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CORRELATION OF HUMAN MOBILITY IN THE CAPITALS OF SEVEN EUROPEAN COUNTRIES DURING THE COVID-19 PANDEMIC

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Reseacrh paper

Abstract: *We monitored and compared human mobility for six discrete categories during two year the COVID-19 pandemic in seven European countries: Austria, France, Italy, United Kingdom, Serbia, Spain, and Sweden, and their capitals: Vienna, Paris, Rome, London, Belgrade, Madrid and Stockholm. We have chosen countries whose capitals have more than a million inhabitants and which are located in various parts of Europe. We chose Sweden because it had a policy with the mildest restrictions on population movement during the pandemic. The collected data for the time period from February 15, 2020 until February 11, 2022. Using basic statistical methods, we found that there is a high degree of correlation between the data, which represent the mobility of people across the countries and the mobility of people in the capital of all seven observed European countries for six discrete categories. Based on this, it can be concluded that the mobility of people during the COVID-19 pandemic differs a lot from country to country, because the policies of governments in restricting the movement of people in the past two years have also differed significantly. Through this we want to show that data from Google Community Mobility Reports can be combined with many other data from various areas of human life and work and that various statistical processing of these data can be done to show various types of correlations with human mobility during the COVID-19 pandemic and how it affects the lives and economies of people around the world.*

Key words: *COVID-19 pandemic, mobility, data, country, correlation.*

1. Introduction

At the end of 2019, the first cases of human coronavirus appeared at the end of 2019 in the Chinese province of Wuhan, precipitating the appearance of the disease termed COVID-19 (Tamagusko and Ferreira 2020). In Europe, the first cases of this dangerous disease that spread rapidly among humans were recorded in of January

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2020. As the virus began to spread rapidly among the population of European countries, the governments of most countries have begun to apply various special measures to stop the spread of the virus. Some countries have implemented very drastic measures banning people from leaving the house, gathering and moving people, as well as banning the work of schools and colleges. In contrast, only a few European countries have not decided on a strict ban on leaving the house and all cultural and sporting events (examples Sweden and Belarus). The World Health Organization has recommended to all countries in the world that the best strategy to fight the COVID-19 disease is to prevent the transmission of the virus by social distancing. This has been a major problem for most countries, as most social and economic activities are based on direct interaction between people (Damjanovic, Katanic & Drakul 2021).

Google company 2020 began public publishing data on global mobility daily through a report named Community Mobility Reports (further in the work CMR). This document in CSV format contains data collected from 135 countries of the world. The first data on human mobility began to be published from February 15, 2020. From then until today, this data has been updated every working day. This report in addition to the data collected for each country, its regions and cities, it also presents certain statistics for this data. In this way, Google wanted to promote various studies and works on the topic the fight against COVID-19 disease. Through this work we want to show how these are very useful data and how they can be statistically processed and based on that various conclusions and comparisons of human mobility for certain locations between countries can be made in each of the observed countries. In our opinion, it is especially interesting to compare the collected data within one country and between countries, in order to conclude which country had a better policy towards its citizens during the COVID-19 pandemic. We hope that governments around the world will use this information to act differently in the event of a new pandemic, because we believe that a total ban on leaving the house and going even to parks has not fully contributed to preventing the spread of the virus in all countries.

Google's CMR is based on the data that Google collects from individuals who use smartphones or handheld devices in the Google app. The only necessary condition for this is that the option to record "location history" be enabled on mobile devices, which almost all users of mobile devices have accepted today. Most smartphones users are not even aware that their movements are constantly monitored and that Google later uses this data for various studies of human behavior. Each day, Google compares the physical locations of each mobile device observed throughout the all day and how much time it spends in those locations. All data collected are sorted into six discrete categories locations, which can be summarized as follows:

- retail and recreation (restaurants, cafes, shopping malls, museums, libraries, theaters, cinemas, gyms);
- pharmacies and grocery stores (pharmacies, grocery stores, agricultural markets);
- parks (city parks, national parks, public beaches, marinas, camps, dog parks);
- transit stations (public transport hubs such as metro, bus and train stations, seaports, taxi stands, motorway rest areas);
- workplaces;

- and places of residence (houses and residential buildings).

The numbers in the CMR represent a percentage change in human activity for each of the six observed category locations. Each day of the week, the data collected are compared with the data collected for that day a month before the pandemic COVID-19 (from January 3, 2020 to February 6, 2020). Google has collected data for each Wednesday and compared it only with the data for Wednesdays before the pandemic COVID-19. This comparison of the collected data has one significant limitation, because the mobility of people at some of the six observed locations in January is quite different from the mobility of people at other times of the year, especially in the summer months and during the holidays. By showing a relative percentage change in human activity, Google ensured that it was not possible to determine the exact number of people who were present at the observed locations. If there were not enough people at a location during the day to ensure the anonymity of each of the visitors, then the CMR lacks data for that location that day.

In this work, we have monitored and analyzed the dynamics of human mobility during the COVID-19 pandemic in seven European countries: Austria, France, Italy, United Kingdom, Serbia, Spain, and Sweden, and their capitals: Vienna, Paris, Rome, London, Belgrade, Madrid and Stockholm. We have chosen countries whose capitals have more than a million inhabitants and which are located in various parts of Europe. We chose Sweden because it is the country that had the mildest restrictions on population movements during the pandemic. In this paper, we used the data collected over time from February 15, 2020 until February 11, 2022.

The main aim of this paper is to use basic statistical functions to determine whether there is a correlation between the data, which represent the mobility of people across the country and the mobility of people in the capital of that country for seven countries in Europe for six discrete categories. For discrete categories for which a high degree of correlation is found, we can say that the mobility of people in other cities of that country behaves in a similar way.

Another aim of the paper is to use Student's t-test to determine whether there are significant differences between two arithmetic means for two data sets. One set of data is data for the whole country, and the other set of data is for the capital. First, the data for the entire observed period were analyzed, and then especially for the first two months of the 2020 pandemic. In all the analyzes we did in this paper, we left out the data for weekends, because we noticed that there are large differences in the behavior of human mobility on weekends compared to the mobility of people for five working days for all six observed locations. Based on the obtained results, we want to draw a conclusion whether on the basis of these data it is possible to predict the data in some future period.

The third idea of the paper is to check the correlation between the data for the list of selected countries and England. We chose England because it has the largest population among the selected countries and it had less strict measures taken by the state to restrict the movement of people compared to continental Europe, but still stricter measures compared to Sweden. In this way, we want to show how the many different measures on the restriction of movement in individual observed countries had different effects on human mobility for the six discrete categories. By comparing the data between the seven observed countries, we hope that the positive effects of Sweden's policy towards its citizens will be noticed.

2. Related Literature

Since the beginning of the COVID-19 pandemic, a lot of scientific and professional papers have been written, which deal with the influences that this pandemic had on people's behavior. A number of papers deal with topics dealing with political decisions made by governments and parliaments around the world, which imposed various restrictions primarily on gathering people in public places. Some papers highlight the positive effects of the measures taken, and some papers show that some political decisions were wrong. Possibly current works describing work from home, as well as online teaching in schools and colleges. Now that the pandemic has mostly passed, pupils and students have returned to schools, but a large number of people are still working from home and we can consider this to be one of the great legacies of the COVID-19 pandemic. In this paper, we aim to compare the mobility of people in capitals and across the country in seven European countries by using a data from Google Community Mobility Reports. We are in this literature review presented briefly the works of some authors who statistically processed the data that Google publishes daily for 135 countries around the world. We want to show only a part of their research and the conclusions they came to.

The study by Tamagusko and Ferreira (2020) is one of the first presents several statistics and aims to promote studies that can help combat COVID-19. Most European countries face with a problem falling gross national product. This provoked demands for re-opening of services, public communal areas, and public transport. The paper monitors how citizens has adopted the lockdown measures. In this paper finds relationships between the mobility patterns, the social distancing measures adopted, and the spread of the disease in Portugal. During the first lockdown in Portugal, some cities imposed restrictions on parks. Some measures were completely different in a second wave. Studies show the impact of restrictive policies on physical and mental health people. The authors believe that similar research should be conducted in other countries. As the main result of this study, we can single out the conclusion that people are in Portugal reacted quickly, adopting social distancing, and changing their mobility pattern, even before the government decreed restrictive measures. It was also observed that people significantly reduced the use of public transport during the pandemic, and that the use of their own transport vehicles increased. The authors found that after the initial lockdown, there was a significant increase in the number of people visiting the parks.

