TWIN TRANSITION AND CHANGING PATTERNS OF SPATIAL MOBILITY: A REGIONAL APPROACH

MOBI-TWIN D2.1 REPORT ON CURRENT MOBILITY FLOWS AND EXISTING REGIONAL ATTRACTIVENESS MEASURES IN THE EU

Work package	WP2: Redefining regional typologies based on spatial mobility and twin transition
Task	Task 2.2: Existing definitions of regional attractiveness and regional typologies in EU regions
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Abstract	The report offers an overview of current spatial mobility dynamics within EU regions, combined with considerations of regional attractiveness, left-behind areas, and the Twin Transition. Starting with a comprehensive mapping of mobility flows across EU regions, the report attempts to provide insights between spatial mobility flows and regional characteristics with the inclusion and discussion of the concepts of left-behindness and the Twin Transition. This groundwork sets the theoretical framework for the development of the MOBI-TWIN Regional Attractiveness Index.
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EXECUTIVE SUMMARY

The report offers a review of the current state-of-the-art concerning the interplay among various spatial mobility flows, combined with aspects related to regional attractiveness, left-behind areas, and the Twin Transition. It starts by mapping a set of different types of mobility flows at the regional level for EU Member States and moves on by linking the primary drivers of spatial mobility outlined in D1.1 to the concept of regional attractiveness, broadening its scope to encompass the notions of left-behindness and the Twin Transition. It outlines the emerging connection between spatial mobility types, existing theoretical frameworks, and regional attractiveness, providing key inputs for developing the MOBI-TWIN Regional Attractiveness Index in the next steps of the project. This establishes a comprehensive framework guiding the project's future analyses.

Section 1 focuses on presenting present mobility flow patterns within EU regions, encompassing various forms of mobility types previously identified in D1.1 (Panori et al., 2024). Specifically, it examines 7 types of mobility, ranging from long-term to short-term and circular mobility forms based on the D.1.2 "Complete Mobi-Twin dataset", which is derived from various data sources (Annex C), These movements are scrutinised at the NUTS2 geographical level, emphasising the predominant mobility flows between EU regions and its change after the COVID-19 pandemic, while encompassing various life events, such as student, retirement, and work-related mobility.

Sections 2 and 3 investigate how regional attractiveness, left-behind areas, and the Twin Transition can be integrated within the spatial mobility framework. They inspect existing literature on measures of regional attractiveness, examining common indicators applied in empirical research, encompassing economic factors, creativity, and liveability potential. Additionally, it incorporates two supplementary dimensions: the green and the digital transition, exploring potential factors for linking them to regional attractiveness.

Section 4 offers a detailed presentation of established typologies and classifications for EU regions, which could be relevant to regional attractiveness and the Twin Transition. These include conventional typologies like urban/rural areas, mountain, island, and border regions, alongside novel approaches for classifying EU regions based on their degree of left-behindness, vulnerability to the green transition, and their digital transformation level.

Section 5 builds upon these metrics, conducting a preliminary comparative analysis between EU regions. After classifying NUTS2 regions based on their level and type of left-behindness -encompassing aspects of mobility in its definition-, it aims at exploring the extent to which these regions are vulnerable to the green transition and have embedded digital transition aspects. In this way, it provides an initial approach to measuring regional attractiveness through the notions of interest.

Finally, links to the RRI principles are provided in Section 6, whereas conclusions are provided at the end of this report (Section 7) highlighting the key outcomes that can be used for further analysis in the following tasks of the MOBI-TWIN project.

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LIST OF TERMS AND ABBREVIATIONS

DESI	Digital Economy and Society Index
GTI	Green Transition Index
LFS	Labour Force Survey
RGTVI	Regional Green Transition Vulnerability Index
RIS	Regional Innovation Scoreboard
TT	Twin Transition

INTRODUCTION

The concept of regional attractiveness plays a pivotal role in shaping the spatial mobility of individuals, reflecting the dynamic interplay between the characteristics of different geographic areas and the preferences of those seeking new living or working environments. Understanding the background and context of regional attractiveness requires an exploration of the multifaceted factors that influence people's decisions to move from one region to another.

One of the primary drivers of spatial mobility (e.g. migration) -as we have seen in a previous report- is the pursuit of economic opportunities. Regions offering robust job markets, career advancement prospects, and higher earning potential naturally become magnets for individuals seeking to enhance their economic well-being. Cities with thriving industries, innovation hubs, and diverse employment sectors tend to attract a mobile workforce eager to capitalise on these opportunities. However, the concept of regional attractiveness extends beyond economic considerations to encompass lifestyle preferences and the overall quality of life. Increased access to cultural amenities, recreational opportunities, healthcare facilities, and environmental sustainability initiatives becomes essential for individuals seeking a well-rounded and fulfilling life. In this regard, infrastructure and connectivity play a crucial role in shaping regional attractiveness. Regions with efficient and accessible infrastructure tend to be more attractive to individuals who prioritise ease of travel and connectivity in their decision-making process.

MOBI-TWIN argues that the dynamic nature of these factors continually shapes patterns of various mobility types, with individuals choosing regions that align with their goals and preferences. Policymakers must consider these elements to create environments that not only attract a mobile population but also foster sustainable and inclusive growth. Therefore, it is important to understand the ways in which regional attractiveness is related to the notions of left-behind places - following a multifaceted approach - and the twin transition, being a significant regional policy driver. This should be accompanied by a detailed analysis of the identified mobility flows using a wide set of data sources that cover various aspects of life events to create an initial link between theoretical contexts and empirical data.

The purpose of this report is to understand regional attractiveness and how it relates to the notions of left-behind places and the twin transition, both being essential aspects of regional development.

First, it explores multiple mobility patterns through the presentation of **an extensive mapping exercise encompassing various types of mobility flows**, including short-term, long-term and circular migration movements. It then **examines regional attractiveness as a catalyst for spatial mobility, seeking to offer insights into the interplay between left-behindness, the twin transition, and individuals' mobility decisions**.

Building on the work of WP1, it endeavours to present a comprehensive overview of how regional attractiveness can be linked to existing indicators of left-behind areas and the twin transition, culminating in the proposal of a composite regional attractiveness index.

1. MAPPING CURRENT MOBILITY FLOWS IN EU REGIONS

One of the core cornerstones in the MOBI-TWIN project is the fact that there are various mobility types besides permanent migration that are relevant for regional development. In this project, we focus on nine different mobility types as they have been identified in the report D1.1 State-of-the-art report on the drivers, forms and effects of spatial mobility on EU regions (Panori et al., 2024) that are divided into three groups – long-distance, short-term and circular mobility forms.

Given their varying temporal nature (permanent, temporary, circular) and underlying reason (work, study, retirement), these mobility flows are influenced by various external factors (local, regional, global), but they also have different effects on regional development - increase in permanent population, increase in service demand due to temporary population (multilocal living), increase in workforce due to seasonal workers, and changes in age groups (student vs retirement movement). Therefore, we need to understand how given mobility flows influence regional development, especially given the ongoing twin transition.

We tackled the operationalisation of the seven mobility types at NUTS2 level in Europe by first conceptualising the definitions and framework (Annex B) and developed the methodology to produce mobility flows between NUTS2 regions for the mobility types (Annex C). We were able to produce mobility data for nine types of mobility, as the data for digital nomadism, return migration, and family reunification either does not exist, or existing data is too scarce for meaningful analysis.

In the next subsections, an overview of mobility flows for each mobility type is given, which are retrieved from D.2.1. "Complete Mobi-Twin Dataset". The overview includes the following aspects: spatial distribution of mobility flows for the geographical pattern, ratio of sending (outgoing) mobility from overall (sum of outgoing and incoming) mobility flows by region as an indicator for the attractiveness of mobility of people. Here we focus on the three periods (2012-2015; 2016-2019; 2020-2023) and compare the change in mobility flows between the first and last period for the structural changes of mobility patterns in Europe due to global disruptive factors (such as the COVID-19 global pandemic, Brexit, and Russia's war in Ukraine).

1.1 LONG-TERM MOBILITY

PERMANENT (INTERREGIONAL) MIGRATION

Permanent migration estimation within and between countries in Europe based on Twitter data from 2012 to 2022 predicted a total of 24 million movements. For the first period (2012-2015), the average yearly movement count was approximately 1.7 million, for the second period (2016-2019) it was about 2.4 million, and for the third period (2020-2022) it was around 2.6 million. This shows that the yearly average movement in the third period is 155% of the first period and 107% of the second period. Figure 1 shows the flows of permanent migration between NUTS2 regions in Europe for the third period, as an example.

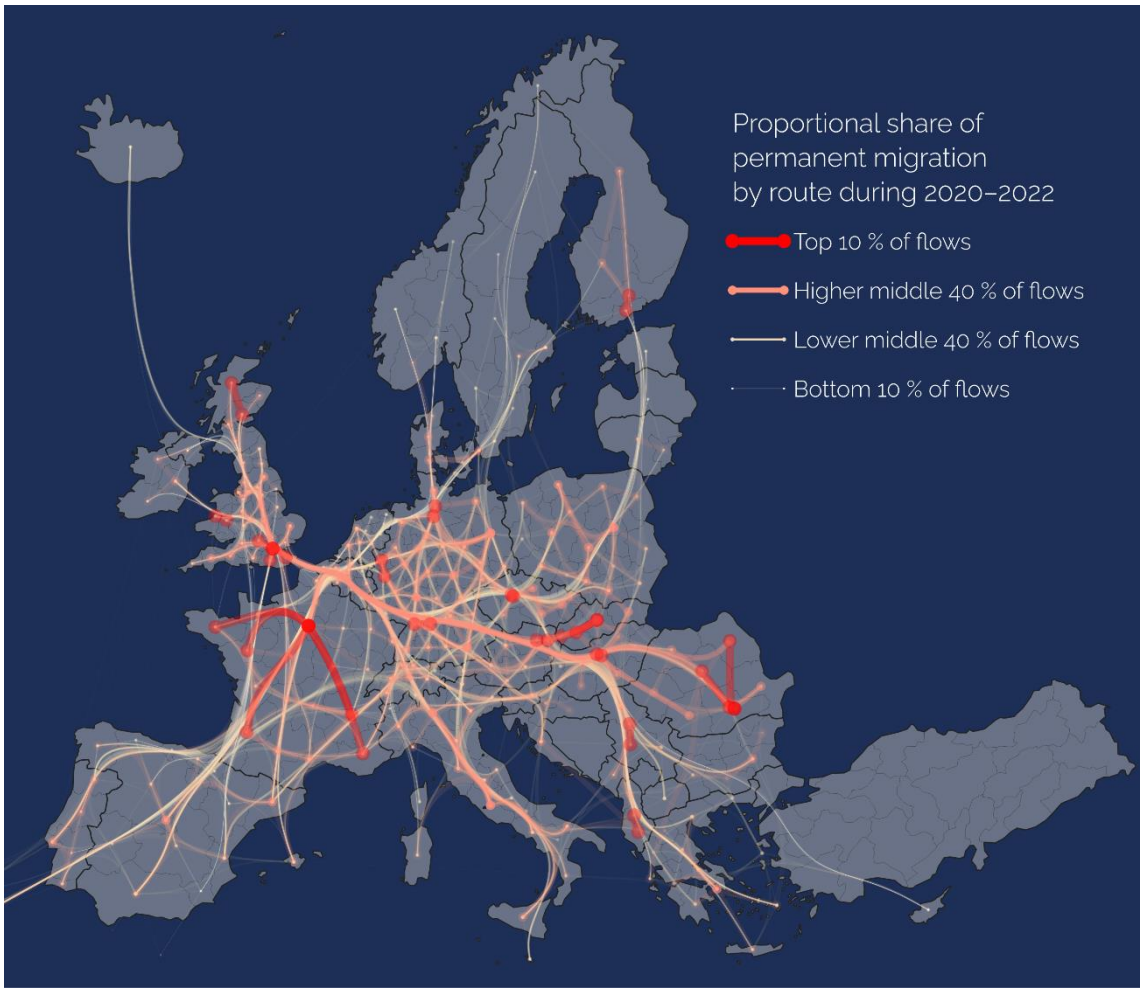

Figure 1. The proportional share of permanent migration during the third period (2020-2022). Note: The values represent how much of the total mobility during the period each flow accounts for. Direction of the flow is not included, but the flows represent total flow between two regions. Major flows are red, while lesser flows are white. Source: Labour Force Survey. Author: Oula Inkeröinen - UH. Full-sized figure HERE.

During the whole period (2012-2022), the countries with the highest numbers of permanent incoming migration within Europe were Germany and France (17% of the total flow),

followed by Spain (14%), Italy (12%), and Poland (5%). At the NUTS2 region level, the highest incoming flows were to Île-de-France in France, Berlin in Germany, Comunidad de Madrid, Cataluña in Spain, and Lombardia in Italy.

The comparison between outgoing (sending) and incoming (receiving) permanent migration at NUTS2 region level shows the geographical variations within each country in Europe regarding from where and to where individuals move. Figure 2 (left) shows the variation during the first period (2012-2015). Overall, most NUTS2 regions with relatively higher incoming permanent migration flows contain capital cities or major urban areas. The top six NUTS2 regions with the highest receiving flows are Luxembourg (85%), Praha (82%), Région de Bruxelles-Capitale/Brussels Hoofdstedelijk Gewest (81%), Cataluña (80%), Berlin (80%), and Notio Aigaio (81%) – the latter region being a notable exception as it is a major tourist region in Greece rather than a capital city.

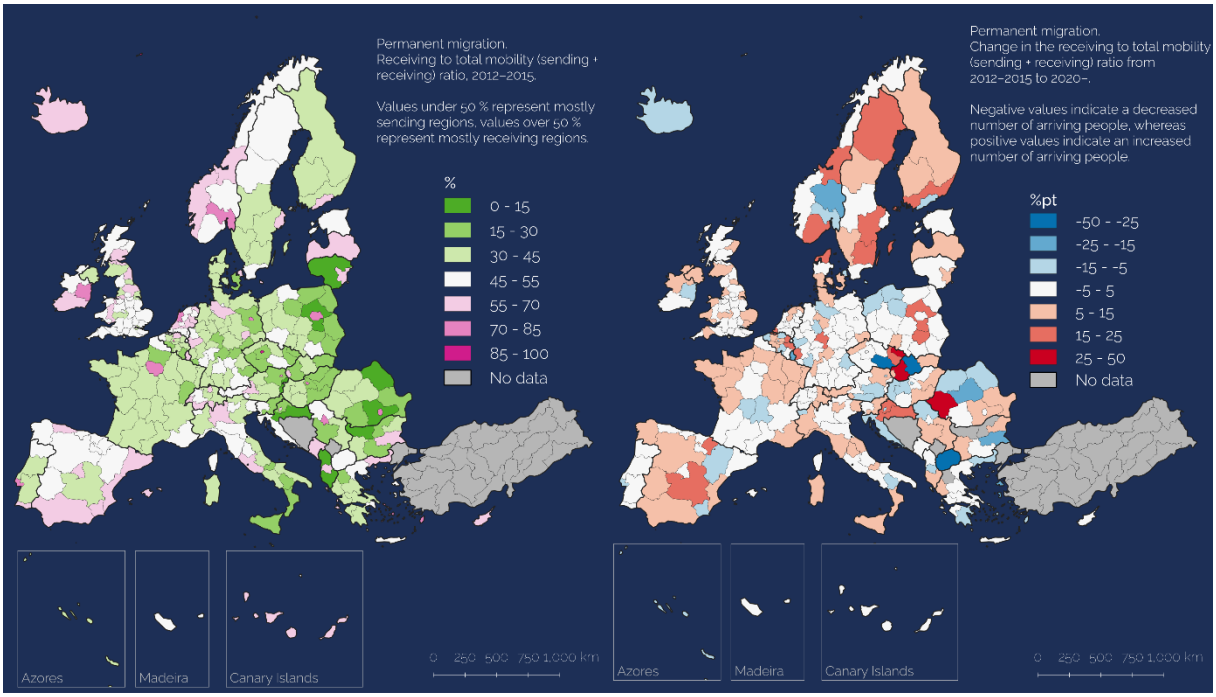

Figure 2. The ratio of incoming permanent migration from total permanent migration flows at NUTS2 regions in Europe for the first period (2012-2015) (left) and the difference of the ratio between the first and third period (2020-2022) as percentage points (right). Source: Labour Force Survey. Author: Maija Havusela - UH. Full-sized Left Figure HERE and Right Figure HERE.

Regions with the relatively highest outgoing migration often share common characteristics such as being more rural and peripheral areas. The top regions with the most outgoing flows are Sud-Muntenia in Romania (receiving ratio of 13%), Nord-Est in Romania (13%), Burgenland in Austria (14%), Severozapaden in Bulgaria (15%), and Panonska Hrvatska in Croatia (15%). The comparison of the ratio of incoming migration from total mobility between the first (2012-2015) and third period (2020-2022) indicates some changes from the geographical perspective (Figure 2, right). In general, incoming migration ratio

increased in more rural NUTS2 regions next to metropolitan regions or more remote regions within a country. In particular, for 8% of NUTS2 regions the incoming migration ratio increased over 15 percentage points (e.g. Gorj County, Moravskoslezsko, Western Slovakia), whereas for 3% of regions the ratio decreased over 15 percentage points (e.g. North Macedonia, Central Slovakia, Jihovýchod).

The GDP of a destination region, as an indicator for overall wealth and salary levels, shows a positive correlation with the ratio of receiving permanent migration - higher GDP potentially attracts more people for permanent migration from regions with a lower GDP due to better economic opportunities and higher wages (Figure 3). The relations regarding intra-country permanent migration remain relatively consistent across periods before COVID-19 (Figure 3, left), however the relations are less evident compared to permanent migration between countries in Europe (Figure 3, right). This indicates economic attractiveness being more prominent for international migration than moving within a country. COVID-19 pandemic affected both intra- and inter country migration flows – people were moving away from primary urban centers not only temporarily, but also permanently within a country (e.g. Willberg et al., 2021), while unexpected border closures within the EU led people working abroad to reconsider their living arrangements (e.g. Järv et al., 2021).

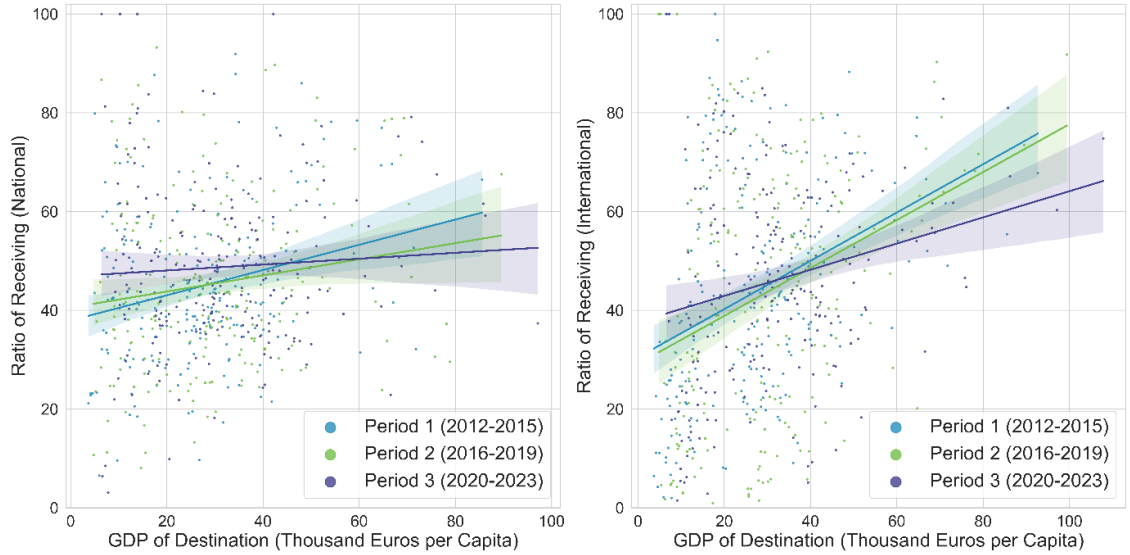

Figure 3. Correlation between GDP of destination regions and ratio of receiving permanent migration mobility by period. Note: The lines represent the best fit for the data, while the shaded areas indicate the variability in the ratio of receiving permanent migration mobility. The periods are color-coded: Period 1 is blue, Period 2 is green, and Period 3 is purple. Source: GDP data from Eurostat, and the mobility data from Twitter. Author: Milad Malekzadeh - UH. Full-sized figure HERE.

