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ASSESSING THE IMPACT OF MEGATRENDS ON REGIONAL INDUSTRIAL TRANSFORMATIONS

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ASSESSING THE IMPACTS OF MEGATRENDS ON REGIONAL INDUSTRIAL TRANSFORMATIONS

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Abstract

Megatrends are long-term, ubiquitous, global and robust transformations influencing the developments of business, environment, economy, society, cultures and citizens' lives on a local and global scale. There is an important grey literature focusing on these megatrends and their impacts. However, this analysis is often not territorialized, despite the gradient of consequences that megatrends might have at the regional level. This working paper proposes a methodological approach combining qualitative insights (including foresight scenarios) and quantitative data to regionalize the impacts of a series of megatrends and types of impacts. This approach is then applied to a sample of megatrends and types of impacts at the EU level.

Findings suggest that the megatrends' impacts are not place-neutral in the EU context and that patterns of the most/least affected regions depend on the individual megatrend. Indeed, different patterns can be observed (e.g., North/South, East/West, urban/non-urban, quasi-homogeneous impacts), often in opposite directions for different megatrends. Moreover, the regional level of development cannot be used as a reliable predictor of the impacts, as the correlation may be positive, negative or even inexistent depending on the megatrend.

Key words: megatrends, EU regions, foresight analysis, impact assessment, technological change, sustainable development, transportation, cities

JEL codes: O18, R11, R58

NOTE:

This working paper has been drafted before the COVID-19 pandemic and thus does not explicitly consider this event's influence on the megatrends and their impacts. However, the pandemic's expected consequences are likely to be consistent with the trends highlighted in this paper. Moreover, the developed methodological framework is suitable for further updates.

1. Introduction

Technologies such as automation and artificial intelligence have been at the center of scholarly and popular interest in the 2010s, with a core focus on their potential impacts on employment, growth and productivity (See, for instance, Acemoglu and Restrepo, 2018; McKinsey Global Institute, 2017; OECD, 2016). More generally, this attention extends to several other transformative forces affecting socio-economic systems, such as urbanization (McKinsey Global Institute, 2012; OECD and CDRF, 2010) or energy and environmental challenges (European Environment Agency, 2014; OECD, 2011b). Collectively, these transformations can be analyzed using the concept of global megatrends, i.e. "large social, economic, political, environmental or technological changes that are slow to form but continue relentlessly over several economic cycles" (Naisbitt, 1982). A key advantage of using megatrends for business and policy-making is their possible incorporation into foresight and forecasting approaches (using different sources of evidence/intelligence) for future-oriented planning and decision-making (Arthur D Little, 2014).

There is an extensive academic and grey literature on megatrends and their impacts, as recently reviewed by the authors in the context of the European Observatory of Clusters and Industrial Change for the European Commission (EOCIC, 2019) and additional documents (see Annex A – Selected list of references for literature review).

However, megatrends' regional or local dimensions are rarely mentioned by this existing literature, even if it is clear that megatrends will have differentiated effects across regions, including those lacking an explicit territorial dimension (OECD, 2019). In particular, EU regions are likely to be in this situation, as they have various levels of economic development (European Commission, 2017) while sharing political and economic institutions (e.g., common market). The few existing studies aiming at understanding the territorial dimension of megatrends are performed through economic modelling such as RHOMOLO (JRC, 2019; OECD, 2019) or estimation through a combination of expert knowledge on sectoral impacts and regional employment data (OECD, 2018). These recent studies bring valuable information to understand how megatrends might transform specific regions to a different extent. However, they do not feature a unified framework to compare diverse megatrends and consider several types of policy-relevant economic impacts (e.g., employment and changes in terms of business organization or market dynamics). Considering the territorial dimensions of impacts that are difficult to quantify objectively but are major consequences of megatrends (e.g., shifts in business organization and practices) would be a valuable addition to the existing body of knowledge.

This paper proposes a methodology to assess the economic impacts of megatrends at the level of regions, that is flexible enough to account for a diversity of impacts and compatible with credible scenarios explaining how these impacts might materialize. The developed methodology is then applied at the level of EU regions to a sample of megatrends that are commonly addressed in the literature, namely:

- Digital and New Production Technologies: including key technologies and their socio-economic aspects (e.g., automation, artificial intelligence, mass customization technologies, robotics, cybersecurity technologies and blockchain…)
- Sustainable Economy Transition: including adaptation to climate change, energy issues, resource scarcity, alternate models of production (e.g., recycling, reusing...)
- Urban-centered world and Smart Mobility: including urbanization, decentralization, smart cities, new models of mobility (e.g., electric and autonomous vehicles, mobility as a service…).

Regarding the types of impacts, the assessment will cover the following dimensions:

- Changes in Business organization: megatrends may transform business organization by fueling different shifts, such as in business models, production or operational organization, technological integration, team/HR management, linkages with the education and training system…
- Creation, destruction or transformation of Markets: megatrends may promote or impede the development of new or existing markets (or market segments) by affecting both supply and demand.
- Shifts in Employment: megatrends may affect the number of employed persons in particular industries, mainly because of technological advances or organizational changes.

Regional impacts estimated for these megatrends are then described and discussed, highlighting the potential insights for public policies. In particular, elements on the identification of most/least affected regions and their characteristics are proposed. The developed method may be extended to other megatrends and/or types of impacts.

2. Methodological approach

2.1. Overall framework

There are different approaches to assess the impacts of megatrends, with various advantages and pitfalls. Purely quantitative approaches such as econometrics or mathematical modelling (e.g., the EU RHOMOLO model, see JRC, 2019) derive insights from a series of assumptions (e.g., on the likely effect of automation on a production function), which may be challenging to reconcile with the complex developments involved in megatrends. Such an approach might thus only be plausible for specific types of impacts and/or megatrends. Similarly, purely qualitative methodologies are not well adapted to assign the impacts of megatrends to many situations in a comparable and systematic way, e.g., between regions. This paper develops a unified framework that can cover multiple megatrends and types of impacts in a coherent way to derive regionalized insights on the effects of megatrends at the 2050 horizon. The methodology here proposed relies on a mixed approach combining qualitative and quantitative tools, thus circumventing limits of purely quantitative or qualitative approaches.

The methodology is based on two building blocks:

- A qualitative one, consisting of the development of foresight scenarios for each megatrend covered by the analysis. Foresight scenarios depict the most credible/likely evolution of megatrends until 2050, making the expected impacts of megatrends and the logical linkages between different types of effects explicit. This analysis builds on a critical literature review and consultation with relevant stakeholders. The extent to which each megatrend is expected to affect specific industrial sectors is assessed through a qualitative rating system.
- A quantitative one, consisting in using employment data at the sectoral level to move from a qualitative impact assessment to a regionalized assessment

This framework rests on the following core assumptions:

(i) It is possible to estimate the economic impacts of megatrends at the sectoral level based on the (observable) characteristics of industrial sectors. This assumption is uncontroversial in the literature of megatrends, as a wide variety of publications routinely assesses their impacts on given sectors. It stems from the fact that individual sectors have similarities that transcend their potential heterogeneities.

(ii) The evolution of the regional economic situations induced by megatrends can be assessed based on the weight of the different sectors in their economy (at the current period, i.e., in the 2010s). Indeed, the more (less) a sector weights in a regional economy, the higher (lower) its evolution will affect the regional economic situation as a whole. Even if the weight of sectors tends to change at the regional level across time, the fact that sectors are likely to boom or decline because of the megatrends is captured by the qualitative assessment of impacts. The rise of entirely new sectors (not considered in the analysis) provoked by the megatrends is probably not random (i.e., depends on the existing regional economic structures) and therefore linked to the evolution of other sectors. However, a limit of this assumption is that it does not allow to capture how specific combinations of interactions between sectors at the regional level might affect the extent of the regional economic transformation across time. Indeed, specific levels of dependencies or complementarities between sectors might strengthen or reduce the deviation from the current situation at the regional level. This issue is mitigated by the fact that the qualitative assessment of impacts shall consider logical linkages between sectors (e.g., the development of downstream markets in a given value chain shall boost the development of related upstream activities). Moreover, other factors influence the economic transformation of specific sectors than their interactions at the regional level (e.g., competition pressure, national/supranational regulations…), and they are likely predominant.

(iii) Regional employment data is a good proxy of the importance of sectors at the regional level. This assumption is commonly used for studies investigating economic specialization at the regional level. It has also been used in previous studies assessing the impacts of megatrends in territories (as found in OECD, 2018, for example). Moreover, we are not aware of any rationale implying that potential alternative proxies (e.g., share of production) would lead to better performance or fewer biases.

A detailed description of the building blocks of the methodology is provided in the following sections.

