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REGIONAL DISPARITIES IN COVID AND MOBILITY IN THE CZECH REPUBLIC (WITH PATTERNS FOR EMPLOYMENT)

Regionální rozdíly v mobilitě v České republice v důsledku Covidu (se vzorci pro zaměstnanost)

ALEKSANDR SHEMETEV

MAREK FEURICH

HELENA MITWALLYOVÁ

Katedra regionálních studií | *Department of Regional Studies*
Národohospodářská fakulta | *Faculty of Economics*
Vysoká škola ekonomická v Praze | *Prague University of Economics and Business*
✉ nám. Winstona Churchilla 1938/4, 130 67 Prague, Czech Republic
E-mail: alexandershemetev@gmail.com, marek.feurich@vse.cz, mitwally@volny.cz

Annotation
The research question is if an increase in pandemics corresponds with significant changes in mobility (supported by the public stay-at-home orders and willing decrease of movements) by the spheres of economic activities (parks (leisure time spending), grocery stores, workplaces, pharmacies, transportation stations, retail, recreation, and home) in the Czech Republic. The additional research question is if this pattern correlates with a high decrease in salaries and employment. This paper aims to answer these research questions. This research applies the graphical analysis and fixed-effects regression methods for high-frequency data for answering these questions. The main result is that an increase in the number of infected people significantly decreases human mobility and increases their visits to pharmacies and staying at homes. At the same time, the government support measures can be effective, because there is no huge drop in salaries and employment in the Czech Regions. This pattern contradicts the expectations based on the US patterns. The output of the regression analysis is that 2-5 thousand new infections a day can paralyze mobility in the entire region.

Key words
COVID, pandemics, Czech Republic, pandemics in the Czech Regions, high-frequency data, mobility

Anotace
Výzkumnou otázkou je, zda pokles mobility (způsobený vládním nařízením zákazu vycházení či dobrovolným omezením pohybu) odpovídá míře snížení šíření pandemie v oblastech ekonomických aktivit (jako jsou parky, obchody, pracoviště, lékárny, dopravní stanice, rekreační zařízení či domácnosti). Další výzkumnou otázkou je, zda tento vzorec koreluje s vysokým poklesem platů a zaměstnanosti. Cílem práce je odpovědět na tyto výzkumné otázky prostřednictvím grafické a regresní analýzy s fixními efekty provedené na vysokofrekvenčních datech. Hlavním zjištěním je, že zvýšení počtu infikovaných osob významně snižuje mobilitu lidí, avšak zvyšuje návštěvy lékáren. Vládou zavedená opatření mohou být považována za účinná, jelikož v českých regionech nedochází k výraznému poklesu platů a zaměstnanosti. Toto zjištění neodpovídá očekáváním založených na základě výsledků analýz z USA. Regresní analýza dále nazančuje, že 2–5 tisíc nových infekcí denně může paralyzovat mobilitu v celém regionu.

Klíčová slova
COVID, pandemie, Česká republika, pandemie v českých regionech, vysokofrekvenční data, mobilita

***JEL classification**: H12, I12, J33*

1. Introduction

Pandemics cause a decrease in mobility. This effect becomes stronger when people receive stay-at-home orders (SHO) from the government. Government can issue orders to close specific businesses (BCO) to decrease the

spread of pandemics. Thus, such measures should cause an additional decrease in mobility. In addition, some people willingly reduce their movements for decreasing the risks of pandemics. People try not to spread the infection in case if they can be sick; they also try not to be infected by the random contacts outdoors.

In addition, there are several spheres of economic activities: parks (potential geospatial IV/proxy for the leisure time spending), grocery stores, workplaces, pharmacies, transportation stations, retail, recreation, and home). The research question is if a decrease in mobility corresponds with the decrease in the spread of pandemics (by the spheres of economic activities). The additional research question is if this pattern correlates with a high decrease in salaries and employment. This paper aims to answer these research questions.

Unregulated mobility is a potential threat that leads to uncontrolled virus expansion. Thus, the most common government measures aim to limit the mobility of people and physical social interaction (Hsiang et al., 2020). Most countries closed their borders in spring 2020 (Worldometer, 2020). Some of them isolated their most affected regions (Affinity Solutions, 2020). Strict measures (like closing shops, schools, factories, restaurants, and entertainment facilities) should keep the spread of pandemics. Many people had to stay in their homes (the government stimulated the reduction in movements). Many measures are in effect for about a year (spring 2020-spring 2021).

