Smart-work and smart cities

National report – Poland

Work package 4

Dominik Owczarek and Maciej Pańków

INSTITUTE OF PUBLIC AFFAIRS

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1. A brief introduction on the topics discussed in the national templates

1.1. The place of the smart cities concept in the Polish public sphere

In Poland, the concept of smart cities does not seem to be a prominent issue in the public debate or in the field of research, despite a number of publications available on the subject, which will be referred to below. In strategic documents, the term 'smart cities' is cited, mainly in the context of targets for broadband and 5G network expansion, alongside terms such as “smart homes” or “smart transport” or even “smart villages”, but nowhere is it defined (cf. e.g. Ministry of Administration and Digitalisation 2014, Council of Ministers 2019). The approach to smart cities seems to be strongly technical, as exemplified by – again, very sparingly and only in tabular form – the listing of certain aspects associated with the concept (Ministry of Administration and Digitalisation 2014). The following solutions attributed to smart cities were identified: smart parking, monitoring of the technical condition of infrastructure and buildings, noise monitoring, optimisation of vehicle and pedestrian traffic, smart lighting, waste management, smart transport systems (ibid: 57). Some of these issues can undoubtedly be related to smart working to some extent and indirectly, but this has not been indicated explicitly. It should be noted at this point that the term "smart working" is practically absent from the public discourse. Terms such as "remote working", "teleworking", "working from home", "hybrid working" or, most broadly, "flexible working" are used instead. Hence, there is a lack, at least at a linguistic level, of association of the concept of “smart cities” with the issue of different forms of smart work.

There is no reference to any form of smart/remote working in the policy documents at the national level. It seems that public authorities do not see their role in shaping this sphere, as also evidenced by the lengthy work on statutory regulation of remote working in response to its increased prevalence during the COVID-19 pandemic (it was only in April 2023 that an amendment to the Labour Code came into force, after three years of work on it) or the low uptake of remote working in the public administration (most employees are able to work from home at most once a week – cf. Owczarek & Pańków 2023). At the same time, overall, the percentage of working from home in Poland, after a short period of significant growth during the lockdown period in 2020, is one of the lowest in Europe. In 2022, only 4.9% of the total working population usually worked from home, while 7.7% sometimes did so. This was a significant decrease compared to 2020, when it was 8.9% and 9.2% respectively due to pandemic-related restrictions. This circumstance should also be seen as causing limited interest in introducing systemic solutions and comprehensive policies for managing smart work, including adapting urban policies to it.

The concept of smart cities is more present in the strategic documents of the largest Polish cities. Apart from Warsaw, the capital of Poland, such large cities being the seats of regional authorities as Gdańsk, Kraków, Łódź, Rzeszów, Szczecin and Wrocław have references to the analysed concept in their

development strategies (Papińska-Kacperek & Wassilew 2021: 64). In the case of Warsaw's development strategy, a smart city was defined as "a city governed in a wise way, which uses digital and telecommunications technologies to increase the efficiency of networks and services, in order to improve the quality of life of its inhabitants and ensure sustainable development" (Warsaw City Hall 2018). Although the strategy indicates the need to use ICT systems to support intelligent transport, and more broadly to develop sustainable urban transport based, among other things, on well-organised public transport while reducing individual car transport (ibid: 40), there is no reference to remote working as an element supporting this concept. The topic of smart-working is not discussed at all in this document.

A perfunctory approach to the topic of smart cities and the lack of a link between this concept - at least explicitly - and other aspects of metropolitan functioning also dominates among strategic documents of other large Polish cities. In the case of Łódź (the fourth largest city in Poland in terms of population), only a short paragraph was also devoted to this issue. It includes, although not explicitly, a definition of smart cities, indicating that "Łódź is a city that integrates data from different areas and uses them for effective management and increasing resilience to critical events" (Łódź City Council 2021: 15). The development strategy of Rzeszów, on the other hand, points out that the city was ranked highest in the smart cities ranking by the universities of Vienna, Delft and Ljubljana, among Polish medium-sized cities. The document also includes a brief discussion of the main components of smart cities, namely smart: economy, people, governance, mobility, environment and life, as well as a declaration that Rzeszów is "the only city in Poland that has tied its future to innovation and is consistently pursuing this strategy" (President of Rzeszów City 2015: 288-289. Interestingly, as will be indicated in later sections of this report, Rzeszów does indeed stand out in terms of smart-workingness compared to many other Polish cities, especially when considering the traditionally rural and peripheral nature of the region in which it is located.

1.2. Challenges of the pandemic period

The COVID-19 pandemic has forced significant changes in the way local communities, as well as authorities at all levels of local government, operate. Particularly the first phase in 2020, when a lockdown was introduced in the spring significantly restricting the spatial mobility of the population, led to revolutionary changes with regard to, among other things, the performance of professional work, but also other spheres such as consumption or the use of public services. According to an analysis by Eurofound (2020), at the peak of the pandemic restrictions, the proportion of homeworkers among the total workforce in Poland slightly exceeded 30%, while in the European Union as a whole it reached almost 40% on average.

The way Poles shop has also changed: 38% more people have started using cashless payments and 60% more people have started using micropayments (Papińska-Kacperek & Wassilew 2021: 65). The number of retail and service outlets where it was possible to pay by card increased. The number of people buying online increased by 11 percentage points. Many more companies began, in turn, to sell through this medium. At the same time, those businesses whose nature of business did not allow them to sell online were able to count on support from the authorities of many cities - for example, a reduction in

rent or local taxes. In Warsaw, such entrepreneurs were offered free business, legal and accounting advice. In addition, some cities have implemented new online services for citizens, such as broadcasting plays on YouTube, virtual tours of museums, helping schools organise distance learning, regular online social media meetings organised by the mayors of Polish cities (e.g. Wrocław or Poznań), and online public consultations (e.g. Lublin, Łódź) (ibid: 66). They have started to publish recordings of city council sessions or organise them in the form of videoconferences with transmission, installing official parcel machines or cameras to detect human clusters or thermal cameras to detect people with elevated body temperatures.

The pandemic has also radically affected the way official matters are dealt with. By 2019, only around 4.65 million Poles had a trusted profile, which allows a citizen to authenticate when dealing with an official matter remotely (Przepiórkowska et al. 2022). This number has increased to 13.43 million by the end of 2021. In Warsaw, the number of cases handled in person at the Residents' Service Departments fell from almost 3.6 million in 2019 to 2.5 million in 2020 and - despite relaxed restrictions - to just over 2.4 million in 2021. The number of cases handled at the city hall via the ePUAP platform increased from just over 60,000. in the second quarter of 2019 to almost 250,000 in the second quarter of 2020, before falling to around 170,000 in the second quarter of 2021. The number of remote birth notifications increased from around 8,000 in 2019 to 21,000 in 2020 and 23,000 in 2021. Applications were also made remotely for additions to the electoral register, for the issue of an identity card, and in connection with the disposal or purchase of a vehicle (ibid: 11).

1.3. State of scientific knowledge on smart-working in smart-cities

The body of Polish research on smart-work are not the most modest - for years at least literature reviews have been conducted (cf. e.g. Jeran 2016) and a number of field studies (mostly on small, non-probability samples), especially inspired by the new situation caused by the pandemic COVID-19 - see, for example, Dolot 2020. The main problem in the light of the objectives of this analysis seems to be a very weak link between the issue of various forms of smart-work and the concept of smart-cities. Explicitly linked the issue of smart cities with remote work Wyrwich-Płotka (2020), who, based on a review of the literature, demonstrated the important role of the latter in the development of smart cities, especially in the face of sudden crises such as the outbreak of the Covid-19 pandemic. In this view, smart cities have become a "training ground for the implementation of remote work" (ibid: 75), since it was thanks to the various solutions they made available that it was possible for thousands of companies and organisations to ensure proper communication with employees who stayed at home, to quickly transition city government employees to remote work, to create new opportunities for citizens to handle official matters remotely, or to use smart infrastructure to reduce the spread of coronavirus infections. According to the author, modern ICT technologies, which characterise smart cities, facilitated the maintenance of social distance and reduction of physical contact between the community and government employees or the monitoring of high-density areas in the context of the spread of the disease (ibid: 75). Other benefits for smart cities from the implementation of remote work, going beyond the context of the pandemic, were also listed, for example, reduction of CO_2 emissions as a result of limiting commuting, professional activation of people with disabilities, reduction of administrative costs, costs of renting real estate and utilities, or eliminating travel-related time losses

and standing in traffic jams (ibid: 79). There are also negative effects, such as limiting social contacts or less control of supervisors/managers over employees. The author cites analytically useful theoretical concepts that allow for a better understanding of the challenges posed by the implementation of remote work, such as the resource-based approach, emphasising intangible resources (especially the knowledge and skills of employees) as a factor of organisational success in implementing innovations (ibid: 77).

