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Rising inequality: A material perspective on the Great Recession in the European Union

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ABSTRACT

The 2007/8 economic crisis and the global Great Recession led to widespread turmoil and instability. In Europe, unprecedented reductions in per capita resource use were crisis-driven rather than the result of deliberate policies. This study examines material use patterns in the EU-27 from 2000 to 2020, covering the period before and the onset of the Great Recession. We find that average material consumption in Europe decreased and has since stagnated, although this trend is uneven, with growing underlying inequalities, as measured using the Theil index of metabolic rates. The patterns in construction materials especially shape overall resource use trajectories. The role of infrastructure and services provisioning, especially where these are fossil-fueled, emerges as key in understanding these patterns. Geographic groupings of EU member states—Northern, Eastern, Mediterranean, and Central—further explain the inequalities that deepened following the recession. These emerging disparities raise important questions about what underpins the European project in a Union in which growth or sustained wealth in some member states systematically coincides with what can only be described as collapse elsewhere.

1. Introduction: the need for an ecological economics perspective on the crisis

Under capitalism, economic growth is invariably linked to material growth, that is, to increasing resource stocks and flows. This relationship has been empirically observed by researchers (reviewed by Haberl et al., 2020) and by political institutions (UNEP, 2011) and has its theoretical basis in the capitalist need for growth and capital accumulation (Martinez-Alier, 2009). The strong ties between growth in resource flows and economic growth become especially apparent in times of economic crisis or recession, which tend to be the only periods in which economies may, temporarily, decrease their annual material throughput (Wu et al., 2019). For example, slow economic growth or recession has a greater impact on emissions than do the targets formulated in the Kyoto protocol (Shao et al., 2017). The 2007/8 economic crisis in the European Union coincided with major shifts in material resource use patterns, not only at the aggregate EU-27 level, but also in the member states. It seems impossible to truly understand the crisis and its impact without developing an ecological economics perspective by considering resource flows alongside financial factors. At the same time, we need to consider the economic crisis in making sense of changing material patterns. Our research therefore focuses on interrelations between the 2007/8 economic crisis in Europe and on the observed material resource use patterns. In this, we follow the concept of social metabolism and investigate the interrelations between socio-economic organization and resource use.

1.1. The economic crisis in Europe

The 2007/8 economic and financial crisis, which began as a subprime mortgage crisis in the United States, quickly spread to the rest of the world and caused widespread turmoil and instability. In an analogy to the ‘Great Depression’ of the late 1920s and 1930s, it is sometimes referred to as the ‘Great Recession’. In Europe, the effects of the 2007/8 crisis were shaped by both the initial crisis and the austerity measures that followed, which we also consider as impacts of the crisis. In fact, the most far-reaching and oftentimes devastating impacts of the crisis came not only from the financial sector but from the interplay of economic and material conditions. Neither these conditions, nor the crisis' impacts, nor the responses adopted were uniform across the EU member states. Instead, the manner in which the crisis unfolded as well as the success of political and economic interventions into the crisis differed widely

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(Alessi et al., 2020; Giannakis and Bruggeman, 2017). We posit that substantial inequalities within any union would weaken its coherence. Increasing material inequality within the European Union in the wake of the Great Recession and likely future crises might jeopardize the "economic, social and territorial cohesion" of its common provisions (Treaty of Lisbon amending the Treaty on European Union and the Treaty establishing the European Community, signed at Lisbon, 13 December *2007*, 2007). We do not suggest that prior to 2007/8 the Union was not already marked by inequalities and discord. We do note, however, that especially in Eastern Europe and the Mediterranean countries, energy poverty increased in the wake of the crisis, often with severe consequences for human health and quality of life and in addition to the impacts of debt and foreclosures (Oliveras et al., 2021; Somarriba Arechavala et al., 2015). Adequate responses to human needs deteriorated with political responses to the crisis overwhelmingly focusing on fiscal performance while neglecting resource use and emissions (Burns et al., 2020) despite the clear signals that this crisis was not just a financial one (Brand, 2016). Continued engagement in environmental activism (Kousis and Uba, 2021) highlights the need for socio-ecological transformation. We take this as our cue to also address the crisis in socio-ecological terms.

1.2. Understanding material resource use patterns in times of crisis

In Europe, the crisis was associated with declining domestic material consumption, measured in the environmental accounting framework as material extraction plus imports minus exports. Where the data has been reconstructed, and with the exception of the United States of America, we can see that even the Great Depression did not have an impact of this magnitude (Krausmann et al., 2018; Schandl and Schulz, 2002; Wiedenhofer et al., 2013). This effect of the crisis seems to exemplify what sustainability researchers have been claiming for decades: That we must either fundamentally transform our societies to reduce their environmental impact or expect crises and conflicts as resource supply becomes, at best, disrupted (Eisenmenger et al., 2020; Liodakis, 2023). A crisis, even when associated with (temporarily) reduced resource use and emissions, is not a sustainable pathway in the long- or even medium-term, much less globally (Peters et al., 2012). It was also clearly not an example of degrowth, of the "a process of political and social transformation that reduces a society's throughput while improving the quality of life" (Kallis et al., 2018, p. 292). Instead, such crises may be associated with deteriorating environmental protection policies and ambitions (Burns et al., 2020) as well as mounting subnational inequalities (Cuadrado-Roura et al., 2016) including widening gender pay gaps as a result of crisis-related austerity measures (Perugini et al., 2019) and, of course, unemployment, plummeting the income of some households (Sánchez-Mira and O'Reilly, 2019). All this has led some researchers to the conclusion that financial and economic crises act as obstacles to much-needed socio-ecological transformations (Geels, 2013).

The need to understand the socio-ecological implications of economic crises is, of course, not limited to the most recent economic crises in Europe. Instead, economic recessions and crises are systematically part of capitalism. This is an analytical angle that was introduced for the European and North American contexts in the 19th century by Karl Marx and his collaborators in *Capital*. Capitalism's contradictions, such as rising exploitation rates and falling profit rates, were considered to systematically lead to both economic and political crises (Marx, 1867). Later Marxian scholars additionally pointed to – and this is of particular interest for our analysis of the economic crisis in Europe – how the response to these recurring crises in capitalism was simultaneously the substrate for future crises (Wood, 2016).

Thanks to the work of national statistical institutes and of Eurostat across the past decades, data on the material resource flows (in Europe and globally) is now easier to come by than ever (cf. Giljum et al., 2014). A wealth of research exists that has begun to make use of this data in understanding not just resource use patterns, but how they are mutually related to political and economic developments.