LONG-TERM STUDENT MOBILITY

Long-term student mobility via the Erasmus Programme within Europe (See Annex B for definition) for the period 2014-2020 had in total over 40 thousand movements. The average

yearly movement count for the first period (2012-2015) and second period (2016-2019) was for both over 6 thousand movements. In 2020, there were over 3 thousand movements that is 46% less yearly mobility compared to the first two periods. Figure 4 shows the flows of long-term student mobility between NUTS2 regions for the first period, as an example.

The main destination countries for long-term student mobility for the whole period 2014-2020 were Germany (32%), followed by France (9%), the UK and Italy (both 8%) and Spain (7%). Overall, the top three mobility flows are from Spain (5%), France (5%) and Italy (4%) to Germany. At NUTS2 region level, the highest incoming flows are to Oberbayern (e.g. Munich), Bedfordshire and Hertfordshire (the UK), Eastern and Midland (e.g. Dublin), Berlin and Île-de-France (e.g. Paris).

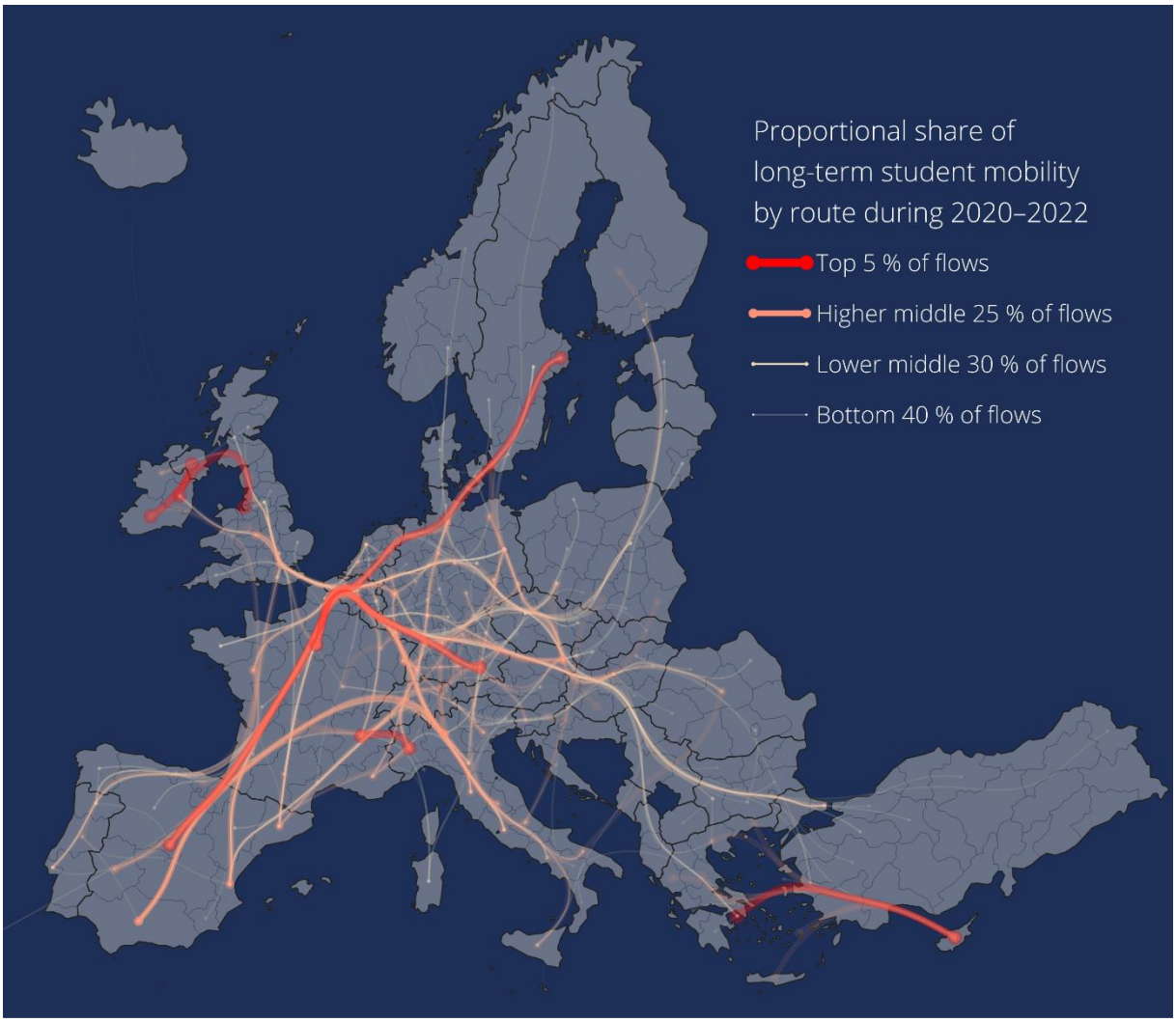

Figure 4. The proportional share of long-term student mobilities during the third period (2020–2022). Note: The values represent how much each flow captures the total flows for the given period. Direction of the flow is not

included, but the flows represent total flow between two regions. Major flows are red, while lesser flows are white. Source: Erasmus Mobility dataset. Author: Oula Inkeröinen - UH. Full-sized figure HERE.

The comparison between outgoing (sending) and incoming (receiving) long-term student mobility at NUTS2 region level shows the geographical variations within Europe regarding from where and to where students move. Figure 5 (left) shows the variation during the period 2014-2015.

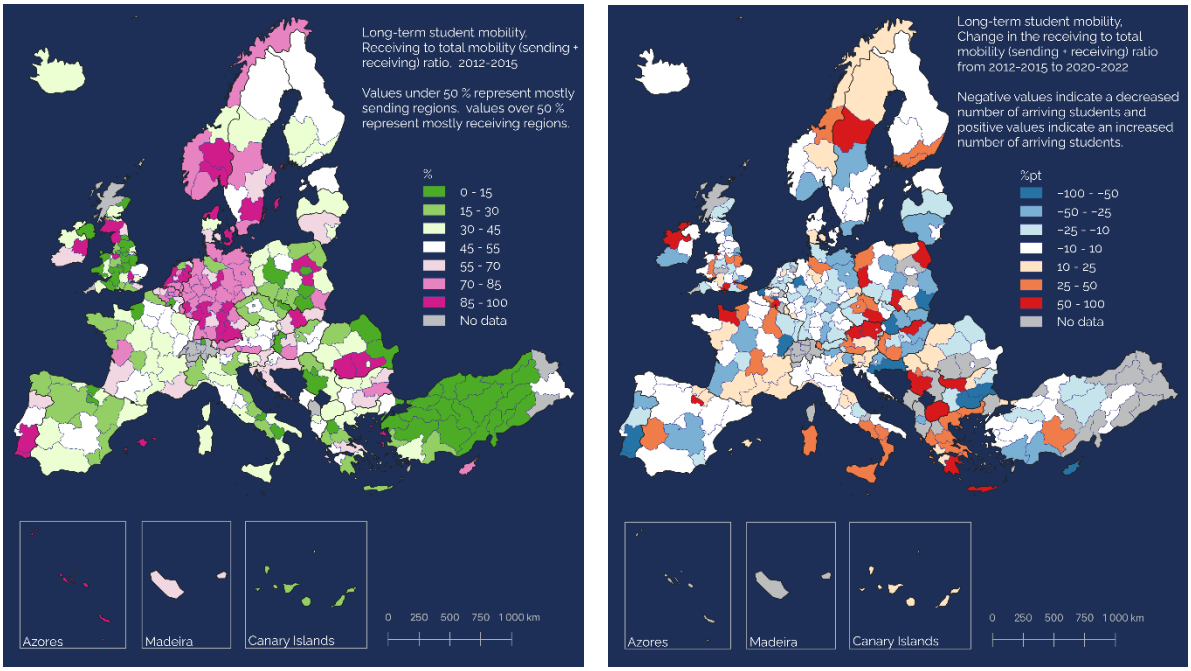

Figure 5. The ratio of incoming long-term student mobility from total long-term student mobility at NUTS2 regions in Europe for the first period (2014-2015) (left) and the difference of the ratio between the first and third period (2020) as percentage points (right). Source: Erasmus Programme data. Author: Maija Havusela - UH. Full-sized Left Figure HERE and Right Figure HERE.

Overall, most of the NUTS2 regions in the Netherlands, Germany and Belgium receive relatively more incoming long-term student mobility than is mobility going out – given countries have the highest ratio of incoming mobility from total mobility (81%, 76% and 75%, accordingly). The top two countries with the highest ratio are Malta (89%) and Luxembourg (87%), yet with markedly lower overall mobility flows. Long-term student mobility is also relatively more received by some regions in the Nordics (Sweden, Denmark, Norway), regions with capital cities (e.g. Dublin) and next to the Mediterranean Sea (e.g. Cyprus, Baleares, Southern Portugal).

Regions with the relatively highest outgoing mobility are in Eastern Mediterranean countries (Turkey, Albania, Cyprus) – given countries have the lowest ratio of incoming mobility from total mobility (11%, 15% and 21%, accordingly). The proportion of outgoing long-term student mobility is noticeable in countries with highest overall mobility flows such as Spain, the UK and Italy - ratio of incoming mobility from total mobility is 29%, 34% and 39%, accordingly. The comparison of the ratio of incoming mobility from total mobility

between the first (2014-2015) and third period (2020) indicates changes from the geographical perspective (Figure 5, right). These changes may be due to the COVID-19 pandemic as well as Brexit.

High level of internet accessibility as an indicator for advanced information and communication technology provision in a region and for the overall digital transition reveals its importance in determining the destinations of long-term student mobility. The association between the ratio of internet access at households and incoming mobility was very clear during the first period (2012–2015) (Figure 6). Later on, the association between high level of accessibility and a high share of received long-term students is less evident yet has a positive association. As the internet has become more ubiquitous in a recent decade, then the availability of (wireless) high-speed internet network technology (e.g., 5G networks) in regions will be a better indicator of long-term student mobility today.

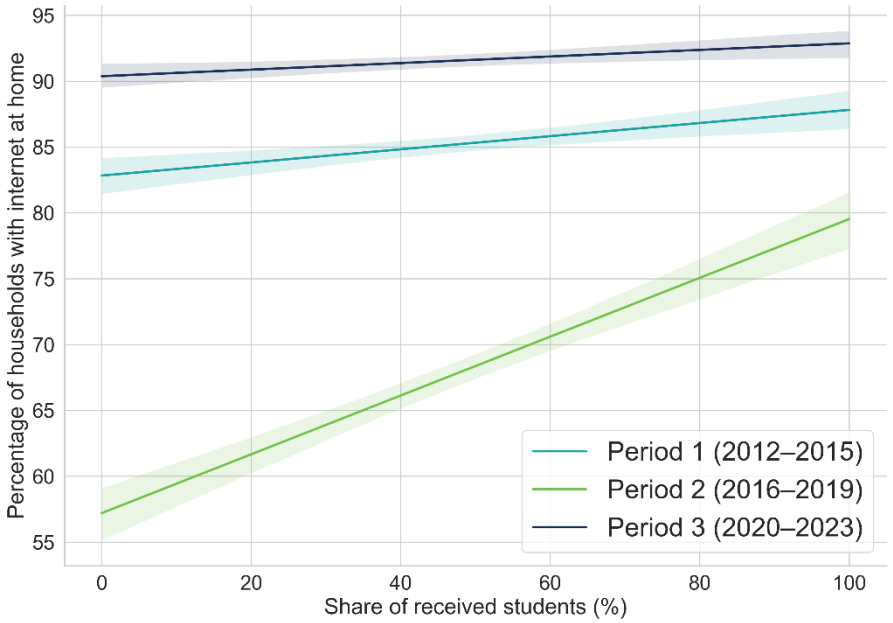

Figure 6. The relation between the ratio of incoming long-term students and the ratio of households with internet at home across the three periods. Note: The confidence intervals represent 95 % confidence. Source: Erasmus Programme data. Author: Tuomas Väisänen. Full-sized figure HERE.

1.2 SHORT-TERM MOBILITY

SEASONAL (WORK) MOBILITY

Seasonal work mobility (See Annex B for definition) estimation between NUTS2 regions within Europe based on the Labour Force Survey dataset for the period 2012-2022 had in total 22 million movements. For the first period (2012-2015), the average yearly movement count was over 2.1 million and for the second period (2016-2019) it was over 2.2 million movements. The third period (2020-2022) had over 1.6 million yearly movements, which is

26% less compared to the first period, and 28% less compared to the second period. Figure 7 shows the flows of seasonal work mobility between NUTS2 regions in Europe for the third period, as an example.

The main destination countries for seasonal work mobility for the whole period 2012-2022 were Germany (64 %), France (6 %), Italy (5 %), Austria (5 %), and Poland (3 %). Note, the inherent over-representation of German seasonal work mobility seems to be caused by the way geographical information is collected in the LFS - at the level of NUTS2 regions, which vary significantly by geographical size between countries. Thus, smaller sized NUTS2 regions in Germany capture seasonal home-work movements between smaller NUTS2 regions more efficiently compared to other countries in Europe with larger regions.

Overall, most seasonal mobility took place within a country. Regarding international incoming seasonal work mobility, the top five countries with highest mobility from abroad were Luxembourg (90 %), Ireland (65 %), Norway (64 %), Greece (60 %), and Switzerland (59 %). At the NUTS2 regional level, the five highest incoming flows were to Germany: Düsseldorf (5 %), Köln (5 %), Arnsberg (4 %), Stuttgart (4 %), and Oberbayern (4 %).

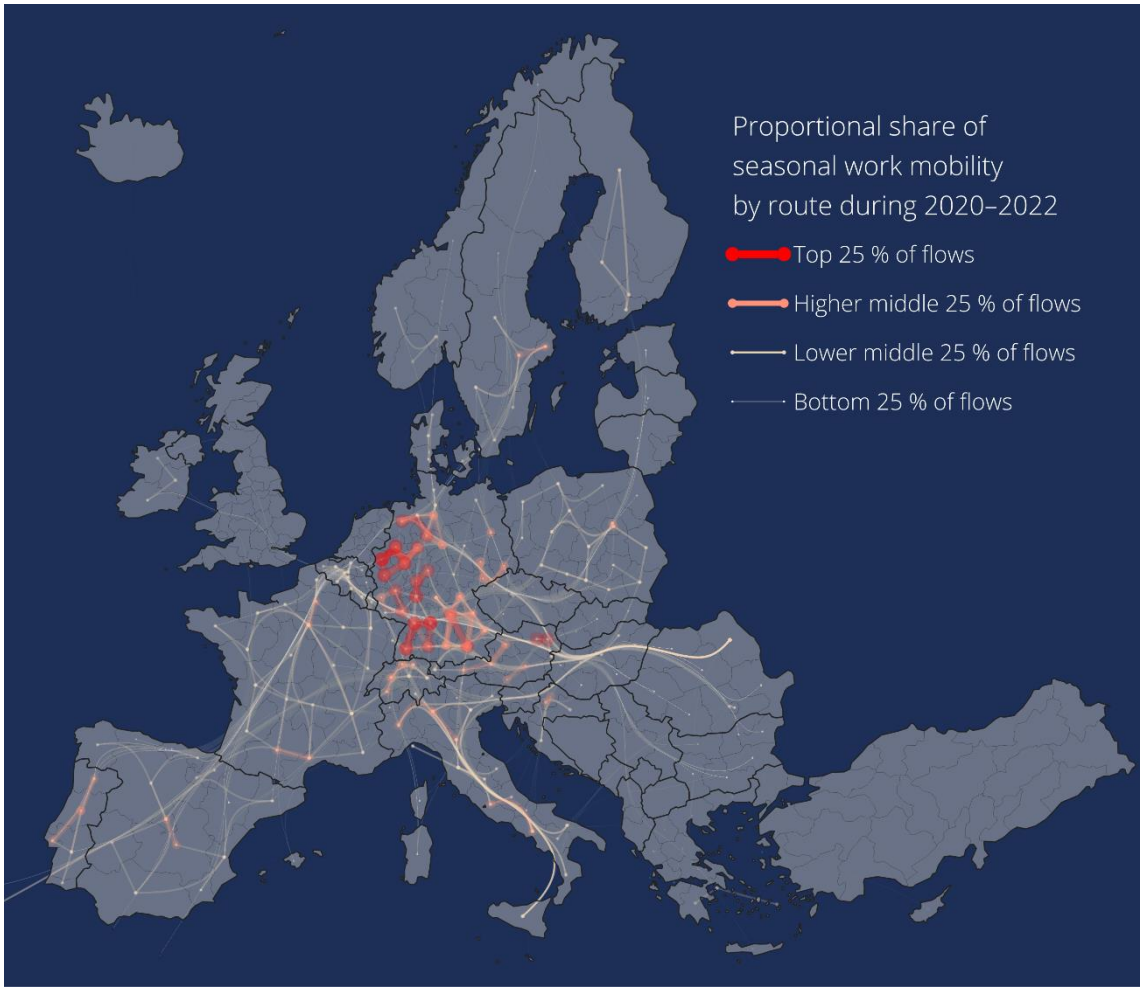

Figure 7. The proportional share of seasonal work mobility during the third period (2020-2022). Note: The values represent how much of the total mobility during the period each flow accounts for. Direction of the flow is not included, but the flows represent total flow between two regions. Major flows are red, while lesser flows are white. Source: Labour Force Survey dataset. Author: Oula Inkeröinen - UH. Full-sized figure HERE.

The comparison between outgoing (sending) and incoming (receiving) seasonal work mobility at NUTS2 region level shows the geographical variations within Europe regarding from where and to where individuals move. Figure 8 (left) shows the variation during the period 2012-2015.

Overall, most of the NUTS2 regions in Luxembourg, Ireland, and Norway experienced relatively more incoming mobility than outgoing mobility during the period 2012-2022. These countries have the highest ratios of incoming mobility from total mobility (90%, 65%, and 64%, respectively). The next three countries with significant ratios are Greece (60%), Switzerland (59%), and Belgium (55%). Seasonal work mobility (including at least 1000 incoming individuals) is predominantly received by regions with larger metropolitan areas such as Közép-Magyarország (Budapest), and Bucureşti-Ilfov (Bucharest), and well-known tourism destination regions in the Mediterranean such as Catalonia, Ionian islands, Crete, the Balearic Islands and Valencia Community in Spain.

Regions with the relatively highest outgoing mobility are in the Baltic countries Latvia (5 %), Estonia (8 %), and the Balkan countries Romania (6 %), and Bulgaria (22 %) – these countries have the lowest ratios of incoming mobility from total mobility. At the NUTS2 regional level, the lowest ratios of incoming mobility from total mobility (with significant outgoing numbers) are regions in Romania (Nord-Est, Sud- Muntenia, Sud-Vest Oltenia, Nord-Ves) and Bulgaria (Severen tsentralen, Severozapaden), as well as Latvia.

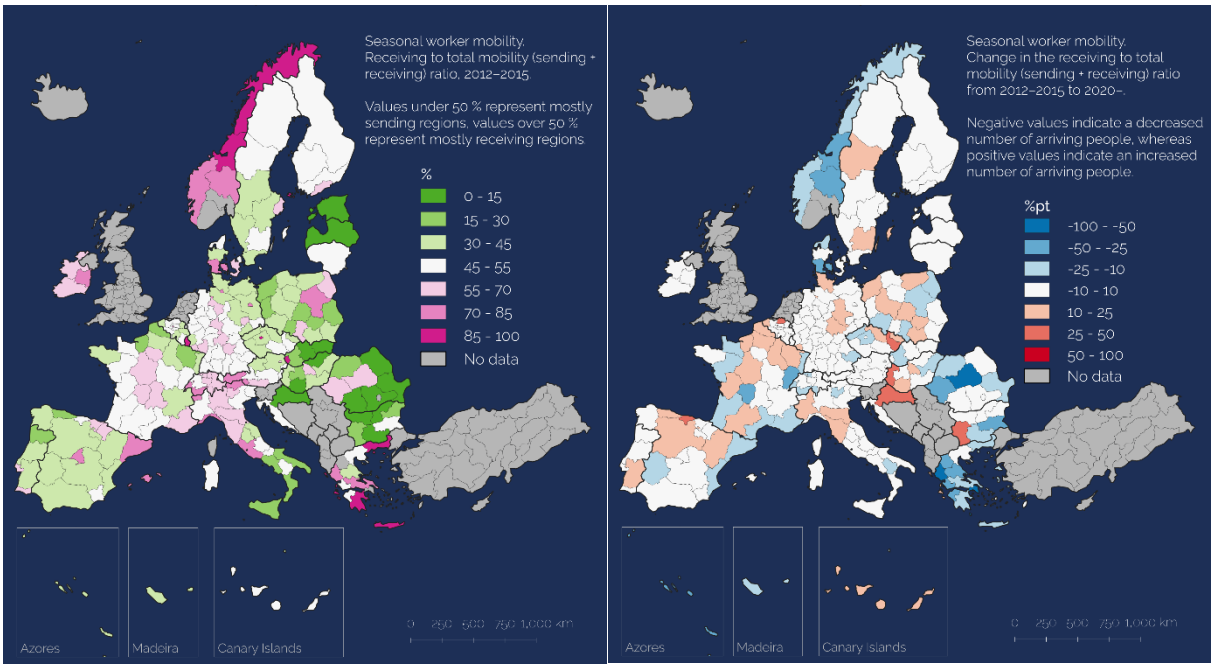

Figure 8. The ratio of incoming seasonal work mobility from total seasonal work mobility at NUTS2 regions in Europe for the first period (2012-2015) (left) and the difference of the ratio between the first and third period (2020) as percentage points (right). Source: Labour Force Survey dataset. Author: Maija Havusela - UH. Full-sized Left Figure HERE and Right Figure HERE.

