Complying with anti-COVID policies.

Causes and effects of subnational variations: a research note

Italy was the first European country to be hit by the COVID-19 pandemic, and for this reason it was the first to experiment and then fine-tune policies against the spread of the virus. In November 2020, the Italian government introduced a color-coding system, adapting its constraining measures to the local epidemiological situation. However, implementation studies and basic empirical experience agree that policies may suffer from different levels of enforcement. In this research note, I first use Google mobility data at the provincial level in Italy to check the effects of the introduction of the color-coding system. Next, I outline the geographical variation in those mobility data for similar levels of constraint as a proxy for the level of local enforcement of the policy. Finally, I highlight the origins and assess the consequences of greater or lesser adherence to the mobility constraints in regard to the further spread of the virus. Contrary to some stereotypes, the level of compliance with the new anti-COVID policy, though uneven across the country, was high, and in any case sufficient to curb the pandemic.

Keywords: COVID-19; Mobility; Implementation; Compliance; Italy.

1. Introduction

Italy was the first European country to be hit by the COVID-19 pandemic, and one of those that suffered most in terms of incidence of the infections, as well as the number of victims. With an excess mortality rate of approximately 13%, as of the end of November 2021 Italy had a cumulative number of confirmed COVID-19 deaths per million people which was more than 17% higher than the European average (Dong et al. 2020). Its early and dramatic exposure to the pandemic probably contributed, for better or worse, to shaping its political and social reactions. In Europe, the Italian government necessarily acted as a forerunner, and since then its policies have been constantly monitored, as a sort of natural experiment able to provide information and advice to other countries.

Public appraisals vary – the president of the EU Commission recognized that «Italy was right» to ask for the help and coordination of the European Union – and short-term positive and negative judgements on the effectiveness of specific models have mostly had to be reversed under the pressure of new events and data. Unsurprisingly, scholars tend to underline more the errors and shortcomings than the measures that have worked (Ricolfi 2021). While no country was prepared to tackle an emergency of this magnitude, many agree on the limitations of the Italian approach to the pandemic (Capano 2020, 2021; Di Mascio et al. 2020).

Amongst other factors, the multilevel organization of the health system in Italy has been identified as one institutional source of the disorganized and reactive style of the Italian anti-COVID policy (Mattei and Vigevano 2021). Different regional models and capacities have shaped local approaches to tackling the spread of the virus, especially in the first phase of the pandemic (Capano and Lippi 2021). Although there are fewer veto points in Italy than in other European countries (Kuhlmann and Franzke 2021; Parrado and Galli 2021), the tension between local decisions and national coordination, between regional policy-makers and central government, has clearly characterized the management of the health crisis (Baldi and Profeti 2020).

At the beginning of the second wave of the pandemic, the Italian government decided to re-centralize management of the pandemic and enacted a decree that defined a more systematic approach to the crisis (Camera dei Deputati 2021). The new decree established homogeneous containment policies and, most importantly, imposed a series of further constraints on the mobility and activity of citizens and firms according to the severity of a set of predetermined epidemiological indicators (Senato della Repubblica 2020). This color-coding system has been in place in Italy since then, together with the state of emergency that the government has repeatedly extended.

Whilst the logic of this type of measure is that of enforcing similar constraints in contexts characterized by a similarly severe epidemiological situation, implementation studies have underlined since the 1970s the many factors that may produce even large gaps between the intentions of the legislator and their actual achievement (Pressman and Wildavsky 1973). This research note sheds some light on the varying degree of compliance with the geographically defined constraints introduced by the color-coding system, and tests if a lack of implementation and enforcement has somehow contributed to the spread of the virus.

The next section describes the situation and the policy problem on the eve of the second wave of the pandemic, and the measures enacted by the aforementioned government decree. Section 3 describes the research design, which was intended to plot a map of the level of compliance with this new anti-COVID policy at the provincial level and test the effects of the diversified enforcement of that policy. Section 4 reports the results of the empirical analysis, while the last section concludes with some general considerations.

2. The introduction of the color-coding system

Before autumn 2020, after the encouraging data of the summer, there was still the hope that the spread of the virus. could be kept under control during the long-announced second wave. h However, things quickly turned out differently from the beginning of October, due to the direct and indirect effects of the opening of schools on the number of new infections (A. 2021; Alfano et al. 2020; Tosi and Campi 2021). This time, the pandemic hit the Italian provinces more homogeneously, partially smoothing the sharp North-South divide apparent in the initial period.