2.2. Foresight scenarios and qualitative impact assessment

Foresight scenarios are conceptual futures, as opposed to the actual (and by definition unpredictable) future, relying on paths of developments, logical linkages and risks/uncertainties stemming from the currently available information (Kosow Hannah and Gassner, 2007). A straightforward method to concretize this approach is to rely on a theory of cause and effects (EOCIC, 2019; UNIDO, 2004), building on logical linkages between processes at play and collecting information from an extensive literature review. Both academic and grey literature, including consultancy reports, are valuable sources. Findings from the literature can be complemented and enriched by experts' opinions, e.g., collected through interviews or surveys.

Thanks to these foresight scenarios, the potential impacts of the different megatrends can be derived, with insights for specific industrial sectors. As the assessment of impacts is performed at the sectoral level, it assumes that the extent to which the economic situation linked to a specific sector will change between 2010 and 2050 will be of a comparable relative magnitude across the different regions. It does not imply that the initial and expected economic situations of the different sectors are and will be identical across the regions, but rather that the *relative deviation* between these two points of time will be comparable. Several arguments can be used to justify that claim. First, the existing differences of economic situation linked to sectors across the different regions in 2010 can reasonably be considered as relatively small compared to the transformations that can be induced by megatrends over 40 years, especially for the highly developed regions. Then, the assessment of the deviation of the economic situation linked to specific sectors (along with the different types of impacts) uses an ordered scale focusing on *relative change* that is compatible with a disparity of initial situations:

- Marginal evolution: the economic situation linked to the sector will only face a marginal degree of transformation between the 2010s and 2050 under the foresight scenario (e.g., minimal changes in business organization, stability of employment…)
- Moderate "minus" evolution: intermediate level between marginal and moderate evolution
- Moderate evolution: the economic situation linked to the sector will face a moderate degree of transformation between the 2010s and 2050 under the foresight scenario (e.g., remarkable transformation of some areas of business organization without complete redefinition of the traditional operations, noticeable innovation in products or services proposed…)
- Moderate "plus" evolution: intermediate level between moderate and massive evolution
- Massive evolution: the economic situation linked to the sector will face a major degree of transformation between the 2010s and 2050 under the foresight scenario (e.g., substantial gains or losses in employment, large-scale introduction of skills requirements previously unknown in the industry…)

This scale is also applicable to a wide variety of types of impacts and megatrends, consistently with the aim of the methodological approach. It should be noted that this assessment makes no assumption regarding the direction of change, i.e., whether it can be considered as "positive" or "negative". Indeed, the objective of the study is to identify the degree of economic transformation faced by the different regions (i.e., which will experience more or less radical changes as compared to the current situation), rather than the potential "winners" and "losers" of megatrends. Such an approach has a subjective dimension, which is mitigated by the reliance on multiple sources of evidence. Moreover, some transformations of the economy can potentially be attributed to more than one megatrend. To avoid overlaps and double counting, the qualitative assessment of impacts shall be performed by focusing on those that are directly associated with the underlying logic of the megatrend. This assessment shall be carried out for all considered sectors for a given megatrend and type of impact.

2.3. Quantification of impacts at the sectoral and regional level

The qualitative impact assessment must be quantified to ensure regionalization. First of all, each level of impact of the previously described ordered qualitative scale can be converted into a numeric value, from 0 (representing an absence of change of the economic situation due to the megatrend) to 100 (representing a radical transformation).

Table 1. Assignment of numeric values to qualitative impacts

Qualitative impact	Numeric impact
Minor	0
Moderate minus	25
Moderate	50
Moderate plus	75
Major	100

Source: Authors' elaboration

Second, using the regional sectoral employment data and the previously quantified sectoral impacts, it is possible to derive a regional impact score for each type of impact $r_{i,t,m}$ using the following equation:

$$r_{i,t,m} = \sum_{n=1}^{N} (s_{n,t,m} \times \frac{emp_{n,i}}{emp_i})$$

Where i, m, n, t are subscripts for regions, megatrend, economic sectors and types of impacts, respectively; $s_{n,t,m}$ is the impact numeric score for a given sector, type of impact and megatrend; $emp_{n,i}$ is the regional sectoral employment and emp_i is total regional employment. Regional employment data at the sectoral level are retrieved from Eurostat for a total of 39 sectors, as explained in the following section.

This score also ranges from 0 to 100. In terms of interpretation, the higher the regional score, the more substantial the alteration of the regional economic situation for that impact as compared to the present situation. The regional scores can be interpreted using the original qualitative scale.

3. Application of the methodology to a sample of three megatrends

In this section, the previously outlined methodological approach is applied to the three megatrends, namely Digital and New Production Technologies, Sustainable Economy Transition and Urban-centered world and Smart Mobility. Three types of impacts have been assessed for each megatrend: Changes in Business organization, Creation, destruction or transformation of Markets, Shifts in Employment.

3.1. Foresight scenarios and qualitative impact assessment at the sectoral level

The foresight scenarios have been derived using the literature collected in the framework of the European Observatory of Clusters and Industrial Change for the European Commission (EOCIC, 2019), completed with additional documents (see Annex A – Selected list of references for literature review). The following table summarizes the main features of the foresight scenarios developed for the megatrends, using an approach focusing on the most likely developments. They are consistent with the ones considered by the EOCIC report on megatrends, which includes a more extensive discussion on future developments (EOCIC, 2019).

Table 2. Synthetic presentation of the foresight scenarios

Megatrend	Core assumptions and developments	Situation by 2050	Key risks and uncertainties
Digital and New Production Technologies	• Strong R&D effort • Fast cost reduction of involved technologies • Customization and population ageing driving the adoption of related technologies • Good social acceptability • Adapted regulatory environment, balancing economic and social concerns • Rise of cyberthreats	• Ubiquity of connected devices • Integration of the customer in the production process • Development of a holistic cybersecurity culture • Generalized and synergetic use of digital and new production technologies • Automation of predictable physical tasks and some intellectual tasks • Human-machine advanced interactions • Adaptation of Human Resources, Training and Education systems • New models of connected and automated factory	• Limited social acceptability of technological change • Inequalities within and between countries • Pace of technological progress • Slow adaptation of the regulatory framework
Sustainable Economy Transition	• Strong R&D effort in supportive technologies • Rise in global energy and resource demand (due to rising population and living standards) • Rise in environmental concerns due to the degrading situation (resources, energy, biodiversity etc.) • Consolidation of environmental regulations	• Still largely fossil-backed energy mix with an increasing share of low-carbon solutions • Generalization of electric vehicles • Partial transition to advanced factory and value chains models (including circular and recycling-based ones) with an emphasis on energy and resource efficiency (different extent depending on the industrial sectors) • Significant adverse impacts of climate change	• Social acceptability of the different alternatives (e.g., strong environmental regulations…) • Speed and level of population and economic growth • Pace of technological progress • Scope of public policies in favor of the environment and disparities between countries
Urban centered-world and Smart Mobility	• Population growth[1] and migrations to urban areas • Urban areas as engines for economic growth • Increased demand for mobility • Rapid technological progress (smart cities, automated vehicles…) • Gradual increasing social acceptability of new mobility solutions	• Rising economic role of cities and increased importance in business strategies • Emergence of a global urban middle class • Development of integrated smart cities • Decentralization and multilevel governance involving cities and regions • Emergence of new models of mobility and logistics (mobility as a service, intermodality, automated and electrical vehicles…)	• Unexpected demographic patterns affecting urbanization • Pace of technological progress • Limited social acceptability, especially regarding the potential consequences of ICT in cities and transportation • Poor governance arrangements

[1] This pattern is true at the global level; population might peak in the EU in the following decades (2040s – 2050s)

Source: Authors' elaboration

As previously mentioned, these foresight scenarios do not constitute a prediction of the future but a snapshot of the likely developments using the most up-to-date information from the literature. As such, it can form a basis for analysis and discussion, subject to adjustments following the acquisition of new knowledge in the future. However, risks and biases have been mitigated by relying on a combination of multiple and distinct recent sources.

Thanks to these scenarios, the potential impacts of the different megatrends have been derived, with insights for specific industrial sectors (e.g., the development of cities and transportation would particularly affect the logistics and transportation sectors). In particular, the scenarios have been used to identify rationales linking the megatrends to industrial characteristics that are observable at the sectoral level. These rationales are used to identify which sectors are more or less likely to be affected by a megatrend for each type of impact (see Table B1 in the Annexes). The existing literature (that is consistent with the scenarios) has also been mobilized to obtain direct insights on the impacts for specific sectors.

Thanks to a triangulation of these different sources of evidence, a qualitative assessment of impacts at the sectoral level has been derived for the different megatrends. It is presented in a series of Tables (B3 to B5) in the Annexes. The granularity of the sectors is consistent with Eurostat's employment data (see the following section).