Lapatinas, Athanasios (2020) have researched the causal impact of different COVID-19 confinement policies on how mobility trends have changed after the spread of the epidemic has not been studied for the European Union Member States. An attempt was made in the paper answering the question when and how the confinement measures can be relaxed, to possible new wave increasing the number of sick citizens and introduction of new measures if needed. The authors are empirical findings indicate that reductions in out-of-home social interactions and visits to public and private places are driven by a combination of restrictive measures introduced by Member States. In this paper suggests that partial and full lockdowns have the strongest causal impact on increasing presence at home and reducing visits to workplaces, public transport hubs, grocery, pharmacies, open public spaces, restaurants, cafes, shopping centers, theme parks, museums, libraries, and movie theatres.

The rapid spread expansion of COVID-19 pandemic in early 2020 has elicited several distinct policy responses from national governments aimed at decreasing the degree of social interactions to slow down the spread of the virus in the affected populations Mendolia, Stavrunova and Yerokhin (2020). These government policies were aimed at the main goal to reduce human mobility. The results imply that self-imposed mobility restrictions in response to the arrival of the pandemic account for up to 14 percentage points of the total observed reduction in mobility across the countries in this paper. The authors determined that government-mandated measures account for a much larger part (up to 50 percentage points) of the reduction of human mobility. It is discussed in the paper cross-country and cross-region dependence on geographical proximity and the spread of COVID-19 disease due to population movements between two regions in two neighboring countries on the example of two regions in Italy and Switzerland.

Sulyok and Walker (2020) paper was thus to examine the relationship between mobility and confirmed case numbers for COVID-19 globally. They tried to prove whether they were whether cross-country events in this relationship were apparent. Such patterns could reflect the range of people movement restrictions implemented, but could also be due to other cultural or socio-economic differences of each particular state. They linked the collected data on sick people with CMR data into disease models, to assess whether it could enhance model quality and enable prediction of data for the next period. For calculations, correlations between the analyzed data were used by the authors Kendall's τ due to the nonparametric nature of the data. Kendall's τ correlations were calculated with a time delay of plus or minus 28 day. Multiple group comparisons were done in study with the Kruskal–Wallis test, pairwise comparisons with the Dunn test on the continent-level data. The authors have proven that there is a high degree correlations between COVID-19 case incidence and changes in people's mobility shown by Google's CMR. Of particular interest are the correlations calculated for large geographical areas North America, Western Europe, Russia and Australia. Mobility of people in locations "Parks" and "Housing" increased in line with COVID-19 incidence, suggesting increased time spent in a location close to home as case numbers rose.

In the United States, such orders have been implemented on a state-by-state basis with considerable variations in compliance Paez (2020). Concurrently, numerous initiatives have been developed to track the progress and the impact of the pandemic. As a result, there are new sources of data such as the recently-released Google Community Mobility Reports, as well as The New York Times repository of COVID-19 data2. These two open data sets offer novel opportunities to investigate in quasi-real time the relationship between mobility patterns and transmission of COVID-19. These results suggest the potential of Google Community Mobility Reports to investigate the potential effects of mobility on the incidence of COVID-19. In particular, growth appears to be more strongly driven by parks-related mobility. In terms of the use of these mobility indicators, there are some limitations that must be acknowledged. The baseline level is not defined in a metric that is amenable to policy development. Without a clearer understanding of the absolute levels of these variables, these indicators are useful for inference and perhaps short-term forecasting, but their potential for applied policy analysis appears to be more limited.

Li et al. (2020) assessed six different mobility metrics rather than a single composite mobility metric. This approach could help refine the components of non-pharmaceutical interventions by restricting certain activities that are shown to increase *R* substantially or relaxing activities that have a smaller effect on transmission. The research was conducted on data collected at 330 locations across the United Kingdom.

In the case study of France Iacus et al. (2020) have found that mobility can explain from 52% up to 92% of the excess deaths reasonably linked to the COVID-19 outbreak. They have found similar results for Italy to 91%, but with great differences between the various provinces. For data of people collected in Spain, a high degree of correlation was found up to 75% between the number of patients with the human mobility.

Ramadhan and Syakurah (2021) in Indonesia used Normality test with Kolmogorov-Smirnov has indicated that the community mobility in retail and recreation, transit station, daily cases were normally distributed ($p>0.05$), while other locations were abnormally distributed ($p<0.05$). They are at work correlations analysis were utilized to find the correlations between community mobility and COVID-19 daily cases. Based on the presented results, the authors determined that it exists very strong positively correlations between community mobility and daily COVID-19 cases were found in locations retail and recreation, parks, and transit stations on the same day to the next three days. On the other side of the location housing were negatively strong correlations between community mobility and daily cases on the same day to the next three days. A weak level of correlation was found at the locations the grocery, pharmacy and workplaces. Still the highest correlation of each of six locations were found for retail and recreation.

We believe that our review of papers will interest many authors to process data on the mobility of people in different countries of the world, in order to draw conclusions that may be useful for the emergence of a new pandemic in the future.

3. Data and Methodology

In this paper, we have processed and presented data of human mobility movements during the COVID-19 pandemic in seven European countries: Austria, France, Italy, United Kingdom, Serbia, Spain, and Sweden, and their capitals: Vienna, Paris, Rome, London, Belgrade, Madrid and Stockholm. Data were processed for a time period from February 15, 2020 until February 11, 2022 for six available categories of locations. We have chosen countries from different parts of Europe. One of the criteria for selecting the observed countries was that the countries have had different policies to control the movement of citizens since the beginning of the COVID-19 pandemic. Another criterion for selecting countries was that the capitals of the selected countries have more than a million inhabitants. We used data from Google's CMR, which has over seven million rows over the time period of two years, with data on country, regions, cities, and percentage changes in people's mobility in six different locations. From this data, we first extracted data for each country individually, and then separately extracted data for the entire country and its capital.

To more easily describe the process of our research, we show the flow diagram of our study in Figure 1.

Aim: Check whether there is a correlation in human mobility for six different location categories during the COVID-19 pandemic between capitals and the whole country in 7 European countries.

↓

1. Description of the research problem:
    - Identify the countries to be analyzed.
    - Identify statistical methods that are to be applied in data processing.

↓

2. Find data on human mobility:
    - Find on the internet a CSV file which containing data on human mobility for 135 countries worldwide.
    - Extract data on human mobility for 7 European countries.
    - For each individual country, separate data on changes in people's mobility for the entire country and its capital.
    - Extract data on changes in people's mobility only for working days of the week.
    - Make graphs that represent the mobility of people for 4 locations.

↓

3. Statistical data processing:
    - Calculation of mean values.
    - Calculation of standard deviations.
    - Calculation of correlations
    - Student's t- test

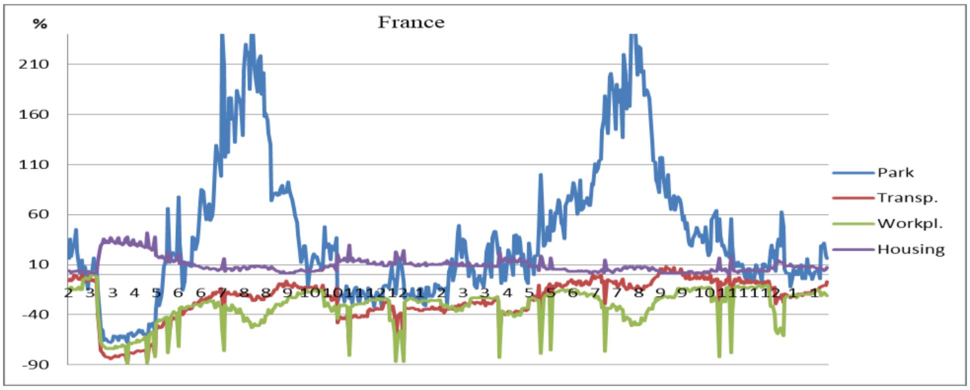
↓

4. Analysis of the resulting data:
    - Comparison of data obtained from different countries.
    - Discussion on the existence of correlation between the observed data.