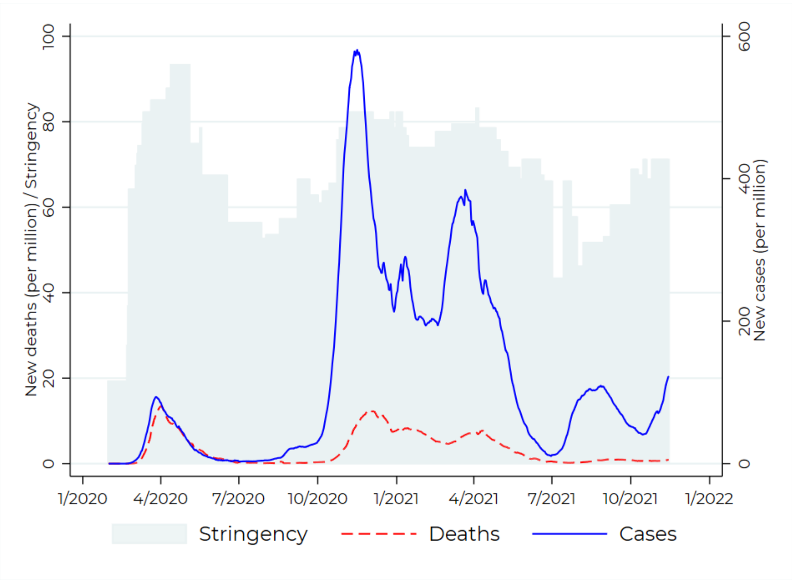
Figure 1 shows the trend of some indices summarizing the epidemiological and normative situation from the beginning of 2020. The solid blue line depicts the daily incidence of new COVID-19 cases on the right-hand scale. The dashed red line represents the incidence of new deaths attributed to the virus on the left-hand scale of the graph. The light grey histogram in the background plots on that same scale the trend of the stringency index, summarizing eight different containment policies – from school closures to restrictions on international travel – plus a measure regarding public information campaigns (Hale et al. 2021).[1]

The increase in infections of the second wave was sudden and dramatic, and it peaked at the end of November 2020. Fortunately, the lower fatality rate due to the better preparedness of the healthcare system produced a lower number of deaths relative to the number of infections. In the meantime, the collective lockdown measure of the spring period had been replaced by a more fine-tuned approach which connected the strictness of the policy to an epidemiological risk

[1] I recomputed the daily index for the summer periods, for which the authors used the same coding for the component referring to school closure policies in place before the end of the school year, thus inflating the strictness of the index in periods in which it was not possible to go to school.

assessment based on 21 indices previously defined by a decree of the Ministry of Health. This more nuanced strategy is reflected in the lower values of the stringency index in Figure 1, which discounts the severity of the measure whenever it was not uniformly implemented throughout the country.

FIG. 1. *Epidemiological and policy indices of the pandemic (January 2020-November 2021)*



The new approach was introduced by a government decree that defined four different scenarios (Dpcm 3 November 2021), later associated with colors ranging from white to red, to be identified at least weekly by the government for each region or autonomous province. The decree identified a set of common measures for the so-called yellow regions – including night curfew, high school and university closures, limits on public transport and some business activities – that could be further tightened in the case of high (orange) or maximum (red) risk.[2] In the former case, any unnecessary

[2] White zones and limits, associated with a scenario of low risk, were defined only in March 2021, when there was a partial reduction in the incidence of new cases.

movement between municipalities and regions was forbidden, and the activity of bars and restaurants was limited to home deliveries; in the latter, there were further restrictions, including ones on movements within the same municipality, on sport activities, the closure of lower-secondary schools, and the suspension of most retailing and commercial activities.

The new policies helped contain the spread of the virus and contributed to the decrease in the incidence of new infections, as evidenced by the sharp downward trend of the corresponding line in Figure 1 that started at the end of November (Ricolfi 2021). Since then, the color-coding scheme, refined and adapted to the most recent circumstances, has been the framework for any anti-COVID measure in Italy.

3. Colors and mobility data

There were multiple issues regarding implementation of the new scheme. The announcement of the upward or downward classification of each region, with its consequences for the daily life and work of millions of people, quickly became a constant concern for citizens and firms, with newspapers publishing maps of differently colored areas, and TV news bulletins reminding the public of the restrictions on their behavior. The many sudden stop-and-go imposed by repeated reclassifications were criticized because of the impossibility to plan any economic activity, so that the new colors and limitations where later decided to be announced in advance and, usually, enforced only from the beginning of the following week. The possibility to self-declare circumstances that permitted the declarant to avoid the limits on intra- and cross-regional movements and circulation, and the discretionary acceptance of those declarations were a second type of weakness.

More generally, it was an extremely complex task to control and enforce a policy characterized by such a high degree of generality, but at the same time by a series of more fine-grained constraints, for example regarding the type of retail activities that were allowed in the different color-coded scenarios, or the difference between permissible and forbidden sport activities. After the initial weeks and months, with the persistence of the system of constraints, there was a growing disaffection with these limitations, and a more intense perception of their economic downside (Dotti Sani 2021). To some extent, this probably also contributed to a decrease in compliance with the limits defined by the color-coding anti-COVID policy.