In addition, many people voluntarily reduced their mobility for minimizing chances for the spread of the pandemics. There could be a shift in behavior patterns subject to the level of education: higher-educated people were mostly able to switch to remote work, unlike lower-educated workers who still went to their workplaces (Dingel and Neiman, 2020). Moreover, many high-mobile-employees (like sport-people) decided to minimize traveling (Bowes et al., 2020).

At the same time, the mobility reports from the population remain unknown (to the best we know) in the current state of study (including studies for the Czech Republic). The most advanced studies compare the mobility data with annual salary at a country-to-county level (Chetty et al., 2020). Thus, this research can spit a light upon a black spot in modern science and compare the level of pandemics and actual mobility change in the Czech regions; in addition, this research compares this data with the employment and salary data available by now for forming a better picture of the difficult year of 2020 in the Czech Republic.

2. Literature review

We can split the mobility pattern into the pre-pandemic (Huggins et al., 2014; Potluka, 2010; Musiałkowska et al., 2020; Pike et al., 2011; Dustmann and Preston, 2019) and pandemics-period-pattern. Pandemics (coronavirus) changed the lifestyles in many nations. People around the world have to stay at their homes; it affects businesses and other institutions. In addition, there are travel restrictions.

For example, the number of individual trips has dropped by more than 50% in the Kelowna region of Canada; at the same time, the mobility of some sectors (like healthcare, community services, and sales) increased during this period (Fatmi, 2020). Another research reveals a similar pattern in Poland (Borkowski et al., 2021): the individual time spent by traveling decreased by 66% across all age groups [March 2020 – April 2020]. A similar pattern is in France (Pullano et al., 2020): 65% drop in overall mobility [March 2020 – April 2020]. There is an additional confirmation of this transportation pattern from the research of a Spanish region of Santander (Aloi et al., 2020). The effect of the government orders to stay at home cannot be the main reason for this pattern, because, for example, the Swedish pattern [in Malmo] (Bohman et al., 2021) reveals similar changes in the overall mobility by categories [Sweden is a country that did not impose any significant governmental restrictions in spring 2020]. Even big countries, such as the USA [NY] (Warren and Skillman, 2020), show a similar reduction in mobility when almost half of the NY population stayed within 30 meters from their homes.

However, Pullano et al. (2020) [who did their research in France] point out uneven drops in mobility associated with disparities in the socio-economic background of individuals. Wealthier populations experience a stronger drop in mobility due to the possibility to work remotely or temporarily not working at all; this pattern is also caused by the imposed ban on the majority of leisure activities. On the contrary, the Italian pattern (Bonaccorsi et al., 2020) reveals that the reduction in mobility is stronger in municipalities with low average individual income. The New York pattern performs different results (Coven and Gupta, 2020) that the majority of the richer residents left the city; moreover, the remained low-income population exhibited more mobility during the work-hours (and during the non-work-hours as well) comparing to the remained richer population. There are findings that people's behavior changes depending on the amount of available information on COVID-19 in a particular region and the rate of aversion to risks; thus, the level of social distancing does not largely depend on the government policy

implementations, but on the inner perception of the pandemic risks in different regions (Mutlu et al., 2020). Thus, the control for the government orders to stay at home might not be a good research strategy for estimating mobility.

As expected, older people have a stronger mobility response to coronavirus pandemics who can rarely take travels longer than 100 kilometers and avoid leisure activities (Pullano et al., 2020). Romanian pattern shows that pandemics shifted the common lifestyle towards the online world (Gherman, 2020). Cancellation of public events, imposing restrictions on private gatherings, and closure of schools have the strongest effect on the reduction of daily incidence of COVID-19 in 135 countries (Askitas et al., 2020). On the other side, they (Askitas et al., 2020) found no evidence that closures of public transport, cross-region movements restriction, or international travel controls would have a significant effect on the daily incidence of COVID-19.

3. Methodology

This research suggests the utilization of the data from the Google community reports (Google, 2020a, c; b) to conduct measures on time people spend in retail and recreation places, grocery stores, transit station locations, parks, and their workplaces. This research understands that this data might be not precise in terms of estimating the true time spent in different locations. It mostly is an estimate of the changes of the time spent in different places compared to some base values. This research calls it "Google mobility" or "specific time spent at a specific location" (for brevity). This data helps to estimate the time spent outside the home places. This can also be regarded as some instrumental variable for the consumption of different types of commodities. Unfortunately, the true regional high-frequency data on consumption is not yet available for the year 2020 in the Czech Republic.