Wiedenhofer et al. (2013) studied resource flows of high-income industrialized economies after World War II, focusing on the United Kingdom, Austria, France, Germany, Italy, the Netherlands, and Sweden. They found that after a period of accelerated growth in the 1950s, the 1970s were marked by a stabilization of per capita extraction and apparent consumption of materials. Although Europe or the European Union are often considered as an aggregate geographic and/or political region in order to provide important insights on the effects of common policy (e.g., Calvo et al., 2016; Mayer et al., 2019), it has also been observed that the material use levels and composition, that is, the metabolic profiles, of the EU members states may differ quite substantially. For the year 2000, which marks the beginning of the period under investigation in our research, Weisz et al. (2006) found significant differences in the per capita material consumption of the EU member states. While five high-consuming countries (Finland, Ireland, Denmark, Sweden, and Greece) exhibited rates of material consumption greater than 20 tons per capita and year (t/cap/a) in 2000, the majority of member states consumed closer to the European average of approximately 16 t/cap/a, and the lowest material consumption occurred in Italy and the United Kingdom at approximately 12 t/cap/a. The authors note that despite these differences, that across the 30-year period under investigation, the inner-European inequalities in material consumption were reduced (Weisz et al., 2006). The EU member states notably rely not just on the material resources that they extract on their territory or directly import, but also appropriate resources through the upstream requirements of imported goods and services, as becomes visible in the material footprint indicator (Giljum et al., 2016). Internationally, inequality as measured based on the material footprint has been significantly higher than based on the material consumption indicator (Schaffartzik et al., 2019). An analysis of the material footprint in times of crisis, that is, an analysis which takes the role of offshoring into account, would clearly be highly relevant. We do not, however, provide it here. Instead, we focus on material consumption as an indicator that does not rely on any component of GDP for its calculation and that provides an indication of the amount of materials that remain on a country's territory, especially important for the construction minerals which tend to be strongly affected by economic crises (e.g., Schaffartzik and Duro, 2022). The extent to which crises play out in the construction sector nudges socio-metabolic research towards seeking to understand the role that investments into fixed capital play in shaping present and future resource use (Pineault, 2023, chapter 5; Schaffartzik et al., 2021). We previously found construction activity and, hence, the use of non-metallic minerals (used in bulk for construction purposes) to be particularly relevant (Schaffartzik and Duro, 2022). The particular role of the construction sector, especially in times of economic crises and their aftermath, points to the relevance of structural change in an economy, that is to the shifts within and between sectors, as they are documented in (monetary) input-output tables. It is to be expected that the observable impacts of the Great Recession on material flows would also be related to country-specific structural change (cf. Hoekstra and van den Bergh, 2004). The literature on structural change likewise suggests that technological developments and their adoption (at the sector level) are important contributors to, if not determinants of, structural change (Święcki, 2017). Not only via the impact on employment, this further links structural change and demographic developments (Vermeulen et al., 2018). Next to the cross-country comparison for the EU member states which we undertake, these findings add to a research agenda which additionally considers developments *within* national economies in a more granular manner.

Material flows are directly linked to the build-up of material stocks with both immediate and long-term impacts on resource requirements (Krausmann et al., 2020). In this way, current material patterns may also facilitate or hinder the provisioning of services to the population (investigated for mobility by Mattioli et al., 2020). To better understand this relations is a prerequisite to figuring out what it might take to enable a good life for all within planetary boundaries (O'Neill et al., 2018). In this sense, the question is not whether the EU members can generate more GDP out of less resource use – that popular, yet elusive, political goal of increased material efficiency and absolute decoupling (Haberl et al., 2020) – but whether human needs can be provided for with less environmental impact.

1.3. The aims of our research

In our research, we were curious to see how material use reductions during the Great Recession played out at the level of EU member states and whether previous reductions of material inequality continued. We pursue this focus bearing in mind that perfect equality of metabolic rates in the EU is neither an attainable nor a desirable goal. Instead, we are interested in how drastically reduced metabolic rates (and remaining within planetary boundaries) might be achieved while realizing the freedom and justice for all that the Union is committed to (Treaty of Lisbon amending the Treaty on European Union and the Treaty establishing the European Community, signed at Lisbon, 13 December *2007*, 2007) – expecting the Great Recession to be an example of how not to do it.

Despite its manifold manifestations, the 2007/8 crisis is still primarily addressed in monetary terms. With the research we present in this article, it is therefore our aim to enrich our understanding of this crisis with what we will refer to as a material or socio-metabolic perspective (Fischer-Kowalski and Haberl, 2015). The question that guides our research is: How did the 2007/8 crisis in the European Union play out in terms of material resource use and what implications does this have for socio-ecological transformations? To this end, we considered the patterns, both at the aggregate EU-27 level and in the member states, of material resource use in the two decades between 2000 and 2020. We examined both aggregate apparent consumption of material resources (using the domestic material consumption DMC indicator) and the four main material types (biomass, fossil fuels, metals, and non-metallic minerals). While the European Union is sometimes considered as a (relatively) homogenous economic region, we were interested in the differences between EU member states in their material responses to the crisis. We therefore conducted a Theil-index based inequality analysis and identified four aggregate regions within the EU that underwent similar changes in the wake of the crisis (more in *2. Data and methods*). We discuss the results of these analyses in light of what the socio-metabolic perspective allows us to see about the economic crisis that monetary indicators may mask, focusing in particular on the question of what this means for socio-ecological transformation. In particular, we relate our findings on (emerging) material inequality in the Union to what this means for cohesion as one of its founding principles and stability as a desired outcome thereof. We also zoom in on the role of construction minerals in shaping material inequality and on how their use is, in turn, prominently shaped by (fiscal) policies. Finally, we also probe our findings in terms of how they might better help us to understand the implications of focusing on resource efficiency as an item on the environmental policy agenda.

2. Data and methods

2.1. Data

The data covered in this analysis encompass Eurostat's (Eurostat, 2023a) population, GDP, and material flow accounts for the EU-27[1] as an aggregate and for its members states for the two decades between 2000 and 2020. This time period was chosen in order to be able to study both the developments prior to and following the 2007/8 economic crisis. As an indicator of material use, our study is concerned with domestic material consumption (DMC). This indicator is calculated by adding the direct material inputs into a national economy, i.e., domestic extraction and imports, and subtracting the material outputs to other national economies, i.e., exports. The unit of measurement is metric tons (1 $t = 1000$ kg). DMC is an indicator of apparent consumption in that it does not cover material resources required as upstream inputs into production processes as the material footprint indicator does (for an in-depth examination of the development of the European material footprint, see Giljum et al., 2016). While the material footprint is a very important indicator for many analyses, for our aim to provide an *additional* socio-metabolic perspective on the crisis, it was important to have a material flow indicator the estimation of which is entirely independent of GDP (Schaffartzik et al., 2015). In addition, the prominence of non-metallic minerals in the DMC of most of the EU-27 countries also recommends it as an indicator corresponding to the mass of material that remains within the European territory and corresponds to the amount of material available for further processing or resulting in waste there (Weisz et al., 2006). The data on material consumption were considered as totals and in terms of the four main aggregate material categories: biomass, fossil fuels, metals, and non-metallic minerals.

2.2. Methods

For the purposes of this analysis, we considered material consumption in terms of the metabolic rate, that is, as per capita material consumption (DMC/cap), based on population *P*. For this analysis, we focus on DMC as an indicator that does not rely on any component of GDP for its calculation and that covers all materials that remain on a country's territory. A corresponding analysis based on an indicator such as the material footprint, that includes upstream material requirements, would certainly constitute a worthy research endeavor, but not one that we can undertake here. For the EU-27, we decomposed the DMC-based metabolic rate (MR) into the factors material intensity (DMC/GDP) and average per capita affluence (GDP/cap) in year *t*:

$$MR_t = \frac{DMC_t}{P_t} = \frac{DMC_t}{GDP_t} * \frac{GDP_t}{P_t} \quad (1)$$

GDP[2] is included here as the internationally accepted measure through which economic crises are commonly understood and communicated and *not* as an indicator of the 'health' of the European economy. The material intensity variable DMC/GDP relates the apparent consumption of material resources to economic activity. If both DMC and GDP grow or decline at the same rate, material intensity remains constant. It becomes larger if DMC grows more strongly than GDP (or GDP decreases more strongly than DMC) and smaller if economic activity grows more quickly than does apparent material resource use. At the level of aggregation of both underlying indicators (GDP and DMC), it says nothing about the "efficiency" or the "productivity" of an

[1] The EU-27 at the time of writing (2024) includes Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden.

[2] One of the reviewers of this article proposed the use of gross value added (GVA) instead of GDP, especially for our assessment of inequality. For the EU member states and our period of analysis, GDP and GVA correlate almost perfectly (with a correlation coefficient of 0.999–1.000) and that, as a result, the inequality between per capita GDP and GVA (as measured using the Theil index) differs only marginally (by up to 0.001). We therefore have continued to rely on the GDP indicator for the purposes of our analysis.

economy, even if it is often referred to in those terms. Such an interpretation would be neglecting that both indicators are macro-level and are the result of different underlying processes. The per capita variables of the metabolic rate and affluence do not represent the availability of material resources or income to the average individual and certainly do not reflect material or economic wealth or well-being. Instead, we scale our extensive variables by population to allow for better international and interregional comparison and to render them somewhat more relatable.