The comparison of the ratio of incoming mobility from total mobility at NUTS2 region level between the first (2012-2015) and third period (2020-2022) indicates some changes from the geographical perspective (Figure 8, right). The largest decreases occurred in the Balkan countries (Romania, Bulgaria, and Greece), whereas the largest increases mostly occurred in Czechia, Hungary, and Croatia, but also in northern Spain and Belgium. Nearly all regions in France and Poland have witnessed changes in the ratio of incoming seasonal work mobility, although mostly minor.

The GDP of a destination region, as an indicator for overall wealth and salary levels, shows a positive correlation with the ratio of receiving seasonal workers (Figure 9) - higher GDP potentially attracts more people for seasonal employment from regions with a lower GDP due to better economic opportunities and higher wages (Figure 3). The relations regarding intra-country seasonal work mobility remain rather weak and relatively consistent across all three periods, suggesting structural stability in economic attractiveness for seasonal work within the country (Figure 9, left), whereas the relation is much stronger regarding seasonal work mobility between countries in Europe (Figure 9, right). Interestingly, the COVID-19 pandemic did not affect this relation regarding international seasonal mobility, whereas the weak relation for intra-country seasonal mobility became more weakened.

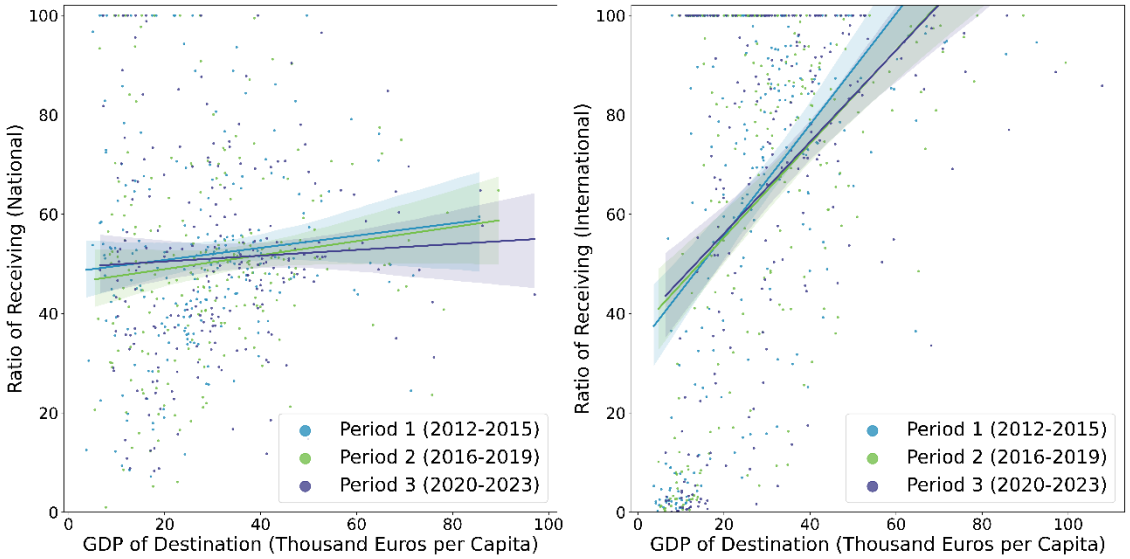

Figure 9. Correlation between GDP of destination regions and ratio of receiving seasonal workers by period. Note: The lines represent the best fit for the data, while the shaded areas indicate the variability in the ratio of receiving seasonal workers. The periods are color-coded: Period 1 is blue, Period 2 is green, and Period 3 is purple. Source: GDP data from Eurostat, and the mobility data from Labour Force Survey. Author: Milad Malekzadeh - UH. Full-sized figure HERE.

Short-term student mobility via the Erasmus Programme within Europe (See Annex B for definition) for the period 2014-2020 had in total almost 1.7 million movements. For the first period (2012-2015), the average yearly movement count was over 210 thousand and for the second period (2016-2019) it was over 276 thousand. In 2020, there were over 150 thousand movements, that is 29% less yearly mobility compared to the first period, and 45% less compared to the second period. Figure 10 shows the flows of short-term student mobility between NUTS2 regions in Europe for the first period, as an example.

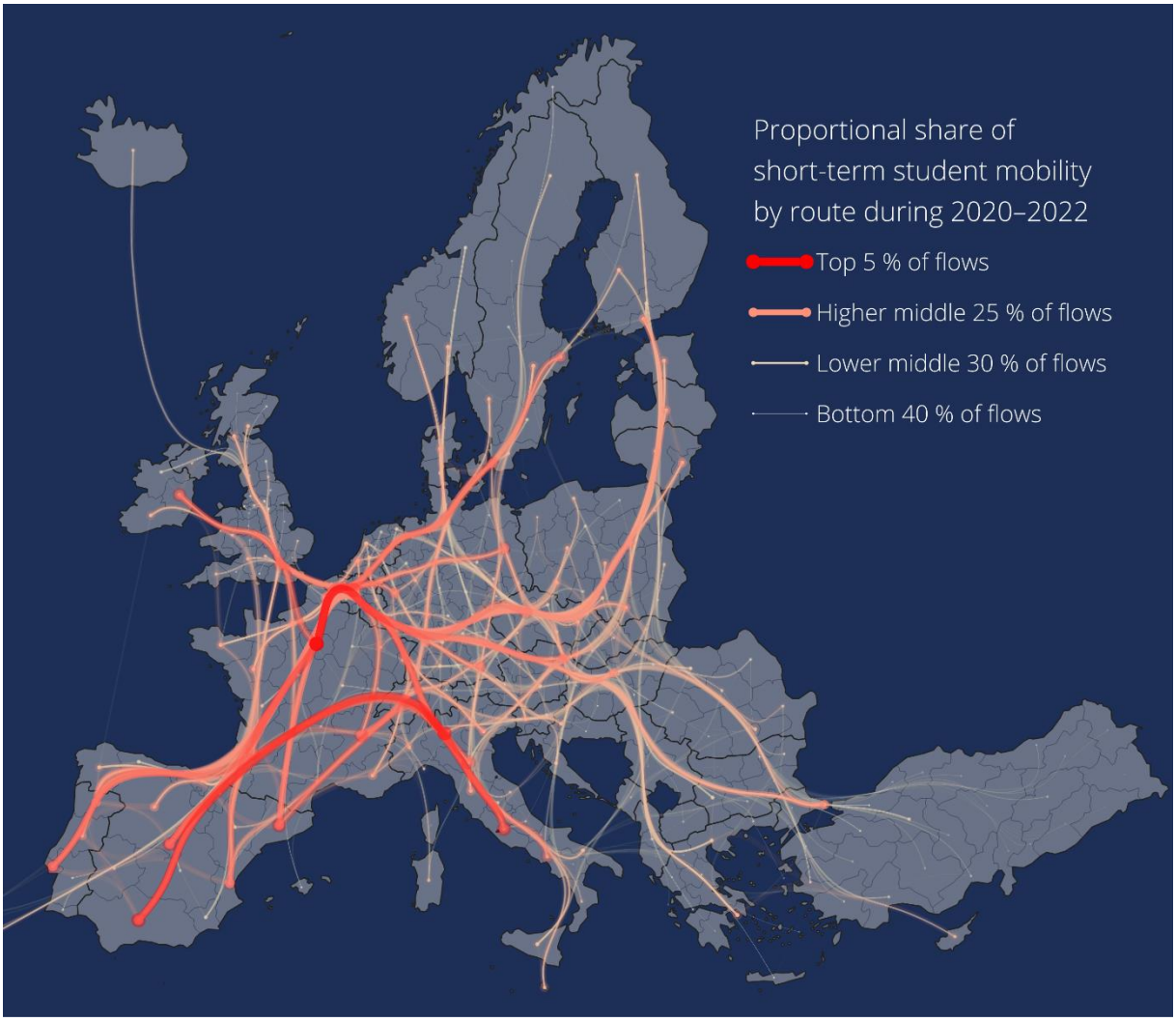

Figure 10. The proportional share of short-term student mobility flows during the third period (2020–2022). Note: The values represent how much the flows represent the total long-term student mobility from the period. The direction of the flow is not included, but the flows represent the total flow between two regions. Major flows are red, while lesser flows are white. Source: Erasmus Programme data. Author: Oula Inkeröinen - UH. Full-sized figure HERE.

The main destination countries for short-term student mobility for the whole period 2014-2020 is Spain (15%), followed by Germany and France (both 10%), the UK (9%) and Italy (8%). Overall, the top three mobility flows are from Italy to Spain (3.6%) and vice versa (2.7%), and from France to Spain (2.5%). At NUTS2 region level, the six highest incoming flows are going

to Île-de-France (e.g. Paris), Andalusia (e.g. Sevilla), Madrid, Catalonia (e.g. Barcelona), Valencia Community (e.g. Valencia) and Área Metropolitana de Lisboa (e.g. Lisbon), which together comprise 16% of all incoming short-term student mobility in Europe.

The comparison between outgoing (sending) and incoming (receiving) short-term student mobility at NUTS2 region level shows the geographical variations within Europe regarding from where and to where students move. Figure 11 (left) shows the variation during the period 2014-2015.

Overall, most of the NUTS2 regions in Norway, Sweden and Ireland have relatively more incoming short-term student mobility than going out during the period 2014-2020 – given countries have the highest ratio of incoming mobility from total mobility (73%, 71% and 71%, accordingly). Other three countries in the top six countries with the highest ratio are Malta (84%), Iceland (71%) and Cyprus (67%), yet with much lower overall mobility flows. Short-term student flows (with at least 1000 incoming students) is relatively more received by regions with metropolitan cities (e.g. Inner London, Greater Manchester, Lisbon Metropolitan Area, Brussels and North Holland), around the Baltic Sea (Finland and Estonia) and the Mediterranean Sea (e.g. Balearic Islands, Valencia Community) and Canary Islands.

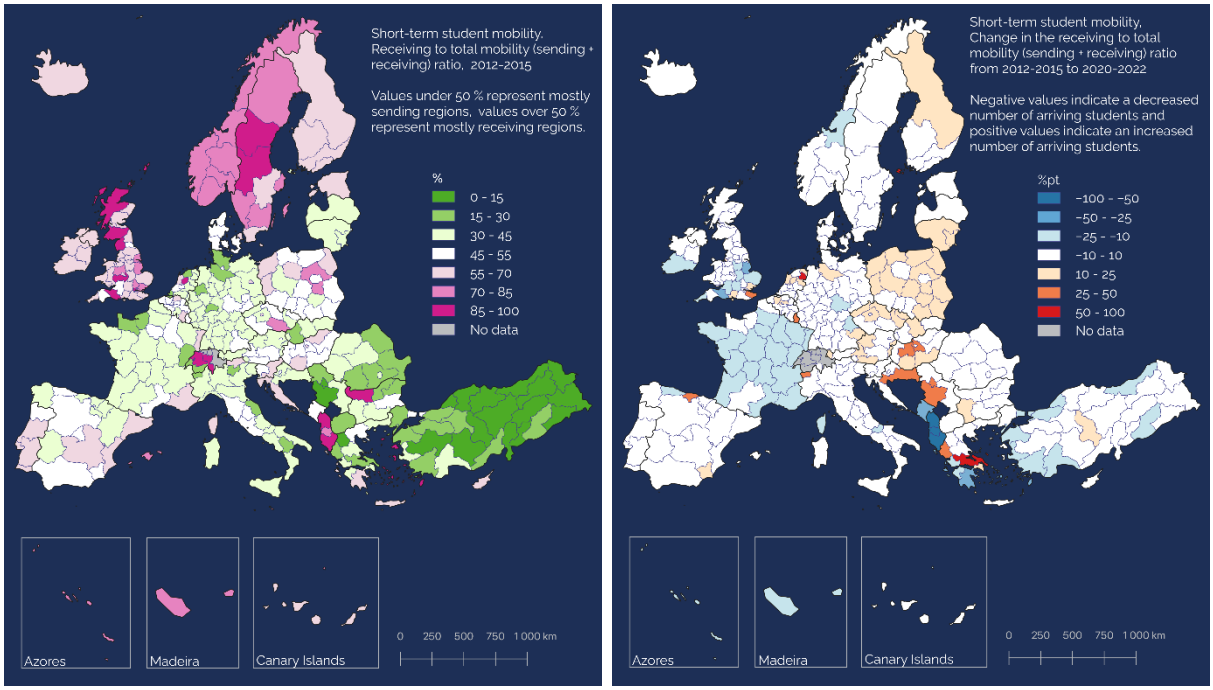

Figure 11. The ratio of incoming short-term student mobility from total short-term student mobility at NUTS2 regions in Europe for the first period (2014-2015) (left) and the difference of the ratio between the first and third period (2020) as percentage points (right). Source: Erasmus Programme data. Author: Maija Havusela - UH. Full-sized Left Figure HERE and Right Figure HERE.

Regions with the relatively highest outgoing mobility are in Eastern Mediterranean countries (Albania, Montenegro, Turkey) and the Balkan countries (Serbia, North Macedonia) – given countries have the lowest ratio of incoming mobility from total mobility

(11%, 20%, 25%, 25% and 28%, accordingly). At NUTS2 region level, the lowest ratio of incoming mobility from total mobility (with at least 3000 outgoing students) are regions in Turkey (Ankara, Bursa, Kocaeli subregions) and in remote regions in France (Franche-Comté, Upper Normandy), Italy (Calabria, Marche) and Germany (Gießen, Münster).

The comparison of the ratio of incoming mobility from total mobility at NUTS2 region level between the first (2014-2015) and third period (2020) indicates changes from the geographical perspective (Figure 11, right). Several regions in the UK and Albania have witnessed a decrease in the ratio of incoming student mobility, which were earlier mostly receiving mobility (Figure 11, left). Regions in France and Turkey also had decrease in the ratio of incoming student mobility, even though they were already mostly sending students. In contrast, Central and Eastern Europe countries have witnessed an increase in the ratio of incoming student mobility, which were earlier mostly sending countries.

In general, 60% of short-term mobility is made by female students during the entire period 2014-2020 (Figure 12). However, short-term student mobility has geographical variations in gender division for both receiving and sending mobility. Gender variations might be due to different preferences regarding societal regulations and social norms as well as prejudice via media in different countries.

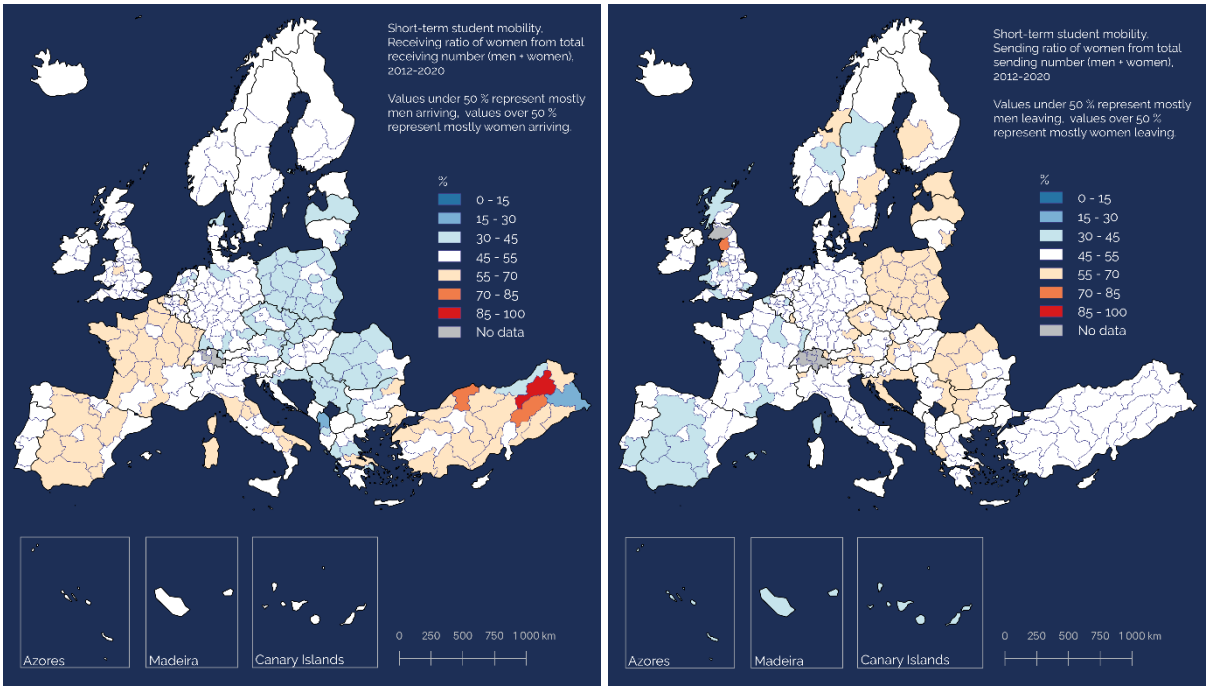

Figure 12. The gender ratio of incoming (left) and outgoing (right) short-term student mobility at NUTS2 regions in Europe for the entire period (2014-2020). Source: Erasmus Programme data. Author: Maija Havusela - Full-sized Left Figure HERE and Right Figure HERE.

The ratio of females among incoming students is the highest in France (68%) and Spain (66%), while it is the lowest in Romania (44%), Poland (46%) and Luxembourg (48%). At

NUTS2 region level, there are nine regions with female ratio over 70% (with at least 500 incoming students), whereas 11 regions with the lowest female ratio below 45%.

The ratio of females among outgoing students is the highest in Poland (71%) and Greece (68%) and Serbia (67%), while it is the lowest in Turkey (50%) and Luxembourg (52%). At NUTS2 region level, there are 19 regions with female ratio over 70% (with at least 500 incoming students), whereas six regions with the lowest female ratio below 45%.

1.3 CIRCULAR MOBILITY

LONG-DISTANCE COMMUTING

Long-distance commuting (See Annex B for definition) estimation between NUTS2 regions within Europe based on Labour Force Survey dataset, for the whole period 2012-2022 had over 250 million commuters in total. The first period (2012-2015) had 22 million yearly commuters on average and the second period (2016-2019) had 23 million, accordingly. The third period (2020-2022) had over 24 million yearly commuters, which is 10 % more than in the first period and 5 % more than in the second period. Figure 13 shows the flows of long-distance commuting between NUTS2 regions in Europe for the third period as an example.