The additional topic of this paper is unemployment. This data has been gathered in the Czech Republic (Český statistický úřad, 2021). It is vital to speak about the data that is available by now for the employment statistics. The data for the Moravia-Silesia region (the Czech Republic) is unavailable in the Google mobility data. The pattern in the Zlin region is too unusual. This research suggests that it would be wise to devote another research to this particular region of the Czech Republic (Zlin region). The pattern for the total coronavirus infections is too unusual there. This could be data errata or just a special pattern. Future research can be devoted to this particular region. The COVID cases are the official medical high-frequency statistical data of the Czech Republic (Ministerstvo Zdravotnictví České Republice, 2021). All the data is properly merged and processed in R and will be available in a separate R package in the future (Shemetev, 2020).

Thus, the effect for estimating the interrelation between the expected outdoors mobility and the COVID might be estimated with the FE (LSDV) model:

$$\mathbf{Activity}_{it} = \mathbf{New\_COVID\_per\_100000}_{it} + \mathbf{Region}_{i} + \mathbf{E}_{it} \quad (1)$$

Where: $Activity_{it}$ - is the change in the expected mobility in percentages from the baseline level (January 2020, pre-COVID) for each region (i) for each period of time (t), daily basis for 2020 [the core types of mobility: parks, retail, recreation, grocery, pharmacy, transit stations, and workplaces. There also is the Avg_Mobility5 indicator – this is a mean value of all the macro-groups of the outdoor activities];

$New\_COVID\_per\_100000_{it}$ - is the new COVID cases in a specific region (i) for a specific period (t) of time (daily basis);

$Region_i$ - is a concrete (i) region of the Czech Republic (Kraj-level);

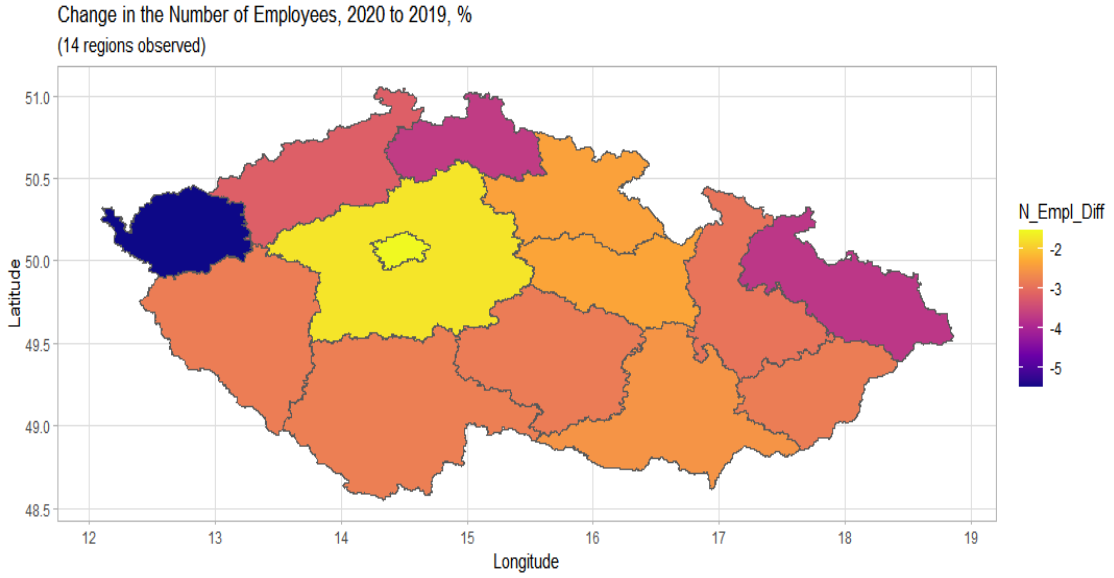
E_{it} - is the residual term.

Therefore, such an approach estimates the fixed effects model through the LSDV (least-square-dummy-variable) concept that has the same coefficients and significances as the original FE model (with some lover R^2, however). This research suggests robust standard errors check for estimating the significance of the coefficients in the model. This regression shows how pandemics change the mobility of people. The researchers have still been gathering the data for the Czech Republic (unfortunately, additional data is unavailable now).

4. Analysis of the data

The first step is the graphical analysis of the difference in employment in the pre-pandemic (2019) and the pandemic (2020) years.