To a very limited extent (not including any significant theoretical component), the relationship of smart cities and remote working was also analysed in the article by Papińska-Kacperek & Wassilew (2021), who wrote, among other things, about remote work of city administrative staff and – more broadly – about increasing the scale of remote work as a certain challenge for the functioning of cities. Generally, however, the two issues are not linked and no analyses have been conducted so far that would take into account the relationship/correlation between telework and the functioning of smart-cities.

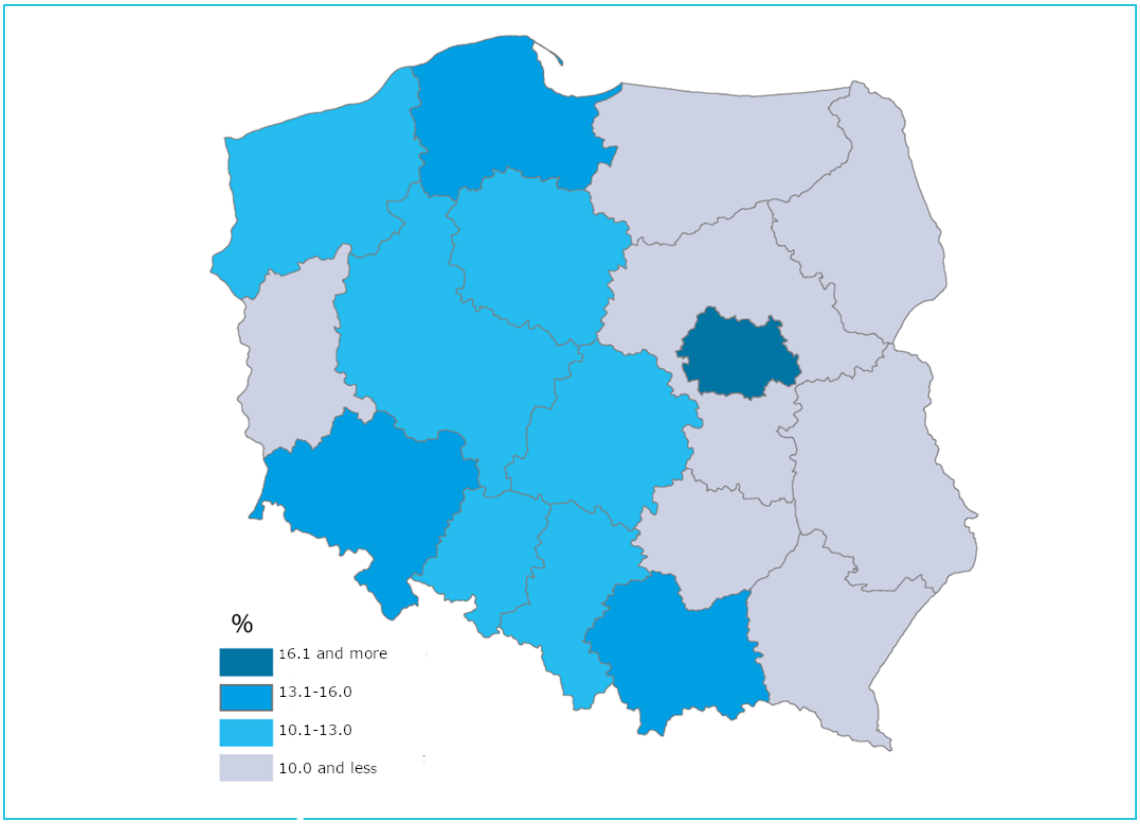
2. Smart cities, smart working and territorial resilience in Poland

2.1 Smart cities vs smart working in Polish scientific research

As indicated above, there are no available analyses linking the issue of smart work with the functioning of smart cities. Research on the impact of various forms of remote work has so far been rather fragmented, based on small and non-probability samples. Therefore, the quarterly studies of the Statistics Poland (cf. e.g.: Statistics Poland 2021), based on the Labor Force Survey, devoted to the impact of the COVID-19 pandemic on the functioning of the labour market, should be considered particularly useful. Especially the early studies in this series, when the restrictions were stronger, give a certain picture of spatial and sectoral differences in the field of smart-working.

Figure 1 (page 6) shows the regional distribution of working from home in the first quarter of 2021. The division takes into account NUTs 2 units, including sixteen voivodeships, of which in the case of the Mazovian voivodeship, the capital region with Warsaw and the surrounding Mazovian region are presented separately. The distribution of homeworkers reflects the division of the country into more urbanised and industrialised western and south-western regions and more agricultural and rural eastern regions. Against this background, the region encompassing the capital city of Warsaw with surrounding areas stands out, where the share of homeworkers was the highest in the whole country. On the plus side, three other voivodeships also stand out: in the north Pomerania (seat of provincial authorities: Gdańsk), in the south Lesser Poland (Cracow) and in the south-west Lower Silesia (Wrocław). These data correspond with the spatial smart-working availability indicators analysed below, as well as with the later discussed data on the decline in the workplace presence during the pandemic period.

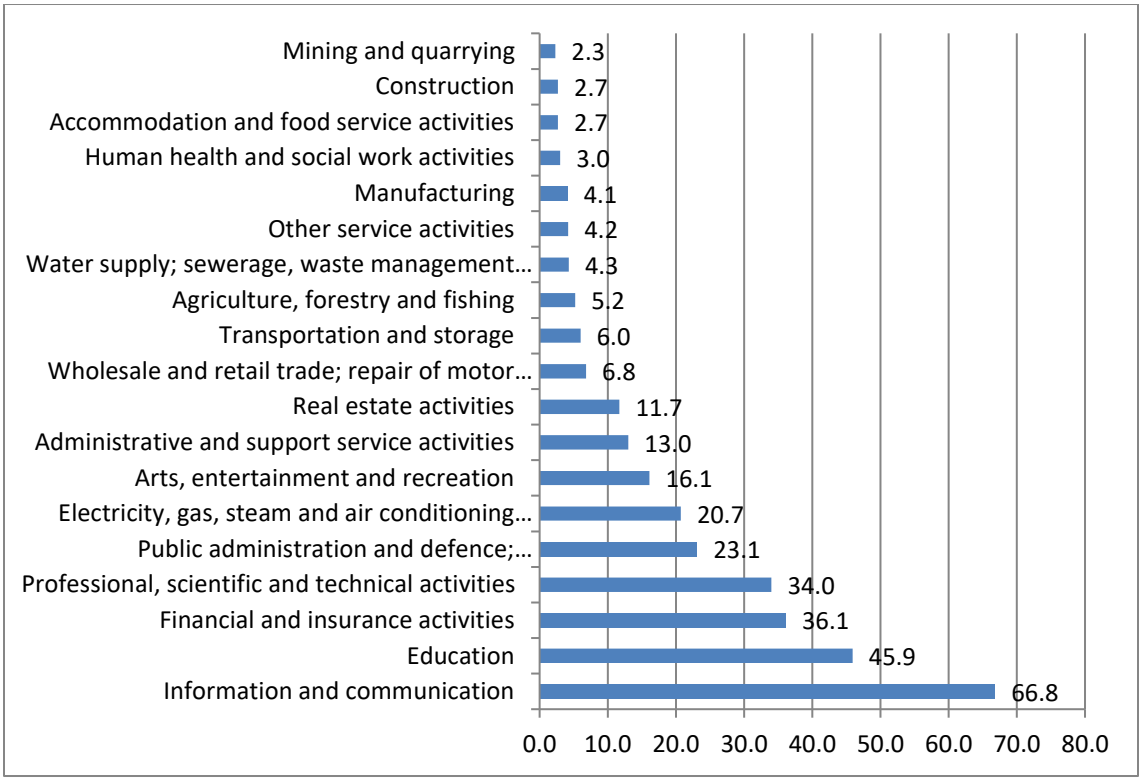
Figure 1: Share of employees working from home in total workforce by region in the first quarter of 2021



Source: Statistics Poland (2021) *Impact of the COVID-19 outbreak on selected elements of the labour market in Poland in the first quarter of 2021*. Warsaw

The next figure shows the distribution of working from home in the first quarter of 2021 by broad economic sectors. We see a very wide variation in the value of this indicator – from a marginal share of such employees in the "traditional" industrial sectors (manufacturing, mining) and services requiring a presence at the venue (catering, hospitality), to very high percentages in new service sectors such as finance and banking, education (here the administrative decisions to close schools were also important) and – in particular – IT and telecommunications services.