Figure 1. General flow diagram of the study

For each seven observed country at Excel, we have created attendance change charts for four categories of locations: parks, transit stations, workplaces, and housing facilities. Due to the clarity of the charts, we omitted data on two categories of human mobility: retail and recreation and pharmacies and grocery stores, but we also statistically processed this data. The X-axis of the chart shows the months from February 2020 to February 2022. The Y-axis of the chart shows the percentage of changes in human attendance of the observed locations. Looking at the constructed charts for seven country, we have determined that on weekends day, on public holidays and religious holidays, there are big peaks in changes in attendance. In order to reduce the noise on the charts that appeared in all countries on weekends, we excluded data for all Saturdays and Sundays from the statistical processing and charts in the observed time period of two years. However, we have left data for non-working days of Christmas, New Year’s Day, May Day and individual non-working days for public holidays in individual countries, so that we can correlate data between the whole country and the respective capital, as well as correlate data between the countries and students t-test for individual locations.

Figure 2 shows graphs of changes mobility of people for 2020, 2021 and 2022 year at four locations in France and Paris. For France, but also for all other countries, it is immediately noticeable a big drop in the movement of people in March 2020, and the biggest drop is noticed in the location of transport and work. On the other side in the same period, we notice a sudden jump in the number of people, who started spending a lot more time at home, than they did before the COVID-19 pandemic. This is precisely the time when the first period of increased numbers of infected people in Europe and around the world began. Following the “Work” curve, we can notice that in July and August 2020 there is a second drop in the number of people visiting the location of their jobs.



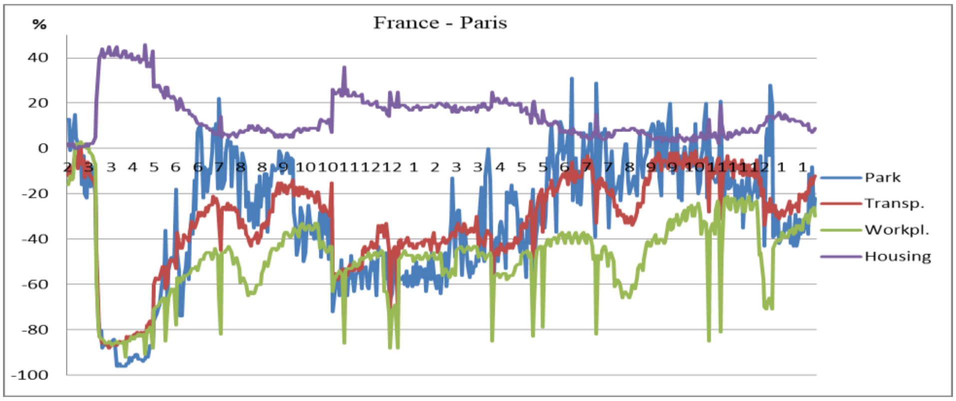


Figure 2. France and Paris mobility of people for 2020, 2021 and 2022 year

But looking at other curves in the graph 2, we can conclude that this decline in attendance is not caused by an increase in the number of sick people or closure measures taken by the French state, but that this decline can be attributed to the holiday season in France. This is confirmed especially by the "Park" curve, because people during the summer, when the holiday season, massively changed their place of residence, spending much more time outside the cities in nature, the coast and places of rest. Following the “Work” curve, it can be seen that the third period of declining job attendance occurred in November and December 2020, then in April and May 2021, and finally again in the summer months of 2021, but this can again be more attributed to annual vacation leaves that employees took.

Comparing the graphs for Paris, as the capital, and for the whole of France, at first glance, we can see very large differences in the number of visits to the Parks site, while the number of visits to the other three sites behaves in approximately the same way. Based on this, it can be concluded that the citizens of Paris spent much less time in parks than the rest of the country, or that a large number of Parisians left their stay in Paris and worked from home outside the capital.

Figure 3 shows graphs of changes mobility of people for 2020, 2021 and 2022 year at four locations in Serbia and Belgrade. Following the line “Workpl.” it can be seen that the first major wave of the pandemic began in March 2020, the second in November 2020, and the third in March 2021. The decline in workplace site visits in the summer months can be attributed more to vacations during this period. We confirm this by the fact that in the summer months there is a sharp increase in attendance at parks.

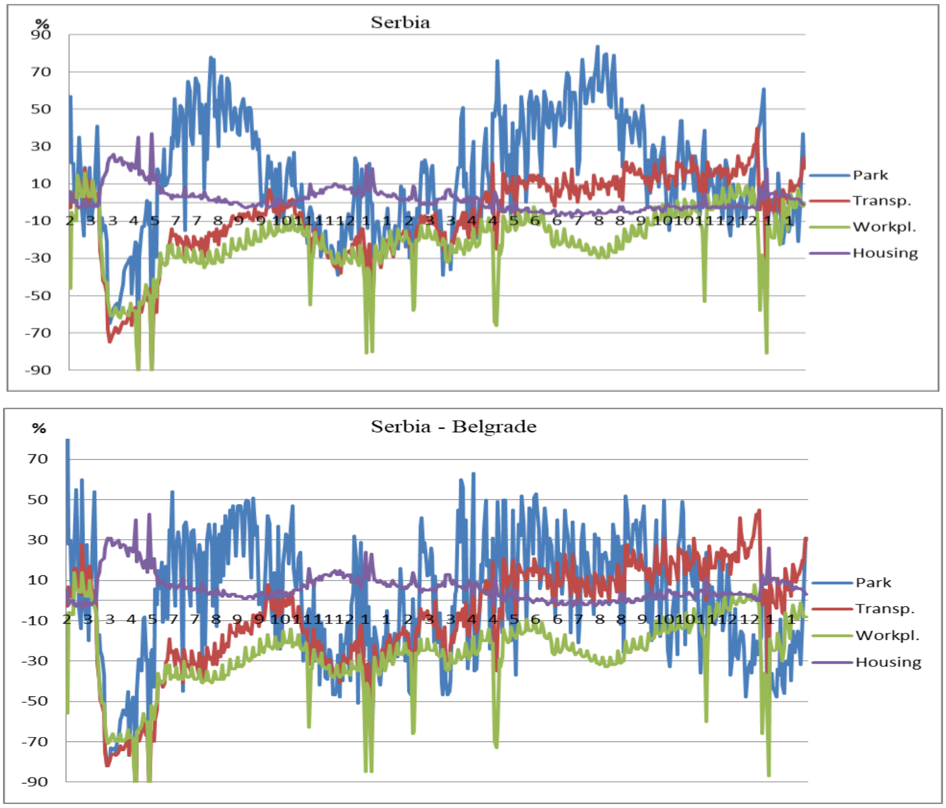


Figure 3. Serbia and Belgrade mobility of people for 2020, 2021 and 2022 year

Comparing the graphs for Belgrade, as the capital, and for the whole of Serbia, we can see very large differences in the number of visits to the Parks site. Based on this, it can be concluded that the citizens of Belgrade spent much less time in parks than the rest of the country, or that a large number of citizens left their stay in Belgrade and worked from home outside the capital. In the first two months of the pandemic, it can be seen that in the capital, compared to the whole country, there was a slightly higher percentage of declining job attendance, and that on the other hand people were more likely to stay at home.

Figure 4 shows graphs of changes mobility of people for 2020, 2021 and 2022 year at four locations in Austria and Vienna. Following the line “Workpl.” it can be seen that the first major wave of the pandemic began in March 2020, the second in November 2020, and the third in March 2021. The decline in workplace site visits in the summer months can be attributed more to vacations during this period. Comparing the curves for the whole country and the capital, one can notice a great coincidence of the shapes of all the curves. Only at the "Park" location it can be noticed that the citizens of the capital stayed about 50% less at this location compared to the whole country. Occurrence of individual narrow peaks at the site "Workpl." which represent a large drop in job attendance of 90% is a consequence of non-working days for public or religious holidays in Austria.