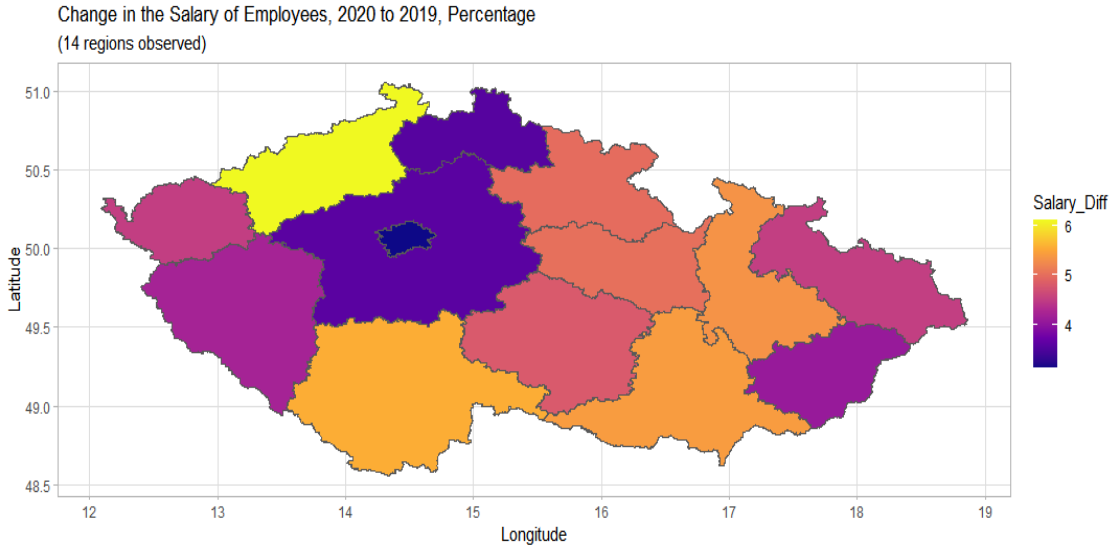
Fig. 1: Changes in the Number of Employees, 2020 to 2019, percentage



Source: own processing (2021)

The differences for the pre-pandemic (2019) and pandemic (2020) years are mostly within 5%. The number of employees dropped down in 2020. At the same time, this drop is not dramatic, this research suggests. The governmental measures helped support employment.

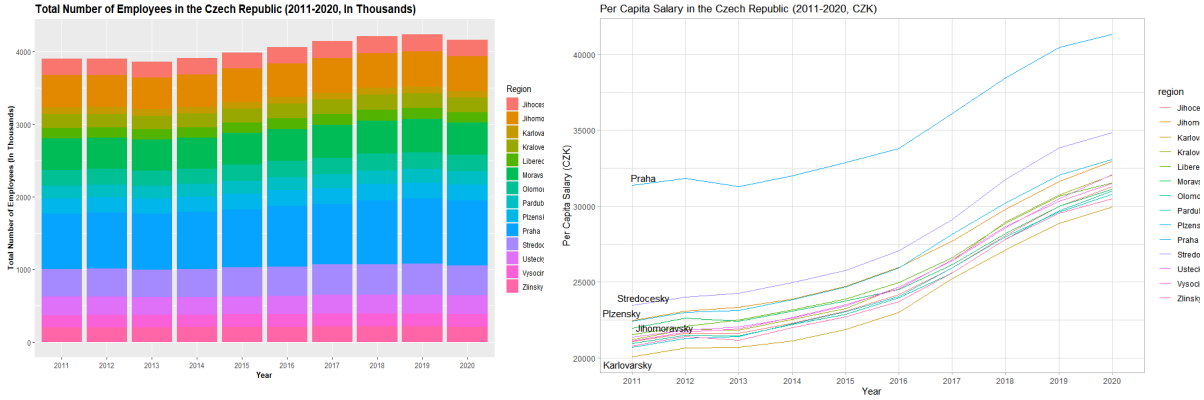
Fig. 2: Income per capita, 2019 – 2020 (in CZK)



Source: own processing (2021)

Although the number of employees decreased in 2020 (fig. 1), the average salary increased (on average) in the regions of the Czech Republic (fig. 2). The governmental measures supported an increase in salary in 2020.