Figure 2. Share of employees working from home in total employment by broad economic sectors in Q1 2021

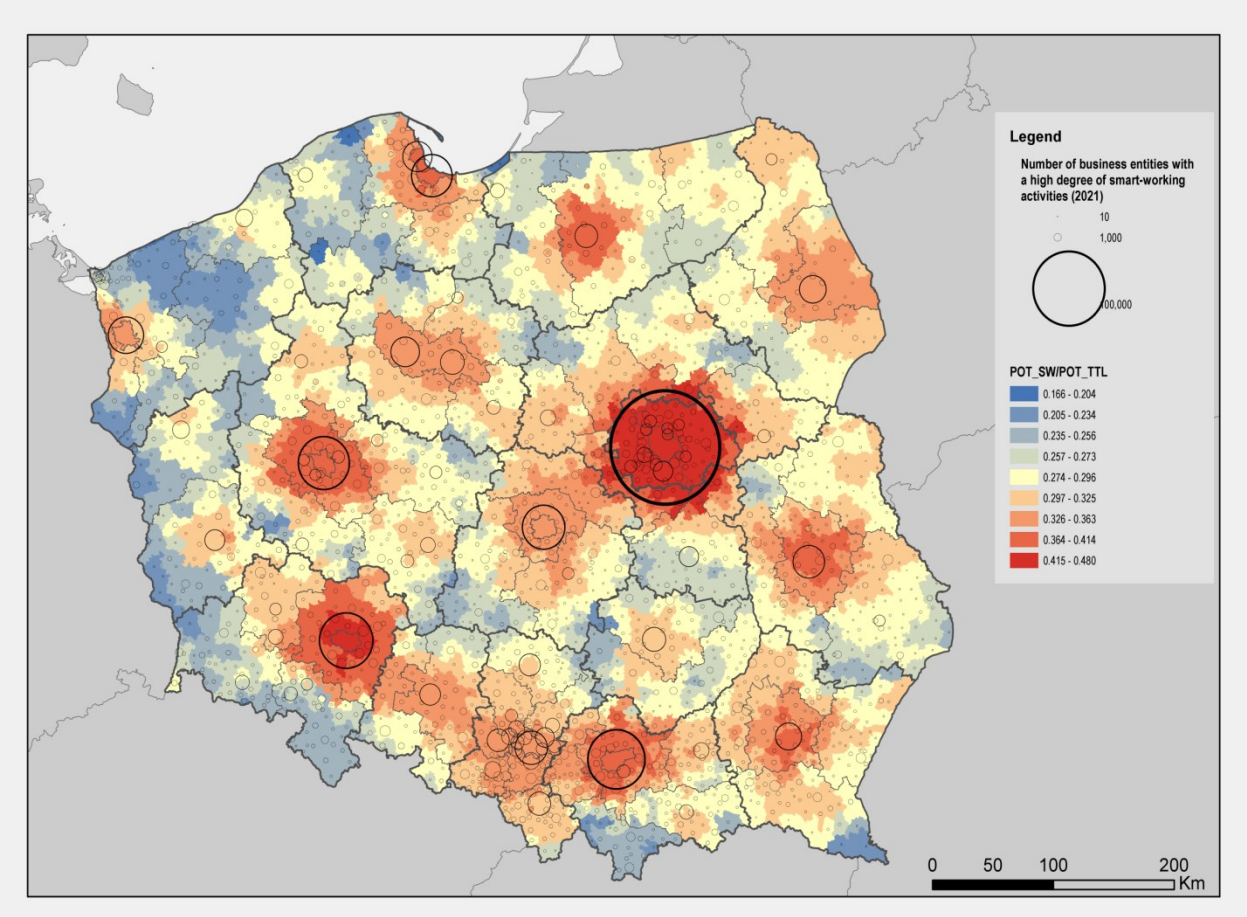


Source: Statistics Poland (2021) *Impact of the COVID-19 outbreak on selected elements of the labour market in Poland in the first quarter of 2021*. Warsaw

2.2.1 – A potential accessibility to the stock of smart working employees or business entities

In the following, we will analyse the accessibility indexes of jobs that provide the opportunity to work from outside the employer's premises - in other words, the smart-working indexes. These indices were developed by the Romanian team, which also provided the data and analysed them accordingly. The indices are based on data for each municipality (basic territorial division of the country) as to the proportion of jobs in economic sectors characterised by a high level of smart-workingness to total jobs. A scale was adopted: 0 for sectors with a low level of this indicator (e.g. manufacturing, health care), 0.5 for an average level of the indicator (e.g. retail trade, public administration) and 1 for a high level (e.g. information and telecommunications, education, finance and insurance). The map below considers the availability of businesses with a commute time of up to 90 minutes from the home address. For a more detailed description of the construction of this indicator with references, please see the Romanian WP4 report.

Figure 3. Share of the smart-working potential accessibility index in the total local potential of employees (SW index 1)



Source: The Romanian team's own calculations as part of the IRSmart project.

In some respects, this map coincides with the map presented as Figure 1: The metropolitan area of Warsaw and its neighbouring municipalities is by far the most prominent, with by far the greatest availability of smart-work-ready areas of economic activity. At the same time, it is by far the area with the highest concentration of economic entities. The maximum values of the SW1 indicator are also reached by the Wrocław agglomeration (Poland's third most populous city), and slightly lower by Kraków and Poznań (2nd and 5th place in the ranking of Polish cities).

However, the map also shows a number of rather unexpected smart-work index values. The biggest 'surprise' is the poor availability of remote working along the western border, while at the same time there is relatively high availability on the so-called 'eastern wall' (as the regions on the eastern periphery, associated with a relatively low level of development and a predominantly agricultural character). The reason for this is the presence of three thriving cities in eastern Poland - from the north these are: Białystok, Lublin and Rzeszów. It has already been mentioned in the introduction that the last of these is considered the Polish leader in the smart cities ranking among medium-sized cities, which is

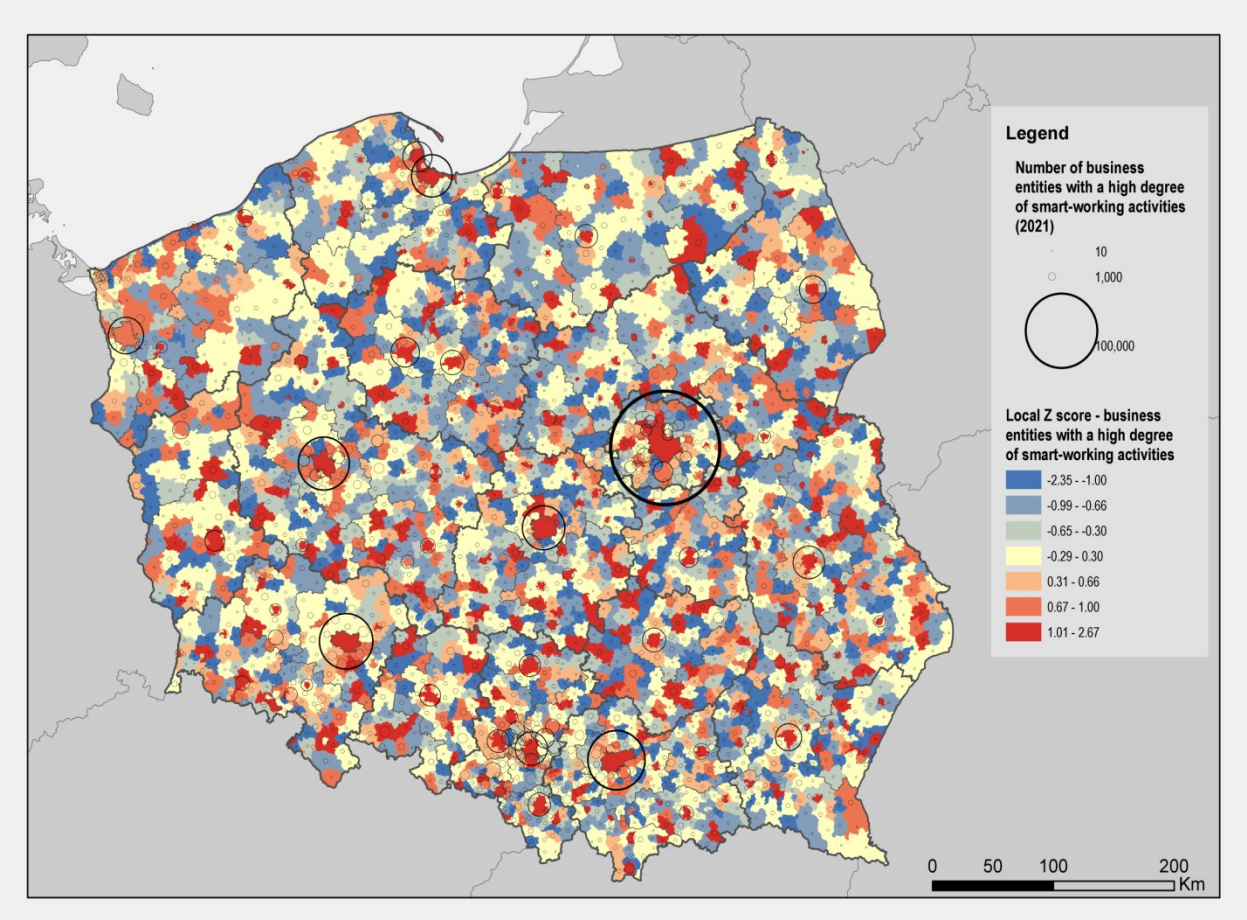
confirmed by the map above. Interestingly, the availability of smart-work is higher there than in the most urbanised and industrialised region of Poland - the Upper Silesian conurbation (neighbouring the Małopolskie Voivodeship, including with its capital in Kraków, to the west). The lower value of the indicator in Upper Silesia, where Katowice is the largest city, is undoubtedly due to the still dominant role of heavy industry (e.g. metallurgy, automotive) and hard coal mining there.

