target is to have 775,000 EVs on the road by 2030[3], whereas Finland is targeting 750,000. These targets imply an increase of 23.1 percentage points in the share of EVs in Denmark and 24.0 percentage points for Finland.

Table 13 Targets for sales of electric vehicles and effect on household motor fuel consumption in 2030

	EV share 2020-2030 (%)	Policy	Policy induced % change in 2030 in H'hld consumption of motor fuels
Denmark	1.9 ->25.0	775000 EV target	-23.5
Finland	2.0 ->26.0	750000 EV target	-24.8
Sweden	6.2->48.1	60% EV sales share	-44.6
Norway	22.1 -> 62.2	70% EV sales share	-51.5
Iceland	4.6-> 47.4	60% EV sales share	-44.9

Sources:
2020 EV shares
Finland: Cars by driving power by Traffic use, Vehicle class, Year, Driving power and Information. PxWeb (stat.fi)
Denmark: Means of transport population - Statistics Denmark (dst.dk)
Norway: landtransport (ssb.no) Also IEA, Private car fleet in Norway by type of fuel, 2016-2021, IEA, Paris https://www.iea.org/data-and-statistics/charts/private-car-fleet-in-norway-by-type-of-fuel-2016-2021, IEA. License: CC BY 4.0
Sweden: Fordonsstatistik - Transportstyrelsen
Iceland: Vehicles - Statistics Iceland (statice.is)
2030 targets
Denmark: https://www.reuters.com/article/us-denmark-climatechange-autos-idUSKBN28E23O on Danish government targeting 775000 EVs.
Finland: Hiilineutraali Suomi 2035 – ilmasto- ja energiapolitiikan toimet ja vaikutukset (HIISI), Synteesiraportti – Johtopäätökset ja suositukset (valtioneuvosto.fi)

[3] The Danish parliament declared a more ambitious target of a million EVs in 2020 but thus far there are policies in place for supporting the earlier government target of 775000 EVs by 2030.

Sweden: Sweden's Country report to UNFCCC 2021. Emissions from diesel cars reduced by 21 % from 2010 in the year 2020, target a reduction of 66% by 2030; thus, reduction of 43% from 2020. From this and the share of diesels in 2020 it is possible to derive the biofuel blending target. [Sweden's long-term strategy for reducing greenhouse gas emissions (unfccc.int)](#)
Norway's Climate Action Plan for 2021–2030. Norwegian Ministry of Climate and Environment, [Meld St. 13 (2020–2021) (regjeringen.no)](#)

For the other Nordic countries, we assume that EV shares in total sales of passenger cars in each year from 2020 to 2030 will be in line with current expectations: 70 per cent in Norway and 60 per cent in Sweden and Iceland. As explained in Section 3.3.6 below, these sale-share assumptions combined with assumptions concerning scrapping rates for cars imply growth in the EV share of the Norwegian passenger car fleet from 22.1 per cent in 2020 to 62.2 per cent in 2030. For Sweden and Iceland, the EV shares grow from 6.2 per cent to 48.1 per cent and from 4.6 per cent to 47.4 per cent.

3.3.2. Household consumption of motor fuels

As shown in the last column of Table 13, we assume that household consumption of motor fuels declines in line with the increase in the EV share of the passenger car fleet. Thus, for example, we assume that EV policies in Denmark mean that household consumption of motor fuels in 2030 will be 23.5 per cent lower because of the EV policy than it would be without the policy [-23.5 = 100*((1-25.0/100)/(1-1.9/100)-1)]. We assume that this 23.5 per cent reduction applies to all NUTS2 regions in DK. Similarly, for the other Nordic countries, we assume that the national reductions in household consumption of Motor fuels in 2030 apply in all regions.

3.3.3. Household demand for electricity

Increases in the numbers of electric vehicles imply increases in the demand for electricity by households. In terms of pure energy, electricity demand does not have to increase in the same proportion as the reduction in demand for Motor fuels. As noted in guidelines published by the Finnish Transport authority (TrafiCom), the cost of driving a car in the compact class one hundred kilometers is about 12.5 euros with fossil fuels but only about 4.5 euros with electricity. This is because electric motors are much more energy efficient than combustion engines. A combustion engine is able to turn roughly a third of the energy content of motor fuels into motion, whereas an electric motor scarcely wastes any energy stored in the battery. Moreover, EVs are able to capture some of the energy lost in braking. Consequently, the increase in the demand for electricity in energy terms is only about a third of that in the replaced motor fuels. Taking the one-third principle into account, together with the baseline (no policy) levels of household electricity consumption, we calculated that EV policies would increase electricity consumption in 2030 at national levels by the percentages shown in Table 14. The percentage shocks applied at the regional level to capture the increases in household electricity consumption varied from the national percentages shown in Table 14. This reflects differences across regions within a country in the shares of total consumption accounted for by Electricity and Motor fuels: regions with a relatively high electricity share and a low motor-fuel share in the baseline solution for 2030 needed a relatively low percentage shock to their electricity consumption to account for replacement of motor fuels by extra electricity.

3.3.4. Cost of home charging stations

As households acquire EVs, they will also need to install home charging stations. The current price of a standard 21 KW station is around 1000 euros. To have it installed costs an additional 1100 euros (estimate from Finland applied to the other Nordic countries). We assume one home charging station per EV. Using 2100 euro and the increase in the number of the EVs gives a rough estimate of the extra cost to households over the period 2020 to 2030 of installing charging stations to accommodate extra EVs. These estimates are given in Table 15, calculated as the increase in EVs times 2100.

Our simulations are concerned with how greenhouse policies affect the Nordic economies of 2030. Consequently, we require an estimate of the cost to households in 2030 of charging stations, not the total cost between 2020 and 2030. To obtain the cost in 2030, we divide the total cost by 10. We assume that the resulting number (e.g. 153m euro for Denmark) is extra expenditure that households are required to make in 2030 on electrical equipment. In allocating the national cost of charging stations to regions within a country, we used regional shares in baseline 2030 household consumption of motor fuels. These shares are a proxy for regional shares in the passenger car fleet, and therefore a proxy for regional shares in the national purchase of EVs.

3.3.5. Prices of EVs

We considered the prices of EVs. Initially these were considerably higher than those of equivalent combustion-engine cars. However, the price of EVs is fast approaching the price of combustion-engine cars. Most industry commentators predict that price equality between EVs and internal combustion vehicles will be achieved around 2025. This seems to be the view of many car manufacturers as well; for example, the CEOs of both VW Group and Volvo have recently shared the above prediction[4]. Some of the Nordic countries are already reducing the subsidization of EVs. In our simulations, we assume that the prices of EVs in 2030 are similar to those of the cars that they replace.

Table 14 EV-related % increase in household electricity consumption in 2030

Denmark	3.32
Finland	2.60
Sweden	2.98
Norway	7.87
Iceland	1.66

Table 15 Calculating extra household expenditures on charging stations

	EVs 2020	EVs 2030	Total cost 2020-30 M€	Cost in 2030, M€
Denmark	48617	775,000	1,525	153

[4] Volkswagen foresees EV price parity with ICE by 2025, 50% EV sales by 2030 - CNET
Volvo CEO's bold prediction: EV-ICE price parity by 2025 | Automotive News (autonews.com)

Finland	55,275	750,000	1,459	146
Sweden	308485	2,915,013	5,474	547
Norway	612136	2,067,528	3,056	306
Iceland	11,988	149,286	288	29

3.3.6. Calculating the EV share of the car fleet

In forming the entries for Denmark and Finland in the first column of Table 13 we deduced the EV shares for 2030 in their passenger car fleets by comparing the explicit EV targets with estimates of the total sizes of their passenger car fleets.

For Norway, Sweden and Iceland, we deduced EV shares for 2030 in their passenger car fleets from assumptions concerning EV shares in annual sales of passenger cars from 2020 to 2030.

To make the link for these three countries between annual EV sales and the EV share in the stock of passenger cars in 2030, we started by assuming that the total stock of cars (internal combustion and EV) at the beginning of year t, S(t), is given by:

$$S(t) = \sum_{\tau=0}^{L} N(t-\tau) * Z(\tau) \quad \text{for t= 2020, 2021, ...} \qquad (A1.3.5)$$

where

N(t-τ) is new cars purchased in year t-τ. For convenience, we assume that all purchases take place at the start of the year.

S(t) refers to the stock at the start of year t.

L is the maximum life of a car, assumed to be 20 years.

Z(τ) is the survival fraction for cars of age τ. The values we have adopted are contained in Table 16. We assume that all cars purchased in the current year and each of the previous 4 years are still on the road (survive). Of the cars purchased 5 years earlier, 93.75 per cent survive to the current year, etc. The survival rates in Table 16 imply an average road life for cars of 12.5 years.

Table 16 Longevity of passenger vehicles

Age (years)	Survival fraction, Z(τ)	Age (years)	Survival fraction, Z(τ)
20	0	9	0.6875
19	0.0625	8	0.75
18	0.125	7	0.8125
17	0.1875	6	0.875
16	0.25	5	0.9375
15	0.3125	4	1
14	0.375	3	1
13	0.4375	2	1
12	0.5	1	1
11	0.5625	0	1
10	0.625		
		Average life	12.5 years

For Norway, Sweden and Iceland, we assume that car sales grew at 2 per cent a year from the start of 2000 to the start of 2020 and that this growth rate continues to the start of 2030.

We adopt an equation similar to (A1.3.5) for the stock of EVs:

$$SEV(t) = \sum_{\tau=0}^{L} NEV(t-\tau) * Z(\tau) \text{ for t= 2020, 2021, ...} \quad (A1.3.6)$$

where

NEV(t-τ) is new EV cars purchased at the start of year t-τ; and

SEV(t) is the stock of EVs at the start of year t.

We assume that there are no EV purchases before 2016. At the start of each of the years 2016, 2017, 2018, 2019 and 2020, we assumed that NEV(t) is $1/5^{th}$ of the EV stock in existence at the start of 2020. Thus, we chose NEV(t) for these 5 years for Norway to imply an EV stock in 2020 of 22.1 per cent (see Table 13) of Norway's total passenger fleet. For Sweden and Iceland, we chose the NEV(t)s for 2016-2020 to imply EV stocks in 2020 of 6.2 and 4.6 per cent of their total passenger fleets.

Finally, we assume that the EV policy in Norway is implemented by setting the EV fraction of sales for each year from 2021 onwards at 70 percent (see Table 13). For both Sweden and Iceland, we assume 60 per cent. Given these percentages, and the assumed paths for total sales, we can calculate the future paths for EV sales according to:

$$NEV(t) = F\_EV(t) * N(t) \text{ for t= 2021, ...} \quad (A1.3.7)$$

where

F_EV(t) is the annual target share for EV sales.

We then apply (A1.3.5) and (A1.3.6) to calculate total stocks of passenger vehicles in 2030, S(2030), and EV stocks in 2030, SEV(2030). These calculations give the EV policy shares shown in Table 13: 62.2 per cent for Norway; 48.1 per cent for Sweden; and 47.4 per cent for Iceland.

3.4. Electricity generation sector

We assume that by 2030 the use of coal in power generation will have almost entirely disappeared. We simulate this by scrapping 90% of the capital (and also investment) in Nordic-TERM's ElecCoal industry. We make a corresponding reduction in the aggregate capital stock of the nation. In our simulations, Coal electricity is replaced endogenously by low or zero-carbon alternatives.

3.5. Measuring the welfare effect of the greenhouse policies

Households choose their consumption vector in year t to maximize utility subject to budget constraint. Their utility function takes the form:

$$U = U\left(\frac{X_1}{B_1}, \ldots, \frac{X_n}{B_n}\right) \quad \text{(A1.3.8)}$$

where

X_i is household consumption of commodity i; and

B_i is a preference variable. Increases in B_i mean that a given level of consumption of i generates less utility.

The parameters of the U function vary across household types, but for simplicity, in (A1.3.8) we suppress the subscripts that identify household type.

In we use movements in the B_is to capture the effects of increased expenditure by households on electrical equipment and electricity and reduced expenditure on petroleum products associated with the uptake of EVs. But we don't want EV-related changes in expenditure levels (changes in X_is) to generate utility. For example, if expenditure on electrical equipment needs to increase by 25 per cent because of the installation of charging stations, then a 25 per cent increase in $X_{ElecEquip}$ should generate no additional utility. Apart from a second-order problem, we meet this requirement in (A1.3.8) with $B_{ElecEquip}$ moving from 1 in baseline to 1.25 in policy. The second-order problem is that the $B_{ElecEquip}$ value of 1.25 should not be applied the movements in $X_{ElecEquip}$ that reflect adjustments in consumption of electrical equipment apart from the required charging stations. However, this is a second-order effect that is ignored in our computations.

Table 17 Gross[1] CO2eq emissions: baseline; policy; and targets

		DK	FI	SE	NO	IS
1	Emissions index 1990	1	1	1	1	1
2	Emissions index 2019*	0.65	0.77	0.73	1.01	1.46
3	% change from 1990 to 2019	-34.65	-23.29	-26.52	1.36	45.74
4	Emissions index no-policy baseline 2030	0.72	0.86	0.88	1.15	1.64
5	% deviations in 2030 due to greenhouse policies	-6.72	-27.36	-39.12	-7.23	-1.12
6	Emissions index in 2030 with greenhouse policies	0.67	0.62	0.54	1.07	1.62
7	Emissions index target for 2030**	0.45	0.57	0.63	0.82	1.29

[1] This table does not include emissions from forestry and land use. This measure of emissions is referred to as gross.

* Source: Eurostat (env_air_gge), available at http://appsso.eurostat.ec.europa.eu/nui/show.do?lang=en&dataset=env_air_gge

** Source: European Environmental Agency, GHG_Projections_2021_xlsx –including pivot chart, available at https://www.eea.europa.eu/data-and-maps/data/greenhouse-gas-emission-projections-for-8

In percentage change form, (A1.3.8) can be written as

$$u = \sum_i S_i * (x_i - b_i) \quad \text{(A1.3.9)}$$

where

u, x_i and b_i are percentage deviations in the variables denoted by the corresponding uppercase symbols; and

S_i is the elasticity of U with respect to X_i/B_i defined by

$$S_i = U_i * \frac{X_i / B_i}{U} , \quad \text{(A1.3.10)}$$

In (A1.3.10), U_i is the derivative of U with respect to its i^{th} argument.

With households choosing X_i, i = 1, …, n, to maximize U defined by (A1.3.9) subject to their budget (Y) constraint:

$$Y = \sum_i P_i * X_i , \quad \text{(A1.3.11)}$$

we have

$$\frac{\partial U}{\partial X_i} = \Lambda * P_i \quad i = 1, \ldots, n, \quad \text{(A1.3.12)}$$

where Λ is the Lagrangian multiplier in the constrained optimization problem.

The derivative on the LHS of (A1.3.12) can be written as:

$$\frac{\partial U}{\partial X_i} = U_i * \frac{1}{B_i} \quad i = 1, \ldots, n, \quad \text{(A1.3.13)}$$

Now substituting into (A1.3.10) from (A1.3.13) and (A1.3.12) we obtain:

$$S_i = \frac{P_i * X_i}{U / \Lambda} , \quad \text{(A1.3.14)}$$

We assume that utility units are defined so that U/Λ is equal to the baseline value of Y. Thus, we can interpret S_i as a budget share.

We measure the welfare effect of policy changes for households of type r by the effect on their utility per capita given by:

$$\text{welfare}(r) = u(r) - \text{pop}(r) \quad \text{(A1.3.15)}$$

Combining (A1.3.15) and (A1.3.9) and instating an r argument to identify households by nation gives

$$\text{welfare}(r) = c(r) - \text{pop}(r) - \sum_i S_i(r) * b_i(r) \quad \text{(A1.3.16)}$$

where

c(r) is the percentage deviation in aggregate consumption of households in country r.

The last term on the right-hand side of (A1.3.16) explains the difference between the consumption results in row 1 of Table 9 in the Main Report and the welfare results in row 16.

Appendix 2. Detailed description of Nordic TERM model

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1. Introduction

The TERM methodology has been used to generate bottom-up regional models of single countries. Bottom-up models treat regions of a country as a group of separate economies connected by trade in goods and services and by flows of capital and labour. Databases of TERM models are formed mainly by splitting national input-output databases and estimating interregional trade flows by application of modified gravity formulae. This paper extends the TERM database procedures to the formation of multi-country, regionally disaggregated databases. We apply the extended methodology to create a master database for a model that we call EuroTERM. The database identifies 74 industries in each of 328 regions of 40 countries. The countries cover all of Europe and also include North Africa.

The paper is organized as follows. Section 1.1 is a brief outline of single-country TERM applications and Section 1.2 describes online materials for the preparation of TERM databases. Section 2 describes the TERM database preparation methodology for a single country and describes the starting point for creating EuroTERM. Section 3 elaborates on the steps undertaken in preparing a database for a multi-country EuroTERM model (sections 3.1 to 3.8). It also presents model modifications required to include trade tax detail with a TERM or EuroTERM model (section 3.9). Section 3.10 describes modifications required to distinguish between sub-national and international trade and initial modifications to labour market theory. Section 3.11 extends the methodology to GlobeTERM, which represents the global economy while including sub-national detail for a subset of nations. Section 4 examines the database of a Nordic aggregation in some detail.

1.1. A brief outline of single country TERM applications

The Enormous Regional Model (TERM) advanced sub-national multi-regional CGE modelling by depicting more sectors and regions than earlier models. The first application of TERM was to analyse the Australian drought of 2002-03. The model included 38 sectors and 45 bottom-up regions (Horridge, Madden and Wittwer, 2003). This level of regional detail enabled the authors to distinguish between urban regions that were relatively unaffected by drought, and agricultural regions in which there were marked falls in income.

Since the initial application, TERM models have been developed for many countries, including Austria, Brazil, Canada, China, Finland, Germany, Italy, Japan, Indonesia, Korea, New Zealand, Poland, South Africa, Sri Lanka, Sweden, the United States and Vietnam. The applications of TERM-based models have proliferated.

In Australian applications, the number of regions depicted in the master database has grown over 300 regions through the use of census data (Wittwer and Horridge, 2010). Modifications include the addition of dynamic theory and additional theory to deal with water allocation in irrigation sectors (Dixon, Rimmer and Wittwer, 2011; Wittwer, 2012). Further drought studies have included Wittwer and Griffith (2011), Wittwer (2019) and Wittwer and Waschik (2021), the latter including the impacts of bushfires. Other analyses of agricultural issues include Wittwer, McKirdy and Wilson (2005 and 2006), covering a hypothetical crop disease outbreak, and Wittwer, Vere et al. (2005) investigating the effects of improved weed management. Wittwer and Dixon (2012) and Wittwer and Banerjee (2015) examined irrigation infrastructure scenarios. Wittwer (2009) and Qureshi et al. (2012) analysed urban water scenarios. Anderson, Giesecke and Valenzuala (2010) examined trade policy scenarios. Wittwer and Anderson (2021) analysed COVID impacts on Australia's wine market and regions. Grafton and Wittwer (2022) outlined climate change impacts.

Brazilian applications have covered land use change (Carvalhoa, Domingues and Horridge, 2017; Tanure et al., 2020; Ferreira Filho, Ribera and Horridge, 2015; Ferreira Filho and Horridge, 2017; Ferreira Filho and Horridge, 2021) and agricultural scenarios (Ferreira Filho and Horridge, 2015; Silva, Ruviaro and Ferreira Filho, 2017; Ferreira Filho and Horridge, 2020; Stocco, Ferreira Filho and Horridge, 2020; Ferrarini et al., 2020; Ferrarini et al., 2019). Other studies have examined government funding of regions (Ribeiro et al., 2017; Ribeiro et al., 2019), oil spill impacts (Ribeiro et al., 2020), biofuel scenarios (Giesecke, Horridge and Scaramuccik, 2009), income distribution (Ferreira Filho and Horridge, 2006a; Ferreira Filho, Santos and Lima, 2010) and trade policy scenarios (Ferreira Filho and Horridge, 2006b).

Applications in China include Horridge and Wittwer (2008), Wittwer and Horridge (2009), Lee and Lin (2015) and Feng et al. (2018). Wittwer and Horridge (2018) extended the regional representation from 31 provinces/municipalities to 365 prefectures.

Finnish applications include analysis of energy scenarios (Peura et al., 2018), forestry (Kujala et al., 2017), hunting tourism (Matilainen, Keskinarkaus and Törmä, 2016), extreme weather events (Simola, Perrels and Honkatukia, 2011) and transport investment (Metsäranta et al., 2014). Törmä, Kujala and Kinnunen (2015) examined mining impacts in the context of an environmental accident. Another study examined the impacts of public funding in small towns (Törmä, 2008).

TERM modelling studies in Poland have covered major transport infrastructure investments Rokicki et al., 2021) and R&D impacts (Zawalińska, Tran and Płoszaj, 2018). Horridge and Rokicki (2017) examined the impact of European Union accession on regional incomes.

Horridge and Wittwer (2006) used IndoTERM, the Indonesian version of TERM, to examine the regional impacts of higher energy prices. Horridge, Wittwer and Wibowo (2006) examined the impacts of the national rice import policy on West Java. Pambudi and Smyth (2008) undertook foreign investment scenarios and Pambudi, McCaughey and Smyth (2009) analysed the economic aftermath of Bali bombing. Horridge et al. (2015) modelled efficiency improvements at a major port. A study modelling major road and sea transport efficiency improvements followed (Horridge et al., 2016). Other studies include analysis of a moratorium on palm oil expansion (Yusuf, Roos and Horridge, 2017) and energy scenarios (Patunru and Yusuf, 2016; Hartono et al., 2021; and Yusuf, Patunru and Resosudarmo, 2017).

The first short course with a TERM model relied heavily on the efforts of Jan van Heerden, using a South African database (see https://www.copsmodels.com/term.htm#Training). Applications in South Africa include analysis of a value-added tax increase (Roos et al., 2019) and energy transition scenarios (Bohlmann et al., 2019).

Wittwer (2017a) documents USAGE-TERM. There has been ongoing demand for analysis using the model from within federal departments in Washington DC. Applications have included civil disruption (Dixon, Rimmer and Wittwer, 2017 and Dixon et al., 2017), Californian drought (Wittwer, 2015) and an illustrative tourism scenario (Wittwer, 2019, chapter 6).

1.2. Online materials on preparation of TERM databases

What is apparent from the published applications of TERM listed above is how widely the TERM models are used. The strategy and methodology for devising a TERM database, outlined in Horridge (2011), is reproducible. GEMPACK software (https://www.copsmodels.com/gempack.htm) plays an integral role in devising massive multi-regional databases. An early step entails converting raw input-output data into a national CGE database. The national database usually is disaggregated into more sectors before regional shares are used to split the national database into regions. The website https://www.copsmodels.com/archivep.htm, in addition to including databases for TERM models for many countries, contains an array of items dealing with database preparation and balancing, for national ORANIG-style models and TERM-style models. Items TPMH0047 and TPMH0058 at the above archive link concern the former. Items TPMH0168 and TPMH0182 detail creation and balancing of TERM databases.

The task detailed in this study is how we move from a single country TERM to a multi-country EuroTERM database and model. Section 2 outlines the TERM approach to sub-national modelling. Details of preparation of a multi-country, sub-national EuroTERM appear in section 2.2. The version described here covers the countries of Europe and some neighbouring countries, 40 in all. The database includes 328 regions in total.

2. Overview of the TERM approach and moving to EuroTERM

Horridge (2011) details the TERM database strategy. Many practitioners in the past have regarded the absence of sub-national input-output tables and inter-regional trade data as barriers to developing a model with sub-national detail. Even when regional input-output tables are available, as in China, they are of limited value. First, such tables typically contain only 30 or so sectors. A single agricultural sector may consist of markedly different outputs in different regions, so that technologies may differ. Even in sectors that may be similar across regions, differences in the cost structure or technologies relative to other regions may reflect differences in convention rather than actual cost differences. This is so in China, where different provincial statistical agencies prepare tables.

The Horridge approach is to split published national input-output sectors, knowing that such a split will simplify the use of regional data. The assumption of identical technologies breaks down with a single agricultural sector across regions. The burden of this assumption lessens with sectoral disaggregation. For example, regional agricultural data may provide crop outputs or livestock herd numbers by small region. Each of wheat, banana or livestock production technologies may be similar across regions. Similarly, census data may enable us to estimate a region's share of disaggregated health sectors, based on employment numbers.

Statistics Canada produces what appear to be most detailed regional tables in the world. The provincial input-output tables are as detailed as the national table, with hundreds of sectors in the commodity and industry dimensions. A close inspection of these tables shows that there many similarities with the Horridge approach. For example, cost structures or technologies are similar for a given industry across regions. A notable exception is electricity generation, in which some provinces rely heavily on coal-fired or gas-fired generation, while others concentrate on nuclear or hydro-generation. The usual practice in TERM is to split electricity generation into different types and use supplementary regional data to estimate generation-specific activities by region.

An absence of customs posts at the sub-national level means that detailed commodity level trades are not available readily for sub-national database preparation. In the U.S. case, the Commodity Flow Survey (CFS) concerns transport nodes, particularly in the Mississippi Basin, rather than providing details of commodity origin or destination. For example, some movements recorded in the CFS concern offloading of bulky goods from river barges to ships in various ports in the New Orleans area. A multi-regional CGE database requires details of origin and destination. The movements recorded in the CFS do not fit readily into a CGE database (Wittwer, 2017b). The CFS is useful in regional CGE database preparation for USA in one aspect, in that it emphasizes the importance of water transport in the Mississippi Basin. In the commodity dimension, the CFS concentrates on relatively bulky items, and details volumes rather than values of flows. Without commodity detail, there is little distinction between bulky goods and high value per weight merchandise. Nevertheless, freight data may help in compiling regional trade detail if not confounded by transport nodes.

The TERM methodology requires estimates of regional shares of national outputs. Activity shares may be based on regional employment numbers by industry from census data; these are more helpful in relatively labour-intensive sectors. Agricultural output data, mining output data and data on the location of electricity generation plants are the main sources of regional estimates, as these sectors tend not to be relatively labour-intensive, reducing the role of employment data as estimators. Sub-national national accounts data on broad sector factor income may provide control totals. For example, such national accounts data are available in Australia for the eight states and territories.

International merchandise trade data by port provide the basis for shares of international trade.[5] Other regional demands rely on estimates of household and government shares by region. Some goods or services are designated as non-traded between regions, so that regional demand must equal regional supply. Estimates of total regional demands and total regional supplies, combined with international trade data, are used to devise inter-regional trades based on a modified gravity assumption.

2.1. Navigating the TERM database

Figure 1 is a representation of the one-country TERM database. We start by describing the arrays that run down the left-hand side (LHS) of Figure 1. The USE matrix includes the value of transactions for each commodity at basic prices plus margins. The TAX matrix includes commodity taxes on corresponding transactions.[6] USE and TAX have dimensions COM x SRC x IND x DST. COM refers to commodities, IND to industries and DST to destination regions. The dimension SRC includes domestic ("dom") and imported ("imp") sources.

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[5] Data for USA are available at https://www.census.gov/foreign-trade/reference/products/catalog/usatradeonline.html#port. In Australia, detailed customised trade data are available on a subscription basis.

[6] Early EuroTERM models do not include details of trade taxes. The representation of tariffs requires splitting from delivered values. This entails subtracting tariffs from the import slice of the USE matrix and adding to the import slice of the TAX matrix. In the case of showing export taxes, the exports (a final use) in the domestic slice of the USE matrix are reduced by the value of the tax, which is added to exports in the domestic slice of the TAX matrix. Ongoing model development will result in representation of trade taxes in EuroTERM. For the present, trade taxes are embedded in the USE matrix. This is detailed in section 3.9.

Final users for USE and TAX include households (HOUS), investment (INV), government (GOV) and exports (EXP). The set USER includes intermediate users IND plus final users. The two satellite matrices shown at the top of Figure 1 are HOUPUR and INVEST. HOUPUR includes provision for multiple households, with dimensions COM x HOUS x DST. INVEST provides the commodity composition of investment, expanding from the commodity dimension in the USE and TAX matrices to include industries. INVEST enables the practitioner to distinguish between different types of investment. Livestock sectors, for example, require some own-inputs to adjust herd levels. Similarly, the education sector requires own-inputs to maintain the training capacity of the sector. We expect the shares of education inputs in total investment to differ between the livestock and education industries, just as the livestock input shares to livestock and education should differ.[7]

In showing the identities linking the satellite matrices for household consumption and investment to the USE and TAX matrices, we introduce PUR, depicting transactions for all Users u at purchasers' prices and source-composite PUR_S:

PUR(c,s,u,d)=USE(c,s,u,d) + TAX(c,s,u,d) (2.1)

PUR_S(c,u,d)=sum{s,SRC,PUR(c,s,u,d)} (2.2)

PUR_S(c,"Hou",d)= sum{h,Hou,HOUPUR(c,h,d)} (2.3)

PUR_S(c,"Inv",d)= sum{i,IND,INVEST(c,i,d)} (2.4)

Figure 1, below the TAX matrix on the LHS, shows primary factor inputs labour (LAB), capital (CAP), land (LND) and production taxes (PRODTAX). Each of these, excepting labour, has the dimension IND x DST. Labour has dimensions IND x OCC x DST, where OCC refers to occupational type. Few applications of TERM have utilized the occupational dimension, an exception being Wittwer and Dixon (2015). Production taxes differ from commodity taxes in that they are based on industry outputs, whereas commodity taxes are based on use, as intermediate inputs in the case of industries.

The total costs of industry production, VTOT, are equal to the sum of intermediate inputs (PUR) and primary inputs:

VTOT(i,d)= sum{c,COM,sum{s,SRC,PUR(c,i,d)}} +sum{o,Occ,LAB(i,o,d)}

+ CAP(i,d)+ LND(i,d)+ PROXTAX(i,d) (2.5)

The MAKE matrix shows the commodity outputs of each industry. Statistical agencies usually prepare MAKE data based on industry surveys. Typically, industries produce many outputs. For example, a wholesaling grocery firm may undertake some food processing. For the purposes of CGE modelling, our usual preference is to diagonalise the MAKE matrix so that each industry produces a unique commodity which has the same name.[8] Exceptions to this practice include Dixon, Rimmer and Wittwer (2011), in which separate dry-land and irrigated technologies produce identical commodities. Industry costs equal MAKE outputs summed across commodities:

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[7] While the provision for investment shares differs between industries, the first EuroTERM master database keeps investment shares the same across industries. Further database development will alter this.

[8] The archive item https://www.copsmodels.com/archivep.htm TPMH0062 includes programs to diagonalise a MAKE matrix and modify the accompanying CGE database.

VTOT(i,d)= sum{c,COM,MAKE(c,i,d) (2.6)

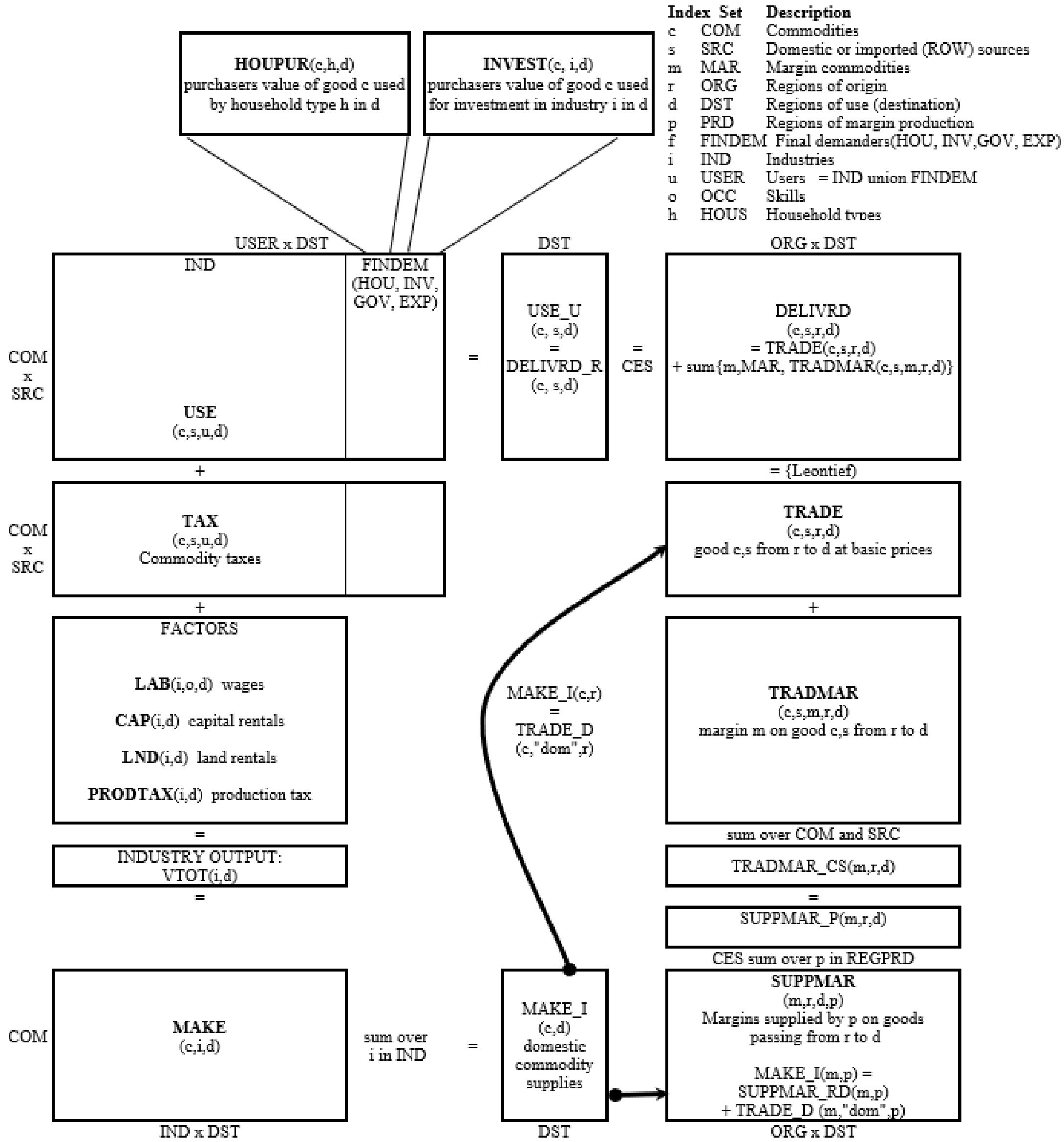
The links between the LHS and RHS of Figure 1 concern theoretical elaborations to reduce a multi-regional model to manageable dimensions. TERM relies on sourcing assumptions that reduce the size of the overall database but increase the number of market clearing identities. Consider a USE matrix that includes domestic origins, unlike that in TERM. A 50 sector, 20 region USE matrix would have dimensions COM x SRC x USER x ORG x DST, a total of 2.16 million cells (=50x2x54x20x20). ORG denotes the region of origin. In TERM, the corresponding USE matrix (COM x SRC x USER x DST) without details of origin has 0.108 million cells (=50x2x54x20) and the accompanying TRADE matrix of dimensions COM x SRC x ORG x DST, without user details, has 0.04 million cells (=50x2x20x20). The TERM configuration uses two matrices with a total of 0.148 million cells, reducing the database size by almost 15-fold. A similar partitioning applies in the GTAP model. The diagonal of TRADE (r=d) shows the value of local usage which is sourced locally. For foreign merchandise (s="imp") the regional source subscript r (in ORG) for merchandise commodities denotes the port of entry.

The TRADMAR matrix shows the accompanying margins (m in MAR) for each cell of the TRADE matrix. DELIVRD is the sum of TRADE and TRADMAR, the delivered (basic + margins) value of all flows of goods within and between regions. TRADMAR does not identify where a margin flow is produced. In the middle of Figure 1, near the top, we see the identity that links the TRADE, which is a component of DELIVRD, and USE matrices (equation 2.8).

USE_U(c,s,d) =sum{i,IND, USE(c,s,i,d)} +USE(c,s,"*hou*",d) +USE(c,s,"*inv*",d)+
USE(c,s,"*gov*",d) +USE(c,s,"*exp*",d) (2.7)

USE_U(c,s,d)=DELIVRD_R(c,s,d) (2.8)

Figure 1: TERM flows



Source: Horridge (2011).

Each matrix needs to be summed across the dimension missing from the other. Therefore, TRADE is summed across ORG and USE is summed across USER. This implies that all users source a given commodity from all origins in common proportions. The TERM strategy to deal with known cases where the common-sourcing assumption may break down is to disaggregate further in the sectoral dimension COM.[9]

Matrix SUPPMAR shows where margins are produced (p in PRD). It lacks the commodity-specific subscripts c (COM) and s (SRC): this indicates that, for all usage of margin good m used to transport any goods from region r to region d, the same proportion of m is produced in region p.

[9] Horridge (2011), Wittwer and Horridge (2010) and Wittwer and Horridge (2018) detail the theory of TERM.

The demand-side TRADMAR, in addition to excluding users, excludes the origin of margins. The missing dimensions in the respective supply and demand margins matrices keep each of them to a manageable size. The identity linking supply and demand of margins require summing across the dimensions missing from the other side:

SUPPMAR_P(m,r,d)= Sum{p,PRD, SUPPMAR (m,r,d,p)} (2.9)

TRADMAR_CS(m,r,d) = Sum{c,COM,sum{s,SRC,TRADMAR_CS(m,r,d}} (2.10)

TRADMAR_CS(m,r,d) = SUPPMAR_P(m,r,d) (2.11)

TRADE summed over all destinations (TRADE_D) should equal supply (MAKE_I) for the non-margins c subset of domestically-produced commodities.

MAKE_I(c,r)=TRADE_D(c,"dom",r) (2.12)

The identity for margins supply and demand requires an additional term, covering margins to facilitate trade flows. For the margins m subset of commodities, total demands equal direct demands TRADE_D("dom") plus margins demand SUPPMAR_RD, the sum of margins demanded over regional sources r and regional destinations d:

MAKE_I(m,r)=TRADE_D(m,"dom",r)+ SUPPMAR_RD(m,r) (2.13)

Figure 2 shows the use, tax and factor inputs in the TERM model, but excludes the trade side of the database. In a single-country model such as ORANI (Dixon et al., 1982), this illustration covers virtually all flows. Trades with the rest of the world appear in the export column and in the imported slice of USE.

Figure 2: TERM-style model excluding trades

		Absorption Matrix				
		Producers	Investors	Household	Export	Government
	Size	← I →	← I →	← 1 →	← 1 →	← 1 →
Basic + margin flows	↑ C×S ↓	USE(Ind)	USE("Inv")	USE("Hou")	USE("Exp")	USE("Exp")
Taxes	↑ C×S ↓	TAX(Ind)	TAX("Inv")	TAX("Hou")	TAX("Exp")	TAX("Exp")
Labour	↑ O ↓	LAB				
Capital	↑ 1 ↓	CAP				
Land	↑ 1 ↓	LND				
Production tax	↑ 1 ↓	PTX				

C = Number of Commodities

I = Number of Industries

S = 2: Domestic, Imported,

O = Number of Occupation Types

2.2. A previous multi-country representation in TERM

An initial effort to represent sub-national, bottom-up detail in a multi-country model concerned Australia and New Zealand. The master database includes 132 sectors in 88 Australian regions and 17 New Zealand regions. This harmonizes disaggregated national CGE databases for both countries, combined with bilateral, international trade data.[10] This approach has one advantage, in that it has a high level of sectoral and regional disaggregation. In some applications, this additional detail may be essential.

The biggest disadvantage of this approach is that it deals only with two countries. Moreover, harmonizing sectors is a non-trivial task.

2.3. A starting point for EuroTERM

The most efficient starting point for devising EuroTERM is to use an existing multi-country database, namely that of GTAP (https://www.gtap.agecon.purdue.edu/databases/default.asp). The alternative would be to revisit efforts already undertaken by contributors to the GTAP database in processing Eurostat input-output tables.

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[10] See https://www.copsmodels.com/archivep.htm#tpgw0199.

Before proceeding with GTAP resources, we note some of the differences between GTAP and TERM-style models. In GTAP, all regions of the world are endogenous. International exports summed over all regions must equal the sum of international imports. In TERM-style models, supplies of international imports are infinitely elastic: import supplies move only with an exogenous shifter. Exports to the rest of the world appear in the export column of final demands in the USE matrix. Export demand curves are down-sloping, depending only on domestic market conditions. If the national depicted in TERM has a large share of international trade, we can adjust the export demand elasticity downwards. Changes in demand and supply conditions in countries external to the model are exogenous. International exports and imports as a share of national GDP may be relatively large. In the 2017-18 Australian TERM database, for example, both exports and imports have values of around 24% of GDP.

Table 1 summarises known differences between national inputs into a single-country TERM database and a multi-country EuroTERM database. The task of reconciling additional data in EuroTERM, such as known national input-output tables and known international trades between nations within EuroTERM, complicates the usual TERM database generation programs.

Table 1: Standard TERM v. EuroTERM

	Standard TERM	EuroTERM
1	Single country, multiple sub-national regions	Multi-country, multiple sub-national regions
2	Identical technologies (cost structures) in industries across all regions	Technologies vary across nations; identical technologies at sub-national level within nations
3	International trade data split using shares based on ports	International import data split using sub-national demand shares + limited port data; export data split using supply shares/port data
4	Single import source in USE matrix	Two import sources: Rest of Europe, Rest of World
5	Inter-regional trades estimated using gravity assumption	Inter-regional trades between European nations based on GTAP/Comtrade data; sub-national allocation of international trades based on regional activity shares + known port activity
6	Two tiers of trade: International, sub-national	Three tiers of trade: Rest of World, Rest of Europe, sub-national

The initial task requires development of a modified database generation methodology. In devising EuroTERM, we aim to provide a relatively bland multi-regional, sub-national database, based closely on the existing TERM database generation process. Our aim is to devise a reproducible methodology. The use of TERM database generation programs and theoretical structure limits the modifications required to implement EuroTERM.

The EuroTERM process splits a CGE database with multiple nations into many sub-national regions (Table 1, row headings 1 and 2). The objective has been to develop a reproducible methodology for this task in building EuroTERM, a NUTS-2 level multi-country representation of Europe. The number of NUTS-2 regions in each nation are: Austria (9), Belgium (11), Bulgaria (6), Croatia (2), Czechia (8), Germany (38), Denmark (5), Greece (13), Finland (5), France (21 continental plus 6, the islands of Corsica, Guadeloupe, Martinique, Mayotte and Réunion, and French Guiana), Ireland (3), Hungary (10), Italy (21), Netherlands (12), Norway (7), Poland (17), Portugal (7), Romania (8), Slovakia (4), Slovenia (2), Spain (19), Sweden (8), Switzerland (7), United Kingdom (41) and Ukraine (25 oblasts). Single region nations include Cyprus, Estonia, Iceland, Latvia, Lithuania, Luxemburg, and Malta. The invasion of Ukraine has motivated the addition of Albania, Belarus, Georgia, Iran, Moldova, Russia, Turkey and North Africa to the list of single-region nations. In total, the master database covers 328 regions in 40 nations, 15 of which are single-region countries. Table A1 at the end of Appendix 2 provides a list of the regions.

The pathway to piggybacking on the existing TERM methodology involved some trial and error. For example, Table 1 row headings 3 to 6 outlines the use of known international trade data to create more detailed trade matrices. In preparing the database, the number of sources increases from two (domestic and imported) to three (domestic, imports from Europe and imports from the Rest of the World). The European slice of the source set enables us to use international trade data from GTAP as national bilateral target totals. The three sources used in intermediate stages of devising the trade matrix within the EuroTERM database are aggregated to two sources later in the database generation process. One step omitted after further consideration was that of including two export columns in final demands in the USE matrix, one for European exports and the column that remains for exports to the rest of the world. Since TRADE matrix details European exports, the additional column in the USE matrix was redundant.

3. Overview of database generation steps

Figure 3 summarises the steps taken to create EuroTERM. In (1), we aggregate the GTAP master database to nations of interest, namely 40 nations covering Europe, the Rest of EFTA, other nations of relevance concerning energy supplies, and a composite Rest of World region, while preserving the 65 sectors of the master database.