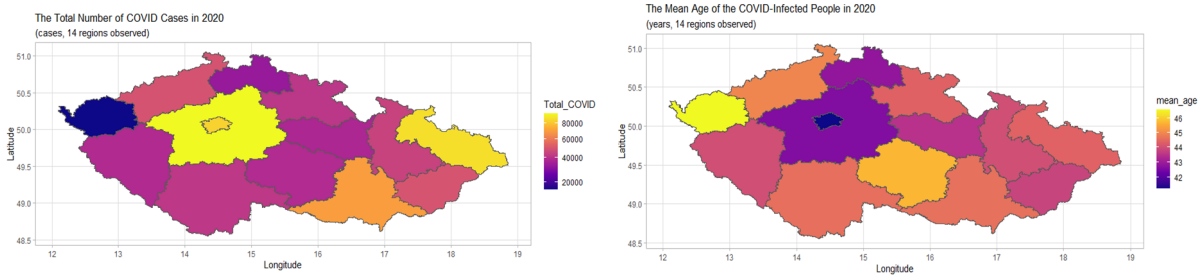
Fig. 3: The total number of employees (in thousands) and their per-capita salary (in CZK)



Source: own processing (2021)

Figure 3 supports the results revealed by figure 1 and figure 2. The level of employment decreased by 5% while the level of salary increased by 3-6%. The governmental measures supported the patterns from significant drops in salary and employment, this research assumes.

Fig. 4: The spread of pandemics in the Czech Republic in 2020 (total cases and age by regions)

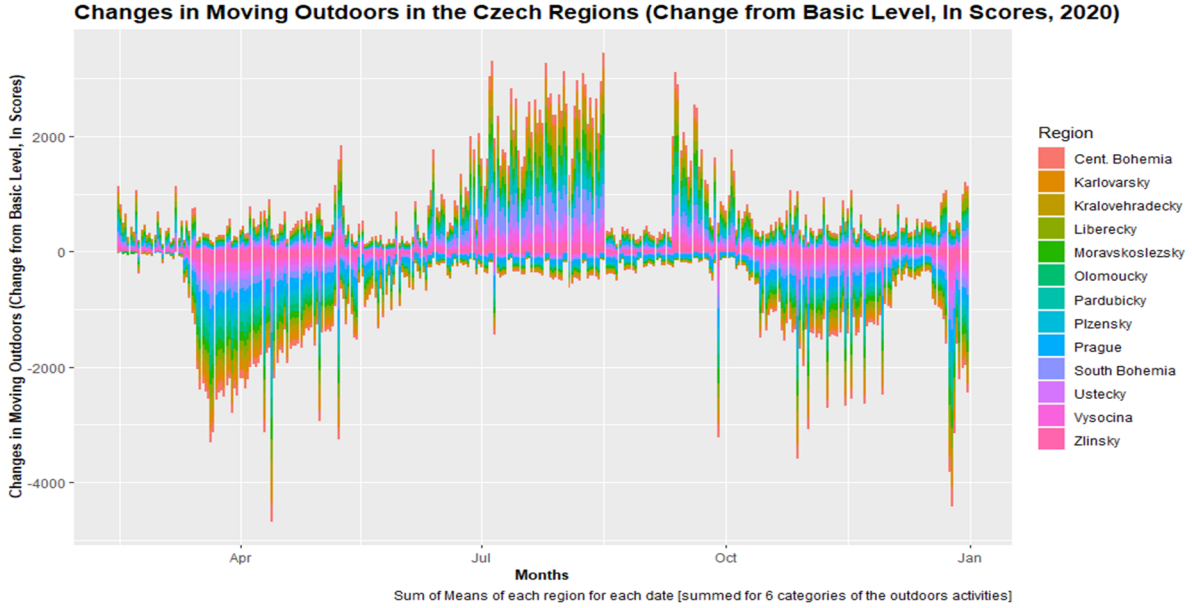


Source: own processing (2021)

The Czech Republic has 718 105 COVID cases in 2020 in total, our data (Ministerstvo Zdravotnictví České Republice, 2021) suggests (as available in early 2021). The situation with the COVID is not easy in the Czech Republic. Figure 4 reveals this. There are regions with higher numbers of infected people; at the same time, these regions have usually lower ages of the infected people. The regions with the lowest numbers of infected people have usually higher age of the infected people (the older the person – the more complications might occur; therefore, the regions with a lower number of infected people do not necessarily have easier situations in healthcare). For example, Karlovarsky Kraj has the lowest number of COVID-infected people; at the same time, it has the highest mean age of infected people in the Czech Republic. This means medics should pay more attention and efforts to older patients, which makes the total situation very complicated.