We additionally calculated the metabolic rate for each of the 27 EU member states and studied developments in its inequalities over time. To do so, we used the Theil index as an inequality measure (for a justification of the choice of index, please see Duro, 2012). As a synthetic distance function, this index I of the metabolic rate MR can be expressed as:

$$I_t(MR) = \sum_{i:1}^{n} p_{i,t} ln\left(\frac{\mu_t}{MR_{i,t}}\right) \quad (2)$$

Here, $p_{i,t}$ is the relative weight of country i, that is, the relative population; μ_t is the mean European metabolic rate; $MR_{i,t}$ is the metabolic rate in country *i* and year *t*; and ln is the natural logarithm. The higher the value we obtain for our index I, the higher the inequality between countries. The Theil index can be further decomposed so that we – in accordance with eq. 1 – can determine the role that material productivity and affluence statistically played in material inequality (see Schaffartzik and Duro, 2022).

This particular index of inequality can additionally be decomposed by groups, making it possible to determine the contribution of within- and between-group inequality to overall inequality (Cowell, 2011; Duro and Padilla, 2006). For the purposes of our analysis, this means that we were able to assess – across the two decades between 2000 and 2020 – to what extent overall EU-27 inequalities could be explained by inequalities *within* or *between* four geographic country groupings (Nordic, Central, Eastern, and Mediterranean countries; see Section 3.4.). The decomposition of the index into between- and within-group addends takes the following functional form:

$$I_t(MR) = \sum_{g=1}^{G} p_g I_t(\mathrm{MR})_g + \sum_{g=1}^{G} p_g ln\left(\frac{MR_t}{MR_g}\right) \quad (3)$$

Here, p_g is the weight of group g (one of our four country groups) in the global population (of the EU-27). $I_t(MR)_g$ denotes the inequality of the metabolic rate *within* that group g. The second addend represents the population-weighted average of the indices for each of the four groups, that is, the *between*-group component.

3. Results

Our point of departure for this analysis were the trends in material resource use, but also in population and the gross domestic product (GDP), observable at the European level in the periods leading up to and following the 2007/8 economic crisis. We then focused on how material flows developed. These results form the basis for our analysis of (material) inequalities within the European Union and allowed us to consider to what extent and in which phases country groupings could be instrumental in helping us understand the observed inequalities.

3.1. Pre- and post-crisis trends in the EU-27

Have the 27 member states of the European Union (EU-27) achieved the coveted, yet elusive, combination of economic growth and declining material resource consumption, not only in per capita but also in absolute terms? A cursory glance at the development trajectory across the past two decades (Fig. 1) might certainly suggest that this is the case. While GDP (current prices) increased significantly from 7.9 trillion Euro in 2000 to 13.4 trillion Euro in 2020, domestic material consumption (DMC = domestic extraction plus imports minus exports) decreased slightly from 6.6 Gigatons (Gt = 10^9 tons) in 2000 to 6.0 Gt in 2020. This means that while 0.8 kg were required to generate one Euro worth of GDP in 2000, it took only half that (0.4 kg/€) in 2020 – colloquially, this is referred to as a significant increase in material productivity (in terms of GDP). During this period, population experienced very slight aggregate growth, so that per capita material consumption decreased from approximately 15 tons of per capita (t/cap) in 2000 to 13.5 t/cap and to a level fairly close to the global average in 2020.

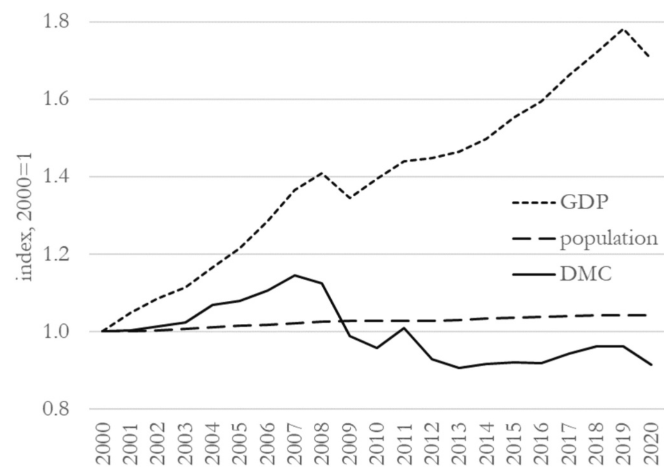

Fig. 1. Indexed development (2000 = 1) of gross domestic product (GDP, current prices), population, and domestic material consumption (DMC = extraction + imports – exports) in the 27 member countries of the European Union between 2000 and 2020. At first glance, these data suggest the reconciliation of economic growth with decreasing material consumption. Source of data: Eurostat (2023a).

Of course, one of the initial and very legitimate objections to interpreting this development in all too positive terms could be that the measure of material consumption considered here (DMC) does not capture the off-shoring of resource-intensive production to third-party countries. In the considering the results presented here, it is important to keep in mind that DMC does not include so-called 'upstream' material requirements. If, for example, the EU-27 countries were to concertedly offshore material- (or energy-)intensive industries, this would ceteris paribus lead to a reduction of the DMC as a measure of apparent consumption but not necessarily to a reduction in the materials required globally to meet European final demand. We consider the DMC as an important indicator of the resources physically processed on European territory and as an indicator independent of GDP, as outlined in *Data and Methods* (Section 2).

Our analysis focuses on two dimensions underlying the overarching European trajectory (Fig. 1): 1) the distinctly different phases of growth and contraction within the EU across this period and 2) the different patterns observable at the (still relatively aggregate) level not of the EU as a whole but of its individual member states. With regards to the first point, Fig. 1 does show that these two decades span a period of distinct growth in both GDP and DMC from 2000 until the 2007/8 economic and financial crisis. After a phase of contraction, growth of DMC then resumes in 2013 and until the onset of the Covid-19 pandemic in 2020. In order to address these distinct phases, our analysis develops a sociometabolic perspective for the periods i) 2000–2007, ii) 2007–2013, iii) 2013–2019, and iv) 2019–2020. To better understand the interrelation between material flows and economic crisis, we consider not only the aggregate developments at the level of the EU, but also compare the trajectories of individual member states and regional groupings.

3.2. Material flows in times of crisis

Did the phases of growth and decline that we can observe in total

DMC also affect the four main material categories (biomass, fossil fuels, metals, and non-metallic minerals? As can be seen in Fig. 2, between 2000 and 2007, biomass consumption decreased slightly, while all other material flows increased. Most notably, almost 1 additional Gt per year of non-metallic minerals was consumed in 2007 compared to 2000. This category of non-metallic minerals is primarily composed of construction materials used in bulk and was the flow to experience the strongest decline in the wake of the 2007/8 crisis (2013 non-metallic mineral consumption 1.3 Gt/a lower than in 2007). Many forms of use of construction minerals cannot easily be offshored: Both from a directly utilitarian perspective and with an eye on indirect economic gains, construction needs to happen within the EU. Roads and other transport infrastructures are built in Europe, built-up land for retail is expanded in the European countryside and on urban outskirts, and real estate development occurs on the member states' territories. These activities may occur in response to (perceived) human needs or to economic stimuli such as political responses to economic crisis (cf. Schaffartzik and Duro, 2022 for the case of Spain). So, it is not just their large mass-share in overall material consumption that leads us to keep a close eye on these non-metallic minerals. With the exception of fossil fuels, moderate growth occurred in all material flow categories between 2013 and 2019 while consumption of material types decreased with the onset of pandemic (2019–2020).