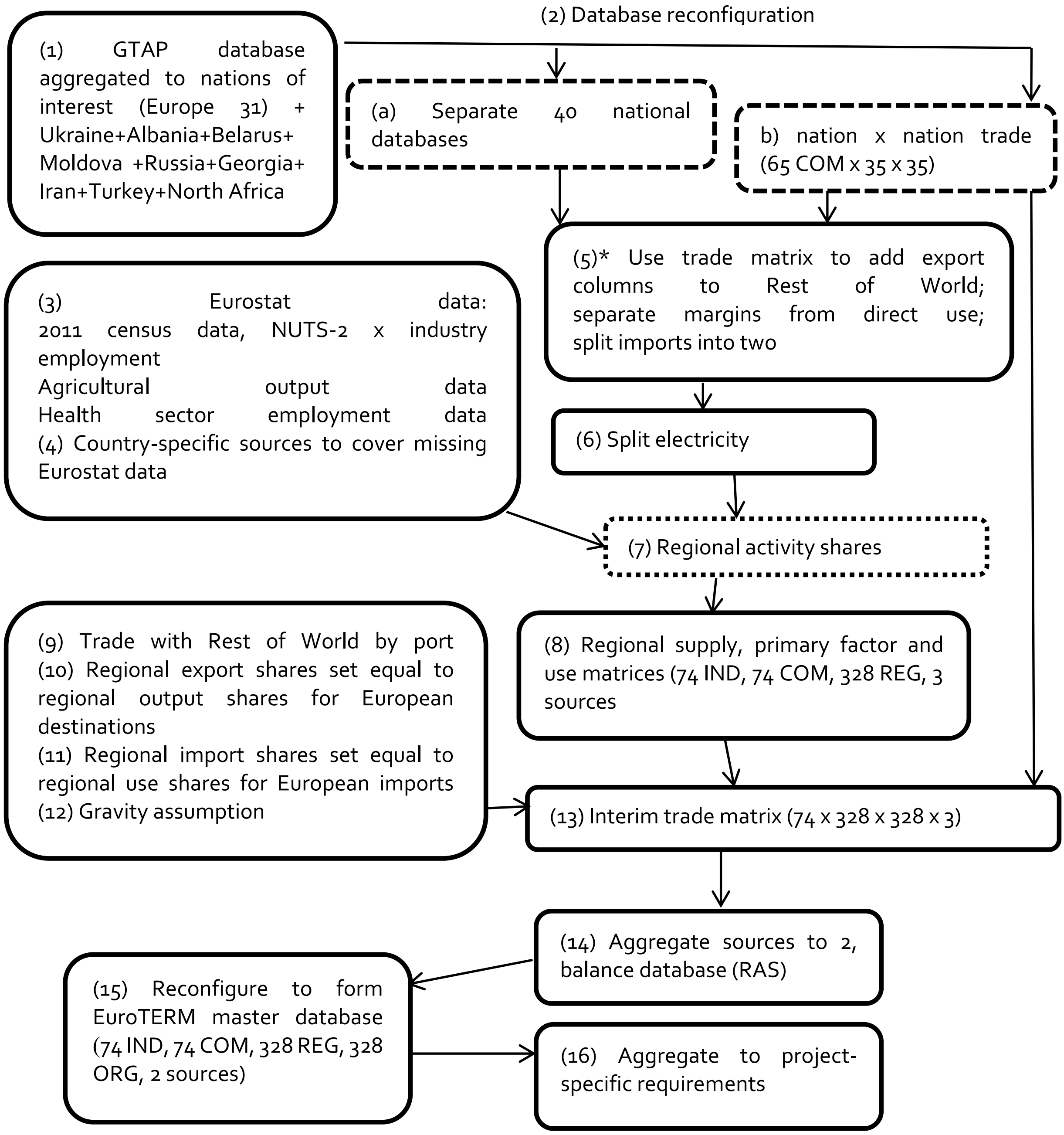
In (2), the GTAP aggregation is reconfigured so that the 40 nations are in a similar format as the single national database split in the TERM database generation process. Unlike the usual TERM process, we know something about inter-regional trades, due to the 65 sector, 41 x 41 trade matrix within the 40 nation plus Rest of World GTAP aggregation.

Eurostat data provide NUTS-2 level regional activity shares (3). Data exist on employment by industry and, in agriculture, regional outputs are available for various crops and livestock sectors. National data sources fill in gaps in Eurostat data, as detailed in Table 3 (4).

In (5), we use the international trade matrix created in (2) for the first time, to add export columns in each nation for sales to the Rest of World. In addition, at this step, the trade matrix is used to split imports to each nation into two sources, Rest of Europe and Rest of World.

In (6), regional activity shares are computed from NUTS-2 level data for each of the national databases created in (2). In (7), these shares split the 25 nations into 313 regions, providing intermediate and primary costs for each industry. The remaining 15 single-nations are embedded into the database without splits in the regional dimension. The process creates a database depicting 328 regions.

Figure 3: Overview of EuroTERM database generation process



* Section 4 under the heading "Iceland" outlines changes to GTAP data to depict Iceland.

Within TERM, international merchandise exports appear in the export column of the use matrix in the port of exit. In the case of a port loading wheat for export, it is possible that the region in which the port is located produces no wheat. Within the trade matrix of TERM, the region of the port would import wheat from another domestic region. Therefore, the movement within the database is depicted as an inter-regional export from the region of production, and an inter-regional import and international export in the region of the port.

Table 6 shows data on activities for major ports. The mapping of these data to the commodities within EuroTERM is relatively coarse. For the present, these port data (8) are the basis of modified estimates of import and export shares for merchandise trade with the Rest of World only. A key exception among merchandise commodities concerns gas. Rather than arriving through ports, much gas is shipped via pipelines. Activity shares provide the basis for sub-national splits of gas trade.

Excepting modifications to deal with major ports in trade with Rest of World, default regional export shares are set equal to regional production shares (9). Default regional import shares are set equal to regional use shares (10).

The regional trade shares (8), (9) and (10) provide starting estimates for splitting the national trade matrix (2b) into 328 regional origins and destinations in step (12). The gravity assumption in which commodity trades are inversely proportional to distance is used at this stage, mainly in the strictly domestic slice of the interim trade matrix; virtually no data exist for sub-national trades. In the case of the Rest of Europe and Rest of World slices, the national trade matrix (2b) provides control totals.

In (13), the database is aggregated from three to two sources. That is, the domestic slice of the trade matrix covers both sub-national and international trades within European origins and destinations. The two-source version of the trade matrix at this stage is adjusted to ensure that the database is balanced.

Stages (14) and (15) are identical to those of the usual TERM procedure. In (15), the database is reconfigured to align with TERM/EuroTERM theory. Finally, the master database is aggregated for a specific project.

3.1. Converting GTAP to suitably configured multiple national databases: steps (1) and (2)

First, the 65 sector by 151 region master database of GTAP is aggregated to the same 65 sectors in the 40 regions of interest plus Rest of World. Mark Horridge of the Centre of Policy Studies has devised coding that puts all transactions in the GTAP database into three core matrices (accessible at https://www.copsmodels.com/msplitcom.htm). These are shown in Table 2.

Table 2: GTAP represented in three matrices

Coefficient	Dimensions
NATIONAL	COST x SRC x USER x REG x TYP
MAKE	COM x IND x REG
TRADE	FLOWTYPE x COM x REG x REG

The sets consist of:

- COM and IND: both 65 elements
- The set COST includes COM (intermediate inputs) plus FACTOR (primary inputs) plus ProdTAX (production taxes). The elements of FACTOR are all labour occupational types, capital, land and natural endowment.
- Set SRC includes “dom” and “imp”. The “dom” slice includes trades within Europe while the “imp” slice includes imports from outside the 40 regions of the model.

- Set USER includes IND plus FINDEM, where the latter includes households, government, and investment. FINDEM excludes exports to the rest of the world.
- TYP includes BAS (basic flows) and TAX (indirect taxes).
- REG includes 40 regions (the set NATION) plus a rest of the world composite.
- FLOWTYPE consists of BASIC transactions, EXPTAX (export taxes), IMPTAX (import tariffs) plus three international transport margins. Section 3.9 outlines the treatment of trade taxes.
- Each nation has its own set of industry technologies (cost shares) for each industry. Within the COST set, the COM elements detail intermediate inputs to industries, and FACTOR and ProdTAX the primary inputs. Sales of COM elements to final users are also in the NATIONAL matrix. Within the NATIONAL matrix, the "BAS" slice of the TYP set for all commodities (a subset of COST) provides the basic commodity usage for all domestic users. The "TAX" slice of the NATIONAL matrix provides corresponding indirect taxes for commodities to all domestic users, and direct taxes on primary factors. The NATIONAL matrix covers all users, that is, industry users (IND) plus final domestic users (FINDEM).
- The MAKE matrix details the value of commodity output by each industry. In the case of the GTAP database, each industry produces a unique commodity so the MAKE matrix is diagonal.
- The TRADE matrix details bilateral trade flows between all nations in the database for 65 commodities.

3.2. Data collection and processing for NUTS-2 regions: steps (3) and (4)

Table 3 shows the main sources used to collect NUTS-2 level data, corresponding to (3) and (4) in Figure 3. The primary source of sub-national data is the Eurostat website. Table 4 maps Eurostat codes to GTAP sectors. There are missing data for some countries and some regions in multi-country Eurostat compilations. For example, health data were missing from the core non-agricultural industry by employment data and were gathered from elsewhere in the Eurostat website. Data for Switzerland are not included in Eurostat employment by industry data. Item 5 in Table 3 provides the link to Swiss data. Eurostat data cover Swiss agricultural output and health employment by region.

Agricultural economic data by NUTS-2 regions were not available in Eurostat data for some countries. Other sources covered Belgium (Table 3, item 6), Finland (item 7), Norway and Slovenia (item 4). Supplementary sources for Norway are sketchy.

The website http://www.ukrstat.gov.ua/ provided Ukrainian data.[11] These data include employment by 24 oblasts plus Kyiv city for 16 broad sectors plus regional data on agricultural output.

Online Eurostat data are the most important source for compiling sub-national activity shares. The GTAP contributors make extensive use of the Eurostat supply-use tables for European nations in preparing national data. It was a straightforward decision to start with the readymade

[11] The main source was State Statistics Services of Ukraine *Statistical Yearbook of Ukraine 2020.*

GTAP database rather than work with available Eurostat supply-use tables. In a single nation TERM preparation, the number of sectors usually far exceeds the 65 sectors of GTAP. For a multi-country exercise, a larger number of sectors would be fraught. Missing data and potential consistencies in data compilation conventions between nations would add to the complexity. It is a difficult task harmonizing sectoral detail for two countries, let alone several dozen.

Table 3: Sources for NUTS-2 activity shares

	Link	Sectoral information
1	https://ec.europa.eu/CensusHub2/query.do?step=selectHyperCube&qhc=false	2011 census data, mainly for NUTS-2 x industry employment
2	https://fgeerolf.com/data/eurostat/	Regional GDP (nama_10r_2gdp), agricultural output by activity (agr_r_accts), industry by employment (sbs_sc_ind_r2 & cens_11empn_r2)
3	https://ec.europa.eu/eurostat/databrowser/view/HLTH_RS_PRSRG__custom_1410955/default/table?lang=en	Health personnel by NUTS-2 region
4	https://ec.europa.eu/eurostat/statistics-explained/index.php?oldid=379564#Main_tables	SI: agricultural census
5	https://www.bfs.admin.ch/bfs/en/home/statistics/industry-services/businesses-employment/jobs-statistics.assetdetail.18505604.html	CH: Employment by industry
6	https://statbel.fgov.be/nl/themas/landbouw-visserij/land-en-tuinbouwbedrijven/plus	BE: agriculture
7	https://stat.luke.fi/en/agricultural-census-2020-agricultural-and-horticultural-labour-force-2020-provisional_en https://www.luke.fi/en/henkilosto/heikki-lehtonen/	FI: agricultural census

In TERM versions of Australia (Horridge, 2011) and USA (Wittwer, 2017a), the health sector is split beyond the representation in official input-output tables. This requires nation-specific data sources, such as detailed census data. The third source shown in Table 3 provided regional detail on health personnel in European nations. However, the census data contain less sectoral detail than is available for Australia or USA. The occupations for which data are available are (1) medical doctors, (2) nurses & mid-wives, (3) dentists, (4) pharmacists and (5) physiotherapists.

Agricultural data shown in Table 3, source 2, are sufficient to provide a regional split for GTAP agricultural sectors. Data are missing for Slovakia, Belgium and Finland, supplemented by sources 4, 6 and 7 respectively. Swiss data shown in source 5 of the table fill in other gaps in Eurostat data.

In any CGE database regional splits, there are sectors in which data are limited. One example in which other data are used to infer shares is "OwnerDwellng". Imputed housing rentals are set equal to each region's share of national labour income. These shares are also used to ascribe regional household spending shares for each commodity. Government regional consumption shares are set equal to "PubAdmDefClb" industry shares.

Table 4: Mapping from Eurostat industries to GTAP 65

(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
A	Pdr	PaddyRice	C10	Pcr	ProcRice	C31-C33	Omf	FurnitRepair
A	Wht	Wheat	C10	Sgr	RefSugar	D	Ely	Electricity
A	Gro	OthCereals	C10	Ofd	FoodPrdsNEC	D	Gdt	GasSupDist
A	v f	RawFruitVeg	C11-	b t	BevTob	E	Wtr	Water
A	Osd	OilSeeds	C13	Tex	Textiles	F	Cns	Construction
A	c b	SugarBeet	C14	Wap	Apparel	G	Trd	TradeWR
A	Pfb	FibreCrops	C15	Lea	LeatherPrd	I	afs	AccomFood
A	Ocr	Fodder	C16	Lum	WoodProds	H49	Otp	LandTransprt
A	Ctl	CattleSheep	C17	Ppp	PaperProds	H50	Wtp	WaterTrnsprt
A	Oap	PigPltOthAnm	C19	p c	PetrolCoalP	H51	Atp	AirTransport
A	Rmk	Milk	C20	Chm	ChemicalPrd	H52	Whs	Warehousing
A	Wol	WoolSilk	C21	Bph	Pharmaceutic	H53	Cmn	Communicatn
A	Frs	ForestryLogs	C22	Rpp	RubberPlas	M69	Ofi	Finance
A	Fsh	FishingAqua	C23	Nmm	NonMetMinPrd	M70	Ins	InsurPension
B05	Coa	Coal	C24	i s	FeMetals	L68	Rsa	RentLease
B06	Oil	Oil	C24	Nfm	NonFeMetals	M71-	Obs	OthBusSrv
B06	Gas	Gas	C25	Fmp	FabriMetals	N77-		
B07-	Oxt	OthMining	C26	Ele	ComputrOptc	R	Ros	RecHeriOtPSv
C10	Cmt	BeefProds	C27	Eeq	ElectricEqp	O	Osg	PubAdmDefClb
C10	Omt	OthMeatPrds	C28	Ome	MachineNEC	P	Edu	Education
C10	Vol	VegFatOils	C29	Mvh	MotorVehicle	Q	Hht	HealthSocRes
C10	Mil	DairyProds	C30	Otn	OthTransEqp	..	Dwe	OwnerDwellng

Key: (1) Eurostat code; (2) GTAP code; (3) EuroTERM name

3.3. Adding an export column and margins to national data; splitting imports into two – step (5)

The Horridge program converting GTAP to single country slices creates a BAS (i.e., values at basic or producer prices, excluding taxes or margins) matrix for all domestic users. This is extended by adding a column of commodity exports to the rest of the world ("Exp"). The data to create these new columns for each nation is in the TRADE matrix above, using the destination detail for each exporter. Figure 4 shows a portion of this matrix for Austria.

The GTAP database includes international transport margins. Within the database, international transport margins are treated as a subset of intermediate input costs. At this stage, we have made no attempt to preserve the GTAP detail on international trade margins. Further model developments may result in existing GTAP margins data being utilized.

Domestic margins, including "TradeWR" (i.e., wholesale and retail trade) and transport margins, are subtracted from direct flows of margins commodities. For intermediate usage other than "Air transport", we assign 80% of each margin commodity as a margin rather than a direct flow. For final household and government consumption, 70% of each transport margin is assigned as a margin, and the remaining 30% as direct usage to reflect passenger transport activity. In the case of "Air transport", only 20% of the initial total is assigned to margins activity. This reflects an assumption that most air transport services are for direct use, namely passenger transport.

"ElecDist" is exclusively a margin, allocated to each electricity generation transaction on the basis of each specific generator's share of total use by source, user and nation.

Figure 4: The national BAS matrix extracted from the GTAP database for Austria

BasN	WaterTrnspr	AirTranspor	Warehousin	Communicat	Finance	InsurPensio	RentLease	OthBusSr	RecHeriOtPS	PubAdmDefC	Educatior	HealthSocRe	OwnerDwelln	Hou	Inv	Gov	Exp	Total
PaddyRice	0.0	0.0	0.3	0.0	0.0	0.0	0.1	0.3	0.3	6.6	0.1	0.0	0.0	1.7	0.0	0.1	0.0	20.5
Wheat	0.0	0.0	0.0	0.2	0.0	0.0	0.1	2.8	0.2	3.7	0.1	2.1	0.0	61.8	4.5	0.0	1.7	255.6
OthCereals	0.0	0.0	0.0	0.3	0.0	0.0	0.1	5.5	0.4	6.0	0.3	4.4	0.1	58.5	12.1	0.2	3.4	557.9
RawFruitVeg	0.0	0.0	0.1	0.3	0.2	0.1	0.1	4.5	1.7	4.2	0.1	6.6	0.2	1761.7	55.5	21.7	8.6	2347.2
OilSeeds	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.1	5.2	0.0	0.2	0.1	25.2	9.9	0.0	1.8	484.3
SugarBeet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.5	0.0	0.0	0.0	5.4	1.1	0.1	0.0	71.3
FibreCrops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	26.8	0.8	0.5	1.1	36.0
Fodder	0.0	0.0	0.2	0.2	0.1	0.0	0.1	7.0	0.5	6.1	1.3	3.7	0.2	326.6	34.2	10.4	8.0	1432.0
CattleSheep	0.0	0.0	0.0	0.1	0.0	0.0	0.0	10.7	0.1	0.7	0.1	0.3	0.1	21.3	37.2	0.6	10.8	1215.7
PigPltOthAnm	0.0	0.0	0.1	0.1	0.1	0.1	0.1	9.6	0.6	2.2	0.1	4.6	0.2	298.3	53.7	5.5	11.0	1905.6
Milk	0.0	0.0	0.4	1.5	0.1	0.1	0.6	2.7	0.8	9.4	1.0	2.2	0.2	217.5	31.2	8.9	1.4	1593.0
WoolSilk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	2.7	0.6	0.0	20.0	1.4	0.0	3.4	77.2
ForestryLogs	0.1	0.1	0.3	0.4	0.2	0.3	0.2	4.6	1.6	3.2	0.3	7.6	0.2	395.1	55.5	14.0	13.0	3840.2
FishingAqua	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.6	2.2	3.0	0.1	6.8	0.0	105.6	0.1	0.0	0.9	216.7
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0	0	0.1	484.3
Oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0.1	3212.7
Gas	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	3.2	0	0	0.0	502.3
OthMining	0.1	0.6	4.4	0.8	0.1	0.0	0.9	21.4	4.7	32.2	1.2	23.3	2.4	46.1	63.7	0.1	43.0	3023.7
BeefProds	3.7	0.0	1.2	0.1	1.1	0.7	0.0	0.9	3.4	17.8	0.2	23.1	0.0	1061.9	0.1	0.1	37.4	1543.4
OthMeatPrds	4.8	0.0	1.5	0.1	1.5	1.0	0.0	0.8	1.6	2.1	0.2	45.7	0.0	1898.2	0.2	0.1	140.0	2597.3
VegFatOils	4.6	0.0	0.6	0.0	0.7	0.4	0.0	1.4	0.7	2.1	0.1	18.7	0.0	156.3	0.1	0.1	12.2	978.5
DairyProds	8.0	0.0	2.4	0.1	2.2	1.5	0.0	1.7	5.7	16.0	0.4	60.8	0.0	1638.9	0.2	0.2	121.2	3327.2
ProcRice	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.9	0.0	145.7	0.0	0.1	0.8	169.5
RefSugar	0.9	0.0	0.3	0.4	0.3	0.2	0.0	0.6	1.8	3.0	0.8	8.9	0.0	216.5	0.0	0.0	69.6	481.0
FoodPrdsNEC	30.5	0.0	9.0	3.2	10.0	7.0	0.4	18.7	9.4	39.8	37.9	261.8	0.0	5597.3	0.6	1.2	415.5	11231.8
BevTob	22.8	0.0	4.9	1.1	3.8	2.6	0.2	2.7	1.9	18.3	11.4	101.5	0.0	3223.8	0.3	0.1	1394.7	6511.2
Textiles	0.8	1.9	8.6	10.7	6.8	3.7	0.1	44.2	19.0	24.9	0.8	50.4	0.5	883.9	58.0	1.9	521.6	3942.1
Apparel	0.8	3.5	15.4	14.0	13.5	8.8	1.4	54.7	27.3	59.4	3.2	38.0	0.3	4946.5	170.1	1.9	86.0	6216.3
LeatherPrd	0.3	0.1	2.1	4.9	5.3	0.3	0.1	2.4	2.6	7.9	2.8	2.5	0.2	1649.8	61.7	1.2	177.0	2712.7
WoodProds	0.1	1.5	7.6	2.8	0.4	0.1	3.2	24.7	10.3	13.9	14.6	19.7	7.3	119.5	1322.4	0.0	646.0	7822.6
PaperProds	3.5	7.8	71.5	1602.5	201.0	72.1	15.9	848.5	138.6	254.4	178.3	126.8	0.9	607.3	586.4	0.0	659.4	11278.4
PetrolCoalP	81.2	1800.3	2.6	4.5	1.8	0.7	4.3	13.9	8.0	21.5	13.4	12.5	0.0	1763.6	0	0	39.9	8849.3
ChemicalPrd	0.8	2.1	16.5	38.5	3.1	0.6	1.1	277.5	83.2	8.8	27.0	65.0	2.4	1442.4	235.1	654.4	1287.8	15310.9

At this point, the trade matrix generated in step (2) is used to split the import slice of the BAS and TAX matrices (i.e, both elements of the set TYP in the NATIONAL matrix). On the assumption that all users source commodities in common proportions, we split imports into Rest of Europe and Rest of World origins.

3.4. Splitting electricity into different types of generation and distribution: step (6)

An assumption that has obvious limitations, at least in some sectors, within the default EuroTERM database creation procedure is that of identical technologies across sub-national regions within a given nation. Electricity is a key sector requiring modifications. We know that some regions within a country have mainly coal-generated electricity, while wind farms may dominate generation in other regions. Differing generation technologies plus the role of electricity generation in the transition to low carbon technologies are motivations for splitting electricity into many generating sectors plus distribution.

Moreover, relatively comprehensive data are available at the sub-national level to split electricity. A website (see Table 5 footnote) provides a global database with estimates of electricity output (Gw-hrs) for 2017 by type of generation, with latitude and longitude coordinates. Table 5 shows the detail from this source for Germany's NUTS-2 regions. The DEA1 region (Düsseldorf), for example, produces mainly coal-generated electricity, whereas DE94 (Weser-Ems) in the coastal north-west corner of the nation has significant wind generation.

Table 5: Germany's electricity output by region, 2017 (Gw-hrs)

	COAL	GAS	HYDRO	NUCLEAR	OIL	OTHER	SOLAR	WASTE	WIND
DE11	9815	391	24	9409	203	0	11	64	0
DE12	0	3241	0	0	0	0	40	94	0
DE13	91	338	2030	0	0	0	53	29	0
DE14	132	880	375	0	105	185	18	45	0
DE21	0	304	2591	0	0	0	15	19	0
DE22	0	190	655	0	0	0	31	26	0
DE23	0	1121	1154	9980	0	0	262	0	0
DE24	0	0	1471	0	0	0	46	0	0
DE25	86	8984	583	0	0	0	524	167	0
DE26	0	605	491	0	37	0	411	99	0
DE27	102	689	880	17285	34	0	416	21	0
DE30	3820	5072	0	0	1810	0	622	76	398
DE40	1028	2821	0	0	0	412	951	63	0
DE50	4405	0	42	0	296	0	42	191	0
DE60	10098	1369	0	9946	848	0	149	121	0
DE71	15579	5132	0	9866	0	65	74	327	0
DE72	0	0	0	0	0	0	34	0	0
DE73	1148	1326	1197	0	0	0	18	31	0
DE80	2527	419	0	0	0	0	711	36	0
DE91	2033	755	251	0	0	954	20	79	0
DE92	4730	632	381	9140	0	0	0	114	0
DE93	0	44	351	0	0	0	93	0	0
DE94	3722	1547	0	0	84	0	105	0	3060
DEA1	68147	12854	0	0	90	507	2	561	0
DEA2	1468	7958	0	0	119	0	11	215	0
DEA3	13422	8686	0	0	0	53	26	31	0
DEA4	4302	1153	0	0	0	0	4	72	0
DEA5	6775	4139	741	0	0	0	0	27	0
DEB1	0	0	135	0	0	0	61	26	0
DEB2	0	0	6640	0	0	0	65	0	0
DEB3	66	45	325	0	0	0	87	0	0
DEC0	10598	312	124	0	0	281	138	58	323
DED2	3842	1956	131	0	0	0	560	49	268
DED4	5007	1141	2232	0	25	0	87	0	0
DED5	14021	3679	188	0	317	0	951	143	0
DEE0	341	1744	0	0	0	46	948	283	757
DEF0	1588	383	0	0	0	0	120	0	471
DEG0	0	1406	2872	0	0	0	230	24	0

Source: Global Power Plant Database, https://github.com/wri/global-power-plant-database

There are different conventions for representing electricity splits within a CGE database. The international input-output convention is that electricity transmission and distribution are margin costs accompanying sales of generated electricity.[12] The Adams convention (Adams and Parmenter, 2013) is that electricity generating sectors sell mainly to the electricity transmission and distribution sector. In preparing the database, the author started with the Adams convention. However, in modelling disruptions to electricity supply, it may be advantageous to keep generation and transmission/distribution separate. An attack on a grid may disrupt

[12] From https://www.abs.gov.au/methodologies/australian-national-accounts-input-output-tables-methodology/2018-19: "This table [Table 4.14] shows the electricity margin associated with the supply of domestic and imported products to intermediate usage and final use categories. In this case the supplied products are entirely in the product group Electricity generation."

electricity supply without damaging generating capacity. In this scenario, we prefer to treat transmission and distribution as a margin. Given this, EuroTERM is now aligned with the international convention.

Mark Horridge developed MSPLITCOM (see https://www.copsmodels.com/msplitcom.htm), a series of database splitting programs for use on GTAP-based databases. The programs have been modified for the present task. For example, all initial coal sales to electricity are assigned to coal-generated electricity, all gas sales to gas-generated electricity and all oil and petroleum sales to oil-generated electricity. The initial activity share of the GTAP electricity sector assigned to electricity distribution is 0.5.

3.5. Splitting national data: steps (7) and (8)

The usual TERM methodology, as developed by Horridge (2011), splits a national CGE database into multiple regions. Every region in the initial split accounts for a given share of national user and sales activity. Table A1 at the end of Appendix 2 lists the 328 sub-national regions (set DST) of the EuroTERM database.

In the database splitting program of TERM, the formula for splitting the national factor inputs of industries into regions (NATFAC) is:

FAC(i,g,d)=R001(i,d)*NATFAC(i,g) (7.1)

The bracketed sets above are those listed in Table 2. The dimensions in (7.1) are IND *i*, FAC *g* and DST *d*. FAC is the value of regional primary factor inputs in each industry and R001 is that region's share of national industry activity.

In the EuroTERM procedure, this is modified first by defining two sets of nations, those with multiple regions (set NationM) and those with single regions (set Nation0 ⊆ DST). Equation (7.2) applies to 313 regions in 25 nations (set NationM), and (7.3) to 15 single-region nations (set Nation0). The use of two sets is practical, to reduce the size of some matrices in database computation.

FAC(i,g,d)=sum{n,NationM,R001(i,d,n)*natFAC(i,g,n)} (7.2)

FAC(i,g,d)= natFAC(i,g,d) (7.3)

In the single-nation TERM generating program, R001 has dimensions IND x DST and R001(i,d) sums to one when added across regions. In EuroTERM, splitting shares are nation-specific, having dimensions IND x DST x NationM. For all non-Austrian regions, R001(i,DST, "AT")=0, while R001(i,DST, "AT") summed across Austrian NUTS-2 regions equals 1.0.

(7.4) provides the example of the split of national margins (i.e., NatMARGINS for set NationM) into regional MARGINS demand for 313 sub-national regions, for commodity *c*, where *s* is the source (domestic or imported), *u* the user and *m* the margin. USHR refers to regional demand shares.

MARGINS(c,s,u,m,d,n)= NatMARGINS(c,s,u,m,n)*USHR(c,s,u,d,n) (7.4)

For the industry subset of users, these shares equal R001, reflecting intermediate input requirements. This leaves final users. Investment shares initially are set equal to regional industry shares. Household and government spending shares are based on preliminary estimates of regional income shares. Import shares across all users are based on estimates of port activity shares for merchandise and, for services, regional shares of overall economic activity. Export shares are based on estimated port activity shares for merchandise and, for services, regional shares of industry activity. In the case of the Nationo subset of regions, national data are carried over to the regional database.

3.6. Trade data by port: step (9)

In typical TERM database generation exercises, international merchandise exports and imports are limited to international ports. The Australian Bureau of Statistics, for example, collects data from 65 ports. In Europe, there are many land borders and water networks along which international trades may proceed. Given the diffuse nature of entry points for trades, as a starting point, NUTS-2 shares of national exports was set equal to corresponding output shares. NUTS-2 shares of national imports are set equal to regional usage shares. In the first step, no attempt was made to utilize port data within Europe. However, available international trade data provide national target totals for the intra-European TRADE matrix within EuroTERM.

It turns out that some data are available from Eurostat on commodity movements through ports. These data are used (see Table 6) to reflect port activity. Indeed, some scenarios, such as depictions of disruptions to port activity, require reasonable estimates of the value of cargo passing through ports.

Table 6: Gross weight of goods handled in each port (2017, thousand tonnes)

NUTS-2	Port	Total	Liquid bulk goods	Dry bulk goods	Large containers	Roll on - roll off	Other cargo
BE21	Antwerpen	201,202	71,944	11,840	101,021	3,809	10,180
DE50	Bremerhaven	49,292	274	108	43,728		571
DE60	Hamburg	118,761	13,650	30,818	72,816		1,117
DE94	Wilhelmshaven	28,210	18,472	4,180	5,554		5
EE00	Tallinn	18,944	7,223	3,958	1,907	590	788
EL30	Peiraias	45,202	418	353	39,420	2,059	14
ES61	Algeciras	83,465	28,935	1,942	48,532	1,129	3,122
ES51	Barcelona	49,825	14,541	4,466	23,828	2,863	5,815
ES52	Valencia	60,116	3,203	2,279	45,881	237	7,038
FRE1	Dunkerque	39,085	5,057	24,239	2,305		1,178
FRD2	Le Havre	66,104	40,053	2,238	22,846	25	18
FRL0	Marseille	75,617	46,328	13,615	10,532	2,836	2,750
ITC3	Genova	50,662	14,124	1,662	21,775	2,450	3,435
ITF4	Taranto	20,149	4,504	12,227		2,155	137
ITH4	Trieste	55,165	42,090	2,437	6,005	3,573	2,817
LV00	Riga	32,106	5,532	20,394	3,729	39	2,320
LT00	Klaipeda	40,027	11,497	19,113	4,691	1,701	1,842
NL32	Amsterdam	98,517	45,961	44,585	344	83	7,008
NL33	Rotterdam	433,293	206,610	74,804	119,933	7,589	20,364
PL63	Gdansk	33,940	13,505	8,712	10,674	81	762
PT18	Sines	46,473	22,498	6,361	17,499		109
RO22	Constanta	37,298	5,737	23,654	5,085		2,653
SE23	Göteborg	40,518	23,281	143	6,016	5,704	509
NO05	Bergen	48,092	44,136	2,856	172	71	780
UKE1	Immingham	54,034	20,065	14,056	2,282		1,191
UKI5	London	49,868	14,660	15,644	10,422		1,313
UKL1	Milford Haven	31,990	30,966	86			40
UKJ3	Southampton	34,471	21,446	2,109	9,552		58

UKC1	Tees & Hartlepool	28,447	19,975	3,519	2,162		623
UKD7	Liverpool	31,000	12,180	2,584	10,000	513	5,700

Source: Eurostat data https://ec.europa.eu/eurostat/databrowser/view/MAR_MG_AM_PWHC__custom_1762379/default/table?lang=en accessed 14 December 2021

Table 6 shows activity through most of the main ports of Europe. What is apparent in examining international trade data from the GTAP database, in turn extracted from Comtrade data,[13] is that the most active ports in Europe are not necessarily in the country of destination or origin of goods passing through. It is no surprise that Rotterdam, as the largest port in Europe and 10th largest in the world (exceeded only by six ports in China, plus Hong Kong, Singapore and Busan, South Korea),[14] is a transshipment port, handling goods neither originating in nor destined for the Netherlands. At issue is how we depict the movement of goods between regions within EuroTERM.

The motivation for improving the depiction of port activities within EuroTERM arose from a requested aggregation to depict the port of Gdansk, Poland, located within the NUTS-2 region PL63 (Pomorskie). Default assumptions noted above underestimated the port's throughput by about five- to ten-fold, based on the value of Poland's trade with non-European nations. Being the largest seaport in Poland, we might expect around 80% of merchandise trade with non-European countries from Poland to pass through Gdansk.

We can use existing data to approximate the trade that might pass through Gdansk. The port accounts for 1.7% of tonnage shown in Table 6. A crude guess is that the table covers 90% of the shipment tonnage between Europe and the rest of the world. In the GTAP database, merchandise exports from Europe to the rest of the world in 2017 are around US$2,000 billion. Assuming that Gdansk handles goods with a similar value per tonne as the average of European ports, a starting estimate might indicate that exports through the port total around US$31 billion (=0.9 x 0.017 x $2000 bn). The GTAP database shows that Polish exports to non-European nations exceed US$40 billion. The initial export shares used in generating EuroTERM lead to only US$4.4 billion of merchandise exports from PL63 (Pomorskie), which includes Gdansk. This exposes a clear case for improving the methodology to estimate international trade shares by region. Once Gdansk is treated as an important port (assigning 100% of initial Rest of World Polish merchandise exports to the port as in Table 7), exports to the rest of the world via PL63 (Pomorskie) increase to US$49 billion. This may be on the large side but improves markedly on the initial estimate.

Table 7 provides a start on how we might use the ports data. As with any estimation procedure, new and more detailed data will provide the basis for improved estimates. An obvious deficiency concerns transshipments from Antwerpen, Rotterdam and Amsterdam to other nations. At present, the modified gravity assumption and database balancing procedures currently impose some merchandise movements from/to these ports to/from regions in other European nations.

[13] See https://comtrade.un.org/data/

[14] See https://www.shipafreight.com/knowledge-series/largest-ports-in-the-world/

The shares assume that all merchandise trade with the Rest of the World in a given nation occurs through ports shown in the table. For nations with a single NUTS-2 region in Table 7, namely Estonia, Latvia and Lithuania, no trade data are split. The main burden of this assumption is that smaller ports, with less than 20 million tonnes of cargo handled each year, are excluded. Table 7 is being used only to impose revised Rest of World trade shares. In Ukraine, the main assumption concerning trade is that 80% of merchandise trade with the rest of the (non-European) world passes through ports in the oblast of Odesa.

Table 7: Estimates of shares of national trade with Rest of World

NUTS-2	Port	Total	Liquid bulk goods	Dry bulk goods	Large containers	Roll on - roll off	Other cargo
BE21	Antwerpen	1	1	1	1	1	1
DE50	Bremerhaven	0.008	0.003	0.358	0	0.337	0.008
DE60	Hamburg	0.421	0.878	0.596	0	0.660	0.421
DE94	Wilhelmshaven	0.570	0.119	0.045	1	0.003	0.570
EE00	Tallinn	1	1	1	1	1	1
EL30	Peiraias	1	1	1	1	1	1
ES61	Algeciras	0.620	0.224	0.410	0.267	0.195	0.620
ES51	Barcelona	0.312	0.514	0.202	0.677	0.364	0.312
ES52	Valencia	0.069	0.262	0.388	0.056	0.441	0.069
FRE1	Dunkerque	0.055	0.605	0.065	0.000	0.299	0.055
FRD2	Le Havre	0.438	0.056	0.640	0.009	0.005	0.438
FRL0	Marseille	0.507	0.340	0.295	0.991	0.697	0.507
ITC3	Genova	0.233	0.102	0.784	0.300	0.538	0.233
ITF4	Taranto	0.074	0.749	0.000	0.264	0.021	0.074
ITH4	Trieste	0.693	0.149	0.216	0.437	0.441	0.693
LV00	Riga	1	1	1	1	1	1
LT00	Klaipeda	1	1	1	1	1	1
NL32	Amsterdam	0.182	0.373	0.003	0.011	0.256	0.182
NL33	Rotterdam	0.818	0.627	0.997	0.989	0.744	0.818
PL63	Gdansk	1	1	1	1	1	1
PT18	Sines	1	1	1	1	1	1
RO22	Constanta	1	1	1	1	1	1
SE23	Göteborg	1	1	1	1	1	1
NO05	Bergen	1	1	1	1	1	1
UKE1	Immingham	0.168	0.370	0.066	0.000	0.133	0.168
UKI5	London	0.123	0.412	0.303	0.000	0.147	0.123
UKL1	Milford Haven	0.260	0.002	0.000	0.000	0.004	0.260
UKJ3	Southampton	0.180	0.056	0.278	0.000	0.006	0.180
UKC1	Tees & Hartlepool	0.167	0.093	0.063	0.000	0.070	0.167
UKD7	Liverpool	0.102	0.068	0.291	1.000	0.639	0.102

The next task is to associate the headings in Table 7 with the 45 merchandise commodities in the database. We align "Liquid bulk goods" with *PetrolCoalP*, *ChemicalPrd* and *Oil*; "Dry bulk goods" covers *Wheat*, *OtherCereals*, *Oilseeds*, *SugarBeet*, *FibreCrops*, *Fodder*, *ForestryLogs*, *Coal*, *OthMining*, *FeMetals*, *NonFeMetals*, *FabriMetals* and *NonMetMinPrd*, "Large containers" includes *WoodProds*, *PaperProds*, *RubberPlas* and *FurnitRepair*; "Roll on-roll off" includes motor vehicles, though tourism may be indistinguishable from merchandise trade; and "Other cargo" includes the merchandise commodities not covered above.

Horridge, Madden and Wittwer (2003) documented the first version of TERM without being aware that the Australian Bureau of Statistics had detailed international trade data by port. Instead, annual reports of port authorities provided the basis for port activity estimates. The main lesson from this is that the absence of very detailed regional data should never impede the process of preparing a multi-regional CGE databases. In any case, CGE databases are periodically updated. As practitioners become familiar with a wider array of database sources, and improve their knowledge of these sources, the data inputs to the model will improve.

The EuroTERM database generation process is a modification of the TERM process. Preparing data programs for the process was a time-consuming task. Once programs are written and running, the process of revising a database is mechanical. Compiling data such as regional shares, port activities, or even better regional household spending data if available, may be a painstaking process. But modifying the selected inputs to the data generation process is a relatively quick mechanical task, which enables the practitioner to generate an improved master database with relative ease.

3.7. Steps to reconcile EuroTERM trades with GTAP's international trade data: steps (10), (11), (12) & (13)

Client-driven demands have resulted in specific EuroTERM database modifications to deal with Nordic regions. Two major additions to the EuroTERM database are the electricity splits outlined in section 3.4, the addition of Iceland (using GTAP's Rest of EFTA region as a starting point) and the addition of single country regions, Russia and Moldova, plus 25 oblasts/cities of Ukraine to the database. Moldova is based on the Rest of Eastern Europe region within GTAP. It appears to be a reasonable representation of the nation's economic activity though not derived from a specific Moldovan database.

In preparing a master database for a multi-regional CGE model, examples help expose problems with the initial modified database generation methodology. In step (8), the example of Gdnask provided the impetus for improving the depiction of port activity within the database. Another early task using EuroTERM concerned NUTS-2 Nordic regions. This early aggregation showed that a defensible estimate of the initial TRADE matrix in EuroTERM requires actual European trade data. These data are prepared in step (2) of the EuroTERM database generation procedure and used in several steps.

The example that clearly exposed the deficiency in early attempts at devising trade matrices, that is, relying excessively on the Horridge gravity methodology without using international trade data prepared in step (2), was oil and gas sales from NO04 (Agder og Rogaland) in Norway. GTAP data indicate that oil exports from Norway to the rest of Europe are around US$40 billion, with another $3 billion to the Rest of the World. NO04's share of national oil output is around 69%, so we might expect the region's international exports to the rest of Europe to be around US$28 billion. Without scaling to GTAP trade data, the preliminary estimation procedure did not compute a reasonable estimate.

In response to the initial deficient estimation process, the revised method entailed revisiting step (5) to split the NATIONAL matrix into three. In step (12), the TRADE matrix also contains three slices: (1) strictly domestic trades ("dom"), (2) sales between European origins and destinations in other European nations ("RoE"), and (3) between Europe and the rest of the world ("RoW").

Within the "dom" slice, there are several steps. First, some commodities are treated as strictly local within each NUTS-2 region, and therefore sales are limited to diagonal elements of the region-by-region matrix. In the next step, partitioning of the matrix of sales shares allocates within country sales for the other commodities. That is, for regions *r* within nation *n*, we multiply initial user share estimates by 1, and by 0 for other regions. For example, the assigned multiplier for NO04 is 1 for sales to all Norwegian NUTS-2 regions, and 0 for sales elsewhere.

Figure 5 shows the strictly domestic slice of the interim TRADE matrix, summed across all commodities. The top left-hand corner shows the trades between the NUTS-2 regions of Austria. For each commodity in the regions of a given nation, the non-zero segment of the domestic matrix slice is based on a single number in the BAS matrix extracted from the GTAP database. An example is BAS("Wheat","dom","AT"). This single number will be split into a matrix of wheat sales across 9 x 9 Austrian NUTS-2 regions. The modified gravity assumption distributes trades within the domestic slice of the TRADE matrix. Across the EuroTERM TRADE matrix, the domestic slice accounts for 79% of the total value of transactions.

Figure 5*: The "dom" slice of the interim TRADE matrix*

TRADE	AT11	AT12	AT13	AT21	AT22	AT31	AT32	AT33	AT34	BE10	BE21	BE22	BE23	BE24	BE25	BE31	BE32	BE33	BE34	BE35	BG31	BG32	BG33	BG34	BG41
AT11	3915	9013	1644	2266	2110	3168	2361	2841	1478	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AT12	6190	47814	4154	11538	5819	8985	13781	9002	3414	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AT13	315	1175	97326	554	3622	3155	467	831	1730	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AT21	1903	14097	2439	9320	3655	5418	4982	4118	1871	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AT22	524	2118	4706	1080	47911	7643	874	1518	1771	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AT31	961	4005	5075	1963	9344	48285	1782	3626	2601	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AT32	2638	22423	2723	6649	3931	6556	11893	8561	2133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AT33	2102	9700	3234	3637	4541	8833	5678	21653	2441	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AT34	133	451	835	202	647	773	174	299	9055	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BE10	0	0	0	0	0	0	0	0	0	37734	6238	8533	1576	1172	1140	219	802	15151	525	586	0	0	0	0	0
BE21	0	0	0	0	0	0	0	0	0	4044	135632	3381	6205	3799	3837	521	1946	2693	2322	2480	0	0	0	0	0
BE22	0	0	0	0	0	0	0	0	0	10056	4990	19002	1499	1069	1085	196	723	11741	468	547	0	0	0	0	0
BE23	0	0	0	0	0	0	0	0	0	2703	16296	2212	49002	10954	16326	701	2565	1822	1030	8211	0	0	0	0	0
BE24	0	0	0	0	0	0	0	0	0	2014	7006	1592	11009	27375	13905	786	2868	1339	753	4115	0	0	0	0	0
BE25	0	0	0	0	0	0	0	0	0	2321	11651	1887	19291	16399	44852	739	2664	1564	816	4470	0	0	0	0	0
BE31	0	0	0	0	0	0	0	0	0	991	4509	750	1845	2084	1636	22161	18114	648	327	724	0	0	0	0	0
BE32	0	0	0	0	0	0	0	0	0	1335	5603	1028	2495	2763	2194	6570	40812	899	463	1005	0	0	0	0	0
BE33	0	0	0	0	0	0	0	0	0	21006	14549	14102	3734	2381	3084	639	1995	34563	563	903	0	0	0	0	0
BE34	0	0	0	0	0	0	0	0	0	1022	5347	788	1179	858	792	141	550	675	5015	525	0	0	0	0	0
BE35	0	0	0	0	0	0	0	0	0	1291	6519	1044	10757	5354	4962	354	1347	874	586	6122	0	0	0	0	0
BG31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8330	401	1068	776	6194
BG32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	301	9548	1360	505	860
BG33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	422	257	7344	683	1123
BG34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	153	73	515	10338	461
BG41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3511	265	1551	991	28808
BG42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	486	149	657	442	1494
CH01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The "RoE" (rest of Europe, Figure 6) slice of the TRADE matrix uses sub-national user shares to distribute known imports, gathered from the GTAP international TRADE matrix (see Table 2), to NUTS-2 regions. Sub-national export shares provide the regional share of known international trades. Note the partitioned pattern of the matrix, with zeroes in all home country cells and the possibility of non-zeroes elsewhere.