The advantage in the availability of smart-work in Olsztyn over Łódź seems to be similarly unexpected. The first of these cities, the capital of the Warmian-Masurian Voivodeship, is located about 100 km north of Warsaw. From the turn of the 1980s and 1990s, this region experienced a deep economic crisis and a high unemployment rate of a structural nature, e.g. as a result of the liquidation of state farms. In turn, Łódź was still the second largest city in Poland in the 1990s, but it is experiencing quite intense depopulation, also a result of a long-term crisis, originally caused by the collapse of the textile industry. It seems, however, that Olsztyn has managed to modernise its economy profile much more, which makes it clearly superior in relation to the indicator analysed here.

When it comes to geographic clusters of areas with an increased availability of smart-work, a belt in the southern part of the country is striking, stretching from Wrocław in the west to Rzeszów in the east, covering Opole, the Upper Silesian conurbation and Kraków. Another "macrostructure" could be considered a triangle, the upper vertex of which is Olsztyn, the lower left - Poznań, and the lower right - Lublin (it also includes the following: a pair of cities Bydgoszcz and Toruń in the middle of the left side, Łódź in the base and Warsaw in the middle of the right side). It seems, however, that we are talking about an area that is too large and not sufficiently coherent in terms of development and socio-economic profile to look for any connections between these very different metropolises.

2.2.2 – A local index of spatial association between smart-working and other economic activities.

Figure 4. SW Index 2 – identifying local concentrations of smart-working employees using an alternative method – the local Z scores.

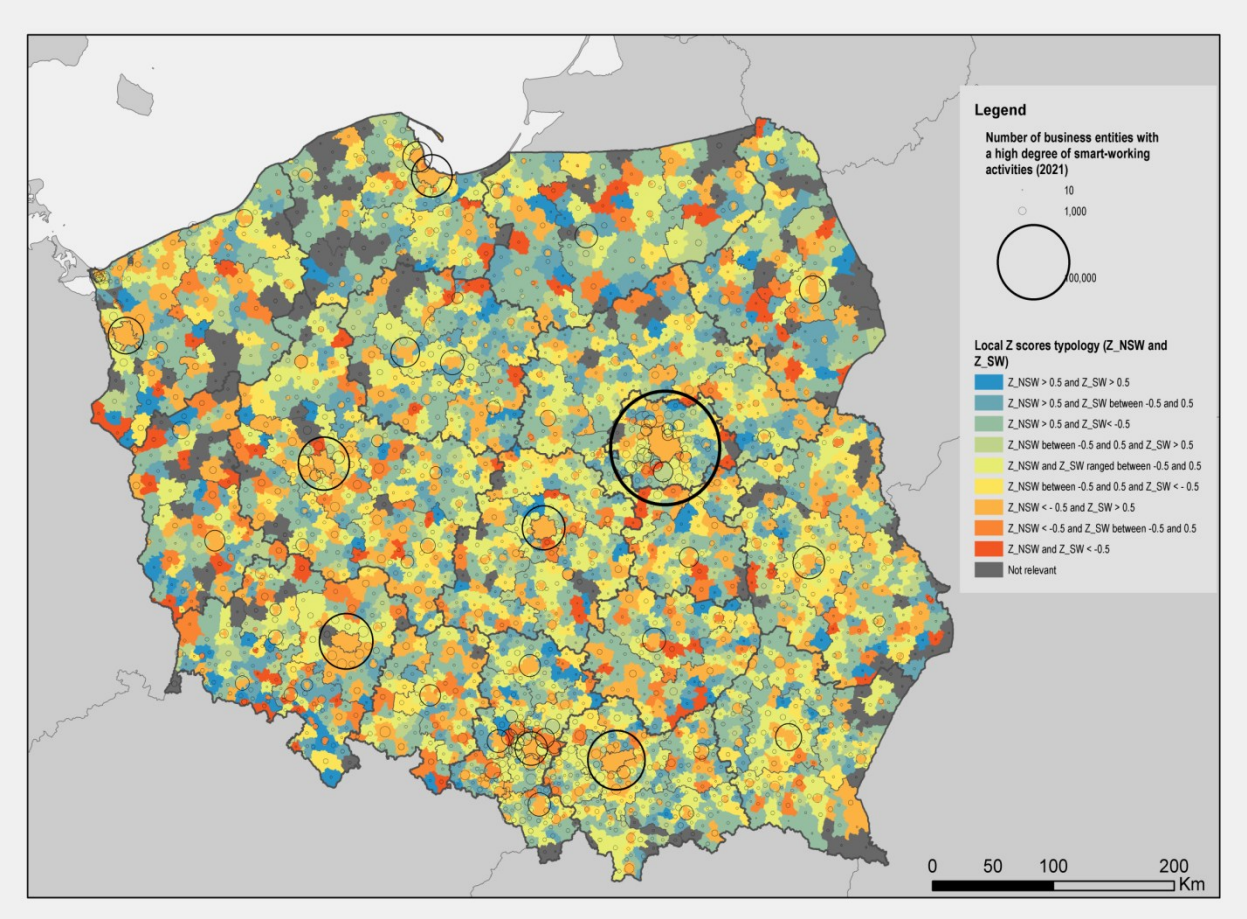


Source: The Romanian team's own calculations as part of the IRSmart project.

The other indicator to be analysed here, proposed by the Romanian team as SW Index 2 (again - please see the WP4 report on Romania for details and references) is based on local Z scores. In simple terms, communes/municipalities characterised by abnormally – relative to surrounding areas – high levels of smart-work availability have been marked with shades of red. Those territorial units with similar levels of accessibility to neighbouring units appear in yellow. On the other hand, those units that stand out with a low level in relation to their surroundings adopt shades of blue. The map giving an insight into the smart-work index calculated in this way (Figure 4) does not seem to provide unexpected observations. All major cities – or at least all 16 voivodeship cities – are clearly distinguished in plus by their level of smart-work availability relative to surrounding areas. Some differences appear when we look at the surrounding communes: some cities are predominantly surrounded by units characterised by at least average Z index values (e.g. Wrocław). It can therefore be assumed that they form fairly coherent metropolitan systems. Others, such as Olsztyn, are more or less "isolated" islands of high smart-work accessibility.

Another indicator of smart-workingness will be presented below, based on a combination of the previous z-index with another variant of it, assigning values to individual territorial units in the opposite direction: units with a high proportion of smart-work-ready companies score negatively instead of positively. This gives us a number of possible combinations (e.g. a high z-index value of the first variant with a medium z-index value of the second variant, etc.). The values of the index constructed in this way are presented in Figure 5. It is worth noting the two positions of the map legend: the third (Z_NSW > 0.5 and Z_SW < -0.5) and the seventh (Z_NSW < -0.5 and Z_SW > 0.5) from the top. Areas marked with the first colour are typical peripheral and agricultural areas, while those marked with the latter are large cities or areas associated with them.

Fig. 5 A qualitative assessment of the smart-working employees vs. traditional employees, using the local Z scores



Source: The Romanian team's own calculations as part of the IRSmart project.

Again, in light of the simplified interpretation of the map data presented above, there are no unexpected elements: all large cities are characterised by a combination of both Z-score variants typical of metropolitan areas.