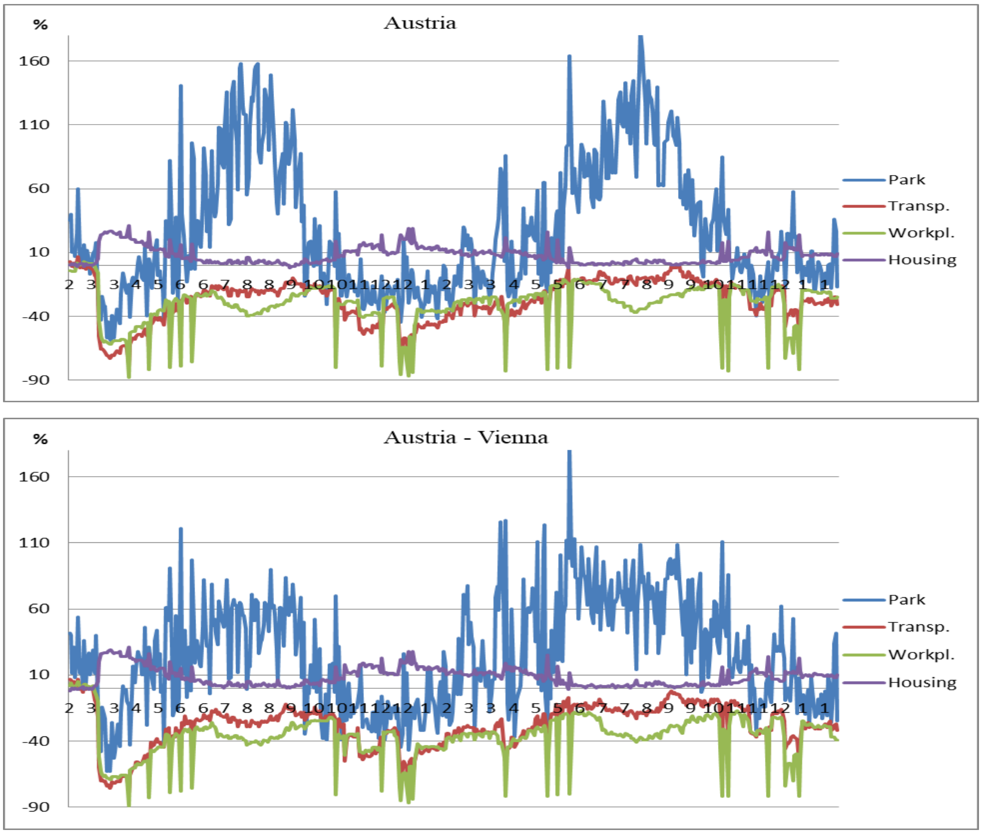


Figure 4. Austria and Vienna mobility of people for 2020, 2021 and 2022 year

Figure 5 shows graphs of changes mobility of people for 2020, 2021 and 2022 year at four locations in Italy and Rome. Following the line “Workpl.” it can be seen that the first major wave of the pandemic began in March 2020, the second in November 2020, and the third in March 2021. The decline in workplace site visits in the summer months can be attributed more to vacations during this period. Comparing the curves for the whole country and the capital, one can notice a great coincidence of the shapes of all the curves. Only at the "Park" location it can be noticed that the citizens of the capital stayed about 50% less at this location compared to the whole country. We explain this by saying that during the summer tourist season 2020 and 2021, Italy had an increase in the number of tourists visiting coastal cities, and that there was no increase in the number of tourists visiting Rome as the capital and as one of the most visited tourist locations in the whole world. Occurrence of individual narrow peaks at the site "Workpl." which represent a large drop in job attendance of 90% is a consequence of non-working days for public or religious holidays in Italy.

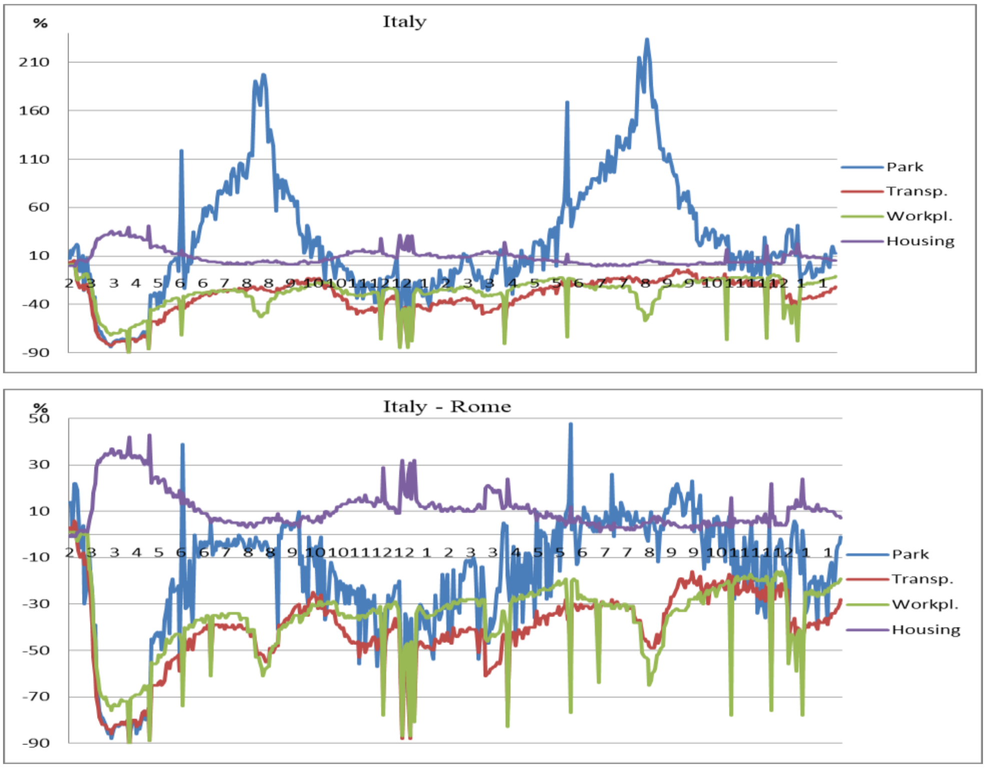


Figure 5. Italy and Rome mobility of people for 2020, 2021 and 2022 year

Figure 6 shows graphs of changes mobility of people for 2020, 2021 and 2022 year at four locations in United Kingdom and London. When comparing the graphs for all seven observed countries, we can say that for the location "Workplace" and "Housing" the least oscillations occur in United Kingdom. Following the line “Housing” it can be seen that in United Kingdom to this day the highest percentage of work from home remains after the first wave of the 2020 pandemic. Comparing the curves for the whole country and the capital, one can notice a great coincidence of the shapes of all the curves. Compared to the other six countries, we can see that the United Kingdom is the country with the lowest percentage difference in the mobility of people between the whole country and the mobility of people in the capital. The United Kingdom also has the largest overlap between the curve "Workplace" and the curve "Transp.". We explain this by saying that with the beginning of the COVID-19 pandemic, people in United Kingdom did not increase the use of their own vehicles for transport to work, i.e. that they continued to use public transport, which is not the case in the other six observed countries.