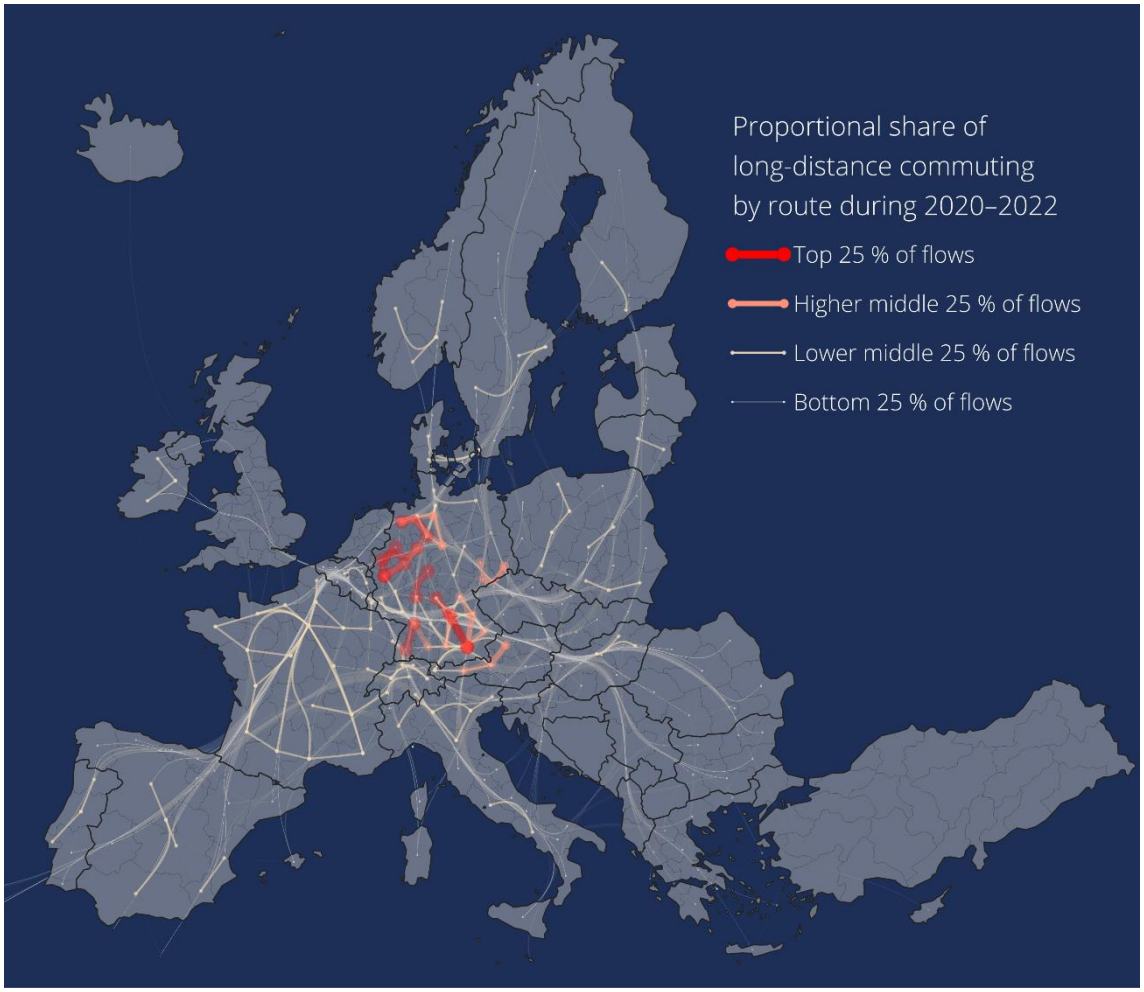

Figure 13. Long-distance commuting flows during the third period (2020-2022). Note: The map does not show directions of the flows, but the flows represent how much of the total mobility the flows capture. The direction of the flow is not included, but the flows represent total flow between two regions. Major flows are red, while lesser flows are white. Source: Labour Force Survey. Author: Oula Inkeröinen - UH. Full-sized figure HERE.

During the whole period of 2012 to 2022, the countries with the highest number of long-distance commuters were Germany (62 % of the total flows), followed by France (9 %) and Austria (6%). The inherent over-representation of German long-distance commuting seems to be caused by the way geographical information is collected in LFS - at the level of NUTS2 regions, which vary significantly by geographical size. Thus, smaller sized NUTS2 regions in Germany capture home-work movements between smaller NUTS2 regions more efficiently compared to other countries in Europe with larger regions.

The comparison between outgoing (sending) and incoming (receiving) long-distance commuting mobility at NUTS2 region level shows the geographical variations in Europe regarding from where and to where long-distance commuters are commuting. Figure 14 (left) shows the variation in the receiving mobility ratio during the period 2012-2015.

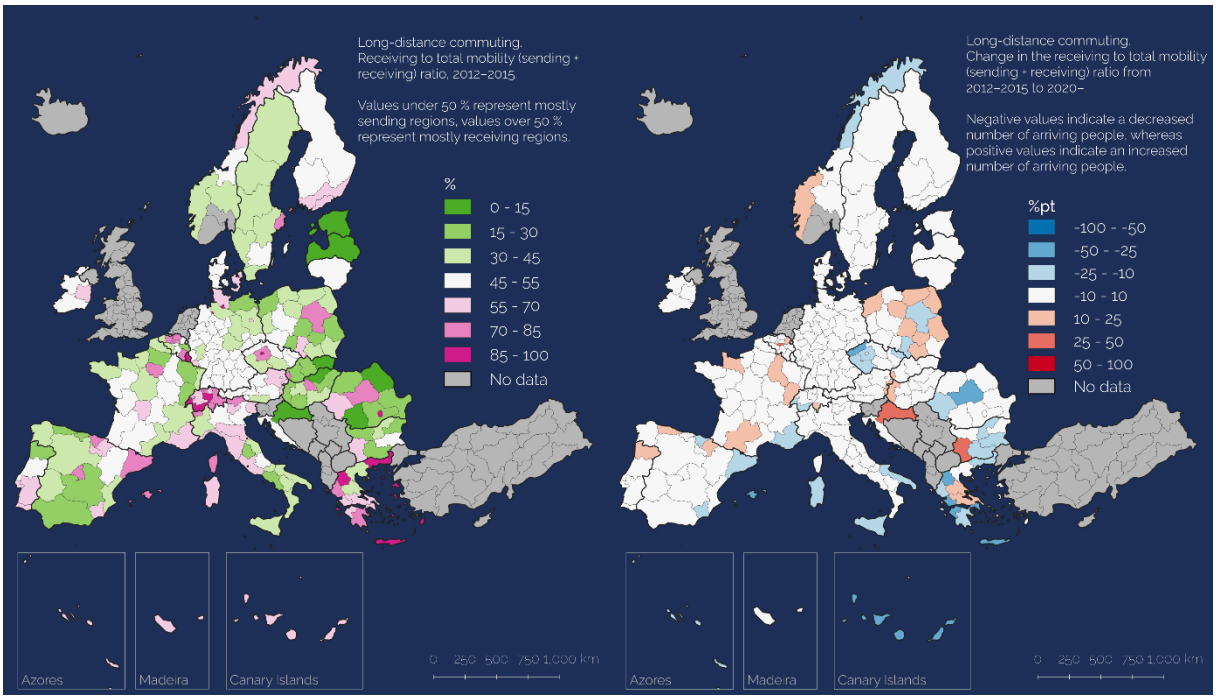

Figure 14. The ratio of incoming long-distance mobility from total long-distance mobility at NUTS2 regions in Europe for the first period (2012-2015) (left) and the difference of the ratio between the first and third period (2020) in percentage points (right). Source: Labour Force Survey. Author: Maija Havusela - UH. Full-sized Left Figure HERE and Right Figure HERE.

Overall, during the whole period of 2012-2020, the top five countries with relatively more incoming long-distance commuting than going out are Switzerland (78 % from total movements), Denmark (56 %), Norway (55 %), Finland (55 %), and Belgium (54 %), in addition to Luxembourg (~100 %). At the regional level, most NUTS2 regions with higher incoming long-distance commuting ratio are mostly regions with larger cities or island regions. The top five NUTS2 regions that received relatively more incoming long-distance commuters than sent out (besides Luxembourg as one NUTS2 region) are Közép-Magyarország (98 %; e.g. Budapest), Ionia Nisia (97%; e.g. Ionian islands), Notio Aigaio (96 %, e.g., South Aegean), Voreio Aigaio (93 %, e.g., North Aegean), and Zentralschweiz (93 %, e.g., Luzern region). Regions with the relatively highest outgoing mobility from total long-distance commuting mobility are in the Baltic and Balkan countries – given countries have the lowest ratio of incoming mobility from total mobility: Latvia (8%), Estonia (11 %), Romania (20 %), Slovakia (26 %), Bulgaria (36 %), and Hungary (41 %). At NUTS2 level, the regions with the highest share of incoming long-distance commuting are Oberbayern (7 %), Köln (5 %), Weser-Ems (4 %), Freiburg (4 %), and Karlsruhe (3 %). The lowest shares of incoming long-distance commuting on NUTS2 level are Podlaskie, Corse, Lubelskie, Ciudad de Ceuta, Ciudad de Melilla) each with less than 0.01 % of share of incoming long-distance commuters.

The comparison of the ratio of incoming long-distance commuting from total commuting at NUTS2 region level between the first (2014-2015) and third period (2020) indicates some changes from the geographical perspective (Figure 14, right). For example, several regions

in Greece, other regions with islands (e.g. Sicily, Sardinia, Baleares), and regions in Czechia and Romania have witnessed significant decrease in the ratio of incoming long-distance commuting, which were earlier mostly receiving mobility (Figure 14, left). Some regions in Croatia (Panonska Hrvatska), Belgium (Brabant Wallon) and Bulgaria (Yugozapaden) have witnessed significant increase in the ratio of incoming long-distance commuting – for example, due to decrease of outward commuting linked to the COVID-19 and Brexit.

CROSS-BORDER COMMUTING

Cross-border commuting (See Annex B for definition) is estimated based on Labour Force Survey datasets covering the whole of Europe during the period 2012-2022. This mobility type represents workers who reside in one country but work in another (neighbouring) country. For the entire study period (2012-2022), cross-border commuting consisted of 22 million movements in total. For the first period (2012-2015) the yearly average cross-border commuter count was 1.8 million movements and for the second period (2016-2019) it was 2.1 million. In the third period (2020-2022), the yearly average cross-border commuter count was 2 million.

Figure 15 shows the flows of cross-border commuting between NUTS2 regions in Europe for the third period, as an example. Note, the exclusion of some countries (Slovenia, the Netherlands, the UK, and countries in the Balkan region) might affect the incoming cross-border flow data of the neighbouring countries like Ireland, Italy, Belgium and Greece.

The comparison between outgoing (sending) and incoming (receiving) cross-border commuting at NUTS2 region level shows the geographical variations within Europe regarding from where and to where commuters move. Figure 16 (left) shows the variation in the receiving cross-border commuting ratio during the period 2012-2015.

Overall, during the whole period of 2012-2020, countries with the highest ratio of incoming (receiving) cross-border commuters from the total of incoming (receiving) and outgoing (sending) cross-border commuting flow are Norway (~100 %), Luxembourg (97 %), Switzerland (97%), Ireland (93%), and Greece (90%). Conversely, countries with highest sending ratio, with the lowest incoming mobility ratio, are Romania (3 %), Poland (5 %), Bulgaria (5 % from total flow), Slovakia (7 %), Latvia (9 %), and Croatia (10 %). In general, the top five country pairs regarding cross-border commuting flows in Europe are France–Switzerland (13% from total flows in Europe), Poland-Germany (7%), France–Luxembourg (6%), Germany–Switzerland (5%), and Italy-Switzerland (4%). These country pairs comprise roughly one third of all cross-border commuting in Europe.

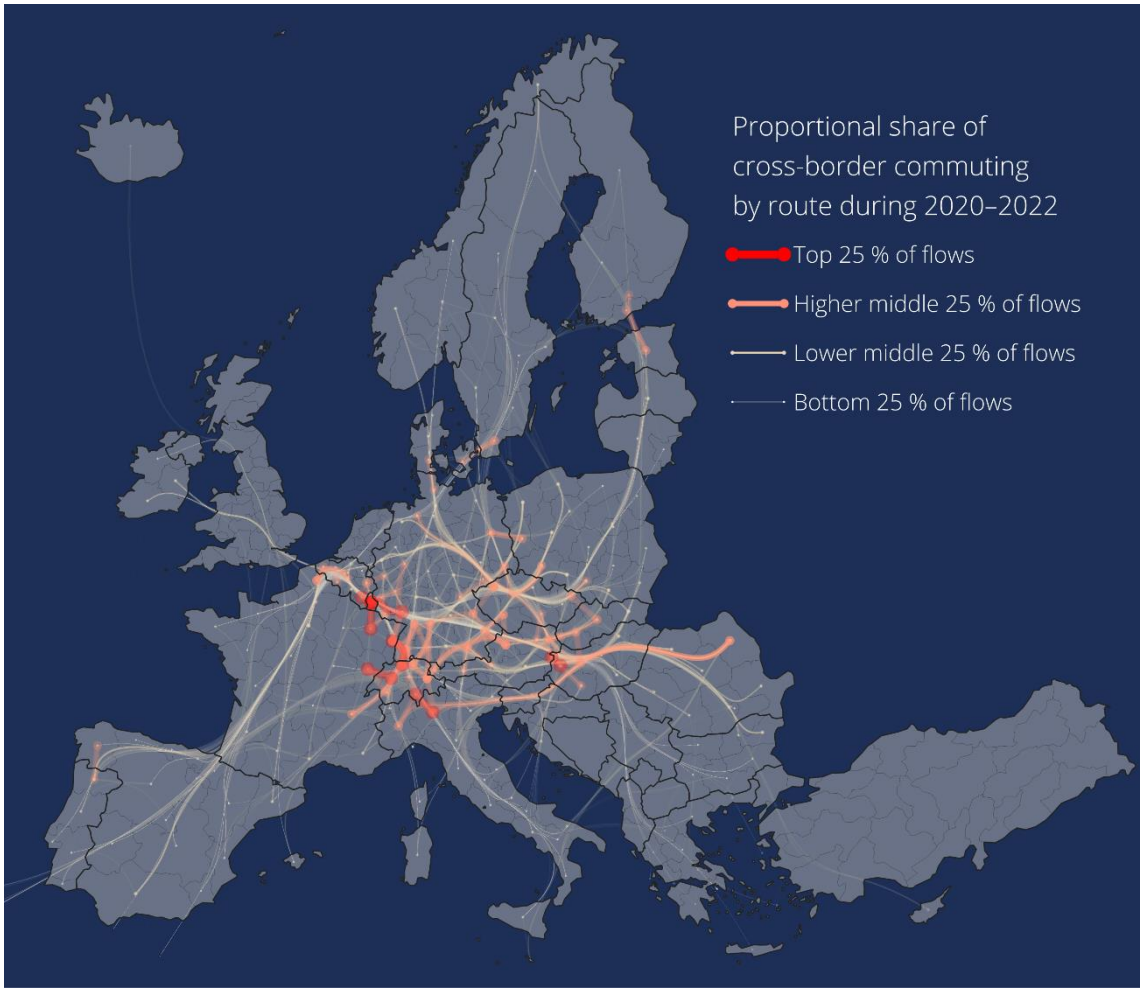

Figure 15. The proportional share of cross-border commuting during the third period (2020-2022). Note: The values represent how much of the total mobility flows each flow captures. The direction of the flow is not included, but the flows represent total flow between two regions. Major flows are red, while lesser flows are white. Source: Labour Force Survey. Author: Oula Inkeröinen - UH. Full-sized figure HERE.

At regional level, during the whole period of 2012-2020 the top 5 NUTS2 regions with the highest volume of incoming cross-border commuters are Luxembourg (97% of receiving commuting; ca 220 thousand yearly commuters), Lake Geneva Region (99%; ca 165 thousand), Northwestern Switzerland (97%; 67 thousand), Eastern Switzerland (94%; ca 59 thousand) and Oberbayern (78%; ca 50 thousand). Conversely, regions with highest sending cross-border commuting volume are Rhône-Alpes (4% of receiving commuting; ca 130 thousand yearly commuters), Lorraine (3%; ca 123 thousand), Alsace (7%; ca 84 thousand), Nord-Est in Romania (1%; ca 74 thousand) and Lombardia (10%; ca 67 thousand).

The comparison of the ratio of incoming cross-border commuting from total cross-border commuting flows at NUTS2 region level between the first (2014-2015) and third period (2020) indicates changes from the geographical perspective (Figure 16, right).

Most drastic changes have been the increase of receiving cross-border commuting flows towards Germany, especially in Eastern regions regarding both relative and absolute

volumes. To a lesser extent increase has occurred in Norther Sweden and some specific regions in Croatia, France and Belgium and Portugal. Most significant decrease in the receiving cross-border commuting has occurred in the Mediterranean region as well some regions in Czech Republic and Romania, however, most of given regions do not have flows with a significant volume (Figure 15).

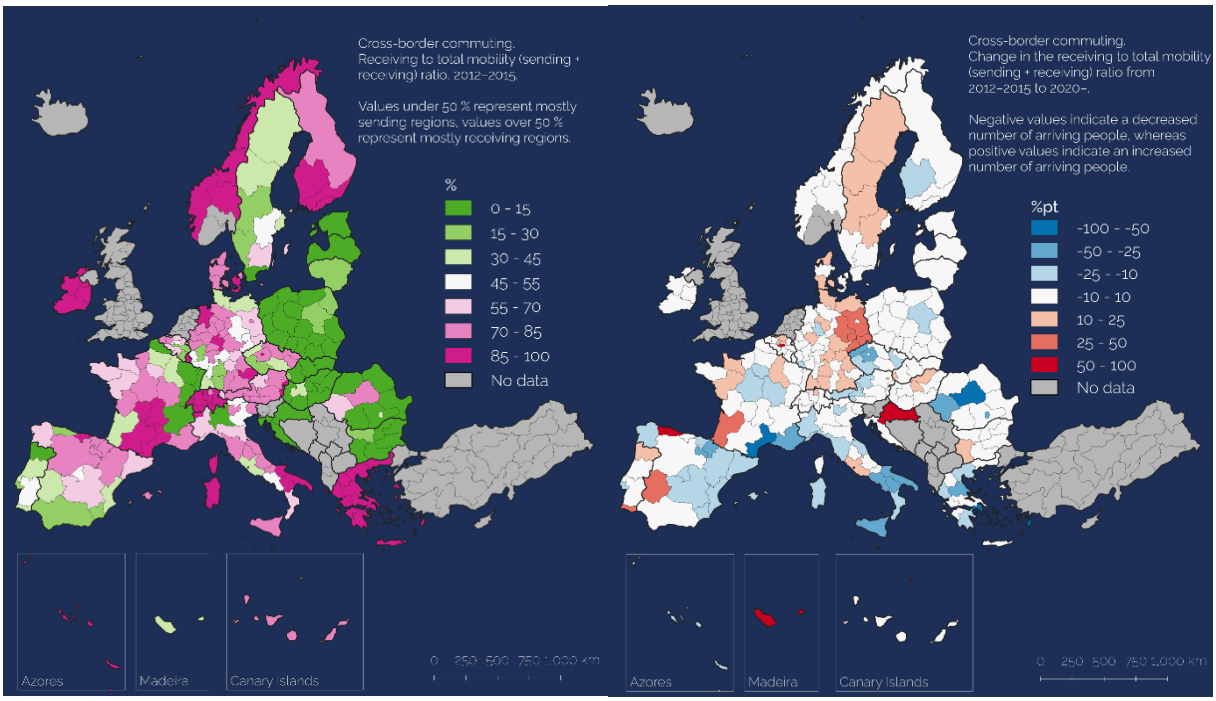

Figure 16. The ratio of incoming cross-border mobility at NUTS2 regions in Europe for the first period (2012-2015) (left) and the difference of the incoming mobility between the first and third period (2020) as percentage points (right). Source: Labour Force Survey dataset. Author: Maija Havusela - UH. Full-sized Left Figure HERE and Right Figure HERE.

MULTILOCAL LIVING

Multilocal lifestyle means people having more than one place where they reside (incl. second homes) and spend a significant amount of time in those places (e.g. Schier et al., 2015). Multilocal living arrangements between NUTS2 regions estimated based on Twitter data from 2012 to 2022 accounted for a total of over 405 thousand people with such a lifestyle in Europe.

The absolute values derived from Twitter data may not reflect the actual number of people with multilocal lifestyle, yet the relative distribution of people with multilocal living arrangements across Europe wide provides a solid perspective on given mobility flows. Figure 17 shows the connections between NUTS2 regions, where these multiple residential locations are situated, throughout the entire period.