It is not just in terms of growth in the expansive period that construction activity is noteworthy: Out of the overall reduction of annual DMC between 2007 and 2013 of 1.6 Gt, 84 % (1.3 Gt) were accounted for by non-metallic minerals. And for the consumption of these materials, in turn, 95 % of the reduction was due to decreased domestic extraction. Once again, a pattern somewhat different from what has been observed for other materials and the role that net-imports play in securing access to them. This means that the unprecedented decline of annual material resource consumption in the European Union during the acute economic crisis period was almost wholly related to decreased domestic extraction of construction minerals. That is, when we approach the crisis from a socio-metabolic perspective, we find ourselves directed to consider the construction sector, in particular.

Even though they are quite heterogenous, the four major material resource categories identified in Fig. 2 correspond to some extent to distinct economic activities for which monetary indicators are available. Biomass is closely tied to agriculture, forestry and fishing while the dominant share of the non-metallic minerals relates to construction activity. According to Eurostat (2023b), for these activities, as for the resource flows, differing behavior of the gross value added (GVA), in chain-linked volumes (2005), can be observed across time. For the EU-27, GVA in the biomass-extracting activities oscillated somewhat from year to year, but generally increased from 169 billion Euro in 2000 to 191 billion Euro in 2020. GVA in construction, on the other hand, increased steadily until 2007, contracted between 2007 and 2014 and then increased again until the onset of the Covid-related crisis after 2019. It is interesting that GVA in this activity, which generally accounts for only approximately one fifth of all industry GVA, so closely mirrors the behavior of material flows (which is not the case for industry without construction or for manufacturing).

During the two decades under observation here, per capita material consumption, also referred to as the metabolic rate, in the EU-27 fell from 15.4 t/cap in 2000 to 13.4 t/cap. This development was the combined effect of an increase before the crisis, followed by a stronger decrease during the crisis years. Between 2013 and 2019, the metabolic rate increased modestly and decreased by a similar amount with the onset of the Covid19-crisis. Based on the decomposition analysis outlined in Section 2,[3] the development of material efficiency – all else remaining equal – would have caused the metabolic rate to decrease during all four phases and across the whole time period but was counterbalanced by the increasing effect of average income (measured as GDP per capita). This development is shown in Fig. 3, which depicts the logarithm of variance in average income and material productivity as explanatory variables for the observed inequality in the metabolic rate. This means that during the crisis years, it was also the collapse of per capita GDP that was highly influential for the development in the metabolic rate. We are concerned here with the GDP not as a measure of the wellbeing of a population nor even the 'health' of an economy, but as the main indicator through which economic crises are currently observed and understood. This allows us to focus on detailing the insights that we gain by additionally considering what happened in the pre- and post-crisis periods from a material point of view.

3.3. Less 'in common'? Rising inequalities between the EU-27 member states

As has been observed for other socio-economic indicators (Alessi et al., 2020; Giannakis and Bruggeman, 2017), the average European development is not necessarily representative of the developments in each of the member states. In fact, as our Theil-index based material inequality analysis for the EU-27 during these two decades demonstrates, a marked increase in metabolic inequality (that is, inequality in per capita material consumption) could be observed, especially from 2009 onwards (Fig. 4). The period leading up to the crisis was marked by an increase in the inequality between the EU-27 member countries in their metabolic rate, especially since 2004. Inequality in material intensity was relatively constant during this phase, while income inequality was steadily decreasing. After decreasing somewhat between 2007 and 2009, metabolic inequality within the European Union began to increase at an unprecedented rate, while material intensity, which was improving on the European average, also became gradually more unequal. Income per capita inequality resumed its declining trend, although not nearly as pronounced as before the crisis.

Material inequalities were not only a consequence of, but already a precursor to the crisis. Especially as an expression of what might be considered emerging divides in what is 'meant' to be a region marked by a shared economy and common policies, this is an interim result worth highlighting. For example, historical and contemporary differences in the energy systems of the EU member states have far-reaching impacts on their metabolic profiles (e.g., see Wiedenhofer et al., 2013). And Weisz et al. (2006) found that per capita material consumption levels within the Union already differed greatly in the year 2000, at the very beginning of the period under investigation here. Our analysis is not based on the premise that we expect material inequality in the EU to decline to zero as a result of common policies and markets, but that it is worth probing whether inequalities are increasing or decreasing (Fig. 4). In fact, the particular phases of rising and falling inequality that can be made out underpin the phases we propose for closer analysis (Fig. 3). And, it is also the acknowledgement of (previously existing) inequalities and differences that directs us to take a closer look at the different trajectories that countries took between 2000 and 2020, from a material perspective.

3.4. The explanatory power of country groupings within the EU-27

In considering country-level trends in the metabolic rate for all 27 European member states between 2000 and 2020, it seemed important to not only identify differences, but also test for similarities. In order to achieve the latter, we consider four geographical country groupings (consisting of three Nordic, 10 Eastern, 8 Mediterranean, and 6 Central countries; see Table 1). Although there is some overlap, this particular grouping does not match existing definitions of European regions completely. Before we get into the results for these groupings in terms of material resource flows and inequalities, it is worth pointing out that not only are these groupings internally heterogeneous, but they also differ

[3] This decomposition is based on equation 1 and can be expressed as: $\Delta\ln(DMC/P) = \Delta\ln(DMC/GDP) + \Delta\ln(GDP/P)$.

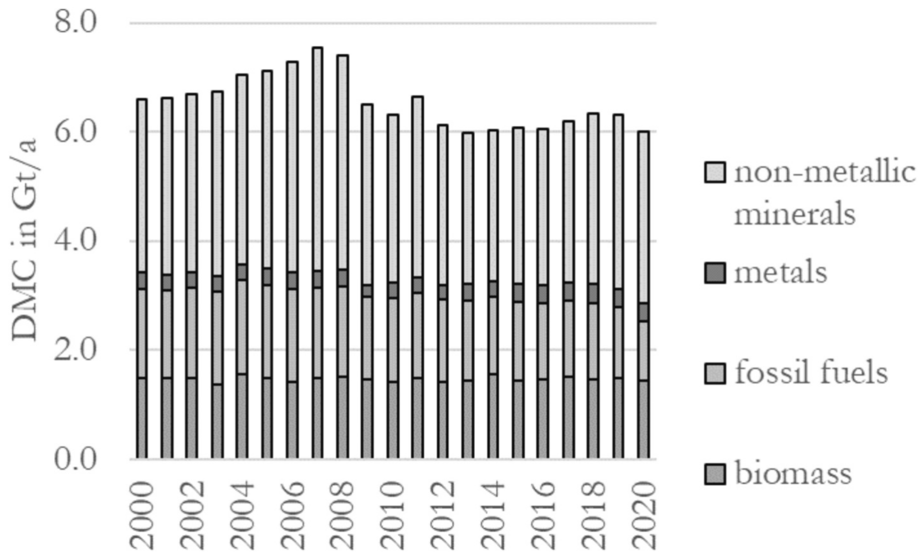

Fig. 2. Domestic material consumption (DMC = domestic extraction plus imports minus exports) in the EU-27 countries between 2000 and 2020 in Gigatons per year (Gt/a) and by the four main aggregate material categories.