Figure 6*: The "RoE" slice of the interim TRADE matrix*

TRADE	AT11	AT12	AT13	AT21	AT22	AT31	AT32	AT33	AT34	BE10	BE21	BE22	BE23	BE24	BE25	BE31	BE32	BE33	BE34	BE35	BG31	BG32	BG33	BG34	BG41	BG42	CH01	CH02
AT11	0	0	0	0	0	0	0	0	0	3	61	2	4	3	4	1	3	3	1	1	3	3	3	4	10	5	44	58
AT12	0	0	0	0	0	0	0	0	0	21	443	14	27	19	24	8	18	17	3	8	16	18	23	25	67	35	284	378
AT13	0	0	0	0	0	0	0	0	0	33	364	22	43	30	38	13	29	27	5	12	14	16	20	22	60	31	309	412
AT21	0	0	0	0	0	0	0	0	0	7	156	5	9	7	8	3	6	6	1	3	6	6	8	9	23	12	108	144
AT22	0	0	0	0	0	0	0	0	0	16	338	11	20	14	18	6	14	13	3	6	13	14	18	20	53	27	216	288
AT31	0	0	0	0	0	0	0	0	0	17	476	11	22	15	19	7	15	14	3	6	17	19	23	26	70	36	282	376
AT32	0	0	0	0	0	0	0	0	0	10	167	7	13	9	12	4	9	8	2	4	7	7	9	10	27	14	105	140
AT33	0	0	0	0	0	0	0	0	0	12	211	8	16	11	14	5	10	10	2	4	8	9	11	12	33	17	136	181
AT34	0	0	0	0	0	0	0	0	0	5	140	3	6	4	6	2	4	4	1	2	6	7	8	9	24	12	81	108
BE10	10	58	70	20	44	51	23	30	14	0	0	0	0	0	0	0	0	0	0	0	7	8	9	10	28	14	113	150
BE21	18	102	124	36	77	89	41	52	25	0	0	0	0	0	0	0	0	0	0	0	12	13	16	18	48	25	182	242
BE22	8	48	58	17	36	42	19	24	12	0	0	0	0	0	0	0	0	0	0	0	5	6	7	8	22	11	94	126
BE23	17	100	122	35	76	88	40	51	25	0	0	0	0	0	0	0	0	0	0	0	12	14	17	19	51	26	177	236
BE24	7	43	52	15	32	37	17	22	10	0	0	0	0	0	0	0	0	0	0	0	5	5	7	7	20	10	81	107
BE25	15	90	109	32	68	79	36	46	22	0	0	0	0	0	0	0	0	0	0	0	12	14	17	18	50	26	163	217
BE31	5	30	36	11	23	26	12	15	7	0	0	0	0	0	0	0	0	0	0	0	3	4	5	5	14	7	62	83
BE32	9	55	66	19	41	48	22	28	13	0	0	0	0	0	0	0	0	0	0	0	6	7	8	9	24	12	107	142
BE33	11	61	74	21	46	53	25	31	15	0	0	0	0	0	0	0	0	0	0	0	7	8	10	11	29	15	191	255
BE34	1	6	7	2	5	5	2	3	2	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	3	2	12	16
BE35	2	13	16	5	10	12	5	7	3	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	6	3	29	38
BG31	2	11	14	4	9	10	5	6	3	1	184	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	4	5
BG32	3	16	20	6	12	14	6	8	4	1	243	1	2	1	2	1	1	1	0	1	0	0	0	0	0	0	5	7
BG33	2	14	17	5	10	12	6	7	3	2	168	1	3	2	2	1	2	2	0	1	0	0	0	0	0	0	5	7
BG34	3	15	18	5	11	13	6	8	4	2	140	2	3	2	3	1	2	2	0	1	0	0	0	0	0	0	5	6
BG41	8	49	60	17	37	43	20	25	12	10	398	7	13	9	11	4	9	8	2	4	0	0	0	0	0	0	20	26
BG42	5	29	35	10	22	25	12	15	7	3	261	2	4	3	3	1	3	2	0	1	0	0	0	0	0	0	10	14
CH01	34	197	239	69	149	172	79	100	48	25	682	17	33	23	29	10	22	21	4	9	4	4	5	6	16	8	0	0
CH02	80	468	567	164	354	408	188	238	114	28	1705	19	36	26	32	11	25	23	5	10	9	10	12	13	37	19	0	0
CH03	47	272	329	95	206	237	109	138	66	21	980	14	27	19	24	9	18	17	3	8	5	6	7	8	21	11	0	0
CH04	42	245	296	86	185	213	98	125	60	32	852	21	41	29	36	13	28	26	5	12	5	5	7	7	20	10	0	0
CH05	58	335	406	117	253	292	135	170	82	18	1224	12	23	16	20	7	15	15	3	6	6	7	9	10	26	13	0	0
CH06	33	194	235	68	147	169	78	99	47	14	702	9	18	13	16	6	12	11	2	5	4	4	5	6	15	8	0	0
CH07	7	43	52	15	33	38	17	22	11	5	155	4	7	5	6	2	5	4	1	2	1	1	1	1	4	2	0	0

The "RoW" (Rest of World, Figure 7) slice initially used a methodology similar to that of the "RoE" slice. That is, initial EuroTERM database development did not use port activities in estimating trade movements. Instead, sub-national import shares were based on user shares. The methodology has been modified to use port data. The example of Gdansk in step (9) exposed problems with an earlier methodology. The revised methodology makes the "RoW" slice of the TRADE matrix less diagonal. The port role of BE21 (Antwerpen) is evident in Figure 7: the BE21 row indicates that imports through the port are sold to many other regions.

Figure 7*: The "RoW" slice of the interim TRADE matrix*

TRADE	AT11	AT12	AT13	AT21	AT22	AT31	AT32	AT33	AT34	BE10	BE21	BE22	BE23	BE24	BE25	BE31	BE32	BE33	BE34	BE35	BG31	BG32	BG33	BG34	BG41	BG42	CH01	CH02
AT11	574	84	12	21	10	18	24	23	10	33	10	28	104	83	142	17	39	72	4	21	80	1	3	2	74	2	13	23
AT12	41	6028	26	101	24	50	107	68	21	78	24	68	297	297	460	42	99	177	10	59	251	2	5	5	45	5	25	62
AT13	2	9	4750	4	13	15	4	6	10	1204	22	284	63	31	51	12	28	1214	9	14	11	1	4	127	7	1	9	39
AT21	10	108	13	1335	13	28	38	29	10	46	12	39	176	245	252	27	64	103	6	38	70	1	2	2	17	3	10	39
AT22	3	15	23	8	2815	44	7	9	12	85	34	72	132	66	101	20	52	189	41	38	18	10	5	5	7	2	9	278
AT31	4	28	20	14	38	3517	14	22	16	95	40	86	513	133	253	25	61	218	17	126	36	3	11	5	11	3	8	120
AT32	13	146	12	46	15	33	1779	55	14	51	14	43	231	246	437	25	59	115	7	43	171	1	3	3	33	3	12	42
AT33	11	73	16	30	16	44	46	2493	14	60	18	52	360	207	957	24	58	137	8	55	131	1	4	3	22	3	11	50
AT34	1	3	3	1	3	4	1	2	181	16	2	14	18	10	17	4	10	36	1	4	4	0	0	1	2	0	2	7
BE10	0	2	127	1	3	3	1	1	2	2331	12	24	5	3	3	1	1	41	1	1	0	0	1	12	2	0	1	5
BE21	17	85	187	37	172	245	34	55	53	790	24700	771	1300	489	919	132	379	1566	193	303	115	23	165	58	69	14	77	909
BE22	1	3	30	1	5	5	1	2	3	50	12	1483	6	3	5	0	2	65	1	2	0	0	1	6	1	0	2	8
BE23	2	13	10	8	9	34	9	16	4	14	33	8	4233	21	52	2	4	6	1	14	2	0	2	1	6	1	3	17
BE24	5	26	10	19	9	17	18	16	4	13	21	8	39	2626	48	2	6	6	2	16	3	0	2	1	10	1	7	15
BE25	4	25	8	14	9	22	23	56	5	11	23	9	65	36	3837	1	6	7	1	11	5	0	1	1	8	1	5	18
BE31	1	4	5	2	3	4	2	2	2	6	7	3	7	6	5	1589	35	2	1	2	1	0	1	0	3	18	22	4
BE32	2	8	6	4	7	7	4	4	4	7	10	7	10	9	10	17	2847	5	1	4	1	0	1	1	3	10	31	10
BE33	1	3	50	1	5	5	1	2	3	108	11	85	5	3	4	0	2	2184	1	2	0	0	1	9	1	0	2	8
BE34	1	2	6	1	14	5	1	2	1	7	16	5	5	4	4	0	2	4	335	3	0	0	1	1	1	0	2	25
BE35	2	9	7	5	9	29	5	8	3	9	19	7	46	23	23	1	4	6	2	777	1	1	2	1	4	0	4	16
BG31	11	108	7	22	7	19	31	43	7	34	8	36	167	119	298	15	47	99	5	29	1388	1	3	3	26	2	7	26
BG32	1	10	9	5	61	23	3	6	5	43	13	44	98	45	77	11	37	122	17	29	16	1000	5	2	4	2	5	118
BG33	2	13	16	6	19	57	5	9	7	58	58	63	155	51	103	11	35	169	13	37	21	3	426	5	8	2	8	80
BG34	1	5	146	2	7	8	2	3	5	563	9	231	38	17	33	6	18	980	5	8	8	1	2	443	4	1	4	21
BG41	30	74	15	23	13	28	25	30	18	66	18	68	228	140	304	31	90	192	9	41	153	2	6	6	2192	5	17	43
BG42	2	16	7	8	9	13	5	7	9	37	7	38	81	55	86	772	883	107	6	19	23	1	2	3	8	1679	63	27
CH01	7	28	27	14	20	25	12	14	19	89	21	72	144	104	145	303	592	141	11	35	21	2	5	6	21	29	12224	99
CH02	2	17	27	11	130	67	9	13	15	189	62	160	291	133	215	38	97	302	90	80	21	13	8	6	9	3	8	17144
CH03	8	64	18	27	18	48	36	71	20	117	19	99	468	259	677	46	107	190	14	75	139	3	3	3	49	3	9	140
CH04	6	28	60	13	84	96	13	18	17	187	262	157	328	137	223	36	88	294	52	88	24	9	46	14	21	4	42	902
CH05	2	14	25	9	54	65	8	11	13	165	137	144	253	107	179	29	73	266	50	66	18	6	10	5	8	2	6	774
CH06	2	15	20	9	24	144	9	13	12	129	42	112	411	124	239	27	66	209	19	84	22	3	16	4	10	2	5	230
CH07	4	16	13	8	10	13	6	7	9	43	11	35	78	59	80	551	512	69	5	19	12	1	3	3	11	70	154	51

3.8. Database balancing, reconfiguration and aggregation: steps (13), (14) & (15)

With one exception, the final steps in creating a EuroTERM master database and project-specific aggregation are identical to the corresponding steps in the TERM process. The only difference is that the source dimension in applicable matrices is aggregated from three to two. The three sources used in the database generation process are necessary to make use of available GTAP data on bilateral trades. In step (5), international imports are split into Rest of Europe and Rest of World. In aggregating the source dimension in preparation for the EuroTERM master database in step (13), the "domestic" slice combines own-country sourcing and imports from the rest of Europe. This reassigning of "domestic" sources enables us to retain the core theory of TERM in EuroTERM.

Step (14) uses a RAS procedure to balance the master database. Step (15) reconfigures the master database so that data are in the form required by the TERM/EuroTERM model.

3.9. Treatment of trade taxes

Export taxes and import taxes are two of the flow types shown in Table 2 in the TRADE matrix. In the initial creation of EuroTERM, all elements of the FLOWTYPE set were aggregated to a single slice in the TRADE matrix before further processing. This is in line with the default TERM convention, in which trade taxes are not identified separately.

The following outlines the method to include data and theory on trade taxes. First, the two trade taxes are excluded from the TRADE matrix and instead form part of a TradTAX matrix with commodity, origin, destination and source dimensions, as for the TRADE matrix. The top right-hand rectangle of Figure 1 deals with TRADE matrix and accompanying margins, TRADMAR. In balancing the database, the original condition from equation 2.9 was

CHECKB(c,s,d) = USE_U(c,s,d)-DELIVRD_R(c,s,d) (12.1)

Figure 1 indicates that

DELIVRD(c,s,r,d)= TRADE(c,s,r,d) + sum{m,MAR,TRADMAR(c,s,m,r,d)} (12.2)

Now that TradTAX has been extracted from TRADE, the old formula for DELIVRD is redefined as DELIVRDo, to which trade taxes are added in revised DELIVRD:

DELIVRDo(c,s,r,d)= TRADE(c,s,r,d) + sum{m,MAR,TRADMAR(c,s,m,r,d)} (12.3)

DELIVRD(c,s,r,d)=DELIVRDo(c,s,r,d)+sum{t,TrTax,TradTAX(c,s,t,r,d)} (12.4)

The set TrTax contains two elements, IMPTAX and EXPTAX. The variable *pdelivrd* is the share-weighted sum of basic and margin prices in the original implementation of EuroTERM, now replaced by *pdelivrdo*:

pdelivrdo(c,s,r,d) =BASSHR(c,s,r,d)*pbasic(c,s,r)

+ sum{m,MAR, MARSHR(c,s,m,r,d)*[psuppmar_p(m,r,d)+atradmar(c,s,m,r,d)]} (12.5)

The variable *atradmar* denotes technical change in margins. The revised equation solving for *pdelivrd* now includes *ttax*, the power of the trade tax:

pdelivrd(c,s,r,d) =pdelivrdo(c,s,r,d) + sum{t,TrTax,ttax(c,s,t,r,d)} (12.6)

The modified variable *pdelivrd* remains elsewhere in EuroTERM as it was prior to the inclusion of trade taxes. An additional formula and equation deal with changes in TradTAX. Since *ttax* is the power of the tax, enabling the level of the tax to start at or move through zero, the appropriate base level adds together TRADE and TradTAX:

TRADEpTAX(c,s,r,d)=TRADE(c,s,r,d)+sum{t,TrTax,TradTAX(c,s,t,r,d)} (12.7)

Next, the variable *delTradTAX* is calculated in ordinary change ($m) terms:

delTradTAX(c,s,t,r,d)=0.01*TradTAX(c,s,t,r,d)*[xtrad(c,s,r,d)+pbasic(c,s,r)+phi]
+ 0.01*TRADEpTAX(c,s,r,d)*ttax(c,s,t,r,d) (12.8)

In the above, in percentage change terms, *xtrad* is the quantity of TRADE, as shown in Figure 1, and *pbasic* is the basic price. The variable *phi* is the nominal exchange rate between the regions within the model and the rest of the world, and is usually the numeraire of the model.

Trade tax revenues are added to indirect taxes on the income side of GDP.

GDPINCSUM(d,"ComTax") = + sum{c,COM, sum{o,ORG,TRADtax(c,"ImpTax",o,d)}+
sum{p,DST,TRADtax(c,"ExpTax",d,p)} + sum{u,USR, TAX(c,u,d)}} (12.9)

Note that export taxes are added across destinations, as revenues accrue to the exporting country. Conversely, we import taxes across origins, as they accrue to the importing country.

3.10. Other multi-country modifications concerning trade and labour markets

In the preparation of the EuroTERM master database, the TRADE matrix contains three (domestic, imports from endogenous nations and imports from exogenous rest of world) instead of two (domestic and import) slices. Trade shares by region are attributed to the trades between endogenous regions of the model.

The "import" slice of the database refers to purchases supplied exogenously. In the case of EuroTERM, these account for a smaller share of transactions than in a typical single country TERM database.

Why are three slices not retained in the master database? Quite simply, the "RoE" slice is separated from the "domestic" slice during preparatory stages of the database to ease the task of fitting regional data to known bilateral trade totals. Once we have estimates of regional origins and destinations, there is no need to retain the "RoE" slice. The "dom" and "RoE" values occupy mutually exclusive cells in the Org x DST dimensions. That is, "RoE" cells are non-zero only for international transactions and "dom" cells, at this stage, are only non-zero for sub-national transactions.

In the EuroTERM context, "domestic" refers to goods and services with supplies and demands endogenous to the model. In single country TERM, the definition of "domestic" aligns with sub-national transactions. In multi-country EuroTERM, corresponding transactions may cross international borders within Europe.

3.10.1. Modifying TERM theory to deal with trade in EuroTERM

Within single-country TERM, equation (2.2) deals with sub-national trades. In the single country Australian version of TERM, the import slice of the TRAD matrix accounts for 11.4% of total trade. This compares with the EuroTERM 40 country version, in which the import slice accounts for 7.3%

of total trade. International exports as a share of the total value of USE transactions are 11.1% in the Australian TERM database and 6.6% in EuroTERM.

Since the “import” slice of EuroTERM deals with imports only from suppliers exogenous to the model, a binary matrix identifies the type of bilateral trade. This matrix also assists in macro accounting. The code of the model includes a Nation set (n and m) and a mapping from regions (sets Org o and DST d, which contain the same elements) to nations denoted by Mnat:

NatFlag(n,m)=0

NatFlag(n,n)=1

HomeFlag(o,d) = NatFlag(Mnat(o),Mnat(d)) (13.1)

HomeXFlag(o,d)= HomeFlag(o,d)

HomeXFlag(o,o)= 0 (13.2)

HomeFlag is a binary matrix of origin by destination pairings. As shown above, for sub-national regional pairs from a common country, the cell value is 1.0. For pairs of regions in different countries, the value is 0. Finally, for macro accounting purposes, HomeXFlag is set equal to the non-diagonal elements of HomeFlag.

HomeFlag enables us to split transactions between sub-national and international trades. DELIVRDH refers to sub-national transactions (=DELIVRD x HomeFlag) and DELIVRDM (=DELIVRD x [1-HomeFlag]) to international transactions. From these, we compute the domestic composite price *puseh* and the international composite *pusem*.

DELIVRDH_R(c,s,d)*puseh(c,s,d) =

sum{o,ORG,DELIVRDH(c,s,o,d)*[pdelivrd(c,s,o,d)+atrad(c,s,o,d)]} (13.3)

DELIVRDM_R(c,s,d))*pusem(c,s,d) =

sum{o,ORG,DELIVRDM(c,s,o,d)*[pdelivrd(c,s,o,d)+atrad(c,s,o,d)]} (13.4)

The equation solving for *xtrad* replacing (2.2) becomes

xtrad(c,s,o,d) - atrad(c,s,o,d) = xuse(c,s,d)

-HOMEFLAG(o,d)*SIGMADOMDOM(c)*[pdelivrd(c,s,o,d)+atrad(c,s,o,d)-puseh(c,s,d)]

-[1-HOMEFLAG(o,d)]*SIGMADOMIMP(c)*

[pdelivrd(c,s,o,d)+atrad(c,s,o,d)-pusem(c,s,d)] (13.5)

The CES parameter SIGMADOMIMP depicts substitutability between origins from different countries and SIGMADOMDOM substitutability between different sub-national regions. In order to speed the solution time, we solve the domestic and imported components as separate equations and backsolve for the variables *xdomdom* and *xdomimp*:

xdomdom(c,s,r,d) =

SIGMADOMDOM(c)*[pdelivrd(c,s,r,d)+ atrad(c,s,r,d)-puseh(c,s,d)] (13.6)

xdomimp(c,s,r,d) =

SIGMADOMIMP(c)*[pdelivrd(c,s,r,d) atrad(c,s,r,d)-pusem(c,s,d)] (13.7)

The revised equation solving for *xtrad* is:

xtrad(c,s,r,d) - atrad(c,s,r,d) = xuse(c,s,d)
- HOMEFLAG(r,d]*xdomdom(c,s,r,d)
-[1-HOMEFLAG(r,d]*xdomimp(c,s,r,d) (13.8)

HomeFlag and HomeXFlag appear in formulae and equations accounting for GDP in region q on the expenditure side. "INTExports" denotes international exports within the 40 countries of EuroTERM and "INTimports" international imports within the same group.

GDPEXPSUM(q,"INTExports") =
sum{c,COM,sum{s,SRC, sum{d,DST, [1-HomeFlag(q,d)]*
TRADE(c,s,q,d)}}} (13.9)
GDPEXPSUM(q,"INTImports") =

- sum{c,COM,sum{s,SRC, sum{r,ORG, [1-HomeFlag(r,q)]*TRADE(c,s,r,q)}}} (13.10)

Similarly, "Xsubnat" denotes sub-national exports and "Msubnat" sub-national imports.

GDPEXPSUM(q,"Xsubnat") =
sum{c,COM,sum{s,SRC, sum{d,DST, HomeXFlag(q,d)*
TRADE(c,s,q,d)}}} (13.11)
(all,q,REG) GDPEXPSUM(q,"Msubnat") =

- sum{c,COM,sum{s,SRC, sum{r,ORG, HomeXFlag(r,q)*TRADE(c,s,r,q)}}} (13.12)

In a single country model version of TERM, the add-ups of the TRADE matrix are not partitioned into international trade within Europe and sub-national trade: all trade add-ups shown in (13.9) to (13.12) are sub-national. In a single country, (13.9) and (13.10) are omitted while the binary matrix HomeXFlag is equal to 1.0 for all non-diagonal elements.

3.10.2. The treatment of ports in EuroTERM

In single country versions of TERM, international merchandise trades appear typically in two parts of the database. Exports from ports appear in the "Exp" column of the USE matrix, with goods originating in a non-port region appearing in the domestic slice of the TRADE matrix as sales from the origin to the port. This rule still applies in EuroTERM for exports to countries beyond Europe.

International merchandise imports appear in the import slice of the USE matrix in the port of import. If sold to other destinations, the port of origin sells to the destination in the import slice of the TRADE matrix. Again, the definition of imports is that commodities originate outside the European countries.

International trades within Europe appear in the TRADE matrix in the domestic slice. The USE matrix will include the value of the transaction in the destination, distributing the sale across users.

Since we do not know the value of merchandise passing through ports, we base estimates on data such as in Table 6. Checking a resultant database requires judgment. For example, are the activities of major ports represented reasonably within the database? An answer to this may arise from better port data that emerge later.

3.10.3. Labour market modifications in EuroTERM

Equation (13.13) links nominal wages to the CPI. The two wage shifters *flab_io* and *flab_iod* are exogenous in the standard short-run closure of comparative static TERM. Real wages are fixed and employment endogenous at both the regional and national level.

plab(i,o,d) = pfin(*"hou"*,d) + flab_io(d) + flab_iod (13.13)

This labour market rule will suffice for the short-run setting in EuroTERM.

In the long run, we may wish to consider relative freedom of worker movement within the European Union or elsewhere. A starting point may be to assign blocs of nations instead of nations to replace national labour market variables as represented in single country TERM versions. One such bloc may consist of the 27 EU members.

Before proceeding further, we need to make a judgment as to how mobile labour is between countries in a labour market bloc. Stráský (2016) noted that in 2015, only 3% of the population across then EU-28 were citizens of another EU-28 country. Stráský notes that in addition to linguistic and cultural differences, difficulties remain in the recognition of professional qualifications. Therefore, in devising a theory of labour migration within a bloc, notably the EU, we need to take care not to exaggerate mobility. A pragmatic step in the early stages of GlobeTERM development is to assume that each country has a closed labour market. This assumption consigns international immigration to exogeneity. This may be more defensible than devising a more elaborate theory that exaggerates international labour market mobility. Specific projects concerning the labour market may require tailored modifications to the labour mobility theory.

In comparative static single-country TERM, there are two national labour market variables, a slack variable enabling a national employment constraint, *labslack*, and a wage shifter *flab_iod*.

xlab_io(d) = 1.0*averealwage(d) + flabsup(d) + labslack (13.14)

Equation (13.14) links aggregate employment in region d to average regional real wages via an elasticity set at 1.0, if *flabsup* and *labslack* are exogenous. This is a long run setting depicting imperfect mobility within regions of a single country. The multi-country version of the equation is:

xlab_io(d) = 1.0*averealwage(d) + flabsup(d) + labslack(Mnat(d)) (13.15)

Since the EU's labour market is not particularly mobile between countries, despite the ostensible objectives of the union, the lack of mobility between nations implied by equation (13.15) remains defensible. Concerning the long run, in which the usual assumption is that labour market changes are reflected in real wage movements rather than changes in national employment, equation (13.13) becomes

plab(i,o,d) = pfin("hou",d)+flab(i,o,d) + flab_io(d) + flab_iod(Mnat(d)) (13.16)

That is, the wage shifter *flab_iod* is nation-wide rather than model-wide. More elaborate theory concerning labour mobility within EU-27 or any other bloc may need to recognize that there is less mobility between different countries than between regions in a given country. A second tier of parameters may require elaborations beyond extending the mapping of MNat from individual nations to blocs of countries.

3.10.4. Trade shifters in EuroTERM

Some scenarios in CGE analysis entail shifts in export demand. Additional shifters have been added to TERM to deal with sub-national demands shifts by origin and destination. In EuroTERM, the same shifters must all also cover international trade within Europe. The equations dealing with demand shifts by origin and destination are:

DELIVRD_R(c,s,d))*atrad_o(c,s,d)= sum{r,ORG,DELIVRD(c,s,r,d)*atrad(c,s,r,d)} (13.17)

ttrad(c,s,r,d) = atrad(c,s,r,d)- {HomeFlag(r,d)*SIGMADOMDOM(c) + [1-HomeFlag(r,d)]* SIGMADOMimp(c)}*[atrad(c,s,r,d)-atrad_o(c,s,d)] (13.18)

atrad(c,s,o,d)=fatrad_o(c,s,d)+fatrad(c,s,o,d); (13.19)

Equation (13.17) calculates the average shifter *atrad_o*. Equation (13.18) has a similar form as the equation solving for *xtrad*, accounting for both sub-national substitutability via SIGMADOMDOM and international substitutability via SIGMADOMIMP. A set group of closure swaps must accompany implementation of *ttrad* shocks. First, consider a group of nations which shift preferences away from a particular source for a group of commodities. Within a command file (*.cmf), in this example we define Switch, a subset of COM in which the preference switch by origin occurs. Exporter is subset of Org, and Importer a subset of DST. Command files require subset declarations. We also need to define the remaining elements of Org as:

RestReg = Org – Exporter;

Swap atrad(Switch,”dom”,Exporter,Importer)= ttrad(Switch,”dom”,Exporter,Importer);
Swap atrad(Switch,”dom”,RestReg,Importer)= fatrad(Switch,”dom”,RestReg,Importer);
Swap fatrad_o(Switch,”dom”,Importer)= atrad_o(Switch,”dom”,Importer);

In the above, we assume that the “imp” slice of trades is relatively small. The average shifter *atrad_o* is made exogenous by the closure swap. A negative shock to *ttrad* in the Exporter subset of Org will be offset by a uniform endogenous positive *ttrad* movement in the RestReg subset.

3.11. Extending the methodology across all GTAP-based regions: GlobeTERM

The starting point of EuroTERM involves splitting the GTAP master database in the sectoral dimension to depict different types of electricity generation. Then the master database is aggregated to 40 nations. Next, we apply a regional split to the NUTS-2 level plus oblasts of Ukraine, involving 25 nations. The remaining 15 nations in the database are represented as single regions. A further step is to extend the methodology to include virtually all countries in the GTAP database. We call this new model GlobeTERM.

Recall that the export column of the USE matrix and the import slices in TERM and EuroTERM concern demands and supplies in countries outside the model. It follows that with virtually all regions of GTAP included in a revised model, we can omit the export column and import slices. In effect, step 5 outlined in section 5 is redundant.

The extended database of GlobeTERM includes 150 regions of GTAP, omitting Comoros, the smallest economy among the GTAP regions. In constructing GlobeTERM, the procedure is virtually identical to that of creating EuroTERM. Instead of all countries other than the 40 European nations being exogenous, with the import slice representing an aggregation of purchases from the exogenous countries and the export column representing aggregated sales to these countries, only Comoros appears in the initial import slices and export columns. Since Comoros is small at the global level, there is relatively little disruption to the database in omitting the import slices and export columns.

The reason for generating a master database that initially keeps Comoros in the import slices and export columns is pragmatic. This bypasses the need for substantial rewriting of the database generation programs. Database imbalances arising from the eventual omission of Comoros are minor, given its small share of global economic activity. It may, for example, appear to simplify the process to omit redundant section 5. This would be so if the process did not entail systemic rewriting of subsequent programs in the data preparation stage.

Four matrices in the master database have the source (SRC) dimension removed. These are TAX (header "UTAX"), USE ("BSMR"), TRADE ("TRAD") and TRADMAR ("TMAR"). That is, the dimensions of USE and TAX reduce from [COM*SRC*USER*DST] to [COM*USER0*DST]. The set USER0 omits exports from final demands. TRADE reduces from [COM*SRC*ORG*DST] to [COM* ORG *DST], and TRADMAR from [COM*Mar*SRC* ORG *DST] to [COM*Mar* ORG *DST]. Overall, the master database size in GEMPACK falls from 987 megabytes to 625 megabytes with the omissions. The master database includes 74 commodities and industries, 5 margins and 438 regions in 150 countries/groups.

3.11.1. Omitted equations in GlobeTERM

TERM and EuroTERM include CES substitutability between "domestic" and "imported" sources for intermediate and final demands accounted in the USE and TAX matrices. This substitutability is also standard in ORANI-type models. In EuroTERM, the CES equations concerning origins and destinations now have different CES parameters for sub-national and international substitutability, accounted for in the TRADE, TRADMAR and TradTAX matrices. The role of substitutability in the USE and TAX matrices decreases in EuroTERM as the endogenous country activity as a share of global economic activity increases. In the extreme case of only Comoros being exogenous, this role is negligible. Omitting the import slices and export columns from the database and model equations in GlobeTERM also implies omission of the CES substitutability equations for intermediate and final users, and omission of the export demand equations.

The source (SRC) dimension of the equations of EuroTERM listed in sections 13.1 and 13.4 are omitted in GlobeTERM.

3.11.2. Choice of numeraire in GlobeTERM

In EuroTERM, *phi* is the nominal rate of exchange between the "currency" of the endogenous part of EuroTERM and the exogenous part of the global economy in the model. Its only purpose in a model of real activity is as a numeraire. With omission of exogenous trades, *phi* is omitted from GlobeTERM. A global CPI becomes the numeraire. An additional endogenous variable, *lambda*, is added to the consumption function to enable global CPI to be exogenous.

3.11.3. Where does GlobeTERM fit in among a suite of CGE models?

The main motivation in creating EuroTERM is to depict sub-national regions across Europe. GlobeTERM extends the methodology to depict all countries in the GTAP database. This brings all trading partners into GlobeTERM, leaving no import supplies or export demands exogenous.

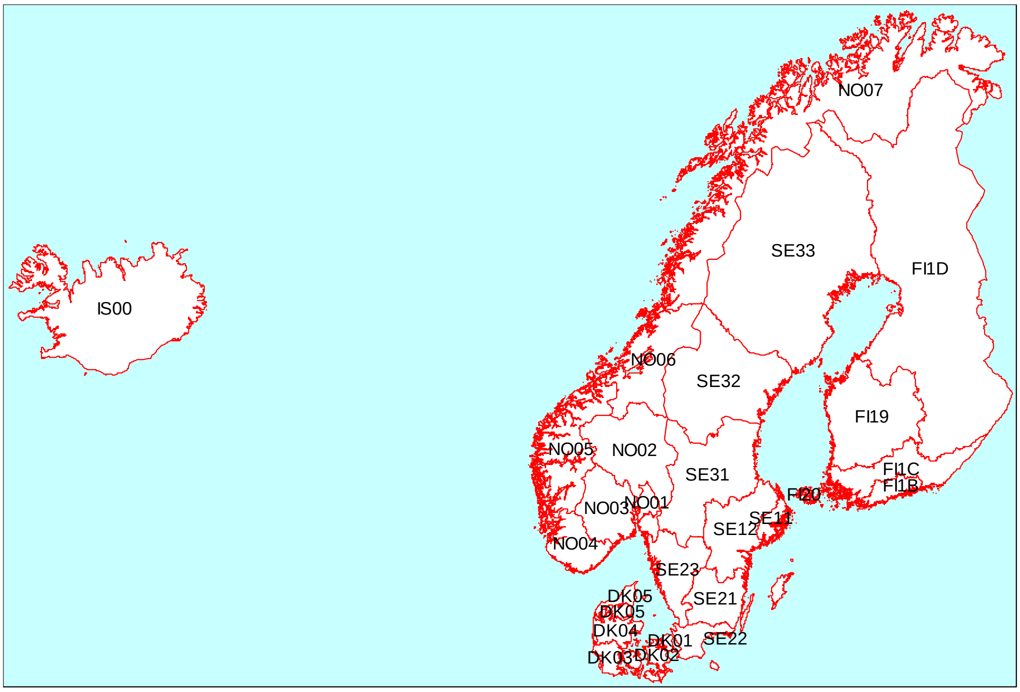
The advantage of EuroTERM over other sub-national models of Europe is that it depicts all GTAP sectors plus electricity generating sectors at the NUTS-2 level. The advantage of extending to GlobeTERM by including the remaining national regions of GTAP is to enable global modelling using the theory and framework of TERM models. In particular, there is provision within TERM for industry-specific investment and, in dynamic modelling, capital accumulation. In EuroTERM or GlobeTERM, further development of the industry-specific investment matrix will follow. At present, livestock sectors, for example, have the same composition of investment inputs as education. This will change with further database development: in this example, both sectors will have investment own-inputs in order to enhance the realism of the model.

The intent in developing GlobeTERM is not to replace highly disaggregated multi-regional single country models such as Australian TERM (see https://www.copsmodels.com/term.htm) or USAGE-TERM (Wittwer 2017a). Most single-country models prepared at the Centre of Policy Studies have hundreds of sectors (216 in the Australian version, over 400 in the US version and over 200 in the Canadian version, for example). Single country data usually are of higher quality than global data, at least for trade data. There appears to be little to gain from including sub-national representation for countries with existing well-developed single-country TERM models.

4. Nordic TERM: A Nordic aggregation of EuroTERM

A final step in data preparation in the procedure is to aggregate to sectors and regions of interest. Figure 8 shows a map of 26 Nordic regions in an aggregation of EuroTERM to these regions plus a composite Rest of Europe region. A task discussed below (but undertaken at step 5 in Figure 3) is to modify the Rest of EFTA region to depict Iceland as a separate region.

Figure 8: Nordic regions in a 27 region aggregation of EuroTERM



4.1. Economic profile of Nordic NUTS-2 regions

Table 8 shows a breakdown of expenditure-side GDP for each of the Nordic NUTS-2 regions plus Poland in EuroTERM. A new feature in multi-country EuroTERM is that there are three tiers of trade in each region in expenditure-side macroeconomic accounting. These tiers are (1) Rest of World, (2) rest of Europe and (3) sub-national inter-regional trades. The addition of Russia, Ukraine and Moldova to the EuroTERM database results in trades between NUTS-2 regions and these three countries being treated as rest of Europe trades instead of Rest of World trades.

4.1.1. Denmark

The agriculture and forestry shares of regional GDP in DK03 (Syddanmark, 2.9%) and DK05 (Nordjylland, 3.2%) are higher than for most Nordic regions. The Nordic-wide average share for these sectors is 2.0%, compared with 1.4% for all of Europe. Nordic regions have lower population densities than the rest of Europe, which may push up the percentage contribution of these primary sectors, though the environment for primary activities is harsher than in more southern parts of Europe.

We can pick Denmark's capital region from the relative size of other services (Table 10, column 14). In DK01 (Hovedstaden/Copenhagen region), other service's share of GDP of 35.0% is much higher than for other Danish regions.

Table 8: Expenditure-side components of GDP, Nordic NUTS-2 and other regions, 2017 (US$m)

	HOU	INV	GOV	STOCKS	ExpRoW	ImpRoW	ExpEU	ImpEU	Xsubnat	Msubnat	NetMar	GDP
DK01	58129	28101	36431	-28	20733	-16053	31477	-33149	45005	-52852	565	118359
DK02	21587	9318	14170	-7	7098	-6248	8541	-13639	36954	-35171	653	43256
DK03	32881	14748	17262	-16	10909	-9316	17228	-20136	42133	-41003	1526	66216
DK04	35642	15591	17652	-10	10899	-10058	16528	-21187	49603	-45183	1100	70577
DK05	15839	6983	9546	61	5184	-4506	6947	-9776	26394	-25881	883	31674
FI19	33251	14493	16078	-188	11174	-5790	13479	-17754	45860	-45230	-281	65092
FI1B	42746	18429	18529	-267	11382	-6939	12745	-20312	40886	-38453	1129	79875
FI1C	28145	12201	13440	-190	9285	-4908	10250	-15248	45258	-43634	393	54992
FI1D	27875	11990	14718	550	7857	-4755	14075	-13344	27005	-32447	263	53787
FI20	1137	936	357	95	242	-201	357	-738	3695	-2939	119	3060
IS	12996	4200	6912	0	4361	-4763	5861	-6595	0	0	81	23053
NO01	49202	25824	31291	-768	5708	-5682	13007	-15304	53634	-57439	3891	103364
NO02	12485	5683	8582	33	984	-1512	2875	-4137	25417	-24922	-238	25250
NO03	31201	14409	16919	-544	2799	-3821	5038	-11320	51561	-44604	1888	63526
NO04	26907	24048	16703	-8	2601	-3226	41378	-9377	39615	-48694	-4046	85901
NO05	30724	15648	16022	624	28060	-29348	30379	-35185	49359	-38517	-2324	65442
NO06	15217	7028	8559	60	1332	-1783	3944	-4527	25634	-24635	-150	30679
NO07	17293	8262	14572	602	1699	-2003	8437	-5182	14424	-20833	-1526	35745
SE11	65064	36415	36788	-903	8884	-7334	17582	-18664	72299	-67870	3429	145690
SE12	35515	18960	25154	43	3433	-3917	14425	-9663	59959	-64726	-406	78777
SE21	18810	10667	11336	-104	1646	-2115	7554	-5515	37541	-36891	100	43029
SE22	33614	18541	20146	38	3592	-3796	16232	-9365	47765	-51108	188	75847
SE23	47637	27119	28291	662	56142	-34402	44333	-63007	66202	-60881	-4173	107923
SE31	18037	10016	13136	-324	1606	-2061	4290	-6598	42887	-40556	865	41298
SE32	9209	5685	7610	216	943	-1040	4441	-3072	22373	-23975	-309	22081
SE33	12200	7114	9195	373	1218	-1338	6948	-3553	21716	-24734	-1007	28132
PL2	89420	25250	29405	-451	2835	-3336	28298	-23187	102826	-107844	-2797	140419
PL4	71271	21119	30536	-126	2295	-2668	20737	-16206	92855	-105892	550	114471
PL5n6r	77144	21381	36825	-149	2346	-2886	17368	-16745	107756	-121942	-1543	119555
PL61	28170	7910	12373	629	36054	-62108	56977	-52931	59629	-37900	-5108	43695
PL7	26025	9569	1115	-111	833	-949	9549	-6990	60922	-55784	2610	46789
PL8	30887	11496	1367	243	1138	-1122	13003	-8532	59965	-55362	3174	56257
PL9	9517	3298	285	-34	141	-172	1607	-2459	12785	-12016	-294	12658
Russia	842298	357314	297216	0	187846	-185104	170517	-152915	0	0	1941	1519113
Ukraine	73517	17278	25425	0	29678	-27506	38896	-46563	0	0	1092	111817
Moldova	8553	2227	1717	0	929	-1990	2481	-4549	0	0	204	9572
RoE	9449499	3425845	3570643	0	2472945	-2401560	529816	-540175	1	-1	-2441	16504572

Key: HOU=household consumption, INV=investment, GOV=government consumption, STOCKS=changes in inventories (balancing item), ExpRoW=international exports to outside Europe, ImpRoW=imports from outside Europe, ExpEU=exports to other European nations, ImpEU= imports from other European nations, Xsubnat = exports to other within-nation regions, Msubnat= imports from other within-nation regions, Net Mar= net margins sales to other regions

Table 9: Income-side components of GDP, Nordic NUTS-2 and other regions, 2017 (US$m)

	Land	Labour	Capital	PRODTAX	ComTax	Total
DK01	590	57881	39261	209	20418	118359
DK02	92	22637	13042	23	7463	43257
DK03	647	33619	20642	-118	11428	66218
DK04	353	36362	21812	236	11813	70576
DK05	178	16273	9777	7	5439	31674
FI19	374	30781	25443	-379	8872	65091
FI1B	116	36707	32354	-525	11222	79874
FI1C	175	26078	21422	-334	7651	54992
FI1D	306	25332	21049	-295	7395	53787
FI20	31	1069	1622	-43	381	3060
IS	74	10401	10559	226	1792	23052
NO01	2591	47466	41908	-1136	12535	103364
NO02	489	12789	9234	-245	2980	25247
NO03	540	32520	23439	-668	7696	63527
NO04	11950	27584	39000	-252	7621	85903
NO05	2133	30328	25431	-819	8371	65444
NO06	833	15107	11404	-326	3660	30678
NO07	1129	16950	13403	-348	4609	35743
SE11	151	60223	54575	12678	18060	145687
SE12	269	33399	28423	7067	9617	78775
SE21	256	17891	15994	3767	5119	43027
SE22	240	31923	27824	6682	9177	75846
SE23	330	44495	40676	9350	13072	107923
SE31	200	17402	15030	3695	4973	41300
SE32	110	8819	8493	2019	2640	22081
SE33	155	11387	10622	2586	3381	28131
PL2	1780	51948	67520	1483	17688	140419
PL4	1356	41316	56445	1184	14170	114471
PL5n6r	1287	44691	57103	1203	15273	119557
PL61	276	16240	21107	464	5609	43696
PL7	655	14843	25627	484	5179	46788
PL8	1021	17560	30797	602	6277	56257
PL9	14	2747	8771	15	1111	12658
Russia	70340	549194	738535	-132	161176	1519113
Ukraine	2941	58453	38338	478	11607	111817
Moldova	116	4682	3370	98	1306	9572
RoE	65936	7533559	6899026	161244	1844807	16504572

Table 10: Value-added share of regional total, Nordic NUTS-2 regions, 2017 (%)

	Crops	Livestock	ForestFishng	CoalOilGas	OthMining	Total primary	FoodProducts	OthManufac	PetrolCoalP	Total manufactures	Utilities	Construction	TradeWR	AccomFood	Transport	OthService	PubAdmHltEdu	OwnerDwellng	Total
	1	2	3	4	5		6	7	8		9	10	11	12	13	14	15	16	
DK01	0.0	0.1	0.1	1.8	0.0	1.9	2.2	13.9	0.1	16.3	0.9	2.8	7.9	2.2	5.6	35.0	22.9	4.6	100
DK02	0.4	0.5	0.3	0.0	0.1	1.2	2.9	16.9	0.2	19.9	2.5	5.2	9.3	1.8	6.2	26.7	24.1	3.1	100
DK03	0.7	1.8	0.4	1.9	0.2	4.8	3.4	19.1	0.0	22.5	2.5	3.3	9.3	1.9	6.7	23.0	22.1	3.8	100
DK04	0.4	1.5	0.4	0.4	0.1	2.8	2.8	19.3	0.0	22.1	2.2	3.5	9.5	1.8	5.3	26.7	22.2	3.9	100
DK05	0.4	2.3	0.5	0.0	0.2	3.5	3.7	18.7	0.0	22.4	3.6	3.6	9.3	2.0	6.4	22.9	22.7	3.6	100
FI19	0.4	1.0	2.1	0.0	0.7	4.2	1.8	17.8	0.2	19.7	2.9	6.9	12.5	2.6	4.5	22.5	17.7	6.5	100
FI1B	0.2	0.4	0.4	0.0	0.1	1.1	1.0	10.3	0.1	11.4	1.2	6.1	12.4	3.0	5.2	33.4	16.8	9.4	100
FI1C	0.2	0.6	1.3	0.0	0.4	2.6	1.8	16.6	0.2	18.6	3.6	7.3	12.5	2.8	5.5	22.2	18.3	6.5	100
FI1D	0.4	0.9	2.3	0.1	0.9	4.6	2.1	12.8	0.2	15.1	4.1	6.6	12.4	3.2	5.5	21.8	19.8	7.0	100
FI20	0.2	0.5	3.3	0.0	0.1	4.1	2.1	4.5	0.0	6.6	42.8	5.6	6.8	3.0	7.1	12.6	7.9	3.7	100
IS	0.2	0.4	0.5	0.0	0.3	1.5	4.9	6.2	0.0	11.1	10.8	4.5	8.7	3.0	6.6	26.9	22.0	5.1	100
NO01	0.2	0.1	0.3	7.8	0.1	8.5	1.0	5.3	0.4	6.6	0.9	4.7	7.8	1.8	7.4	33.6	23.0	5.7	100
NO02	2.5	1.8	3.4	0.0	0.4	8.0	2.7	9.7	0.8	13.2	3.2	8.2	8.8	2.3	5.4	21.8	25.1	4.0	100
NO03	0.9	0.5	1.3	0.5	0.3	3.5	2.0	13.3	0.5	15.8	2.1	8.3	10.1	1.9	6.3	25.4	22.5	4.1	100
NO04	0.4	0.6	0.9	43.1	0.4	45.4	1.1	6.6	0.7	8.4	1.8	4.0	5.0	1.1	5.3	14.0	12.1	2.9	100
NO05	0.7	0.6	1.7	7.9	0.4	11.2	2.3	10.5	0.2	12.9	2.8	6.1	7.3	1.8	10.4	21.2	21.6	4.6	100
NO06	1.6	1.5	2.5	4.2	0.3	10.0	2.5	10.1	0.0	12.6	2.7	5.8	7.6	2.0	6.3	22.3	25.7	4.8	100
NO07	0.8	0.7	2.5	6.4	0.4	10.7	3.6	6.2	0.0	9.8	4.5	5.3	7.2	2.2	8.4	18.5	29.1	4.3	100
SE11	0.0	0.0	0.4	0.0	0.5	1.0	1.1	10.6	0.1	11.8	1.9	5.7	8.5	2.5	6.6	41.2	16.7	4.1	100
SE12	0.2	0.5	1.1	0.0	1.0	2.8	1.6	15.8	0.1	17.4	3.5	6.6	9.1	2.3	6.0	27.3	21.6	3.5	100
SE21	0.3	1.1	2.2	0.0	1.4	4.9	2.1	21.2	0.1	23.4	2.6	6.1	10.0	2.6	5.9	23.7	17.4	3.2	100
SE22	0.4	0.5	0.9	0.0	0.7	2.5	1.9	15.9	0.2	17.9	1.6	5.8	10.6	2.5	6.3	31.0	18.6	3.2	100
SE23	0.2	0.5	1.1	0.0	0.9	2.6	1.6	16.2	0.1	17.9	3.6	6.2	10.1	2.4	7.3	29.1	17.3	3.4	100
SE31	0.1	0.3	2.2	0.0	1.7	4.3	1.8	18.6	0.2	20.5	2.9	7.2	10.0	2.8	6.4	23.9	19.0	3.1	100
SE32	0.1	0.3	2.0	0.0	1.9	4.3	2.4	15.5	0.1	18.0	7.7	6.7	8.5	2.8	7.4	23.4	18.4	2.8	100
SE33	0.1	0.3	1.9	0.0	2.6	4.9	1.9	15.2	0.1	17.2	6.5	5.9	8.1	2.4	7.3	23.9	20.4	3.3	100
PL2	0.4	0.3	0.3	2.7	0.6	4.4	3.9	19.5	0.3	23.7	2.3	6.9	13.0	2.6	6.1	21.1	17.3	2.7	100
PL4	1.6	1.8	0.3	0.3	0.5	4.5	4.3	16.9	0.2	21.4	2.2	8.0	14.5	2.6	6.6	21.0	16.5	2.5	100
PL5n6r	1.3	1.1	0.3	0.2	0.7	3.6	3.4	17.6	0.1	21.1	1.9	7.6	12.5	2.9	6.5	22.3	19.0	2.7	100
PL61	1.9	1.9	0.3	0.2	0.5	4.8	3.9	17.7	0.1	21.7	3.5	6.7	13.1	1.8	6.5	18.2	21.3	2.5	100
PL7	2.2	1.8	0.4	0.3	0.9	5.5	5.7	24.5	0.1	30.4	3.2	7.9	19.5	2.2	7.4	18.3	2.4	3.2	100
PL8	2.5	2.7	0.6	0.3	1.0	7.1	6.5	19.5	0.2	26.2	3.1	9.3	18.2	2.5	8.8	19.1	2.7	3.2	100
PL9	0.0	0.0	0.1	0.1	0.4	0.6	8.8	23.9	0.6	33.3	4.0	1.6	17.2	1.7	3.4	7.2	0.0	31.0	100
Russia	2.1	1.1	0.6	11.4	0.7	15.9	3.4	8.8	0.6	12.9	6.3	9.0	18.1	4.3	6.8	12.7	13.8	0.2	100
Ukraine	9.2	2.5	0.7	2.4	2.8	17.6	2.7	7.1	0.3	10.1	11.2	2.2	14.8	0.5	6.9	15.7	17.6	3.4	100
Moldova	8.0	1.7	0.2	0.0	1.0	11.0	3.8	8.0	0.0	11.8	2.4	3.8	20.2	0.7	8.6	20.4	15.6	5.4	100
RoE	0.9	0.6	0.2	0.2	0.3	2.2	2.3	15.3	0.1	17.7	2.0	5.6	10.5	3.1	4.8	30.2	17.4	6.5	100

4.1.2. Finland

Agricultural shares for Finland's NUTS-2 regions are based on Finland's agricultural census data. In no region does agriculture's share of GDP exceed 1.5%. Åland (FI20), with only 0.5% of Finland's population, has a relatively large share of forestry and fishing in regional GDP, but this appears to reflect the small size of the local economy rather than a substantial forestry sector relative to other Nordic regions.