3.2. Quantification of impacts at the sectoral and regional level using Eurostat data

As this paper focuses on EU regions, the relevant data has been obtained through Eurostat. More precisely, regional employment data at the sectoral level has been retrieved from two complementary datasets available on the Eurostat website:

- Employed persons – number, from the Structural Business Statistics dataset (sbs_r_nuts06_r2) - SBS data by NUTS 2 regions and NACE Rev. 2 (from 2008 onwards). It was downloaded on the 26th of March 2019[2]. It compiles the number of employed persons[3] in different NACE sectors (Sections B to N and Division S95) at the national (NUTS 0) and regional level in the EU (NUTS 1 and 2) between 2008 and 2016. Section C (manufacturing) benefits from a high degree of granularity in this dataset.
- Employed persons, from the Employment by age, economic activity and NUTS 2 regions (NACE Rev. 2) 1000 dataset (lfst_r_lfe2en2). It was downloaded on the 23rd of May 2019[4]. It compiles the number of employed persons[5] in different NACE sectors (including Sections A, K, O-Q and R-U) at the national (NUTS 0) and regional level in the EU (NUTS 1 and 2) between 2008 and 2018.

As the first dataset (sbs_r_nuts06_r2) has the highest level of detail regarding individual sectors, it is considered as the primary source for this paper. The two datasets have been checked for missing values and potential outliers/errors. The most recent data present in both datasets (2016) has been retained for the analysis, with information at the regional level (NUTS 2 if possible, NUTS 1 otherwise[6]) for the highest number of sectors. Interpolation has been used to complete missing values. Finally, the two datasets have been combined into a single unified dataset, using the fact that lfst_r_lfe2en2 dataset also contains reliable information on the total employment at the regional level, considering all the NACE sectors (from A to U).

The sectoral employment data compiled by Eurostat uses the NACE nomenclature, with two levels of details (called Sections and subsections). All the NACE sectors are included in the analysis, though with different levels of detail. The level with the highest granularity is only retained for manufacturing sectors because they typically benefit from a relatively in-depth description of impacts in the literature and/or their specific sectoral characteristics can be more easily linked to the impacts of megatrends using rationales derived from the foresight scenarios (e.g., technological intensity, use of specific resources…). Some sectors are only available as a combination of multiple NACE Sections (e.g., O-P-Q). As such, the source datasets and final list of 39 sectors included in the analysis are presented in the Annexes (Table C1).

[2] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=sbs_r_nuts06_r2&lang=en

[3] Defined as the total number of persons who work in the observation unit (inclusive of working proprietors, partners working regularly in the unit and unpaid family workers), as well as persons who work outside the unit who belong to it and are paid by it (e.g. sales representatives, delivery personnel, repair and maintenance teams). It excludes manpower supplied to the unit by other enterprises, persons carrying out repair and maintenance work in the enquiry unit on behalf of other enterprises, as well as those on compulsory military service.

[4] https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=lfst_r_lfe2en2&lang=en

[5] Defined as all persons in private households between 15 and 64 years old (common definition of the working age population)

[6] NUTS 2 regions are used for all Member States, except Germany for which NUTS 1 regions are preferred due to extensive missing values at the NUTS 2 level. Mayotte (French overseas département) is excluded because of missing data. Iceland and Norway are included in the dataset.

The values for regional sectoral employment in the final consolidated database are briefly presented in the Annexes (Table C2). The analysis of these values (geographical distribution, shares of sectors corresponding to the major characteristics of the EU economy…) suggests that there are no major credibility issues with the consolidated database.

Following the collection of the regional sectoral employment data, numeric values have been assigned to the qualitative assessment described in the Annexes (Tables B2 to B4) using Table 1 mentioned in the methodological approach. Then, the regional impact scores have been computed using the formula outlined in section 2.3.

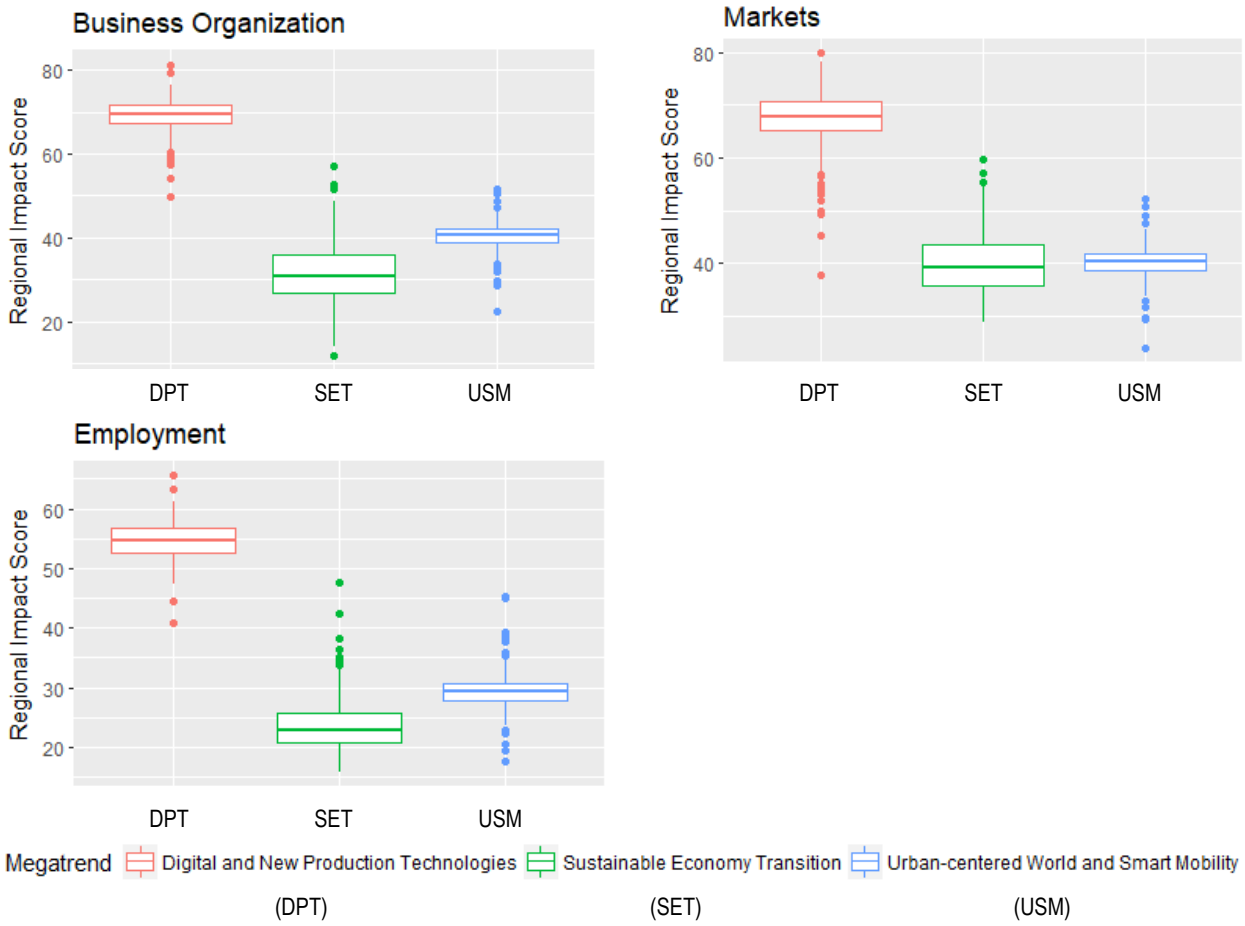
4. Results and discussion

The main results of the application of the methodology to the sample of three megatrends are first briefly presented using descriptive statistics. These results are then analyzed and discussed, highlighting key issues of interest (i.e., territorial disparities, linkages with levels of development).

4.1. Descriptive statistics

For the three megatrends under study, the regional impact scores can be summarized through different salient facts. Overall, some megatrends are likely to provoke more significant changes than others at the regional level (see Figure 1). It is expected because regional impact scores are based on foresight scenarios but also depend on the industrial structure of each region. In particular, the regional impact of Digital and New Production Technologies is much higher (close to the "moderate plus" qualitative assessment) compared to those of Sustainable Economy Transition and Urban-Centered World and Smart Mobility, regardless of the type of impact considered. Sustainable Economy Transition and Urban-Centered World and Smart Mobility are likely to have similar levels of impacts on markets (moderate influence). In contrast, Urban-Centered World and Smart Mobility could have a slightly greater influence on business organization and employment. Then, the distribution of regional impact scores also yields valuable findings. Indeed, the possible range of impacts varies greatly depending on the megatrend and type of impacts (see Figure 1).