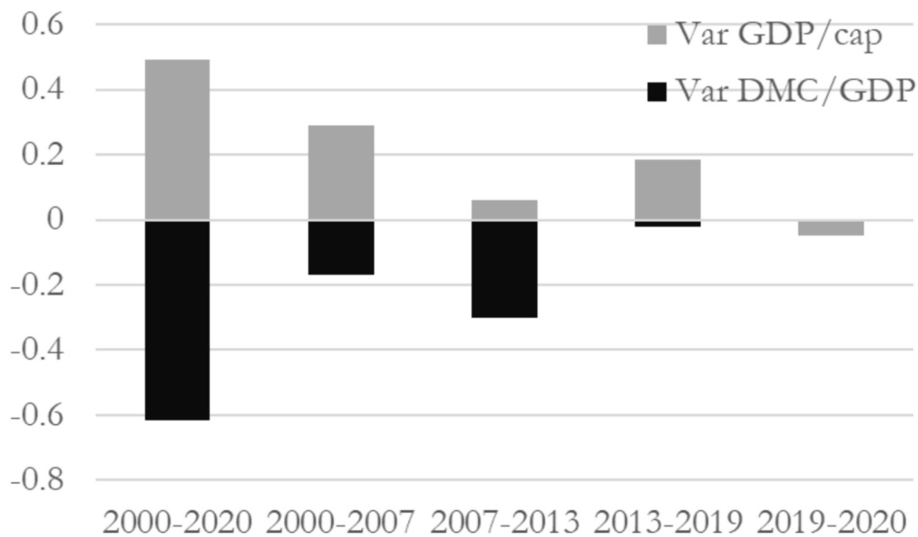

Fig. 3. Decomposition of changes in the metabolic rate (per capita material consumption) into the factors of per capita GDP (GDP/cap) and material efficiency (DMC/GDP), expressed as logarithmic differences for the entire time period (2000–2020), for the pre-crisis 2000–2007, the crisis 2007–2013, the post-crisis growth (2013–2019) and the onset of the Covid19-crisis (2019–2020) in the 27 member countries of the European Union.

quite strongly from one another in terms of size and internal structure. The largest grouping, based on population, material consumption, and GDP is that consisting of the eight Mediterranean countries, which includes France, Italy, and Spain. The Central grouping, which includes Germany, has the second largest population and GDP but only the third highest level of material consumption. The Nordic countries, although they differ quite substantially from the other groupings in their metabolic rate, are the smallest of the four groupings, in terms of population, material consumption, and GDP.

Fig. 5 shows the trajectory of average per capita material consumption in each of these four groups, alongside drop-lines indicating the respective maximum and minimum per capita consumption in each year. In each of the four groups, an impact of the 2007/8 crisis on material consumption can be observed, but the trajectories preceding and following the crisis are quite different. In the Nordic countries (group A), material consumption was comparatively very high before the crisis (reaching almost 29 t/cap in 2007), so that even the lowest level it reached in 2009, of approximately 24 t/cap, was *still* high by international and European comparison. Consumption increased gradually after 2009 and reached 27 t/cap in 2018. The highest metabolic rates in this group tend to correspond to Finland (above 30 t/cap/a) while even the lowest values (Denmark or Sweden, depending on the year) remain above 20 t/cap/a.

The Eastern countries (group B), in contrast, were consuming at a much lower level prior to the crisis and reached approximately 18 t/cap in 2008. After a low of 15 t/cap in 2011, consumption increased to 18 t/cap in 2011 and to 19 t/cap in 2020. In this larger group, the highest metabolic rates generally correspond to Estonia (more than 30 t/cap/a in some years), while Latvia and Lithuania often exhibit the lowest per capita material consumption (below 10 t/cap in some years).

In group C, the Mediterranean countries, the effect of the crisis was, in a way, most pronounced and also long-lasting: Material consumption increased to 16.5 t/cap until 2007 and then dropped to below 10 t/cap (and thus significantly below the global average) until 2016, stagnating from then on. The outlying peak in this group in 2008 corresponds to Cyprus, with 65 % of the country's material consumption that year

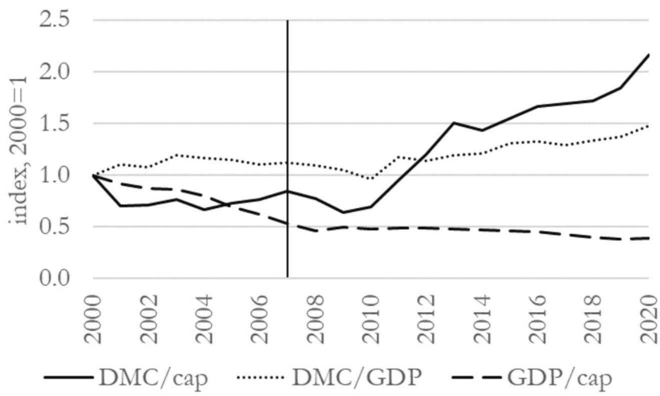

Fig. 4. Indexed development (2000 = 1) of Theil-inequality between the EU-27 for their metabolic rate (DMC/cap), their material intensity (DMC/GDP), and their average income (GDP/cap), 2000–2020.

Table 1
Overview of the four geographic country groupings used in this analysis, including aggregate population in 1000 people (cap), domestic material consumption (DMC in Megatons Mt), and GDP in billion € current prices for each grouping in 2020. Source of data: Eurostat (2023a).

Group	Countries	Population (1000 cap)	DMC (Mt)	GDP (billion €)
Group A (**Nordic**, 3 countries)	Denmark, Finland, Sweden	21,715	578	1026
Group B (**Eastern**, 10 countries)	Bulgaria, Czechia, Estonia, Latvia, Lithuania, Hungary, Poland, Romania, Slovenia, Slovakia	98,124	1855	1401
Group C (**Mediterranean**, 8 countries)	Croatia, Greece, Spain, France, Italy, Cyprus, Malta, Portugal	200,646	1913	5532
Group D (**Center**, 6 countries)	Belgium, Germany, Ireland, Luxembourg, Netherlands, Austria	126,677	1693	5441

consisting of non-metallic minerals.[4] Very low levels in the metabolic rate are most often those of Malta.

The Central countries in group D had the second highest level of consumption in 2000 (after group A) and experienced slight decline in this indicator *prior* to the crisis. This trend generally continued, bringing the group below the global average from 2015 on. Individual Central countries did experience noticeable growth in their material consumption prior to the crisis, as the drop lines in Fig. 5 indicate. This was notably (and at a very high level of per capita consumption) true for Ireland, where the metabolic rate surpassed 40 t/cap/a in 2006 and 2007 and fell sharply to 19 t/cap/a by 2011.

Although levels of fossil fuel consumption differ amongst the four country groups, the general trend they follow is comparable (Fig. 6, top right): Stagnation around 5 t/cap/a for the Central countries and around 3 t/cap/a for the Mediterranean countries until 2008. Thereafter, gradual decline to 3.5 t/cap in 2020 for the Central and to below 2 t/cap (and approximately to world average) for the Mediterranean countries can be observed, with the other two groups falling somewhere between this maximum and minimum. The European average initially is similar to the Eastern European group and then follows the Nordic average quite closely. While rates of consumption for biomass and metal ores are similar for groups B—D and are relatively stable across the entire period, Group A (Nordic) is marked by high rates of consumption in these two categories (Fig. 6, top left and bottom left): between 6 and 7 t/cap/a for biomass compared to 3 to 4 t/cap/a for the other three country groupings and increasing metal ores consumption from 2 t/cap in 2000 to 4.5 t/cap in 2020 compared to 0.5 to 1 t/cap/a in the other groups. The European average for metals follows groups B—D and for biomass most strongly mirrors the Eastern European countries. For non-metallic minerals with their dominant role in the overall metabolic rate of the European Union (cf. Fig. 2), differences between the country groups can also be observed: Fig. 6 (bottom right) illustrates that, again, consumption in the Nordic countries (group A) is highest, increasing to almost 16 t/cap in 2007 while values from a low 4 t/cap in 2000 in the Eastern countries (Group B) to around 8 t/cap that same year in the Mediterranean and Central countries. Aside from this latter group, all groups experience an increase in this material category up until the crisis and a decline in the annual consumption thereafter. However, how long this decline lasts and what follows it, does differ: By 2020, non-metallic mineral consumption in the Nordic countries has returned to a similar value as the one observable in 2000 (13 t/cap). The Eastern countries have experienced growth in their non-metallic mineral consumption to approximately 11.5 t/cap in 2020, while the Central countries consumed approximately 6 and the Mediterranean approximately 4.5 t/cap.