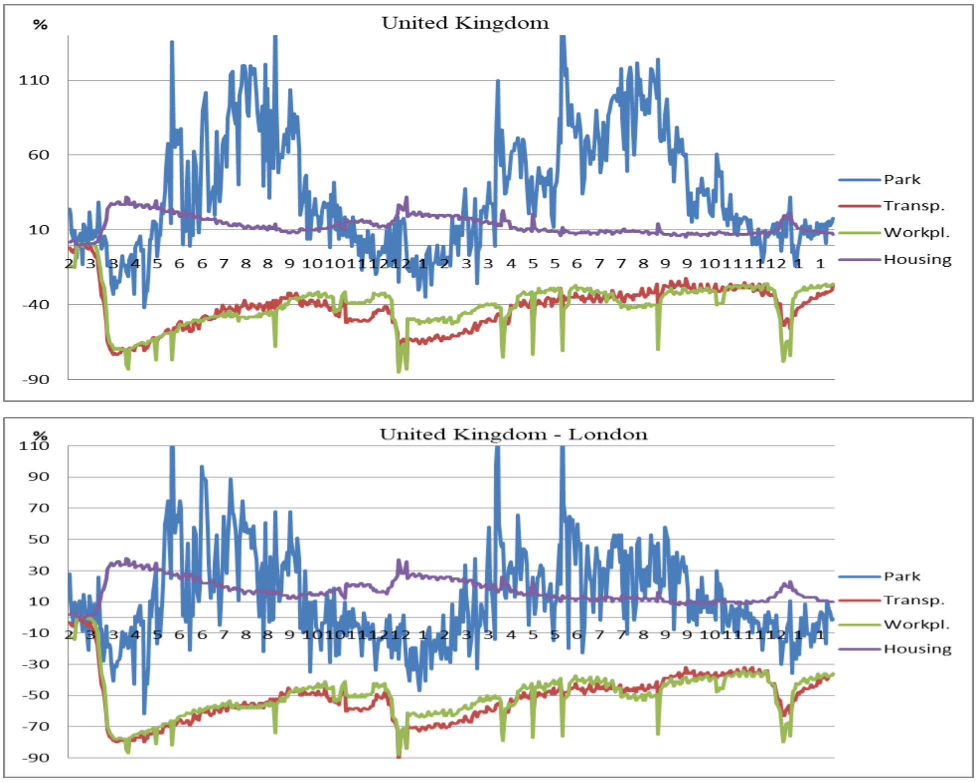


Figure 6. United Kingdom and London mobility of people for 2020, 2021 and 2022 year

Figure 7 shows graphs of changes mobility of people for 2020, 2021 and 2022 year at four locations in Spain and Madrid. Following the line “Workpl.” it can be seen that the first major wave of the pandemic began in March 2020, the second in October 2020, and the third in January 2021. The decline in workplace site visits in the summer months can be attributed more to vacations during this period. Comparing the curves for the whole country and the capital, one can notice a great coincidence of the shapes of all the curves. Only at the "Park" location it can be noticed that the citizens of the capital during the summer months, especially 2021, stayed about 100% less at this location compared to the whole country. We explain this by saying that during the summer tourist season 2021, Spain had an increase in the number of tourists visiting coastal cities, and that there was no increase in the number of tourists visiting Madrid as the capital.

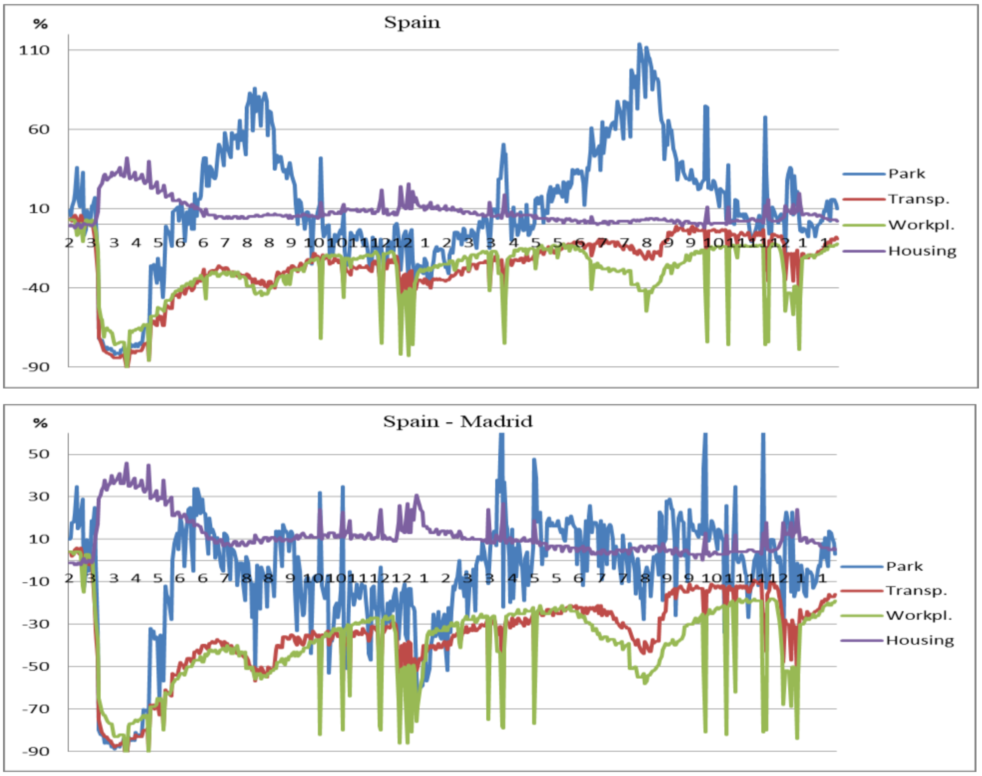


Figure 7. Spain and Madrid mobility of people for 2020, 2021 and 2022 year

Figure 8 shows graphs of changes mobility of people for 2020, 2021 and 2022 year at four locations in Sweden and Stockholm. Despite the fact that in Sweden there was no classic ban on gathering of people or visiting sporting events, the diagram shows that at the time of the pandemic there was a reduction in time spent at work. The large narrow peaks representing the decline in going to work probably stem from some public holidays in Sweden, and similar peaks exist in all other countries and their capitals whose graphs are not shown in this paper. Of particular interest to Sweden is the curve representing the mobility of people at park locations. From the graphs it can be seen that people in Sweden started spending more time in parks immediately with the first signs of a pandemic in March 2020, unlike other countries, where in March 2020 there is a sharp decline in human mobility at the parks , and that only after a few months the number of people at this location begins to increase. We would also like to point out that people in Sweden in the summer months had by far the highest percentage of increased visits to the Parks site compared to all other observed countries. This confirms the thesis that the policy of the Swedish government towards restrictions on the movement of people was completely different from the rest of the countries on the European continent. All these conclusions are confirmed by the statistical data presented in the following tables.

Comparing the graphs for Stockholm, as the capital, and for the whole of Sweden, at first glance, we can see very large differences in the number of visits to the Parks site more than 250% during the summer months. Based on this, it can be concluded that the citizens of Stockholm spent much less time in parks than the rest of the country, or that a large number of citizens of the capital during the summer months left their stay in the capital and that they went on vacation or even worked outside the capital much more than all the other six countries observed. It can also be noticed that the drop in job attendance and the increase in work from home percentage was the largest difference between the whole country and the capital in Sweden in relation to all other six observed countries.

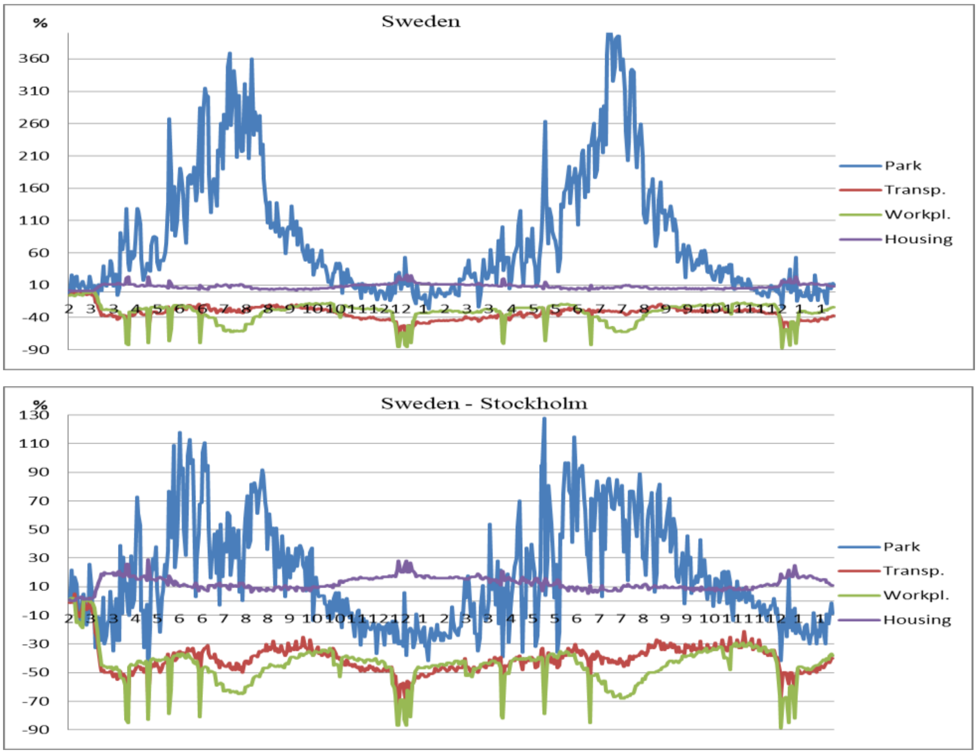


Figure 8. Sweden and Stockholm mobility of people for 2020, 2021 and 2022 year

4. Discussion

We have statistically processed Google's CMR data for seven European countries and their capitals. We processed data for all six available locations on human mobility, but first we removed data for all Saturdays and Sundays for all observed countries and all six locations. Data for weekends were omitted because for the observed period of two years we noticed the existence of a large noise in these data, during the statistical processing of these data. This noise that exists on weekends disturbs the appearance of graphs, but also and the calculated statistical parameters shown in the following tables. That is the reason why we decided to exclude data for weekends from our analysis in the entire observed period, but we kept the data for national and religious holidays, so that we could correlate the data between countries.