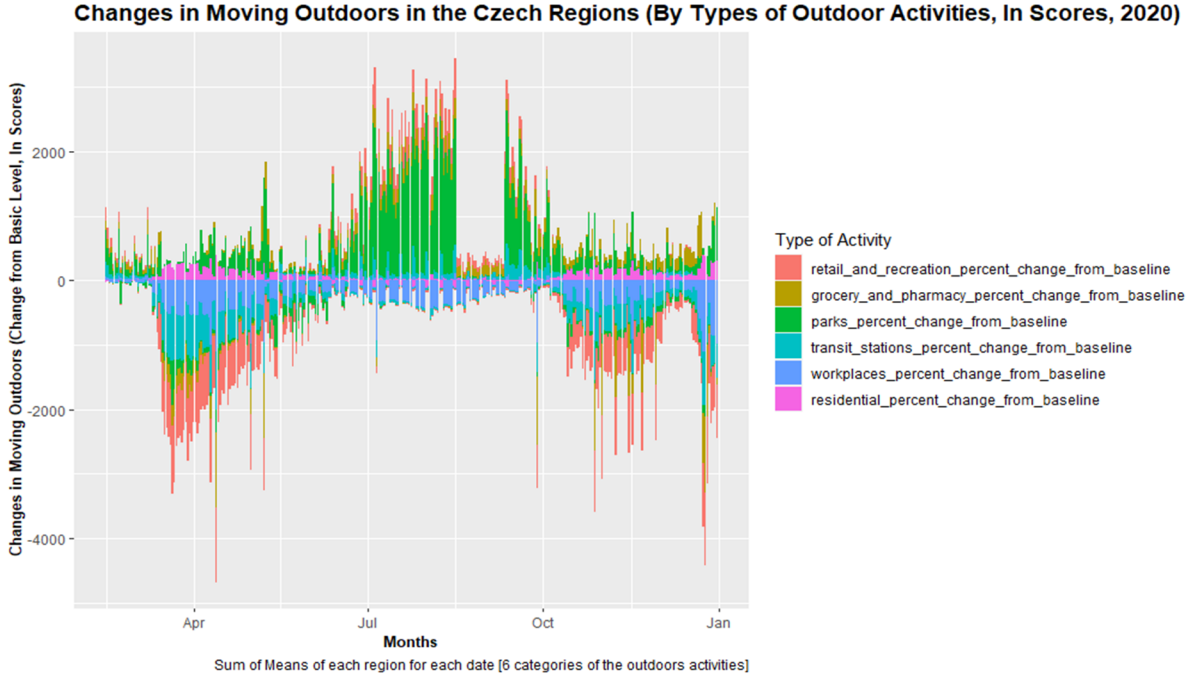
This research suggests six main outdoor activities: retail and recreation, grocery and pharmacy, parks (leisure time spending), transit stations, workplaces, and residential for all the Czech regions and sub-regions (the notes to fig.5 and fig.6 are below fig.6). There is a huge drop in the outdoor activities in the Czech Republic in 2020 due to the COVID, this research suggests. This is important to reveal the data in terms of the mean values of the change of the mobility of people for each day for each region of the Czech Republic; such an approach represents the data as a mean value for all sub-regions of each region for each date of the Czech Republic. The plot below represents this data.

Fig. 5: Changes in mobility in the Czech Republic in 2020 (as of January level summed by means for regions)



Source: own processing (2021)

Fig. 6: Changes in mobility in the Czech Republic in 2020 (as of January level summed by means for regions)



Source: own processing (2021)

Notes to figures 5 – 6: Each figure sums the average mobility for all six categories of mobility. Figure 5 sums the values for all types of mobility for all sub-regions; fig. 6 reveals the mean for each type of activity for each region and then sums these means for all 6 types of activities for all 13 regions (maximum value is thus |13x6x100|=|7800| scores of mobility).

Walks in parks (mostly) drive the increase of the outdoor activities during the pandemic period. Each wave of the COVID caused a significant decrease in all types of activities (except parks). People visited their workplaces less often; they used transit stations less often, and they decreased the time spent in retail and recreation centers (most of which were closed).

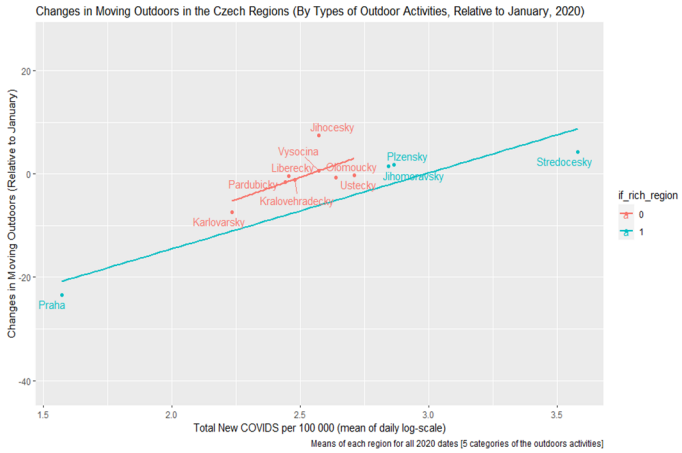
5. Results and discussion

The two plots below reveal the binned data for the Czech Regions for 2020. The high-frequency (daily) data shifted each region to its mean dot for a better outlook and representation of results. The dots represent the mean position of each region in its bin.