In order to evaluate the general level of compliance, and also its geographical variation, I used Google's Community Mobility Dataset (Google LLC 2021). Google provides anonymized aggregated data, directly derived from the devices of Google and Android users, that measure the relative presence and length of stay at different places compared to a baseline period before the start of the pandemic – the median of the five weeks between 3 January and 6 February 2020. There are six place categories for these mobility trends – grocery and pharmacy stores, parks, transit stations, retail and recreation facilities, residential areas, and workplaces – and my research focused on the last four of them.[3]

Mobility data have been increasingly used in analyses of the pandemic dynamics. A query in Scopus on titles and abstracts including the words «COVID» and «Google mobility» returned more than 200 articles, most of them either with cross-country comparisons or with a much more local perspective focused on single regions or areas.[4] I retrieved mobility data for all Italian provinces from the beginning of November 2020, with the introduction of the color-coding system, to the end of June 2021, when all the regions were classified as white, i.e. the lowest risk scenario.

Figure 2 reports the spline graph describing the daily median mobility change across all the Italian provinces in four major types of location. As expected, there have been symmetrical changes of mobility in residential areas (dashed red line) and workplaces (solid blue line) due to the spread of smart working after the beginning of the pandemic. The smaller changes in the former category, compared to the much larger reductions for the other three location types, should not be surprising. Residential areas are the only ones for which Google computes a change in the duration of permanence, and not a change in visitors, and this «because people already spend much of the day at places of residence (even on workdays)» (Google LLC 2021). Apart from the smaller fluctuations, also clearly visible is the Christmas vacation period at the end of 2020, for which the Italian government ordered a nation-wide red zone for most of the holidays.

[3] There were no direct limits on visits to supermarkets, grocery stores and pharmacies, while, especially for a country like Italy where mobility to parks, beaches and gardens is strongly dependent on the season, January was certainly not a good benchmark to check the increased attendance of those places. Interestingly, the latter data have been used in an analysis on the global scale that found that mobility in these blue-green spaces did not affect COVID-19 transmission (Venter et al. 2021): a further reason for not deepening their investigation in this within-country compliance study.
[4] A simpler query with only «COVID» and «mobility» returned more than 3000 articles.

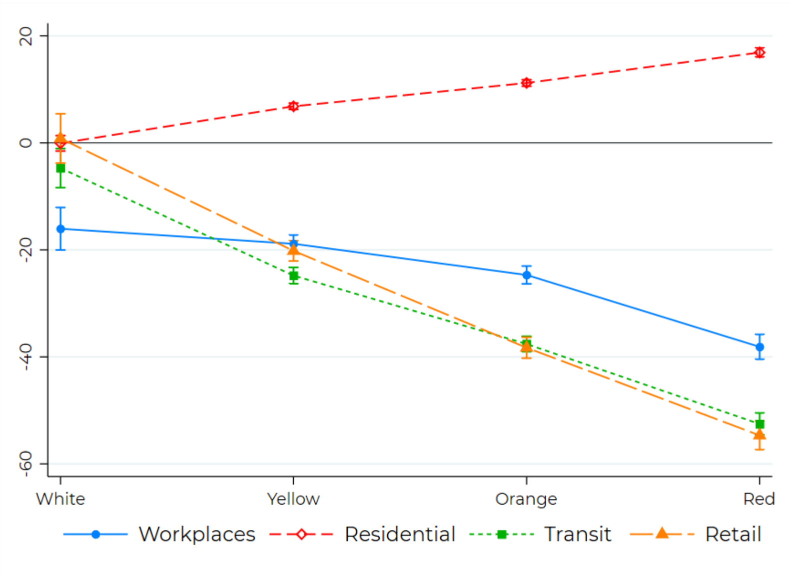
FIG. 2. *Change in mobility and presence in four different types of location (November 2020-June 2021)*

The plot depicts only the median change in mobility. However, there are large within-country variations of those quantities, not least because of the diversity of the epidemiological situations and, thus, of the stringency of the various policies. In fact, while Italian regions and autonomous provinces experienced a red code for approximately 18% of the days between November 2020 and June 2021, some of them, like Campania and the Aosta Valley, were under those constraints for more than 30% of the time. If we cumulate the percentages of days coded in orange and red, the national average was around 48%, while this time the record was held by the province of Bolzano with almost 63% of the days strictly constrained.

In order to more systematically explore the connection between anti-COVID policies and mobility, I started by running a series of regression models using Google provincial data as dependent variable, and the categorical variable with the different color restrictions as independent one.[5]

Figure 3 plots the mobility predictions for each type of location for provinces under the different policy constraints, from white to red coding. Mobility predictions in workplaces are plotted with circles and connected with a solid blue line, and for residential areas with diamonds connected by a dashed red line. Estimates of the mobility in transit stations are represented by a square with short-dash green connections; for retail and recreational areas the expected trend in mobility is marked by a triangle and a long-dash orange line.

FIG. 3. *Estimated mobility changes in the different locations depending on the type of policy constraint (prediction and 95% confidence interval)*



A white-coded policy had no effect on mobility in retail and residential areas: that is, visiting or remaining in those places was not

[5] More specifically, given the panel structure of the data, with the number of time periods (240) being larger than the number of units (107), I used panel corrected standard errors (Beck and Katz 1995). Similar results were obtained when recognizing the hierarchical structure of the data and using multilevel regression models, with longitudinal observations nested within provinces that, in their turn, were nested within regions.

systematically different from before the pandemic. In fact, white areas are those with the lower epidemiological risk: for three consecutive weeks they have to record a number of new cases lower than 50 for each 100,000 inhabitants, something that happened for only 7.5% of the period analyzed, mostly just before the summer of 2021. In those areas, most constraints, including the use of face masks and protection devices in open spaces, were simply abolished, apart from some restrictions on the capacities of movie theaters and museums, together with the closures of discotheques and dance halls.