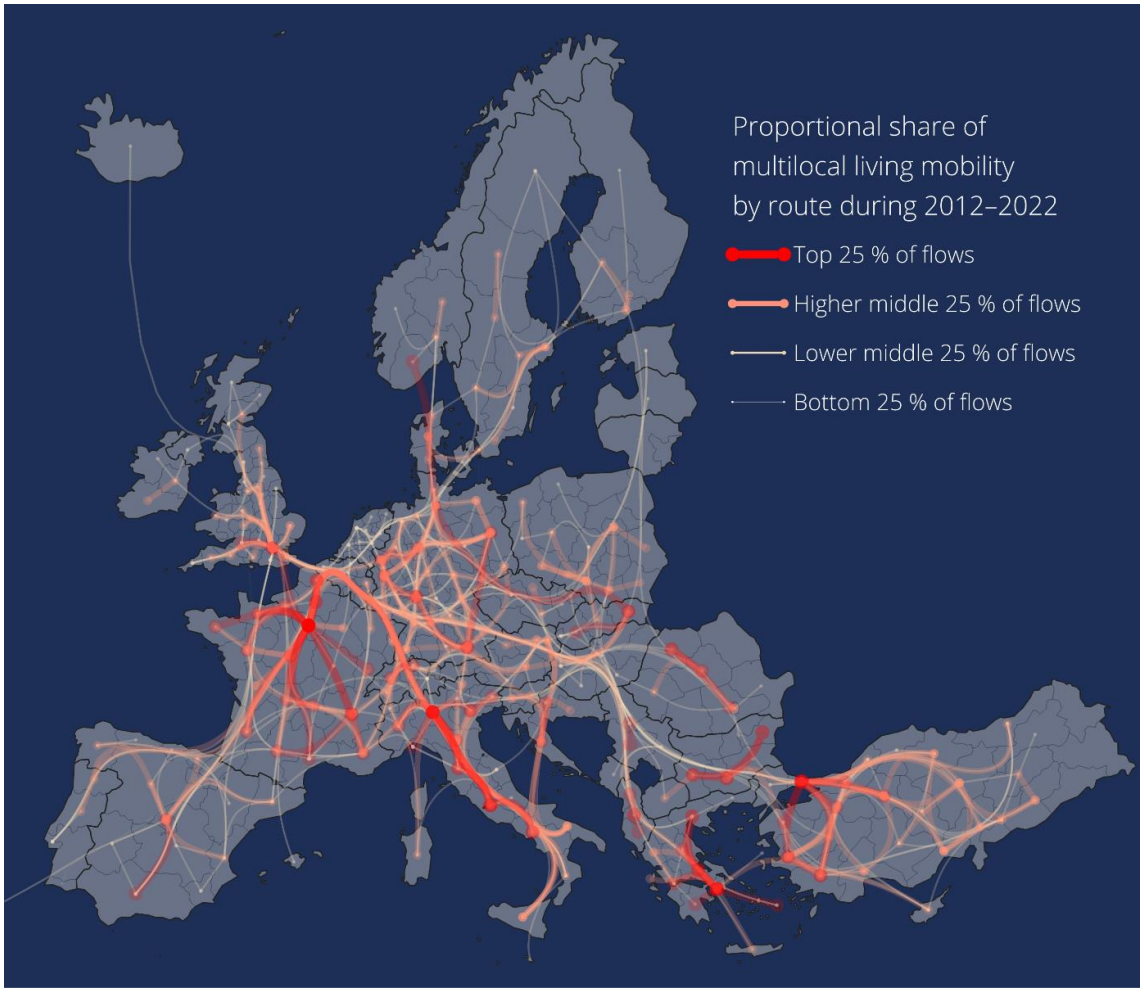

Figure 17. The proportional share of multilocal living mobility during 2012-2022. Note: The values represent how much of the total multilocal mobility flows each flow captures. The direction of the flow is not included, but the flows represent total flow between two regions. Major flows are red, while lesser flows are white. Source: Twitter (X). Author: Oula Inkeröinen - UH. Full-sized figure HERE.

The main countries with people having multilocal living arrangements for the whole period 2012-2022 is France (14% from total flow in Europe), followed by Germany and Italy (both 13%), Turkey (12%), and the UK (11%). All top ten region pairs where people with multilocal living arrangements are sharing their residence are intra-country. For inter-country multilocal living arrangement - people residing in various countries at the time - the top three region pairs are between France and Italy (1.33%), France and the UK (1.21%), and Spain and the UK (1.07%). At NUTS2 region level, the regions with the highest level of multilocal living arrangements are Île-de-France (e.g. Paris), Lombardia (e.g. Milan), Attica (e.g. Athens), Lazio (e.g. Rome), and Oberbayern (e.g. Munich), which all together comprise 18.3% of all multilocal living arrangements in Europe.

The geographical distribution of people with multilocal living arrangements across Europe varies significantly (Figure 18). Regions in the highest decile class (top 10%), representing the highest level of people with multilocal living arrangements, are predominantly located

in Southern Europe, including areas in France, Italy, Spain, and Turkey. Conversely, regions in the lowest decile class (bottom 10%), representing the lowest level of people with multilocal living arrangements, are primarily in Northern and Eastern Europe.

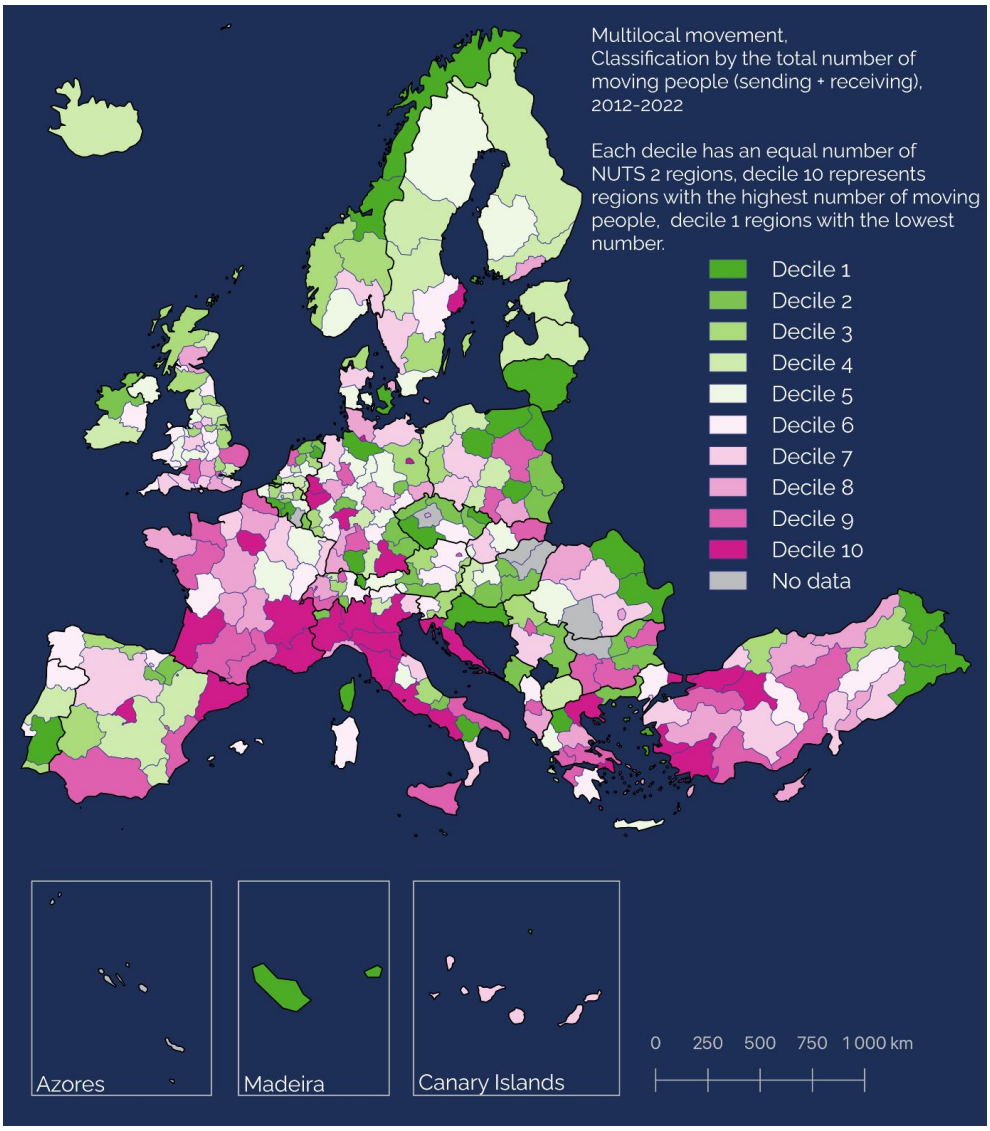

Figure 18. The classification of total multilocal mobility at NUTS2 regions in Europe for the period of 2012-2022. Source: Twitter (X). Author: Maija Havusela - UH. Full-sized figure HERE.

2. REGIONAL ATTRACTIVENESS, LEFT BEHIND PLACES AND THE TWIN TRANSITION

The mapping exercise outlined in preceding sections has unveiled a wealth of insights into various forms of spatial mobility and their interplay with regional dynamics. Consequently, a deeper examination is warranted to elucidate the influence of regional attributes on the emergence of spatial mobility patterns. Within this context, MOBI-TWIN contends that this pertains to a body of literature centered around the concept of regional attractiveness, contextualised within the framework of Twin Transition, with particular attention to areas left behind.

Starting from the idea of regional attractiveness, this is a concept that encompasses the various factors and characteristics that make a particular geographic area appealing and desirable to individuals. It involves a comprehensive evaluation of the attributes that contribute to the overall allure of a region, encompassing both tangible and intangible elements. These factors may include economic opportunities, educational institutions, job markets, quality of life, cultural amenities, and environmental considerations. The concept of regional attractiveness is dynamic and multifaceted, as it takes into account diverse aspects that influence the decision-making processes of people relocating to a specific geographical area.

Silvanto and Ryan (2018) identified five key **factors affecting the attractiveness of a place** focusing on the movements of highly skilled human capital. These include (i) economically related factors, such as employment opportunities and the economic dynamism of a region; (ii) cultural diversity, referring to the ability of a region to efficiently welcome foreigners; (iii) policy-related factors, including legal and regulatory aspects; (iv) network-based aspects, integrating the dimensions of geographical concentration of talent and other relevant professions; and (v) quality of life features, encompassing place-based characteristics, such as cultural amenities and social interactions. According to their study, regions being eager to maximise their ability to attract and retain talent in the long run should emphasise on developing employment opportunities and boosting the acceptance of foreigners (Silvanto and Ryan 2018).

In this regard, regional characteristics play an essential role in making regions capable of keeping their existing human capital and attracting new forms of activity as well as specific groups of people (Ruzzier and De Chernatony, 2013). Rising inequalities between European regions in terms of their ability to attract human capital constitute a significant barrier to achieving even developmental opportunities, leading to the emergence and persistence of lagging behind and less favoured regions (European Commission 2014; Relocal 2018). Therefore, regional policies should clearly consider aspects related to regional attractiveness towards enabling less developed regions to construct a concrete human capital based for triggering new developmental paths and opportunities (Nadeau and Olafsen 2015). Technological progress, sustainability elements and intangible factors

constitute essential factors -in addition to economic-related conditions- that should be considered when exploring the idea of regional attractiveness (Eggert and Schweyer 2007; Romão et al. 2018).

When trying to conceptualise the relationship between **regional attractiveness and left-behind places**, it is important to understand the framework under which these areas operate and are affected by mobility choices. The term 'left behind places' has reshaped how geographical inequalities are perceived in the post-2008 crisis, highlighting spatial disparities resulting from globalisation and economic shifts. It contrasts the dynamism of 'superstar' cities with negative associations of decline and marginalisation in certain regions (Kemeny & Storper, 2020). This spatial imaginary draws attention to previously overlooked areas, broadening interpretations beyond mere economic issues to include social, political, environmental, and cultural dimensions (Pike et al., 2023). Understanding these conditions requires a nuanced approach, considering peripheralisation and metropolitanisation concepts (Lang et al., 2015). The term's definition impacts policy responses and shapes discussions on development. Therefore, avoiding the pitfalls of simplistic terminology is crucial, urging a return to foundational concerns of reducing geographical inequalities and promoting social and spatial justice through clearer and more comprehensive spatial imaginaries (Pike et al., 2023; Lange et al., 2021).

According to Velthuis et al. (2023), 'left behindness' can be identified as the lack of regional capability to benefit from the economic shifts and dominant growth paradigms happening during the last decades. This means that their regional characteristics not only make them less competitive in terms of attracting new residents, but instead they act as drivers of outward mobility for people already living there. At the same time, it is important to stress that not all mobility-relevant factors will affect left-behind regions to the same extent. This means that some places may lag in a specific measure, while in other aspects they may perform better (Martin et al., 2021). Empirical findings illustrate that there is a variegated nature of population decline across diverse locations (Karp et al., 2022). These shrinking places not only host different demographic groups but also exhibit varying economic conditions, housing quality, and social capital. More specifically, research identifies distinctive clusters, such as working-class homeowners and immigrant-dominated areas, each facing unique challenges and opportunities (Karp et al., 2022). Furthermore, the identification of prosperous clusters characterised by higher education and income, alongside the stressed clusters with diverse populations, highlights the need for tailored policy interventions. The findings advocate against a one-size-fits-all approach, emphasising the necessity of acknowledging the wide-ranging scenarios within shrinking regions.

In general, left-behind regions have emerged as a global challenge, captivating academic attention due to their intricate connections with demographic, social, political, and economic factors (Martin et al., 2021). The phenomena of depopulation are historically linked to deindustrialisation, suburbanisation, and demographic shifts, forming a complex tapestry of challenges for policymakers (Franklin, 2021). The consequences of decline are

disproportionately borne by these left-behind areas, often characterised by financial vulnerability and a diminishing capacity to provide essential public services. Connecting the notions of regional attractiveness and left behind places to the Twin Transition discussion is essential, as the TT shapes a large share of policy discussions and choices within the European context (Komninos et al., 2023; Angelidou et al., 2022). It is important to understand the ways in which the green and the digital transition shapes individual choices on spatial mobility, and therefore, their impact on the developmental dynamics of regions.

A recent study by Rodríguez-Pose and Bartalucci (2023) points out that there are indirect effects resulting from the **green transition** affecting individual mobility and its spatial outcomes. More specifically, they indicate that the European Green Deal is anticipated to have indirect consequences, primarily driven by increased factor mobility and the redistribution of economic and social assets. This redistribution may lead to the concentration of green technologies, employment, and innovation in regions better equipped for sustainable economic activities. Skilled migration is identified as crucial in the context of skill-biased technological changes related to the green transition (Atkinson et al., 2019). Specialisation in green technologies requires a qualified workforce, economic specialisation, and appropriate infrastructure. Hence, left-behind regions may face challenges tapping into opportunities presented by green technologies, potentially resulting in unemployment, skill mismatches, and brain drain (Moreno and Ocampo-Corrales, 2022). This brain drain, where skilled individuals migrate to more prosperous areas, can exacerbate regional disparities, leaving less-skilled workers and lower-productivity firms in vulnerable regions. This concentration of opportunities in affluent areas may accelerate skilled migration, deepening existing territorial divides and causing discontent in internally polarised societies (Fratesi and Rodríguez-Pose, 2016).

The **digital transition** impacts regional attractiveness by reshaping accessibility to services and influencing migration patterns. Despite concerns about the digital divide and potential marginalisation, the dematerialisation of services like telemedicine and e-government offer economic, environmental, and social benefits, facilitating virtual access to services (Salemink et al., 2017). However, rural communities may face challenges due to a lack of digital competencies or resistance to change (Löfving et al., 2022). Moreover, the relationship between migration and development complicates the landscape, as migrants often represent agents of development through the transfer of knowledge and resources. In Europe, debates focus on the resilience of local communities and the potential of migrant newcomers to stimulate innovation and local development, particularly in left-behind areas (Tietjen and Jørgensen, 2016). While the presence of newcomer migrants can strengthen resilience and mitigate risks, migration and development do not always align, emphasising the need for nuanced approaches tailored to the diverse characteristics of regions.

In both cases, we can see that regional attractiveness is affected by the lack of regional skills to effectively integrate new technologies and attitudes towards green facilities and

transformations. Therefore, spatial mobility -especially when combined with highly educated individuals- can be considered either as a driving force or an outcome related to left behind areas.

3. MEASURING REGIONAL ATTRACTIVENESS

In the contemporary landscape of global development, the assessment of regional attractiveness has expanded beyond conventional metrics to embrace the transformative dynamics of the digital and green transition. Traditionally, regions were evaluated based on factors such as infrastructure, economic stability, and workforce availability. However, the ongoing digital revolution and increasing emphasis on sustainability have ushered in a new era, prompting the integration of innovative criteria into the assessment process. As we navigate this paradigm shift, measures of regional attractiveness must now consider not only the traditional aspects that have long defined economic success but also the evolving facets associated with the digital age and the imperative for environmental sustainability. This comprehensive approach ensures a nuanced understanding of regions' potential, aligning with the imperatives of a rapidly changing global landscape.

Below, we present a set of indicators that have been used when exploring regional attractiveness and performance in relation to traditional aspects of regional branding, as well as aspects linked to the digital and green transition. We focus specifically on indicators developed for the European framework and target mostly the regional level. However, given the data availability limitations, we also present previous studies that target the country level of analysis.

1.4 COMMON INDICATORS FOR REGIONAL ATTRACTIVENESS

When exploring the geographical preferences of people, prior research sheds light on the pivotal role played by location-specific factors in steering individuals towards particular regions, with London serving as a notable example (Dickmann and Mills, 2010; Dickmann and Cerdin, 2014). The quality of social interactions and work opportunities emerge as crucial determinants influencing such choices. Additional studies expand the discourse to incorporate broader national contexts (Oliinyk et al., 2022 ; Braun and Recchi, 2009; Florida, 2006). Living conditions and political stability are identified as influential factors that shape the ability of regions as preferred destinations for skilled professionals seeking both residence and employment. However, the complexities of location dynamics extend beyond mere attractions. As highlighted by Morgan et al. (2003), some regions face unique branding challenges, such as encompassing an excess of stakeholders, limited management control, and low-level development of distinct "place" identities. These challenges stress the multifaceted nature of people's choices, underscoring the need for a nuanced understanding of the interplay between location-specific elements, regional contexts, and the intricate dynamics shaping the attractiveness of different places.

Factors related to regional attractiveness, and especially to the ability of regions to pull human capital, can be grouped into broad categories like those identified by Silvanto and Ryan (2018). These include indicators relevant to employment and economic opportunities of a place; cultural diversity, indicating the degree to which a region can effectively welcome foreigners; a clear immigration policy framework, referring to legal and regulatory factors; existing networks increasing professional and integration opportunities; and quality of life, encompassing aspects related to regional amenities and social interaction.

Diving into the complex exploration of regional attractiveness, researchers have extensively delved into the **economic dimensions** of places, incorporating variables intricately tied to employment and economic opportunities. In the first case, investigation involves traditional metrics gauging employment dynamics within a given region, including parameters such as employment rates and the prevalence of unemployment. This approach provides a fundamental understanding of the labour market landscape, elucidating the factors that contribute to a place's appeal. In parallel, scholars have probed deeper into the economic fabric of regions by leveraging GDP per capita as a predominant proxy for assessing economic opportunities. The utilisation of this measure allows researchers to discern the per-person economic output, thereby capturing the broader economic viability of a locale. Silvanto and Ryan (2018), for instance, underscore the significance of GDP per capita as a pivotal determinant in shaping perceptions of regional attractiveness. Furthermore, wage differentials emerge as a noteworthy dimension influencing a place's capacity to allure new residents, particularly when focusing on highly skilled individuals. Solimano (2008) highlights the pivotal role played by wage differentials in shaping migration patterns, as skilled professionals are often drawn to locales offering competitive compensation packages. Housing prices are also another essential factor affecting mobility flows, due to hgh differences that may arise between regions. This nuanced exploration of economic facets enriches our comprehension of regional attractiveness, underlining the interplay between employment dynamics, economic opportunities, and wage differentials in shaping the desirability of diverse locales.

The previous dimension can be enriched by incorporating considerations of innovation and cultural elements in the discourse, thereby adopting a more **creative perspective** (Currid-Halkett & Scott, 2013). Past research has examined indicators linked to cultural or research and development (R&D) activities as potential determinants of the appeal of a location, providing insights coming from both consumption and production-based approaches to regional attractiveness (Arribas-Bel et al., 2016; Florida, 2016). Emerging evidence indicates that creative activities exert a diversified impact in attracting new residents, influencing not only individual preferences but also varying across different regions based on their characteristics (Romão et al., 2015). Variables such as international visitation, cultural facilities, conferences, and events are commonly utilised as proxies for the cultural factor, demonstrating a positive influence on population growth rates (Romão et al., 2018). Concurrently, the innovation potential of a region has also been identified as significant in

numerous instances, contributing to heightened cultural interaction and increased international flows (Romão et al., 2018).

When considering a more social perspective, studies point out the importance of factors related to the quality of life within a place framing its **liveability potential** (Romão et al., 2018). Academic discourse on livability encompasses a spectrum of perspectives, fostering considerable debate about its definition. The complexity arises from the inherently subjective nature of liveability, as pointed out by de Chazal (2010), who argues that it represents a dynamic expression of values and desires, rendering a definitive characterisation challenging. Despite this inherent ambiguity, de Chazel acknowledges the necessity for operational definitions tailored to specific contexts, proposing a broad definition of liveability as the satisfaction with life in a particular location. At the same time, Van Kamp et al. (2003) highlight the complex nature of liveability, positing it as a conglomerate of desires within distinct domains, such as the physical environment and personal and community development. Buys et al. (2013) further contribute to the discourse by emphasising the intricate, personal, and relative nature of what constitutes a livable place, subject to individual perspectives and environmental perceptions. Despite the various approaches taken to understand and apply the concept of livability in recent literature, there is a prevailing agreement on the significance of assessing the quality of life across multiple dimensions. This includes considerations of social aspects (Lloyd et al., 2016; Ruth and Franklin, 2014), as well as the examination of intangible factors associated with the urban environment (Kashef, 2016).