Figure 1. Boxplots of the regional impact scores of the different megatrends by type of impacts



Source: Authors

Some megatrends are characterized by their relative heterogeneity of impacts, with a comparatively high range of possible effects depending on the EU regions. In particular, Sustainable Economy Transition seems to lead to this situation, with a standard deviation reaching as high as 7.2 points on the regional impact score scale for business organization. By contrast, other megatrends seem to have relatively uniform effects across the different EU regions, regardless of the type of impact. For instance, the Urban-Centered World and Smart Mobility megatrend features this pattern, with standard deviations close to 3 for all types of impacts (even though it has a significant number of outliers). Digital and New Production Technologies typically have a relatively homogenous influence on

the EU regions (standard deviations for business organization and employment ranging from 3 to 4), with a greater heterogeneity for markets (standard deviation of 5.5). Moreover, it has not only the highest average and median effects for all types of impacts but also the maximum recorded impact scores (the most affected regions for the three studied megatrends).

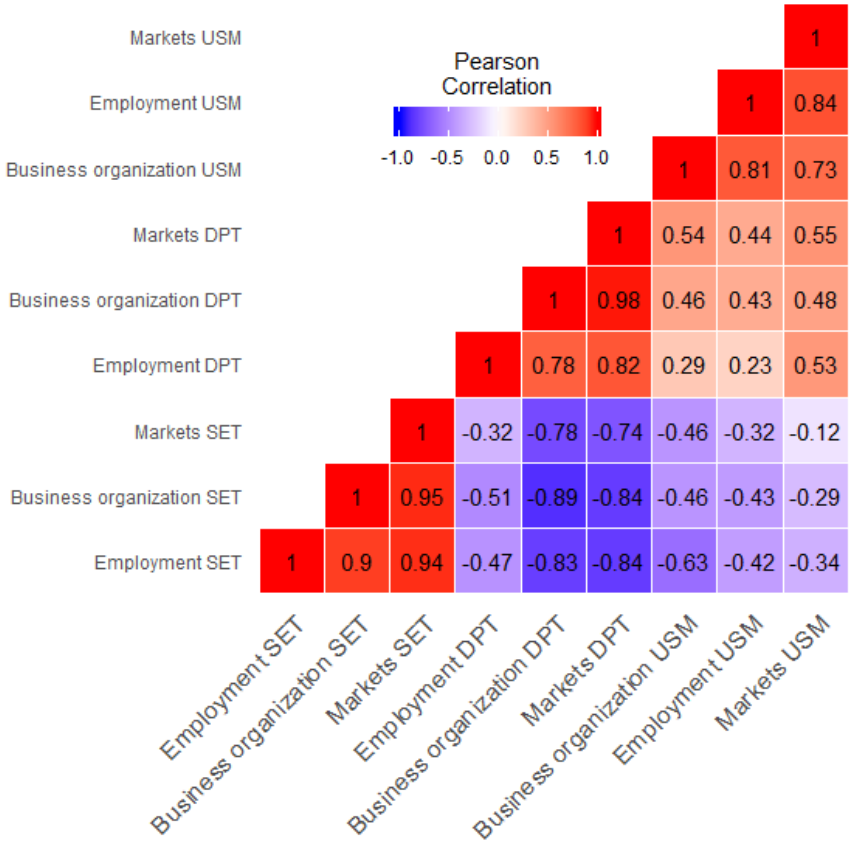
4.2. Analysis and discussion

The results derived from the methodology can be further analyzed to tackle highly policy-relevant issues. In particular, evidence can be obtained regarding:

- Whether a region tends to be affected to a similar extent by different megatrends
- Whether there are territorial patterns for the impacts of megatrends
- Whether the impacts of megatrends are linked to the regional level of development

It is relevant to analyze whether the most affected regions by one megatrend / one type of impact are also the most affected by others. Indeed, it can provide valuable information on the adequate approach to address these impacts, e.g., on the coverage of public policies to design and implement. Correlations between the impact scores at the regional level are presented in Figure 2.

Figure 2. Correlation of regional impact scores by megatrend and type of impact



Source: Authors

Note: USM = Urban-centered World and Smart Mobility, DPT = Digital and new Production Technologies, SET = Sustainable Economy Transition

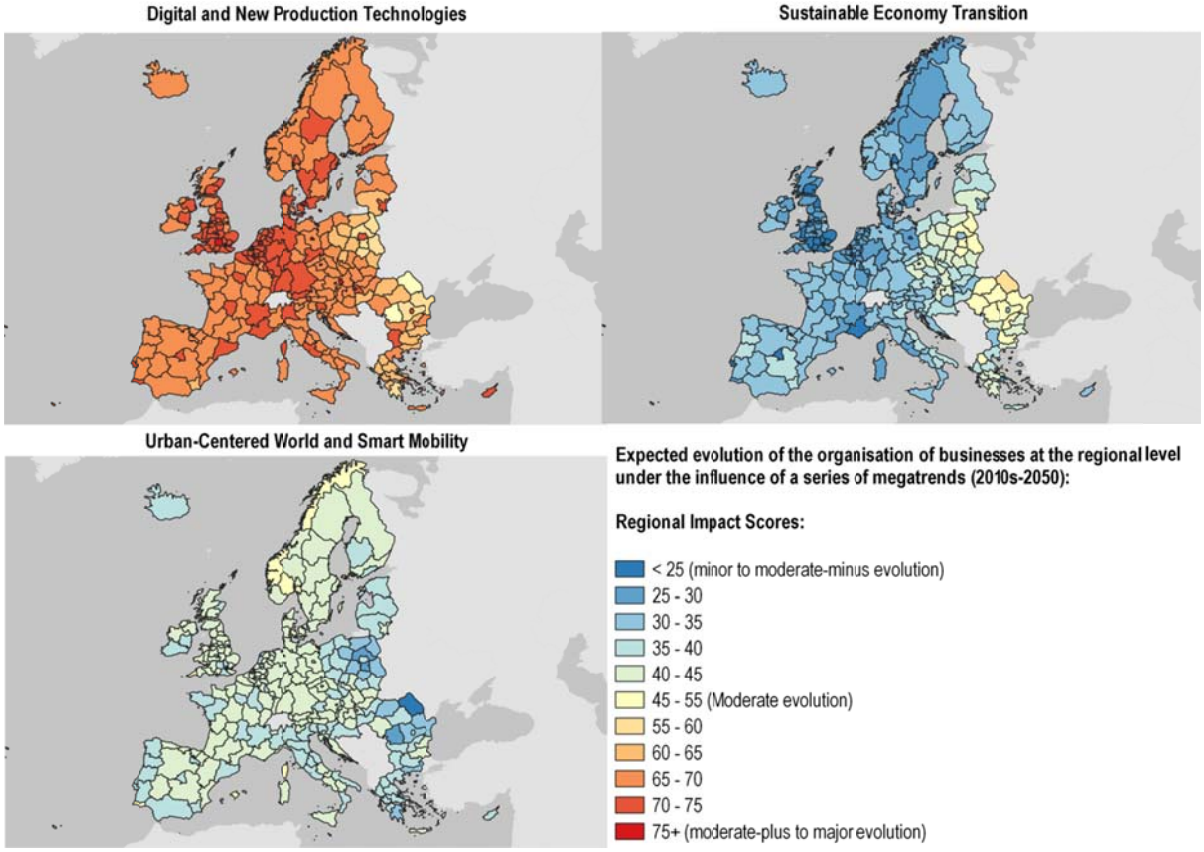
Firstly, within a given megatrend, there is clear evidence that regions that are more affected by a type of impact tend to be more affected by the other types of impacts. Indeed, correlation coefficients for these cases are all above 0.70. They are particularly strong (0.90 to 0.95) for the Sustainable Economy Transition megatrend and somewhat weaker – but still very high (0.73 to 0.84) - for the Urban-centered World and Smart Mobility megatrend. This suggests that when a region is strongly affected by a given megatrend, it tends to materialize through a range of different types of consequences.