As in the other Nordic nations, the capital region FI1B (Helsinki-Uusimaa), the business centre of the nation, has the highest other services share of regional GDP among Finnish NUTS-2 regions (Table 10, column 14).

4.1.3. Iceland

The GTAP database includes a "Rest of EFTA" region, ostensibly combining Liechtenstein and Iceland. The Comtrade trade data for the region are relatively reliable, but since there is no input-output table produced by statistical authorities for Iceland, it is more appropriate to treat the default GTAP data for the Rest of EFTA as a residual. Adjustments to Iceland are made early in database processing, prior to the split of GTAP-based national data into sub-national regions.

Iceland's relatively abundant hydroelectricity provides energy for non-ferrous metals which is a major export. The other major merchandise export is seafood products.

Since Statistics Iceland (SI) does not produce a publicly available input-output table, the task of estimating the Icelandic component of the CGE database uses available national accounts and other data (Table 11). A potentially useful database source is Eurostat employment data, compiled at the NUTS-2 regional and NACE sectoral levels for all of Europe. The raw data include 87 sectors. These map conveniently to 39 of the 65 sectors of the GTAP master database. However, so far these have played no role in refining Iceland's sectoral detail.

Table 11: Summary of national accounts data for Iceland

Data source	Table	Description	Sectors
Landshagir	16.7	Turnover data	69
Landshagir	11.6	Value added shares	11
Landshagir	18.1	Agricultural data	
Landshagir	18.2	Macroeconomic EXP side	
Landshagir	5.8	Household consumption shares	
Landshagir	11.1	Macro income side	
Eurostat	11.5	NUTS level NACE employment data	87

The SI statistics yearbook Landshagir 2015[15] provides national accounts data, and industry turnover data which provide an approximate guide to CGE database flows (Table 8). The GTAP "Rest of EFTA" region has been scaled to fit Iceland national accounts macro targets. In addition, the database has been adjusted using broad value-added targets from Landshagir. Ownership of

[15] See https://www.statice.is/publications/yearbook/

dwellings rentals have been scaled up to align better with the expected share of the sector's rentals in GDP.

For the present, default GTAP trade data are not adjusted. That is, Rest of EFTA international trades are treated as though they are Iceland's trades. Export data are available from the following,

https://www.pcc.eu/en/silicon-project-iceland/ and https://commodity.com/data/iceland/.

Detailed household consumption expenditure are downloadable from https://www.statice.is/statistics/economy/national-accounts/consumption-expenditure/.

4.1.4. Norway

The distinctive sales pattern of NO04 data (Agder og Rogaland) signaled early database generation problems. Table 8 shows that NO04 has one of the largest exports to the rest of Europe compared to the other Nordic regions. Exports to the rest of Europe amount to 45% of NO04's regional GDP (US$41.4 bn out of US$85.9 bn). The distinctiveness of NO04 is observable in the income-side GDP breakdown (Table 9). Labour's share of regional GDP is only 32% (US$27.6 bn out of GDP of US$85.9 bn). This is a consequence of the high oil & gas share (43%, Table 10) of total regional income. That is, NO04 is a resource-based economy and oil & gas is capital- and resource-endowment-intensive in its cost structure. Norway's continental shelf oil fields straddle the west coast, adjacent to the NO04, NO05 and NO06 regions. The most solid evidence for NO04's dominance in the oil & gas sector is based on 2011 census data, which is becoming dated.[16] However, available forecasts indicate that Norway's oil & gas production plateau is likely to continue through the 2020s.[17]

The smallest NUTS-2 economy in Norway is the inland NO02 region (Hedmark og Oppland). Agriculture, forestry and fishing account for almost 7% of the region's income, unmatched in other Nordic NUTS-2 regions. In NO01 (Oslo, the national capital), agriculture's share of GDP is around 0.3%. The high oil & gas share indicated by Table 10 for the Oslo region appears to reflect fly-in, fly-out workers on the oil fields.

The manufacturing share of GDP is lower in Norway's NUTS-2 regions than in other Nordic regions. This may reflect in part the impact of relatively high wages driven by oil revenues on manufacturing competitiveness. An indicator of the degree of urbanization of given NUTS-2 regions is the share of other services, covering an array of business and entertainment services (table 10, column 14), in overall economic activity. As expected, NO01's other services' share of 33.6% is higher than for other Norwegian regions.

4.1.5. Sweden

In Sweden, no NUTS-2 region has an agricultural base that exceeds 1.4% of regional GDP, the European-wide average. However, almost all NUTS-2 regions excluding the capital region of

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16 https://www.offshore-technology.com/features/featurenorways-giants-the-biggest-oil-fields-on-the-norwegian-continental-shelf-4191946/ lists each oil field.

17 See https://www.norskpetroleum.no/en/production-and-exports/production-forecasts/

Stockholm (SE11), have forestry & fishing sectors exceeding 1% of regional GDP. In each of these regions, forestry & fishing value-added is substantially greater than that of agriculture.

Coal, oil & gas output in Sweden varies from zero to low levels across all NUTS-2 regions. However, there is non-energy mining activity across all Swedish NUTS-2 regions.

Stockholm's (SE11) other services share of regional GDP is 41%.

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Table A1: NUTS-2 regions, Ukraine oblasts and single region countries in EuroTERM

1	AT11 Burgenland (AT)	41	CZ07 Strední Morava	81	DK01 Hovedstaden	121	FRE1 Nord-Pas-de-Calais
2	AT12 Niederösterreich	42	CZ08 Moravskoslezsko	82	DK02 Sjælland	122	FRE2 Picardie
3	AT13 Wien	43	DE11 Stuttgart	83	DK03 Syddanmark	123	FRF1 Alsace
4	AT21 Kärnten	44	DE12 Karlsruhe	84	DK04 Midtjylland	124	FRF2 Champagne-Ardenne
5	AT22 Steiermark	45	DE13 Freiburg	85	DK05 Nordjylland	125	FRF3 Lorraine
6	AT31 Oberösterreich	46	DE14 Tübingen	86	EE00 Estonia	126	FRG0 Pays-de-la-Loire
7	AT32 Salzburg	47	DE21 Oberbayern	87	EL30 Attiki	127	FRH0 Bretagne
8	AT33 Tirol	48	DE22 Niederbayern	88	EL41 Voreio Aigaio	128	FRI1 Aquitaine
9	AT34 Vorarlberg	49	DE23 Oberpfalz	89	EL42 Notio Aigaio	129	FRI2 Limousin
10	BE10 Brussels Gewest-Hoofdstad	50	DE24 Oberfranken	90	EL43 Kriti	130	FRI3 Poitou-Charentes
11	BE21 Provincie Antwerpen	51	DE25 Mittelfranken	91	ES11 Galicia	131	FRJ1 Languedoc-Roussillon
12	BE22 Provincie Limburg	52	DE26 Unterfranken	92	ES12 Principado de Asturias	132	FRJ2 Midi-Pyrénées
13	BE23 Provincie Oost-Vlaanderen	53	DE27 Schwaben	93	ES13 Cantabria	133	FRK1 Auvergne
14	BE24 Provincie Vlaams Brabant	54	DE30 Berlin	94	ES21 País Vasco	134	FRK2 Rhône-Alpes
15	BE25 Provincie West-Vlaanderen	55	DE40 Brandenburg	95	ES22 Comunidad Foral de Navarra	135	FRL0 Provence-Alpes-Côte d'Azur
16	BE31 Provincie Waals Brabant	56	DE50 Bremen	96	ES23 La Rioja	136	FRM0 Corse

17	BE32 Provincie Henegouwen	57	DE60 Hamburg	97	ES24 Aragón	137	FRY1 Guadeloupe
18	BE33 Provincie Luik	58	DE71 Darmstadt	98	ES30 Comunidad de Madrid	138	FRY2 Martinique
19	BE34 Provincie Luxemburg	59	DE72 Gießen	99	ES41 Castilla y León	139	FRY3 Guyane
20	BE35 Provincie Namen	60	DE73 Kassel	100	ES42 Castilla-la Mancha	140	FRY4 La Réunion
21	BG31 Severozapaden	61	DE80 Mecklenburg-Vorpommern	101	ES43 Extremadura	141	HR03 Jadranska Hrvatska
22	BG32 Severen tsentralen	62	DE91 Braunschweig	102	ES51 Cataluña	142	HR04 Kontinentalna Hrvatska (NUTS 2016)
23	BG33 Severoiztochen	63	DE92 Hannover	103	ES52 Comunitat Valenciana	143	HU21 Közép-Dunántúl
24	BG34 Yugoiztochen	64	DE93 Lüneburg	104	ES53 Illes Balears	144	HU22 Nyugat-Dunántúl
25	BG41 Yugozapaden	65	DE94 Weser-Ems	105	ES61 Andalucía	145	HU23 Dél-Dunántúl
26	BG42 Yuzhen tsentralen	66	DEA1 Düsseldorf	106	ES62 Región de Murcia	146	HU31 Észak-Magyarország
27	CH01 Lake Geneva	67	DEA2 Köln	107	ES63 Ciudad de Ceuta	147	HU32 Észak-Alföld
28	CH02 Espace Mitterland	68	DEA3 Münster	108	ES64 Ciudad de Melilla	148	HU33 Dél-Alföld
29	CH03 Northwestern Switzerland	69	DEA4 Detmold	109	ES70 Canarias	149	IS00 Iceland
30	CH04 Zurich	70	DEA5 Arnsberg	110	FI1A West Finland	150	ITC1 Piemonte
31	CH05 Eastern Switzerland	71	DEB1 Koblenz	111	FI1B Helsinki-Uusimaa	151	ITC2 Valle d'Aosta/Vallée d'Aoste
32	CH06 Central Switzerland	72	DEB2 Trier	112	FI1C South Finland	152	ITC3 Liguria

33	CH07 Ticino	73	DEB3 Rheinhessen-Pfalz	113	FI1D North and East Finland	153	ITC4 Lombardia
34	CY00 Cyprus	74	DEC Saarland	114	FI20 Åland	154	ITF1 Abruzzo
35	CZ01 Praha	75	DED2 Dresden	115	FR10 Île de France	155	ITF2 Molise
36	CZ02 Strední Cechy	76	DED4 Chemnitz	116	FRB0 Centre - Val de Loire	156	ITF3 Campania
37	CZ03 Jihozápad	77	DED5 Leipzig	117	FRC1 Bourgogne	157	ITF4 Puglia
38	CZ04 Severozápad	78	DEE0 Sachsen-Anhalt	118	FRC2 Franche-Comté	158	ITF5 Basilicata
39	CZ05 Severovýchod	79	DEF0 Schleswig-Holstein	119	FRD1 Basse-Normandie	159	ITF6 Calabria
40	CZ06 Jihovýchod	80	DEG0 Thüringen	120	FRD2 Haute-Normandie	160	ITG1 Sicilia

NUTS-2 regions in EuroTERM (continued)

161	ITG2 Sardegna	196	PL41 Wielkopolskie	231	UKC1 Tees Valley and Durham	266	EL53 Dytiki Makedonia
162	ITH1 Provincia Autonoma di Bolzano/Bozen	197	PL42 Zachodniopomorskie	232	UKC2 Northumberland and Tyne and Wear	267	EL54 Ipeiros
163	ITH2 Provincia Autonoma di Trento	198	PL43 Lubuskie	233	UKD1 Cumbria	268	EL61 Thessalia
164	ITH3 Veneto	199	PL51 Dolnoslaskie	234	UKD3 Greater Manchester	269	EL62 Ionia Nisia
165	ITH4 Friuli-Venezia Giulia	200	PL52 Opolskie	235	UKD4 Lancashire	270	EL63 Dytiki Ellada
166	ITH5 Emilia-Romagna	201	PL61 Kujawsko-Pomorskie	236	UKD6 Cheshire	271	EL64 Sterea Ellada

167	ITI1 Toscana	202	PL62 Warminsko-Mazurskie	237	UKD7 Merseyside	272	EL65 Peloponnisos
168	ITI2 Umbria	203	PL63 Pomorskie inc. Gdansk	238	UKE1 East Yorkshire and Northern Lincolnshire	273	FRY5 Mayotte
169	ITI3 Marche	204	PT11 Norte	239	UKE2 North Yorkshire	274	HU11 Budapest
170	ITI4 Lazio	205	PT15 Algarve	240	UKE3 South Yorkshire	275	HU12 Pest
171	LT00 Lithuania	206	PT16 Centro (PT)	241	UKE4 West Yorkshire	276	IE04 Northern and Western
172	LU00 Luxembourg	207	PT17 Área Metropolitana de Lisboa	242	UKF1 Derbyshire and Nottinghamshire	277	IE05 Southern
173	LV00 Latvia	208	PT18 Alentejo	243	UKF2 Leicestershire, Rutland and Northamptonshire	278	IE06 Eastern and Midland
174	MT00 Malta	209	PT20 Região Autónoma dos Açores (PT)	244	UKF3 Lincolnshire	279	Lódzkie PL71
175	NL11 Groningen	210	PT30 Região Autónoma da Madeira (PT)	245	UKG1 Herefordshire, Worcestershire and Warwickshire	280	Swietokrzyskie PL72
176	NL12 Friesland (NL)	211	RO11 Nord-Vest	246	UKG2 Shropshire and Staffordshire	281	Lubelskie PL81
177	NL13 Drenthe	212	RO12 Centru	247	UKG3 West Midlands	282	Podkarpackie PL82
178	NL21 Overijssel	213	RO21 Nord-Est	248	UKH1 East Anglia	283	Podlaskie PL84

179	NL22 Gelderland	214	RO22 Sud-Est	249	UKH2 Bedfordshire and Hertfordshire	284	PL91 Warszawski stoleczny
180	NL23 Flevoland	215	RO31 Sud - Muntenia	250	UKH3 Essex	285	PL92 Mazowiecki regionalny
181	NL31 Utrecht	216	RO32 Bucuresti - Ilfov	251	UKJ1 Berkshire, Buckinghamshire and Oxfordshire	286	SI03 Eastern Slovenia
182	NL32 Noord-Holland	217	RO41 Sud-Vest Oltenia	252	UKJ2 Surrey, East and West Sussex	287	SI04 Western Slovenia
183	NL33 Zuid-Holland	218	RO42 Vest	253	UKJ3 Hampshire and Isle of Wight	288	UKI3 Inner London - West
184	NL34 Zeeland	219	SE11 Stockholm	254	UKJ4 Kent	289	UKI4 Inner London - East
185	NL41 Noord-Brabant	220	SE12 Östra Mellansverige	255	UKK1 Gloucestershire, Wiltshire and Bristol/Bath area	290	UKI5 Outer London - East and North East
186	NL42 Limburg (NL)	221	SE21 Småland med öarna	256	UKK2 Dorset and Somerset	291	UKI6 Outer London - South
187	NO01 Oslo og Akershus	222	SE22 Sydsverige	257	UKK3 Cornwall and Isles of Scilly	292	UKI7 Outer London - West and North West
188	NO02 Hedmark og Oppland	223	SE23 Västsverige	258	UKK4 Devon	293	UKM7 Eastern Scotland
189	NO03 Sør-Østlandet	224	SE31 Norra Mellansverige	259	UKL1 West Wales and The Valleys	294	UKM8 West Central Scotland
190	NO04 Agder og RogÅland	225	SE32 Mellersta Norrland	260	UKL2 East Wales	295	UKM9 Southern Scotland

191	NO05 = NO0A Vestlandet	226	SE33 Övre Norrland	261	UKM5 North Eastern Scotland
R192	NO06 Trøndelag	227	SK01 Bratislava	262	UKM6 Highlands and Islands
193	NO07 Nord-Norge	228	SK02 Západné Slovensko	263	UKN0 Northern Ireland (UK)
194	PL21 Malopolskie	229	SK03 Stredné Slovensko	264	EL51 Anatoliki Makedonia, Thraki
195	PL22 Slaskie	230	SK04 Východné Slovensko	265	EL52 Kentriki Makedonia

NUTS-2 regions in EuroTERM (continued)

296	VinnytsiaUKR
297	VolynUKR
298	Dnipropetrov
299	DonetskUKR
300	ZhytomyrUKR
301	ZakarpattyaU
302	ZaporizhiaUR
303	IvanoFrankiv
304	KyivUKR
305	KirovohradUR
306	LuhanskUKR
307	LvivUKR

308	MykolaivUKR
309	OdesaUKR
310	PoltavaUKR
311	RivneUKR
312	SumyUKR
313	TernopilUKR
314	KharkivUKR
315	KhersonUKR
316	KhmelnytskUR
317	CherkasyUKR
318	ChernivtsiUR
319	ChernihivUKR
320	KyivCityUKR
321	Albania
322	Belarus
323	Russia
324	Moldova
325	Georgia
326	Iran
327	Turkey
328	North Africa

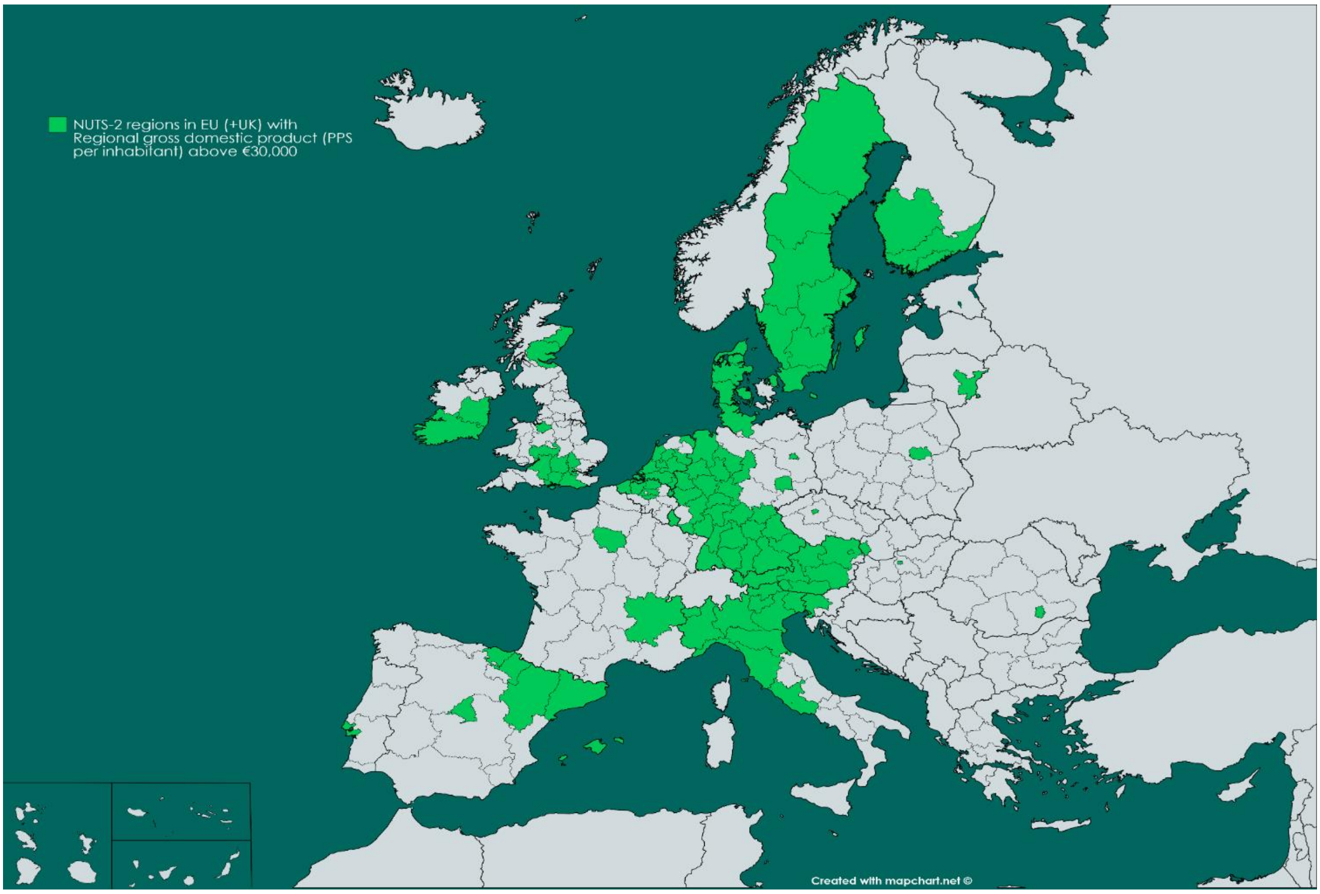
Table A2: Single region countries in GlobeTERM in addition to those of EuroTERM

328	Serbia	365	Peru	402	RofNthAfrica*
329	RofEurope	366	Uruguay	403	Benin
330	Australia	367	Venezuela	404	BurkinaFaso
331	NewZealand	368	RestSthAmerc	405	Cameroon
332	RofOceania	369	CostaRica	406	IvoryCoast
333	China	370	Guatemala	407	Ghana
334	HongKong	371	Honduras	408	Guinea
335	Japan	372	Nicaragua	409	Nigeria
336	Korea	373	Panama	410	Senegal
337	Mongolia	374	ElSalvador	411	Togo
338	Taiwan	375	RofCentAmer	412	RofWAfrica
339	BruneiDaruss	376	DominicanRep	413	Chad
340	Cambodia	377	Jamaica	414	Congo
341	Indonesia	378	TrindadTobgo	415	Gabon
342	Laos	379	Caribbean	416	CentAfrica
343	Malaysia	380	Kazakhstan	417	SthCntAfrica
344	Philippines	381	Kyrgyzstan	418	Ethiopia
345	Singapore	382	Tajikistan	419	Kenya
346	Thailand	383	RofFrmSovU	420	Madagascar
347	VietNam	384	Armenia	421	Malawi
348	RestSEAsia	385	Azerbaijan	422	Mauritius

349	Bangladesh	386	Bahrain	423	Mozambique
350	India	387	Iraq	424	Rwanda
351	Nepal	388	Israel	425	Sudan
352	Pakistan	389	Jordan	426	Tanzania
353	SriLanka	390	Kuwait	427	Uganda
354	RofSouthAsia	391	Lebanon	428	Zambia
355	Canada	392	Oman	429	Zimbabwe
356	USA	393	Palestine	430	RofEAfrica
357	Mexico	394	Qatar	431	Botswana
358	Argentina	395	SaudiArabia	432	Namibia
359	Bolivia	396	Syria	433	SouthAfrica
360	Brazil	397	UAE	434	RofSouthAfr
361	Chile	398	RestofWAsia	435	RestEastAsia
362	Colombia	399	Egypt	436	RestNthAm
363	Ecuador	400	Morocco*	437	PuertoRico
364	Paraguay	401	Tunisia*	438	RoW

* Part of composite North Africa in EuroTERM representation

Figure A1: NUTS-2 regions of Europe



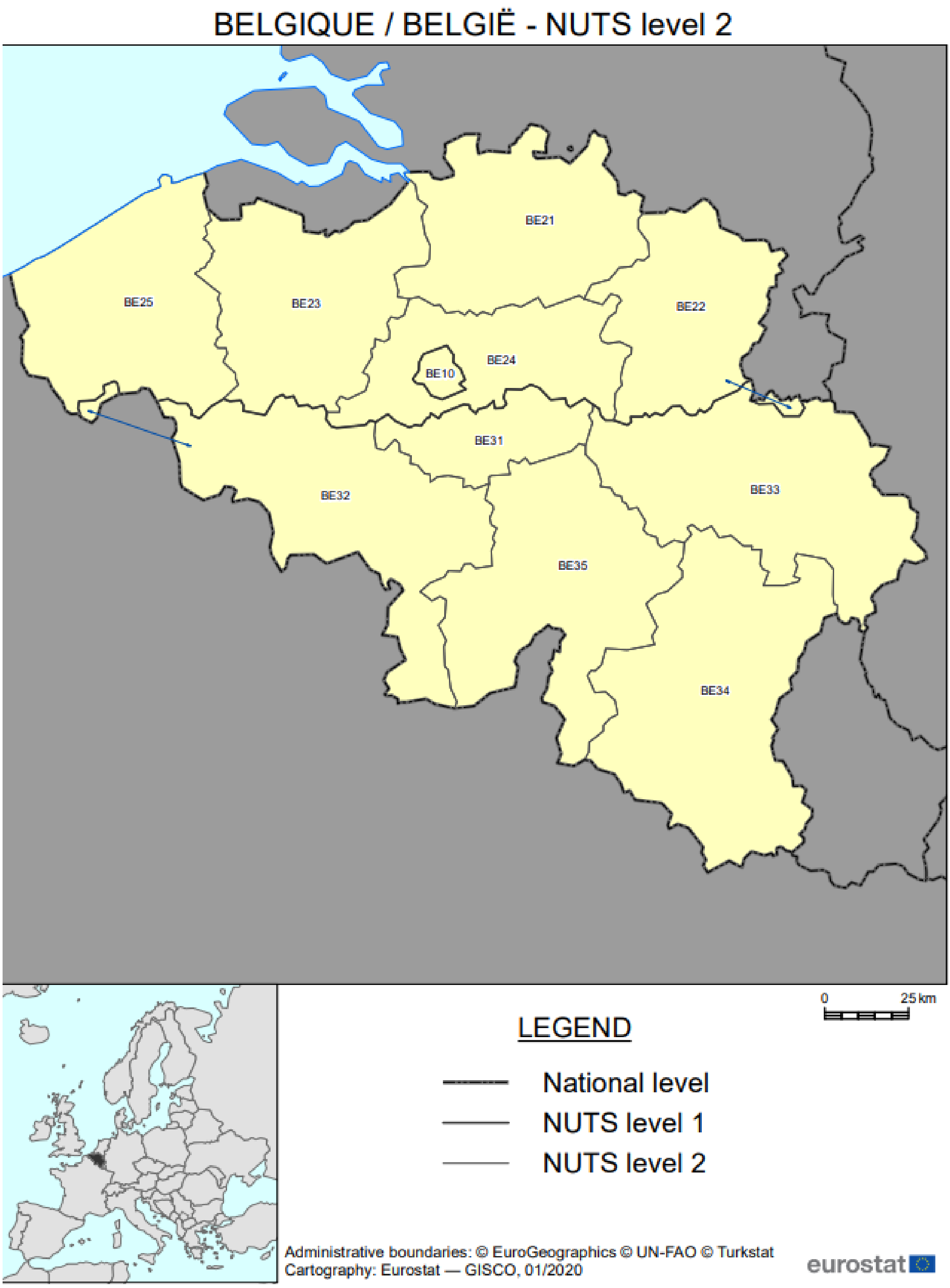
Source: https://www.mapchart.net/europe-nuts2.html

Figure A2: UK regions

Figure A3: Austrian regions

Figure A4: German regions

Figure A5: Belgian regions



Appendix 3. Greenhouse Gas Emissions data for the Nordic-TERM model

Authors: Philip Adams, Victoria University. Melbourne, Australia

Nordic-TERM is a bottom-up economic model of the NUTS2 regions in each of the five Nordic countries plus a single Rest of Europe (RoE) region. Its database consists, in part, of regionally connected input-output data showing the value of flows within and between the Nordic regions and the RoE.

For greenhouse modelling it is useful to have additional data on greenhouse gas emissions which are consistent with the input/output account of underlying economic flows. This memorandum documents the compilation of emissions data for the calendar year 2019. Data for 2020 are available, but they are affected by COVID-lockdown reductions in the use of (and emissions from) transport fuel. Because 2020 is atypical, in this document we focus on 2019.

Statistics from two sources are used.

1. For emissions by major UNFCCC categories[18], the *European Environment Agency* data portal https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer; and
2. For emissions by combustible fuel, the *European Environment Agency* and *Our World in Data* portal https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions.

From these statistics we generated the final three-dimension matrix of emissions expressed in kt of CO2-e. The three dimensions are: emission *source*, emitting *agent* and *country*.

There are four sources of emissions:

- Combustion of coal
- Combustion of gas
- Combustion of petroleum products (from crude oil)
- *Other*, covering all non-combustion emissions associated with agriculture, fugitives, industrial processes, waste, land, and forestry.

Fifty-four emitting agents:

- The 53 Nordic-TERM industries plus the residential sector.[19]

Six countries:

- Denmark (incudes Greenland)

[18] UNFCCC is short for the United Nations Framework Convention on Climate Change. Cross-country reporting of greenhouse gas emissions is almost always done using UNFCCC reporting guidelines. More details are available at https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/reporting-requirements. For each major category there are one or more minor categories. For example, emissions from industrial processes (major) are separated into emissions from cement manufacture, metal manufacture, etc. For our purposes, to avoid inconsistency with the structure of the input-output data, we ignore the more detailed data and use only information for the major categories.

[19] We assume that only industries for current production and households emit greenhouse gas through the burning of fuel and from non-combustion activity.

- Finland
- Iceland
- Norway
- Sweden
- RoE (= EU28 countries plus the UK).

1. Step 1: Allocation of non-combustion emissions.

The UNFCCC data provides information on non-combustion emissions for the following categories:

- emissions produced in agriculture by livestock and soil disturbance;
- net emissions from Land Use, Land Use Change and Forestry (LULUCF), including forestry sequestration;
- fugitive emissions, such as methane emissions from open-cut coal mines;
- emissions produced from manufacturing processes, such as from the manufacture of cement (known as industrial process emissions); and
- waste emissions, including methane from the breakdown of solid wastes.

These estimates are spread by country across the 53 Nordic-TERM industries in proportion to basic-value input/output (IO) data for industry costs. Specifically, for each country

- agricultural emissions are allocated to industries 1. Crops and 2. Livestock;
- net LULUCF emissions to the single industry, 3. Forestry;
- fugitive emissions to 4. Coal mining, 5. Oil mining and 6. Gas mining;
- industrial process emissions to the chemical, non-ferrous building products and metal refining industries, 15. Petroleum products, 16. Basic chemicals, 18. Rubber and plastic products, 19. Non-metallic building products, 20. Iron and steel, and 21. Non-ferrous metals; and
- waste emissions to 36. Water, drainage and waste services.

This fills in all elements of our final matrix for the "other" element of the first dimension.

2. Step 2: Allocation of combustion emissions

For the three fuels, we start with total emissions from the second of the two data sources noted above.

In principle, for each country total emissions from fuel should equal total emissions from stationary and transport use in the UNFCCC data. However, initial differences exist because the second source of data includes emissions from international bunkers (emissions from fuel used for international aviation and maritime transport - international bunker fuels) while the first does not. We deal with this inconsistency by removing international bunker emissions from total petroleum emissions given in the second source. This ensures in the primary data, for each country:

Total emissions from the UNFCCC categories, transport and stationary energy.

=

Total emissions from burning coal, gas and petroleum products.

The adjusted data for fuel emissions are distributed across the fifty-four agents by country in proportion to basic-value IO data for industry and household purchases of fuels.

The allocation is straightforward apart from one adjustment. The input/output data show relatively large own use of fuels by the coal mining, gas mining and petroleum refining industries. For these industries, own use generally reflects the use of fuels as part of conversion, rather than combustion, processes. We assume emissions from own use of fuel are zero, with the fuel-use shares adjusted accordingly.

3. Tabulation of initial and final data on emissions.

Data from the two primary sources are given in Tables 1 and 2. Tables 3 to 8 show the final allocation of emissions for each country and RoE.

Table 1: Data for Greenhouse Gas Emissions by Major UNFCCC category in 2019 (kt of CO_2-e)

UNFCCC category		*Denmark*	*Finland*	*Iceland*	*Norway*	*Sweden*	*RoE*
U1. Energy sector, total	U2 + U7	30,052	38,922	1,849	35,916	34,996	2,967,132
U2. Fuel combustion	U3 + U6	29,746	38,830	1,682	33,745	34,418	2,894,865
U3. Stationary	U4 + U5	16,633	27,581	607	21,021	17,427	1,995,425
U4. Electricity generation		6,500	14,242	5	1,483	5,994	796,013
U5. Other stationary		10,133	13,339	602	19,538	11,433	1,199,412
U6. Transport		13,114	11,249	1,075	12,724	16,991	899,441
U7 Fugitive emissions from fuel		306	92	167	2,171	578	72,267
U8. Industrial processes		1,842	5,395	2,020	9,259	7,910	352,851
U9. Agriculture		11,183	6,624	621	4,518	6,824	393,821
U10. Waste		1,160	1,793	223	1,382	1,081	126,812
U11. LULUCF		2,893	-13,590	9,020	-16,436	-36,736	-178,342
U12. Total	U1 + U7 + U8 + U9 + U10 + U11	47,130	39,145	13,733	34,639	14,074	3,662,273

Table 2. Data for Greenhouse Gas Emissions by Fuel in 2019 (kt of CO_2-e)

UNFCCC category	*Denmark*	*Finland*	*Iceland*	*Norway*	*Sweden*	*RoE*
Coal	3,588	15,250	685	4,085	8,098	732,517
Gas	6,012	4,314	0	13,707	1,775	1,070,308
Petroleum products	20,146	19,267	997	15,953	24,545	1,092,040
Total	29,746	38,830	1,682	33,745	34,418	2,894,865

Table 3. Denmark: Data for Greenhouse Emissions by Agent and Source in 2019 (kt of CO2-e)

Agent	*Coal*	*Gas*	*Petroleum*	*Other*
1 Crops	26	18	222	4,789
2 Livestock	1	0	69	6,393
3 Forestry	0	0	16	2,893
4 Fishing	0	1	239	0
5 Coal mining	0	0	0	0
6 Oil mining	0	0	0	287
7 Gas mining	0	0	0	19
8 Other mining	7	69	22	0
9 Food and drink products	79	430	72	0
10 Textiles	0	0	0	0
11 Apparel	0	0	0	0
12 Leather products	0	0	0	0
13 Wood products	0	1	5	0
14 Paper products	0	7	6	0
15 Petroleum products	0	0	0	274
16 Basic chemicals	24	111	14	406
17 Pharmaceutical products	1	61	0	493
18 Rubber and plastic products	2	44	0	242
19 Non-metallic building products	170	15	278	183
20 Iron and steel	0	91	4	136
21 Non-ferrous metals	0	0	1	107
22 Fabricated metal products	0	16	7	0
23 Computer products	0	21	5	0
24 Other electrical equipment	0	15	7	0
25 Other machinery	0	25	12	0
26 Motor vehicles and parts	0	3	2	0
27 Other transport equipment	0	2	1	0
28 Other manufacturing	0	2	2	0
29 Electricity generation – coal	3,262	0	0	0
30 Electricity generation – gas	1	1,766	0	0
31 Electricity generation – other	3	4	96	0
32 Electricity generation – hydro	0	0	0	0
33 Electricity generation – nuclear	0	0	0	0
34 Electricity distribution	1	1	0	0
35 Gas distribution	0	969	0	0
36 Water, drainage and waste	0	0	2	1,160
37 Construction services	0	29	423	0
38 Retail and wholesale trade services	0	17	17	0
39 Accommodation and restaurants	0	9	8	0
40 Land transport services	0	18	3,146	0
41 Water transport services	0	0	4,013	0
42 Air transport services	0	0	4,973	0
43 Warehousing	0	4	3	0
44 Communication services	0	10	5	0
45 Banking and finance	0	1	2	0
46 Insurance services	0	0	1	0
47 Rental and leasing services	0	5	7	0
48 Other business services	0	14	14	0
49 Recreation and other services	0	1	12	0
50 Public administration and defence	0	5	11	0
51 Education services	0	3	6	0
52 Health services	0	5	6	0
53 Dwelling services	0	0	0	0
54 Residential	10	2,216	6,417	0
Total	3,588	6,012	20,146	17,384

Table 4. Finland: Data for Greenhouse Emissions by Agent and Source in 2019 (kt of CO2-e)

Agent	Coal	Gas	Petroleum	Other
1 Crops	29	0	180	2,960
2 Livestock	54	0	86	3,664
3 Forestry	181	0	243	-13,590
4 Fishing	6	0	21	0
5 Coal mining	0	0	0	80
6 Oil mining	0	0	0	11
7 Gas mining	0	0	0	1
8 Other mining	0	0	101	0
9 Food and drink products	58	2	63	0
10 Textiles	0	0	4	0
11 Apparel	0	0	1	0
12 Leather products	0	0	1	0
13 Wood products	8	0	20	0
14 Paper products	1,102	74	192	0
15 Petroleum products	0	0	0	1,335
16 Basic chemicals	0	16	1,504	979
17 Pharmaceutical products	0	1	8	302
18 Rubber and plastic products	0	3	43	555
19 Non-metallic building products	252	1	167	507
20 Iron and steel	157	2	353	972
21 Non-ferrous metals	6	0	53	746
22 Fabricated metal products	0	0	20	0
23 Computer products	0	0	12	0
24 Other electrical equipment	0	0	15	0
25 Other machinery	0	0	18	0
26 Motor vehicles and parts	0	0	13	0
27 Other transport equipment	0	0	6	0
28 Other manufacturing	0	0	17	0
29 Electricity generation – coal	13,290	0	2	0
30 Electricity generation – gas	8	4,194	3	0
31 Electricity generation – other	21	6	347	0
32 Electricity generation – hydro	7	2	3	0
33 Electricity generation – nuclear	7	2	2	0
34 Electricity distribution	8	2	3	0
35 Gas distribution	0	4	0	0
36 Water, drainage and waste	1	0	23	1,793
37 Construction services	0	0	819	0
38 Retail and wholesale trade services	5	1	103	0
39 Accommodation and restaurants	1	0	60	0
40 Land transport services	1	3	4,013	0
41 Water transport services	0	0	1,317	0
42 Air transport services	0	0	2,656	0
43 Warehousing	0	0	17	0
44 Communication services	1	0	54	0
45 Banking and finance	0	0	39	0
46 Insurance services	0	0	2	0
47 Rental and leasing services	0	0	69	0
48 Other business services	1	1	147	0
49 Recreation and other services	0	0	30	0
50 Public administration and defence	4	0	60	0
51 Education services	1	0	32	0
52 Health services	3	0	33	0
53 Dwelling services	0	0	4	0
54 Residential	38	1	6,292	0
Total	15,249	4,314	19,267	315

Table 5. Iceland: Data for Greenhouse Emissions by Agent and Source in 2019 (kt of CO2-e)

Agent	*Coal*	*Gas*	*Petroleum*	*Other*
1 Crops	0	0	26	198
2 Livestock	0	0	31	423
3 Forestry	0	0	6	9,020
4 Fishing	0	0	60	0
5 Coal mining	0	0	0	16
6 Oil mining	0	0	0	129
7 Gas mining	0	0	0	21
8 Other mining	1	0	0	0
9 Food and drink products	0	0	3	0
10 Textiles	0	0	0	0
11 Apparel	0	0	0	0
12 Leather products	0	0	0	0
13 Wood products	0	0	0	0
14 Paper products	0	0	0	0
15 Petroleum products	0	0	0	2
16 Basic chemicals	0	0	1	243
17 Pharmaceutical products	0	0	0	84
18 Rubber and plastic products	0	0	0	127
19 Non-metallic building products	3	0	0	215
20 Iron and steel	674	0	12	234
21 Non-ferrous metals	0	0	0	1,116
22 Fabricated metal products	0	0	0	0
23 Computer products	0	0	0	0
24 Other electrical equipment	0	0	0	0
25 Other machinery	0	0	0	0
26 Motor vehicles and parts	0	0	0	0
27 Other transport equipment	0	0	0	0
28 Other manufacturing	0	0	0	0
29 Electricity generation – coal	0	0	0	0
30 Electricity generation – gas	0	0	0	0
31 Electricity generation – other	0	0	0	0
32 Electricity generation – hydro	1	0	1	0
33 Electricity generation – nuclear	0	0	0	0
34 Electricity distribution	2	0	1	0
35 Gas distribution	0	0	0	0
36 Water, drainage and waste	0	0	0	223
37 Construction services	0	0	19	0
38 Retail and wholesale trade services	0	0	2	0
39 Accommodation and restaurants	0	0	2	0
40 Land transport services	0	0	210	0
41 Water transport services	0	0	201	0
42 Air transport services	0	0	105	0
43 Warehousing	0	0	0	0
44 Communication services	0	0	0	0
45 Banking and finance	0	0	0	0
46 Insurance services	0	0	0	0
47 Rental and leasing services	0	0	0	0
48 Other business services	0	0	1	0
49 Recreation and other services	0	0	1	0
50 Public administration and defence	0	0	1	0
51 Education services	0	0	1	0
52 Health services	0	0	1	0
53 Dwelling services	0	0	0	0
54 Residential	2	0	311	0
Total	685	0	997	12,051

Table 6. Norway: Data for Greenhouse Emissions by Agent and Source in 2019 (kt of CO2-e)

Agent	*Coal*	*Gas*	*Petroleum*	*Other*
1 Crops	0	2	30	2,046
2 Livestock	0	5	32	2,472
3 Forestry	0	8	19	-16,436
4 Fishing	0	140	125	0
5 Coal mining	0	0	0	0
6 Oil mining	0	0	0	1,296
7 Gas mining	0	0	0	874
8 Other mining	9	13	50	0
9 Food and drink products	37	632	65	0
10 Textiles	1	1	1	0
11 Apparel	0	1	0	0
12 Leather products	0	3	0	0
13 Wood products	7	74	6	0
14 Paper products	36	261	9	0
15 Petroleum products	0	0	0	3,012
16 Basic chemicals	1,453	4,294	949	1,614
17 Pharmaceutical products	18	1,137	6	451
18 Rubber and plastic products	165	2,806	31	853
19 Non-metallic building products	665	850	338	1,049
20 Iron and steel	1,199	6	66	735
21 Non-ferrous metals	170	435	68	1,545
22 Fabricated metal products	7	9	3	0
23 Computer products	2	18	3	0
24 Other electrical equipment	1	11	3	0
25 Other machinery	2	17	5	0
26 Motor vehicles and parts	1	0	0	0
27 Other transport equipment	3	37	4	0
28 Other manufacturing	0	6	1	0
29 Electricity generation – coal	1	0	0	0
30 Electricity generation – gas	57	347	4	0
31 Electricity generation – other	52	0	3	0
32 Electricity generation – hydro	39	0	3	0
33 Electricity generation – nuclear	0	0	0	0
34 Electricity distribution	69	0	5	0
35 Gas distribution	1	618	2	0
36 Water, drainage and waste	1	2	9	1,382
37 Construction services	39	9	500	0
38 Retail and wholesale trade services	6	41	85	0
39 Accommodation and restaurants	3	25	50	0
40 Land transport services	1	1,520	3,827	0
41 Water transport services	1	3	5,090	0
42 Air transport services	0	50	1,208	0
43 Warehousing	0	20	5	0
44 Communication services	3	68	13	0
45 Banking and finance	1	3	3	0
46 Insurance services	0	28	4	0
47 Rental and leasing services	2	29	14	0
48 Other business services	14	113	39	0
49 Recreation and other services	0	3	13	0
50 Public administration and defence	2	17	41	0
51 Education services	3	8	22	0
52 Health services	3	20	27	0
53 Dwelling services	0	6	1	0
54 Residential	12	4	3,175	0
Total	4,085	13,707	15,953	894

Table 7. Sweden: Data for Greenhouse Emissions by Agent and Source in 2019 (kt of CO2-e)

Agent	*Coal*	*Gas*	*Petroleum*	*Other*
1 Crops	0	1	129	3,086
2 Livestock	0	0	14	3,738
3 Forestry	0	2	95	-36,736
4 Fishing	0	1	242	0
5 Coal mining	0	0	0	97
6 Oil mining	0	0	0	461
7 Gas mining	0	0	0	21
8 Other mining	1,364	4	165	0
9 Food and drink products	0	11	77	0
10 Textiles	0	1	5	0
11 Apparel	0	0	1	0
12 Leather products	0	0	0	0
13 Wood products	1	0	35	0
14 Paper products	61	11	228	0
15 Petroleum products	0	0	0	1,265
16 Basic chemicals	42	776	1,843	1,586
17 Pharmaceutical products	2	19	19	1,138
18 Rubber and plastic products	4	72	39	729
19 Non-metallic building products	1,986	62	153	643
20 Iron and steel	680	254	580	1,622
21 Non-ferrous metals	446	21	48	925
22 Fabricated metal products	1	9	23	0
23 Computer products	0	5	8	0
24 Other electrical equipment	0	3	13	0
25 Other machinery	0	5	23	0
26 Motor vehicles and parts	1	0	34	0
27 Other transport equipment	0	0	8	0
28 Other manufacturing	0	0	9	0
29 Electricity generation – coal	8	0	0	0
30 Electricity generation – gas	452	269	1	0
31 Electricity generation – other	792	0	153	0
32 Electricity generation – hydro	705	0	2	0
33 Electricity generation – nuclear	642	0	1	0
34 Electricity distribution	863	0	2	0
35 Gas distribution	1	45	0	0
36 Water, drainage and waste	1	0	9	1,081
37 Construction services	2	0	790	0
38 Retail and wholesale trade services	2	53	54	0
39 Accommodation and restaurants	0	28	35	0
40 Land transport services	2	50	4,623	0
41 Water transport services	0	0	2,442	0
42 Air transport services	0	0	1,798	0
43 Warehousing	0	4	13	0
44 Communication services	0	15	27	0
45 Banking and finance	0	0	4	0
46 Insurance services	0	0	1	0
47 Rental and leasing services	0	6	28	0
48 Other business services	1	28	82	0
49 Recreation and other services	0	0	11	0
50 Public administration and defence	2	0	33	0
51 Education services	2	2	17	0
52 Health services	2	0	19	0
53 Dwelling services	0	0	0	0
54 Residential	32	13	10,605	0
Total	8,098	1,775	24,545	-20,343

Table 8. RoE: Data for Greenhouse Emissions by Agent and Source in 2019 (kt of CO2-e)

Agent	*Coal*	*Gas*	*Petroleum*	*Other*
1 Crops	1,607	1,111	13,772	230,402
2 Livestock	652	1,268	4,413	163,419
3 Forestry	229	1,060	2,425	-178,342
4 Fishing	16	649	3,186	0
5 Coal mining	0	0	0	8,608
6 Oil mining	0	0	0	44,299
7 Gas mining	0	0	0	19,360
8 Other mining	595	3,094	4,021	0
9 Food and drink products	5,644	27,360	3,352	0
10 Textiles	1,099	3,546	247	0
11 Apparel	249	1,463	203	0
12 Leather products	168	620	166	0
13 Wood products	160	1,186	664	0
14 Paper products	2,887	12,298	864	0
15 Petroleum products	0	0	0	54,356
16 Basic chemicals	8,032	85,932	89,046	84,832
17 Pharmaceutical products	358	7,312	906	43,891
18 Rubber and plastic products	1,483	24,279	3,379	44,468
19 Non-metallic building products	23,608	39,200	13,114	36,083
20 Iron and steel	18,549	29,100	22,733	48,797
21 Non-ferrous metals	1,255	7,638	1,478	40,424
22 Fabricated metal products	270	4,017	1,677	0
23 Computer products	126	3,088	566	0
24 Other electrical equipment	73	2,120	888	0
25 Other machinery	84	3,001	1,111	0
26 Motor vehicles and parts	700	4,163	506	0
27 Other transport equipment	84	871	581	0
28 Other manufacturing	100	37	1,491	0
29 Electricity generation – coal	597,792	3	1,765	0
30 Electricity generation – gas	919	439,674	1,595	0
31 Electricity generation – other	1,150	3,744	23,820	0
32 Electricity generation – hydro	605	2,002	1,661	0
33 Electricity generation – nuclear	228	550	1,780	0
34 Electricity distribution	1,155	2,917	2,299	0
35 Gas distribution	865	15,803	520	0
36 Water, drainage and waste	328	537	884	126,812
37 Construction services	254	6,410	24,049	0
38 Retail and wholesale trade services	3,786	29,118	6,741	0
39 Accommodation and restaurants	1,729	13,800	3,664	0
40 Land transport services	692	36,271	236,751	0
41 Water transport services	40	199	56,229	0
42 Air transport services	4	209	113,867	0
43 Warehousing	257	2,814	554	0
44 Communication services	262	5,636	1,476	0
45 Banking and finance	81	699	657	0
46 Insurance services	34	174	549	0
47 Rental and leasing services	118	1,701	1,292	0
48 Other business services	1,077	5,994	3,541	0
49 Recreation and other services	279	968	1,061	0
50 Public administration and defence	1,818	1,463	2,229	0
51 Education services	1,329	7,226	1,299	0
52 Health services	1,922	1,728	1,385	0
53 Dwelling services	7	23	9	0
54 Residential	47,760	226,236	431,574	0
Total	732,517	1,070,308	1,092,040	767,408

Appendix 4. Disaggregated employment results for regions in Nordic countries

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In its current configuration, Nordic-TERM generates results for employment in 52 industries in the 26 NUTS2 regions of the 5 Nordic countries plus the single region, Rest of Europe.