Interestingly, in spite of the absence of significant constraints, even in white-coded provinces/periods there was a small reduction in attendance at transit stations, and a much larger decrease of that in workplaces. Both these systematic declines make sense, because there has been a change in the travel habits of citizens that goes beyond the actual limitations, whilst smart-working agreements introduced a more general and long-standing transformation of the workplace environment that exceeded the immediate needs connected with the pandemic.

What is most important is that the predicted mobility under each of the increasingly stringent color codings was exactly in line with expectations.[6] Under a yellow policy, there was lower mobility in workplaces, transit stations, and retail and recreational areas than under a white policy, while the time spent in residential areas was higher. Orange coding further depressed movements in the former areas and increased the duration of the stay in the latter. Finally, a red policy produced the highest reduction in mobility in all non-residential places and the most lasting presence at home. The trend in each area was monotonic and, also thanks to the large N, the confidence intervals were small and did not overlap between different policies.

On looking at the steepness of each connecting line, it is possible to appreciate also the differing magnitude of the impact of the different color-coding in diverse areas. The smallest difference in mobility between white and red policies is the one regarding residential areas, for the reasons already stated above, i.e. that it is a measure of duration and people always spend a great deal of time at home also in normal times. The second smallest change regards mobility to workplaces. On the one hand, in certain sectors smart working has replaced more traditional forms of labor, and is now a sort of new routine; on the other, certain types of work can only be performed in

[6] Notwithstanding their simplicity, the four bivariate models have a non-trivial explained variance: 54% for the retail and recreational areas, 34% for transit stations, 29% for workplaces, and 53% for residential places.

person, and only the severest restrictive policies can put a stop to them. This explains the flattest decrease in mobility for workplaces and also the fact that the largest drop is between orange and red areas. Finally, retail outlets and transit stations are the places most sensitive to the policy, with a reduction in mobility between white and red codes larger than 50%.

Having ascertained a systematic impact of the policy on mobility, can one also suppose a homogeneous effect across provinces? Most likely not, but to answer this question, I included fixed effects in the regression models by adding dummy variables for each province. It was thus possible to verify whether some provinces had mobility levels systematically higher or lower than the average national prediction, or some specific benchmark level. The exact reference point was not particularly important, since the analysis returns for each province the relative effect, i.e. the excess or lack of mobility, without in any case altering the rankings and relative magnitudes of those effects. I inductively chose the province of Ancona as the benchmark, since it had mobility levels in all four areas that were very close to the national average.[7]

The inclusion of provincial fixed effects does not modify the systematic impact of the color-coding system, but yields a very interesting and differentiated map of local behaviors.[8] Keeping the effect of the policy constant, some provinces clearly exhibited more mobility in certain areas than the predicted level, while some others did so less than the estimates. The picture is not necessarily homogeneous among places, so that an excess of mobility in workplaces may not correspond to an excess of mobility also in retail and recreational areas, or in transit stations.

The maps of these local effects, representing the coefficients of the dummy provincial variables relative to Ancona, are included in the Appendix. For retail areas, transit stations and workplaces, the intensity of the red color represents different degrees of excess mobility, while different shades of blue represent lack of mobility. The colors are inverted for residential areas, since higher than expected permanence at home reflects the hopes of policy-makers regarding containment of the pandemic. These quantities can be conceived as proxies for the

[7] More in detail, the overall national changes in mobility in retail areas, transit stations, workplaces and residential areas were respectively, -30.3%, -32.3%, -23,9% and + 9.5%. In the province of Ancona they were -35.3%, -31.5%, -23.2% and +9.7%.

[8] I do not include here the complete tables with all the coefficients. However, all the analyses can be replicated with the datasets and code that I provide in Harvard Dataverse at https://xx.yy

level of compliance with the policy, since the color-coding system has been introduced to limit the spread of the virus by limiting human circulation.[9] However, there may be relevant reasons why, in certain provinces, people moved more, or stayed at home less, than the average level under a certain type of constraint. Consequently, these maps should not be conceived as fully reflecting the rule of law, or enforcement capacities in different parts of the country. Incidentally, it can be seen that reds and blues are not uniformly distributed in the different maps, so that each one of them most likely requires specific explanation.

4. Causes and effects of mobility

Once I have mapped the geography of excesses/lacks of mobility, there are have two main research avenues that can be followed: treating those maps as dependent or independent variables, as *explanandum* or as *explanans*. The former option reflects more a sociological interest, whereas the latter reflects more a policy perspective. In this section I will provide a couple of examples of the types of research questions which Google's mobility data can help answer.