Secondly, the regional impact scores exhibit various patterns between megatrends, meaning that the situation is not as systematic as within a single megatrend. Indeed, the correlation between regional impact scores across megatrends can be either positive or negative. For instance, regional impact scores for the Digital and New Production Technologies are positively correlated to those for

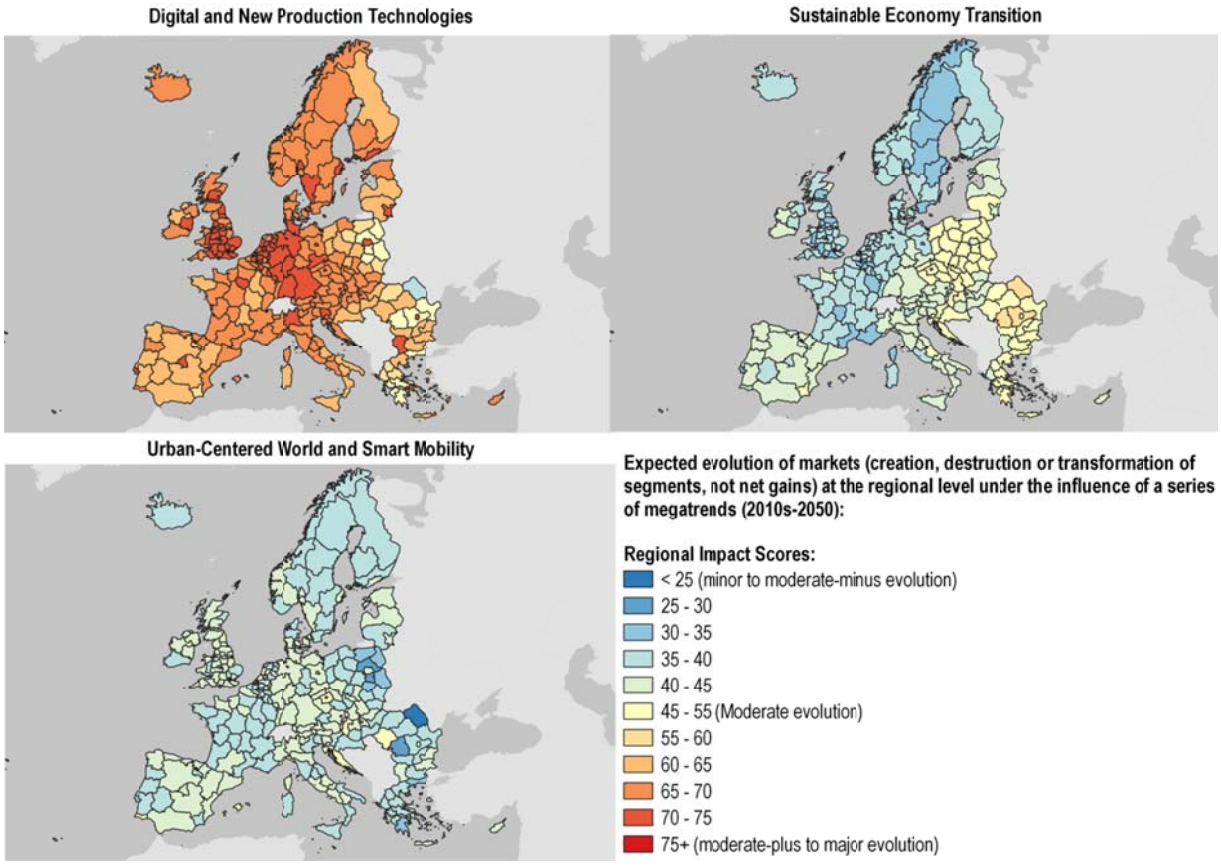
the Urban-centered World and Smart Mobility (from 0.23 to 0.55). Inversely, there is a negative correlation of regional impact scores between Sustainable Economy Transition and the two other megatrends (ranging from -0.12 to -0.89). Moreover, the strength of these correlations across megatrends is also varied, ranging from almost no correlation (e.g., -0.12 for the scores for the development of markets between Sustainable Economy Transition and Urban-Centered World and Smart Mobility) to very strong correlation (e.g., -0.89 for the scores for business organization between Digital and New Production Technologies and Sustainable Economy Transition). It suggests that strong impacts for a megatrend at the regional level cannot be systematically generalized for other megatrends, implying the need for megatrend-specific analyses.

Spatial analysis can be realized to reflect on potential disparities and cohesion issues linked to megatrends. The following maps present the territorial distribution of regional impact scores for the studied sample of megatrends and impacts.

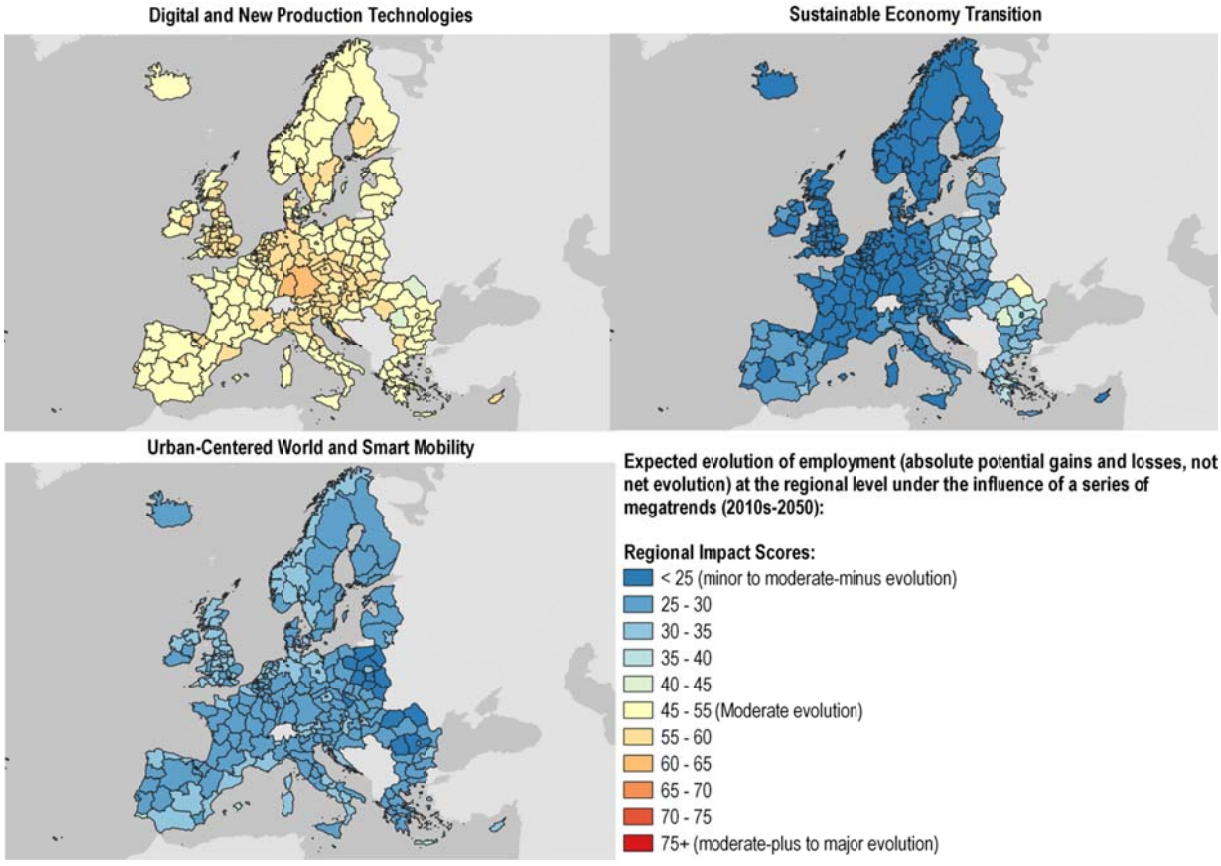
Map 1. Expected evolution of the organization of businesses at the regional level under the influence of a series of megatrends (2010s-2050)



Map 2. Expected evolution of markets at the regional level under the influence of a series of megatrends (2010s-2050)



Map 3. Expected evolution of employment at the regional level under the influence of a series of megatrends (2010s-2050)