Table 1, Table 2 and Table 3 show twelve statistical parameters of human mobility data for Serbia, France and Sweden. We calculated all these statistical parameters for the other four observed European countries, but due to the large number of data we did not show them in the work in the tables. Part of that the statistical data is graphically shown in Figures 9 to Figure 17. Abbreviated labels in the tables and graphs have the following meaning:

- Avg All- Average value of percentage change of human mobility from February 15, 2020 until February 11, 2022;

- Avg 2020- Average value of percentage change of human mobility for 2020;

- Avg 2021- Average value of percentage change of human mobility for 2021;

- Avg 2022- Average value of percentage change of human mobility for 2022;

- Avg 2 month- Average percentage change of human mobility from March 20, 2020 to May 20,2020 (first wave of the COVID-19 pandemic);

- SD All- Standard deviation of the percentage change of human mobility from February 15, 2020 until February 11, 2022;

- SD 2020- Standard deviation of the percentage change of human mobility for 2020;

- SD 2021- Standard deviation of the percentage change of human mobility for 2021;

- SD 2022- Standard deviation of the percentage change of human mobility for 2022;

- SD 2 month- Standard deviation of percentage change of human mobility from March 20, 2020 to May 20,2020 (first wave of the COVID-19 pandemic);

- COR Coun-Cap - Correlation of the percentage change of human mobility between the whole country and the capital in country from February 15, 2020 until February 11, 2022;

- COR Coun-GB - Correlation of the percentage change of human mobility between the whole country data and United Kingdom from February 15, 2020 until February 11, 2022.

Table 1. Changes in attendance for 6 location in Serbia.

	Retail	Pharmacy	Park	Transport	Work place	Housing
AV All	-6	18	14	-8	-21	2
AV 2020	-17	1	7	-23	-28	6
AV 2021	1	28	20	2	-17	-2

AV 2022	4	39	3	3	-14	4
AV 2 month	-50	-22	-26	-57	-53	17
SD All	22	23	31	23	17	7
SD 2020	23	17	34	22	18	8
SD 2021	18	18	28	17	14	4
SD 2022	15	23	21	13	19	3
SD 2 month	21	21	28	15	14	8
COR Coun-Cap	0.97	0.97	0.83	0.99	0.99	0.98
COR Coun-GB	0.64	0.61	0.50	0.63	0.51	0.59

Table 2. Changes in attendance for 6 location in France.

	Retail	Pharmacy	Park	Transport	Work place	Housing
AV All	-24	4	39	-25	-32	9
AV 2020	-31	-7	30	-35	-38	12
AV 2021	-19	12	51	-17	-28	7
AV 2022	-16	17	6	-18	-20	7
AV 2 month	-74	-32	-51	-74	-65	29
SD All	24	19	70	21	17	8
SD 2020	28	19	78	24	20	10
SD 2021	19	16	65	14	14	4
SD 2022	3	4	11	4	2	1
SD 2 month	15	19	22	12	12	7
COR Coun-Cap	0.90	0.79	0.67	0.98	0.93	0.96
COR Coun-GB	0.81	0.76	0.81	0.78	0.70	0.77

Analyzing the statistical data presented for Serbia in Table 1, France in Table 2, Sweden in Table 3, but also data for the other four analyzed countries (due to the volume, not all data are presented in the paper) we can conclude that there is a very high degree of correlation between the percentage change in attendance between the whole country and the capital for all processed countries. Because for the approximate limits of correlations when the value is from 0.75 to 1 (analogously -1 to -0.75) there is a close functional connection between two variables, and when the value is from 0.50 to 0.75 (analogously -0.75 to -0.50) there is a significant degree of connection between two variables (Damjanovic, Katanic & Krsmanovic, 2020). Based on this, it can be concluded that there is a high degree of correlation between data for the whole country and other cities or regions, whose data is collected and published by Google in its CRM. In all analyzed countries, the lowest degree of correlation occurs at the park location. At parks only in France and Spain, the correlation coefficient between the percentage change in attendance between the whole country and the capital is in the range of 0.50 to 0.75, while in all other observed countries for all observed locations the correlation coefficient is in the range of 0.75 to 1.

Table 3. Changes in attendance for 6 location in Sweden.

	Retail	Pharmacy	Park	Transport	Work place	Housing
AV All	-9	1	83	-33	-32	8
AV 2020	-9	0	92	-30	-31	8
AV 2021	-7	3	85	-35	-32	8
AV 2022	-20	-4	2	-44	-34	12
AV 2 month	-18	-3	55	-36	-32	11
SD All	14	10	99	10	15	4
SD 2020	13	8	96	12	17	4
SD 2021	16	12	103	8	14	4
SD 2022	5	4	14	5	11	3
SD 2 month	9	8	35	7	14	4
COR Coun-Cap	0.81	0.68	0.81	0.91	0.95	0.92
COR Coun-BG	0.55	0.52	0.71	0.66	0.51	0.63

We used the Student's t-test to test whether there were significant differences between the two arithmetic means for the two data sets, one of which was for six locations across the country and the other data sets for the capital. Based on the calculated t-value and the limit table for the appropriate number of degrees of freedom, the rules for deciding whether there is a significant difference between two sets of data (i.e. whether the hypothesis is accepted as correct or rejected) are defined (Damjanovic, Katanic & Krsmanovic, 2020). Based on the calculated t-value for the Student's t-test, we can say that the difference between the data is statistically significant, because the risk is less than 1% ($p > 0.01$), i.e. the level of safety is greater than 99%.

The graphs in Figure 9 to Figure 17 shows a comparison of attendance changes for 7 countries and capitals between the first two months of the pandemic and the entire 2-year period for the workplace, housing and park location. Abbreviated labels in the graphs have the following meaning: RS - Serbia; AT - Austria; IT - Italy; FR - France; GR - United Kingdom; ES - Spain; SW - Sweden;

- Avg 2 Month - Average percentage change of human mobility for whole country from March 20, 2020 to May 20,2020 (first wave of the COVID-19 pandemic);

- Avg All - Average percentage change of human mobility for whole country from February 15, 2020 until February 11, 2022;

- Avg 2 M Cap - Average percentage change of human mobility for capital from March 20, 2020 to May 20,2020 (first wave of the COVID-19 pandemic);

- Avg All Cap - Average percentage change of human mobility for capital from February 15, 2020 until February 11, 2022;

- Coun - Cap - Comparison of the correlation of changes in attendance between the whole country and the capital;

- Coun - GB - Comparison of the correlation of changes in attendance between six country and United Kingdom.

The graph in Figure 9 shows a comparison of attendance changes between the whole country and the capital of 7 countries for the first two months of the pandemic and the whole period of 2 years for the location of Workplaces. We note that the largest decline in attendance in the first two months of the pandemic was observed in: France, United Kingdom and Spain. It can also be noticed that in relation to other observed countries in Sweden, the decline in the number of visits to workplaces is completely different and that it is approximately the same in the first two months of the pandemic as for the entire observed period of two years.