The case study of the regions of the Czech Republic might be a confirmation that the lockdown policies can have a positive effect on decreasing the number of COVID-infected people. The chart above shows that, on average, the more mobile the people were - the greater number of the new COVID-accidents per 100,000 people is possible (in the Czech Republic). This means lockdown might be a useful measure to prevent the spread of pandemics. This pattern contradicts the US pattern both for rich and poor regions (Chetty et al., 2020). Unlike the US pattern, the pattern in the Czech Republic shows that a decrease in mobility corresponds with a slower increase of the new COVID cases. This is an important difference with the state of knowledge revealed from the unique Czech Republic pattern. The interpretation of figure 7 is quite logical for the Czech Republic. For example, Prague has $Ln(x) = 1.7 \Rightarrow e^{1.7} = 5.5$ new cases a day per 100 000 population, on average (in 2020); the mean for the Czech Republic is about 2.8, or: $e^{2.8} = 16.5$ new cases a day, or around 600 000 cases in total for 2020[1] (excluding two regions, which would give 718 105 COVID cases in 2020 in total). This perfectly matches the official statistics. We have no mobility data for one of the excluded regions, and the pattern of the second excluded region is too unusual for the Czech Republic, this study suggests (methodology part). This is sufficient to analyze the US-dependency-direction on figure 7 for comparison, this study offers. Thus, doubtfully effective policy in decreasing mobility in the US regions is different from the Czech Republic pattern where we cannot blame such policy for inefficiency in a similar way.

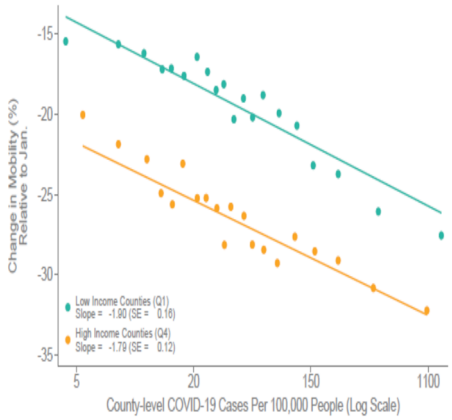
Fig. 7: Changes in mobility in the Czech Republic and new COVID cases per 100 000 in 2020

The Czech Republic pattern



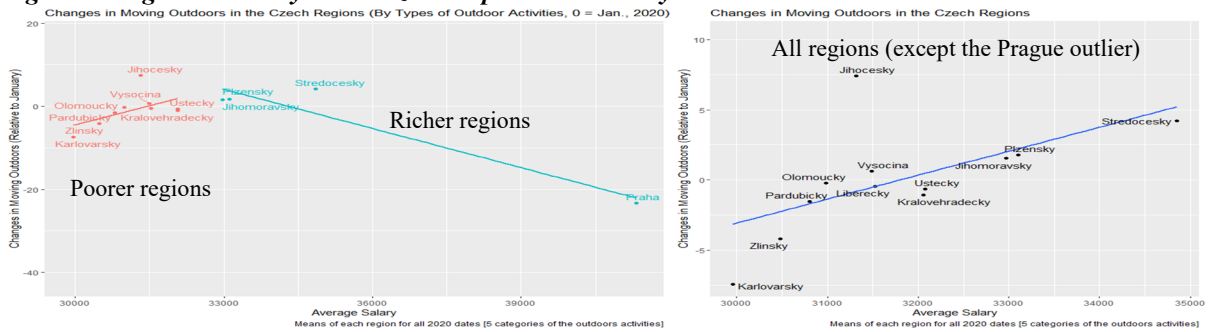
Source: own processing (2021)

The US pattern



Source: (Chetty et al., 2020, p. 82), annual log-scale

Fig. 8: Changes in mobility in the Czech Republic and salary in 2020



Source: own processing (2021)

[1] 16.5 [avg. cases per 100,000/day]*365[days per annum]*[10,000,000/100,000 population]=602,250 cases

This research suggests that an increase in mobility corresponds with a higher salary. This pattern is not obvious for one region (Prague). Prague has a lower territory, higher population density, and a unique high salary for the Czech Republic. Thus, salary could be a motivating factor for moving more. Future research can spit more light on this phenomenon (no additional salary data is available now).