We are extending the employment coverage to include occupation, education level, age, and wage band.

1. Add-on equations to determine effects of policy changes on employment disaggregated by industry, occupation, age, education, region and wage band

In the extended model, we determine in Nordic-TERM the percentage change in employment by industry (j), occupation (o), age (a), education (e) and region [N(r)] by assuming that:

$$\mathrm{lab52}(j,o,a,e,N(r)) = \mathrm{lab52}(j,N(r)) \tag{1}$$

where

$\mathrm{lab52}(j,N(r))$ is the percentage change, generated by Nordic-TERM, in employment in industry j in region r of country N.

In (1) we assume that employment in industry j,N(r), $j \in$IND52, in every (o,a,e) cell moves by the same percentage.

Using (1), we can compute a variety of results elucidating the effects of policies and other changes in the economic environment on employment opportunities for different groups in the workforces of the Nordic countries. Examples include the following.

Employment by education level in region N(r)

$$\mathrm{lab52\_ioa}(e,N(r)) = \frac{\sum_{i,o,a} \mathrm{E52}(i,o,a,e,N(r)) * \mathrm{lab52}(i,o,a,e,N(r))}{\sum_{ii,oo,aa} \mathrm{E52}(ii,oo,aa,e,N(r))} \tag{2}$$

Employment by education level in country N

$$\mathrm{lab\_ioa}(e,N) = \frac{\sum_{r \in N} \sum_{i,o,a} \mathrm{E52}(i,o,a,e,N(r)) * \mathrm{lab52}(i,o,a,e,N(r))}{\sum_{r \in N} \sum_{ii,oo,aa} \mathrm{E52}(ii,oo,aa,e,N(r))} \tag{3}$$

Employment by education level in combined Nordic countries

$$\mathrm{lab\_ioa}(e,\mathrm{Nordic}) = \frac{\sum_{N \in \mathrm{Nordic}} \sum_{i,o,a} \mathrm{E52}(i,o,a,e,N) * \mathrm{lab\_ioa}(e,N)}{\sum_{N \in \mathrm{Nordic}} \sum_{ii,oo,aa} \mathrm{E52}(ii,oo,aa,e,N)} \tag{4}$$

where

$E52(i,o,a,e,N(r))$ is employment in region N(r) of people with the characteristics (i,o,a,e)

and

$E52(i,o,a,e,N)$ is employment in country N of people with the characteristics (i,o,a,e) given by

$$E52(i,o,a,e,N) = \sum_{r \in N} E52(i,o,a,e,N(r)) \quad . \tag{5}$$

Equations similar to (2), (3), and (4) can be used to determine employment in each region or country by occupation and age.

Unlike the i,o,a,e and N(r) dimensions, wage rates are a continuous variable. We create a wage-band dummy for every (i,o,a,e,N(r)) cell. These dummies are defined by

$$D(i,o,a,e,N(r),b) = \begin{cases} 1 & \text{if } W52(i,o,a,e,N(r)) \text{ is in wage band b} \\ 0 & \text{otherwise} \end{cases} \tag{6}$$

where

$W52(i,o,a,e,N(r))$ is the average wage rate of (i,o,a,e) workers, $i \in 52$, in region N(r).

We plan to use about 8 wage bands. For example, the wage bands for Denmark might be: 0-100 DKK per hour; 101-250; 251-400; 401-550; 551-700; 701- 850; 851-1000; and 1001+.

With the wage bands in place, we can show whether a policy favours high or low wage activities. For example, we can compute employment by wage band, region and country.

Employment by wage band in region N(r)

$$eb\_ioae(N(r),b) = \frac{\sum_{i,o,a,e} D(i,o,a,e,N(r)) * E52(i,o,a,e,N(r)) * lab52(i,o,a,e,N(r))}{\sum_{ii,oo,aa,ee} D(ii,oo,a,ee,N(r),b) * E(ii,oo,aa,ee,N(r))} \tag{7}$$

Employment by wage band in country N

$$eb\_ioae(N,b) = \frac{\sum_{r \in N} \sum_{i,o,a,e} D(i,o,a,e,N(r)) * E52(i,o,a,e,N(r),b) * lab52(i,o,a,e,N(r))}{\sum_{r \in N} \sum_{ii,oo,aa,ee} D(ii,oo,aa,ee,N(r),b) * E(ii,oo,aa,ee,N(r))} \tag{8}$$

2. Data

To implement equations such as (2) – (8), we need data on employment and average hourly wage rates for workers identified by industry, occupation, age and education.

Carlos Tapia from Nordregio has supplied us with detailed Eurostat data. From these data we obtained average hourly wage rates in 2018 for workers in Nordic countries disaggregated by 25 industries, about 122 occupations, 6 age groups and 4 education levels. The data also show the number of sampled people in each industry, occupation, age and education cell.

Before we could use the data we had to solve problems concerning industry classifications. We decided to start by working on Denmark. Then having setup methods using Danish data we expect that it will be straight-forward to deal with the data for the other Nordic countries.

Eurostat industry 16_to_18_58_to_60

One of the 25 Eurostat industries is particularly unsuitable for our purposes. This is industry 16_to_18_58_to_60. It is a combination of Wood, paper products and printing (16_to_18) and Publishing and broadcasting (58_to_60). The occupational and educational requirements for these two parts of the Eurostat industry are likely to be quite different. For example, the second part is likely to employ authors, and media personnel.

We decided to split the Eurostat industry into two parts using the occupational data. As indicated in Table 1, the original Eurostat industry 16_to_18_58_to_60 in Denmark employs significant numbers of people in 4 occupations that clearly belong in Publishing and broadcasting. We created an employment profile for a Wood, paper products and printing industry by deleting the entries for the 4 occupations. This reduced Denmark's employment in 16_to_18_58_to_60 from 41,268 to 32,016 (a reduction of 22.42 per cent). We scaled the entries for the remaining occupations by the fraction 32016/41268. In this way we recognized that the now smaller industry requires less general-purpose administrators etc. The resulting industry is what we will call Wood, paper products and printing (16_to_18), shortened to WoodPapPrint. We form a 26th Eurostat industry that we call Residual. Employment in this industry is made up of all of the workers that are moved out of industry 16_to_18_58_to_60 in forming Wood, paper products and printing (16_to_18). We denote the set of 26 Eurostat industries as IND26.

Linking IND26 with industries in the master database for Nordic-TERM

The 52 industries in the current configuration of Nordic-TERM are an aggregation of the 70 industries in the master database. We denote these 70 industries by IND70. As indicated in Table 2, with the exception of agriculture, we associate a 26-order Eurostat industry (includes Residual) or combination of industries with each of the 70-order Nordic-TERM industries. The purpose of the association is to provide a basis for disaggregating employment in each of the Nordic-TERM industries into occupation, age and education categories. For most of the 70 industries the association is straight forward. For example, for each of the Nordic-TERM industries 19 to 24, the associated Eurostat industry is FooBevTobTex (10_to_13). This means that we are assuming the same (o,a,e) composition of employment in each of the food, beverage, tobacco and textile industries in country N.

For some 70-order industries, the associated indicator from Eurostat is an aggregation of two Eurostat industries. There are 6 examples: trd (Nordic-TERM industry 55); cmn (56); rsa (64); obs (65); osg(67); and dwe (70).

As indicated in Table 2, our Eurostat database provides no information for Agriculture, forestry and fishing (AFF). We return to this problem shortly.

Wage rates

For each of the 26 Eurostat industries we calculate the average wage according to

$$\text{WAGE\_ave26}(j,N) = \frac{\sum_{o,a,e} \text{num26}(j,o,a,e,N) * \text{WAGE26}(j,o,a,e,N)}{\sum_{oo,aa,ee} \text{num26}(j,oo,aa,ee,N)} \tag{9}$$

where

num26(j,o,a,e,N) is the number of people in the Eurostat sample with characteristics (j,o,a,e,N) for $j \in$ IND26; and

$\text{WAGE26}(j,o,a,e,N)$ is the average wage rate shown in the Eurostat data for people with characteristics (j,o,a,e,N), $j \in$ IND26.

Next, we calculate the Eurostat-implied average wage rate for each of the 70 Nordic-TERM industries excluding AFF. This is given by

$$\text{WAGE\_ave70}(i,N) = \frac{\sum_{j \in \text{IND26}} \text{DASSOC}(i,j) * \text{num26}(j,N) * \text{WAGE\_ave26}(j,N))}{\sum_{j \in \text{IND26}} \text{DASSOC}(i,j) * \text{num26}(j,N)} \tag{10}$$

where

num26(j,N) is the number of people in Eurostat industry j in country N, $j \in$ IND26, given by

$$\text{num26}(j,N) \quad = \quad \sum_{a,o,e} \text{num26}(j,a,o,e,N) \ , \tag{11}$$

and

DASSOC(i,j) is 1 if $j \in$ IND26 is associated with $i \in$ IND70, see Table 2.

Agriculture, forestry and fishing

We gave employment in AFF industries (o,a,e) dimensions as follows.

For o we assumed that all workers in these industries have a new occupation, AFF worker. We gave workers in AFF industries a similar age profile to that of their country but scaled up so that the average age is 5 years higher than that of their country's workforce. For e, we assumed that all AFF workers have secondary education.

To implement these decisions we needed to calculate average ages of workers in each country. For country N this is given by

$$\text{Ave\_age}(N) \qquad = \sum_{a} \text{Sh}(a,N) * \hat{a} \tag{12}$$

where Sh(a,N) is the share of non-AFF workers in age group a in country N,

$$\text{Sh}(a,N) = \frac{\sum_{j,o,e} \text{num26}(j,o,a,e,N)}{\sum_{jj,oo,aa,ee} \text{num26}(jj,oo,aa,ee,N)} \tag{13}$$

and $\hat{a}$ is the central age in age group a. For :

a = 1, the age group 14-19, $\hat{a} = 17$;

a = 2, the age group 20-29, $\hat{a} = 25$;

a = 3, the age group 30-39, $\hat{a} = 35$;

a = 4, the age group 40-49, $\hat{a} = 45$;

a = 5, the age group 50-59, $\hat{a} = 55$;

a = 6, the age group 60+, $\hat{a} = 68$.

For i∈AFF, we assume that the share of workers in age group a is given by:

$$\mathrm{Sh(AFF,a,N)} = \mathrm{f}\left(\mathrm{AFF,a,N}\right) * \mathrm{Sh(a,N)} \tag{14}$$

where

$$\mathrm{f}\left(\mathrm{AFF,a,N}\right) = \left[1 + \mathrm{b(N)} * \left(\mathrm{a} - 1\right)\right] * \mathrm{NORM1(N)} \tag{15}$$

and b(N) and NORM1(N) are determined via

$$\sum_{\mathrm{a}} \mathrm{Sh(AFF,a,N)} = 1 \tag{16}$$

$$\mathrm{Ave\_age(AFF,N)} = \sum_{\mathrm{a}} \mathrm{Sh(AFF,a,N)} * \hat{a} \tag{17}$$

and

$$\mathrm{Ave\_age(AFF,N)} = \mathrm{Ave\_age(N)} + 5 \tag{18}$$

To determine b(N) and NORM1(N) we start by combining (14) and (15)

$$\mathrm{Sh(AFF,a,N)} = \left[1 + \mathrm{b(N)} * \left(\mathrm{a} - 1\right)\right] * \mathrm{NORM1(N)} * \mathrm{Sh(a,N)} \tag{19}$$

Combining (16) and (19) gives

$$\mathrm{NORM1(N)} * \sum_{\mathrm{a}} \left[1 + \mathrm{b(N)} * \left(\mathrm{a} - 1\right)\right] * \mathrm{Sh(a,N)} = 1 \tag{20}$$

Simplifying

$$\mathrm{NORM1(N)} * \left[1 + \mathrm{b(N)} * \sum_{\mathrm{a}} \left(\mathrm{a} - 1\right) * \mathrm{Sh(a,N)}\right] = 1 \tag{21}$$

Combining (18), (17) and (19)

$$\mathrm{Ave\_age(N)} + 5 = \mathrm{NORM1(N)} * \left[\sum_{\mathrm{a}} \mathrm{Sh(a,N)} * \hat{a} + \mathrm{b(N)} * \sum_{\mathrm{a}} \left(\mathrm{a} - 1\right) * \mathrm{Sh(a,N)} * \hat{a}\right] \tag{22}$$

Eliminating NORM1(N) from (21) and (22)

$$\left[\mathrm{Ave\_age(N)} + 5\right] * \left[1 + \mathrm{b(N)} * \sum_{\mathrm{a}} \left(\mathrm{a} - 1\right) * \mathrm{Sh(a,N)}\right] = \left[\sum_{\mathrm{a}} \mathrm{Sh(a,N)} * \hat{a} + \mathrm{b(N)} * \sum_{\mathrm{a}} \left(\mathrm{a} - 1\right) * \mathrm{Sh(a,N)} * \hat{a}\right] \tag{23}$$

Now we start rearranging to obtain an expression for b(N)

$$\left[\text{Ave\_age}(N)+5\right]-\sum_a \text{Sh}(a,N) \ * \hat{a} =$$

$$\left[b(N) * \sum_a (a-1) * \text{Sh}(a,N) \ * \hat{a} \ \right] - \left[\text{Ave\_age}(N)+5\right] * \left[b(N) * \sum_a (a-1) * \text{Sh}(a,N) \ \right]$$

(24)

Hence

$$\frac{\left[\text{Ave\_age}(N)+5\right]-\sum_a \text{Sh}(a,N) \ * \hat{a}}{\left\{ \sum_a (a-1) * \text{Sh}(a,N) \ * \hat{a} - \left[\text{Ave\_age}(N)+5\right] * \sum_a (a-1) * \text{Sh}(a,N) \ \right\}} = b(N) \quad (25)$$

which can be simplified to

$$\frac{5}{\left\{ \sum_a (a-1) * \text{Sh}(a,N) \ * \hat{a} - \left[\text{Ave\_age}(N)+5\right] * \sum_a (a-1) * \text{Sh}(a,N) \ \right\}} = b(N) \quad (26)$$

Then NORM1(N) can be found using (21).

Now we can calculate WAGE_ave70(i,N) for i∈AFF. We do this according to the formula:

$$\begin{aligned} &\text{WAGE\_ave70}(i,N) \\ &= \sum_a \text{Sh}(\text{AFF},a,N) * \text{WAGE\_ave}(a,\text{"G2"},N)) \end{aligned} \quad \text{for all } i \in \text{AFF} \quad (27)$$

where

G2 denotes secondary education and

$\text{WAGE\_ave}(a,\text{"G2"},N)$ is the average wage rate in each age group in country N for people with secondary education, given by:

$$\text{WAGE\_ave}(a,\text{"G2"},N) = \frac{\sum_{j,o} \text{num26}(j,o,a,\text{"G2"},N) * \text{WAGE26}(j,o,a,\text{"G2"},N)}{\sum_{j,o} \text{num26}(j,o,a,\text{"G2"},N)} \quad (28)$$

Using the average wage rates by industry at the 70-order level in calculating employment by industry at the NUTS2 level compatible with Nordic-TERM wagebill data

The Nordic-TERM database shows wagebills for 70 industries in 27 regions. We estimate employment in industry i, region r, country N according to

$$\text{E70}(i,N(r)) = \frac{\text{WB70}(i,N(r))}{\text{WAGE\_ave70}(i,N) * \text{NORM2}(N(r))} \quad (29)$$

In equation (29), NORM2(N(r)) is a normalizing vector calculated so that

$$\sum_{i \in IND70} E70(i, N(r)) = E(N(r)) \quad (30)$$

where E(N(r)) is total employment in region N(r), available from Eurostat data.

We estimate the number of people, E70(i,o,a,e,N(r)), in industry $i \in IND70$, occupation o, age group a, education level e in region r of country N as

$$E70(i,o,a,e,N(r)) = E70(i,N(r)) * \frac{\sum_{j \in IND26} DASSOC(i,j) * num26(j,o,a,e,N)}{\sum_{j \in IND26} \sum_{oo,aa,ee} DASSOC(i,j) * num26(j,oo,aa,ee,N)}$$

for $i \notin AFF$ (31)

For $i \in AFF$ we have

$$E70(i, AFF\_worker, a, G2, N(r)) = E70(i, N(r)) * Sh(AFF, a, N) \text{ for } i \in AFF \quad (32)$$

For other (o,e)s, employment in AFF industries is zero.

Translating from 70 Nordic-TERM industries to the 52 industries in the current Nordic-TERM model

As mentioned earlier, the current Nordic-TERM model as 52 industries whereas the master database has 70 industries. In going from 70 to 52, we aggregated the 14 AFF industries in the master database to 3 and the 8 food beverages and tobacco industries into 1.

In the previous sections we have described the calculation of employment at the 70 level. For implementing the employment disaggregation equations, (2) through (8), we need employment at the 52 level. We calculate employment at the 52 level as

$$E52(i,o,a,e,N(r)) = \sum_{j \in IND70:MP52(j)=i} E70(j,o,a,e,N(r)) \quad (33)$$

where

MP52(j) is the 52-order industry of the which the 70-order industry j is part.

For implementing wage-band disaggregation equations such as (6) to (8), we need (o,a,e,N(r)) wage rates at the 52-industry level. We calculate these as follows:

$$W70(i,o,a,e,N(r))) = \frac{\sum_{j \in IND26} num26(j,a,o,e,N(r)) * DASSOC(i,j) * WAGE26(j,o,a,e,N))}{\sum_{jj} num26(jj,o,a,e,N) * DASSOC(i,jj)}$$

for $i \in IND70$ (34)

and

$$W52(k,o,a,e,N(r))) = \frac{\sum_{i \in IND70:MP52(i)=k} E70(i,o,a,e,N(r) * WAGE70(i,o,a,e,N(r)))}{\sum_{ii \in IND70:MP52(ii)=k} E70(ii,o,a,e,N(r))}$$

for $k \in IND52$ (35)

In (34), disaggregated wage rates at the 70-industry level are calculated as weighted averages of the Eurostat wage rates at the 26-industry level. Then in (35) disaggregated wage rates at the 52-industry level are calculated as weighted averages of the disaggregated wage rates at the 70-industry level.

Concluding remarks

Eurostat provided data on employment and wage rates by industry, occupation, age, education level and Nordic country. This note describes how we have processed the Eurostat data so that it can be used in conjunction with Nordic-TERM. Fundamental to our method is the assumption that the proportion of country N's workforce in a particular (i,o,a,e) cell is the same as the proportion of the Eurostat sample in that cell. For Denmark, the assumption that population shares are the same as sample shares is reasonable. This is because the Eurostat sample has 2.3 million workers in Denmark which is most of the employed population of about 2.8 million. However, for Sweden the sample seems to contain only 276 thousand people, a small fraction of the Swedish workforce which is about 5 million. Consequently, our assumption is problematic for Sweden.

Another important assumption is that the (o,a,e) characteristics of workers in industry i in region N(r) are the same as for country N.

Table 1. Splitting employment in Denmark by occupation in Eurostat industry 16_to_18_58_to_60 (Wood, paper prods, printing, publishing, broadcasting)

Occupation	Industry 16_to_18_58_to_60	% moved to Residual	26th industry, Residual	Industry 16_to_18
1 ChiefExec	0	22.42	0	0
2 SciEngProf	0	22.42	0	0
3 SciEngAsProf	0	22.42	0	0
4 LegSenOffic	26	22.42	5.83	20.17
5 ManagDirect	534	22.42	119.72	414.28
:::	:::	:::	:::	:::
34 LibrArchCura	117	100.00	117	0
:::	:::	:::	:::	:::
40 AuthJourLing	6728	100.00	6728	0
41 CreaPerfArt	1796	100.00	1796	0
:::	:::	:::	:::	:::
57 ArtCulAsProf	611	100.00	611	0
:::	:::	:::	:::	:::
122 RefuseWrk	5	22.42	1.12	3.88
Total	41,268		16,430	24838

Table 2. 70-order Nordic-TERM industries and associated 26 Eurostat industries

Associated 26-order Eurostat industries	No.	70 Nordic-TERM industries	Description
NA	1	pdr	Rice:
NA	2	wht	Wheat:
NA	3	gro	Other Grains:
NA	4	v_f	Veg & Fruit:
NA	5	osd	Oil Seeds: oil seeds and oleaginous fruit
NA	6	c_b	Cane & Beet: sugar crops
NA	7	pfb	Fibres crops
NA	8	ocr	Other Crops:
NA	9	ctl	Cattle:
NA	10	oap	Other Animal Products
NA	11	rmk	Raw milk
NA	12	wol	Wool:
NA	13	frs	Forestry:
NA	14	fsh	Fishing:
MinUtil	15	coa	Coal: mining and agglomeration of hard coal, lignite and peat
MinUtil	16	oil	Oil: extraction of crude petroleum
MinUtil	17	gas	Gas: extraction of natural gas,
MinUtil	18	oxt	Other Mining Extraction
FodBevTobTex	19	cmt	Cattle Meat:
FodBevTobTex	20	omt	Other Meat:
FodBevTobTex	21	vol	Vegetable Oils:
FodBevTobTex	22	mil	Milk: dairy products
FodBevTobTex	23	pcr	Processed Rice:
FodBevTobTex	24	sgr	Sugar
FodBevTobTex	25	ofd	Other food
FodBevTobTex	26	b_t	Beverages and Tobacco products
FodBevTobTex	27	tex	Manufacture of textiles
ApparlLeaPrd	28	wap	Manufacture of wearing apparel
ApparlLeaPrd	29	lea	Manufacture of leather and related products
WoodPapPrint	30	lum	Lumber:
WoodPapPrint	31	ppp	Paper & Paper Products:
PetChemPlas	32	p_c	Petroleum & Coke:
PetChemPlas	33	chm	Manufacture of chemicals and chemical products
PharmComEle	34	bph	Manufacture of pharmaceuticals
PetChemPlas	35	rpp	Manufacture of rubber and plastics products
NonMetMinPrd	36	nmm	Manufacture of other non-metallic mineral products
MetalProds	37	i_s	Iron & Steel: basic production and casting
MetalProds	38	nfm	Non-Ferrous Metals:
MetalProds	39	fmp	Manufacture of fabricated metal products,
PharmComEle	40	ele	Manufacture of computer, electronic and optical products
PharmComEle	41	eeq	Manufacture of electrical equipment
MachEquip	42	ome	Manufacture of machinery and equipment n.e.c.
TrnEqpFurnO	43	mvh	Manufacture of motor vehicles, trailers and semi-trailers
TrnEqpFurnO	44	otn	Manufacture of other transport equipment
TrnEqpFurnO	45	omf	Other Manufacturing: includes furniture
MinUtil	46	ElecCoal	Electricity, coal-fired
MinUtil	47	ElecGas	Electricity, gas-fired
MinUtil	48	ElecOther	Electricity,other-fired

MinUtil	49	ElecHydro	Electricity, hydro-fired
MinUtil	50	ElecNuc	Electricity, nuclear-fired
MinUtil	51	ElecDist	Electricity; distribution
MinUtil	52	gdt	Gas manufacture, distribution
SewWastRemed	53	wtr	Water supply; sewerage, waste management and remediation activities
Construct	54	cns	Construction: building houses factories offices and roads
WhlsMVRet, RetExMV	55	trd	Wholesale and retail trade; repair of motor vehicles and motorcycles
AccomFoodSrv	56	afs	Accommodation, Food and service activities
TrnspStore	57	otp	Land transport and transport via pipelines
TrnspStore	58	wtp	Water transport
TrnspStore	59	atp	Air transport
TrnspStore	60	whs	Warehousing and support activities
PostInfoComm, Residual	61	cmn	Information and communication
FinInsLegSec	62	ofi	Other Financial Intermediation:
FinInsLegSec	63	ins	Insurance (formerly isr): includes pension funding, except compulsory social security
ReRDAdvtech, MngAdminServ	64	rsa	Real estate activities
ReRDAdvtech, MngAdminServ	65	obs	Other Business Services nec
ArtEntRecPer	66	ros	Recreation & Other Services:
PubAdminDef, MembOrg	67	osg	Other Services (Government):
Education	68	edu	Education
VetHlthSocWk	69	hht	Human health and social work
ReRDAdvtech, MngAdminServ	70	dwe	Ownership of dwellings (imputed rents of houses occupied by owners)

Appendix 5. Household data in the Nordic countries: an overview

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1. Introduction

This Appendix describes the data situation regarding household income and expenditure derived from survey or register data in the Nordic countries. Section 2 lists the datasets collected from Eurostat, the OECD and the National Statistical Institutes (NSI) of the Nordic countries. Section 3 explains the characteristics of selected social surveys at European level and the variables included in the related Eurostat microdata files. The surveys in scope include the Structure of Earnings Survey (SES), the European Statistics on Income and Living Conditions (EU-SILC), the European Labour Force Survey (EU-LFS) and the Household Budget Survey (HBS). All microdata files are accessible from Eurostat for scientific use. The document further explains the limitations of these microdata tables as means to build indicators at a relevant territorial level (NUTS 2) and describes potential data strategies to overcome such limitations.

2. Overview of existing datasets and indicators from official statistical offices

The following table lists the data files that were collected for analysis of the different themes. Some of the files were also used to validate the expenditure data produced using the microdata files (see Appendix 6).

Table 1. Survey-based Indicators (microdata, census, etc.)

	Eurostat[1]	OECD[2]	Denmark[3]	Finland[4]	Iceland[5]	Norway[6]	Sweden[7]
1. Number of families of various structures (such as 2 adults with 3 children under 15, etc)	Private households by type, tenure status and NUTS 2 region (cens_11htts_r2). 2011 census data, 24 types of households classified by tenure status (owner vs tenant). The classification places the emphasis on internal unions and single-parent household structures rather than on their composition	NA	FAM55N: Households 1 January by region, type of household, household size and number of children in the household. Annual data on number of children, household size, region and type.	12c1 -- Key figures on families by family type and area, 2006-2020. Yearly data. 16 family compositions, 528 regions, 7 family types	Nuclear families by municipalities and type of family 1998-2022 (MAN07108). Data available by region and municipality.	06081: Persons in private households, by type of household (M) (UD) 2005 - 2021 6 types of households. Yearly data. Various regional aggregates 06070: Private households, by	Number of households and persons by region, type of household and number of children. Year 2011 – 2021 (HushallT05). Various regional levels, 9 types of households, information of number of children,

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[1] https://ec.europa.eu/eurostat/web/main/data/database

[2] https://stats.oecd.org/Index.aspx?DataSetCode=REGION_DEMOGR#

[3] https://www.statbank.dk/statbank5a/SelectTable/Omradeo.asp?SubjectCode=2&ShowNews=OFF&PLanguage=1

[4] https://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/

[5] https://statice.is/

[6] https://www.ssb.no/en/statbank

[7] https://www.statistikdatabasen.scb.se/pxweb/en/ssd/

	(number of members, age and gender) Population by sex, age group, size of household and NUTS 3 regions (cens_01rhsize). Census data. Households classified by number of persons in each age range and gender. Data for 2001 only, and should be reaggregated at NUTS 2 level Number of households by degree of urbanisation and NUTS 2 regions (EU-LFSt_r_EU-LFSd2hh). Data from Labour Force Survey for 2020. Degree of urbanisation in Cities, Towns and suburbs and Rural areas. No information on households characteristics other than number and degree of urbanisation					type of household (M) (UD) 2005 – 2021. 11 types of households. Yearly data. Various regional aggregates 09747: Private households, persons in private households and persons per private houshold (M) (UD) 2005 – 2021. Yearly data. Various regional aggregates	

	but can be useful to calculate estimates for the remaining indicators							
2. For each family identified in (1) we need data on their sources of income. This includes wage income by industry from which it is derived, government payments (social security pensions etc) and capital income (e.g. dividends)	Income of households by NUTS 2 regions (nama_10r_2hhinc). Table from the regional accounts. 13 indicators (various types of income – regional averages at per-capita and household level).	NA	INDKF101: Income by region, unit, owner/ tenant of dwelling and type of income. Yearly data on 39 types of income, by type of tenure INDKF111: Income for families by region, unit, family type and type of income. Same as above by 9 types of families. INDKF112: Income by region, unit, family type, number of children and	127m -- Income and income structure of household-dwelling units by region, 1995-2020 Classification by various types of households and 34 types of income sources. Data also available at NUTS 3 (128i) and LAU 2 - municipal level (118w)	Income by municipalities and sex 1990-2020 - Current municipalities (TEK01003) Mean and median values (for men and women, not households). 2 types of income (total income and salaries)	10678: Average income account for households, by type of household (C) 2006 – 2020 Information for 10 types of income and 16 types of household. County level data 06946: Household income, by type of household. Number of households and median (C) 2005 – 2020. Data at county level (NUTS 2). 15 types of households. The	Disposable income for households by region, type of households and age. Year 2011 – 2020 (Tab4bDispInkN) Measures: Mean and median values Indicators: 15 types of households, 7 age groups Geo: NUTS 3 (counties; NUTS 2 not available)

			type of income. Same as above by number of children INDKF104: Income by region, unit, socio-economic group and type of income. Same as above, plus the socio-economic group provides limited information on 19 "occupations"			table num. 06944 provides similar data at municipal level for 4 types of households	
3. For each family identified in (1) we need expenditures disaggregated into as much commodity detail as possible.	NA	NA	NA	NA	Average household expenditure and size by residence from 2002-2016 (VIS05302). Data disaggregated at NUTS 3 level (capital region vs rest of the country) and 68 COICOP categories (large SD errors). No information on	10237: Expenditure per household per year, by commodity and service group and various regions 1999 – 2012. Yearly data for NUTS 2 regions. Up to 149 commodities.	NA

					type of households. Data by type of households (VIS05303) and disposable income is only available at the national level		

Table 2. Indicators derived from register data and other sources

	Eurostat[8]	OECD[9]	Denmark[10]	Finland[11]	Iceland[12]	Norway[13]	Sweden[14]
1. employment by industry in each region;	SBS data by NUTS 2 regions and NACE Rev. 2 from 2008 onwards (sbs_r_nuts06_r2). 5 indicators; 100 industries; 2008-2019.	Regional Employment at place of work, by ISIC Rev. 4 activities (REGION_ECONOM) Employment and GVA in 11 sectors at regional (NUTS 1 to 3 level)	RAS301: Employed (end November) by region (workplace), industry (DB07), socioeconomic status, age and sex. Register data RAS302: Employed (end November) by	115m -- Employed labour force by area, industry (TOL 2008), occupational status, age, sex and year, 2007-2019. 23 industries. Tables 115h and 115i provide the information	Number of employed persons, jobs and hours worked by economic activity 2008-2021 (THJ11002). Data at national level for 90 industries.	11657: Employees and jobs, by place of work and industry division (8 groups) (M) 2016K1 - 2021K4. Quarter data from Labour Force Survey, 9 industries. Data available at various territorial	Gainfully employed 16-74 years by region of residence (RAMS), by region, industry SNI2007 and sex. Year 2019 – 2020 (NattSni07KonKN). Tables based on administrative sources. Data for 16 industries (NACE 2). Data for 52 industries available at the national level

[8] https://ec.europa.eu/eurostat/web/main/data/database

[9] https://stats.oecd.org/Index.aspx?DataSetCode=REGION_DEMOGR#

[10] https://www.statbank.dk/statbank5a/SelectTable/Omradeo.asp?SubjectCode=2&ShowNews=OFF&PLanguage=1

[11] https://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/

[12] https://statice.is/

[13] https://www.ssb.no/en/statbank

[14] https://www.statistikdatabasen.scb.se/pxweb/en/ssd/

			region (residents), industry (DB07), socioeconomic status, age and sex. Register data	disaggregated by place of residence and workspace.		levels. Requires re-aggregation to NUTS 2 13470: Employed persons, by industry division (5 digit level, SIC2007). 4th quarter (M) 2008 – 2021[15]. Register data (9 industries; monthly). Municipal level	
2. employment by occupation in each region;	Population by status in employment, occupation and NUTS 2 region (cens_11empo_r2).		Same as above. Socioeconomic status provides 8 occupation categories	115s -- Employed persons by occupational group (Classification of	The previous table (THJ11002) includes the number of observations, so it could be	11619: Employed persons, by place of residence, sex, age and occupation.	Employees 16-64 years by region of residence, occupation (3-digit SSYK 2012), age and sex. Year 2019 - 2020 Register data,

[15] Given the number of dimensions in the dataset, this table requires a manual download from the web of Statistics Norway (the complete dataset is large several GB and the automatic download fails): https://www.ssb.no/en/statbank/table/13470/

	Census data (for 2011 only)			Occupations 2010, levels 1 to 3), area, sex and year, 2010-2019. 184 occupational groups. 115l -- Employed labour force in area (workplaces) by area, sector (Classification of Sectors 2012) and year, 2014-2019 provides information on employment by sectors (21)	to map employment by occupation (at the national level)	4th quarter (M) 2015 – 2021. Register data, annual since 2015, 11 sectors, various regional aggregates	information for 149 occupations, 9 age groups, gender. Data for 2 years only Employees 16-64 years by region of work, occupation (3-digit SSYK 2012), age and sex. Year 2019 – 2020. Same as above by region of work
3. employment by wage-band in each region;			LONS30: Earnings by region, sector, salary, salary earners, components and sex. Yearly data on personal	139z -- Earnings of full-time salary and wage earners by region and employer sector, 2020. Only average	Earnings for full-time employees by occupation and sex 2014-2020 (VIN02001). 259	11654: Employees, jobs, earnings, and earnings index, by place of work and industry division (17	Income from employment by region, sex, age and income bracket.

			earnings by sector (7)	earnings by broad sector (4)	occupations. Data for the national level only	groups, SIC2007) (C) 2016K1 - 2021K4. Data on number of jobs, average earnings per quarter and region (NUTS 3) in 18 industries.	Year 2000 – 2020 (InkAvTjanst)[16] Tax data. Number of persons and mean value for persons in 17 income brackets, NUTS 3 region or municipality, 8 types of income, gender, 5 age groups, years (2000-2020)
4. number of households by family structure in each region;	Private households by type, tenure status and NUTS 2 region (cens_11htts_r2), data for 2011		FAM55N: Households 1 January by region, type of household, household size and number of children in the household	12c3 -- Families by family type, number of persons in family and area, 1992-2020. Same as 12c1 above plus number of persons	Nuclear families by municipalities and type of family 1998-2022 (MAN07108). Data available by region and municipality.	Tables 06081, 06070, 09747 mentioned above	Number of households and persons by region, type of household (rough division), number of children and age of youngest child. Year 2011 – 2021 (HushallT10) 4 types of households. Many other tables available. See also table HushallT05 above

[16] Given the number of dimensions in the dataset, this table requires a manual download from the web of Statistics Sweden (the complete dataset is large several GB and the automatic download fails): https://www.statistikdatabasen.scb.se/pxweb/en/ssd/START__HE__HE0110__HE0110B/InkAvTjanst/

5. number of households by family structure and income in each region;	NA	NA	NA	128i -- Income and income structure of household-dwelling units by sub-regional unit, 1995-2020	Median equivalized incomes by household type 2004-2016 (LIF01123). Derived from the EU-SILC microdata. National level only	Tables 06946 and 6944 mentioned above	See
6. consumption expenditures by commodity for households classified by structure, income and region.	Final consumption expenditure of households by consumption purpose COICOP 3 digit (nama_10_co3_p3) Data only available at the national level	Final consumption expenditure of households (SNA_TABLE5) Data only available at the national level by 73 COICOP 5 digit transactions	FU07: Consumption by group of consumption, region and price unit. Data from the Household Budget Survey, providing annual data on household consumption for 47 commodities and 6 regions	003 -- Household consumption expenditure by major region 1985-2016 (NUTS2). Household and consumption unit. Consumption by >1000 commodities. No information on household structure	Household final consumption expenditure 1990-2021 (THJ02103). Data from national accounts for 58 sectors. Available national level only. The table THJ02105 provides the same data at constant prices	10237: Expenditure per household per year, by commodity and service group and various regions 1999 – 2012. Total household expenditure in NOK and share for 13 commodities. Most recent data for 2012. NUTS 2 level	Expenditures per household (0-79 years)(HBS) - aggregated municipalities and type of expenditure. (Survey) Year 2006 – 2009. Data from Household Budget Survey. 139 commodities for 9 Municipal aggregates based on DEGURBA. There is also data at the national level for fewer commodity aggregates, but this information is not included in the

							statistical database[17]

[17] See here: https://www.scb.se/en/finding-statistics/statistics-by-subject-area/household-finances/household-expenditures/household-budget-survey-hbs/pong/tables-and-graphs/time-series-20032012/expenditures-per-household-20032009-in-sek/

3. Main EU household surveys and related microdata files

This section gives an overview of the surveys that are normally used to build the indicators on household labour, income and expenditure at the European level. The overview also includes a description of the key variables included in the Eurostat microdata files.

3.1. The Structure of Earnings Survey (SES)

The European Union Structure of Earnings Survey (SES) is conducted in the (pre-Brexit) 28 Member States of the European Union as well as candidate countries and countries of the European Free Trade Association (EFTA). The SES is a large enterprise sample survey covering enterprises with at least 10 employees operating in all areas of the economy except public administration. The 4-yearly SES microdata sets are available for reference years 2002, 2006, 2010, 2014 and 2018.

The objective of the SES is to provide accurate and harmonised data on earnings for policymaking and research purposes. The SES provides detailed and comparable information on the relationships between the level of remuneration and individual characteristics of employees (sex, age, occupation, length of service, highest educational level attained, etc.) and those of their employer (economic activity, size and location of the enterprise).

The following table shows the list of variables in the SES microdata. Variables highlighted in bold are those used in this research.

Table 3. List of SES variables

Description	Variable name*
Identification of the reference period (e.g.2010)	**YEAR**
Geographical location of the statistical unit (local unit) - NUTS-1	**A11**
Size of the enterprise to which the local unit belongs	A12
Principal economic activity of the local unit (NACE Rev. 2)	**A13**
Form of economic and financial control	A14
Collective pay agreement	A15
Total number of employees in the local unit in the reference month	A16
Affiliation of the local unit to a group of enterprises	A17
Size class category of enterprise to which the local unit belongs	A12_CLASS
Sex	**B21**
Age group category	**B22_CLASS**
Occupation in the reference month (ISCO- 08)	**B23**
Management position / supervisory position	B24
Highest successfully completed level of education and training (ISCED-97)	**B25**

Length of service in enterprise *(in years)*	B26
Full-time or part-time employee	B27
percent share of a full-timer's normal hours (to 2 decimal places)	B271
Type of employment contract	B28
Number of weeks to which the gross annual earnings relate (to 2 decimal places)	B31
Number of hours paid during the reference month	B32
Number of overtime hours paid in the reference month	B321
Annual days of holiday leave (in full days)	B33
Other annual days of paid absence	B34
Gross annual earnings in the reference year	B41
Annual Bonuses and allowances not paid at each pay period	B411
Annual payments in kind	B412
Gross earnings in reference month	**B42**
Earnings related to overtime	B421
Special payments for shift work	B422
Compulsory social contributions and taxes paid by the employer on behalf of the employee	B423
Compulsory social security contributions	B4231
Taxes	B4232
Average gross hourly earnings in the reference month (to 2 decimal places)	B43
Grossing-up factor for employees (to 2 decimal places)	B52
Key identifying the employee	KEY_E
Key identifying the local unit	KEY_L
Country code	COUNTRY
Economic Sector in NACE Rev. 1.1 (2002 and 2006) and NACE Rev. 2 (2010)	**NACE**

* Variables A provide Enterprise information. Variables B refer to employee information.

3.2. Labour force Survey (EU-LFS)

The EU-LFS is the largest European household sample survey providing quarterly and annual results on labour participation of people aged 15 and over, including those outside the labour force. Due to the diversity of information and the large sample size[37], the EU-LFS is also an important source for other European statistics, like education statistics or regional statistics. The EU-LFS covers residents in private households. It is conducted under shared EU methodology since the 1970s and has been subject to several updates. The most recent change was adopted in 2021.

The EU-LFS currently covers 35 countries. This includes the whole of the EU, the United Kingdom, three EFTA countries (Iceland, Norway and Switzerland), and four candidate countries (Montenegro, North Macedonia, Serbia and Turkey). The EU-LFS is conducted by the National Statistical Institutes and the data are centrally processed by Eurostat.

The core of the EU-LFS data collection covers the following topics: person and household characteristics, labour market participation, educational attainment and background, job tenure, work biography and previous work experience, working conditions including working hours and working time arrangements, participation in education and training, health status and disability, income, consumption and elements of wealth. Moreover, the EU-LFS includes rotational questions on specific topics (ad-hoc modules), among which some are collected with a regular periodicity of eight years.

The following tables provide an overview of the variables in the EU-LFS microdata files.

Table 4. EU Labour Force Survey Database: Core variables

Description	Variable name
Demographic background	
Sequence number in the household	HHSEQNUM
Relationship to reference person in the household	HHLINK
Sequence number of spouse or cohabiting partner	HHSPOU
Sequence number of father	HHFATH
Sequence number of mother	HHMOTH
Sex	SEX
Year of birth *	YEARBIR
Date of birth in relation to the end of reference period *	DATEBIR
Marital status *	MARSTAT
Nationality *	NATIONAL
Years of residence in this Member State *	YEARESID
Country of birth *	COUNTRYB
Nature of participation in the survey	PROXY
Labour status	WSTATOR

[37] For the 2018 EU-LFS, the achieved quarterly sample is 1.743 million individuals for all participating countries, of which 1.333 million are in the age group of 15–74 years.

Labour status during the reference week	
Reason for not having worked at all though having a job	NOWKREAS
Employment characteristics of the main job **Professional status ***	STAPRO
Continuing receipt of the wage or salary	SIGNISAL
Economic activity of the local unit *	NACE3D, NA113D
Occupation *	ISCO4D
Supervisory responsibilities	SUPVISOR
Number of persons working at the local unit *	SIZEFIRM
Country of place of work	COUNTRYW
Region of place of work	REGIONW
Year in which person started working for this employer or as self-employed	YSTARTWK
Month in which person started working for this employer or as self-employed	MSTARTWK
Involvement of the public employment office at any moment in finding the present job	WAYJFOUN

Note: A * following the description of a variable indicates that this variable is included in the anonymised LFS microdata only after application of general aggregation criteria (see the methodological manual for details).