Recently, there have been efforts to **connect regional attractiveness with left-behind areas** by investigating and developing new measures of 'left-behindness' (Velthuis et al., 2023). This is a complex issue as it encompasses multiple dimensions expressed through a variety of indicators (Karp et al., 2022; Ribant and Chen, 2020). Velthuis et al. (2023) identify a composite indicator of left-behind areas in order to investigate the spatial distribution of these places across the EU. More specifically, the study employs a multi-dimensional approach to measure the 'left-behindness' of regions in the EU15, focusing on economic, demographic, and social dimensions. Economic indicators include regional GDP per capita as a percentage of national GDP per capita, measuring economic development, and the growth in GDP per capita since 1991, indicating long-term economic performance. Employment growth and industrial employment changes offer insights into a region's ability to generate jobs and adapt to structural shifts. On the demographic front, the study considers net migration rates from 2014 to 2019 and the average annual rate of population growth from 1991 to 2018. Specific demographic aspects, such as old-age dependency ratios and youth migration, provide additional insights into regional demographic dynamics. For the social dimension, estimated at-risk-of-poverty rates are utilised as indicators of regional poverty levels (Copus, 2014; Melo & Copus, 2014; Panori, 2017), highlighting potential drivers of discontent. Accessibility of services, particularly travel times to supermarkets and convenience stores, is assessed using ESPON PROFECY project data (Noguera et al., 2017), offering insights into the challenges faced by individuals and families in accessing essential services. The methodology involves expressing each

indicator relative to national averages, ensuring a comparative perspective. The study addresses data limitations and focuses on the more recent pre-Covid period, acknowledging the potential fluctuation in net migration by averaging over five years. The combination of workplace-based and demographic indicators provides a comprehensive understanding of regional disparities, contributing to the broader discourse on 'left-behind' regions within the EU15.

1.5 INDICATORS RELATED TO THE DIGITAL TRANSITION

Indicators for digital regional attractiveness play a pivotal role in gauging the technological appeal and competitiveness of specific geographic areas within the context of spatial mobility. In the dynamic realm of spatial movement, regions that effectively leverage and integrate digital technologies emerge as focal points for businesses, talent, and investments. These indicators encompass various facets, including the strength of connectivity infrastructure, the availability of digital skills, the extent of technological adoption by local businesses, and the prevalence of digital services throughout the region. By assessing these indicators, policymakers, businesses, and stakeholders gain crucial insights into the digital landscape's impact on spatial mobility. This understanding informs strategic decisions, targeted interventions, and planning initiatives, facilitating the creation of environments that attract mobile populations seeking not only economic opportunities but also a technologically advanced and digitally connected lifestyle. The pursuit of digital regional attractiveness, within the framework of spatial mobility, becomes integral to fostering innovation, driving economic growth, and enhancing overall well-being in our interconnected and technology-driven world.

The **Digital Economy and Society Index (DESI)** is a comprehensive tool developed by the European Union (EU) to assess and compare the digital performance of Member States. Introduced as part of the EU's broader Digital Single Market strategy, the DESI index measures various aspects of a country's digital readiness, including connectivity, digital skills, internet usage, integration of digital technology by businesses, and the availability of digital public services. The primary goal of the DESI index is to provide policymakers, businesses, and citizens with insights into the digital landscape of EU member states, fostering a competitive and inclusive digital economy.

The DESI index comprises five key dimensions, each representing a critical aspect of a country's digital readiness:

- Connectivity: This dimension evaluates the deployment of broadband infrastructure and the availability of high-speed internet. Metrics include the coverage of fast broadband, the take-up of ultra-fast broadband, and the price of broadband.
- Human Capital: Assessing the digital skills of the population is crucial in the digital age. This dimension considers the level of digital skills among the workforce and the general population, including basic and advanced digital skills.

- Use of Internet Services: This dimension focuses on the extent to which individuals and businesses use online services. Metrics include the use of internet services by citizens, the internet use by businesses for selling goods and services, and the level of e-commerce.
- Integration of Digital Technology: Evaluating the digitisation of businesses and the public sector, this dimension assesses the digital technology adoption by businesses, the use of e-commerce by enterprises, and the provision of digital public services.
- Digital Public Services: This dimension measures the availability and sophistication of online public services. Indicators include the eGovernment Development Index, the user-centricity of public services, and the cross-border availability of digital public services.

Each dimension is scored based on a set of indicators, and countries are then ranked accordingly. The overall DESI index provides a holistic view of a country's digital performance, allowing for comparisons and identification of areas for improvement. The index is regularly updated to reflect the evolving nature of the digital landscape. The index serves multiple purposes, including policy development, benchmarking, monitoring progress and decision-making, making it a valuable tool for assessing and promoting the digital readiness of EU Member States alongside EU's commitment to fostering a digitally inclusive and innovative society.

Given that the DESI index is developed at a country level, our review also presents the **Regional Innovation Scoreboard (RIS)** as an additional index that sheds light on aspects of digital transformation at the regional level. Specifically, RIS is a valuable tool developed by the EU to assess and compare the innovation performance of European regions. This scoreboard provides a comprehensive overview of the innovation landscape, helping policymakers, businesses, and researchers understand the strengths and weaknesses of different regions in terms of innovation. The RIS employs a set of dimensions to evaluate a region's innovation capacity, including investments in research and development (R&D), human resources devoted to innovation, collaboration between academia and industry, and the overall innovative output. The indicators used in the RIS range from traditional measures like R&D expenditure and patent applications to more contemporary factors, such as employment in knowledge-intensive activities and the presence of fast-growing innovative firms. This holistic approach ensures a comprehensive evaluation of a region's innovation ecosystem.

One of the key features of the RIS is its ability to categorise regions into different innovation performance groups, allowing for a nuanced understanding of the innovation dynamics across the European Union. These groups include Innovation Leaders, Strong Innovators, Moderate Innovators, and Emerging Innovators. Such categorisation facilitates benchmarking and enables regions to identify areas for improvement in comparison to their peers. The Regional Innovation Scoreboard is regularly updated offering a dynamic

and relevant resource in understanding the evolving landscape of innovation across European regions.

1.6 INDICATORS RELATED TO THE GREEN TRANSITION

Green indicators for regional attractiveness serve as essential metrics in evaluating the environmental sustainability and eco-friendly appeal of specific geographic areas. As the global focus on environmental stewardship intensifies, regions that demonstrate a commitment to sustainable practices, renewable energy adoption, and ecological conservation become increasingly attractive to businesses, residents, and investors. These green indicators encompass a diverse range of factors, including the prevalence of green infrastructure, renewable energy initiatives, waste management practices, and overall environmental quality. By assessing these indicators, policymakers, businesses, and communities gain valuable insights into a region's environmental consciousness and its potential to provide a high quality of life while minimising ecological impact. The pursuit of green regional attractiveness is not only instrumental in mitigating the effects of climate change but also plays a pivotal role in shaping the preferences of a mobile population seeking environmentally conscious and sustainable living environments.

The **Green Transition Index (GTI)** developed by Oliver Wyman[1] serves as a comprehensive benchmark for evaluating the progress of 29 European countries in transitioning towards environmental sustainability. The index assesses seven key categories: Overall Economy, Nature, Manufacturing, Utilities, Waste, Buildings, and Transport, using a total of 28 key performance indicators (KPIs). The selection of categories is rooted in the primary sources of emissions in the European economy. Manufacturing, Utilities (electricity and gas), Transport, and the heating/cooling of Buildings together contribute to 61% of total greenhouse gas (GHG) emissions in the EU-27 in 2020. Nature and Waste categories are included to evaluate environmental practices related to natural resource use, protection, waste generation, and treatment. The Economy category assesses overall country-level performance, considering emissions, energy consumption, and government actions promoting the green transition.

To enable fair cross-country comparisons, KPIs often use "intensities" representing emissions, waste, or energy consumption in relation to normalising denominators such as nominal GDP, value added by sectors, or population. The index consistently uses nominal GDP for this purpose. In the Utilities category, attention is given to "transition technologies" crucial for emissions reduction and clean energy systems. This includes renewable energy, green hydrogen, carbon capture and storage (CCS), and other components vital for a sustainable energy future, like the quantity of battery storage available.

Each country's performance in each KPI is indexed, with the highest-performing country receiving a score of 100, and the lowest-performing country receiving a score of zero,

[1] https://www.oliverwyman.com/our-expertise/insights/2022/jun/green-transition-index.html

whilst intermediate values are scored linearly. These KPI scores are then aggregated at the category level. Finally, all seven category scores are aggregated, evenly weighted, to calculate an overall GTI score.

Recently, Rodríguez-Pose and Bartalucci (2023) developed the **Regional Green Transition Vulnerability Index (RGTVI)** trying to reveal any potential green vulnerabilities at the regional level. The Regional Green Transition Vulnerability Index is a composite measure designed to capture the multidimensional impacts of the transition to low-carbon societies and economies within the European context. The index aims to assess regional vulnerability based on the direct and indirect effects of policies implemented for the green transition. It employs a composite approach, incorporating a broad set of variables to address the complexity of the transition's impacts, differentiating it from other existing empirical attempts.

This index comprises six pillars, each representing a specific aspect of vulnerability: (i) fossil fuel dependency and emissions; (ii) tourism; (iii) energy; (iv) transportation; (v) agriculture and land use; and (vi) industry. While the first and sixth pillars primarily cover direct impacts, the remaining pillars include sectors identified to be at greater risk of undergoing major transformations. Each pillar is composed of several indicators, detailed in Table 1., with the expectation that these indicators correlate with a region's vulnerability to the green transition. The index focuses on short- and medium-term effects, encapsulating impacts of current and expected policies and transformations. Overall, RGTVI aims to provide an empirical measure, acknowledging data constraints and focusing on the potential negative impacts of the green transition on regions.

Table 1. presents some indicative studies and their main outcomes in relation to regional attractiveness for EU regions,

Table 1. Indicative composite indexes, their main dimensions and indicative indicators for measuring the various aspects of regional attractiveness for EU regions.

Index	Dimensions	Indicators
Left-behind areas as measured by Velthuis et al. (2023)	• Economic • Demographic • Social	• GDP per head relative to national GDP per head • Growth in GDP per head relative to growth in national GDP per head • Change in the industrial sector as a share of regional employment • Employment growth relative to national employment growth • Demographic Population growth relative to national population growth • Average annual rate of net migration (per 1,000 population) • Old-age dependency ratio

		• Proxy youth migration indicator (implied net migration among 15–24-year-olds, per 1,000 population) • Social At-risk-of-poverty rate • Population-weighted median travel time to shops
Digital Economy and Society Index (DESI) *Some indicators for 2023 are available at the regional level	• Human capital • Connectivity • Use of Internet Services • Integration of Digital Technology • Digital Public Services	• Internet user skills • Advanced skills and development • Fixed broadband take-up • Fixed broadband coverage • Mobile broadband • Broadband prices • Digital intensity • Digital technologies for businesses • e-Commerce • e-Government
Regional Innovation Scoreboard (RIS)	• Investments in research and development (R&D) • Human resources devoted to innovation • Collaboration between academia and industry • Innovative output	• R&D expenditure • patent applications • employment in knowledge-intensive activities • presence of fast-growing innovative firms
The Green Transition Index (GTI)	• Overall economy • Nature • Manufacturing • Utilities • Waste • Buildings • Transport	• 28 key performance indicators (KPIs) presented in detail here: https://www.oliverwyman.com/our-expertise/insights/2022/jun/green-transition-index/methodology.html
Regional Green Transition Vulnerability Index (RGTVI)	• Fossil fuels dependency • Industry • Agriculture & land use • Tourism • Energy • Transportation	• CO2 emissions from fossil fuels per head (2018) • Change in CO2 emissions per head from fossil fuels between 1990 and 2018 • Coal transition region with at least 100 jobs in the coal industry (1 if the region is identified as transition region, 0 if not) (2022)

		• Total value of wages and salaries in mining and quarrying, as a share of GDP (2019) • Gross value added (GVA) in agriculture, relative to GDP (2019) • Employment in agriculture as a share of the employed population (2019) • Bovine cattle by land area (2020) • Tourist arrivals relative to GDP (2019) • Touristic establishments, as a share of GDP (2019) • Cooling degree days (2020) • Road freight transport (loading) (2020)

4. TYPOLOGIES AND CLASSIFICATIONS OF EU REGIONS

In this section, we provide an overview of established EU regional typologies to enhance comprehension of how regional characteristics influence the attraction and retention of residents. The section commences with a compilation of conventional EU typologies and subsequently broadens its scope by incorporating additional classifications from the literature that contribute to describing the developmental potential of EU regions.

The **Urban-Rural Typology**, which includes a dimension of remoteness, represents a classification integrating elements from the OECD classification and an urban-rural typology developed by the Commission. Originating in the early 1990s, the OECD classification initially featured a three-way categorisation based on population density, later extending to include remoteness in 2009. The Commission's typology, building upon the OECD's approach but applied to population grid cells and NUTS3 regions, distinguishes between: (i) predominantly urban (NUTS3 regions where more than 80% of the population live in urban clusters); (ii) intermediate (NUTS3 regions where more than 50 % and up to 80 % of the population live in urban clusters); (iii) and predominantly rural regions (NUTS3 regions where at least 50 % of the population live in rural grid cells). The remoteness dimension categorises predominantly rural or intermediate regions as remote if less than half of their residents can reach a city of 50,000 inhabitants within 45 minutes. The typology, subject to modifications based on stakeholder feedback, serves as a dynamic tool for understanding and classifying European regions, with updates planned upon the availability of a new EU-wide population grid.

The **Metropolitan Typology** delineates regions into metropolitan and non-metropolitan categories based on the proportion of the population living in functional urban areas (FUAs) of at least 250,000 inhabitants. Metropolitan regions, either single NUTS3 entities or aggregations of such regions, have 50% or more of their population residing in a FUA. Non-metropolitan regions are those NUTS3 regions that do not meet this criterion. The typology includes subdivisions for capital city metropolitan regions, encompassing the metropolitan

region that includes the national capital. The methodology involves classifying grid cells, identifying FUAs, and ultimately determining metropolitan regions by assessing the share of regional populations living in FUAs. This dynamic process acknowledges that metropolitan regions may span multiple NUTS3 regions due to commuting zones around major cities. The approach rectifies distortions in data interpretations arising from commuting patterns, providing a more accurate basis for analyses such as GDP per inhabitant. Cross-border considerations are noted, particularly in instances like Luxembourg, where the metropolitan region may not cover the entire commuting zone, impacting data interpretation. The typology's adaptability and refinement, including ongoing work with the OECD, underscore its robustness and relevance in capturing the evolving dynamics of metropolitan areas within the EU.

The **Border Typology** comprises two main categories: border regions and non-border regions. Border regions are defined as NUTS3 regions situated along or very close to land borders, categorised into internal (between EU Member States and/or EFTA countries) and external (between EU Member States and non-member countries, excluding EFTA) border regions. For analytical precision, a broader definition includes regions within 25 km of a land border, acknowledging that the impact of border effects diminishes with distance. This comprehensive typology encompasses land and maritime borders, both individually and within 25 km, leading to various border region classifications. The methodology, solely based on distance without requiring additional data sources, facilitates ease of application. While not officially recognized within the NUTS Regulation, the border typology is valuable for understanding regional dynamics influenced by international borders. Potential legislative considerations may extend beyond land borders to maritime borders or a combination of both, highlighting the typology's flexibility and applicability in diverse contexts beyond the scope of NUTS Regulation.

The **Coastal Typology** classifies regions within the EU into two main categories: coastal regions and non-coastal regions. Coastal regions are further differentiated based on the sea basin they belong to, including the Baltic Sea, North Sea, North-East Atlantic Ocean, Mediterranean Sea, Black Sea, and outermost regions. The methodology for identifying coastal regions involves three criteria: regions with a sea border, regions where more than half of the population resides within 50 km of the coastline, and specific regions like Hamburg in Germany due to their maritime influence. This typology allows for a comprehensive understanding of the demographic and geographic characteristics of coastal areas within the EU, facilitating targeted policies and interventions to address challenges unique to these regions.

The **Island Typology** within the European Union classifies regions into island and non-island categories based on specific criteria. Island regions, designated at the NUTS3, must be entirely composed of one or more islands, with defined parameters such as a minimum surface area of 1 km^2, a distance of at least 1 km from the mainland, a resident population exceeding 50 inhabitants, and the absence of fixed links like bridges or tunnels to the mainland. The geographical information systems of the European Commission assist in

verifying these criteria. Island regions may comprise a single island or multiple islands, and major islands within regions are further categorised based on population size, ranging from less than 50,000 to over 1 million inhabitants. Notably, the Island Typology is not recognised within the NUTS Regulation, and the definition requires complete island composition, excluding regions with mixed mainland and island territories. Examples include regions along the Adriatic coastline in Croatia, which are classified as non-island regions due to the presence of mainland areas. Certain regions, like Great Britain, are excluded from the island category due to connections like the Channel Tunnel, while Bornholm in Denmark stands as the sole island region, meeting the typology criteria. Despite its absence in official regulation, Island typology provides a valuable framework for identifying and understanding the unique characteristics of island regions within the EU.

The **Mountain Typology** within the European Union classifies regions into mountain and non-mountain categories, presenting three distinct subcategories at the NUTS3. These include regions with more than 50% of their surface covered by topographic mountain areas, regions where over half of the population resides in such areas, and regions that satisfy both criteria. Once these areas are defined, the typology utilises grid-based population data to identify regions where more than half of the population lives in mountain areas, allowing for a nuanced distinction between regions predominantly characterised by mountainous surface and those with a predominantly mountainous population. Despite not being officially recognised in the NUTS Regulation, the Mountain Typology provides a valuable framework for understanding the distribution and impact of mountainous regions within the EU. The detailed methodology ensures a comprehensive and precise classification of mountain regions, contributing to a nuanced understanding of their significance in the broader regional context.

Alongside the physical typologies described until now in this section, we choose to include a set of regional classifications deriving from the definition of some of the composite indexes presented in the previous section.

Following the work of Velthuis et al., (2023), the classification of regional disparities and left-behindness developed by their research produced six discrete clusters of EU NUTS3 regions, capturing diverse economic and demographic trajectories. More specifically, there are the following:

(i) long-term economic prosperity regions that exhibit sustained economic prosperity with high GDP per capita, outpacing national growth rates. Despite modest GDP growth, these regions experience significant population and employment growth. Concentrated in Germany and the UK, this cluster comprises mostly large and medium-sized cities;

(ii) high growth regions, which are characterised by remarkable economic growth, having high rates of GDP growth, employment, and population growth. Spread across various EU15 countries, they have successfully caught up with national GDP levels. Low poverty rates and moderate old-age dependency ratios define this cluster;

(iii) regions with relative economic and demographic stability, including regions with moderate economic and demographic characteristics. While GDP per capita slightly lags behind the national average, these regions maintain stability, with average population growth and low poverty rates. Found in Austria, Belgium, Denmark, France, Italy, and the Netherlands, this cluster is widespread;

(iv) regions experiencing economic decline and deindustrialisation evident in per capita GDP growth below the national rate. Affected by deindustrialisation, these regions experience a decrease in industrial employment and above-average poverty rates. Dominant in the UK, Ireland, Spain, and pockets in Belgium, France, the Netherlands, and Portugal;

(v) regions of demographic decline and aging. Characterised by low GDP per capita, these regions suffer from demographic decline and aging. Population and employment decline, coupled with negative net migration of younger age groups, contribute to high old-age dependency ratios. Prevalent in northern and central EU15 countries, including Sweden, Finland, Denmark, Germany, France, and parts of the UK; and

(vi) disconnected and high poverty regions, which despite their similarities with cluster 5, are distinguished by high poverty rates and limited-service accessibility. In spite of lower population aging, these regions experience population decline and are characterised by disconnectedness. Predominant in Mediterranean countries, including Spain, Italy, Greece, and Portugal, these regions face challenges of poverty and limited-service access.