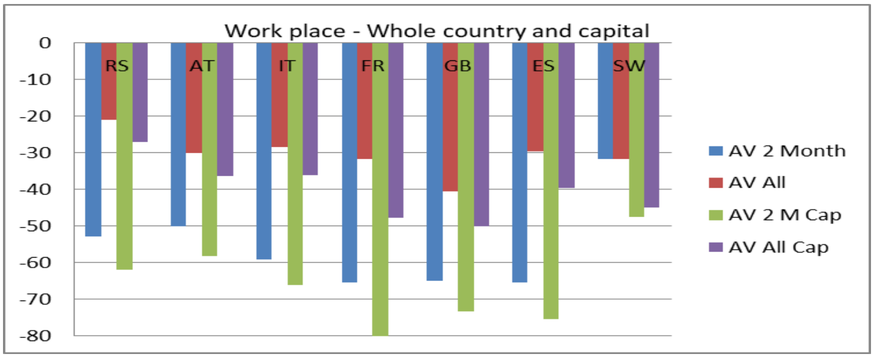


Figure 9. Comparison of attendance changes between the whole country and the capital of 7 countries for the first two months of the pandemic and the whole period of 2 years for the location of Workplaces

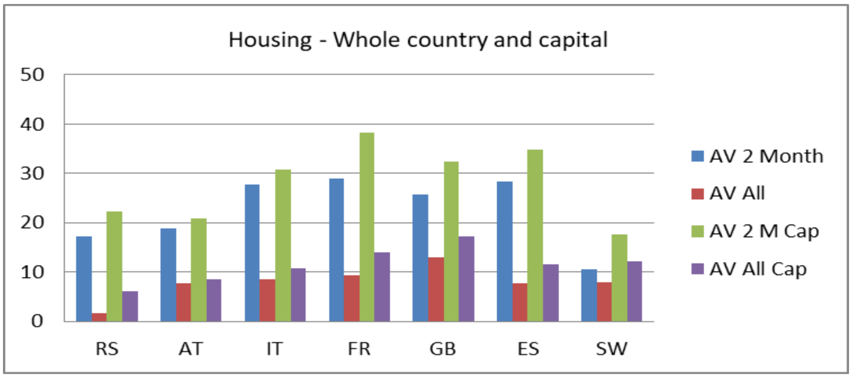


Figure 10. Comparison of changes in attendance between the whole country and the capital of 7 countries for the first two months of the pandemic and the whole period of 2 years for the location of Housing

The graph in Figure 10 shows a comparison of attendance between the whole country and the capital of 7 countries for the first two months of the pandemic and the whole period of 2 years for the location of Housing. We note the increase in traffic to this site in almost all countries is similar to the corresponding decline in work place site traffic.

The graph in Figure 11 shows a comparison in attendance between the whole country and the capital of 7 countries for the first two months of the pandemic and the whole period of 2 years for the location of Park. We notice that the biggest drop in attendance in the first two months of the pandemic was in Italy and Spain, and these are the countries where the strictest lockdown policy was put in place. Attendance at the park's location in Sweden is the highest compared to all other observed countries, especially in the first two months of the pandemic. Sweden was one of the few countries in Europe that did not ban its citizens from park visits in the first two months of the pandemic.

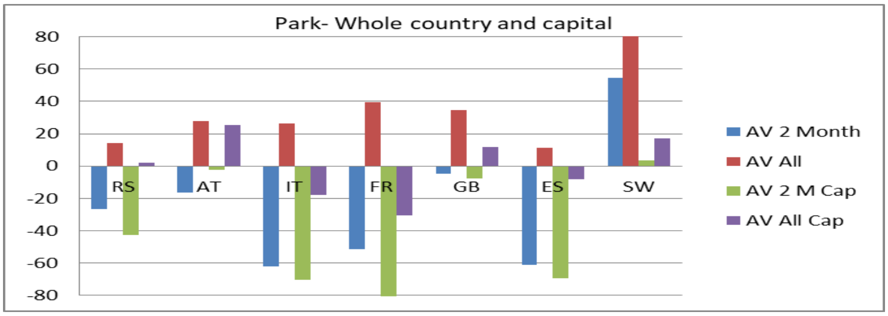


Figure 11. Comparison of changes in attendance between the whole country and the capital of 7 countries for the first two months of the pandemic and the whole period of 2 years for the location of Park

The graphs 12 shows a comparison of the difference in attendance changes between the whole country and the capital of 7 countries for the first two months of the pandemic and the whole period of 2 years for the location of Workplaces. The biggest difference in the mobility of people at the location of Workplaces appears in Serbia and Sweden, and the smallest in France and Spain.

Graphs 14 and Graphs 15 show that France is the country with the largest difference in the mobility of people between the capital and the whole country at the three locations shown. Based on this, it can be concluded that a large number of Parisian citizens left the city and moved to live and work somewhere outside the city or in other cities.

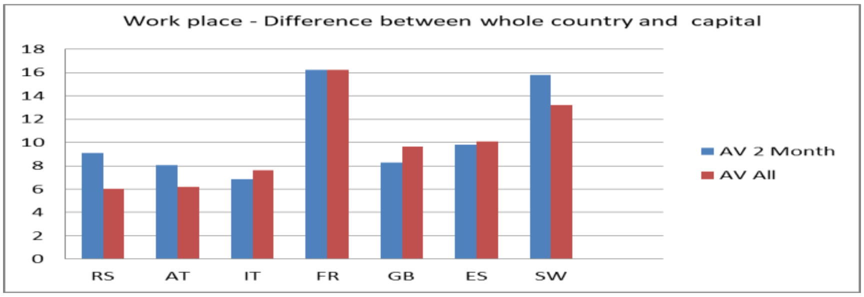


Figure 12. Comparison of the difference in attendance changes between the whole country and the capital of 7 countries for the first two months of the pandemic and the whole period of 2 years for the location of Workplaces

The graphs 13 shows a comparison of the difference in attendance changes between the whole country and the capital of 7 countries for the first two months of the pandemic and the whole period of 2 years for the location of Home. The biggest difference in the mobility of people at the location of Home appears in France, United Kingdom, Spain and Sweden, and the smallest in Serbia.

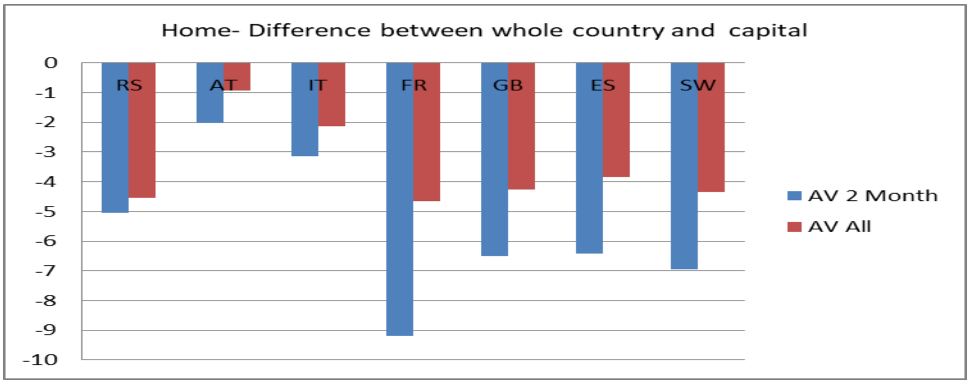


Figure 13. Comparison of the difference in attendance changes between the whole country and the capital of 7 countries for the first two months of the pandemic and the entire period of 2 years for the Housing location

The graphs 14 shows a comparison of the difference in attendance changes between the whole country and the capital of 7 countries for the first two months of the pandemic and the whole period of 2 years for the location of Park. The biggest difference in the mobility of people at the location of Home appears in Austria, Italy, France and United Kingdom, and the smallest in Serbia.