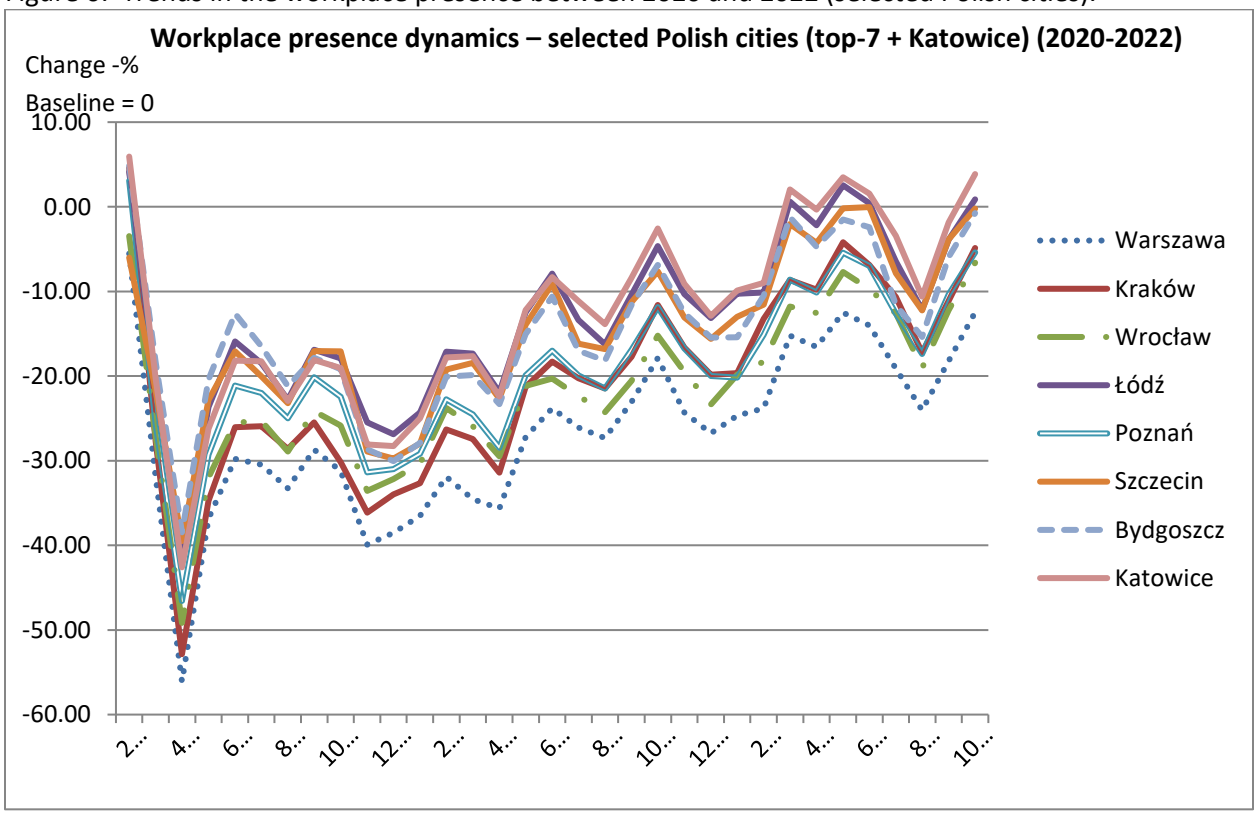
3. The impact of smart working on urban and regional mobility – lessons from the COVID19 pandemic period

Practically from the beginning, smart-work has been considered as a means of avoiding commuting to work, reducing traffic congestion and air pollution in cities. These benefits formed the foundations of the idea of telecommuting, formulated by Jacek Nilles in the early 1970s (cf. e.g. Nilles 1988). Unprecedented for many European countries, the restrictions introduced as a result of the COVID-19 pandemic, leading to limited spatial mobility of the population, mass work from home and limiting economic activity in many areas, may be a favorable opportunity to verify hypotheses on the impact of smart-work on mobility or pollutant emissions.

3.1 Impact on mobility

Below the data will be analysed on the workplace presence for several of the largest cities in Poland. Similarly to other countries, mobility is expected to decrease as a result of the introduction of the lockdown and numerous restrictions related to the pandemic and a sharp increase in the use of working from home (at its peak in March-April 2020, about 30% of employees in Poland performed it). Thereafter, a gradual increase in mobility as measured by presence in the workplace is to be expected as restrictions have been relaxed.

Figure 6. Trends in the workplace presence between 2020 and 2022 (selected Polish cities).



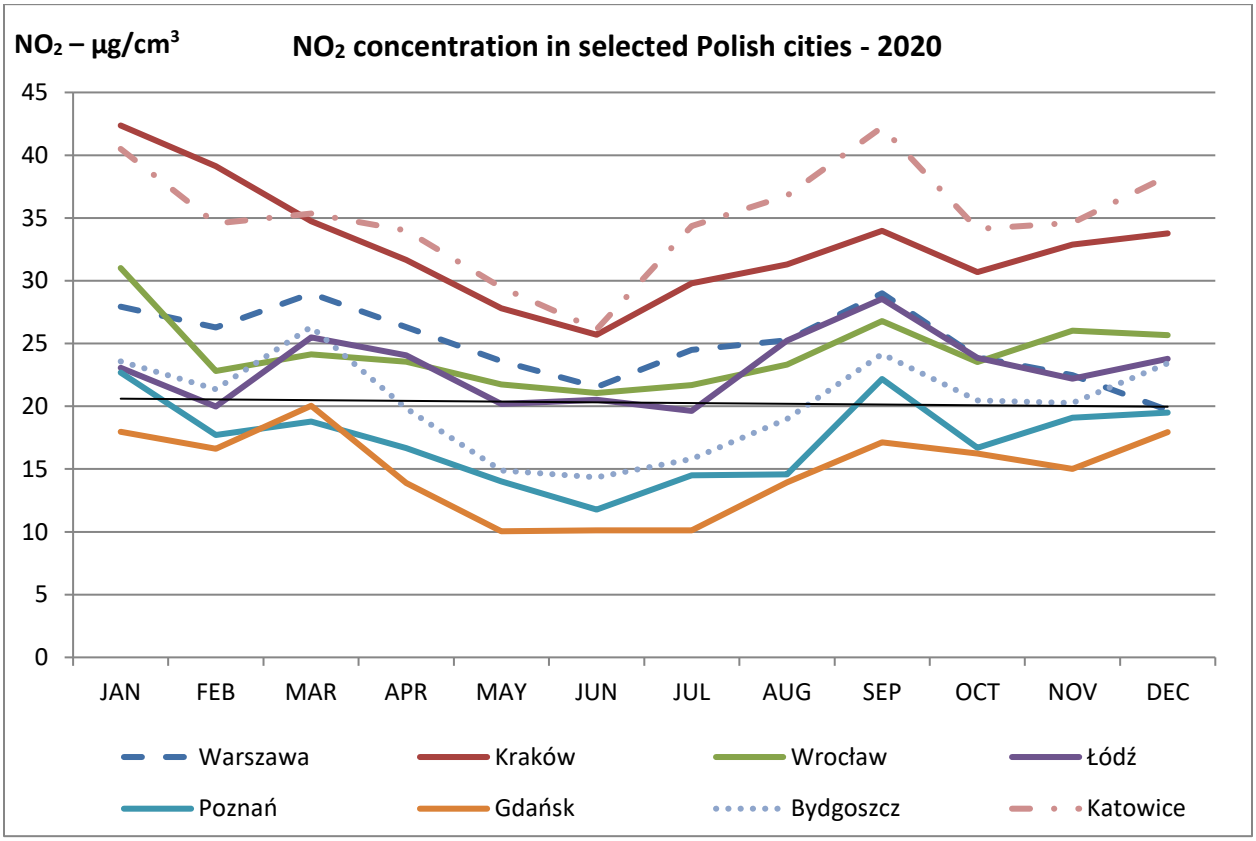
Data source: Google LLC "Google COVID-19 Community Mobility Reports". https://www.google.com/covid19/mobility/

The data on mobility was aggregated by month, in order to eliminate a part of the inherent data noise (weekends, celebrations day, free days etc.). The figure shows a decrease in workplace mobility compared to the reference period (median value over a 5-week period from 3 January to 6 February 2020) in Poland's seven largest cities and the slightly smaller Katowice. The cities has the following population in 2021: Warsaw - 1.86 million, Kraków - 800,000, Wrocław - 672,000, Łódź - 670,000, Poznań - 546,000, Gdańsk - PLN 486,000, Szczecin - 396,000, Bydgoszcz - 337,000. Katowice was ranked 11th, but is included here due to its location within the Upper Silesian conurbation, consisting of a very large number of medium-sized cities (the Upper Silesian Voivodeship has a population of almost 4.4 million people and is the most urbanised and populated region).
In the figure, we observe a strong decrease in the workplace mobility in April 2020, when the lockdown was introduced, in all the cities included in the compilation, followed by a gradual increase in this mobility, with some cycles due to the tightening and loosening of restrictions (the impact of the tightening of the sanitary regime due to the second wave of illnesses in the autumn and early winter of 2020/2021 is most evident). The influence of the holiday seasons on the temporary decrease in mobility in the summer months of 2021 and 2022 is also marked, although not very strongly. The data shown in the figure suggest a clear correlation between the size of the city and the degree of decrease in mobility at the venue. The decline was greatest in the capital Warsaw and proved to be the most persistent. It was also large in Kraków, Wrocław and Poznań. In contrast, mobility was relatively higher in Łódź, the fourth largest city in terms of population, second only to that measured in Katowice. This may be due to the relatively less modern structure of the local economy and the presence of more traditional industrial sectors. On the other hand, the smallest city in the list - Katowice - is, as already indicated earlier in this report, a location of concentration of still relatively strong “traditional” industries, including coal mining and the metal or automotive industry. As expected, the average decline in mobility over the period under review was the smallest (despite a rather significant drop in 2020, which can be linked to the problems the mines were facing - very many miners were falling ill with COVID-19, there were work stoppages), and in October 2022 it was even higher than in the reference period. So it seems that in this city, under normal circumstances, remote or even hybrid working does not fit in with the companies' business profile and typical job specifications.