These noticeable patterns on the level of the material categories also translate into relative homogeneity in the country groups in the period following the crisis. In Section 3.3 (Fig. 4), we noted that inequality in metabolic rate, material intensity, and income within the European Union has been increasing sharply since the 2007/8 economic crisis. Based on the groupings of member states identified in this section, we find that during the two decades under investigation here, the differences between these four groupings have become more meaningful by the end of the period under investigation. On the one hand, this supports the discussion, which we will later return to, as to whether the increasing inequalities within the European Union, especially concerning the impacts of crisis, may be detrimental to the "economic, social and territorial cohesion" of the Union's common provisions (Treaty of Lisbon amending the Treaty on European Union and the Treaty establishing the European Community, signed at Lisbon, 13 December *2007*, 2007). On the other hand, this is a finding that also supports the country groupings as a valid form of complexity reduction when it comes to the interpretation of developments in the European Union. Based in eq. 3 (Section 2) and as is visualized in Fig. 7, rising material inequality amongst the EU-27 member states in the wake of economic crisis (cf. Fig. 4) coincides with an increasing relevance of the country groupings in explaining that inequality. In 2007, 75 % of material inequality amongst the EU-27 could be explained by differences *within* the four country groupings we've identified: In the period leading up to the crisis, the country groupings would not have been meaningful and, in fact, grouping countries this way would have masked some of the inequalities *within* the groups. This share decreases from 2007 onwards and by the end of the time series (2020), 78 % of EU-wide material inequality can be explained by differences *between* the four country groups such that these groups have become very meaningful in explaining overall European material inequality. The critical phase for this shift lies in the second sup-period we have identified (from 2007 to 2013).

3.5. Results summary

Our analysis of Europe's material flows preceding and following the economic crisis of 2007/8 has shown that this crisis obviously had quite an impact on the material requirements of production within the EU-27, with a notable decrease in per capita material consumption between 2007 and the end of the period under investigation here, 2020. This

[4] We cannot offer an in-depth analysis of Cyprus' construction activity here, but the year 2008 does represent the culmination of a noticeable boom in construction activity, especially for housing in urban areas (Şafakli, 2011).

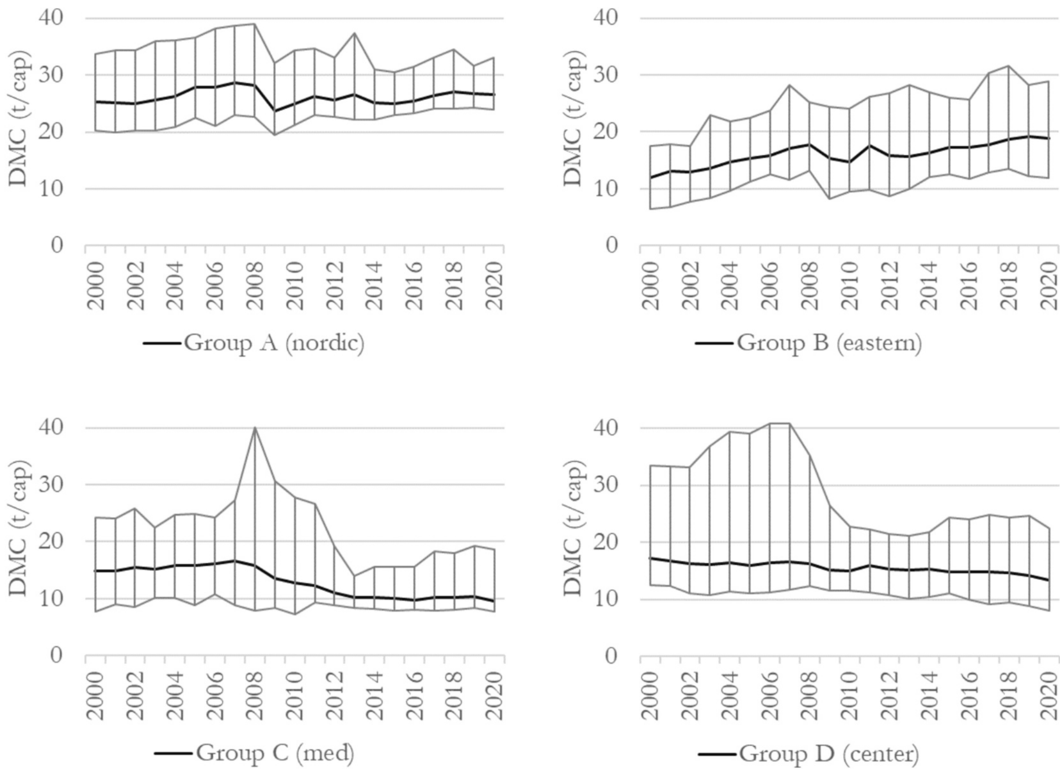

Fig. 5. Material consumption (DMC = extraction plus imports minus exports) in tons per capita (t/cap) in four country groupings of the EU-27 countries, 2000–2020. The drop lines indicate the maximum and minimum values for material consumption in each grouping and year.

change in the material trajectory adds a layer of information to what can be seen when considering economic 'performance' as measured by GDP, which experiences only a brief dip and then resumes its growth trajectory (Fig. 1). In Europe, lower material consumption was mainly driven by a drop in bulk construction materials, which had grown before the crisis (2000–2007, Fig. 2). The metabolic rate, that is, material consumption per capita can be analyzed as the product of average per capita GDP and material productivity, measured as DMC/GDP. When it is thus decomposed, we find that the driving force behind the reductions in the metabolic rate following the economic crisis was (increased) material productivity rather than per capita GDP – which, in fact, would have ceteris paribus caused the metabolic rate to increase after the crisis (Fig. 3). Not only did the average European metabolic rate decrease following the crisis, but its downward trajectory was also associated with increasing inequality – as measured by the Theil index – in per capita material consumption and in material productivity amongst the EU-27 (Fig. 4). This rising inequality was not evenly 'dispersed' amongst the 27 EU member states but was (increasingly, Fig. 7) the result of distinct country groups (we identify four: the Nordic, Eastern, Central, and Mediterranean countries) following similar patterns with regards to their material use (Fig. 5). As was perhaps to be expected, based on the importance of non-metallic minerals in explaining the material flows at the European level, one of the key differences amongst the country groups is their consumption of non-metallic minerals (Fig. 6).

4. Discussion: future crises in the making

In light of our aim to provide the socio-metabolic perspective that an ecological economics approach to the 2007/8 economic crisis in Europe requires, several themes stand out prominently when we consider the role of material developments leading up to and following the 'Great Recession'. The most prominent is perhaps that of increasing inequality amongst the EU-27 member states after the crisis. As we have demonstrated, this inequality in material terms is very strongly tied to the consumption of construction minerals (included in our analysis as non-metallic minerals) and thereby to questions of not just which materials are being used in which amounts but also to what end. We question whether the material efficiency gains made in Europe during this period are meaningful if they led to rising inequality. Can these gains truly contribute to the socio-ecological transformations we need?

4.1. *Stability in the face of inequality?*

At first glance, the development of the EU-27's metabolic rate between 2000 and 2020 is reminiscent in the pattern of the post-World War II growth in material consumption and the stagnation of the 1970s (Wiedenhofer et al., 2013). While this phase in the 1970s has sometimes been referred to as 'stability' in (per capita) resource consumption, our analysis suggests that this trend, when disaggregated, does not signal stability for the EU, but increasing inequality within the Union. The phase of stagnating per capita material resource consumption at the European level following the 2007/8 crisis is the result not only of greater off-shoring of material- and energy-intensive production for final consumption in Europe to third-party countries (Giljum et al., 2016) but also, as we have shown, of widely diverging patterns within the EU. This is signaled by increasing inequality, as measured by the Theil index, in per capita material consumption of the EU-27, especially from 2009 onwards, and by the fact that four geographical country groupings (Nordic, Central, Eastern, and Mediterranean countries) become more meaningful in explaining this inequality from the crisis onwards. Until 2007, most of the (lower) inequality within the EU-27 could be explained by inequalities within these geographical groupings. But the rise in inequality following the crisis coincides with the groupings becoming increasingly meaningful until most of the observable inequality occurs within (rather than between) these groupings.