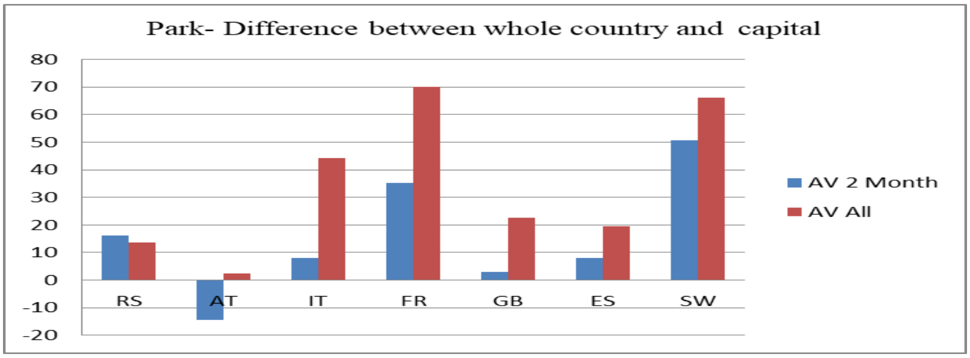


Figure 14. Comparison of the difference in attendance changes between the whole country and the capital of 7 countries for the first two months of the pandemic and the entire period of 2 years for the Park location

The graphs 15 show comparison of the correlation of changes in attendance between the capital and the whole country, and observed country and United Kingdom for the location Workplace. United Kingdom was chosen as the reference country for statistical comparison with other six countries, because it has the biggest population of all observed countries. It can be noticed that in all observed countries there is a very high degree of correlation of the data between the capital and the whole country at the location Workplace. These graphs can also show the degree of correlation of each observed country in relation to England the smallest in Serbia and Sweden.

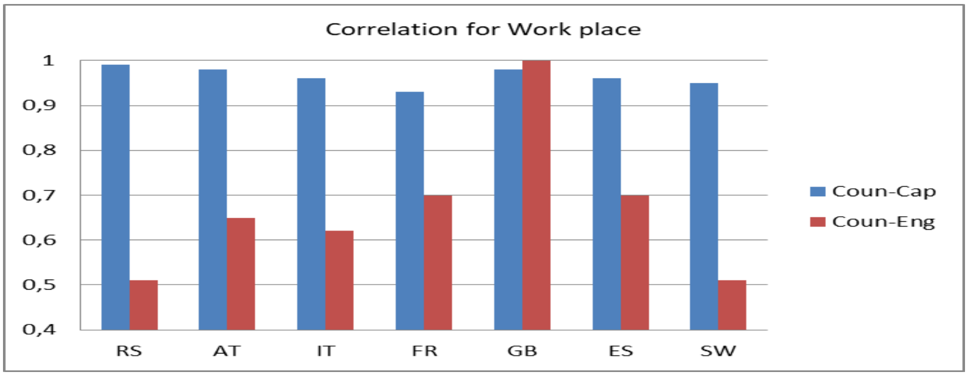


Figure 15. Comparison of the correlation of changes in attendance between the capital and the whole country, and observed country and United Kingdom for the location Workplace

The graphs 16 show comparison of the correlation of changes in attendance between the capital and the whole country, and observed country and United Kingdom for the location Housing. It can be noticed that in all observed countries there is a very high degree of correlation of the data between the capital and the whole country at the location Housing. These graphs can also show the degree of correlation of each observed country in relation to England the smallest in Serbia and Sweden.

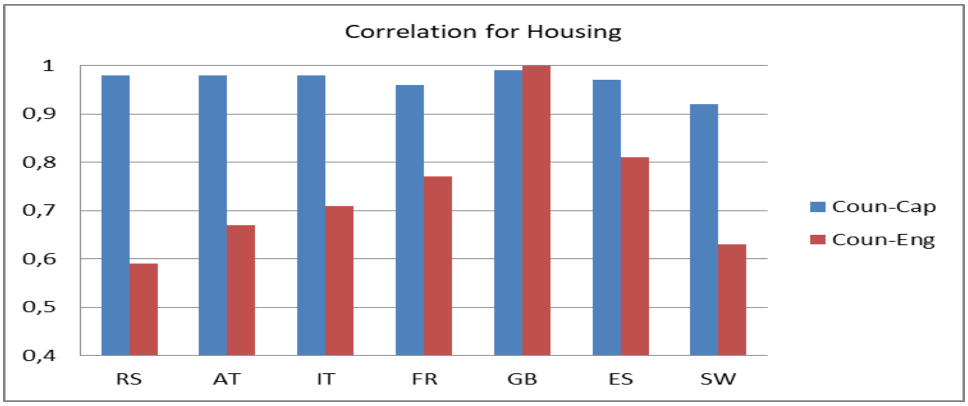


Figure 16. Comparison of the correlation of changes in attendance between the capital and the whole country, and observed country and United Kingdom for the location Housing

The graphs 17 show comparison of the correlation of changes in attendance between the capital and the whole country, and observed country and United Kingdom for the location Park. It can be noticed that in all observed countries there is a very high degree of correlation of the data between the capital and the whole country at the location Park, but still a lower degree of correlation compared to the other two locations shown. This can be explained by the fact that in the summer months parks were visited much less in the capitals than in the whole country, i.e. that people spent a lot more time outside the capitals in the summer months. These graphs can also show the degree of correlation of each observed country in relation to England the smallest in Serbia.

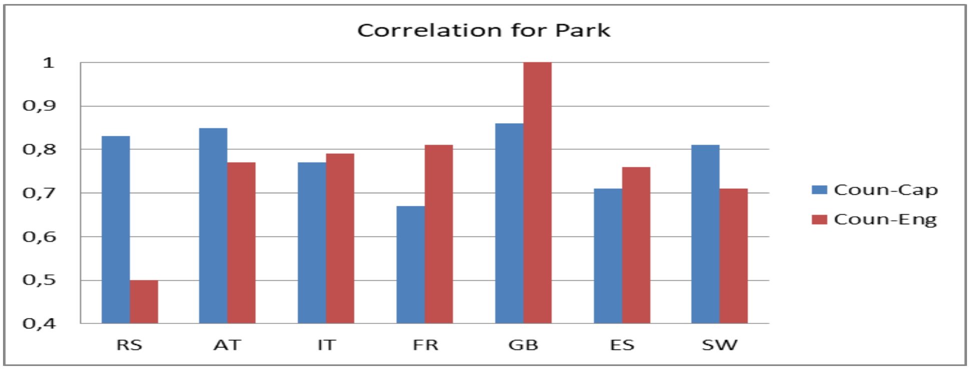


Figure 17. Comparison of the correlation of changes in attendance between the capital and the whole country, and observed country and United Kingdom for the location Park

5. Conclusion

In the past two years, most European countries have taken policies aimed at reducing the mobility of people and increasing their presence in their homes. State governments believed that the reduced number of people outside homes caused lower rates of transmission of COVID-19 disease and mortality. These political measures have produced a high social and economic cost. In this paper, we wanted to show how the mobility of people has changed in the last two years in seven European countries and their capitals. The main contribution of the paper is reflected in the fact that we have shown for which locations and which countries there is a high degree of correlation between the mobility of people in the capitals and the whole country. As a result of this, we believe that based on the data on the mobility of people throughout the country, we can predict how the mobility of people behaved in individual cities in that country. Especially in this paper, we want to highlight the data presented the mobility of people in Sweden in the last two years. We chose Sweden because it had a policy with the mildest restrictions on population movement during the pandemic. Of all the countries observed, only Sweden has never banned citizens from visiting parks. We believe that it was the right decision of their government, because it did not lead to an increase in the number of patients in that country, but on the contrary, it had a positive effect on people's health. I think that all other European countries should accept this policy if there is another pandemic in the future. Based on a comparison of data on the mobility of people from individual countries with the mobility of people in England, it can be concluded that the mobility of people during the COVID-19 pandemic varies greatly from country to country in the 2 years.

The set of observed data in this paper has a several limitations. First, data for only seven European countries are presented. Second, persons who do not use in any way smartphones or handheld devices or person who do not carry their smart device when visiting one of the six observed locations are not included in Google CRM. Third, Google CRM only includes persons who on your smart device have Google Accounts and with the Location History option activated.

We believe that the results and conclusions presented in this paper can serve as a basis for many future research. The social distancing of people in the last two years in European countries has caused a great decline in many economic, social, cultural, sporting and social events. We believe that data from Google CRM can be combined with many other data sets from diverse areas of human life and work and that various statistical processing techniques of these data can be done to show various types of correlations with human mobility during the COVID-19 pandemic. All future research related to preventing the mobility of people during the COVID-19 pandemic, should give us various recommendations on how to behave governments and citizens themselves, if in the future there is a new pandemic around the world. The main goal of this research is to recommend ways to control the spread of disease, reduce the number of patients, reduce the number of deaths and to minimize the economic consequences in the economy.

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