There may be several factors that impact on the higher or lower level of compliance with the policy measures, increasing or limiting their effects on mobility compared to the average Italian province. Without falling into the trap of ecological fallacy in the interpretation of the empirical results, I tested four major groups of variables.[10] Some of them varied across provinces, some across time, and others simultaneously across both dimensions.

The first group was composed of epidemiological variables such as the positivity rate and the share of fully vaccinated population. The former was expected to reduce extra-residential mobility by inducing greater respect for the severity of the health situation. The latter quantity represents an index of adherence to the wider policy

[9] In an interesting data-rich article with similar aims, Panarello and Tassinari (2021) use as direct measure of compliance the complement to 1 of the sanctioning rate (number of police fines for violations of COVID policies on the total number of controls on a given day). Apart from not being available if not at an aggregate national level, the measure is likely to be endogenous to the same systems of controls. Not surprisingly, the authors find an increase in compliance from March 2020 to February 2021, while the time variable in our model shows exactly the opposite.

[10] In the appendix I detail the exact definition of each index and the sources used to collect all the data

recommendations, but also, on the contrary, could promote a sense of immunity and lower risk. The second group comprised economic factors, such as the share of the labor force in the service sector, and the percentage of those working as employees (as opposed to entrepreneurs, self-employed and contingent workers, etc.): these factors should contribute to both reducing extra-residential mobility and increasing the permanence at home, because of smart-working or because of the weaker connection between working hours and salary. The average per person available income is another variable related to the economic group that should be controlled for. The third group of indices captured the important sociological notion of civicness (Putnam 1993), which is supposed to contribute to compliance through a collective sense of responsibility, and also to the good enforcement performances of local governments. I used two different variables for this group: the first one is an aggregate index of social capital, developed by Cartocci (2007) and recently updated by Colombo and Vlach (2021); the second one is the number of non-profit organizations per population, which is often seen as a proxy for civicness. The fourth group introduced into the model the demographic dynamics, such as the size of the population (logged) and its density, and finally a time variable controls for temporal dynamics such as the increasing fatigue of the population and the desire to return to a normal life.

Table 1 reports the coefficients of a series of regressions with panel corrected standard errors having daily provincial mobility in the four areas as dependent variables and all the covariates mentioned above as independent ones. Including the new explanatory factors did not affect the influence of the color-coding policy, at least not under an orange or red policy, the ones with stricter and more extensive mobility limitations. Their coefficients, representing the relative effect of the policy compared to the baseline white policy, are always significant and with the expected signs (positive for the increase of permanence at home, and negative for the decrease in extra-residential mobility). Most expectations regarding the effects of the main covariates of interest are confirmed, but some of them were contradicted or proved to have opposite effects in areas that should have behaved similarly.[11]

[11] The use of partially associated indices within the same group of variables may have produced collinearity issues that confounded some results. Given the exploratory character of the models, these issues may be addressed in future studies.

TAB. 1. *Causes of excess/lack of mobility*

	Retail	Transit	Workplaces	Residential
Yellow	-1.29	2.86**	1.22	1.58***
	(2.25)	(1.45)	(1.96)	(0.56)
Orange	-13.97***	-4.06**	-3.84*	4.49***
	(2.39)	(1.58)	(2.08)	(0.60)
Red	-31.67***	-19.39***	-17.73***	10.06***
	(2.84)	(1.83)	(2.47)	(0.71)
Positivity	20.82	5.02	-36.71***	20.68***
	(13.34)	(9.04)	(11.62)	(3.36)
Vaccinations	1.20***	0.81***	-0.88***	0.00
	(0.23)	(0.15)	(0.20)	(0.06)
Service sector	0.07***	0.02	-0.13***	0.01*
	(0.02)	(0.02)	(0.01)	(0.00)
Employees	-0.39***	-0.40***	-0.19***	0.03***
	(0.02)	(0.03)	(0.01)	(0.00)
Income	-0.76***	-1.04***	-0.21***	0.24***
	(0.05)	(0.06)	(0.04)	(0.02)
Non profit	-0.09***	0.20***	-0.03***	0.00
	(0.01)	(0.01)	(0.01)	(0.00)
Social capital	0.69***	0.57***	0.89***	-0.06***
	(0.05)	(0.05)	(0.05)	(0.02)
Population	2.18***	0.42***	1.12***	-0.18***
	(0.14)	(0.15)	(0.12)	(0.04)
Density	-0.01***	-0.01***	-0.01***	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)
Time	0.04	0.69***	1.43***	-0.35***
	(0.25)	(0.15)	(0.21)	(0.06)
Constant	-22.44*	-53.02***	-96.79***	22.49***
	(13.27)	(8.86)	(11.44)	(3.27)
R squared	0.71	0.57	0.50	0.77

Positivity rates, signaling the epidemiological risk, were expected to reduce extra-residential mobility and increase the permanence at home. The effects are confirmed only for residential areas and workplaces, but not for retail and transit areas. There are two possible reasons for this incomplete outcome. Either the variable is partially correlated with, and its effects absorbed by, the color constraints of the province, or the necessity to shop in retail areas or to move to other places was anelastic and not sensitive to signals of epidemiological risk. The vaccination rate, in the same group, constituted one of the variables showing contradictory effects. It was negative for the mobility in workplaces, following the hypothesis that, all other variables being equal, provinces that strictly follow the vaccination plans are also those that are more compliant with anti-COVID policies; but it was positive for retail and transit areas, consistently with expectations regarding the decrease in compliance due to the sensation of increased security generated by the vaccine coverage.