Table 5. EU Labour Force Survey Database: Derived variables

Description	Variable name
Age of interviewed person *	AGE
Age at which person last established their usual residence in the country*	AGERESID
ILO work status	ILOSTAT
Economic activity (coded 1 digit)	NACE1D, NA111D
Economic activity by sector (NACE Rev 1)	NA11S
Occupation (coded 1 digit)	ISCO1D
European Socio-economic Groups (ESeG)	ESEG2D
Time since person started to work	STARTIME
Economic activity in second job (coded 1 digit)	NACE2J1D,NA112J1D
Economic activity in second job by sector (NACE Rev 1)	NA112JS
Time since person last worked	LEAVTIME
Time since person last worked (classes)	LEAVCLAS

Economic activity in previous job (coded 1 digit)	NACEPR1D, NA11PR1D
Economic activity in previous job by sector (NACE Rev 1)	NA11PRS
Occupation previous job (coded 1 digit)	ISCOPR1D
Duration of unemployment *	DURUNE
Education or training received during previous four weeks (formal + non formal)	EDUC4WN
Level of education (3 levels)	HATLEV1D
Economic activity one year before survey (coded 1 digit)	NACE1Y1D, NA111Y1D
Economic activity one year before survey by sector (NACE Rev 1)	NA111YS
Reference month	REM
Fixed reference quarter	QUARTER
Fixed reference year	YEAR
Classification of individuals (private household members)	HHPRIV

Note: A * following the description of a variable indicates that this variable is included in the anonymised LFS microdata only after application of general aggregation criteria (see the methodological manual for details).

Table 6. EU Labour Force Survey Database: Derived household variables (not disclosed)

Description	Variable name
Definition of children and adults	HHPERS
Presence of the father and/or mother of the person in the same household	HHPARENT
Presence of the partner of the person in the same household	HHPARTNR
Presence of the children of the person in the same household	HHCHILDR
Education level of the mother (if she lives in the same household, same codification as the core variable HATLEV1D)	HATLMOTH
Education level of the father (if he lives in the same household, same codification as the core variable HATLEV1D)	HATLFATH
Country of birth of the mother (if she lives in the same household, same codification as the core variable COUNTRYB)	COUBMOTH
Country of birth of the father (if he lives in the same household, same codification as the core variable COUNTRYB)	COUBFATH
Nationality of the mother (if she lives in the same household, same codification as the core variable NATIONAL)	NATMOTH
Nationality of the father (if he lives in the same household, same codification as the core variable NATIONAL)	NATFATH

Total number of persons in the household (whatever the age)	HHNBPERS
Number of children in the household (aged less than 15 years)	HHNB0014
Number of persons aged 65 or older in the household	HHNBOLD
Number of children in the household (aged less than 25 years), based on HHPERS code 1, 2 and 3	HHNBCHLD
Number of persons between 0 and 2 years in the household	HHNBCH2
Number of persons between 3 and 5 years in the household	HHNBCH5
Number of persons between 6 and 8 years in the household	HHNBCH8
Number of persons between 9 and 11 years in the household	HHNBCH11
Number of persons between 12 and 14 years in the household	HHNBCH14
Number of children between 15 and 17 years (in the household), based on HHPERS code 2	HHNBCH17
Number of children between 18 and 24 years (in the household), based on HHPERS code 2	HHNBCH24
Age of the youngest child in the household (aged less than 25 years)	HHAGEYG
Age of the youngest child in the household (aged less than 15 years)	HHAGE14
Household type (families; aggregated household composition)	HHCOMP
Number of employed persons in the household (aged 15 years and more, whatever the values of HHPERS)	HHNBWORK
Number of employed adults in the household (aged 15 years and more, based on HHPERS code 4)	HHNBEMPL
Number of unemployed adults in the household (aged 15 years and more, based on HHPERS code 4)	HHNBUNEM
Number of inactive adults in the household (aged 15 years and more, based on HHPERS code 4)	HHNBINAC
Working status of adults living in the same household	HHWKSTAT

The following table shows the indicators used in this research

Table 7. EU Labour Force Survey variables used to calculate population subdomains

Variable name	Description	Coding
REGION		
NACE1D	Economic activity of the local unit (coded on 1 digits), NACE Rev.2 from 2008	21 industries (A B C D E F G H I J K L M N O P Q R S T U)
NA111D	Economic activity of the local unit (coded on 1 digits), NACE Rev. 1 from 1992 to 2007.	17 industries (M L H K N D I F G A O C J E P B Q)

ISCO4D	Occupation (coded on 3 digits – 4 digits in certain countries on a voluntary basis). ISCO-88(COM) until 2010, ISCO-08 from 2011 onwards. No comparable information in 1983-1991	

3.3. The EU Statistics on Income, Social Inclusion and Living Conditions (EU-SILC).

The EU Statistics on Income, Social Inclusion and Living Conditions (EU-SILC) cover objective and subjective aspects of these themes in both monetary and non-monetary terms for households and individuals. The EU-SILC provides two types of annual survey data:

- Cross-sectional data with variables on income, poverty, social exclusion and other living conditions
- Longitudinal data pertaining to individual-level changes over time, observed periodically over a four-year period

There are two kinds of variables in EU-SILC. The primary (target) variables are collected every year, whereas secondary variables are collected every five years or less frequently via ad-hoc modules similar to those in the EU-LFS. Both primary and secondary variables are collected at two different levels, household and individual.

Survey results are distributed in four different microdata files:

- Household Register (D)
- Personal Register (R)
- Household Data (H)
- Personal Data (P)

The household register file (D) includes every selected household, including those where the address could not be contacted or those households that could not be interviewed. In the other files, records related to a household only exist if the household was contacted and has a completed household interview in the household data file (H) and at least one member has complete data in the personal data file (P). This member must be the selected respondent if this mode of selection is used.

The personal register file (R) contains a record for every person currently living in the household or temporarily absent. In the longitudinal component it also contains a record for every person registered in the R-file of the previous year or who has lived in the household for at least three months during the income reference period. The personal data file (P) contains a record for every eligible person for whom the information could be completed from interview and/or registers.

Sample sizes in the EU-SILC surveys are substantially smaller than the EU-LFS ones but are still quite large.

Table 8. Minimum effective sample size in the Nordic countries (EU-SILC)

EU-Member States	Households		Persons aged 16 or over to be interviewed	
	Cross-sectional	Longitudinal	Cross-sectional	Longitudinal
Denmark	4 250	3 250	7 250	5 500
Finland	4 000	3 000	6 750	5 000
Sweden	4 500	3 500	7 500	5 750
Iceland	2 250	1 700	3 750	2 800
Norway	3 750	2 750	6 250	4 650
Total (EU, EFTA and candidate countries)	164750		310150	

The following tables summarise the information provided by the EU-SILC for households and persons, respectively.

Table 9. EU-SILC household (H) data*

Domains	Areas	Number of variables
BASIC DATA (B)	Basic household data including degree of urbanisation	10
INCOME (Y)	Total household income (gross and disposable)	32
	Gross income components at household level	
SOCIAL EXCLUSION (S)	Housing and non-housing related arrears	19
	Non-monetary household deprivation indicators, including problems in making ends meet, extent of debt and enforced lack of basic necessities	
	Physical and social environment	
LABOUR INFORMATION (L)	Childcare	
HOUSING (H)	Dwelling type, tenure status and housing conditions	12
	Amenities in dwelling	
	Housing costs	
AD-HOC (I)	Ad-hoc modules	4 (optional)

* The letters in brackets correspond to the coding system used to identify the variables. The variables in the EU-SILC are composed of three parts: 1st character: file, 2nd character: domain, 3 digits: sequential number. For example, a variable labelled "HY[XXX]" is a household income variable.

Table 10. EU-SILC personal (P) data*

Domains	Domains	Number of variables
BASIC DATA (B)	Basic personal data	23
	Demographic data	
EDUCATION (E)	Education, including highest ISCED level attained	4
LABOUR INFORMATION (L)	Basic labour information on current activity status and on current main job, including information on last main job for unemployed	42
	Basic information on activity status during income reference period	
	Total number of hours worked on current second/third… jobs	
	Detailed labour information	
	Activity history	
	Calendar of activities	
HEALTH (H)	Health, including health status and chronic illness or condition	7
	Access to healthcare	
INCOME (Y)	Gross personal income, total and components at personal level	39
AD-HOC (T)	Ad-hoc modules	34

* The letters in brackets correspond to the coding system used to identify the variables.

The variables in the EU-SILC are composed of three parts: 1st character: file; 2nd character: domain; 3 digits: sequential number. For example, a variable labelled "HY[XXX]" is a household income variable.

3.4. The Household Budget Survey (HBS)

The Household Budget Survey (HBS) is a national survey focusing on households' expenditure on goods and services. The survey gives a picture of living conditions in the EU. It is carried out by each Member State and is used to compile weightings for important macroeconomic indicators, such as consumer price indices (used as measures of inflation) and national accounts.

Two-thirds of the Member States carry out annual surveys, while the remainder have five-year or even longer intervals between surveys. Probability sampling is used in the large majority of surveys in the EU but the high incidence of non-response is a common and major problem. Moreover, despite the common focus of the surveys on the study of patterns of consumption of private households in different population groups, the national HBS represent a diversity of structures and designs, as well as differences in the topics covered. The Eurostat harmonisation methodology strives to capture and describe the diversity between Member States from a comparative perspective, taking national surveys conducted around the reference year of 1999 as a basis.

The basic unit of data collection and analysis in the HBS is the household. Data collection involves a combination of one or more interviews and diaries or logs maintained by households and/or individuals, generally on a daily basis. The personal characteristics of the reference person in each household is used in the classification and analysis of information on the whole unit. The socio-economic group, occupation and employment status, income, sex and age of the reference person is often used to classify and present results.

The data from the survey are broken down by household characteristics, such as income, socio-economic characteristics, size and composition, degree of urbanisation, and region (NUTS 1 only). Expenditure made by households to acquire goods and services is recorded at the price actually paid, which includes indirect taxes (VAT and excise duties) borne by the purchaser.

HBS scientific-use files are comprised mainly of 2 groups of data, namely variables concerning the household as a whole and variables concerning household members. Basic variables at the household level provide information about the households as they are collected in the surveys. These variables relate to:

- Identification, weighting, demographic characteristics of the households
- Income
- Household consumption expenditure
- Household consumption in quantities

Derived variables at household level include:

- Household size and equivalent size
- Type of household
- Activity and economic situation

Basic variables at the member level give information about individual household members. The following basic information is collected:

- Identification, weighting
- Demographic characteristics (gender, age, marital status, country of birth, citizenship and of residence)
- Education (Level of studies Completed and currently followed), this is an aggregation of the ISCED nomenclature
- Activity (current activity status, hours worked, type of work contract, economic sector, occupation, status in employment)
- Income

3.5. Regional information in Eurostat microdata sets

Unfortunately, the microdata files provided by Eurostat are seldom available at NUTS 2 level, and some variables other than the geographic location of the statistical units are re-classified or excluded from the files made accessible to researchers. This is motivated by a combination of technical reasons (limited sample sizes) and the application on strict anonymisation rules on the microdata.

In the case of the EU-LFS, the tables are delivered at NUTS 2 level. The information on occupations is very detailed (around 140 ISCO codes) and the variables on economic activity of local units is disaggregated by an acceptable number of 21 NACE categories. However, the files lack of most of the household-derived indicators that, among the other things, allow to characterise households by size and composition.

In the case of the EU-SILC survey, the observations are only coded at NUTS 1 level. This is a coarser geographical level than NUTS 2. In some countries, the NUTS 1 level simply reflects the national boundaries, while in others this level represents a statistical re-aggregation of lower administrative divisions. In practice, the sub-national NUTS 1 level has limited practical interest since the administrative divisions in most European countries (including all the Nordics) correspond to the NUTS 2 and/or 3 levels. In the Nordics, the meaning of NUTS 1 is as follows: Denmark, Norway and Iceland the information is only available at the national level, whereas Sweden and Finland provide the data at a highly aggregated regional level.

In the case of the HBS, due to the presence of two different (non-nested) classifications related to the geographical detail of the household (the classical NUTS classification and the degree of urbanisation), for many Member States there were several unique cases in the size of municipalities at NUTS 2 level. For this reason, as in the previous case the information is released at NUTS 1 level. Similarly, many other variables are dropped or reclassified in a smaller number of categories.

Nevertheless, the variable on the degree of urbanisation is present in all the data files. It refers to a territorial typology developed by Eurostat and the Joint Research Centre of the European Commission. The classification is based on grid cells. Depending on the share of local population living in urban clusters and in urban centres, municipalities are classified into three classes: (1) Densely-populated area (cities); (2) Intermediate area (towns and suburbs) and; (3) Thinly-populated area (rural areas)[38,39]. In the microdata files respondents (households and individuals) are assigned to the relevant class based on the municipality where they reside.

[38] https://ec.europa.eu/eurostat/web/degree-of-urbanisation/background

[39] https://nordregio.org/maps/municipalities-by-degree-of-urbanisation-and-functional-urban-areas/

Appendix 6. Expenditure indicators based on Household Budget Survey microdata

Authors: Carlos Tapia, Nordregio. Stockholm, Sweden.

1. Introduction

This Appendix describes the source microdata and statistical method used to calculate the household expenditure indicators presented in Chapter 3 of the main report. These calculations have been the basis for the estimate of cost of living effects for different types of households presented in the Report.

2. Overview

The **mean consumption expenditure by household or by adult-equivalent household member** estimates are calculated for population subdomains defined as a combination of the following variables: region (NUTS1), degree of urbanization (HA09), income decile (incdcl) and product category (COICOP). The estimates are calculated for the available years after 2010 for Denmark, Finland and Sweden. The estimates are not calculated for Norway and Iceland due to lack of survey microdata sets in these countries.

The mean consumption expenditure indicator is delivered in three versions:

- The first one is expressed as *mean household consumption expenditure* by commodity group, income decile and economic sector in employment of the household member providing the largest share of income (NACE code) and region (NUTS code).
- A second version is delivered as *mean adult-equivalent expenditure* by commodity group and income decile, basing on the equivalent household size indicator (modified OECD scale). Hence, mean expenditure values included in this strand take account of different household sizes. Expenditure values are also classified by economic sector in employment of the household member providing the largest share of income (NACE code) and region (NUTS code).
- A third version also considers totals at equivalence-adjusted household member level but disregards economic sector in employment of the member providing the largest share of income to the household (NACE code) and region (NUTS code). Hence, the data are delivered as single point estimates per year and country.

Each table includes the number of observations in each population subdomain (n), the mean consumption expenditure at household or equivalent-adjusted household member levels (value), as well as the standard deviation for each point estimate (se).

3. Origin of data

The indicators have been calculated using microdata from the European Household Budget Survey (HBS). The HBS represents the harmonisation of the classifications and coding system of essential variables of the national HBSs at a European Union Level. The HBS provides information about household final consumption expenditure on goods and services, plus information on income and some demographic and socio-economic characteristics of households. The main objective of the HBS is to collect information on household consumption expenditure for use in calculating the Consumer Price Indices (CPI) and the harmonised index of consumer prices (HICP) at an EU level.

4. Methodology

Estimating a mean in a subpopulation domain from a survey is generally done by applying ratio estimators derived as regression coefficients. This approach delivers correct point estimates and also the standard error associated to each of them. The method can be applied on any number of population sub-domains. Still, it becomes computationally intense when the number of sub-categories to account for is large. At the same time, the reliability of the estimates decreases as sample size shrinks. For these reasons, it is advisable that the number of variables and classes used to generate the population domains is kept at the absolute minimum.

4.1. Variables used

Considering our specific needs in this research, we have calculated one population parameter (mean consumption expenditure by household) based on population subdomains drawn by combining information on time (YEAR), country (COUNTRY), region (NUTS1), COICOP commodity (EUR_HE01 to EUR_HJ90), income groups (EUR_HH099) and economic sector in employment of the household members - NACE Rev. 2 (ME04).

The following table shows all the variables used in this work:

Table 1. List of household variables used

Codes	Description	Level
COUNTRY	Country (26 possible)	Household
NUTS1	Regional code at NUTS-1 level. Reaggregated from variable HA08 (region) due to anonymisation	Household
YEAR	EU-HBS wave Reference Year	Household
HA04	Identification number of the household in the household file	Household
HA09	Population density-level: 1. Densely populated (at least 500 inhabitants/km2); 2. Intermediate (between 100 and 499 inhabitants/km2); 3. Sparsely populated (less than 100 inhabitants/km2) 9 Not specified)	Household
HA10	Sample weight	Household

EUR_HH099	Net income (total income from all sources including non-monetary components minus income taxes. ROUNDING, no decimals). (HH099 = HH095 + HH012 + HH023 + HH032)	Household
EUR_HE01 to EUR_HJ90	Household consumption expenditure on different commodities, classified by COICOP group (level 3)	Household
HB062	Equivalent household size (modified OECD scale), according to method developed by Eurostat	Household
MA04	Identification number of the household in the household member file	Household member
MB03_Recoded_5Classes	Age (5 classes) of household member	Household member
ME04	Economic Sector in Employment of the HH Member (NACE Rev. 2)	Household member
EUR_MF099	Total income from all sources (net amount) corresponding to each single member of the family (in euro). This variable does not include any household allowances	Household member

4.2. Data preparation

We have performed two data preparation steps:

4.2.1. Reclassification

Reclassification of the original list of product categories in a shorter number of classes. This allowed to reduce the number of product categories from around 450 to 27. We applied the following reclassification system:

Table 2. Correspondences and reclassification of product categories

Own code	COICOP code[40]
FoodBevTob	HE01+HE02
SolidFuels	HE0454
ClothFoot	HE03
FurnWoodProd	HE051

[40] The detailed COICOP classification is available here: https://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL&StrNom=COICOP_2018&StrLanguageCode=EN&IntPcKey=&StrLayoutCode=HIERARCHIC

Textiles	HE052
HhldAppl	HE053
HldUtens	HE054
HldToolEquip	HE055
CleaningMat	HE056
Pharmaceutic	HE061
MotorVehicle	HE071+HE0721+HE0723
OthTransEqp	HE0921
PaperProds	HE095
PetrolCoalP	HE0722+HE0453
ComputrOptc	HE091
LandTransprt	HE0731+HE0732+HE0735+HE0736
AirTransport	HE0733
WaterTrnsprt	HE0734
Electricty	HE0451
GasSupply	HE0452 +HE0455
Water	HE0441+HE0442+HE0443
AccomFood	HE11
Communicatn	HE08
Education	HE10
DwellngRent	HE041+HE042+HE043+HE0444
InsurPension	HE125
Finance	HE126
OthBusSrv	HE127
HealthSoc	HE062+HE063+HE124
Recreation	HE0922+HE093+HE094+HE096
OtherGoodsServ	HE121+HE122+HE123+HE0724

4.2.1. Identification of the main economic sector

For the identification of the main economic sector in each household based on the source of income, the tables on household and individuals within the EU-HBS were joined. Thereafter, each household was assigned to the economic sector (NACE rev. 1) that provided the largest share of income to the household, based on individual employment of household members.

Table 3. Economic sectors in scope

NACE code (1 digit)	Economic activities
A	Agriculture, forestry and fishing
B	Mining and quarrying
C	Manufacturing
D	Electricity, gas, steam and air conditioning supply
E	Water supply; sewerage, waste management and remediation
F	Construction

G	Wholesale and retail trade; repair of motor vehicles and
H	Transportation and storage
I	Accommodation and food service activities
J	Information and communication
K	Financial and insurance activities
L	Real estate activities
M	Professional, scientific and technical activities
N	Administrative and support service activities
O	Public administration and defence; compulsory social sec
P	Education
Q	Human health and social work activities
R	Arts, entertainment and recreation
S	Other service activities
T	Activities of households as employers; undifferentiated
U	Activities of extraterritorial organisations and bodies
Z	Not specified

The maximum number of sub-population domains obtained by combining all possible classes above was 48 600. However, the actual number of point estimates for each country and year ranged between 12 501 (Denmark, 2010) and 22 464 (Sweden, 2015). This number varies depending on the availability of sample observations within each subdomain, which tends to increase with sample size.

4.3. Calculation of population parameters

Two population parameters were calculated on the survey sample data, namely income quantiles and mean expenditure. Both were calculated on totals and values normalised by equivalent household size. Confidence intervals and standard errors were also calculated for quantiles and population means, respectively. Calculations were done using the survey package for R (Lumley 2020).

For the **income quantiles** and their associated confidence intervals the target variable was the net household income (EUR_HH099). For the calculation of the equivalised household income, the net income was divided by the equivalent household size, according to the modified OECD scale (EUR_HH099/H062). Quantiles were estimated through a continuous gamma probability function, with $\gamma = g$ and m given by:

$$m = 1 - p.p[k] = (k-1)/(n-k)$$

with, $p[k] = mode[F(x[k])]$.

This is one of the quantile algorithms discussed in Hyndman and Fan (1996). Confidence intervals for the quantiles were estimated using Woodruff's method (Woodruff 1952).

The point **estimates for population means** at household or equivalent-adjusted household member levels were calculated by applying ratio estimators derived as regression coefficients, following the method described in Lumley (2004). This approach delivers correct point estimates and also the associated standard errors.

In the case of the mean adult-equivalent expenditure, the target variable was the total household expenditure on each commodity (EUR_HE01 to EUR_HJ90), divided by the equivalent household size (H062, modified OECD scale).

The so-called OECD-modified scale (OECD-II) is defined as follows:

$$ES_{OECD-II} = 0.5 + 0.5 \times A + 0.3 \times K$$

where ES denote the equivalent household size, that is, the number of equivalent adults. The first adult (A) is given a weight of 1. Other adults are given a weight of 0.5, to reflect economies of scale. Children (K) are given a weight of 0.3 to reflect their lower consumption.

Cross-tables for mean consumption expenditure values by commodity and income decile are also provided based on the above indicators. These tables are provided for each of the three categories of households, in terms of degree of urbanization.

5. Household expenditure structure

Tables 4 to 12 summarise how much the different commodities account for household expenditure in each country where the Eurostat microdata was available (Denmark, Finland and Sweden) and type of household (urban, rural and intermediate). Within each table, data are classified by product category, as classified in the Nordic-TERM model (see Appendix 1) and income deciles. All numbers have been rounded off to decimals of up to 4 digits. The tables do not differentiate by the industry originating the main household income. These tables are however provided as supplementary materials.

Table 4. Distribution of household expenditure by income decile in urban households (Denmark, 2015)

Commodity	01	02	03	04	05	06	07	08	09	10
AccomFood	0.0767	0.0652	0.0277	0.0371	0.0553	0.0564	0.0688	0.0796	0.0785	0.0738
AirTransport	0.0187	0.0081	0.0035	0.0028	0.0128	0.0145	0.006	0.0086	0.0035	0.0126
CleaningMat	0.0089	0.009	0.0137	0.0104	0.0087	0.0094	0.0093	0.0106	0.0109	0.0136
ClothFoot	0.0741	0.0424	0.0401	0.0272	0.0337	0.0364	0.0401	0.0363	0.0472	0.0502
Communicatn	0.0289	0.0355	0.0324	0.0311	0.0262	0.0262	0.0302	0.0242	0.0238	0.0178
ComputrOptc	0.0213	0.0287	0.0088	0.0075	0.0081	0.0225	0.0129	0.0137	0.0073	0.0103
DwellngRent	0.2566	0.268	0.2962	0.3312	0.2216	0.2407	0.251	0.2494	0.2615	0.3033
Education	5e-04	0.0055	8e-04	0.0014	0.0099	0.0071	0.0075	0.003	0.0026	0.0034
Electricty	0.0247	0.0247	0.0299	0.0328	0.0219	0.0219	0.0206	0.018	0.0192	0.0189
Finance	0.004	8e-04	7e-04	7e-04	0.0066	0.0021	0.0018	0.0055	0.0038	0.0195
FoodBevTob	0.1747	0.177	0.1749	0.1509	0.152	0.1595	0.1602	0.1447	0.1448	0.1305
FurnWoodProd	0.0236	0.0269	0.0139	0.0075	0.0421	0.0232	0.018	0.0202	0.0247	0.0216
GasSupply	0.0808	0.0765	0.0718	0.0744	0.0382	0.0404	0.0519	0.0398	0.0399	0.0437
HealthSoc	0.0207	0.0348	0.025	0.03	0.0316	0.0254	0.0301	0.0323	0.0337	0.0195
HhldAppl	7e-04	0.0035	0.0106	0.003	0.0053	0.0096	0.0083	0.0079	0.0058	0.0059
HldToolEquip	0.0012	0.0022	0.0035	0.0017	0.0043	0.004	0.0049	0.0051	0.0036	0.0059
HldUtens	0.0036	0.0035	0.0073	0.0038	0.0105	0.0076	0.0052	0.0058	0.0118	0.0074
InsurPension	0.0242	0.0293	0.051	0.0509	0.0438	0.0512	0.0478	0.0577	0.0468	0.0506
LandTransprt	0.0342	0.0177	0.0133	0.011	0.0142	0.015	0.0143	0.008	0.0139	0.0069
MotorVehicle	0.0133	0.001	0.0375	0.026	0.0632	0.0696	0.0662	0.0798	0.0696	0.0569
OthBusSrv	0.0042	1e-04	3e-04	5e-04	9e-04	0.0024	2e-04	0.0069	0.0019	0.0032
OthTransEqp	0	0	0	0	0.0032	0	0.0014	2e-04	3e-04	1e-04
PaperProds	0.0063	0.0141	0.0073	0.0146	0.0086	0.0112	0.0081	0.0062	0.0092	0.01
PetrolCoalP	0.0056	0.0079	0.0139	0.0242	0.0219	0.0183	0.0258	0.0268	0.0184	0.0173
Pharmaceutic	0.0063	0.0182	0.0125	0.0081	0.0194	0.0154	0.0098	0.009	0.0149	0.0065
Recreation	0.0599	0.0648	0.0729	0.0659	0.0865	0.0863	0.0744	0.0729	0.074	0.0654
SolidFuels	2e-04	1e-04	0	6e-04	3e-04	0.001	0.0014	0.0035	7e-04	4e-04
Textiles	8e-04	0.0053	0.0024	0.0172	0.024	0.0015	0.0025	0.003	0.0068	0.0028
Water	0.025	0.0289	0.028	0.0273	0.0226	0.0209	0.0203	0.0209	0.0194	0.021
WaterTrnsprt	4e-04	3e-04	0	1e-04	0.0026	2e-04	0.001	5e-04	0.0016	0.001

Table 5. Distribution of household expenditure by income decile in intermediate households (Denmark, 2015)

Commodity	01	02	03	04	05	06	07	08	09	10
AccomFood	0.0459	0.0277	0.0344	0.0307	0.0567	0.0491	0.041	0.0632	0.0532	0.0768
AirTransport	0.0041	0.0018	0.0025	0.0071	0.0027	0.0027	0.0039	0.005	0.0048	0.0087
CleaningMat	0.011	0.011	0.0112	0.0102	0.0105	0.0102	0.0084	0.0111	0.011	0.0105
ClothFoot	0.0314	0.0468	0.0328	0.0392	0.0466	0.0439	0.0396	0.0395	0.0462	0.0371
Communicatn	0.0525	0.0296	0.029	0.0259	0.0297	0.0254	0.0261	0.023	0.0241	0.0181
ComputrOptc	0.0145	0.0145	0.0042	0.0193	0.0092	0.0118	0.0116	0.0085	0.0113	0.0111
DwellngRent	0.2998	0.2774	0.309	0.2718	0.2465	0.2457	0.2456	0.2044	0.2326	0.2629
Education	3e-04	0.0012	0.0018	0.0045	0.004	0.0028	0.0034	0.0022	0.0038	0.001
Electricty	0.0335	0.0293	0.0345	0.0281	0.0237	0.0275	0.0231	0.023	0.0229	0.0253
Finance	0.0014	7e-04	0.0013	0.0019	0.0031	0.0066	0.0022	0.0022	0.0047	0.0022
FoodBevTob	0.164	0.1562	0.1699	0.1393	0.1409	0.1307	0.126	0.15	0.1382	0.124
FurnWoodProd	0.0151	0.024	0.0083	0.0163	0.0212	0.0325	0.0181	0.0203	0.0215	0.0316
GasSupply	0.0608	0.0782	0.0758	0.0471	0.0509	0.0316	0.0383	0.0433	0.0434	0.0326
HealthSoc	0.0166	0.033	0.0172	0.0222	0.0222	0.0226	0.0215	0.0226	0.0271	0.0161
HhldAppl	0.0037	0.0035	0.0029	0.0042	0.0075	0.0074	0.0079	0.0056	0.0053	0.0081
HldToolEquip	0.0052	0.0039	0.0045	0.0037	0.0042	0.0031	0.0057	0.007	0.0051	0.0081
HldUtens	0.0033	0.0045	0.0056	0.0059	0.0097	0.006	0.005	0.0116	0.0082	0.0091
InsurPension	0.0455	0.0424	0.0402	0.0601	0.0594	0.0629	0.0676	0.0604	0.0602	0.06
LandTransprt	0.0185	0.0134	0.0088	0.0057	0.0171	0.0086	0.0062	0.006	0.0089	0.0088
MotorVehicle	0.0322	0.0276	0.0402	0.108	0.0558	0.111	0.1389	0.0977	0.0832	0.075
OthBusSrv	9e-04	0.0091	0.0044	5e-04	0.0016	0.0045	9e-04	9e-04	0.0033	0.0043
OthTransEqp	0	0	9e-04	9e-04	3e-04	0.0067	8e-04	0	0.0087	0.0022
PaperProds	0.0113	0.0125	0.0087	0.0121	0.0116	0.0081	0.0115	0.0091	0.0074	0.0095
PetrolCoalP	0.0164	0.016	0.0195	0.0325	0.0302	0.0363	0.0301	0.0352	0.0328	0.0386
Pharmaceutic	0.0119	0.0295	0.0128	0.0088	0.0112	0.0072	0.0065	0.0315	0.0093	0.0103
Recreation	0.067	0.0698	0.0785	0.0633	0.0887	0.0623	0.0756	0.0806	0.0868	0.0728
SolidFuels	8e-04	0.0028	0.0023	0.0015	0.0025	0.0037	0.0024	0.0021	0.0032	0.0038
Textiles	0.0019	0.0032	0.0058	0.0025	0.0058	0.0032	0.0027	0.0092	0.0074	0.0073
Water	0.0307	0.0304	0.0305	0.0265	0.0258	0.0232	0.0228	0.0212	0.0218	0.0206
WaterTrnsprt	1e-04	1e-04	0.0024	2e-04	7e-04	0.0027	0.0066	0.0036	0.0035	0.0034

Table 6. Distribution of household expenditure by income decile in rural households (Denmark, 2015)

Commodity	01	02	03	04	05	06	07	08	09	10
AccomFood	0.0427	0.0311	0.0282	0.0262	0.0357	0.0328	0.0743	0.0504	0.0486	0.0444
AirTransport	0	1e-04	0.0022	0.0071	0.0026	0.0038	0.0023	0.002	0.006	0.0037
CleaningMat	0.0068	0.0124	0.0125	0.01	0.013	0.0132	0.0097	0.011	0.0113	0.0113
ClothFoot	0.041	0.0317	0.0361	0.0304	0.0322	0.0326	0.0379	0.0401	0.0428	0.0406
Communicatn	0.0391	0.03	0.0303	0.0241	0.0289	0.0293	0.0246	0.0258	0.024	0.0209
ComputrOptc	0.0102	0.0118	0.012	0.0141	0.0164	0.0078	0.0105	0.0106	0.0101	0.0107
DwellngRent	0.2572	0.2687	0.2577	0.1975	0.2028	0.2303	0.1824	0.1999	0.1818	0.2
Education	0.0034	0.0017	8e-04	0.0065	0.0043	0.0069	0.0067	0.0037	0.0015	0.0038
Electricty	0.0347	0.0367	0.0385	0.033	0.0281	0.0309	0.0257	0.0272	0.0249	0.0262
Finance	0.0011	0.0015	0.0036	0.0022	0.0032	0.0033	0.0026	0.0036	0.0045	0.0052
FoodBevTob	0.1522	0.1576	0.1688	0.1514	0.1632	0.1664	0.1401	0.1343	0.1395	0.1287
FurnWoodProd	0.0154	0.0446	0.0158	0.0249	0.0159	0.0216	0.032	0.0307	0.0221	0.0447
GasSupply	0.0561	0.0714	0.0519	0.0346	0.0436	0.0409	0.052	0.0314	0.0344	0.0245
HealthSoc	0.0241	0.0152	0.0214	0.018	0.021	0.0243	0.0256	0.0175	0.0196	0.0155
HhldAppl	0.0024	0.0087	0.0047	0.0061	0.0061	0.0049	0.0071	0.0082	0.0083	0.0108
HldToolEquip	0.0029	0.0019	0.0028	0.0032	0.0057	0.0051	0.0061	0.0059	0.0042	0.0044
HldUtens	0.0159	0.0054	0.006	0.0053	0.0127	0.0088	0.0072	0.0108	0.0128	0.0124
InsurPension	0.0491	0.0488	0.0682	0.063	0.0621	0.0778	0.0732	0.0799	0.0678	0.062
LandTransprt	0.0228	0.0094	0.0039	0.0075	0.0049	0.007	0.0029	0.0042	0.005	0.0036
MotorVehicle	0.0631	0.0396	0.0537	0.1513	0.0985	0.0714	0.1081	0.1242	0.1586	0.1214
OthBusSrv	9e-04	0.0018	8e-04	0.004	0.0017	0.003	0.001	0.0019	0.0025	0.0027
OthTransEqp	0	-0.0029	3e-04	0	0.0045	0.002	0.0028	0.0016	0	0.0174
PaperProds	0.0082	0.0154	0.0133	0.0084	0.0093	0.0073	0.0076	0.0098	0.0089	0.0089
PetrolCoalP	0.0317	0.0291	0.0457	0.033	0.0419	0.0531	0.0491	0.0381	0.0432	0.0467
Pharmaceutic	0.0105	0.0273	0.0159	0.0179	0.0199	0.013	0.0065	0.0108	0.0043	0.0042
Recreation	0.0615	0.0634	0.0654	0.0866	0.0861	0.0647	0.0611	0.0796	0.0718	0.0836
SolidFuels	0.006	0.0021	0.0039	0.0035	0.0063	0.0064	0.0134	0.0077	0.0113	0.0106
Textiles	0.0087	0.001	0.0044	0.0029	0.0025	0.0034	0.0021	0.0034	0.0084	0.0052
Water	0.0322	0.034	0.0306	0.0266	0.0262	0.0272	0.023	0.024	0.0215	0.0242
WaterTrnsprt	0	4e-04	7e-04	6e-04	4e-04	6e-04	0.0023	0.0019	4e-04	0.0015

Table 7. Distribution of household expenditure by income decile in urban households (Finland, 2015)

Commodity	01	02	03	04	05	06	07	08	09	10
AccomFood	0.0659	0.0483	0.0556	0.0507	0.0578	0.0665	0.0769	0.0642	0.0717	0.0917
AirTransport	0.0199	0.0026	0.0104	0.014	0.0115	0.003	0.0251	0.0055	0.0148	0.0257
CleaningMat	0.0062	0.0083	0.0088	0.0067	0.0066	0.0095	0.0084	0.007	0.0114	0.0129
ClothFoot	0.0429	0.0372	0.0375	0.0329	0.0356	0.0325	0.0343	0.0322	0.0314	0.0324
Communicatn	0.0332	0.039	0.0327	0.0323	0.0269	0.0268	0.0253	0.0231	0.024	0.0177
ComputrOptc	0.017	0.0103	0.0102	0.0153	0.0185	0.0104	0.0133	0.0092	0.0083	0.0112
DwellngRent	0.3763	0.3796	0.3664	0.3228	0.3462	0.3144	0.303	0.3146	0.3185	0.2746
Education	0.0048	0.0017	0.0038	0.0011	0.0014	0.0015	0.0018	0.0014	0.0013	0.0029
Electricty	0.017	0.0167	0.0204	0.0155	0.0173	0.0197	0.0147	0.0173	0.018	0.0182
Finance	0.0042	0.0074	0.0069	0.0064	0.0115	0.0066	0.0064	0.0144	0.0057	0.0066
FoodBevTob	0.1606	0.1934	0.173	0.1438	0.1656	0.161	0.1258	0.1375	0.1208	0.1096
FurnWoodProd	0.0085	0.0127	0.0081	0.0149	0.0128	0.0116	0.0167	0.0137	0.0141	0.0217
GasSupply	9e-04	4e-04	5e-04	6e-04	9e-04	0.003	0.004	0.0016	0.001	0.0033
HealthSoc	0.0176	0.0266	0.0195	0.029	0.0198	0.0306	0.0211	0.0314	0.0234	0.0217
HhldAppl	0.0056	0.0078	0.0087	0.0081	0.0082	0.0079	0.0067	0.0083	0.0072	0.0072
HldToolEquip	0.0025	0.0016	0.0028	0.0036	0.0048	0.0044	0.0052	0.0045	0.0042	0.0045
HldUtens	0.0027	0.0016	0.0035	0.0028	0.0027	0.0021	0.0031	0.004	0.0028	0.0037
InsurPension	0.0188	0.0171	0.0209	0.0275	0.0241	0.027	0.0288	0.0312	0.0269	0.0277
LandTransprt	0.0372	0.0294	0.027	0.022	0.0263	0.0266	0.0193	0.0171	0.0163	0.0164
MotorVehicle	0.043	0.0438	0.0423	0.0577	0.0538	0.0505	0.0895	0.0824	0.0858	0.0931
OthBusSrv	0.0157	0.0245	0.0218	0.0375	0.0243	0.0384	0.0375	0.0415	0.0453	0.039
OthTransEqp	0.0011	4e-04	0	0.0021	0.001	0.0016	0.0017	0.0018	0.0013	0.0099
PaperProds	0.007	0.0109	0.0146	0.0132	0.0129	0.0115	0.0109	0.0132	0.0137	0.0153
PetrolCoalP	0.0132	0.0137	0.0197	0.0211	0.023	0.0247	0.0214	0.0251	0.0263	0.0224
Pharmaceutic	0.0135	0.0202	0.0262	0.0171	0.0212	0.0208	0.0163	0.0219	0.0181	0.0153
Recreation	0.0516	0.0335	0.0415	0.0814	0.0483	0.0711	0.0663	0.0607	0.0722	0.0798
SolidFuels	0.0015	5e-04	0.004	0.0014	0.0019	0.0028	0.0017	0.0026	0.002	0.0026
Textiles	0.0019	0.0013	0.0023	0.0064	0.0044	0.0023	0.0054	0.0028	0.0046	0.0038
Water	0.0068	0.0084	0.0086	0.0108	0.0088	0.0106	0.0076	0.0093	0.008	0.0068
WaterTrnsprt	0.0029	0.0012	0.0024	0.0013	0.002	5e-04	0.0017	6e-04	6e-04	0.0022

Table 8. Distribution of household expenditure by income decile in intermediate households (Finland, 2015)

Commodity	01	02	03	04	05	06	07	08	09	10
AccomFood	0.0436	0.0301	0.034	0.0433	0.034	0.0334	0.048	0.047	0.0512	0.0527
AirTransport	0.0097	0.0023	0.0023	0.0037	0.0029	6e-04	0.0036	0.0059	0.0064	0.0126
CleaningMat	0.0047	0.0083	0.0084	0.0114	0.0083	0.0134	0.0081	0.0099	0.0081	0.0109
ClothFoot	0.0234	0.0226	0.0266	0.0203	0.0285	0.0256	0.0266	0.0264	0.0325	0.0257
Communicatn	0.0332	0.0309	0.0343	0.0308	0.0275	0.0272	0.0266	0.027	0.0257	0.021
ComputrOptc	0.0116	0.0165	0.0097	0.0091	0.0135	0.0097	0.0118	0.0117	0.0111	0.0089
DwellngRent	0.3619	0.3604	0.323	0.3311	0.2865	0.3052	0.2713	0.2743	0.263	0.2436
Education	0.0049	0.0011	0.001	4e-04	6e-04	8e-04	7e-04	0.0014	9e-04	0.0017
Electricty	0.0212	0.0243	0.0279	0.0306	0.0286	0.0294	0.0288	0.0293	0.0276	0.027
Finance	0.0079	0.0103	0.007	0.0092	0.0088	0.0053	0.0075	0.0069	0.0072	0.0086
FoodBevTob	0.1949	0.1595	0.1956	0.1666	0.1431	0.1563	0.1507	0.1395	0.119	0.1099
FurnWoodProd	0.0122	0.0108	0.0118	0.01	0.0154	0.0185	0.0186	0.0167	0.0168	0.0156
GasSupply	0.0016	5e-04	6e-04	3e-04	0.0011	8e-04	0.0028	0.0028	0.0038	0.0069
HealthSoc	0.011	0.0381	0.0294	0.0208	0.0201	0.0205	0.0279	0.0203	0.0249	0.0188
HhldAppl	0.0077	0.0077	0.0056	0.007	0.007	0.007	0.0073	0.0078	0.0068	0.0101
HldToolEquip	0.0026	0.0024	0.0044	0.0054	0.0052	0.0054	0.0065	0.008	0.0082	0.0084
HldUtens	0.0033	0.0024	0.0033	0.0033	0.0051	0.0037	0.0023	0.0026	0.0026	0.0031
InsurPension	0.0247	0.0245	0.0302	0.0323	0.0347	0.0341	0.0356	0.0401	0.0378	0.034
LandTransprt	0.015	0.0221	0.0138	0.0117	0.0077	0.0102	0.0109	0.0055	0.0075	0.0056
MotorVehicle	0.0517	0.0627	0.0529	0.0619	0.1551	0.0883	0.1079	0.1128	0.1251	0.1711
OthBusSrv	0.0203	0.0272	0.0312	0.0339	0.0349	0.0404	0.0479	0.0519	0.0562	0.0553
OthTransEqp	6e-04	0.0024	0.0047	0.002	0.002	0.0022	0.0032	0.0017	0.0012	0.0113
PaperProds	0.0099	0.0114	0.0161	0.0153	0.0106	0.0181	0.0121	0.0145	0.0127	0.0131
PetrolCoalP	0.0292	0.0308	0.0301	0.0392	0.0374	0.047	0.0387	0.0438	0.0358	0.0339
Pharmaceutic	0.0178	0.0206	0.0382	0.0262	0.0227	0.0247	0.0174	0.0196	0.0155	0.0125
Recreation	0.0576	0.0548	0.0383	0.0501	0.0375	0.0489	0.0568	0.0483	0.0705	0.0566
SolidFuels	0.002	0.0022	0.0028	0.0039	0.0055	0.0049	0.0051	0.0063	0.0049	0.005
Textiles	0.002	0.0012	0.0022	0.0059	0.0015	0.0035	0.0014	0.0039	0.0045	0.0041
Water	0.0103	0.0115	0.0142	0.0138	0.0133	0.0136	0.0127	0.012	0.0117	0.0104
WaterTrnsprt	0.0034	5e-04	7e-04	2e-04	7e-04	0.0016	0.0011	0.0021	9e-04	0.0017

Table 9. Distribution of household expenditure by income decile in rural households (Finland, 2015)

Commodity	01	02	03	04	05	06	07	08	09	10
AccomFood	0.0223	0.0196	0.0222	0.028	0.0284	0.0313	0.0398	0.0353	0.0406	0.0495
AirTransport	0	0	5e-04	0.0078	7e-04	0.0022	0.0067	0.004	0.0046	0.0114
CleaningMat	0.0153	0.0112	0.0096	0.0122	0.0074	0.0094	0.0108	0.0087	0.0122	0.0089
ClothFoot	0.0202	0.0264	0.0245	0.0263	0.0189	0.028	0.0222	0.0279	0.0366	0.0215
Communicatn	0.0364	0.0333	0.0313	0.0274	0.0248	0.0285	0.0282	0.026	0.0247	0.0227
ComputrOptc	0.0244	0.0091	0.0075	0.0083	0.0093	0.0129	0.008	0.0092	0.0096	0.0098
DwellngRent	0.3324	0.3406	0.2908	0.2513	0.2445	0.2586	0.2416	0.249	0.2468	0.2506
Education	0.0025	0.0016	0.001	6e-04	7e-04	0.001	7e-04	0.0016	0.0016	0.0016
Electricty	0.0348	0.046	0.0412	0.0324	0.0395	0.038	0.0415	0.0345	0.0348	0.035
Finance	0.0066	0.0055	0.0117	0.0078	0.013	0.0093	0.0101	0.0078	0.0137	0.0095
FoodBevTob	0.1956	0.1779	0.1872	0.1663	0.1564	0.1546	0.1553	0.1519	0.1345	0.1188
FurnWoodProd	0.007	0.0082	0.0125	0.0103	0.0138	0.0094	0.0102	0.0164	0.0182	0.0162
GasSupply	0.001	0.0021	0.002	0.002	0.0012	0.0016	0.0025	0.0019	0.002	0.0024
HealthSoc	0.0353	0.0413	0.025	0.032	0.0225	0.036	0.0222	0.0282	0.021	0.0138
HhldAppl	0.0087	0.0088	0.0082	0.0069	0.0067	0.0084	0.0068	0.0088	0.0062	0.0069
HldToolEquip	0.0055	0.0041	0.0087	0.0067	0.0077	0.0104	0.0073	0.0079	0.0102	0.0089
HldUtens	0.0014	0.0021	0.0032	0.0028	0.0021	0.0027	0.0043	0.0032	0.0046	0.0027
InsurPension	0.0294	0.0253	0.0363	0.035	0.0389	0.0404	0.0407	0.0413	0.0442	0.0411
LandTransprt	0.0086	0.0086	0.0077	0.0079	0.0104	0.008	0.0036	0.0048	0.0078	0.0042
MotorVehicle	0.0398	0.0466	0.0721	0.1447	0.1505	0.09	0.1205	0.105	0.1074	0.1344
OthBusSrv	0.0251	0.0206	0.0369	0.0316	0.037	0.0469	0.0593	0.0566	0.052	0.0532
OthTransEqp	7e-04	0.0019	7e-04	0.0015	0.0054	0.0032	0.0029	0.0037	0.004	0.0258
PaperProds	0.0173	0.0166	0.0162	0.0161	0.0163	0.0167	0.0133	0.0143	0.0139	0.0127
PetrolCoalP	0.0324	0.0417	0.0404	0.0464	0.0471	0.0481	0.0507	0.0526	0.0499	0.044
Pharmaceutic	0.0298	0.0284	0.0282	0.0224	0.0188	0.0279	0.0178	0.0158	0.0187	0.0171
Recreation	0.0463	0.0457	0.0435	0.0401	0.0527	0.0503	0.0431	0.0603	0.0551	0.0551
SolidFuels	0.0047	0.0068	0.013	0.0084	0.0096	0.0079	0.0087	0.0086	0.0064	0.0068
Textiles	0.0018	0.0028	0.0044	0.0025	0.0032	0.0031	0.0052	0.0025	0.0037	0.0039
Water	0.0143	0.0143	0.0132	0.0126	0.0121	0.0129	0.0131	0.0117	0.0104	0.0115
WaterTrnsprt	4e-04	0.0028	1e-04	0.0018	5e-04	0.0022	0.003	8e-04	0.0045	1e-04