The European regions are categorised into four innovation performance groups by the **Regional Innovation Scoreboard Typology**, determined by their standings on the RIS index. These groups are as follows: (i) Innovation Leaders, surpassing the EU average by more than 125%; (ii) Strong Innovators, performing within the range of 100% to 125% of the EU average; (iii) Moderate Innovators, achieving performance levels between 70% and 100% of the EU average; and (iv) Emerging Innovators, recording performance below 70% of the EU average. Innovation Leaders exhibit the highest average performance on 18 indicators, excelling in areas such as tertiary education completion, lifelong learning participation, international scientific co-publications, and patent applications. Strong Innovators perform above average on all indicators, particularly excelling in digital skills, R&D expenditures, and collaborations. Moderate Innovators perform above the EU average in six indicators, showcasing strength in non-R&D innovation expenditures and SME innovation. On the contrary, Emerging Innovators fall below the EU average on all indicators, with notable weaknesses in lifelong learning participation, scientific co-publications, employed ICT specialists, and patent applications. Despite variations, regional performance groups align with corresponding country groups in the European Innovation Scoreboard, indicating consistency in innovation performance at both regional and national levels. Regional "pockets of excellence" are identified within Moderate and Emerging Innovator countries, highlighting specific regions that stand out in innovation performance even within less innovative national contexts.

The **Regional Green Transition Vulnerability Index** for European NUTS2 regions reveals distinctive patterns in vulnerability to the green transition (Rodríguez-Pose and Bartalucci, 2023). Notably, metropolitan areas and capital cities, such as Dublin, Bratislava, and Copenhagen, appear less vulnerable, showcasing greater adaptability to green transition challenges. The results suggest that despite higher emissions in cities, their structural characteristics enhance their ability to withstand both direct and indirect impacts of the green transition. However, concerns arise regarding the disproportionate concentration of capital investments for green transition adaptation in cities, given their lower vulnerability. Conversely, many lagging-behind regions in Central and Eastern Europe, Southern Italy, and the Iberian Peninsula, particularly those highly dependent on sectors like tourism and heavy industry, emerge as more vulnerable to the green transition. Coal transition regions, including areas in Bulgaria, Greece, Spain, Italy, and Poland, face heightened vulnerability, with structural factors in Germany being more conducive to mitigating the impact of green transition policies. Hence, the regional typology deriving from the RGTVI index underscores the dichotomy between metropolitan and lagging-behind regions, emphasising the need for targeted fiscal investments in retraining and re-skilling human capital. These investments are pivotal for regions to successfully transition to green jobs and skills, ultimately reshaping their productive and industrial systems.

Table 2 below presents a list of the identified regional typologies developed within the European framework to capture different aspects of regional characteristics that can be used as a starting point and baseline for our analysis during the development of the MOBI-TWIN Regional Attractiveness Index.

Table 2. Indicative indexes and their corresponding regional typologies and classifications.

Typology	Classes of the typology
Urban-Rural Typology	• predominantly urban - NUTS3 regions where more than 80% of the population live in urban clusters. • intermediate - NUTS3 regions where more than 50 % and up to 80 % of the population live in urban clusters. • predominantly rural regions - NUTS3 regions where at least 50 % of the population live in rural grid cells.
Metropolitan Typology	• metropolitan - either single NUTS3 entities or aggregations of such regions, have 50% or more of their population residing in a FUA. • non-metropolitan - NUTS3 regions that do not meet this criterion.
Border Typology	• All NUTS3 regions along land borders, plus NUTS3 regions that have at least 50% of their population in areas of 25 km width along a land border. • Other regions
Coastal Typology	• non-coastal • coastal (on coast) • coastal (>= 50% of population living within 50km of the coastline)

Island Typology	• island - NUTS3 entirely composed of one or more islands, with defined parameters such as a minimum surface area of 1 km^2, a distance of at least 1 km from the mainland, a resident population exceeding 50 inhabitants, and the absence of fixed links like bridges or tunnels to the mainland. • non-island - NUTS3 regions that do not meet this criterion.
Mountain Typology	• > 50 % of population live in mountain areas. • > 50 % of surface are in mountain areas. • > 50 % of population and 50 % of surface are in mountain areas. • Other regions
Left-behind area classification as measured by Velthuis et al. (2023)	• Cluster 1 - Long-term economic prosperity • Cluster 2 - High growth • Cluster 3 - Relative economic and demographic stability • Cluster 4 - Economic decline and de-industrialisation • Cluster 5 - Demographic decline and ageing • Cluster 6 - Disconnected, high poverty
Regional Innovation Scoreboard (RIS)	• Innovation Leaders - surpassing the EU average by more than 125%. • Strong Innovators - performing within the range of 100% to 125% of the EU average. • Moderate Innovators - achieving performance levels between 70% and 100% of the EU average. • Emerging Innovators - recording performance below 70% of the EU average.
Regional Green Transition Vulnerability Index (RGTVI)	• 1st quartile – far more vulnerable • 2nd quartile – more vulnerable • 3rd quartile – less vulnerable • 4th quartile – least vulnerable

5. COMPARING EU REGIONS ON THE BASIS OF LEFT BEHINDNESS, THE GREEN AND THE DIGITAL TRANSITION

The purpose of this section is to establish an initial descriptive link between the notion of left-behind regions and the dimensions of green and digital transition that enhance regional attractiveness. To accomplish this, we utilize the composite indexes outlined in previous sections to capture the various aspects associated with these concepts. Initially, we use Velthuis et al. (2023) classification approach to address left behind areas and apply it to the NUTS2 level of EU regions. Through this approach, we can compare the clusters of NUTS2 regions identified in terms of left behindness, and subsequently broaden the

analysis by incorporating green and digital transition indexes at the regional level[2]. Table 3 presents a list of the variables being used for the EU regions' classification, based on the methodology proposed by Velthuis et al. (2023).

Table 3. Variables used for the classification of the NUTS2 EU regions.

Indicator	Description	Source
GDP per head	GDP per head relative to national GDP per head (2020)	ARDECO (2021)
Growth in GDP per head	Growth in GDP per head relative to growth in national GDP per head (1995 – 2020)	ARDECO (2021)
Change in industrial employment share	Change in the industrial sector as a share of regional employment (1995-2020)	ARDECO (2021)
Employment growth	Employment growth relative to national employment growth (1995-2020)	ARDECO (2021)
Population growth	Population growth relative to national population growth (1995-2020)	ARDECO (2021)
Net migration	Average annual rate of net migration (2016-2020)	EUROSTAT
Old-age dependency ratio	Old-age dependency ratio 1st variant (population 65 years or over to population 15 to 64 years) (2020)	EUROSTAT
Net youth migration	Proxy youth migration indicator[3] (2015-2020)	EUROSTAT
Poverty rate	At-risk-of-poverty rate (%) (2021)	EUROSTAT
Median travel time to shops	Population-weighted median travel time to shops (2016)	ESPON (2016)

We utilised the k-means method to cluster the NUTS2 regions just to have a preliminary overview of EU regions in relation to left-behindness and try to connect it with insights for mobility flows and relevant Twin Transition dimensions. We determined the optimal number of clusters through the Krzanowski-Lai index (Krzanowski and Lai, 1988). Table 4 provides an overview of our regional classification results, while Annex A contains a comprehensive list of NUTS2 regions assigned to each cluster. Our analysis reveals five distinct clusters, each accompanied by a brief overview of the characteristics and trends observed within each cluster based on the indicators provided in Table 4.

[2] Velthuis et al. (2023) developed their composite index at the NUTS3 level. We apply their proposed methodology at the NUTS2 level to identify a new set of regional clusters. The Krzanowski-Lai index has been used for identifying the best number of clusters (Krzanowski and Lai, 1988).

[3] See Velthuis et al. (2023) for the specification of this proxy.

- **Cluster 1 – High growth regions:** This cluster demonstrates the highest GDP per capita among all clusters, indicating economic prosperity. GDP per capita growth is positive, reflecting ongoing economic growth, whereas there is a slight decline in industrial employment share, possibly due to economic diversification. Employment and population growth rates are notably high, indicating a growing workforce and population. Positive net migration suggests an influx of people into these regions, while the relatively low old-age dependency ratio indicates a younger population structure. Poverty rates are low, and median travel time to shops is minimal, indicating well-connected and prosperous regions.
- **Cluster 2 – Regions experiencing demographic decline and aging:** This cluster portrays economic struggles, characterised by lower GDP per capita and stagnant or declining economic activity compared to the national levels. Negative growth in industrial employment share implies a lack of industrial development or declining industries. Moreover, negative employment and population growth rates signify a declining workforce and population. The notably high old-age dependency ratio points to an aging population within these regions. Despite moderate poverty rates, residents enjoy reasonable access to amenities, as indicated by the relatively low median travel time to shops.
- **Cluster 3 – Regions facing de-industrialisation:** This cluster reflects a moderate level of GDP per capita with a slight negative growth trend, indicating a stable but stagnating economy. Notable deindustrialisation is evident through a decline in industrial employment share. Employment and population growth rates show slight negative trends, suggesting mild population and economic declines. Despite positive net migration, it remains lower than in other clusters. The moderate old-age dependency ratio indicates a balanced population structure. Although poverty rates are moderate, residents experience higher median travel time to shops compared to regions with high growth, indicating relatively less accessibility to amenities.
- **Cluster 4 – Disconnected regions:** This cluster illustrates moderately low GDP per capita, indicating economic challenges. A slightly negative GDP per capita growth suggests economic stagnation compared to the national levels. Negative employment and population growth rates point to a declining workforce and population. Although net migration is positive, it remains lower compared to other clusters. The moderately high old-age dependency ratio highlights an aging population. Despite relatively low poverty rates, residents face significantly higher median travel times to shops, emphasising limited accessibility to amenities within these regions which is the main characteristic of the regions belonging to this cluster.
- **Cluster 5 – High poverty regions:** This cluster is characterised by notably low GDP per capita, signaling economic challenges within these regions. A strongly negative GDP per capita growth underscores significant economic decline, reflecting the overall economic hardship experienced. While there is a slight decline in industrial employment share, indicating some industrial challenges, the more pressing issue

lies in negative employment and population growth rates, which highlight a declining workforce and population. The negative net migration further suggests people are leaving these regions, exacerbating the population decline. The moderate old-age dependency ratio indicates a somewhat balanced age structure, albeit with a tilt towards an aging population. Poverty rates are notably higher compared to other clusters, indicating widespread economic hardship among residents. Despite this, the relatively moderate median travel time to shops suggests reasonable access to amenities, offering some degree of support within these economically challenged regions.

Table 4. NUTS2 EU regional clusters identified using the Velthuis et al.'s (2023) classification methodology.

Indicator	Cluster 1 – High growth	Cluster 2 - Demographic decline & ageing	Cluster 3 - De-industrialisation	Cluster 4 - Disconnected	Cluster 5 - High poverty
GDP per capita	1.190	0.820	0.900	0.915	0.729
Growth in GDP per capita	0.033	0.029	-0.013	-0.006	-0.251
Change in industrial employment share	-0.054	-0.030	-0.058	-0.046	-0.036
Employment growth	0.137	-0.152	-0.020	-0.024	-0.092
Population growth	0.092	-0.127	-0.003	-0.020	-0.051
Net migration	4.834	1.959	3.977	3.029	-1.269
Old-age dependency ratio	29.116	40.966	32.630	35.572	30.880
Net youth migration	0.006	-0.002	0.003	0.001	-0.002
Poverty rate	14.45	16.27	14.26	13.67	22.15
Median travel time to shops	0.039	0.040	0.065	0.434	0.108
Number of regions	45	29	54	32	45
% of total regions	21.95%	14.15%	26.34%	15.61%	21.95%

Following this analysis, we can observe that the classification unveils **four distinct types of left-behind areas**. The first type (Cluster 2) refers to regions where left-behindness manifests as *demographic decline and aging*. The second type (Cluster 3) primarily consists of areas undergoing *economic decline and de-industrialisation*, resulting in their being left behind economically. The third type (Cluster 4) encompasses *disconnected regions* where left-behindness is largely attributed to inadequate accessibility and poor living conditions. Lastly, Cluster 5 encompasses regions characterised by *high poverty rates* suffering by low GDP per capita, economic and population decline. In this case we can argue that left-behindness results as an outcome of poor living conditions compared to other clusters.

As a next step, we combine the identified regional clusters with the different types of **mobility flows** described in the first part of this report. More specifically, we capture the outcoming to incoming ratio of individuals for each regional type as given in eq.1:

Ratio = number of incoming individuals / number of outcoming individuals (1)

Table 5 presents the key findings of this exercise. As observed, regions experiencing *high growth* consistently draw larger numbers of incoming individuals (ratios > 1) across various mobility categories, signaling their pronounced appeal for both short- and long-term student mobility, as well as permanent relocation among young adults. Moreover, these regions exhibit a notable allure for potential future mobility, particularly among younger age groups (ratio = 1.51), indicating a positive outlook for sustained growth and development.

Conversely, regions burdened by *high poverty* demonstrate a contrasting trend, characterised by higher outflow values across all categories except for permanent mobility among individuals aged 35 and older (ratio = 1.18). This suggests a significant challenge in retaining residents, especially among economically disadvantaged demographics.

Regions grappling with *demographic decline and aging*, as well as those contending with *de-industrialisation*, typically showcase ratios close to 1, reflecting relatively balanced mobility patterns in most instances. However, noteworthy exceptions emerge concerning potential future mobility. Firstly, demographically declining regions appear to struggle in attracting young individuals for potential future mobility (ratio = 0.62), indicating potential challenges in revitalising aging populations. Secondly, de-industrialized regions witness an increased preference, particularly among persons older than 35 years old (ratio = 1.65), hinting at opportunities for economic renaissance and reinvention.

It is worth noting that *disconnected regions*, despite their limited accessibility, maintain attractiveness for permanent and future mobility options. However, they exhibit lower ratios for short-term student mobility (ratio = 0.74) and future mobility of young persons (ratio = 0.89), suggesting room for improvement in enhancing their appeal to certain demographic segments.

Table 5. Ratio between incoming and outcoming individuals for the different mobility types for the identified regional clusters.

Type of mobility	Cluster 1 – High growth	Cluster 2 - Demographic decline & ageing	Cluster 3 - De-industrialisation	Cluster 4 - Disconnected	Cluster 5 - High poverty
Short-term student mobility	1.16	1.07	1.00	0.74	0.84
Long-term student mobility	1.20	1.04	0.89	1.08	0.58
Permanent mobility (18-34 years old)	1.07	0.80	1.06	1.23	0.95
Permanent mobility (35+ years old)	0.80	1.06	0.97	1.27	1.18
Potential future mobility (18-34 years old)	1.51	0.62	1.25	0.89	0.48
Potential future mobility (35+ years old)	1.13	1.02	1.65	1.63	0.61

When combining the outcomes of the classification with indicators referring to **traditional regional typologies** proposed by the EU, we also get some interesting results. According to Table 6, Cluster 1 which refers to *developed regions* is characterised by areas with the highest percentage of urban population among all clusters (77.83%). While a considerable portion resides in or close to coastal areas (38.15%), the percentage living in areas with mountainous terrain or on islands is relatively low (28.58% and 6.71% respectively). When moving on to different types of left-behind areas Table 5 shows that regions experiencing *demographic decline and ageing* (Cluster 2) indicate a relatively lower average share of urban population compared to other clusters (49.04%). A significant portion of the population in these regions resides in rural areas (50.96%), with a substantial percentage living in or close to coastal areas (45.28%). However, the proportion living in areas with mountainous terrain or on islands is minimal (29.56% and 0.00% respectively). Moreover, regions characterised by *de-industrialisation* (Cluster 3) consist of regions with an increased percentage of urban population (61.83%), with a higher proportion residing in non-mountainous areas compared to other clusters (79.11%). *Disconnected regions* (Cluster 4) indicate a moderate percentage of urban population (57.27%) and the highest average share of populations residing in non-coastal areas (75.83%). Additionally, a relatively high percentage of the population lives in areas characterised by mountainous terrain (42.31%). Lastly, *high poverty regions* (Cluster 5) include regions with a moderate percentage of urban population (55.94%) and a significant proportion residing in or close to coastal areas (40.81%). Additionally, this cluster indicates the highest shares of populations living on islands (13.07%).

Table 6. Summary values using traditional typologies for each regional cluster.

Indicator	Cluster 1 – High growth	Cluster 2 - Demographic decline & ageing	Cluster 3 - De-industrialisation	Cluster 4 - Disconnected	Cluster 5 - High poverty
Population that lives in urban areas (%)	77.83	49.04	61.83	57.27	55.94
Population that lives in rural areas (%)	22.17	50.96	38.17	42.73	44.06
Population that lives in areas where more than 50 % of population live in mountain areas (%)	0.46	0.18	0.13	0.00	0.00
Population that lives in areas where more than 50 % of surface is in mountain areas (%)	10.95	14.33	13.80	24.18	16.17
Population that lives in areas where more than 50 % of population and more than 50 % of surface are in mountain areas (%)	17.17	15.05	6.96	18.14	14.05
Population that lives in other regions than all the previous	71.42	70.44	79.11	57.69	69.78
Population that lives in coastal areas (%)	34.16	43.96	28.15	21.22	39.33
Population that lives in coastal areas where 50 % or more of the population live within 50 kilometers of the coastline (%)	3.99	1.31	3.48	2.95	1.49
Population that lives in non-coastal areas (%)	61.85	54.72	68.36	75.83	59.19
Population that lives on islands (%)	6.71	0.00	1.85	0.22	13.07

Note: Values indicated in the table refer to average values of regions belonging to each cluster.

To expand the analysis and include the **Twin Transition** perspective in the discussion, we compare the identified clusters based on the identified green and digital transition indicators. More specifically, we utilise the RGTVI index to capture regional vulnerability to the green transition, and since the DESI index is not available at the NUTS2 regional level, we identify a set of indicators corresponding to specific dimensions utilised in constructing the DESI index to evaluate the level of the digital capabilities in each region which are essential for performing an efficient digital transition. Lastly, we employ the RIS index to assess and compare the innovation potential across these clusters, recognising innovation's pivotal role in regional attractiveness. Table 7 presents the main variables being used for the comparisons between the regional clusters.

Table 7. List of variables used for comparing the green and digital strengths and weaknesses of EU regions.

Name	Description	Source
RIS	Regional Innovation Scoreboard index - 2023	Regional innovation scoreboard 2023
RGTVI	Regional Green Transition Vulnerability Index - 2023	Rodríguez-Pose & Bartalucci, 2023
Household internet access	Households with access to the internet at home (%) - 2023	Eurostat [isoc_r_iacc_h]
Daily use	Frequency of internet access: daily (%) - 2023	Eurostat [I_IDAY]
Social media	Individuals participating in social networks (creating user profile, posting messages or other contributions to facebook, twitter, etc.) (%) - 2023	Eurostat [I_IUSNET]
Internet banking	Individuals who used the internet for Internet banking (%) - 2023	Eurostat [I_IUBK]
Sell goods or services	Individuals who used the internet for selling goods or services (%) – 2023	Eurostat [I_IUSELL]
Order goods or services	Individuals who ordered goods or services over the internet for private use and last online purchase in the last 3 months (%) - 2023	Eurostat [I_BUY3]

Table 8 presents the key findings from this descriptive exercise for each one of the identified clusters. As we can see, regions with *high development levels* (Cluster 1) stand out with the highest average level of RIS values (111.03) and the lowest vulnerability to the green transition (-0.68). Household internet access is widespread (94%), and a significant majority of residents use the internet daily (88.58%), with active engagement in social media and internet banking (62.36% and 69.03% respectively). Moreover, a considerable portion of residents utilise online platforms for selling or ordering goods and services (20.75% and 61.96% respectively), indicating a high level of digital integration.

Moreover, regions experiencing *demographic decline and ageing* (Cluster 2) demonstrate moderate levels of regional innovation (93.35) and higher vulnerability to the green transition (0.52). Household internet access again is high (91.17%), with a significant proportion of residents using the internet daily (84.55%) and engaging in social media and internet banking (59.99% and 68.70% respectively). A considerable portion of residents also sell or order goods and services online (21.36% and 60.86% respectively), indicating again a relatively high level of digital engagement.

Cluster 3 regions characterised by *de-industrialisation* exhibit slightly lower RIS values compared to cluster 1 (103.25), and low vulnerability to the green transition (-0.45). Household internet access is widespread (93.28%), and there is active daily internet use among residents (86.98%). Engagement in social media and internet banking is also high (61.48% and 69.97% respectively). Moreover, a significant proportion of residents utilise online platforms for selling or ordering goods and services (22.74% and 64.10% respectively), indicating also a high level of digital integration.