Economic variables were expected to influence mobility mostly in workplaces and residential areas, and their effects are confirmed by the models and sometimes extend to mobility in other places. It is easier to adopt smart working technologies in the service sector compared to manufacturing and agriculture, reducing the permanence in office and increasing that at home. Complying with the mobility limitations has fewer income consequences in provinces relying more on dependent workers compared to self-employed, contract workers and independent entrepreneurs; and, all other things being equal, safety concerns prevail in richer provinces.

The two variables capturing civicness are those that showed the most unexpected behaviors.[12] Social capital had consequences that were perfectly symmetrical with those anticipated, probably due to some hidden spurious relationship, while the presence of non-profit organizations sometimes confirmed the predictions (for retail and workplaces areas), sometimes had opposite effects (for transit stations), and sometimes was irrelevant (for the permanence at home). Demography also seemed to play a role, with larger provinces being harder to control, and those with higher population density complying more with the mobility limitations. Moreover, the time variable shows that the overall level of compliance diminished systematically week

[12] Panarello and Tassinari (2021) find some similar contrasting evidence, which they justify by supposing opposite effects due to different types of bonding and bridging social capital, as originally suggested by Alfano and Ercolano (2020) .

after week, indicating a general relaxation in the enforcement of the rules or, from a different perspective, a gradual draining of the patience of the population, which, after months of restrictions, increasingly tried to find ways to get round the mobility limits.

Finally, to be noted is that, in spite of all the imperfections and odd results of these analyses, all the models exhibit an increase in the level of explained variance compared to the original regressions having only the policy as independent factor. The R-squared are now between 0.50 and 0.77, with an additional explanatory power of 17% for mobility in retail and recreational areas, of 23% for transit stations, 22% for workplaces, and 24% for residential areas. Nevertheless, again introducing the fixed effects into those improved model still highlights that the provincial dummies maintain part of their idiosyncratic explanatory power, adding a supplementary explained variance that ranges between 1% (for permanence in residential areas) and 19% (for transit station visitors).[13]

The above-described models shed some light on the potential origins of the geographical variation in mobility and compliance. The opposite side of the coin is verification of its effects afterwards. In this case, it is irrelevant to understand if the registered extra-mobility is due to a lack of enforcement or has some more systematic causes. The dependent variable used to estimate those effects is the incidence of new certified COVID cases, which is primarily a function of that same quantity one week before.[14] The number of infections discovered is also dependent on the number of tests performed in that same week, and for this reason I added that measure in the right-hand side of the equation. Other epidemiological control variables were the (lagged) share of fully vaccinated population, which, starting from the beginning of 2021, reduced the number of infections, and the (lagged) positivity rate, which was obviously expected to increase the incidence of new cases.

In the following table, the covariates of interest are mobility trends in the four mentioned places, supposed to positively influence the number of infections if regarding extra-residential mobility and negatively otherwise. By further introducing in the equations the

[13] I have been unable to include meteorological data, like average temperature and rainfall, which could account for some of the remaining cross-provincial variability.

[14] The European Centre for Disease Prevention and Control estimates that the incubation period lasts between 1 and 14 days; Linton et al. (2020) suggest that it «falls within the range of 2–14 days with 95% confidence and has a mean of around 5 days». I chose a 7-day lag to add another couple of days for actually registering the results of the tests; using slightly different lag-structures did not systematically affect the results.

provincial color-policy in the different days and weeks, Table 3 shifts the attention towards the excesses/lacks of mobility in the four places, to test the statistical significance and magnitude of the effects of non-compliance.

TAB. 2. *Effects of mobility trends on the incidence of new COVID cases*

	(1a)	(2a)	(3a)	(4a)
Lag incidence	0.75***	0.74***	0.74***	0.75***
	(0.02)	(0.02)	(0.02)	(0.02)
Retail	0.36***			
	(0.09)			
Transit		0.23***		
		(0.06)		
Workplaces			0.12	
			(0.12)	
Residential				-1.29***
				(0.33)
Tests	0.99***	0.93***	0.93***	0.92***
	(0.09)	(0.09)	(0.09)	(0.09)
Vaccinations	-1.51***	-1.36***	-1.09***	-1.54***
	(0.27)	(0.27)	(0.26)	(0.28)
Positivity	339.64***	349.45***	350.01***	359.82***
	(41.18)	(41.70)	(41.01)	(40.69)
Constant	3.07	0.88	-4.92	5.17
	(5.62)	(5.33)	(5.81)	(5.95)
R squared	0.90	0.90	0.90	0.90