Table 10. Distribution of household expenditure by income decile in urban households (Sweden, 2015)

Commodity	01	02	03	04	05	06	07	08	09	10
AccomFood	0.0292	0.0454	0.031	0.034	0.0257	0.0498	0.0605	0.0608	0.0715	0.0761
AirTransport	0	0	0	0	0	3e-04	0.0023	0	0	0.0108
CleaningMat	0.0067	0.0065	0.0075	0.0079	0.0064	0.0067	0.0054	0.0057	0.0048	0.0074
ClothFoot	0.0621	0.0398	0.0313	0.0277	0.0248	0.0682	0.0313	0.0679	0.0405	0.055
Communicatn	0.0341	0.0407	0.0434	0.0391	0.0445	0.0441	0.0408	0.0299	0.0308	0.0235
ComputrOptc	0.1342	0.0175	0.0298	0.0122	0.0174	0.026	0.0165	0.0223	0.0215	0.0219
DwellngRent	0.3258	0.3801	0.3625	0.3913	0.4094	0.313	0.3116	0.2948	0.312	0.2951
Education	6e-04	0.0012	0.0407	0	0	0	0	0.0014	1e-04	0
Electricty	0.018	0.0213	0.0219	0.0169	0.025	0.0226	0.0174	0.0223	0.0197	0.0231
Finance	0	0.0033	0.0048	0	0.0017	0.0031	0.0058	0.004	1e-04	0.0018
FoodBevTob	0.1414	0.1665	0.1605	0.1553	0.1564	0.1487	0.132	0.1428	0.1208	0.1271
FurnWoodProd	0.0203	0.0127	0.0114	0.0209	0.0208	0.0263	0.0251	0.0153	0.0246	0.0453
GasSupply	0	0	0	0	8e-04	0.0021	0.0017	0.002	0.0028	0
HealthSoc	0.0052	0.0212	0.0084	0.0471	0.0327	0.0113	0.0042	0.0205	0.0086	0.0238
HhldAppl	0.0172	0.0042	0.0046	0.0083	0.0076	0.0083	0.0045	0.0086	0.0074	0.0053
HldToolEquip	0.003	0.0021	0.0019	0.0065	0.0055	0.0088	0.0047	0.0065	0.007	0.0064
HldUtens	0.0031	0.0035	0.0019	0.0016	0.0049	0.004	0.0039	0.0045	0.005	0.0058
InsurPension	0.0163	0.0207	0.0231	0.0218	0.0288	0.0287	0.0308	0.028	0.0262	0.0266
LandTransprt	0.0226	0.0295	0.0179	0.0217	0.0214	0.0287	0.0191	0.0272	0.0312	0.0226
MotorVehicle	0.0368	0.0273	0.0155	0.046	0.0149	0.0309	0.0899	0.0401	0.0455	0.0323
OthBusSrv	0	4e-04	0.0042	0.0016	2e-04	0	0.0014	0.001	0.0012	0.0045
OthTransEqp	0.008	-9e-04	0.0085	0.0049	-6e-04	0.0067	0.001	9e-04	0.0036	0.0071
PaperProds	0.0029	0.0108	0.017	0.008	0.0106	0.004	0.0233	0.0108	0.0087	0.0085
PetrolCoalP	0.0233	0.0184	0.0248	0.0327	0.0299	0.0421	0.0449	0.0334	0.0404	0.031
Pharmaceutic	0.0083	0.0199	0.0238	0.0096	0.0075	0.0058	0.0077	0.0078	0.0136	0.0059
Recreation	0.0747	0.1041	0.0956	0.0821	0.1016	0.1006	0.1016	0.1363	0.1376	0.1221
SolidFuels	2e-04	0	0	0	0	6e-04	0	0	0	0
Textiles	0.0041	0.0016	0.007	0.0011	3e-04	0.0014	0.0104	0.0022	0.0094	0.0058
Water	0.0019	0.0021	9e-04	0.0016	0.0015	0.0036	0.0021	0.0031	0.0032	0.0035
WaterTrnsprt	0	0	0	0	0	0.0038	3e-04	0	0.0023	0.0018

Table 11. Distribution of household expenditure by income decile in intermediate households (Sweden, 2015)

Commodity	01	02	03	04	05	06	07	08	09	10
AccomFood	0.0427	0.0155	0.0145	0.0194	0.0347	0.047	0.0306	0.0258	0.0353	0.0442
AirTransport	0	0	3e-04	0	0	0	0	0	0	0
CleaningMat	0.0038	0.011	0.007	0.0074	0.0049	0.0108	0.0071	0.0059	0.0062	0.0074
ClothFoot	0.0531	0.0308	0.02	0.0674	0.0569	0.0475	0.0653	0.0524	0.0503	0.0453
Communicatn	0.0322	0.0412	0.0394	0.034	0.0403	0.0363	0.0389	0.0309	0.0299	0.0191
ComputrOptc	0.0251	0.0322	0.0126	0.0239	0.022	0.031	0.0152	0.0215	0.0193	0.0189
DwellngRent	0.331	0.3489	0.3434	0.3675	0.3304	0.3199	0.3098	0.3005	0.2787	0.2986
Education	0	0.0016	0	0.0013	0	0	5e-04	0	0	3e-04
Electricty	0.0327	0.0217	0.0345	0.0327	0.0384	0.0318	0.0329	0.0339	0.0327	0.026
Finance	0	0	3e-04	0	0	0.0024	0.0012	0.001	1e-04	0.0037
FoodBevTob	0.1674	0.2052	0.1569	0.1372	0.152	0.1424	0.1262	0.1228	0.1295	0.1192
FurnWoodProd	0.0269	0.0144	0.0148	0.0193	0.0199	0.0224	0.0524	0.0281	0.0317	0.0313
GasSupply	0.0032	0.0022	0.0016	8e-04	0.0032	7e-04	0.0017	0.006	0.0052	0.0036
HealthSoc	0.0146	0.0328	0.0081	0.0125	0.0071	0.0045	0.0077	0.0072	0.0125	0.0077
HhldAppl	0.0041	0.0055	0.0081	0.0071	0.0069	0.0069	0.0088	0.0232	0.0126	0.0072
HldToolEquip	0.0247	0.0075	0.0048	0.0039	0.0075	0.0061	0.0165	0.009	0.0102	0.0047
HldUtens	7e-04	0.0021	0.0033	0.005	0.006	0.0038	0.0032	0.005	0.005	0.0033
InsurPension	0.014	0.02	0.0786	0.0284	0.039	0.0289	0.0291	0.0326	0.0399	0.0602
LandTransprt	0.0259	0.0154	0.0184	0.0094	0.007	0.0177	0.0058	0.0097	0.0086	0.0097
MotorVehicle	0.0098	0.0477	0.0663	0.0462	0.0314	0.0451	0.0754	0.0859	0.0709	0.0874
OthBusSrv	3e-04	0.0018	3e-04	2e-04	0.003	9e-04	0.0012	8e-04	0.0019	6e-04
OthTransEqp	0	0.0015	0.0183	8e-04	2e-04	-0.0018	0.0031	0.0029	0.0125	0.0017
PaperProds	0.0266	0.0039	0.0139	0.0051	0.0302	0.0088	0.007	0.0062	0.011	0.0105
PetrolCoalP	0.0192	0.0323	0.0405	0.0478	0.0654	0.0518	0.0553	0.0517	0.0591	0.0382
Pharmaceutic	0.0166	0.0289	0.0178	0.0215	0.0059	0.0115	0.0076	0.0198	0.0069	0.0051
Recreation	0.1144	0.0719	0.0691	0.093	0.0779	0.1152	0.0853	0.1011	0.1146	0.1341
SolidFuels	0.0036	5e-04	0	7e-04	7e-04	2e-04	6e-04	0.001	9e-04	0
Textiles	0.0032	0.0011	8e-04	7e-04	0.0036	0.0032	0.0022	0.0016	0.0076	0.0053
Water	0.004	0.0024	0.006	0.0059	0.0055	0.005	0.0093	0.0098	0.007	0.0062
WaterTrnsprt	0	0	4e-04	6e-04	1e-04	0	0	0.0039	0	6e-04

Table 12. Distribution of household expenditure by income decile in rural households (Sweden, 2015)

Commodity	01	02	03	04	05	06	07	08	09	10
AccomFood	0.0253	0.0191	0.0232	0.0261	0.0305	0.0343	0.033	0.0466	0.0369	0.0497
AirTransport	0	0	0	0.0014	0	0.0046	0.0017	0	0	0.0011
CleaningMat	0.0087	0.0087	0.0122	0.0087	0.009	0.0081	0.0064	0.0072	0.0054	0.0088
ClothFoot	0.0434	0.0243	0.0303	0.0376	0.0355	0.044	0.0485	0.0367	0.0376	0.0425
Communicatn	0.0323	0.0397	0.0381	0.0358	0.0366	0.0386	0.0288	0.028	0.0292	0.023
ComputrOptc	0.0364	0.0433	0.0152	0.0204	0.0255	0.0423	0.0169	0.0214	0.0299	0.0159
DwellngRent	0.32	0.3876	0.3101	0.3083	0.293	0.2537	0.2736	0.2578	0.2418	0.2664
Education	0	5e-04	1e-04	0	3e-04	1e-04	2e-04	0	0.0011	0
Electricty	0.0372	0.0346	0.0443	0.0368	0.0394	0.0327	0.0351	0.0292	0.0364	0.0307
Finance	2e-04	0.0011	7e-04	0	0.0012	3e-04	0.0037	8e-04	0.0028	7e-04
FoodBevTob	0.1686	0.1556	0.1554	0.1643	0.1447	0.1334	0.1427	0.1147	0.1301	0.1041
FurnWoodProd	0.0142	0.0113	0.0098	0.0273	0.0196	0.0226	0.0218	0.0195	0.0198	0.0221
GasSupply	0.0015	8e-04	0.0019	0.002	0.0035	0.0025	0.0047	0.0051	0.0069	0.0031
HealthSoc	0.0118	0.0111	0.0187	0.0174	0.0179	0.0154	0.0207	0.0114	0.0098	0.0194
HhldAppl	0.0044	0.0087	0.0101	0.0073	0.0059	0.012	0.0092	0.0094	0.0082	0.0091
HldToolEquip	0.0061	0.0041	0.0129	0.0129	0.0092	0.014	0.0078	0.0111	0.0109	0.0492
HldUtens	0.0049	0.0023	0.0036	0.0064	0.0034	0.0101	0.0037	0.0068	0.0042	0.0065
InsurPension	0.0207	0.0332	0.0362	0.0317	0.0333	0.0359	0.0273	0.033	0.0293	0.028
LandTransprt	0.0133	0.0107	0.0161	0.0127	0.0106	0.0063	0.0061	0.0106	0.0068	0.0069
MotorVehicle	0.0867	0.0215	0.0597	0.0564	0.0892	0.1042	0.077	0.1	0.1513	0.0922
OthBusSrv	5e-04	0.0025	0.0056	4e-04	0.0039	0.0013	6e-04	0.002	7e-04	0.0191
OthTransEqp	0	0.0019	-1e-04	0.009	8e-04	0.0014	0.0071	0.0144	0.0078	0.0021
PaperProds	0.0123	0.0131	0.0207	0.0164	0.0108	0.0071	0.0106	0.0062	0.0082	0.0082
PetrolCoalP	0.0432	0.0565	0.0543	0.0553	0.0644	0.0697	0.0665	0.0808	0.0621	0.051
Pharmaceutic	0.0081	0.0138	0.0191	0.0222	0.0124	0.0093	0.0176	0.0088	0.0054	0.0102
Recreation	0.0874	0.0839	0.0854	0.0703	0.0826	0.0828	0.1167	0.1247	0.1027	0.1178
SolidFuels	0.0016	0.0027	0.0032	0.001	0.0031	5e-04	9e-04	0.0016	8e-04	0.001
Textiles	0.0046	0.0011	0.0054	0.0044	0.0033	0.0043	0.0027	0.0043	0.0031	0.0022
Water	0.0064	0.006	0.0077	0.0075	0.0106	0.0084	0.0082	0.0079	0.0103	0.0085
WaterTrnsprt	0	3e-04	0	0	0	0	2e-04	0	1e-04	5e-04

The above tables provide detailed information on the distribution of household expenditure across income categories and regions. However, the tables are difficult to read. Figure 7 in the main report provides a visual representation of the same information. As shown on the individual bar plots, household expenditure is distributed very differently across countries and across different types of households within each of country. In general, the main expenditure categories in most households are 1) housing, mainly dwelling and rentals but also goods related to property ownership, 2) food and non alcoholic beverages, 3) recreation, culture and accommodation, 4) water and sanitation, and 5) miscellaneous good and services. Expenditure on house ownership and rent tends to decrease with income levels. The opposite holds true for expenditure on motor vehicles and recreation, culture and accommodation, particularly in urban households.

Motor fuels and electricity costs have a considerable relevance for household finances. The combined expenditure on energy fuels ranges from circa 1% to 6%, depending on the country and type of household. Expenditure on electricity goes from 2% to 5%. Household expenditure on energy commodities tends to be greater in rural areas compared to densely populated municipalities. This is motivated by a higher dependence on private motorised transportation and greater heating requirements of household dwellings located in these areas. On the one hand, there is a larger proportion of isolated family houses in rural municipalities compared to intermediate or urban ones. This reinforces reliance on individual transport systems and increases heating costs per individual household. On the other hand, in Finland and Sweden low-density municipalities tend to be located in regions with longer and harsher winters, hence increasing heating requirements in this type of households.

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Appendix 7. Detailed decarbonisation trajectories and climate policies in the EU

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1. Introduction

In spite of the increasing awareness on climate risks, and the proliferation of efforts at the regional, national, and local levels, greenhouse gas (GHG) emissions, including CO2 emissions, have been steadily rising over the past three decades and are now 60 percent higher than they were in 1990 (Stoddard et al. 2021).

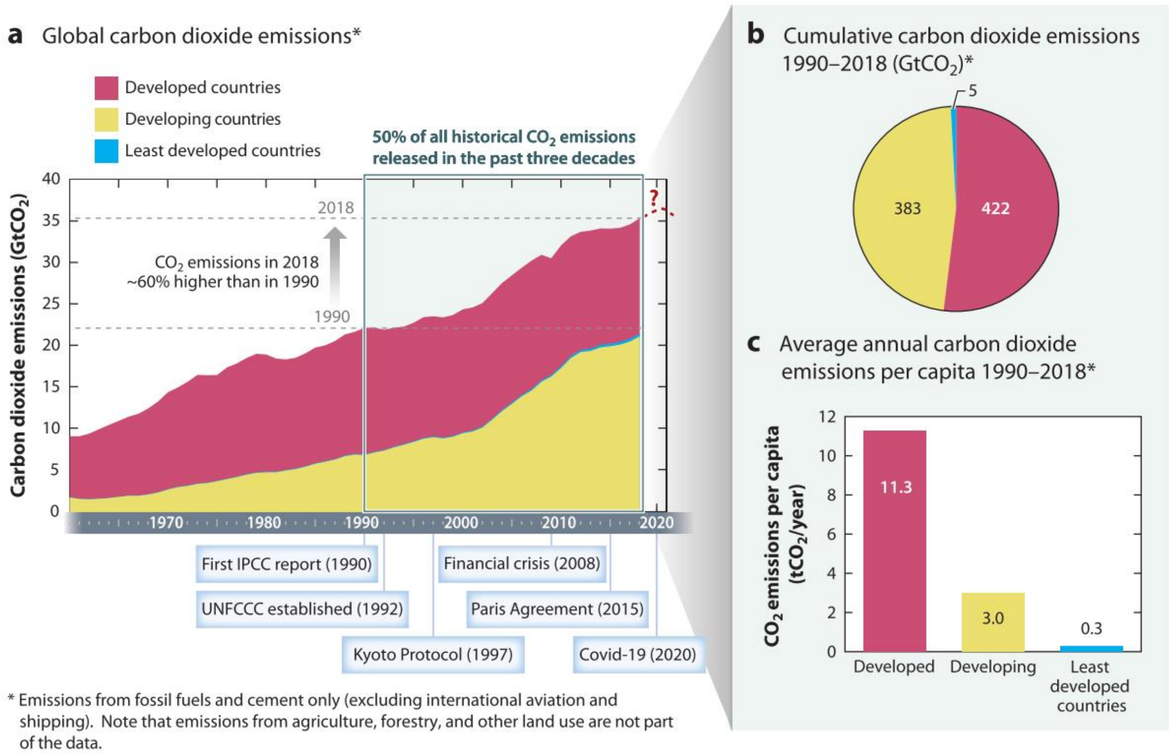

Figure 1. Territorial carbon dioxide (CO2) emissions of different country groupings (Stoddard et al. 2021)

2. International agreements and climate goals

Several multi-lateral tools are in place at global level to mitigate the emissions of greenhouse gases and climate change. The United Nations Framework Convention on Climate Change (UNFCCC) sets the main international framework for climate policy. It was established in 1992 and entered into force in 1994. The Convention was ratified by 197 parties, which is a near universal membership.

One of the early fruits of the Convention was the approval of the Kyoto Protocol, adopted in 1997 and in force since 2005. The Kyoto protocol is a legally binding instrument for cutting greenhouse gas emissions at the global level through national climate measures adopted by developed economies (United Nations). The instrument builds on a reporting instrument that quantifies the greenhouse gas emissions released by its members on annual basis. Another important novelty by the Kyoto Protocol was the introduction of flexible market mechanisms, based on trading emissions permits. While the protocol was joined by 192 Parties, some countries with large emissions did not ratify the agreement. This led to a coverage of only 12 percent of the total global greenhouse gas emissions.

The Paris Agreement sets the first legally binding international treaty on mitigating climate change that was generally adopted globally. It was agreed by 196 Parties at the Conferences of the Parties (COP21) in Paris, December 2015, and entered into force in November 2016. Its overall goal is to limit global warming below a 2 degrees Celsius threshold, compared to pre-industrial levels. However, the Paris Agreement also stipulates that efforts shall be taken to limit warming up to 1.5 degrees compared to pre-industrial levels.

A key feature of the Paris Agreement is to ensure a transparent and efficient planning and reporting system on the emission levels and status of implementation of the agreement in each country (UNFCCC 2015). Two key tools were adopted. The most important one is the Nationally Determined Contribution (NDC) scheme. The NDCs are reporting and evaluation documents submitted every five years to the UNFCCC by each signatory country. The NDCs report on the emission levels incurred, according to an internationally-agreed accounting protocol, and inform on the actions taken by each country to reduce greenhouse gas emissions. The NDCs and are evaluated by the UNFCCC against the commitments made by each country. Moreover, the Paris agreement also invited countries to develop the so-called "long-term low greenhouse gas emission development strategies". These are mid- and long-term greenhouse gas emission reduction strategies, typically by mid-century, to be adopted by each signatory.

3. The EU 2030 climate & energy framework

The 2030 Climate and Energy Framework was introduced by the EU Council on 23/24 October 2014 (EU Council 2014). The Framework defines the EU-wide targets and policy objectives for the period from 2021 to 2030.According to this Framework, the EU as a whole committed to:

- At least 40 percent cuts in GHG emissions (from 1990 levels)
- At least 32 percent share for renewable energy
- At least 32.5 percent improvement in energy efficiency

The Framework establishes that the effort to meet the 40 percent GHG target should be distributed between the EU Emissions Trading System, the Effort Sharing Regulation, with Member States' emissions reduction targets, and the Land use, Land Use Change and Forestry (LULUCF) Regulation.

In September 2020, as part of the European Green Deal, the European Commission (EC) committed to develop a comprehensive plan to increase the EU target for 2030 towards 55 percent compared to 1990, going beyond the previous 40 percent goal. On 14 July 2021, the EC adopted a series of legislative proposals, the "Fit for 55" legislative package, that represent the backbone of the 2030 Climate Target Plan (EC 2021a). This Plan aims to set Europe on a realistic path to becoming climate neutral by 2050, increasing the ambition of many of the existing instruments of the EU Climate Policy. The Plan is in its final negotiation stages at the time of writing (European Council 2021). If ratified by the European Council, the Fit for 55 Plan will:

- Increase the EU greenhouse gas emissions target to 55 percent compared to 1990 levels
- Increase the share of renewable energy in the Union's gross final energy consumption to 40 percent
- Increase the target for improvement in energy efficiency to 36 percent for final, and 39 percent for primary energy consumption.

In May 2022, in response to Russia's invasion of Ukraine, the European Commission launched the REPowerEU strategy. Its goals are saving energy, diversifying sources and speeding up the transition to a fully renewable energy system. Among other targets, the REPowerEU aims to raise the EU-wide renewable energy production target for 2030 from 40 percent to 45 percent of gross final energy consumption (EC 2022a).

3.1. Emissions covered by the EU Emissions Trading System

The EU ETS is the world's first and largest international carbon market (EC 2022b). The scheme requires large emitters of GHG in the EU, including energy-intensive industries and energy producers, accountable for around 40 percent of the EU's total GHG emissions, to surrender an emission right for each tonne of CO2 emitted. The EU ETS works on the 'cap and trade' principle. A cap is a limit set on the total amount of certain GHG that can be emitted by the installations covered by the system. This cap is reduced over time so that total emissions fall.

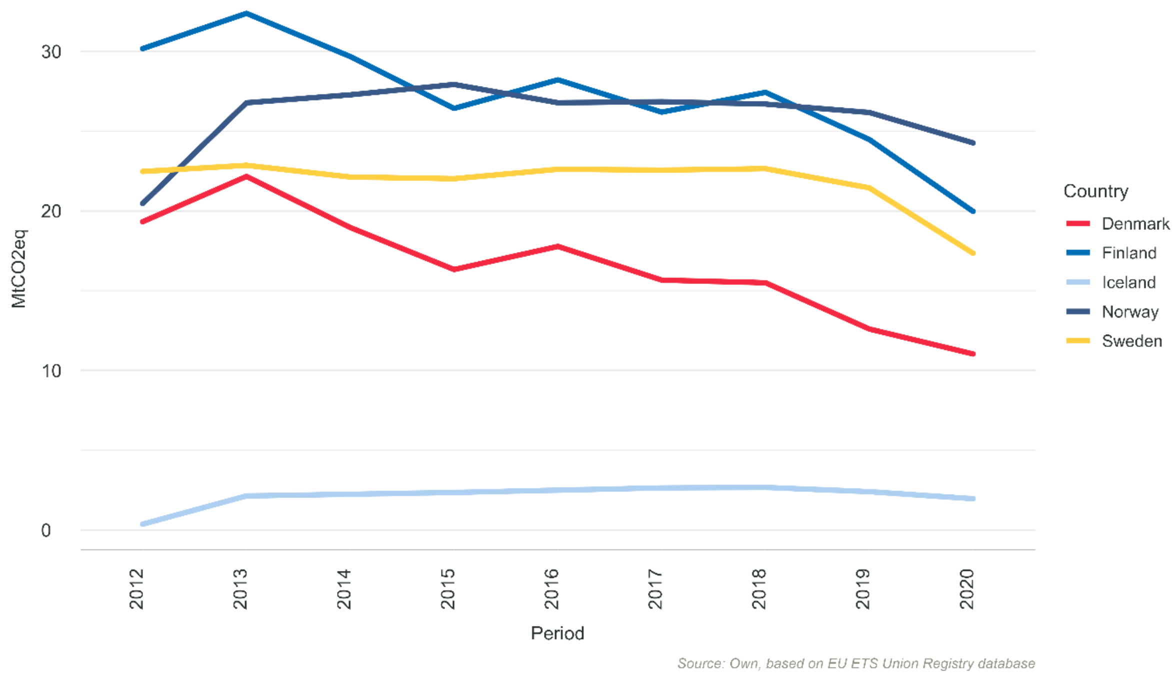

Figure 2. Verified GHG emissions under the ETS Directive (2003/87/EC)

Today, the EU ETS covers roughly half of CO_2 emissions within the EU (Silbye et al. 2019). Since the system was introduced in 2005, GHG emissions have been curbed by around 43 percent in the sectors covered by emissions trading and it is ambitioned that sectors represented in the EU ETS should contribute with a further reduction of 43 percent of emissions by 2030, compared to the 2005 levels (EU Council 2014).

The Union Registry serves to guarantee accurate accounting for all allowances issued under the EU ETS (EC 2022c). The Registry provides updated statistics on single emitters, as well as verified emissions for each year. Figure provides an overview of the evolution of GHG emissions of industrial origin reported to the Union Registry by registered operators from facilities located in the Nordic countries. The values are expressed in million tonnes, CO_2 equivalents ($MtCO_2eq$).

Within the cap, installations buy or receive emissions allowances, which can also be traded in the market. The limit on the total number of allowances available ensures that they have a value. After each year, an installation must surrender enough allowances to cover each ton of CO_2 that is actually emitted, otherwise sanctions are imposed (EC 2022b).

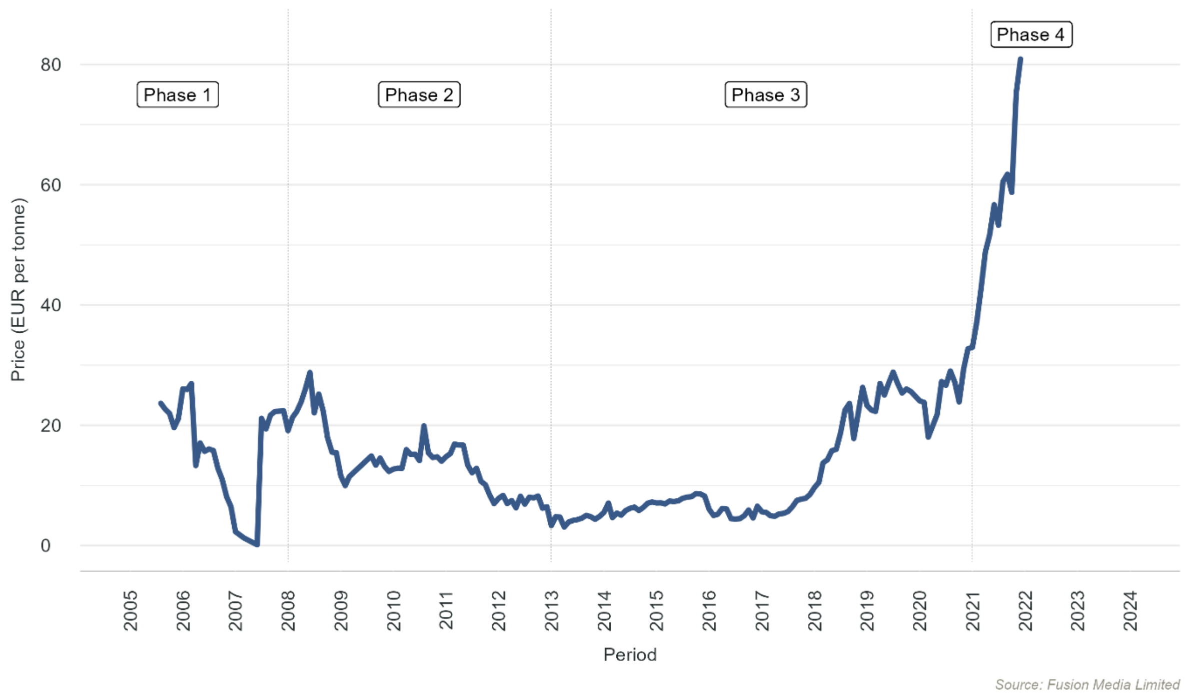

Figure 3. Historical change of ETS allowance prices (Carbon Emissions Futures)

In practice, if an installation reduces its emissions, it can keep the spare allowances to cover its future needs or else sell them to another installation in short of allowances. Since 2008, a large stock of saved emission rights roughly corresponding to one year of emissions in the system has been built up (Silbye et al. 2019).

The EU ETS has been deployed in different *phases*. The initial ones were characterised by a large number of free allocations and demand-supply mismatches, particularly after the Great Recession starting in 2008. This caused that permit prices remained for long at levels deemed inconsistent with the EU's long-term vision for a climate neutral economy by 2050 (Carlén and

Kriström 2020). The two more recent phases were accompanied by an increase in the share of auctioned rather than allocated allowances, accompanied by several other changes on the rules, in particular by the creation of a Market Stability Reserve (MSR) to absorb allowances. This led to a substantial reduction in the emissions allowance surplus and a subsequent surge of permit prices, as clearly shown in Figure 3 (Carlén and Kriström 2020; Bua et al. 2021).

As part of the 2030 Climate Target Plan, the EC proposes a new target to reduce emissions from the EU ETS sectors by 61 percent by 2030, compared to 2005 levels. This represents an increase of 18 percent compared to the -43 percent target under the current legislation. To reach this target, the Commission proposes a one-off reduction of the overall emissions cap by 117 million allowances, and a steeper annual emissions reduction of 4.2 percent, instead of 2.2 percent per year under the current system (EC 2021b). If these proposals are finally adopted, it is likely that the price of carbon allowances in the EU ETS will increase even further. This shall contribute to internalize climate costs in the economy, through production and consumption channels, increasing the associated costs for companies and households.

3.1.1. Localising Nordic industrial emissions using data from the European Pollutant Release and Transfer Register

In Europe, major industrial plants are subject to different protocols and regulations that require operators to report the nature and volumes of substances emitted to the environment, including various sources of atmospheric emissions. These are reported to different administrative bodies in member states and the EU, and are kept in ad-hoc databases that can be publicly accessed from the European Environmental Agency (EEA 2022).

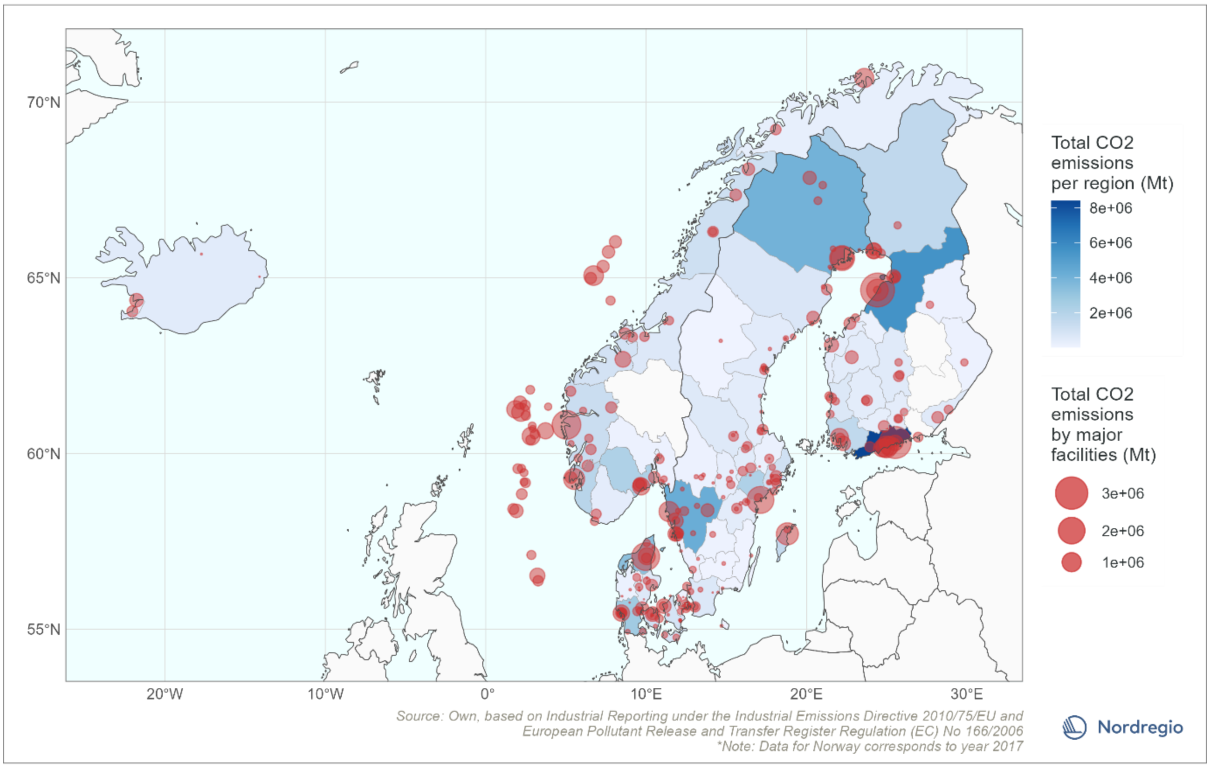

Figure 4. Nordic CO2 emissions of fossil origin by region and major industrial facilities (2019)

The Industrial Reporting Database (IRD) contains releases and transfers of regulated substances to all media (water, air and soil), waste transfers reported from 2007 to 2020 under the European Pollutant Release and Transfer Register (E-PRTR). The IRD also provides very detailed data on energy input and emissions for large combustion plants (reported under IED Art.72) from 2016 to 2020. It has data for EU member states, Iceland, Liechtenstein, Norway, Serbia, Switzerland and the United Kingdom.

The information on GHG emissions in the IRD is overall consistent with the one in the Union Registry that keeps track of EU ETS emissions. The main value added of the IRD in relation to the Union Registry of the EU-ETS is that the former includes information on several pollutants, other than GHG, and that it also includes further details on the emission facilities, including detailed georeferencing information. This makes this information suitable for cartographic purposes.

Figure 4 shows the emissions of fossil CO2 by major plants in the Nordic Region, based on the information reported to the E-PRTR. The emissions included in this map represent around 37 percent of the total GHG emissions in the Nordic Region, excluding LULUCF. The information allows to identify which regions face greatest challenges related to industrial GHG emissions and hence where social impacts on household might occur via income channels, assuming that the activities by these companies, often large employers in the regions, could imply partial or total discontinuation of the operations of these plants.

Table 1. Emissions of fossil CO2 by major combustion plants (2019)

Country	Fossil CO2 emissions (Mt)
Denmark	9.438
Finland	22.154
Iceland	0.764
Norway	23.275*
Sweden	17.435

*Data for Norway is for 2017. Source: E-PRTR.

3.2. Sectors covered by the Effort Sharing Regulation

But, of course, not all GHG emissions come from industrial sources. Sectors outside the EU ETS are covered by different regulation mechanisms. The most important of those instruments is the Effort Sharing Decision under Regulation (EU) 2018/842 (ESR). Activities like domestic transport, housing, agriculture, small industry and waste management, which are responsible for around 60 percent of total territorial EU GHG emissions, are covered by the ESR. All EU member states, plus Iceland and Norway have committed to apply the ESR.

The 2030 Climate and Energy Framework of 2014 determined that sectors of the economy covered by the ESR must reduce emissions by 30 percent by 2030 compared to the 2005 levels (EU Council 2014). Based on this comprehensive target, the ESR sets binding annual GHG emission limits for each signatory country for the period 2021-2030.

The annual limits for GHG emissions per member state under the ESR are set out in implementing decision (EU) 2020/2126, for the EU member states (EU 2020a), and Decision of the EEA Joint Committee No 269/2019, for the EFTA countries (EEA Joint Committee 2019). The targets for each year and country are defined as the end point of a linear reduction trajectory drawn from a point defined by the average 2016-2018 emissions of each member states as value, placed on the time axis at five twelfths of the distance from 2019 to 2020.

Country limits are set by applying the principles of "fairness, cost-effectiveness and environmental integrity". Such principles imply that better-off countries, such as Sweden and Luxembourg are obliged to reduce their yearly emissions by 40 percent, and Denmark and Finland by 39 percent. Poorer countries, such as Bulgaria and Rumania, are given target levels for 2030 that are just slightly below or equal to their 2005 emission levels. The ESR leaves the design of policies that fulfil these obligations up to the member states (Carlén and Kriström 2020). Figure 5 shows the annual ESR targets agreed for the period 2021-2030 in all of the Nordic countries (dotted, thinner line), alongside an estimated trajectory under the Fit for 55 package (dashed, thicker line).

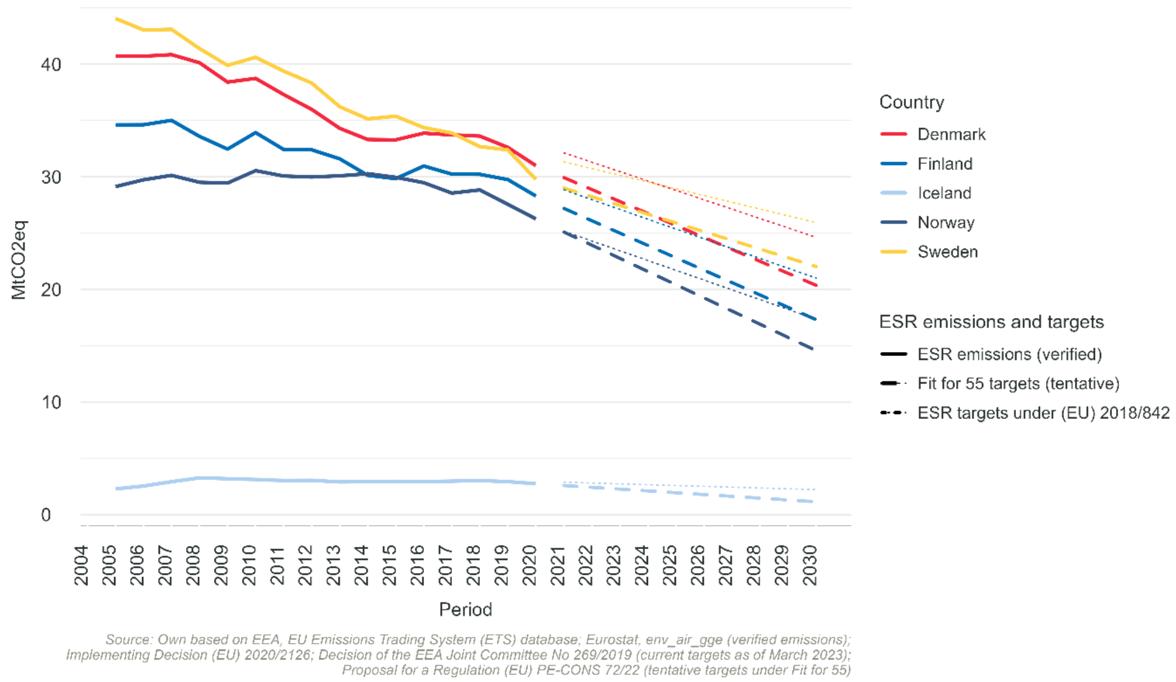

Figure 5. Total GHG emissions and targets covered by the Effort Sharing Decision (Regulation (EU) 2018/842)

To ensure compliance with these targets, a penalty is imposed on member states that fail to meet its ESR binding obligation for one given year. However, as a means to enhance the overall cost-effectiveness of total reductions, member states can bank and borrow part of their annual emission allocations from the following year, as well as buy and sell allocations to other member states. Also, countries can compensate excess annual emissions with net removals from LULUCF (up to a combined quantity of 280 $MtCO_2eq$).

Moreover, the ESR allows nine countries, including the three Nordic EU members, as well as Iceland and Norway, to use a limited amount of ETS allowances for offsetting emissions in the effort-sharing sectors for the period 2021 to 2030. The allowances are deducted from the amounts that would normally be auctioned under the EU ETS. The maximum limit that can be used annually in 2021-2030 is set at 2 percent of each country's effort sharing emissions in 2005, except for Ireland, Luxembourg and Iceland that are allowed up to a limit of 4 percent.

As part of the EU Fit for 55 legislative package and the 2030 Climate Target Plan, the European Commission (EC) has proposed to increase the EU-wide emission reduction target for the Effort Sharing sectors to achieve at least 40 percent emission reductions by 2030 in relation to 2005 levels, compared to the current 29 percent (EC 2021c). The EC initiative also proposes to reinforce the principles of fairness and cost-efficiency and to improve the flexibility mechanisms. If the proposal is finally accepted by the Council, more ambitious national targets should be set for member states.

3.3. The role of Land use and Forestry regulation

The 2030 Climate and Energy Framework did not define specific targets for the land use and forestry sector but established that policies on how to include LULUCF into the 2030 GHG mitigation framework should be defined at EU level before 2020. These policies should reconcile EU's food security and climate change objectives, optimising the contribution of the LULUCF sector to GHG mitigation, as well as carbon sequestration via afforestation (EU Council 2014).

The Land Use, Land Use Change and Forestry (LULUCF) Regulation (EU) 2018/841 fulfilled this mandate by setting out the commitments of member states for the LULUCF sector and by laying down the rules for the accounting of emissions and removals from LULUCF (EU 2018). According to this regulation, EU member states must ensure that the accounted GHG emissions from LULUCF are balanced by at least an equivalent accounted removal of CO_2 from the atmosphere in the period 2021 to 2030. In other words, emissions from LULUCF should be entirely compensated by an equivalent accounted removal of CO_2 from the atmosphere through targeted action in the sector[1]. This is known as the "no-debit" rule. Initially, the scope is limited to land use, but since 2020 the scope is extended to all forms of natural or seminatural land cover, including wetlands. Based on the no-debit commitment, the LULUCF Regulation should generate no less than -225 MtCO2eq of net GHG removals in the EU by 2030.

When it comes to forest carbon management, the member states revised their national forestry accounting plans, and, in some cases, proposed Forest Reference Levels (FRLs) that were later revised and ratified by Regulation (EU) 2021/268. These are forward-looking benchmarks for accounting net emissions from the existing forests between 2021 and 2025. FRLs are based on the reference period 2000-2009, drawing on the best available data and taking into account forest characteristics (EU 2020b).

Under the LULUCF Regulation (EU) 2018/841, emissions from biomass used in energy applications are recorded and accounted in relation to individual climate commitments of

[1] In most Nordic countries, LULUCF acts as a carbon sink, namely captures carbon from the atmosphere and stocks it in woodland and vegetation in general. Thereby, sustainable forestry management is called to play a paramount role for the decarbonization in the region. In particular, it is widely accepted that a Nordic sustainable forest management is crucial for supporting production of biofuels and maintaining carbon sinks (Weber and Søyland 2020).

individual member states, through the correct application of accounting in LULUCF. This approach emerges emissions from biomass combustion that were previously not accounted for under previous EU law.

As the EU ETS and ESR, the LULUCF Regulation also includes several flexibility mechanisms. Member states can use allocations from the ESR to satisfy the "no-debit" commitment in the LULUCF Regulation. Reversely, member states can choose to enhance removals or reduce emissions in the LULUCF sector, thereby helping compliance in the ESR sector, where agricultural emissions are accounted for, and bank saved emissions. Countries can also buy and sell net accounted removals from and to other countries. Finland has also a special treatment when it comes to the maximum amount of MtCO2eq that may compensate using managed forests.

In the 2030 Climate Target Plan, the European Commission proposed to increase the annual carbon removals through LULUCF management to -310 MtCO2eq by 2030, aiming at achieving "climate neutrality" in the combined land use, forestry and agriculture sector by 2035 at EU level (EC 2021c). The Commission proposed that the EU -310 MtCO2eq removal target should be distributed among member states during the 2026-2030 period based on the recent performance and the potential to expand carbon sinks.

3.4. Emissions from maritime and air transport

3.4.1. Aviation in EU Emissions Trading System

Unfortunately, no consistent and harmonised dataset on emissions from international aviation is currently available. According to recent estimates, emissions from all forms of aviation represent around 1.9 percent of global GHG, or 2.5 percent of CO2 emissions (Graver 2018; Lee et al. 2021). According to the Eurostat data, in 2019 the international and domestic aviation in the EU-27 emitted slightly more than 148 MtCO2eq of GHG. This amount represents 3.9 percent of total GHG emissions, excluding LULUCF and memo items.

Importantly, aviation also has an impact on the climate through the release of various substances at high altitudes, which have a significant climate effect, also known as *radiative forcing*. It is estimated that aviation is accountable for 3.5 percent of the total radiative forcing caused by human action (Lee et al. 2021).

The largest share of these releases come from passenger travel (81 percent), and a smaller fraction from freight traffic (19 percent). Among passenger aviation, 60 percent of emissions come from international travel, and 40 percent from domestic flights (Ritchie 2020). In Europe, domestic aviation accounts for around 11.6 percent of total emissions in the sector.

The substation improvements on energy efficiency of aircrafts achieved during the last two decades[2] have been greatly outpaced by a sustained growth in air traffic, with passengers in 2017 flying on average 60 percent more than 10 years back (EC 2022d). Overall, Lee et al. (2021) estimate that aviation emissions have doubled since the mid-1980s, with rather constant

[2] For instance, the amount of fuel burned per passenger dropped by 24 percent between 2005 and 2017 (EC 2022d).

contribution in relative terms (in the range of 2 percent to 2.5 percent). Since 1990, GHG emissions by international aviation has increased by 78 $MtCO_2eq$ (+145 percent) in the EU. By contrast, emissions by domestic aviation have increased by 30 percent.