3.2 The environmental effects of the smart working

The consequence of the decrease in mobility associated with the reduction in commuting should be a reduction in local pollution by gases such as nitrogen dioxide, especially significant in the case of big cities (please see: Romanian WP4 national report for details). Data from the European Environment Agency (EEA) allows an analysis of trends in the concentration of this gas measured at a number of measuring stations in the largest Polish cities. Of particular interest in the context of this study may be the tracing of trends from 2020, when the lockdown was introduced in March, leading to a significant reduction in the mobility of the population, a temporary spike in the proportion of people working from home to around 30% and a reduction in some economic activities (e.g. catering services). This should be reflected in the nitrogen dioxide concentration data presented in Figure 7. These are data averaged for each month of 2020 from all measuring stations from each city, taking into account the different sources of pollution (industrial, urban, traffic).

Figure 7. Dynamics of the NO_2 concentration at urban scale (2020 – Polish selected cities)



Data source: https://discomap.eea.europa.eu/App/AirQualityStatistics/index.html#, EEA.

First of all, we can see some variation between the largest Polish cities in terms of pollution levels: two cities stand out in terms of high pollution levels. These are industrial Katowice and the located in a deep basin and struggling with smog for years Krakow. Perhaps surprisingly, trends in 2020 do not indicate a sharp drop in pollution. Moreover, in March, there was even an increase in emissions in most of the cities analysed. However, there was some later decline, and after reaching a minimum in June, there was a gradual increase in most cities. In September, there was a medium-term maximum (Katowice and Łódź even exceeded January levels, Warsaw and Poznań equalled them), followed by another decline, which should be linked to the tightening of restrictions in connection with the second wave of illnesses. Overall, it can be concluded that the decrease in NO_2 pollution was discernible and correlates with the two waves of restrictions introduced in 2020, although at least in some of the large cities the impact of reduced mobility and economic activity did not have a dramatic effect on emissions. This is particularly the case for Łódź, which had already been identified as the city that experienced the relatively smallest decrease in commuting mobility.

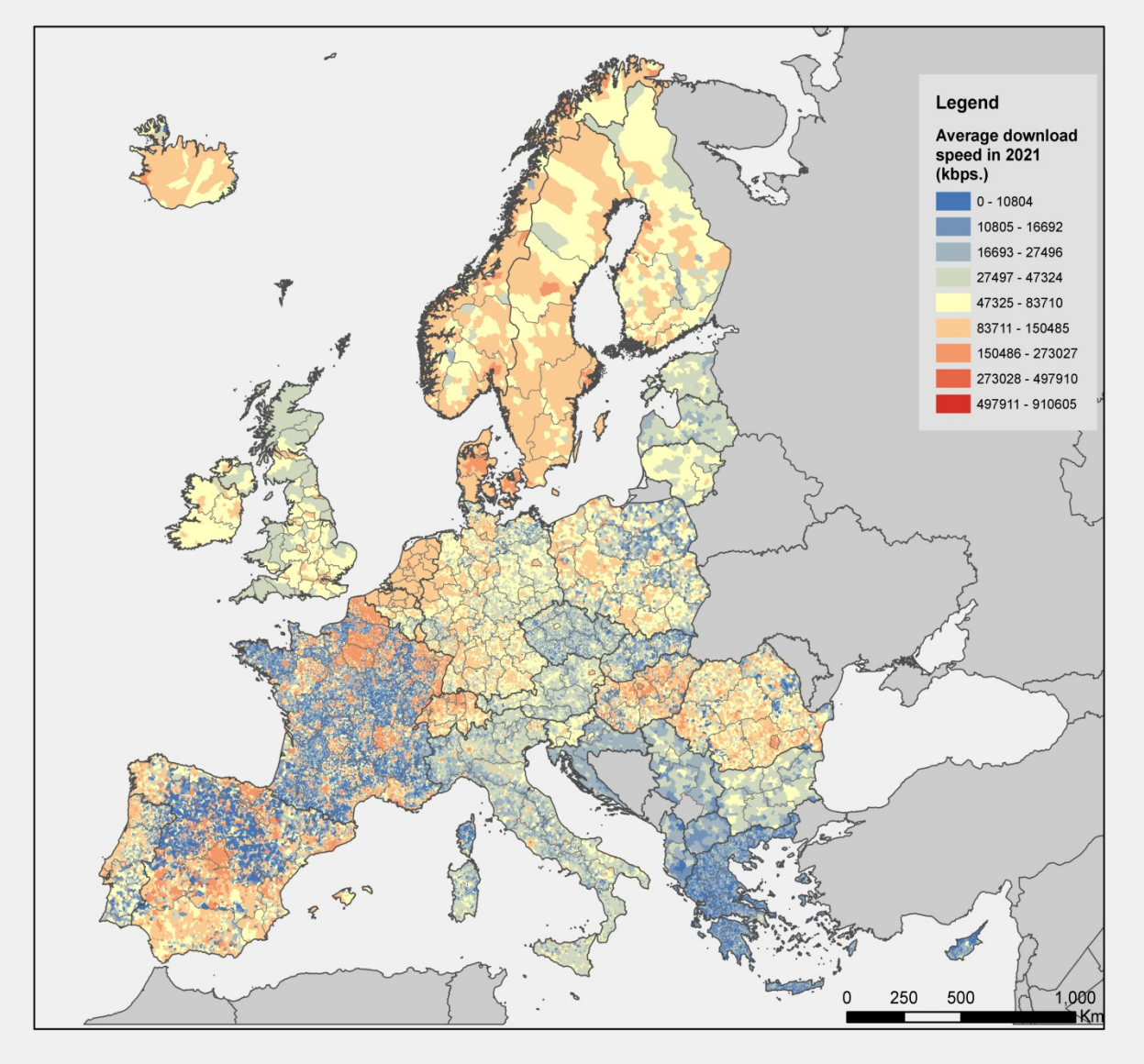
4. Framing the bottlenecks impeding the development of smart working in Poland

Undoubtedly, one of the main conditions for the development of smart-work is the presence of an efficient, stable and consistent broadband Internet network. The final part of this report will analyse the quality of this network in Poland in comparison with other European countries, as well as the territorial variation within it. The study will focus on the inter-regional inequalities, but also on the intra-regional disparities (e.g. metropolitan vs. rural areas). Trends in Internet use among Poles will be analysed next

4.1. Polish broadband internet in the EU and its territorial differentiation

Data allowing for the assessment of the quality of Internet connections in Poland in relation to other European Union countries and its diversity within the country will be discussed here.