Panel corrected standard errors *** $p<0.01$ ** $p<0.05$ * $p<0.10$

Table 2 confirms that extra-residential mobility increases the likelihood of new contagions, whereas staying at home decreases it. Judging directly from their outcomes, mobility constraints are effective in limiting the spread of the virus. For each 1% increase in mobility in retail areas – or for a 1% comparatively lower reduction, since there has been a generalized decrease in mobility compared to the pre-pandemic period – there have been approximately 3.6 more new daily COVID cases per million persons. The impact of increased mobility is slightly lower for transit stations (2.3 more new cases per million persons), while the impact of permanence at home has a greater effect, decreasing the number of new per million cases by almost 13. The only areas for which mobility has no effect on COVID diffusion are work places, where internal controls and good practices (face masks, social distancing, handwashing, etc.) are more likely to be enforced and respected.

All the control variables manifest the expected highly significant effect. The incidence of new cases is for large part determined by the same values in the previous week, and it is positively associated with the number of COVID tests. All other things being equal, the percentage of fully vaccinated people consistently reduces the new infections, while the positivity rate increases them. The overall explained variance is very high, with an R-squared close to 0.9.

By adding the color measures, Table 3 simultaneously serves two purposes: testing if the policies actually reduce the spread of the virus, and verifying if the residual unconstrained mobility is sufficient to systematically trigger new infections. All epidemiological control variables confirm their impact on the incidence of new cases, positive for the lagged incidence, number of tests and positivity rate, and negative for the percentage of vaccinated population. The introduction of more stringent policies systematically reduces, at a week's distance, the contagions, with effects whose magnitudes increase moving from yellow, to orange, to red constraints.

However, the most interesting result is the negative evidence regarding extra-mobility, i.e. the effect of the residual mobility in the different places once the effect of policy and all the other control variables are kept constant. The impact of mobility on the incidence of new cases registered in the previous Table 2 is entirely balanced by the reductive effects due to the different policies. The coefficients for retail, transit and residential areas have the same signs but lose their statistical significance. Interestingly, the only mobility variable that has a weak – $p<0.10$ – statistical significance is the one regarding workplaces, exactly the variable that in the previous table was not systematically associated with incidence. However, this time the sign of its coefficient is negative, meaning that an extra-presence in workplaces reduces rather than increases the likelihood of infections. This indirectly confirms the previous intuition that workplaces are relatively safer areas, and it reinforces the impression that being at work also reduces the chances of being in a situation of greater interactions.

TAB. 3. *Policy, extra-mobility and their effects on new COVID cases*

	(1b)	(2b)	(3b)	(4b)
Lag incidence	0.77***	0.77***	0.77***	0.77***
	(0.02)	(0.02)	(0.02)	(0.02)
Retail	0.05			
	(0.10)			
Transit		0.04		
		(0.05)		
Workplaces			-0.22*	
			(0.13)	
Residential				-0.21
				(0.39)
Yellow	-14.15**	-14.47**	-13.11**	-14.29**
	(6.03)	(6.02)	(5.95)	(6.02)
Orange	-25.16***	-25.73***	-25.56***	-25.34***
	(6.54)	(6.37)	(6.27)	(6.40)
Red	-37.22***	-38.46***	-41.36***	-37.07***
	(7.63)	(7.14)	(7.16)	(7.44)
Tests	0.92***	0.91***	0.90***	0.91***
	(0.09)	(0.09)	(0.09)	(0.09)
Vaccinations	-1.48***	-1.49***	-1.31***	-1.51***
	(0.28)	(0.27)	(0.26)	(0.29)
Positivity	329.30***	329.38***	312.05***	332.62***
	(40.81)	(41.28)	(40.12)	(39.92)
Constant	13.83*	14.46*	6.81	14.71*
	(8.08)	(7.83)	(8.27)	(8.45)
R squared	0.90	0.90	0.90	0.90