CO_2 emissions from aviation have been included in the EU ETS since 2012. Under the EU ETS, all airlines operating in Europe, European and non-European alike, are required to monitor, report and verify their emissions, and to surrender allowances against those emissions. Like any other installation registered in the ETS system, the airlines receive tradeable allowances covering a certain level of emissions from their flights per year. The EU ETS applies to all flights within the European Economic Area (EU member states, plus Iceland, Liechtenstein and Norway), but excludes flights from or to destinations outside this area.

Extra- European Economic Area flights are covered by the global market-based measure by the International Civil Aviation Organization (ICAO), starting in 2021. Within this framework, the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) seeks to stabilise CO_2 emissions at 2020 levels by requiring airlines to offset the growth of their emissions after this year. Under this mechanism, air carriers are required to monitor emissions on all international routes and offset emissions from routes included in the scheme by purchasing eligible emission units generated by projects that reduce emissions in other sectors (e.g. renewable energy). Even if the first phases of the system are voluntary, all EU countries have joined the scheme from the start (EC 2022d).

3.4.2. Climate policies targeting maritime emissions

According to the International Maritime Organization (IMO 2020), the share of shipping (international, domestic and fishing) in global anthropogenic CO_2 emissions represented 2.89 percent in 2018. Between 2012 and 2018, the contribution of international shipping to global CO_2 emissions increased both in absolute (+94 $MtCO_2eq$) as well as in relative terms (0.13 percent). If mitigation measures are not adopted, emissions are projected to increase up to a 40 percent by 2050 in relation to 2008 for a range of plausible long-term economic and energy scenarios (IMO 2020). According to the proposal regulation on the use of renewable and low-carbon fuels in maritime transport, in 2018 CO_2 emissions from international shipping in the EU27 were around 36 percent above 1990 levels (COM(2021) 562).

A global approach to address GHG emissions from international shipping led by the IMO has so far made limited progress. Only after substantial efforts, the IMO finally agreed in April 2018 on a preliminary GHG emissions reduction strategy that includes objectives to reduce total annual GHG emissions from shipping by at least 50 percent by 2050 compared to 2008 levels. However, specific emission reduction measures, as well as research and innovation, necessary to achieve the objectives under the strategy remain to be developed and agreed.

This framework is also missing in the EU. The international maritime transport was the only transport mode not covered by legislation to deliver the GHG reduction target in the Europe 2020 Strategy. For the time being the emphasis was on monitoring, reporting and verification of CO_2 emissions from large ships using EU ports. These principles are embodied by the Communication (EU) 2013/479 on integrating maritime transport emissions in the EU's GHG reduction policies, Regulation (EU) 2015/757 on monitoring, reporting and verification of carbon dioxide emissions from maritime transport, (the MRV Shipping Regulation), amended by Delegated Regulation 2016/2072. This legal framework applies to all voyages involving ports of call located in a EU territory and, since 1st January 2018, also in Iceland and Norway (except those on Svarbald). Ports of call in Greenland and the Faroe Islands are excluded (EC 2022e).

The proposal regulation on the use of renewable and low-carbon fuels in maritime transport (COM(2021) 562) includes a basket of measures, including the possible extension of the EU ETS to shipping, that will be likely referenced to more ambitious targets than those agreed at the international level. It is hence expected that the new policy package currently under preparation will include binding targets for the maritime sector.

4. Long-term emission trajectories

4.1. Overview of progress towards Nordic climate goals

Even if most countries are doing substantial efforts to decarbonise their economies, the Nordic Region is not homogeneous when it comes to the decarbonisation pathways. Figure 6 shows the evolution of territorial GHG emissions over the last three decades in the five Nordic countries. The Figure shows the different decarbonisation trajectories followed by Denmark, Finland and Sweden, in contrast to Norway and Iceland. Whereas the former trio managed to reduce their emissions considerably (between 20 percent and 25 percent in relation to 1990), in Norway and Iceland progress has been much more modest, if any.

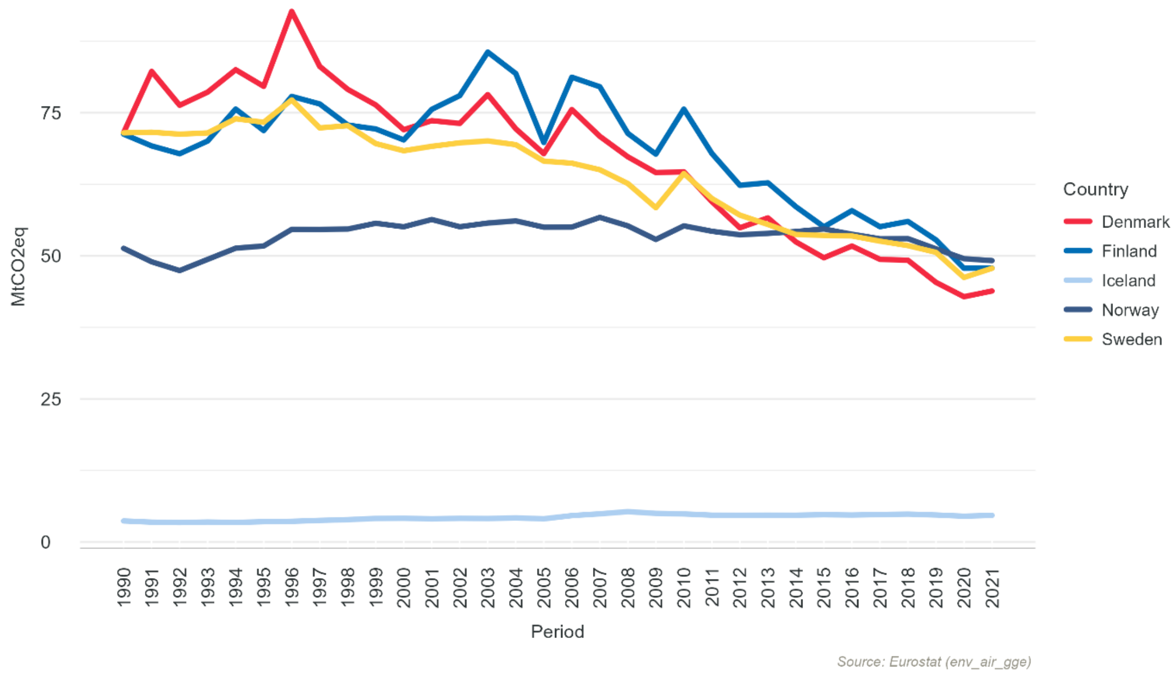

Figure 6. Territorial GHG emissions in the Nordic countries (Total emissions, excluding LULUCF and memo items)

However, both Iceland and Norway have very specific characteristics that make them hardly comparable to the other Nordic countries. Norway is the only major oil producer in the region. The composition of its GHG emissions clearly reflects this condition and represents a major obstacle for the decarbonisation of its whole economy. Iceland falls somehow in the opposite situation. The country has an energy system characterised by an almost entirely renewable mix, but the expansion of several carbon-emitting industries, particularly aluminium smelters, has increased its emission rates. Still, the country remains on absolute emission levels that are well below most other countries in the world, even when considering aviation, another relatively large source of GHG emissions in the country.

All considered, the progress in the reduction of GHG emissions made by the Nordic countries over the last decades has been remarkable, in particular considering that during this same period the region has experienced a steady increase of its population and economic output. Between 1990 and 2019, the total population in the Nordic countries increased by 18 percent, on average, whereas the GDP boosted to somewhere between 64 percent in Finland, and 93 percent, in Norway. Therefore, per capita emissions of territorial CO2 have curbed across the Nordics, with the only exception of Iceland. In Sweden (-180 percent) and Denmark (-113 percent) the reduction on per capita CO2 emissions was very substantial. These figures contrast with the more modest reductions in Finland (-13.6 percent) and Norway (-3.7 percent), and the substantial increase in Iceland (+36.1 percent). From 1990 to 2019, the country increased its annual per capita emissions by almost 2 tonnes, from 8.7 to 10.5 tonnes per person (Figure 7).

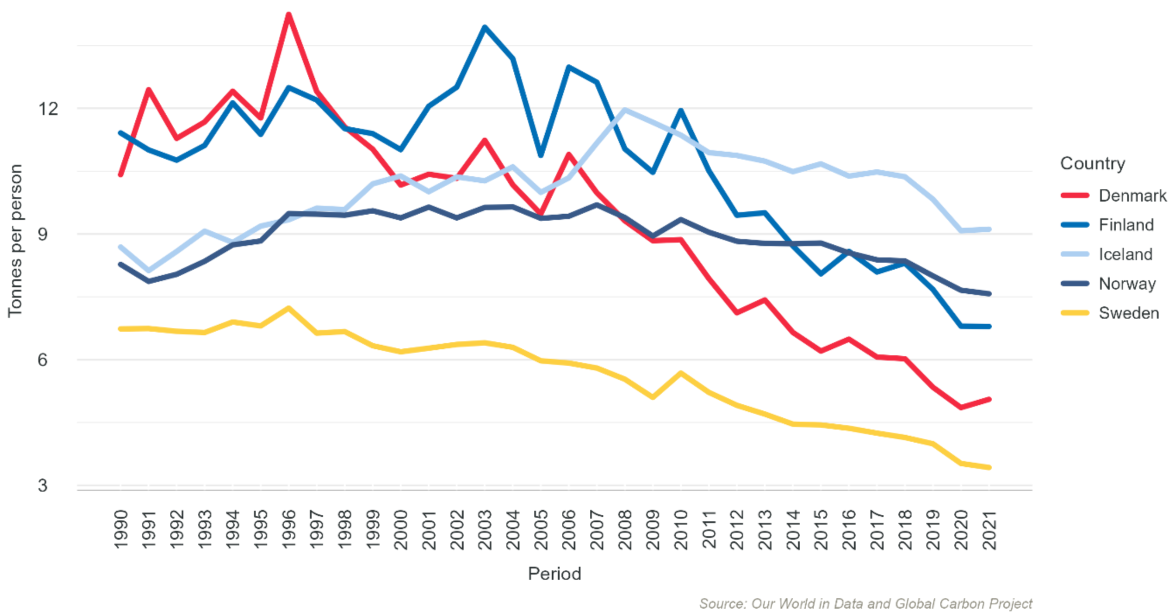

Figure 7. Per capita CO_2 emissions in the Nordic countries

4.2. Emissions embodied in consumption of traded goods

Even if the decoupling of economic processes from carbon emissions seems to be ongoing in the Nordic Region, it is important to acknowledge that the emission plots shown so far refer to the so-called *territorial* emissions. These provide a partial snapshoot of total emissions from fossil sources, or emission *footprints*. More precisely, territorial emissions account for emissions at production stage but disregard the emissions embedded in imported products. In other words, territorial emissions are only a fraction of total emissions driven by local economic activity, as a share of those are de facto embodied in imported goods consumed locally.

The consumption perspective on carbon accounting is important because it addresses the social justice perspective more distinctly than territorial emissions. Consumption-based carbon accounting captures the highly different global impact on the climate of extremely diverse lifestyles and the need for long-term equality in per-capita carbon emission allowances (Semieniuk and Yakovenko 2020), connecting to the well-established debate on the spatial and inter-generational equity of carbon accounting in general (Grübler and Fujii 1991). Moreover, the approach is useful to address the concern that decarbonization processes in many highly developed countries may have only occurred due to a shift of consumption towards imported products and/or due to the delocalization of carbon-intensive production towards foreign sites with better resource access (e.g. steel, aluminum) and/or weaker emission mitigation strategies (Wood et al. 2020).

According to Meinrenken et al. (2020), who built a database of 866 product carbon footprints from 145 companies, 30 industries and 28 countries, on average 45 percent of total value chain emissions arise upstream in the supply chain, 23 percent during the company's direct operations, and 32 percent downstream. Based on a vast collection of international studies, Peters et al. (2012) showed that 1) production-related emissions shrunk in major developed economies and Russia, 2) production-related emissions increased substantially in developing economies (China and India), 3) with the only exception of Russia, embedded emissions of all major economic regions increased between the 1990-2010 period, particularly in China, India and the US, and less sharply in Japan and the EU. Similar conclusions were drawn by Hou et al. (2020). This work confirms that during the first decade of this century global consumption emissions have grown faster than production emissions and show that developed industrialised economies are the largest net importer group of GHGs.

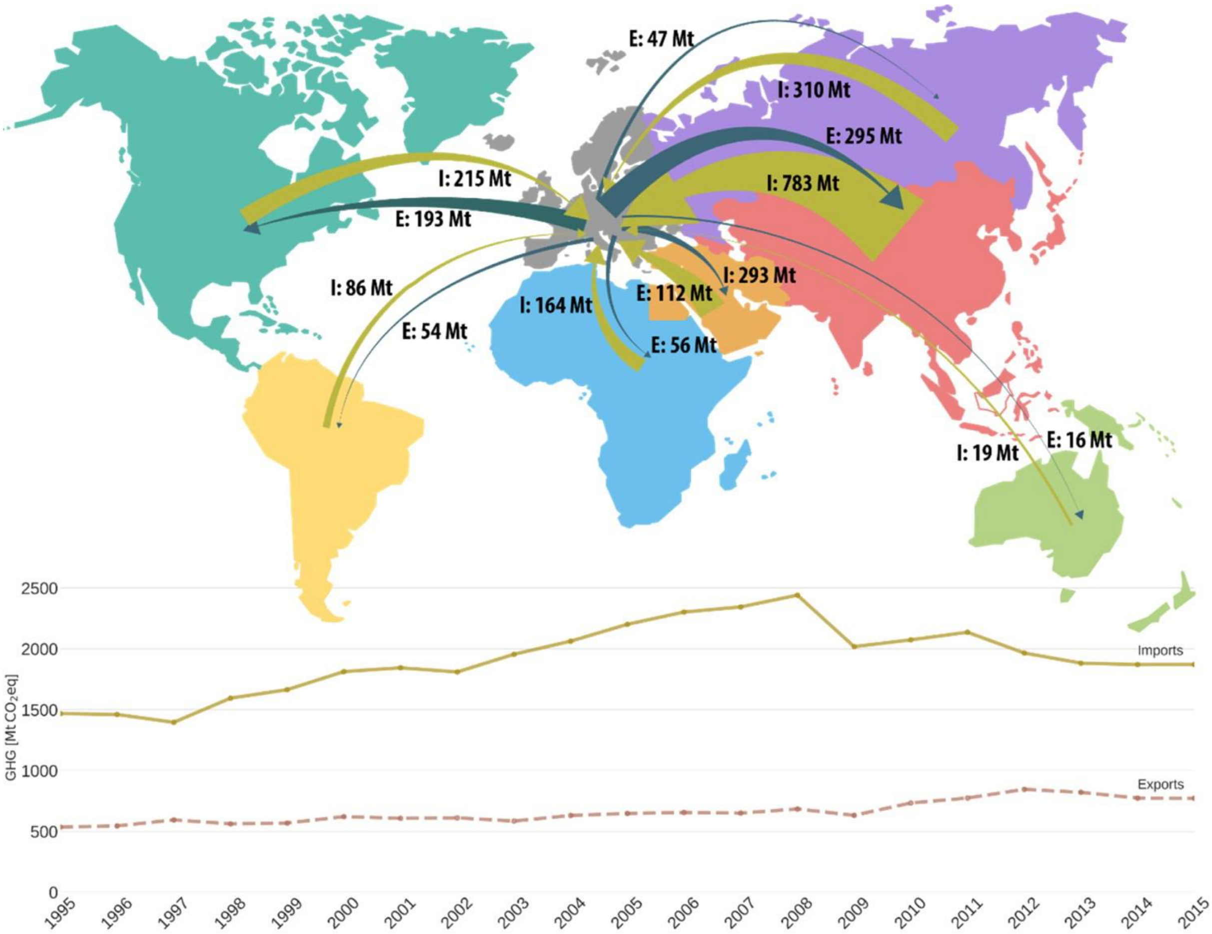

Figure 8. GHG emissions embodied in the EU trade, 2015 (Wood et al. 2020)

Wood et al. (2020) quantify the emissions embedded in EU consumption and international trade (Figure 8). The authors show how the EU carbon footprint has declined since 2007, but at a slower rate than production-based emissions. The authors also claim that consumption growth has had a much greater impact on the EU carbon footprint than the offshoring of production.

When adding consumption emissions, the Nordic carbon footprint is considerably higher than the figures that are often reported, including those which are often used to promote policy on carbon neutrality (Weber and Søyland 2020). Still, Figure 9 illustrates how consumption-related emissions follow a similar trajectory to total territorial emissions. Based on statistics provided by the Global Carbon Project (Andrew and Peters 2021; Friedlingstein et al. 2021), consumption-based emissions declined substantially in most Nordic countries during the last thirty years. In Denmark, Finland and Sweden, consumption-embedded emissions curbed by around 30 percent from 1990 to 2019. This contrasts with the more modest drop of 22.3 percent in the US and the substantial 126 percent increase in China. In Norway, the data series starts in 2003 and shows that the contraction since that year has been of around 9 percent, which contrasts with the 30 percent reduction in the remaining countries.

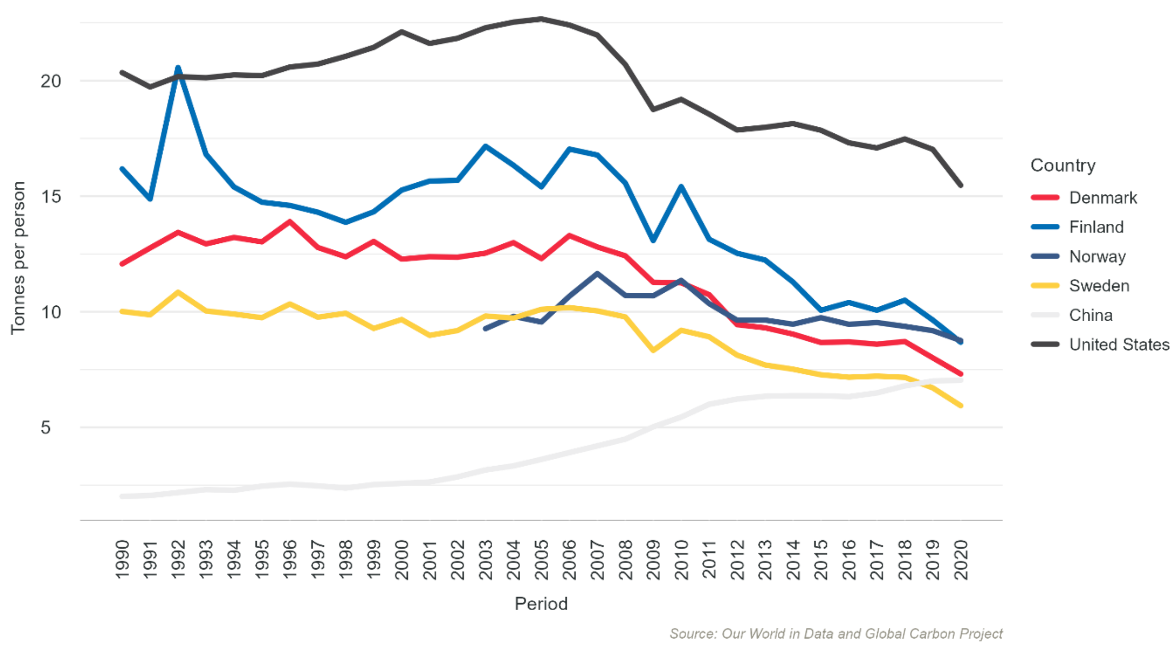

Figure 9. Per capita consumption-based CO_2 emissions in selected countries. Original data from the Global Carbon Project (Andrew and Peters 2021; Friedlingstein et al. 2021)

However, it should be considered that net reductions of per capita consumption-embedded emissions in the Nordics took place only after 2007, a period characterised by modest economic growth in the aftermath of the 2008 financial crisis, and by a steady population increase in all countries. Regardless of climate policies and trade balances, both trends certainly contribute to explain the better performance of CO2 emissions embodied in consumption.

As shown in Figure 10, which also shows data from the Global Carbon Project (Andrew and Peters 2021; Friedlingstein et al. 2021), consumption CO2 emissions contribute more than territorial emissions to the carbon footprint in the four larger Nordic countries. Consumption-embodied CO2 emissions represent an equivalent to 62 percent of the total per capita carbon footprint in Sweden in 2019. This percentage compares to Denmark (61 percent), Finland (59 percent), Norway (53 percent) the US (52 percent) and China (47 percent).

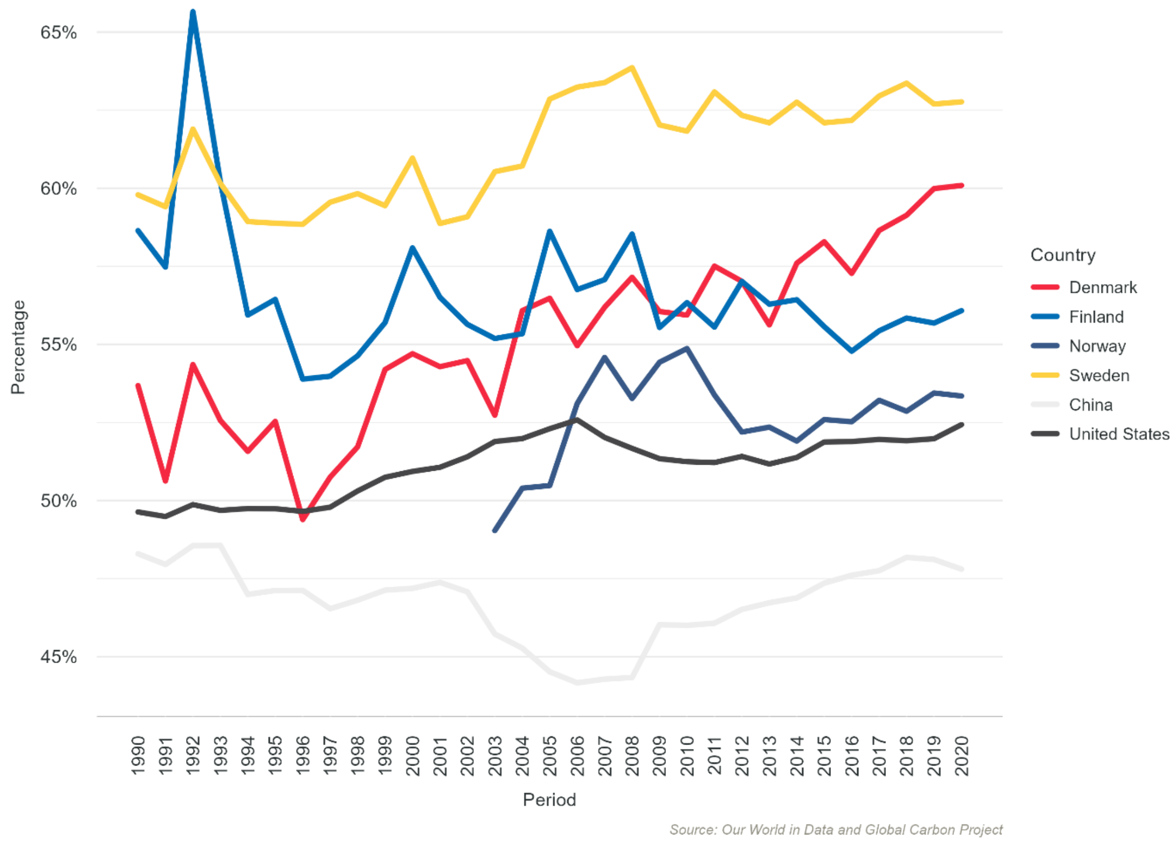

Figure 10. Contribution of consumption-based CO_2 emissions to total per capita CO_2 emissions in the Nordic countries (1990-2020).

At aggregated level, total emissions of the products consumed in situ essentially depend on the technologies used at production stage and the energy mixes in the manufacturing countries. Hence, when designing carbon policies, it is important to consider not only the territorial emissions, but also emissions embedded in traded commodities. For this same reason, it is very important to understand the potential consequences of delocalising carbon-intensive activities to other geographies where production technologies and carbon mixes could lead to higher emissions.

Ultimately, the differences on the decarbonization processes in the various countries can only be understood if analysed considering their specific energy mixes, economic structures and policy commitments. The following section attempts to deliver on this objective by providing a brief overview on how these aspects shape the emissions composition of the Nordic countries.

4.1. Emissions by source

This section presents an overview of the decarbonisation trajectories of each of the Nordic countries considering sources. The analysis covers the 1990-2020 period and focuses on all types of territorial GHG emissions, excluding LULCCF, but including international aviation and navigation. The analysis shows a great diversity of situations in each country, depending on the economic specialisation and energy mixes. Most of the countries have made substantial progress in reducing emissions from fuel combustion systems in industry. This technology behaved as a low-hanging fruit in terms of emission abatement. Progress in other sectors and industries, such as transport, aviation and other industrial sectors, particularly in process industry, are clearly more difficult to abate.

4.1.1. Denmark

Since 1990, the annual territorial emissions of greenhouse gas in Denmark declined by 26.6 MtCO2eq. This implies a 37.6% reduction in total territorial greenhouse gas emissions. All emissions from fuel combustion other than transport declined substantially. The largest cuts took place in the energy sector (-22.4 MtCO2eq, or -42.8% decrease in relation to 1990), particularly in the *Fuel consumption in the public electricity and heat production* sector (-18.3 MtCO2eq, or -73.9% less than in 1990). Emissions in this sector were reduced mainly as result of a large increase in wind power generation, which replaced carbon-intensive coal and gas power (IEA 2017). Emissions by *Manufacturing industries and construction* dropped by -1.7 MtCO2eq (-31.1%) and *Fuel combustion by households* curbed by -3.3 MtCO2eq (-63.4%).

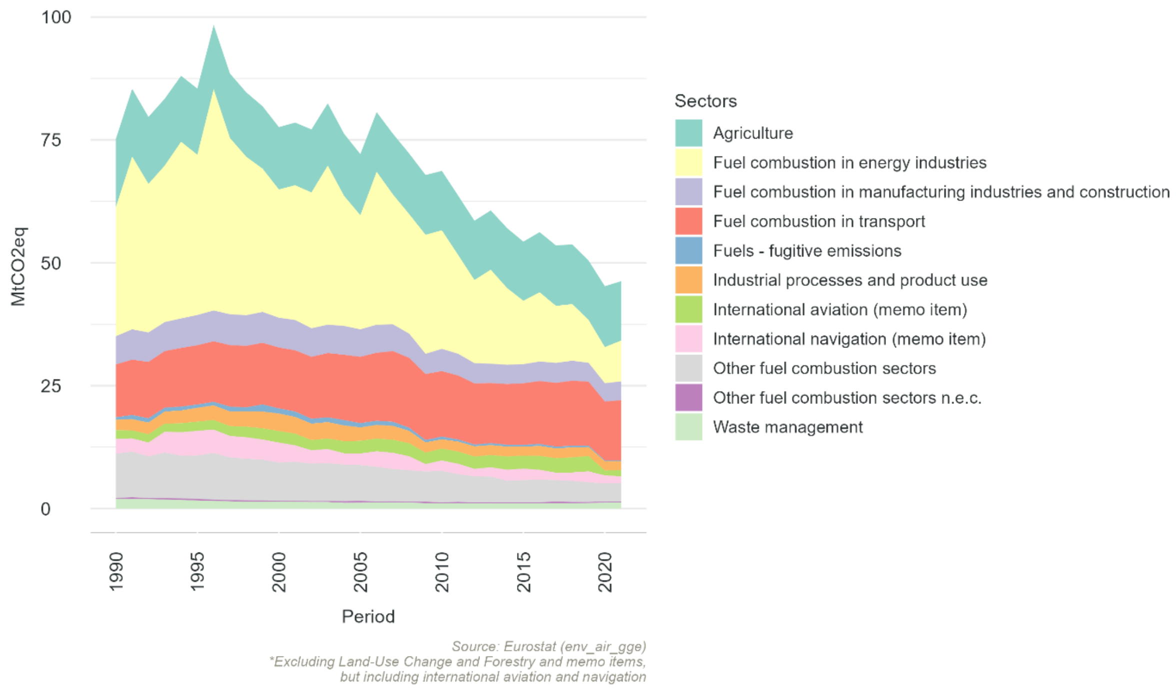

Figure 11. Territorial GHG emissions in Denmark, by source sector

In spite of substantial relative increases of emissions linked to cattle manure management (5.5% increase) and some forms of enteric fermentation (27% increase), the *Agriculture* sector as a whole managed to reduce its greenhouse gas emissions by -2.2 MtCO2eq, or -16.7% fewer emissions than in 1990. By contrast, *Fuel combustion in transport* (excluding international transport and aviation), increased net emissions by 2.4 MtCO2eq, or 22.0% more than 1990. The international transport memo items showed contrasting performance. Whereas *International aviation* increased emissions by 1.4 $MtCO_2eq$ (76.6% increase), *International navigation* managed to reduce emissions by -0.8 $MtCO_2eq$ (-26.2%).

4.1.2. Finland

In Finland, total territorial emissions (excluding LULUCF and memo items, but including international transport), declined by -17.4 $MtCO_2eq$ of CO_2 equivalents, or -23.5% in relation to the 1990 levels. The sector that contributed the most to these cuts was the *Fuel combustion in energy industries*, which accounted for the entire reduction in the energy sector (-14.4 $MtCO_2eq$, or -26.9%). However, in contrast with the Danish example, the *Fuel consumption in public electricity and heat production* sector only contributed -2.3 $MtCO_2eq$ to such reduction (-14.0% less than in 1990). Greater improvements were recorded in sectors such as *Fuel combustion in manufacture of pulp, paper and printing* (-6.9 $MtCO_2eq$, -50.9%) and *Fuel combustion by households* (-2.1 $MtCO_2eq$, -62.5%), included in the *Fuel combustion in manufacturing industries and construction*, and *Other fuel combustion sectors*, respectively. Agriculture contributed with a reduction of almost -1 $MtCO_2eq$ (-11.8%), compared to the emission levels in 1990.

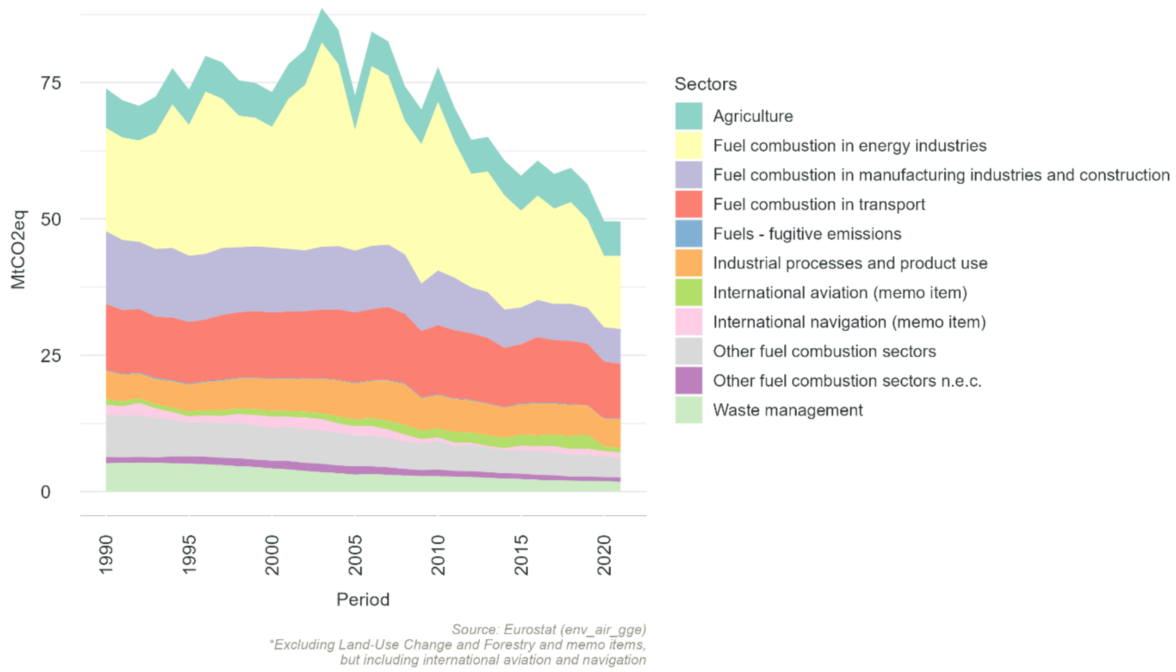

Figure 12. Territorial GHG emissions in Finland, by source sector

Among the largest contributors to territorial emission inventories in Finland, the only sector to increase net greenhouse gas emissions was *Industrial processes and product use*. Here, product used as substitutes of ozone depleting substances for refrigeration and air conditioning, and the chemical industry were the sectors accounting for a larger increase in emissions (around 1 MtCO2eq each, with total emissions in 2019 that were several times larger than those reported in 1990). The overall reduction in the *Fuel combustion in transport* sector was quite modest (-1 MtCO2eq, -6.9%). These sectors seem to be those with greater decarbonization potentials in Finland.

4.1.3. Iceland

Iceland seems to be an outlier in the Nordic context in two respects. First, it is the only Nordic country where greenhouse gas emissions increased in absolute as well as relative terms over the 1990-2019 period. The largest increase of Icelandic greenhouse gas emissions took place in the *Industrial processes and product use* sector, and specifically in the *Metal industry* sector, which in the case of Iceland essentially refers to aluminium smelting. Sector-wise, territorial greenhouse gas emissions increased by 114%. But in absolute terms the expansion was of a modest upsurge of 1 MtCO2eq, roughly. 70% of this amount is directly attributable to aluminium production and the rest to ferroalloys production.

The increase on industrial emissions is significant for the size of the country but very small in a global context. Moreover, as stressed by Weber and Søyland (2020), the low-carbon energy inputs used by Iceland's industry are offsetting higher carbon-intensive processes, if these would take elsewhere in the world. This is because emissions in the energy sector are negligible in Iceland, since all primary energy used to produce electricity comes from renewable sources, most notably hydro and geothermal.

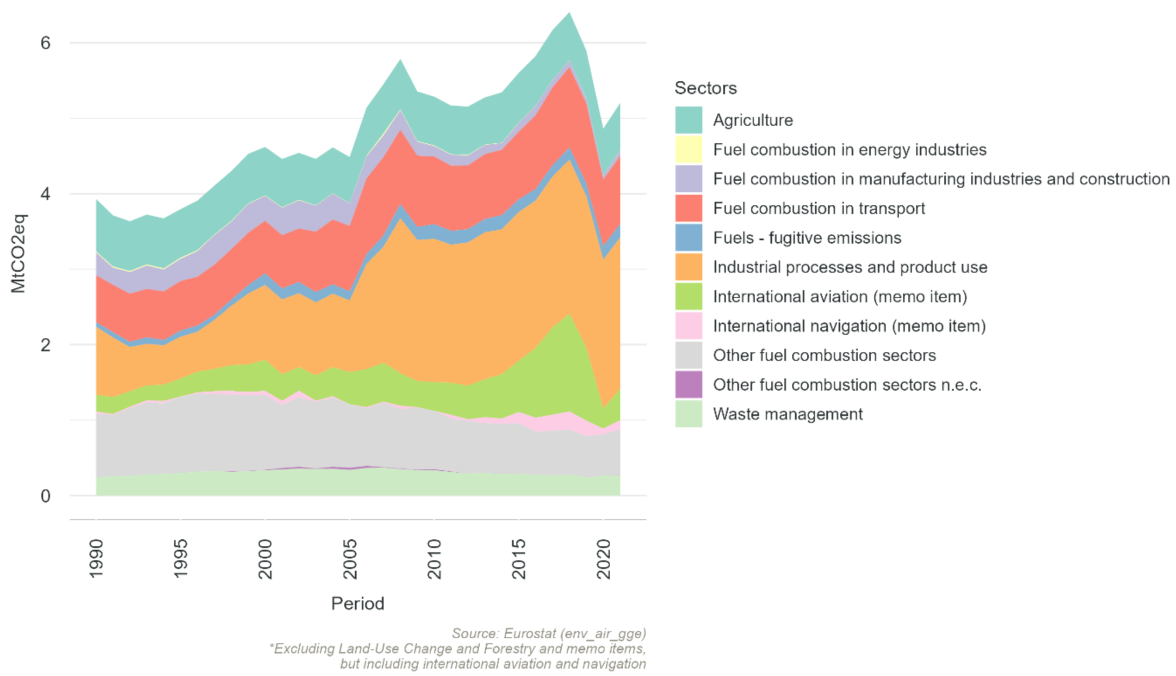

Figure 13. Territorial GHG emissions in Iceland, by source sector

Alongside industrial processes, the other major rise in Icelandic carbon emissions was motivated by the *Fuel combustion in road transport* sector (0.4 MtCO2eq, 82% increase). These inventories add up to the increase of emissions related to international aviation and maritime transport, which are not subject to the limitation and reduction commitments under the UNFCCC and the

Kyoto Protocol. In Iceland, these memo items have a very substantial entity, compared to territorial emissions subject to the agreements in the Kyoto protocol, and have also increased substantially over time.

4.1.4. Norway

In Norway, climate goals are greatly conditioned by domestic oil production. In 2019, the country remained one major exporter of crude oil, natural gas and gas condensates, valued NOK 463 billion (StatBank, table 09189). Oil production methods have a great toll on territorial emissions. As in Iceland, *Industrial processes and product use* (9.3 MtCO2eq, 18.4% of total territorial emissions), alongside *Fuel consumption in energy industries* (15.2 MtCO2eq, 30.2% of total emissions), and *Fuel combustion in manufacture of solid fuels and other energy industries* (12.6 MtCO2eq, 25.1% of total emissions) remain the two largest sectors by greenhouse gas emissions in 2019. A significant share of these (14.16 MtCO2eq in 2018) are composed by upstream oil and gas activities, comprising exploration, production, transportation, processing and vessel loading (Hall 2020).

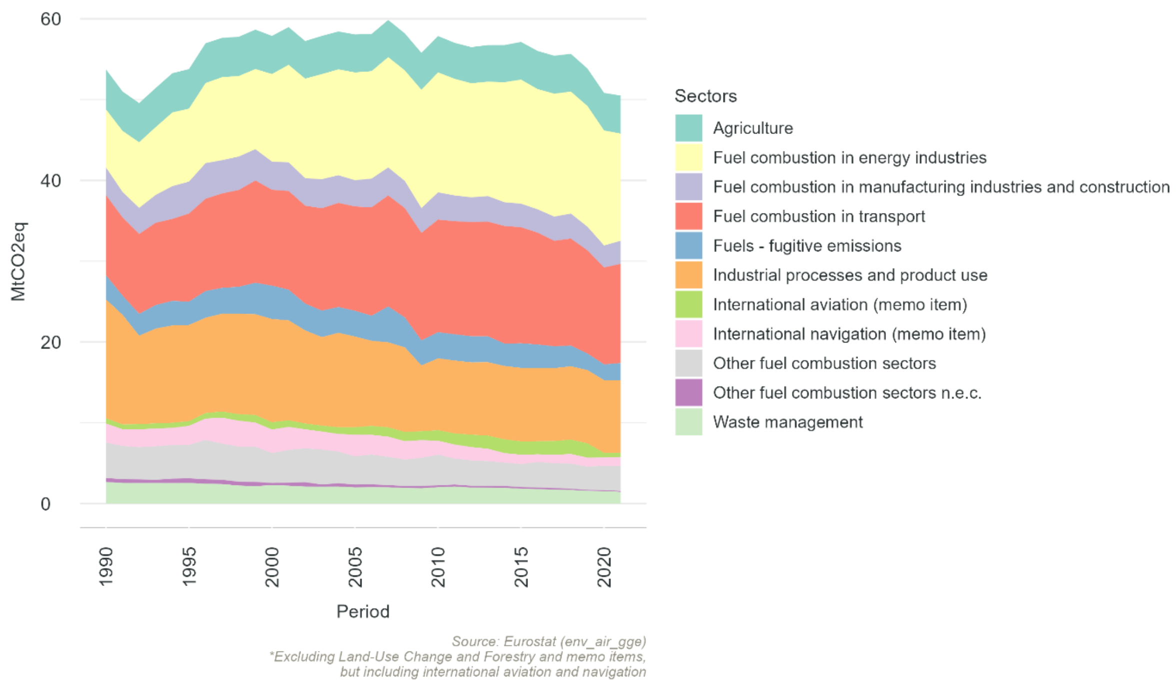

Figure 14. Territorial GHG emissions in Norway, by source sector

While *Fuel consumption in manufacturing* decreased its footprint over the 1990-2019 period (-6.1 MtCO2eq, -39.7% reduction), *Fuel combustion in energy industries* (7.9 MtCO2eq, 108.7% increase in relation to 1990) and *Fuel combustion manufacture of solid fuels and other energy industries* (6.7 MtCO2eq, 113.6% expansion since 1990) have both increased their emissions substantially. Due to the still high international demand for oil, alongside its own financial reliance on oil production, Norway has so far prioritised nature-based carbon sink options as fundamental decarbonisation strategy. The strategy has been developed domestically, by developing its own forestry, and abroad, by contributing to accredited programmes in developing countries to abate emissions and to preserve natural carbon sinks (Hall 2020).

4.1.5. Sweden

The long-term evolution of sectoral greenhouse gas emissions in Sweden from 1990 to 2019 reflects substantial progress, particularly when considered against a background of intense economic and demographic expansion during the same period. Focusing on territorial emissions, excluding LULCF and international transport, the overall greenhouse gas emissions in 2019 declined by -20.2 MtCO2eq, or -28.5% in relation to 1990. Among the largest emitters, the sector that witnessed greater progress over these 30 years was the *Other fuel combustion sectors* (-8.6 MtCO2eq, -77.0% compared to 1990). Emission reductions in this sector are mostly driven by the cuts in stationary combustion for heating purposes in the residential sector (-91% reduction in relation to 1990). Here, oil- fired furnaces have been replaced by district heating, and electric heat pumps (Ministry of Environment 2019). Substantial reductions took also place in the *Fuel combustion in manufacturing industries and construction* (-3.8 MtCO2eq, -34.9% in relation to 1990). Here, fossil fuels have been increasingly replaced by electricity or biomass (Ministry of Environment 2019).

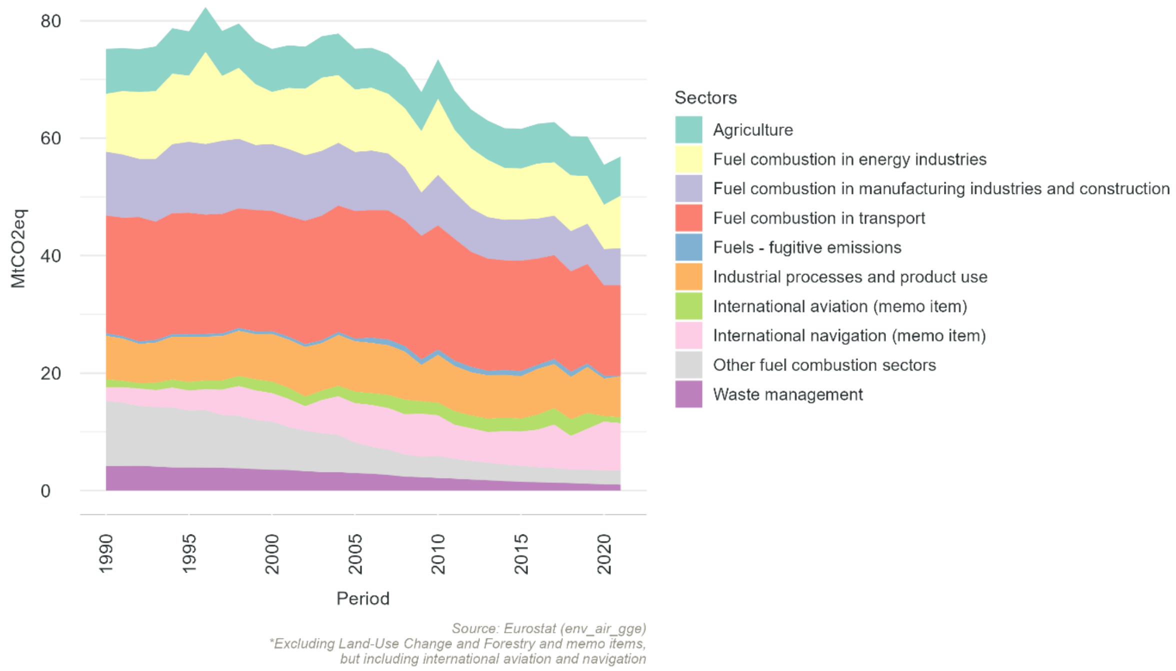

Figure 15. Territorial GHG emissions in Sweden, by source sector

Relevant challenges remain in key industrial sectors beyond fuel combustion, particularly in the *Industrial processes and product use sector*. Essentially, greenhouse gas emissions in this sector remain on similar level compared to 1990, whereas emissions in some of the key contributing industries increased since then. This holds for the iron and steel production industry (0.3

MtCO2eq, 12.3% in comparison to 1990), for the chemical industry (0.2 MtCO2eq, 38.2% than 1990), for the mineral industry (4.5% in relation to 1990), as well as for cement production, which contributes 1.3 MtCO2eq per year (2.6% of total emissions in 2019) and has increased its annual emissions by 6.0% in relation to the 1990 levels due to the demand boost by the construction sector.

Even if road transport sector remains the largest contributor to net territorial greenhouse gas emissions in Sweden (15.0 MtCO2eq, 29.5% of total emissions), the sector, particularly *Fuel combustion in cars*, made substantial progress over the last thirty years (-2.6 MtCO2eq, -20.7% compared to 1990). This is a remarkable achievement, considering that the number of vehicles has increased substantially over this same period. For example, between 2001 and 2019, Sweden added 2667 passenger cars to its stock (1.1% increase). During this same period, however, emissions from fuel combustion in cars were cut by -2.6 MtCO2eq, or -20.6%. The flipside on Swedish progress towards decarbonization has been international transport (5.9 MtCO2eq, 159.4% increase in relation to 1990), including both international shipping (4.6 MtCO2eq, 194.5% more than in 1990), and international aviation (1.3 MtCO2eq, 97.9% increase compared to 1990).

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