At the same time, *disconnected regions* (Cluster 4) indicate moderate levels of regional innovation (98.44) and low vulnerability to the green transition (-0.48). Household internet access is widespread (93.39%), and there is active daily internet use among residents (85.92%). However, engagement in social media is slightly lower compared to other clusters (55.56%). Nonetheless, a substantial proportion of residents still utilise internet banking (65.93%) and online platforms for selling or ordering goods and services (22.05% and 60.94% respectively).

Finally, *high poverty regions* (Cluster 5) are the ones indicating some diversification compared to the other clusters. More specifically, these regions are characterised by the lowest levels of regional innovation (61.75) and the highest average vulnerability to the green transition (1.20). Household internet access is slightly lower compared to other clusters (90.28%), but there is still widespread daily usage of the internet (79.81%). Even though engagement in social media is high (62.15%), a smaller proportion of residents engage in internet banking (50.48%), as well as selling or ordering goods and services online (15.21% and 44.29% respectively).

Focusing on the green and digital indicators being used in this last part of our descriptive analysis, we observe significant similarities between Clusters 2, 3 and 4, not only amongst themselves but also in comparison to Cluster 1. This indicates that when considering left-behindness in demographic, economic and accessibility terms, there are no substantial variations at the regional level concerning the green and digital transition. However, this pattern does not hold true for Cluster 5. Regions within Cluster 5 appear to exhibit heightened levels of vulnerability to the green transition, lower innovation levels, and markedly lower degrees of digital transition (including reduced daily usage, internet banking and selling and ordering goods). In this context, we observe that when left-behindness derives as an outcome of poor living conditions, it can be related to Twin Transition aspects, affecting regional attractiveness.

Table 8. Average values in relation to the green and the digital transition for each regional cluster.

Indicator	Cluster 1 – High growth	Cluster 2 - Demographic decline & ageing	Cluster 3 - De-industrialisation	Cluster 4 - Disconnected	Cluster 5 - High poverty
RIS	111.03	93.35	103.25	98.44	61.75
RGTVI	-0.68	0.52	-0.45	-0.48	1.20
Household internet access (%)	94.00	91.17	93.28	93.39	90.28
Daily use (% of population)	88.58	84.55	86.98	85.92	79.81
Social media (% of population)	62.36	59.99	61.48	55.56	62.15
Internet banking (% of population)	69.03	68.70	69.97	65.93	50.48
Sell goods or services (% of population)	20.75	21.36	22.74	22.05	15.21
Order goods or services (% of population)	61.96	60.86	64.10	60.94	44.29

Note: Values indicated in the table refer to average values of regions belonging to each cluster.

Table 9 provides a qualitative summary of the descriptive analysis findings, highlighting the distinctive characteristics of each cluster. There are notable differences among the identified clusters, encompassing various types of left-behindness and levels of twin transition. Clusters 1 and 5 represent the extremes of the distribution. Cluster 1 comprises highly developed regions with minimal vulnerability to the green transition, significant innovation potential, and substantial digital transition. In contrast, Cluster 5 consists of the least developed regions with pronounced poverty rates, high vulnerability to the green transition, limited innovation potential, and modest digital transition, despite widespread internet access. Clusters 2, 3, and 4 fall between these two extremes, exhibiting similar characteristics regarding the twin transition despite their varying types of left-behindness.

Table 9. Summary insights in relation to the type of left-behindness, the green and the digital transition for each regional cluster.

Cluster	Type of left-behindness	Mobility	Green transition	Digital transition
1	High growth regions (not being left behind)	- Increased student, permanent (18-34) and future mobility inflows	- Very low vulnerability	- Very high innovation potential - High internet access - Active use and engagement to online activities
2	Demographic decline & ageing	- Balanced mobility flows in most cases - Low potential for young permanent and future mobility inflows	- Moderate vulnerability	- High innovation potential - High internet access - Active use and engagement to online activities
3	De-industrialisation	- Balanced mobility flows in most cases - Increased potential for future mobility inflows	- Low vulnerability	- High innovation potential - High internet access - Active use and engagement to online activities
4	Lack of accessibility	- Low levels for short-term student and young future mobility inflows - Increased potential for all other types of mobility	- Low vulnerability	- High innovation potential - High internet access - Active use and engagement to online activities
5	High poverty	- Low level mobility inflows in almost all cases - Increased mobility inflows for permanent migration (35+ years old)	- High vulnerability	- Very low innovation potential - High internet access - Low use and engagement to online activities

6. INTEGRATION OF RELEVANT RRI PILLARS

MOBI-TWIN places the societal dimension of spatial mobility at the core of its research activities. It aligns the project's activities with the pillars of Responsible Research and Innovation (RRI) — science education, gender equality, governance, open science, public engagement and ethics — to ensure that outcomes, outputs and impacts meet as much as possible the needs of society (MOBI-TWIN D4.1).

The RRI pillars mainstreamed into the activities described in this report are gender equality, open science and ethics.

The integration of the gender dimension

The analysis of short-term student mobility from 2014 to 2020 reveals significant gender disparities influenced by geographical and societal factors. Women constituted 60% of the total short-term mobility, with marked differences between regions and countries. In countries like France (68%) and Spain (66%), a higher proportion of incoming female students was observed, whereas countries like Romania (44%), Poland (46%), and Luxembourg (48%) had notably lower ratios. This trend was similarly reflected at the NUTS2 regional level, where regions such as Centre-Val de Loire in France and Kent in the UK had female ratios exceeding 70%, contrasting sharply with regions in Poland, Romania, and Norway where the ratio fell below 45%.

Outgoing mobility showed different patterns, with the highest female ratios in Poland (71%), Greece (68%), and Serbia (67%), and the lowest in Turkey (50%) and Luxembourg (52%). These disparities underscore the importance of incorporating gender-sensitive approaches in policies and programs to better understand the mobility drivers and foster equitable mobility opportunities.

Intersecting the gender dimension with other dimensions of inequalities was not possible at this stage, being the primary limitation of the availability and granularity of the existing data. These aspects will be further explored and discussed in the upcoming tasks of the project. However, it will remain a challenge, as existing data on spatial mobility from EU and national/regional surveys and censuses, seldom integrate other relevant demographics, such as race/ethnicity, sexual orientation, gender identity beyond binary, disability, religion. This integration is key to analyse the results from an intersectional perspective and address the specific needs of vulnerable populations.

The integration of open science

As for the open science pillar, this report, as well as all the project public deliverables, will be made available in an open access repository after approval by the EC. The data collected, the commented scripts written for the analysis, and detailed results will also be made available in open access repositories along with the related forthcoming scientific publication.

The integration of ethics

The work carried out in T2.1 and T2.2 followed the ethical standards set by the GA article 14 (Ethics and Values), specific ethics rules are set out in Annex 5.

7. CONCLUSIONS

This report provides an in-depth analysis of regional attractiveness and its relationship with spatial mobility flows, the twin transition, and the concept of left-behind places. Through extensive mapping and examination of various mobility patterns, we have identified key insights and outcomes relevant to regional development.

Regarding the mapping of spatial mobility flows, the analysis of permanent intra-country migration between NUTS2 regions in Europe reveals significant mobility patterns. From 2012 to 2022, major metropolitan regions like Andalusia, Catalonia, Madrid, and Île-de-France attracted the highest incoming flows, underscoring the trend towards urbanisation. However, the COVID-19 pandemic introduced more complex migration patterns, including movements to less populated regions. Retirement migration showed similar trends, with Spain, France, and Italy being top destinations, and a growing trend among older populations. Long-term student mobility, primarily driven by the Erasmus Programme, was significant in Germany, France, the UK, Italy, and Spain, although the pandemic and Brexit impacted these patterns. Seasonal work mobility increased, with metropolitan and tourism-oriented regions in Spain, Germany, Poland, France, and Italy being the main destinations. Short-term student mobility exhibited significant geographical variations, with Spain, Germany, France, the UK, and Italy as top destinations, and a notable gender disparity in mobility flows. Long-distance commuting was predominantly observed in Germany, France, and Spain, with cross-border commuting emphasising Luxembourg, Switzerland, and Norway as key destinations.

Moving on the investigation of the regional attractiveness notion, the report proposes a composite regional attractiveness index, incorporating factors such as GDP, internet accessibility, and the twin transition (digital and green transitions). Higher GDP and advanced digital infrastructure were positively correlated with regional attractiveness. When considering the role of the Twin Transition, it argues that the Twin Transition plays a critical role in shaping regional attractiveness and mobility patterns. Regions with higher levels of internet accessibility and digital infrastructure attracted more long-term student mobility. This trend underscores the importance of digital readiness in regional development strategies. Additionally, regions advancing in green transitions are likely to become more attractive, fostering sustainable mobility patterns.

Overall, the report highlights the intricate relationship between regional attractiveness, spatial mobility flows, and the Twin Transition. Understanding these dynamics is crucial for policymakers aiming to address regional disparities and promote balanced regional development across Europe. The proposed regional attractiveness index offers a comprehensive tool for assessing and enhancing the appeal of regions, thereby supporting informed decision-making in regional policy and planning.

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ANNEX A

Table A1 presents the list of NUTS2 regions belonging to the identified clusters after applying Velthuis et al.'s (2023) classification methodology on NUTS2 EU regions.

Table A1: NUTS2 regions and their connection to specific clusters.

AT13	DE80	AT11	AT21	BE32
AT33	DED2	AT12	AT22	BG32
AT34	DED4	AT31	AT32	BG33
BE21	DEE0	BE22	CZ03	BG34
BE24	DEG0	BE23	CZ07	BG42
BE31	DK02	BE25	DE13	CZ04
BG41	EL53	BE33	DE22	CZ08
CZ02	EL54	BE34	DE26	EL51
DE11	EL61	BE35	DE40	EL52
DE12	EL64	CZ05	DE91	EL62
DE14	EL65	CZ06	DEA3	EL63
DE21	ES11	DE24	DEB2	ES42
DE23	ES41	DE72	FRB0	ES43
DE25	FI1C	DE73	FRF2	ES61
DE27	FI1D	DE92	FRG0	FRD2
DE30	FRC1	DE93	FRI1	FRE1
DE50	FRC2	DEA1	FRL0	FRE2
DE60	FRD1	DEA4	ITC1	FRF3
DE71	FRI2	DEA5	ITC3	HU23
DE94	FRI3	DEB1	ITF1	HU31
DEA2	FRK1	DEB3	ITH4	HU32
DK01	NL12	DEC0	ITH5	HU33
EL30	NL34	DED5	ITI1	IE04
EL42	NL42	DEF0	ITI2	ITF2
ES22	PT16	DK03	ITI3	ITF3
ES30	PT18	DK04	NL13	ITF4
ES51	SE31	DK05	NL21	ITF6
ES62	SE32	EL43	NL41	ITG1
ES70	SE33	ES13	PL72	ITG2
FI1B		ES21	SE21	LT02
FR10		ES23	SI03	PL42
IE06		ES24	SK03	PL43
ITC4		ES52		PL52

ITH1 ITH2 ITI4 LT01 NL31 NL32 PL51 PL63 PT15 PT17 SE11 SI04		FI19 FRF1 FRH0 FRJ1 FRJ2 FRK2 HU21 HU22 ITH3 NL22 NL33 PL21 PL22 PL41 PL71 PT11 RO11 SE12 SE22 SE23 SK02		PL61 PL62 PL81 PL82 PL84 PT20 PT30 RO12 RO22 RO31 RO41 SK04

ANNEX B

The specification of definitions for each mobility type that were used to operationalize their extraction from the datasets.

Long-term mobility form

Permanent migration. For permanent migration we consider individuals who are at least 18 years old and who move from one NUTS2 region to another NUTS2 region for 12 months or longer.

Long-term student mobility. We consider mobility for student exchange to be long-term student mobility if its duration is 12 months or longer.

Short-term mobility form

Seasonal work mobility. We consider seasonal work mobility to constitute of mobility by individuals who are a seasonal worker directly or, more indirectly, to have a fixed-term work contract the duration of which ranges between three and twelve months, and work in a different region than where they live.

Short-term student mobility. We consider student mobility that lasts for at least 3 months and less than 12 months as a short-term student exchange.

Circular mobility form

Long-distance commuting. We consider an individual to be a long-distance commuter if their commute is between two NUTS2 regions and the distance is longer than 100 kilometres. As a subtype for long-distance commuting, **cross-border commuting** is considered if the place of residence and the main place of work are in different countries regardless of commuting distance.

Multilocal living mobility. We consider mobility linked to multilocal living arrangements, when a person has more than one place of residence and where one is regularly present in these places and visits repeatedly over time.

ANNEX C

Methodology

We used several datasets that required using different pre-processing steps and methodologies to extract mobility flows (Figure A1). Below, we describe methodology how the defined mobility types (Annex B) were operationalised, and how the produced mobility flow data were visualised.

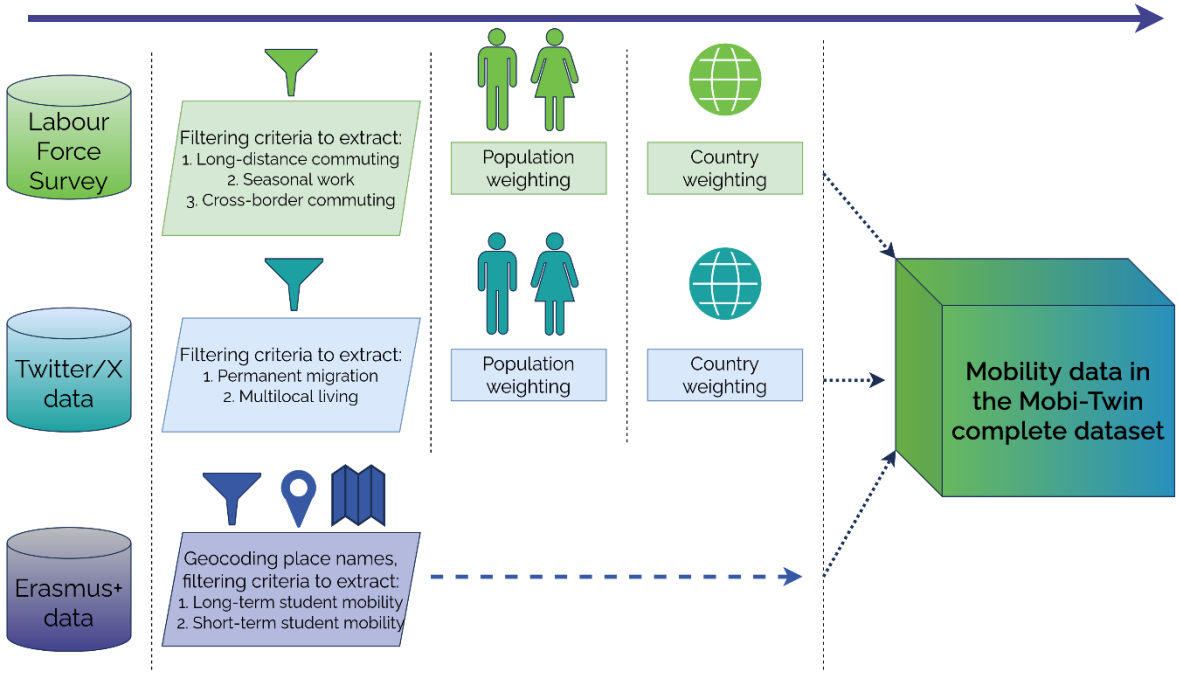

Figure A1. The production and weighting of the mobility data for the complete Mobi-Twin dataset across the various sources of mobility data. Author: Tuomas Väisänen. Full-sized figure HERE.

Labor Force Survey

We used individual-level Labor Force Survey (LFS) data to map three mobility types: long-distance commuting, seasonal work mobility and cross-border commuting (Figure A1). We used the quarterly data to extract permanent migration, retirement migration and seasonal work mobility, and we used the annual data to extract long-distance and cross-border commuting. We filtered the respondents to be at least 15 years age or older (AGE, AGE_GRP) to only include respondents that match the criteria set in the Mobi-Twin project proposal. We use the population weights provided in the LFS when aggregating the flows from quarterly (COEFFQ) and annual (COEFFY) data between NUTS2 regions (GISCO, 2024). To make the data comparable across Europe we apply an additional country weight using the working age population per country per year to multiply the population weight (Figure A1).

Long-distance commuting is extracted by filtering respondents who have a different region of residence (REGION) to the region of work (REGION_W). We also apply additional criteria to only include respondents for whom the commute is 100 kilometers or longer in Euclidean distance. We do this by comparing the distance between the centroids of NUTS2 regions. While this introduces some uncertainty of whether all included parties are long-distance commuters, the varying size of NUTS2 regions themselves make estimating long-distance commuting challenging. Some NUTS2 regions cover vast areas (e.g. Northen Finland covers nearly ¾ of the whole country), while some are tiny (e.g. Inner London). Thus, long-distance commuting within large regions is not captured and countries with numerous small NUTS2 regions are overrepresented in the data (e.g. Germany).

Seasonal work mobility is extracted by using filtering criteria to extract respondents who explicitly state they are seasonal workers (JATTACH, SEEKWORK), but also workers who have a short-term contract (3-11 months in duration, TEMP, TEMPDUR) and work in a different region (REGION_W) than where they live (REGION).

Cross-border commuting is a subset of long-distance commuting. Here the criterion is that the region of work must be in another country (COUNTRY_W) than the region of residence for a respondent (COUNTRY).

Erasmus data

The Erasmus data consists of the Erasmus Mobility Report 2014–2020, which reports the student exchanges on individual level (Directorate-General for Education, Youth, Sport and Culture 2023). We filtered out students whose mobility duration was less than three months, the remaining data set was then divided into two, capturing **long-term student mobility** (11 months) and **short-term student mobility** (3 and 11 months) based on the duration of the mobility (Figure A1).

The locations in this data source are in written form for sending/receiving cities and institutions. We used the detected place names to geocode their location using the Photon geocoding service implemented in GeoPy (2024). We were able to successfully recognise place names from 97 % of all mobility flows on the accuracy level of cities. Using this location information we then aggregated the origins and destinations to NUTS2 level and mapped the interregional flows.

Twitter/X data

We used a comprehensive dataset from Twitter (now known as X), encompassing geotagged tweets from across Europe between 2012 and 2022 (Poorthuis & Zook 2017), and used it to extract **permanent migration** and **multilocal living arrangements**. Each tweet in this dataset is timestamped and geolocated at the H3 level (Uber's hexagonal hierarchical spatial index), providing precise spatial and temporal information. To ensure data quality, we filtered out the top 5% of users with the highest number of tweets, typically

generated by automated bots. We also excluded users with less than 180 days (about 6 months) of data to capture our defined mobility types. Each user in the dataset was assigned a unique identifier, enabling us to track individual movements and identify significant places (e.g. region of residence).

Permanent migration was identified by comparing users' residential locations. We first determined significant locations for each user at the NUTS3 level. These significant locations were defined by two criteria for each year: they had to be in the top 75th percentile for tweet frequency, and the user must have spent at least 30 days at that location within the year. The location with the highest dwell time was selected as the primary residence for each user. A migration event was recorded when a user's primary residence changed within two years, marking it as a permanent migration from the origin to the destination. To ensure consistency with other datasets, we then aggregated the data from the NUTS3 level to the NUTS2 level. Finally, to contend with data scarcity on the annual level we grouped the data temporally into three periods: 2012–2015; 2016–2019; 2020-2022.

Multilocal living arrangements were identified by first determining the significant locations for each user at the NUTS3 level. Significant locations were defined by two criteria for each year: they had to be in the top 75th percentile in terms of tweet frequency, and the user must have spent at least 90 days at that location within a five-year window (two years before and two years after the considered year). This process yielded significant places for each user annually. Next, we calculated the number of movements between these significant places. Movements that constituted more than 50% of the total movements between significant places were likely due to long-distance commuting. We classified all less frequent pairs of significant places as multilocal living arrangements, indicating that individuals spent substantial time in these locations without showing a commuting pattern between them.

For analysis purposes, we aggregated the data to the NUTS3 level. The results were then further aggregated to the NUTS2 level.

Calculating Mobility flow network

To visualize the mobility flows in a sensible and legible manner, we created an origin-destination matrix of all possible NUTS2 regions using their centroids to form lines. We then performed edge-bundling on this raw geometrical line data, where lines going the same direction are bundled together. This creates a line network of smooth curves that is easier to understand compared to several straight lines overlapping each other. The edge bundling only bundled the edges if the bundled line's length was less than 2 times the original length, the remaining lines were not bundled. To perform the edge bundling, we used Edge-Path bundling techniques developed by Wallinger, et al. (2022) which had been implemented in Python by Peterka (2024).

TWIN TRANSITION AND CHANGING PATTERNS OF SPATIAL MOBILITY: A REGIONAL APPROACH

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