Panel corrected standard errors *** $p<0.01$ ** $p<0.05$ * $p<0.10$

5. Conclusion

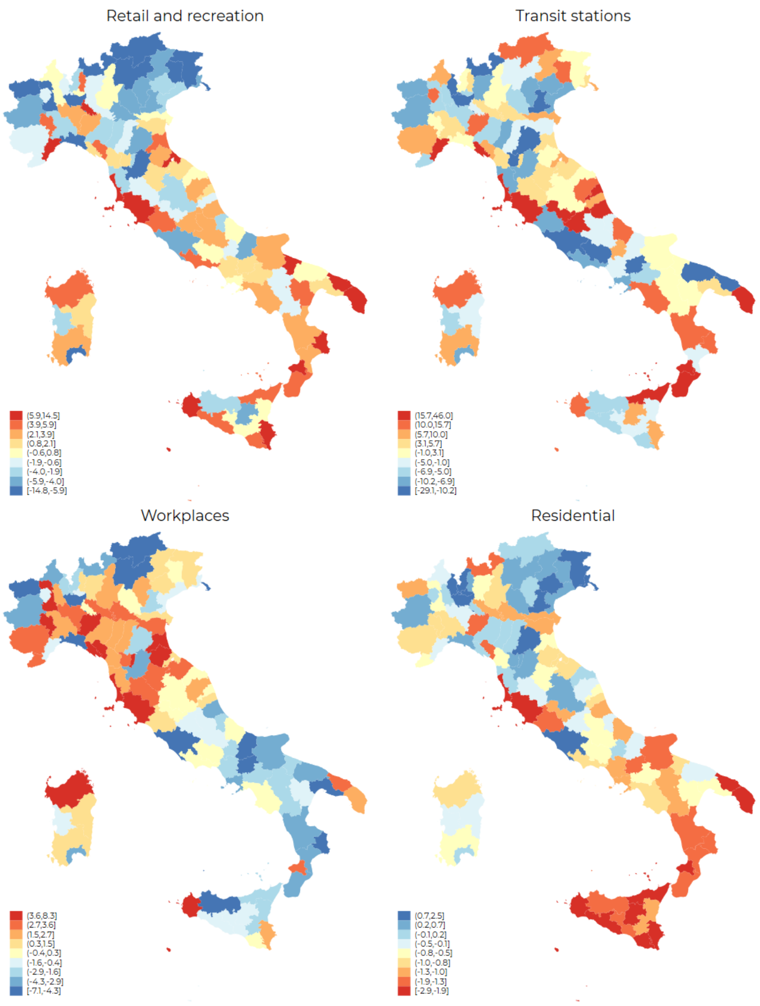
In this research note, the analysis has proceeded step by step. First, it has been shown that the color-coding system has been effective in reducing mobility in several different areas, as well as in increasing the permanence at home. The second step recognized the existence of a certain degree of what I have called «extra-mobility», demonstrated by the significance of the coefficients of many provincial dummies and illustrated by the maps in the appendix. There are numerous explanations for this extra-mobility, and the third step of the analysis provided some evidence regarding several epidemiological, economic and demographic variables, and also some odd contradictory results regarding sociological proxies for civicness. In the fourth step, a series of regression models checked the positive relationship between mobility in extra-residential areas and the incidence of new COVID cases, and then assessed their reduction connected to more stringent policies.

To synthesize: Mobility, with its inevitable social interactions, contributes to the persistence and spread of the pandemic. The color-coding system is effective in reducing mobility and, thus, also in limiting the spread of the virus. The good news is that the level of compliance is sufficiently large to ensure that any physiological residual extra-mobility is not enough to further contribute to the pandemic. Alternatively, but no less positively, any excess of mobility is sufficiently justified, so that it is also informed by the good practices that the health authorities have continuously recommended. While these conclusions contrast with some stereotypes regarding the Italian character, they do not do so with some systematic evaluations of Italian policies using very diverse methods (Gaeta et al. 2021; Panarello and Tassinari 2021; Spinella and Mio 2021), and nor with some international recognitions received by the government for the way in which it has coped with the unprecedented emergency that hit Italy first among all the countries in Europe.

APPENDIX

Maps

FIG. A.1. *Excess and lack of mobility compared to the predicted level according to the policy*



Codebook

The dataset and codes are available in Harvard Dataverse at https://xx.yy

Google mobility: Percentage change in mobility compared to the correspondent median weekday in 5 weeks before the beginning of the pandemic; https://www.google.com/covid19/mobility/ (accessed on 15 November 2021).

Color coding: Giorgio Tsiotas and Luca Lorello elaboration on government and journal sources: https://github.com/tsiotas/covid-19-zone (accessed 20 July 2021)

Epidemiological weekly data: Positivity rate; New cases per 100000 inhabitants; Tests per 1000 inhabitants Dipartimento protezione civile – Dati COVID Italia: https://github.com/pcm-dpc/COVID-19 (accessed 5 July 2021)

Vaccines: Percentage of fully vaccinated population: Commissario straordinario per l'emergenza Covid-19 - Presidenza del Consiglio dei Ministri https://github.com/italia/covid19-opendata-vaccini (accessed 5 July 2021)

Population: Log of provincial population; Dipartimento Protezione Civile - Dati COVID-19 Italia; https://github.com/pcm-dpc/COVID-19

Density: Population per squared km, Istat; https://www.tuttitalia.it/

Service sector: Percentage of people working in the service sector (ATECO 2007 classification); Istat (Imprese e addetti, 2019 data, columns from I to S, excluding health and welfare)

Employees: Percentage of dependent workers (ATECO 2007 classification); Istat (Imprese – occupati, 2019 data)

Income: Average per person available income (1000 euro); Istat (Misure del benessere dei territori); https://www.istat.it/it/archivio/260716

Non-profit: Number of non-profit organizations per 10000 inhabitants; Istat (Misure del benessere dei territori); https://www.istat.it/it/archivio/260716

Social capital: Aggregated index of the diffusion of daily newspapers, the level of electoral participation, the distribution of sport associations, and the diffusion of blood donation (Colombo and Vlach 2021)

Time: Progressive week number (starting from 45th week in November 2020)

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