Figure 8. Average download speed by LAU in 2021

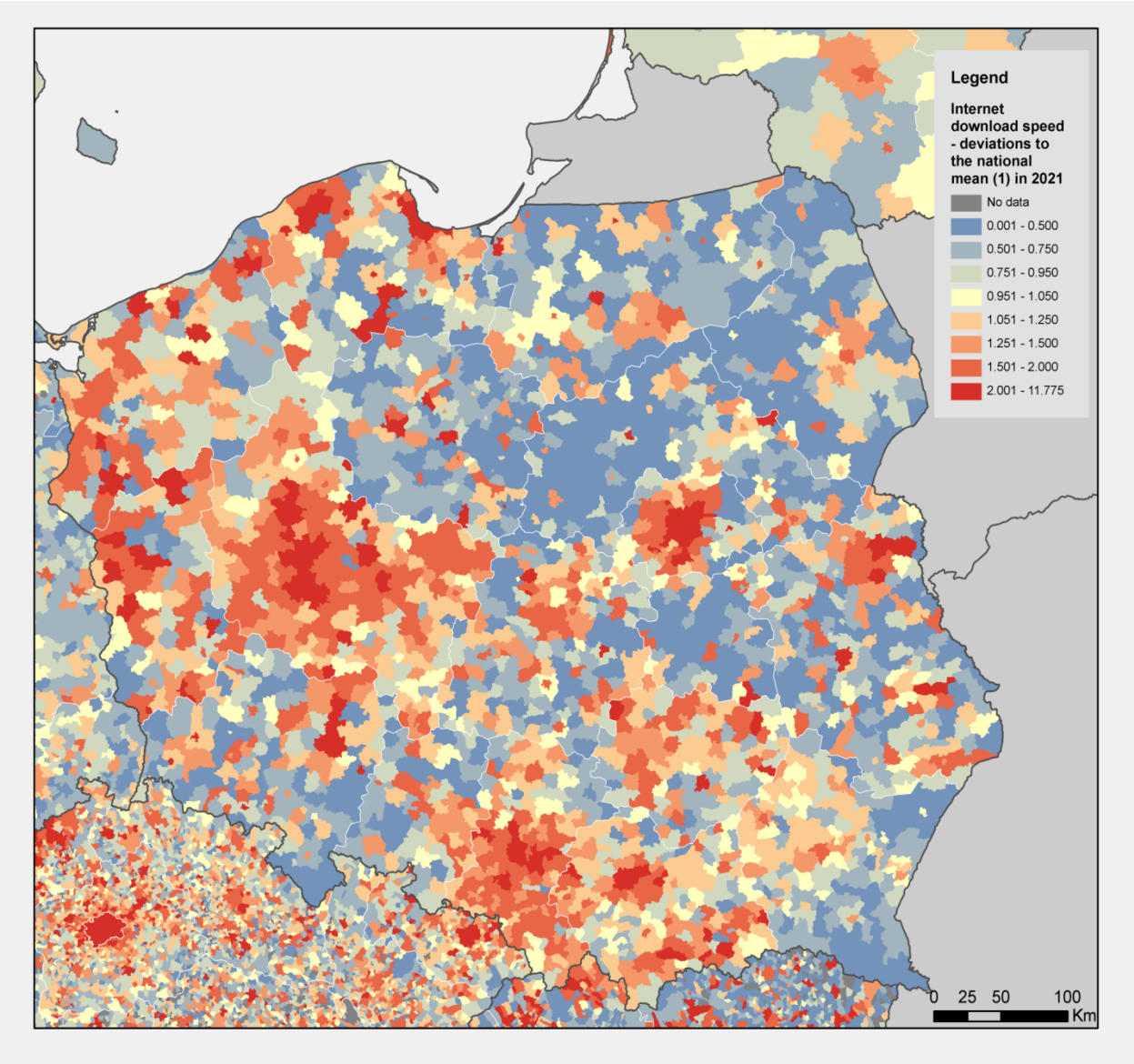


Source: The Romanian team's own calculations based on the OOKLA database.

As the map shows, in 2021 Poland was characterised by relatively average data download speeds. Its quality seems to be better than in neighboring countries such as Lithuania, Czechia or Slovakia. At the same time, the quality of the national network is quite varied: it is clearly better in the western (Lubusz, West Pomerania, Greater Poland) and southern (Silesia, Lesser Poland) voivodeships and in the Warsaw region, while the internet speed is particularly low in the north-eastern part of the country (Warmia-Masuria, Podlasie voivodeships), but also in areas relatively close to the centre of the country (Masovia voivodeship outside the Warsaw region, Świętokrzyskie, Kuyavia-Pomerania). While the low internet speed in large areas of the eastern regions – Subcarpathia and Lublin voivodeships – Is not particularly unexpected, the low speed in the south-western ones (Lower Silesia, Opole voivodeships) may be a bit surprising.

A glance at the map of Poland broken down by communes showing the standard deviation from the national average speed (Figure 9) confirms the belief that the spatial differentiation of the quality of the Internet is significant. In addition to high-quality: the Warsaw region, the Łódź region, the Greater Poland voivodeship, the Silesian conurbation, large areas of the Lesser Poland voivodeship in the vicinity of Krakow, large areas of the Lubusz and West Pomerania voivodeships in the west, Pomerania in the north, Świętokrzyskie in the central and southern part of the country and Lublin voivodeship, we have a number of areas that look almost like deserts on the national internet network map. Particularly noticeable is the extensive belt of very low-speed connections north of Warsaw, running through the Kuyavia-Pomerania, North Masovia and Podlasie voivodeships. Deficits are also clearly visible in the south of the Masovia and Łódź voivodeships, as far as the areas of the Opole and Lower Silesia voivodeships. The situation is also unfavourable in the north, especially in the Warmia-Masuria voivodeship. The factor explaining the presence of these regions of low-speed internet is undoubtedly the (relatively) considerable distance from large cities, the rural and agricultural character of these areas, and often the historically conditioned underdevelopment of some of them (e.g. the already mentioned crisis in the Warmia-Masuria voivodeship, caused by the liquidation of state-owned farms during the political transformation in the early 1990s). It is also worth noting that – unlike the previously analysed map of the availability of companies ready for smart-work – it is the areas adjacent to the eastern border of the country that experience low quality of the Internet, while the situation along the western border is usually favourable. Therefore, there may be a serious barrier to remote or even hybrid employment of people living in more distant locations by companies from cities such as Białystok, Lublin and Rzeszów.

Figure 9. Deviations to the national mean – Internet download speed in 2021.

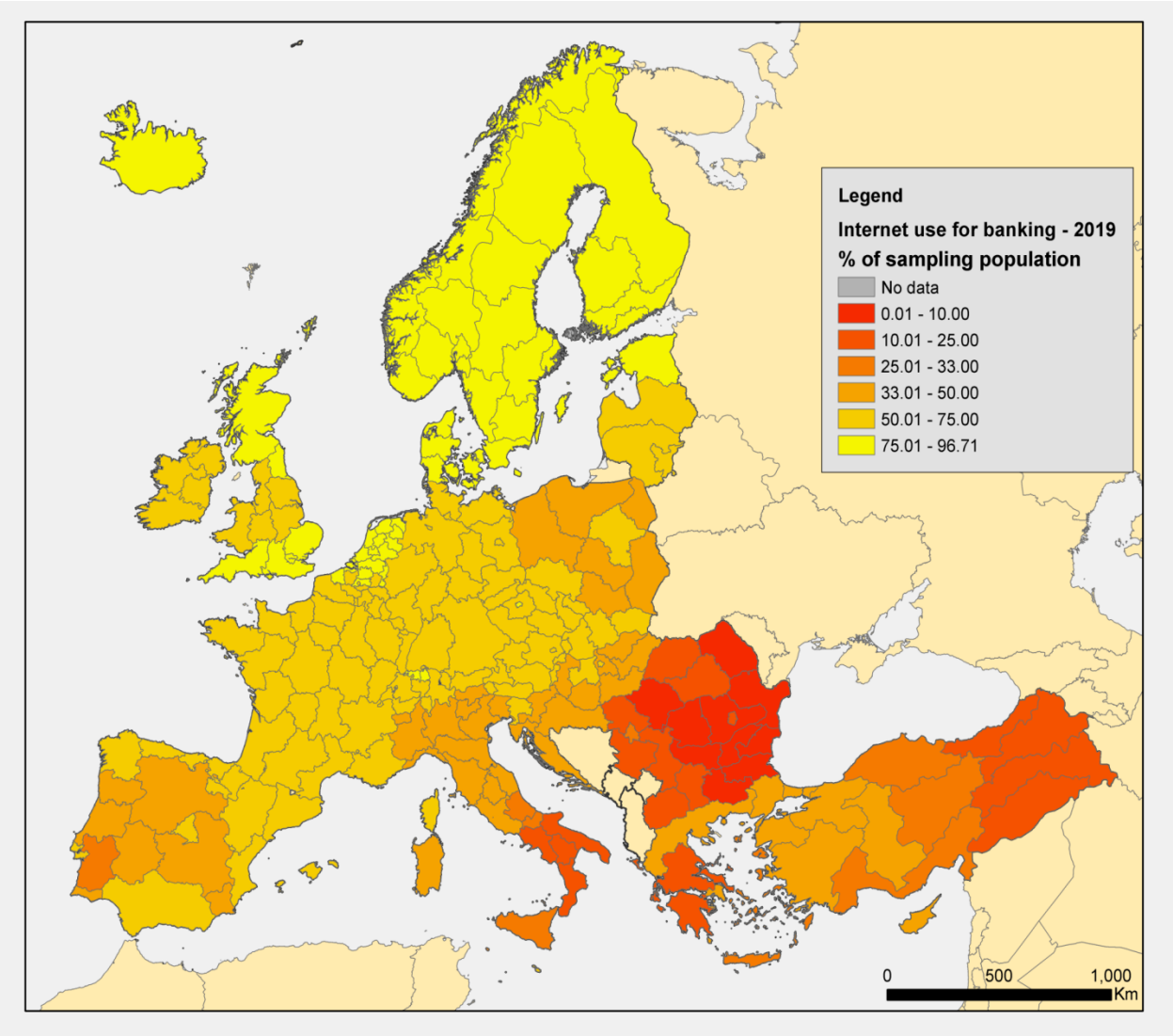


Source: The Romanian team's own calculations based on the OOKLA database.

4.2 Internet use by Poles

An important measure of readiness for smart-work is also the practice of using the Internet by the population. Undoubtedly, this medium is widespread in the country: in 2021, according to Eurostat data, only 6.9 to 15.1% of the population, depending on the region, did not use it. A more advanced use of the Internet, and thus the possibility of smart-working, may be evidenced by the use of electronic banking. Figure 10 and 11 show, respectively, the percentage of people using online banking in 2019 and the growth rate of its use in 2019-2022.