The further step of this research is the regression analysis mentioned in the methodology section. This research suggests COVID is an exogenous factor (no person choosing if being infected or not - it comes from the force-majeure factors that nobody can foresee). Mobility is an endogenous factor because people might make their mobility choices depending on the pandemic situation. The average outdoor mobility (and activity) decreases with an increase in the number of new COVID cases (based on the Czech Republic data; the data for the Moravia-Silesia region is unavailable for the mobility analysis). At the same time, pandemics increase the number of visits and time spent in pharmacies and at home. Pandemics makes people less mobile (except visits to pharmacies and related institutions), this study suggests. This regression suggests that above 2000-5000 new cases a day in their region might make people sitting at their homes.

Fig. 9: Analysis of the effect from the pandemics by regression analysis as a change from 100.00 percent of the activity in January 2020

	Dependent variable:						
	Avg_Mobility5 (1)	retail_and_recreation (2)	grocery_and_pharmacy (3)	parks (4)	transit_stations (5)	workplaces (6)	residential (home) (7)
Total_COVID_per_100000	-0.018***	-0.033***	0.003**	-0.032***	-0.018***	-0.014***	0.009***
	(0.001)	(0.002)	(0.001)	(0.003)	(0.001)	(0.001)	(0.0004)
Constant	9.478***	-1.482	7.440***	74.399***	-13.345***	-14.200***	3.458***
	(1.416)	(1.806)	(1.220)	(3.323)	(1.363)	(1.033)	(0.410)
Regional FE (LSDV)	V	V	V	V	V	V	V
Observations	3,862	4,112	4,138	3,862	3,988	4,148	4,173
R2	0.123	0.123	0.024	0.117	0.154	0.081	0.134
Adjusted R2	0.120	0.120	0.021	0.114	0.151	0.078	0.131
Residual Std. Error	23.863 (df = 3848)	31.846 (df = 4098)	21.620 (df = 4124)	55.993 (df = 3848)	23.175 (df = 3974)	18.305 (df = 4134)	7.268 (df = 4159)
F Statistic	41.520*** (df = 13; 3848)	44.206*** (df = 13; 4098)	7.856*** (df = 13; 4124)	39.285*** (df = 13; 3848)	55.685*** (df = 13; 3974)	27.944*** (df = 13; 4134)	49.459*** (df = 13; 4159)
Note:							*p<0.1; **p<0.05; ***p<0.01

Source: own processing (2021)

This research supports the conclusions of the core discussion (Hsiang et al., 2020) by other means (mobility data) and in other regions (territorial units of the Czech Republic). It means the social distancing measures might be effective in terms of the medical effect on the number of infected people. Our research inquires further; it separates the effect for different economic sectors (like pharmacy, retail, recreation, and visits to workplaces), and estimates different effects produced by pandemics to the mobility and social distancing issues in terms of how it affects these sectors. Each new pandemic case leads to a significant change in the behavior of people and might lead to a comparable drop (or increase for some spheres [like pharmacies]) in terms of the offline trade. Thus, only the factors of public support and online trade might support these branches of economics. Although, further research is necessary to correct the size of the pure effect to the factors of public support and online trade (no such high-frequency data is available now for the regions of the Czech Republic).

The majority of researchers on similar topics base their conclusions on local surveys and questionings (Dingel and Neiman, 2020; Bowes et al., 2020; Fatmi, 2020; Borkowski et al., 2021). Our research steps further and analyses the proxy for the population data (based on the geo-positioning of the smartphones of the big part of the population of the Czech Republic). This can provide a more stable basis for the statistical estimates of the expected effects from the limited data available now. Moreover, none of such researches bases their conclusions on the regions of the Czech Republic. This fact is another important contribution of our research.

Although some researchers applied similar approaches and data (Chetty et al., 2020; Warren and Skillman, 2020), their conclusions are fair for the US pattern. Nevertheless, the pattern of the Czech Republic might be different (figure 7) and, thus, the results of these researches might not be fully applicable for the Czech Republic.

6. Conclusion

The research question is if a decrease in mobility (supported by the public stay-at-home orders and willing decrease of movements) corresponds with the decrease in the spread of pandemics by the spheres of economic activities (parks, grocery stores, workplaces, pharmacies, transportation stations, retail, recreation, and home). The additional research question is if this pattern correlates with a high decrease in salaries and employment.

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At the same time, pandemics increase the number of visits and time spent in pharmacies and at home. Pandemics makes people less mobile (except visits to pharmacies and related institutions), this study suggests. The average outdoor mobility (and activity) decreases with an increase in the number of new COVID cases.

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