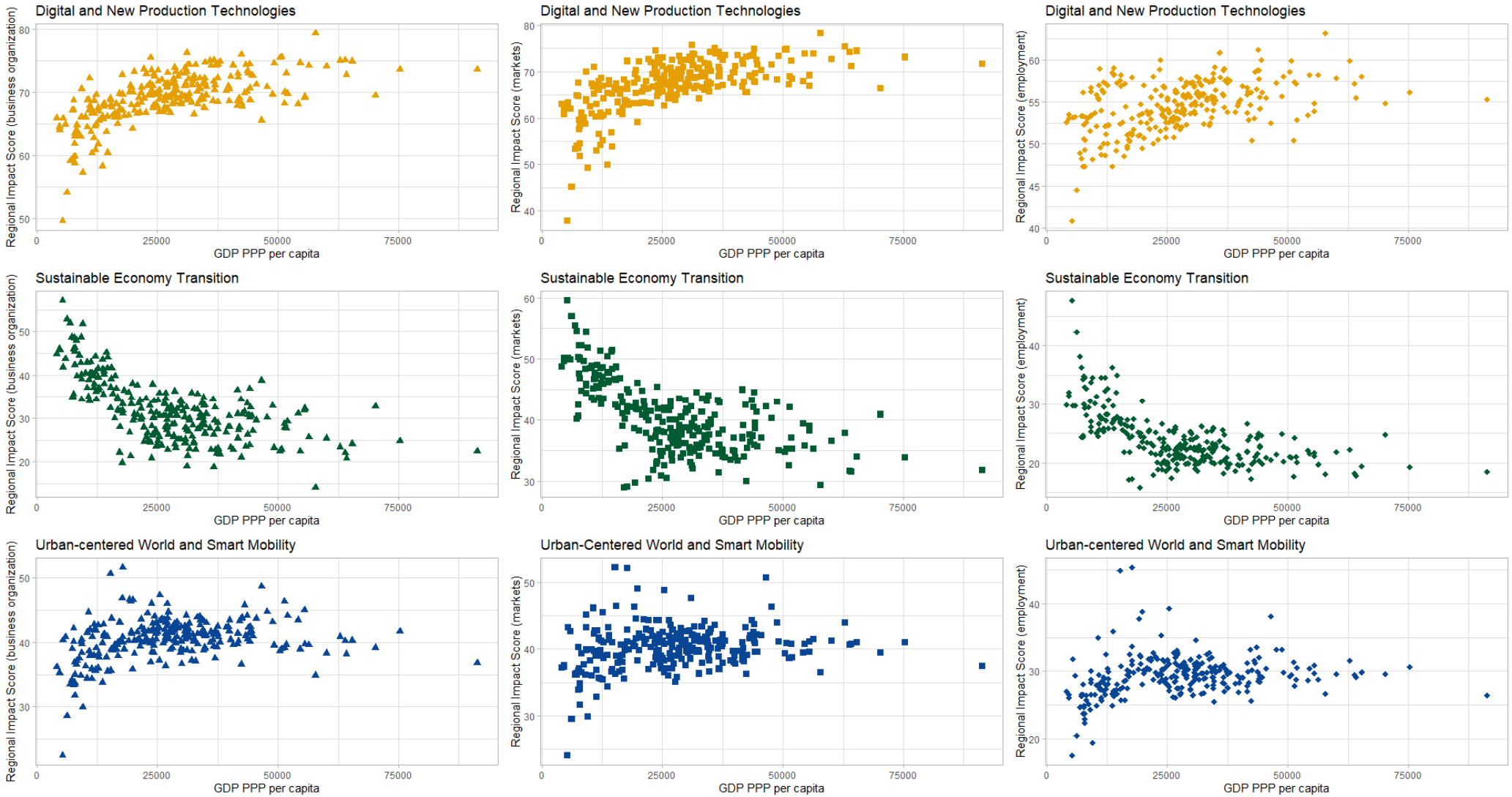
Based on these maps, different geographical patterns can be identified:

- East/West and/or South/North patterns, with the most affected regions depending on the megatrends and types of impacts. For instance, the impact of Digital and New Production Technologies on employment features this pattern, with Western and Northern regions of Europe typically more affected. For the organization of businesses, Sustainable Economy Transition is characterized by the fact that Eastern and Southern regions tend to be more affected.
- Urbanized, capital regions / lower density regions patterns, with the highly urbanized/capital regions typically at the end of the spectrum (either most or least affected). It probably stems from the sectoral specialization of such areas in many countries. For instance, capital regions and urbanized dense areas are strongly affected by the Digital and New Production Technologies megatrend.
- (Quasi-)Homogeneous patterns, in cases where there is (almost) no distinguishable difference between regions regarding the impacts of the megatrend. For instance, the regional impacts of an Urban-centered World and Smart Mobility on employment are expected to be relatively uniform across the EU regions.

These patterns are not necessarily mutually exclusive; for instance, the "Urbanized, capital regions / lower density regions" pattern is often observed combined with the others. The central insight that can be derived from these patterns is that some megatrends have relatively uniform impacts, while others are largely territorialized. It also depends on the considered type of impact. It could imply that, at least for some megatrends, territorial-specific policies or interventions may be relevant.

Finally, EU regions differ by level of development (European Commission, 2017), and some existing policies (i.e., Cohesion Policy, other regional development national policies) take this factor into account. Thus, the potential linkages between the impacts of megatrends and the level of development at the regional level are highly critical from a policy perspective. The level of development of regions can be proxied using GDP PPP per capita, with the advantage that this metric is widely available thanks to harmonized EU statistics. Correlations between GDP PPP per capita and the regional impact scores for the different megatrends/types of impacts are presented in the figure below.

Figure 3. Correlations between regional impact scores and level of development



Source: Authors, Eurostat

Note: Rows correspond to the three megatrends (yellow: Digital and New Production Technologies; green: Sustainable Economy Transition; Blue: Urban-centered World and Smart Mobility), columns correspond to types of impacts (triangles: business organization; squares: markets; diamonds: employment)

The analysis of this data shows that there is no general rule linking the regional level of development to the impacts of megatrends. Indeed, in some cases, there is a positive correlation (e.g., in the case of Digital and New Production Technologies), in others, a negative one (e.g., Sustainable Economy Transition) or even a lack of correlation (e.g., Urban-centered World and Smart Mobility). Moreover, the relationships are not linear, with a plateau typically being reached at a given GDP PPP per capita level (though it may be an artefact of the methodology). Still, the conclusion is that the level of development (GDP PPP per capita) is a relatively limited proxy to estimate the potential impacts of megatrends at the regional level. In particular, less/more developed regions are not necessarily less/more affected. Instead of relying on the level of development, more detailed analyses that are specific to single megatrends and/or regions should be favored when possible to explore these dynamics and their territorial consequences.

Regarding the interpretation of findings, it shall be highlighted that the most affected regions identified by this methodology are not necessarily those that will face the hardest challenges. Indeed, the adaptation capabilities (e.g., highly skilled population, quality institutions…) of a given region will likely interact with the expected impacts of megatrends, modulating the extent of the challenges that will be experienced in a given territory. For instance, highly developed regions may have more resources to cope (relatively) smoothly with the consequences of megatrends, even in cases where they will likely be the most affected (e.g., Digital and New Production Technologies). By contrast, a region with limited resources may experience difficulties even to face relatively small changes induced by a megatrend. Similarly, there might be infra-regional disparities that imply that, otherwise, similar regions at the aggregate level may take different trajectories.

Moreover, important changes (as identified by high regional impact scores) could well be linked to high potential future gains (e.g., through the adoption of relevant technologies, development of future-oriented skills, etc.). Thus, limited changes in the short term may be detrimental in the longer run. It suggests that public policies shall combine the analysis of megatrends with one of the capabilities of specific regions to deliver the best results.

Consistency of the findings with other methods (e.g., econometric estimates of employment change etc.) is difficult to assess given the specificities of the approach (i.e., complex set of assumptions bundled into narrative scenarios, analysis of the magnitude of change rather than net impacts, etc.). The risk of inconsistencies is mitigated by the fact that this study uses other approaches to estimate impacts. Its main benefit is to provide a pathway towards regionalization, where other methods are impractical. Moreover, its emphasis on qualitative assumptions makes it relatively more tractable/appropriable by general audiences and policy-makers (thanks to qualitative identification of critical factors and causal chains).

5. Conclusions

The analysis of megatrends is a foresight method often used in policy-making and business to reflect on long-term issues. However, it is typically blind to territorial aspects. The regionalization of the impacts of megatrends is thus a novel approach that enables a context-rich analysis of potential changes at the territorial level, thanks to scenarios with tractable assumptions. It is also valuable to set a common framework for different megatrends and/or types of impacts where other methods are challenging or unpractical. This working paper proposes a tentative methodology to regionalize the impacts of megatrends. It relies on exploiting regional differences in economic sectors, using a qualitative assessment that is then quantified using employment data. This approach is then applied at the EU level for a sample of megatrends and types of impacts.

The choice of the EU regions is fueled by the fact that they face significant inequalities while sharing a common institutional framework and public policies that are designed explicitly at tackling territorial disparities. As a consequence, the information derived from this analysis could inform policy-making.

This methodological approach also has limits that should be acknowledged and considered when interpreting the results. It has a fundamental dimension of subjectivity linked to the selection of assumptions and causal linkages. It focuses on the expected evolution of the situation in terms of deviation from a starting point rather than on the estimation of net impacts. Moreover, it relies on a single assessment of impacts at the sectoral level that is common between all regions. Some of these limits have been mitigated through different means, such as using multiple sources to reduce subjectivity, reliance on complementary approaches to estimate impacts, etc. Other limits could be addressed in the following studies, for instance, by developing alternative scenarios to compare their impacts.