Not only can significant differences in per capita consumption be observed, with the metabolic rate ranging from above 20 t/cap/a in the Nordic countries to below 10 t/cap/a in the Mediterranean, but the

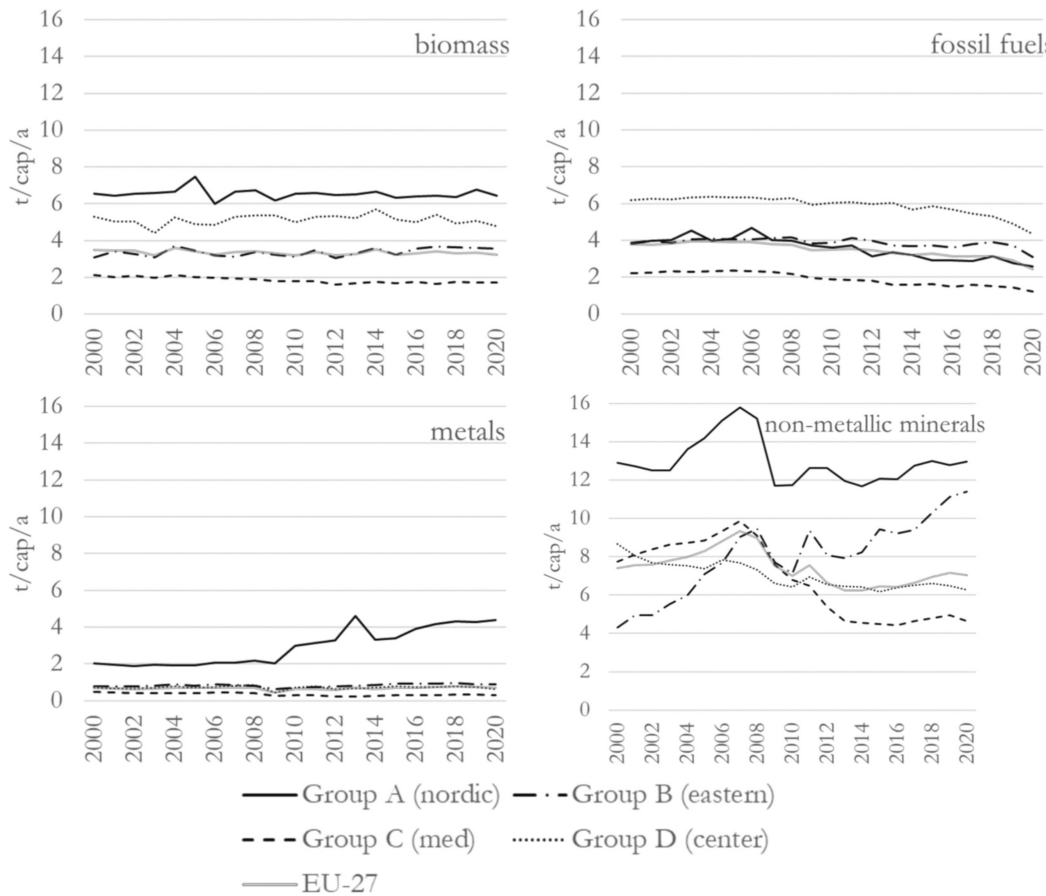

Fig. 6. Domestic consumption (DMC) of biomass (top left), fossil fuels (top right), metals (bottom left), and non-metallic minerals (bottom right) in the four groups of the EU-27 member states and for the EU-27 average between 2000 and 2020 in tons per capita and year (t/cap/a).

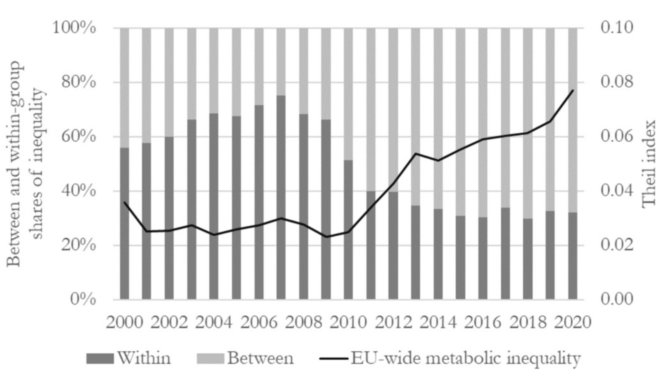

Fig. 7. Decomposition of the metabolic inequality (Theil index of per capita domestic material consumption, secondary y-axis) amongst the EU-27 member states into the inequality **within** and **between** the four country groupings (primary y-axis) between 2000 and 2020.

trends in metabolic rates also differ and neither the increasing material consumption leading up to the crisis nor the stagnation following it, for the EU-27 average, were experienced by all countries. Instead, the growth prior to the crisis was mainly the result of an increased metabolic rate in the Eastern countries and a slighter increase (albeit at a high level) in the Nordic countries, while both the Mediterranean and the Center countries already experienced stagnation during this period. Following the crisis, the average stagnation of the metabolic rate for the EU-27 was the result of significant decreases in per capita material consumption in the Mediterranean countries and slight reductions in the Center, while both the Nordic and the Eastern countries, after the first impact of the crisis, experienced increases that returned them to their 2000 level of consumption, or even above. Our data series ends in 2020 so that it is difficult to say what the impact of the other crisis occurring during this period, the Covid-19 pandemic, was on the observable patterns of material resource use of the EU-27 member states. What does seem likely, based on the one data point we have per country for 2020 is that this crisis, too, did not affect all EU member states in the same way: The Nordic countries experienced the slightest decrease in their average metabolic rate between 2019 and 2020 (by 0.2 t/cap), followed by the Eastern countries (−0.4 t/cap); for the Mediterranean (−0.8 t/cap) and the Central countries (−0.9 t/cap), the initial impact looks more severe. Of course, it is possible that this new crisis would require us to reconsider whether the geographic country groupings continue to hold explanatory power for the potentially resulting inequalities. What can be said with certainty, however, is that we must expect further socio-economic crises in the future, which will have an impact on patterns of resource use and hence on our environment, including through the responses to the crisis (cf. Wood, 2016). Barring far-reaching systemic change, crises may continue to exacerbate inequalities. In our analysis, we have shown that although the four country groupings held quite some explanatory power, there were also significant differences between the countries within these groupings. And, of course, if we were to become more granular in our analysis, we would expect to find inequalities at the subnational level in how the population shares in or is excluded from the benefits and services derived from the national average levels of material consumption. Beyond the scope of our analysis here, these subnational inequalities could be expected to lead to additional instability, especially in the face of further crises. At the same time, so long as crisis responses focus specifically on economic growth for growth's sake, we must also ask what impact this has on the efficacy of environmental policies: If, when in doubt, the response to an economic crisis is to incentivize construction activity, including of fossil-fueled structures, then what does this mean for our chances of achieving much-needed drastic reductions in greenhouse gas emissions?

4.2. Constructing resource use

The divergences in the patterns of resource use exhibited by the EU-27 member countries during this period were not limited to the *levels* of the metabolic rate. In this study, we also pointed to the prominent differences in the *composition* of material consumption and to the role of non-metallic minerals, that is, in particular, of construction minerals. This type of consumption was critical in explaining the differences between the country groupings. Leading up to the crisis, all country groupings except for the Center experienced pronounced growth in per capita consumption of non-metallic minerals and in all country groupings, this consumption category took a plunge after the crisis. This is in line with the severe impact the crisis had on construction activity, not just in Spain (Schaffartzik and Duro, 2022) but across the European Union. However, while the Nordic and Eastern countries resumed their pre-crisis growth in non-metallic mineral consumption relatively quickly (from 2010 onwards), the countries of the Center as well as the Mediterranean countries continued to experience a decline in this category of consumption.