Figure 10. Internet use for banking in 2019

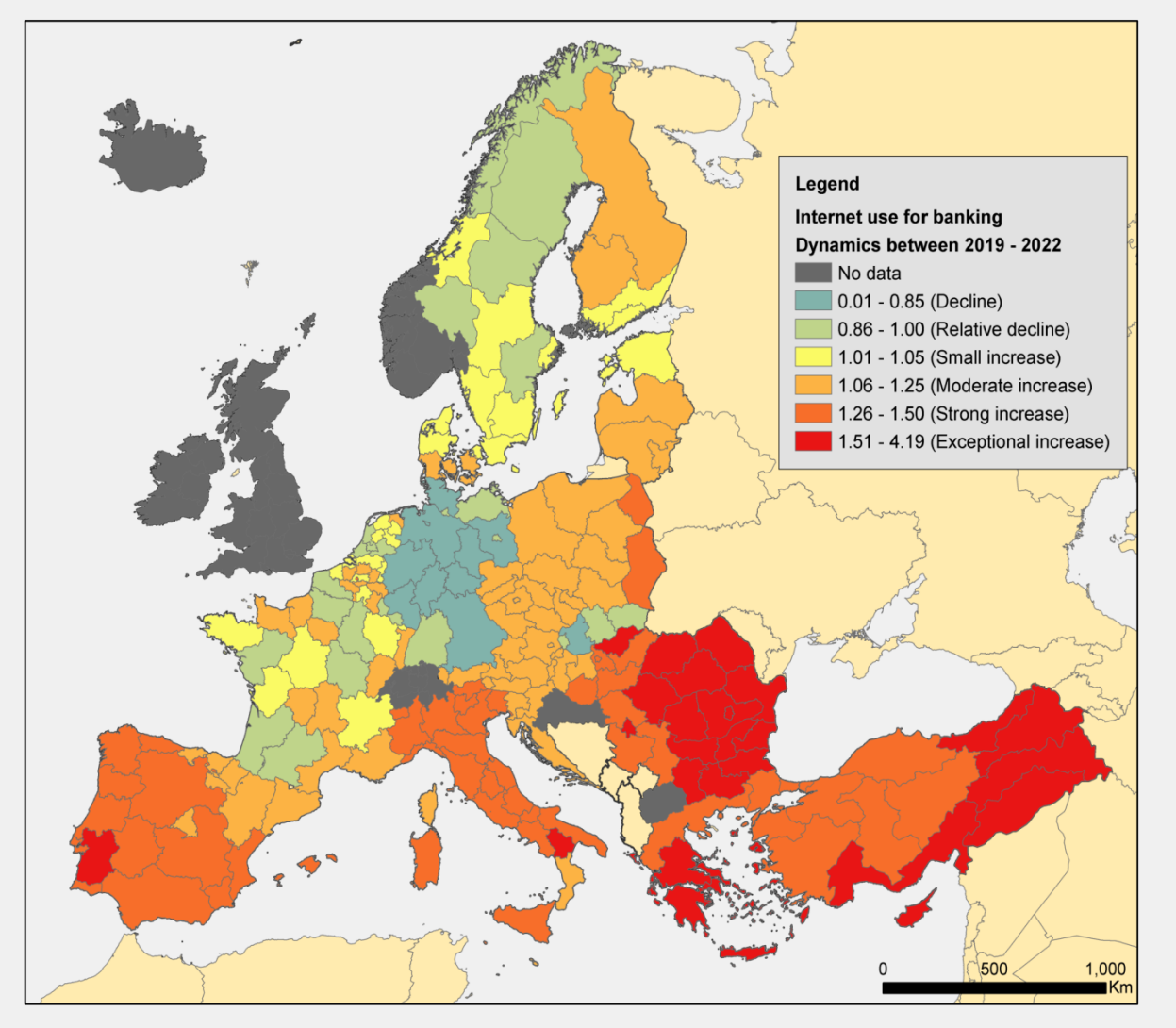


Source: The Romanian team's own calculations based on the Eurostat data.

The map shows the relatively lower use of online banking in Poland in 2019 compared to neighboring countries such as Germany, Czechia, Slovakia or Lithuania. The distance was particularly large in relation to the leaders in this area, i.e. the Scandinavian countries, Benelux, Estonia and Great Britain. On the other hand, Poland was ahead of the countries of South-Eastern Europe (southern Italy, Greece, Serbia, Romania and Bulgaria) in terms of the spread of electronic banking. Within the country, the higher value of the indicator was achieved by the following voivodeships: Masovia (undoubtedly due to the Warsaw region) and Lower Silesia. The next map (Figure 11) shows that during the pandemic there was a clear increase in the use of e-banking, especially in eastern voivodeships. However, on the map of Europe, the growth leaders were in particular: Romania, Bulgaria and Greece. Eurostat data for 2022 show that in two regions: the South-West macroregion (Lower Silesia and Opole voivodeships) and the Masovia voivodeship, the use of electronic banking exceeded 60% among the population. The lowest percentage (approx. 50%) was characteristic of the central macroregion (Łódź and Świętokrzyskie voivodeships).

If the use of electronic banking is considered a measure of readiness for smart-work, Poland should be considered as an area with a fairly average readiness, with a certain tendency to improve.

Figure 11. Internet use for banking - evolution of users ratios between 2019 and 2022



Source: The Romanian team's own calculations based on the Eurostat data.

5. Key findings and policy recommendations

The analysis carried out in this report showed a weak link between the smart cities concept and the smart-work issue, which is already rooted in language practices (the lack of use of the term "smart-work" - the term "remote working" is used instead, or, less frequently, "teleworking"). The issue of smart cities appears in a number of scientific studies, as well as in strategic documents of a number of Polish cities. In the latter, however, it is usually referred to as a buzzword, associated mainly with the presence of modern, intelligent infrastructure (e.g. transmission, transport) and the provision of fast

Internet connections. What is missing, however, is any reference to how cities could support employees in performing any form of remote work.

As a result of the COVID-19 pandemic and the associated restrictions, smart-work began to be performed on a mass scale for some time. Different regions differed in the degree of smart-workingness. It was highest in highly urbanised areas with large cities - especially the capital region. This is related, among other things, to the structure of the local economy. Certain modern service activities allow smart-work to a much greater extent than 'traditional' industries.

A spatial analysis of the readiness of local labour markets for smart-work shows the considerable potential of the capital region and the surroundings of several other major cities such as Kraków, Wrocław and Poznań, but also smaller and more peripheral centres such as Olsztyn, Lublin and Rzeszów. Unexpectedly, the belt along the western border turns out to be, due to its considerable distance from major cities, less prepared for smart-work than the regions neighbouring the country's eastern border.

The decline in mobility caused by pandemic austerity and the temporary increase in popularity of smart-work, as measured by the scale of presence at the workplace, turns out to be higher in the largest cities and, at the same time, those that show the highest smart-work readiness in the analyses – there is a convergence of results here. The period of highest restrictions in 2020 also resulted in a decrease in urban nitrogen dioxide emissions from both traffic and industrial activity. At the same time, it is not legitimate to link the drop in emissions to the mere spread of smart-work - a number of other factors may have influenced the reduction. The fact is, however, that the decrease in emissions has taken place (both waves of the spring and autumn 2020 restrictions are discernible in the figures), and to some extent this is undoubtedly linked to the decrease in commuting.

An analysis of the Internet speed in Poland shows an average level compared to our European region and significant spatial variation within the country. In addition to good quality connections in the Warsaw region and numerous areas in western Poland, there is a vast belt of very low quality Internet in the north, and numerous areas in the north-east of Poland. A number of other areas (e.g. south-west of the country, areas south of Warsaw and Łódź) also perform below expectations. Low availability of high quality connections is characterised by a belt along the eastern border of the country.

The advanced use of the Internet by the population turns out to be less widespread than in Poland's neighbouring EU countries, although there has been a clear improvement in this respect over the last few years. Internet banking, depending on the region of the country, is used by 1/2 to 3/5 of the population. Undoubtedly, there is still a need to improve the digital competences of Poles so that smart-work can spread unhindered.

Among the policy recommendations, the need for an in-depth analysis of the relationship between the functioning of various aspects of smart cities and smart work should be indicated first. This is a task primarily for urban planners who create expert opinions for the purpose of developing strategic documents of Polish cities. Research on the relationship between the volume of pollutant emissions and the degree of popularity of remote work should be deepened, and analyses of the impact of the latter on the mobility of employees and the functioning of urban transport systems (both individual and

public) should be conducted. It is also necessary to invest in telecommunications infrastructure, especially in those areas adjacent to large agglomerations, where the quality of Internet connections is unsatisfactory (within the cities themselves, it does not raise any objections). More peripheral areas, especially in the northern and north-eastern parts of the country, should not be neglected either, as they are characterised by particularly low Internet speeds, and could also play a role as regions for recruiting remote workers (given the current state of transport infrastructure in Poland and the possibilities created by modern ICT technologies, employing specialists from even very distant locations in the hybrid work formula is not unthinkable). Support should be provided - at least through various incentives or infrastructural facilities - to those companies that offer smart-work to their employees (which, however, has its limitations in the case of those sectors of the economy where the nature of the tasks forces the presence of the employee at the workplace). At the same time, the educational system, both encompassing formal education of young people and life-long learning, should include in particular the transfer of advanced digital skills, enabling employees of all ages to effectively undertake smart-work.

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