The main insights of the study can be summarized as follows:

- The range of regional impacts varies strongly depending on the megatrend and type of impacts, with Digital and New Production Technologies typically having significant effects, while those from Sustainable Economy Transition and Urban-centered World and Smart Mobility tending to be more moderate
- There is no general rule linking the impacts of one megatrend at the regional level to those of another megatrend. Indeed, the correlations of the regional impact scores may be positive, negative or neutral. However, there is a strong positive correlation between the different types of impacts of a given megatrend in a specific territory.
- The impacts of megatrends among EU regions feature different territorial patterns (not necessarily mutually exclusive):
    - East/West and/or South/North patterns, with the most affected regions depending on the megatrends/types of impacts.
    - Urbanized, capital regions / lower density regions patterns, with the highly urbanized/capital regions typically at the end of the spectrum (either most or least affected).
    - (Quasi-)Homogeneous patterns, in cases where there is (almost) no distinguishable difference between regions regarding the impacts of the megatrend.
- There is no general rule linking the level of development of regions (proxied by the GDP PPP per capita) and the impacts of megatrends. Indeed, in some cases, the linkages will be positive, in others negative or neutral.

These findings can deliver important messages from a policy perspective. Firstly, the concept of megatrend emphasizes large-scale, global and long-term changes. However, there is clear evidence that these changes are not place-neutral and that the territorial dimension is relevant in analyzing their impacts and planning to anticipate them. Then, each megatrend has its set of specificities that alter its impacts at the regional level. Findings on a given megatrend shall thus not be generalized to others. In particular, the level of development (as proxied by the GDP PPP per capita) is not a robust predictor of likely impacts at the regional level. A refined analysis shall thus be conducted when possible. Finally, it shall be mentioned that there is a difference between the magnitude of expected changes caused by megatrends and the potential difficulties/challenges that will be experienced by the regions in the process. Indeed, a region with important resources and capabilities shall face significant changes relatively easily, while a less ad-

vanced region may struggle to tackle more modest changes. Ideally, the analysis of megatrends shall thus be complemented by a detailed review of regional specificities and assets to devise relevant public policies.

Further research could update the methodology with new evidence, apply it to other megatrends and types or impacts, and develop/compare findings with alternative methods for the regionalization of impacts.

Annexes

A. Selected list of references for literature review (sample to design the foresight scenarios)

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B. Qualitative impact assessment at the sectoral level

Table B1. Logical linkages between observable characteristics at the sectoral level and the likely effects of megatrends in the context of the foresight scenarios

Megatrend	Business organization	Markets	Employment
Digital and New Production Technologies	• Sectors with a high-share of low-skilled routine tasks (e.g., data collection, predictable physical tasks)[7] will be the most affected in their business organization because the technologies supporting the megatrend are particularly likely to substitute them (also resulting in alternate business models, schedules etc.). It will be particularly the case for services with an important share of low to middle-skill workers, as manufacturing is already widely automated in the EU (reducing the deviation from the current situation). • Sectors with a higher technological intensity[8] will be more affected because they tend to adopt new technologies faster (McKinsey Global Institute, 2017b) and to adapt their organization accordingly. • Sectors, where personalization of products or services is critical, will be more affected because the use of the involved technologies is particularly adapted to address this issue (e.g., integration of customer feedback in the design or production process using ICT) resulting in a greater incentive for adaptation for these sectors	• Sectors contributing directly to the supply of technologies, objects (consumer goods and machinery), software and advanced services that are associated with the megatrends will be by definition, more affected. • Sectors, where personalization of products or services is critical, will be more affected because the use of the involved technologies is particularly adapted to address this issue (e.g., integration of customer feedback in the design or production process using ICT) resulting in a greater incentive for adaptation for these sectors.	• Sectors with a high-share of low-skilled routine tasks (e.g., data collection, predictable physical tasks)[9] will be the most affected in terms of employment because the technologies supporting the megatrend are particularly likely to substitute them (resulting in job losses). • Sectors contributing directly to the supply of technologies, objects (consumer goods and machinery), software and advanced services that are associated with the megatrends could be slightly more affected in terms of employment, given the rise of the demand to meet.
Sustainable Economy Transition	• Sectors with high energy intensity[10] will be more affected because they will have a stronger incentive to change their business organizations (e.g., adapt schedules to operate when energy prices are low, introduce new business models…) to face environmental constraints (including potential price volatility and regulations). • Sectors producing or intensively using natural resources (notably manufacturing relying on non-renewable resources) will be more affected because they will have a stronger incentive to change their business organizations (e.g., change of production lines to consume fewer resources) • Sectors with an important environmental footprint[11] will be more affected because they will face stronger pressure to change their organization to tackle environmental demands and regulations.	• Sectors with products tackling, responding to environmental/energy issues or extracting resources will be more affected because of the increased/changing demands in these areas induced by the megatrend (e.g., new markets will develop in the sustainable energy sector).	• Sectors with products tackling, responding to environmental/energy issues or extracting resources will be more affected because of the increased/changing demands in these areas induced by the megatrend (e.g., new markets will develop in the energy or recycling sector) • Sectors, where energy/capital can be substituted by human labor (i.e., manufacturing sectors of consumer goods, agri-food…), will be more affected because this trade-off will become more relevant to tackle environmental constraints (e.g., in agri-food)

[7] These sectors are determined using an analysis of the technical potential for automation crossing types of tasks and sectors. It is based on US data, however the situation should be comparable as it is also a developed country. (McKinsey, 2017)

[8] These sectors are determined using the Eurostat classification of NACE sectors by technological intensity (Eurostat, 2016)

[9] These sectors are determined using an analysis of the technical potential for automation. It is based on US data, however the situation should be comparable as it is also a developed country. (McKinsey, 2017)

[10] These sectors are determined using a classification of the EIA using an international perspective (EIA, 2016)

[11] These sectors are determined using data on Greenhouse Gas Emissions induced by the final consumption of products in the EU, under the CPA classification (that can be related to NACE sectors). (Eurostat, 2019b)

Megatrend	Business organization	Markets	Employment
Urban-centered world and Smart Mobility	• Sectors with a stronger direct linkage to urban and mobility issues in their operations will be more affected because of the transformation of these areas induced by the megatrend (e.g., transportation and logistics will change their work organization, including business models to adapt to new social needs and technologies)	• Sectors with products or services directly tackling or responding to urban and mobility issues in will be more affected because of the transformation of these areas induced by the megatrend (e.g., new markets will develop to update urban infrastructures or to deliver automated vehicles) • Sectors addressing the demands that are disproportionately associated with a middle-class lifestyle[12] will be disproportionately affected; due to the rise of a global urban middle class	• Sectors with products or products directly tackling or responding to urban and mobility issues (e.g., utilities, smart city, transportation and logistics…) in will be more affected because of the transformation of these areas induced by the megatrend. This effect will be larger for sectors with high labor intensity[13] (e.g., substitution of drivers by automated vehicles).

[12] These sectors are determined using data on the consumption patterns of products when income rises (HSBC, 2012)

[13] Sectors with high labor intensity are determined using data on the number of employed persons divided by the value of production by NACE sector (Eurostat, 2019a).

Table B2. Qualitative impact assessment of Digital and New Production Technologies at the sectoral level

NACE Sector	Business organization	Markets	Employment
A	Moderate minus	Minor	Moderate minus
B	Moderate	Moderate	Moderate
C10	Moderate	Moderate minus	Moderate
C11	Moderate	Moderate minus	Moderate
C12	Moderate	Moderate minus	Moderate
C13	Moderate plus	Moderate plus	Moderate
C14	Moderate plus	Moderate plus	Moderate
C15	Moderate plus	Moderate plus	Moderate
C16	Moderate	Moderate minus	Moderate
C17	Moderate	Moderate minus	Moderate
C18	Moderate	Moderate minus	Moderate
C19	Moderate	Moderate	Moderate plus
C20	Moderate plus	Moderate	Moderate plus
C21	Major	Moderate plus	Moderate
C22	Moderate	Moderate	Moderate plus
C23	Moderate	Moderate	Moderate plus
C24	Moderate	Moderate	Moderate plus
C25	Moderate	Moderate	Moderate plus
C26	Major	Major	Major
C27	Moderate plus	Major	Major
C28	Moderate plus	Major	Major
C29	Moderate plus	Moderate plus	Moderate plus
C30	Moderate plus	Moderate plus	Moderate plus
C31	Moderate plus	Moderate plus	Moderate
C32	Moderate	Moderate	Moderate plus
C33	Moderate	Moderate plus	Major
D	Moderate plus	Moderate	Moderate
E	Moderate plus	Moderate	Moderate
F	Moderate	Moderate	Moderate minus
G	Moderate plus	Moderate plus	Moderate
H	Moderate	Moderate plus	Moderate
I	Moderate plus	Moderate plus	Moderate plus
J	Major	Major	Major