We turn our attention to non-metallic minerals not only because of their dominance in terms of consumption in units of mass, but also because of their potential legacy effects. Construction minerals used now have the potential to heavily impact future resource use (Krausmann et al., 2020): It can be expected to make a tremendous difference whether and where additional land is built-up and roads for individual motorized transport (Mattioli et al., 2020) or airports and (additional) runways are built, whether and where buildings for accommodation are constructed and how well insulated they are. In fact, such decisions in terms of investments and construction activity have the potential to derail (quite literally) existing environmental policies. Fixed capital assets often lock in resource use patterns (Schaffartzik et al., 2021), making it harder to meet emission reduction targets, especially if investments focus on fossil-fueled areas. But these types of lock-in effects are not only problematic from an environmental perspective (from which they perpetuate extractive expansion and destruction as well as the generation of wastes and emissions), they are also highly concerning in light of the limited availability of any and all resources on a physically finite planet. What are the implications of us globally carrying out the transition *to* fossil energy systems (Schaffartzik and Fischer-Kowalski, 2018), not only in light of the climate crisis, but also of the ultimately limited availability of fossil fuels? Wars, conflicts, and crises and the corresponding impacts on material and energy supply chains will eventually force reduced and drastically altered material use patterns, but at what cost? Through their role in the material stocks we build up, non-metallic minerals play a pivotal role here and require us to go beyond what we have been able to offer in this article: An understanding is required not just of levels of use and phases and inequalities therein, but also of what construction materials are used for: Whether they are integrated into public transport networks or systems of runways and airports makes a huge difference for the sustainability of the associated provisioning of mobility, for instance. In the context of economic crises, we may be able to see especially clearly the extent to which construction activity is driven by post-crisis stimulus packages (as was the case in Spain, see Schaffartzik and Duro, 2022), rather than by the needs of the population for the provisioning of services in an environmentally sustainable and socially just manner. Further advancing such research might eventually also allow us to better explain the (time-lagged) link between non-metallic mineral and fossil fuel use that the large, international material flow data sets (such as the data used for this analysis: Eurostat, 2023a; but also the long-term international database introduced here: Schaffartzik et al., 2014) seem to suggest but that has, to the best of our knowledge, not yet been rigorously tested analytically. This, however, would be important to uncover if we are to have a chance at mainstreaming into resource use decisions the need to drastically reduce fossil fuel use.

4.3. Material efficiency at the cost of inequality

What we have discussed up until this point is focused on the underlying material use patterns surrounding the 2007/8 economic crisis in Europe and how they reveal that the 'European project' in its current form may be marked by stark and growing inequalities, for which we have provided evidence at the international level. This, we think, is important in terms of alerting us to the potential for future crises and conflicts. We would be remiss, however, not to consider that – even if we focus very narrowly on the time frame, the geography, and the level of data aggregation covered in our analysis – such crises and conflicts are no longer a remote future possibility. As we outlined in the introduction, research on the 2007/8 crisis in Europe has already revealed considerable subnational inequalities as a result of the crisis and related austerity measures (Cuadrado-Roura et al., 2016; Perugini et al., 2019; Sánchez-Mira and O'Reilly, 2019). So, not only is the curbing of (per capita) material resource use post-crisis not shared by all European countries and country groupings as previously discussed, but it also comes at an unacceptable social cost. This, in turn, must lead us to question whether the rise in material productivity that the EU-27 has experienced as the result of growth in GDP far outstripping growth in material consumption (cf. Fig. 1), is evidence of Europe becoming more resource-efficient, not only in terms of the ability to generate GDP but also and more importantly in achieving s good life for all within planetary boundaries (cf. O'Neill et al., 2018). While it can certainly be argued that at the level of aggregation at which we operate in this study, it is difficult and perhaps impossible to assess whether or not we are looking at relative decoupling between GDP and DMC that might be the precursor to much needed absolute dematerialization at the European level, the fact that we were able to show that these gains in material productivity coincided with increasing inequality in the EU-27, both in material terms (metabolic rate) and monetary terms (average income; see Fig. 4), should perhaps lead us to more critically view the drivers of the observable efficiency gains. Further research into this field might also consider the role of sector-specific adoption of technology (and so-called innovation) in structural change and perhaps even in economic crisis.

5. Conclusions

In the face of multiple, intersecting socio-ecological crises worldwide, urgently needed transformations are required both from a social and an ecological perspective, they must be *socio-ecological*. At the same time, our own research and that of others (Schaffartzik and Duro, 2022; Shao et al., 2017; Wu et al., 2019) suggests the most notable changes in resource consumption patterns occur not as the result of a well thought-out and implemented plan to prioritize basic human needs with the minimal environmental impact possible, but occur in the face of crisis and conflicts, at tremendous cost to large parts of the human population. This generally holds true for European experiences around the 2007/8 crisis as well. What is more, the observable stabilization of European resource consumption at the aggregate level post-2008 was, as we have shown, the result of quite disparate developments within the European Union.

The analysis of country-level trends in material consumption reveals significant differences not only in the levels of consumption but also in the trajectories of recovery and decline amongst the four groupings of European countries (Nordic, Eastern, Mediterranean, and Central). These differences point to deeper structural issues within the European Union, highlighting the uneven socio-economic and environmental impacts of the 2007/8 economic crisis. The Mediterranean countries (Group C), with their sharp and prolonged decline in material consumption, suggest a high degree of vulnerability to economic shocks, particularly in sectors like construction that are heavily tied to non-metallic mineral consumption. The reliance on infrastructure-driven growth could make these economies more susceptible to future crises. In contrast, the relatively quick recovery of the Nordic countries (Group A) in material consumption points to greater resilience, although we question the desirability of 'bouncing back' to high levels of consumption.

The disparities in metabolic rates between countries highlight growing inequality within the EU, which, if left unchecked, could threaten the "economic, social, and territorial cohesion" that is foundational to the Union. The increasing divergence between the groups—especially the Nordic and Eastern countries' relative recovery compared to the Mediterranean and Central groups—suggests that future crises could further deepen existing inequalities, both in economic terms and in resource distribution. This is additionally true for material inequality between the EU and the rest of the world and requires (in addition to what we have covered here) an analysis of off-shoring of particularly material- and energy-intensive steps of production from the Global North (Giljum et al., 2014), especially in times of economic crisis. While our work – which did not consider trade directly and much less track bilateral trade flows – does not directly address this issue, it does also lead us to question what actually underpins the European project. If growth and/or sustained wealth in some member states systematically coincides with much greater material and monetary impacts elsewhere, then this development trajectory potentially intensifies future crises and conflicts. Finally, our study focused on *material* inequalities, and we recognize that the relationship between material and social inequalities is complex and may involve bidirectional causality. Future research using econometric approaches could help clarify these dynamics and further enhance our understanding of their interaction.

The grouping of countries into four regional blocks reveals valuable insights into shared trajectories within Europe. However, the internal heterogeneity of each group, especially in terms of population size, GDP, and material consumption, suggests that country-specific factors still play a significant role. The broader geographic groupings help to simplify the analysis, but the distinct national differences within these groups—such as Finland's significantly higher metabolic rate within the Nordic group—highlight the need for more granular, country-level analysis when designing policy interventions. The dominance of non-metallic minerals across all country groups, and especially in the Mediterranean, points to the significant environmental costs associated with traditional forms of economic recovery, such as infrastructure development. This type of resource use, often incentivized by stimulus packages, locks countries into resource-intensive development patterns that may undermine long-term sustainability goals, including efforts to reduce emissions and limit resource extraction. Our findings suggest that any and all policy measures taken now (especially including austerity packages and other incentives for economic growth in times of crisis) must be assessed in terms of their environmental and social impact. Socio-ecological transformations must be economy-wide, holistic projects that cannot be limited to the 'core domains' of environmental policy.

CRediT authorship contribution statement

Anke Schaffartzik: Writing – review & editing, Writing – original draft, Visualization, Investigation, Data curation, Conceptualization. **Juan Antonio Duro:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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