NACE Sector	Business organization	Markets	Employment
K	Major	Major	Moderate plus
L	Moderate plus	Moderate plus	Moderate
M	Major	Major	Major
N	Moderate plus	Moderate plus	Moderate
O, P, Q	Moderate plus	Moderate plus	Moderate
R, S, T, U	Moderate	Moderate minus	Moderate minus

Source: Authors' elaboration

Table B3. Qualitative impact assessment of Sustainable Economy Transition at the sectoral level

NACE Sector	Business organization	Markets	Employment
A	Moderate plus	Moderate plus	Moderate plus
B	Moderate	Moderate plus	Moderate
C10	Major	Moderate	Moderate minus
C11	Major	Moderate	Moderate minus
C12	Major	Moderate	Moderate minus
C13	Moderate plus	Moderate	Moderate minus
C14	Moderate plus	Moderate	Moderate
C15	Moderate plus	Moderate	Moderate
C16	Moderate	Moderate	Moderate minus
C17	Moderate	Moderate	Moderate minus
C18	Moderate minus	Moderate	Moderate minus
C19	Major	Moderate plus	Moderate minus
C20	Moderate plus	Moderate	Moderate minus
C21	Moderate	Moderate minus	Minor
C22	Moderate	Moderate	Moderate minus
C23	Moderate	Moderate	Moderate minus
C24	Moderate	Moderate	Moderate minus
C25	Moderate	Moderate	Moderate minus
C26	Moderate	Moderate plus	Moderate
C27	Moderate	Moderate plus	Moderate
C28	Moderate	Moderate plus	Moderate
C29	Moderate plus	Moderate plus	Moderate
C30	Moderate	Moderate plus	Moderate
C31	Moderate	Moderate	Moderate minus
C32	Moderate	Moderate	Moderate minus

NACE Sector	Business organization	Markets	Employment
C33	Moderate minus	Major	Moderate minus
D	Major	Major	Moderate minus
E	Moderate	Major	Moderate minus
F	Major	Moderate plus	Moderate minus
G	Moderate	Moderate plus	Moderate
H	Moderate plus	Moderate plus	Moderate minus
I	Moderate minus	Moderate	Moderate minus
J	Moderate minus	Moderate minus	Moderate minus
K	Minor	Moderate minus	Moderate minus
L	Minor	Minor	Minor
M	Minor	Moderate	Moderate minus
N	Minor	Moderate minus	Moderate minus
O, P, Q	Minor	Minor	Minor
R, S, T, U	Minor	Minor	Minor

Source: Authors' elaboration

Table B4. Qualitative impact assessment of Urban-centered world and Smart Mobility at the sectoral level

NACE Sector	Business organization	Markets	Employment
A	Minor	Minor	Minor
B	Moderate minus	Moderate minus	Minor
C10	Minor	Minor	Minor
C11	Minor	Minor	Minor
C12	Minor	Minor	Minor
C13	Minor	Minor	Minor
C14	Minor	Minor	Moderate minus
C15	Minor	Minor	Minor
C16	Minor	Minor	Minor
C17	Minor	Moderate minus	Minor
C18	Minor	Moderate minus	Minor
C19	Moderate	Moderate	Minor
C20	Moderate minus	Moderate minus	Minor
C21	Minor	Moderate minus	Minor
C22	Moderate minus	Moderate minus	Minor
C23	Moderate minus	Moderate minus	Minor
C24	Moderate minus	Moderate minus	Minor

NACE Sector	Business organization	Markets	Employment
C25	Moderate minus	Moderate minus	Minor
C26	Moderate	Moderate	Moderate minus
C27	Moderate	Moderate	Minor
C28	Moderate	Moderate minus	Minor
C29	Moderate plus	Major	Moderate
C30	Moderate plus	Major	Moderate
C31	Minor	Moderate minus	Minor
C32	Minor	Minor	Minor
C33	Moderate minus	Minor	Moderate minus
D	Moderate	Moderate	Minor
E	Moderate	Moderate	Moderate minus
F	Moderate plus	Moderate	Moderate
G	Moderate	Moderate plus	Moderate
H	Moderate plus	Major	Moderate plus
I	Moderate plus	Moderate plus	Moderate plus
J	Minor	Moderate minus	Minor
K	Minor	Moderate minus	Minor
L	Moderate	Moderate plus	Moderate minus
M	Moderate minus	Moderate minus	Moderate minus
N	Moderate minus	Moderate minus	Moderate minus
O, P, Q	Moderate	Moderate minus	Moderate minus
R, S, T, U	Minor	Moderate minus	Minor

Source: Authors' elaboration

C. Employment data at the regional level

Table C1. List of NACE codes selected for the sectoral analysis and their source datasets

Sec-tor code	Description of the sector	Data source
A	Agriculture, forestry and fishing	lfst_r_lfe2en2
B	Mining and quarrying	sbs_r_nuts06_r2
C10	Manufacture of food products	sbs_r_nuts06_r2
C11	Manufacture of beverages	sbs_r_nuts06_r2
C12	Manufacture of tobacco products	sbs_r_nuts06_r2
C13	Manufacture of textiles	sbs_r_nuts06_r2
C14	Manufacture of wearing apparel	sbs_r_nuts06_r2
C15	Manufacture of leather and related products	sbs_r_nuts06_r2
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of	sbs_r_nuts06_r2

Sec-tor code	Description of the sector	Data source
	straw and plaiting materials	
C17	Manufacture of paper and paper products	sbs_r_nuts06_r2
C18	Printing and reproduction of recorded media	sbs_r_nuts06_r2
C19	Manufacture of coke and refined petroleum products	sbs_r_nuts06_r2
C20	Manufacture of chemicals and chemical products	sbs_r_nuts06_r2
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	sbs_r_nuts06_r2
C22	Manufacture of rubber and plastic products	sbs_r_nuts06_r2
C23	Manufacture of other non-metallic mineral products	sbs_r_nuts06_r2
C24	Manufacture of basic metals	sbs_r_nuts06_r2
C25	Manufacture of fabricated metal products, except machinery and equipment	sbs_r_nuts06_r2
C26	Manufacture of computer, electronic and optical products	sbs_r_nuts06_r2
C27	Manufacture of electrical equipment	sbs_r_nuts06_r2
C28	Manufacture of machinery and equipment n.e.c.	sbs_r_nuts06_r2
C29	Manufacture of motor vehicles, trailers and semi-trailers	sbs_r_nuts06_r2
C30	Manufacture of other transport equipment	sbs_r_nuts06_r2
C31	Manufacture of furniture	sbs_r_nuts06_r2
C32	Other manufacturing	sbs_r_nuts06_r2
C33	Repair and installation of machinery and equipment	sbs_r_nuts06_r2
D	Electricity, gas, steam and air conditioning supply	sbs_r_nuts06_r2
E	Water supply; sewerage, waste management and remediation activities	sbs_r_nuts06_r2
F	Construction	sbs_r_nuts06_r2
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	sbs_r_nuts06_r2
H	Transportation and storage	sbs_r_nuts06_r2
I	Accommodation and food service activities	sbs_r_nuts06_r2
J	Information and communication	sbs_r_nuts06_r2
K	Financial and insurance activities	lfst_r_lfe2en2
L	Real estate activities	sbs_r_nuts06_r2
M	Professional, scientific and technical activities	sbs_r_nuts06_r2
N	Administrative and support service activities	sbs_r_nuts06_r2
O, P, Q	Public administration and defense; compulsory social security; Education; Human health and social work activities	lfst_r_lfe2en2
R, S, T, U	Arts, entertainment and recreation; Other services activities; Activities of households as employers; undifferentiated goods - and services - producing activities of households for own use; Activities of extraterritorial organizations and bodies	lfst_r_lfe2en2

Source: Authors' elaboration based on Eurostat

Table C2. Average values for the shares of employment of different sectors at the regional level

Sector code	Average share of regional employment	Sector code	Average share of regional employment	Sector code	Average share of regional employment
A	4.8%	C21	0.2%	D	0.5%
B	0.3%	C22	0.7%	E	0.7%
C10	2.1%	C23	0.6%	F	6.0%
C11	0.2%	C24	0.5%	G	14.9%
C12	0.0%	C25	1.6%	H	4.8%
C13	0.3%	C26	0.4%	I	5.9%
C14	0.4%	C27	0.6%	J	2.3%
C15	0.2%	C28	1.0%	K	2.6%
C16	0.6%	C29	1.0%	L	1.2%

Sector code	Average share of regional employment	Sector code	Average share of regional employment	Sector code	Average share of regional employment
C17	0.3%	C30	0.3%	M	5.2%
C18	0.3%	C31	0.5%	N	6.0%
C19	0.0%	C32	0.3%	O-Q	26.7%
C20	0.4%	C33	0.6%	R-U	5.0%

Source: Authors' elaboration based on the consolidated database

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