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Italy was the first European country to be hit by the COVID-19 pandemic, experimenting and fine-tuning its policies against the virus. In November 2020, the Italian government introduced a color-coding system, adapting its constraining measures to the local epidemiological situation. In this research note, I first use mobility data to check the effects of this policy, and then analyse their geographical variation for similar levels of constraint as a proxy for its local enforcement. Finally, I explore some ex-ante and ex-post correlates 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 was reasonably 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[1].

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[1] The article is complemented by supplementary material, dataset and code that can be downloaded from Harvard Dataverse at https://doi.org/10.7910/DVN/E4CJCR.

Public appraisals vary – the president of the European Union (EU) Commission recognized that «Italy was right» to ask for the help and coordination of the EU – 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 intervention 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. This color-coding system has been in place in Italy since then, together with the state of emergency that the government has repeatedly extended until the end of March 2022.

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 is somehow associated with an additional 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 explore the correlates of the diversified enforcement of that policy. Sections 4 and 5 report 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. 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 (Alfano *et al.* 2020; Giuliani 2022; 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.

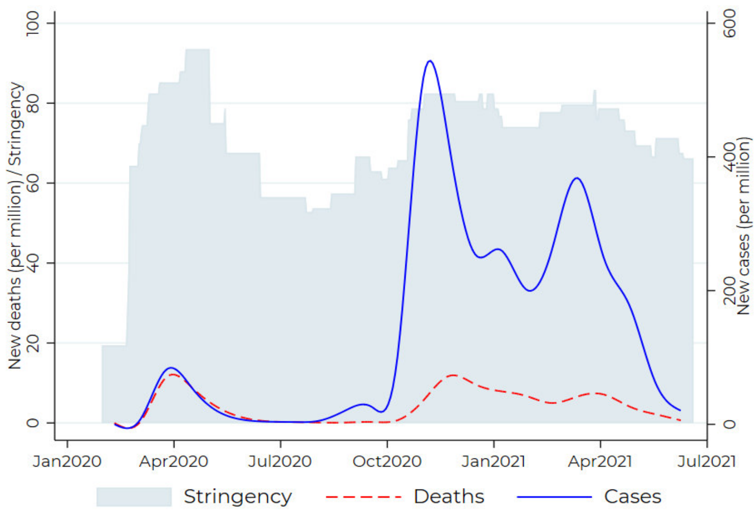
Figure 1 shows the trend of several indices summarizing the epidemiological and normative situation from the beginning of 2020. The solid blue line depicts the daily incidence of new COVID-19 cases on the right-hand scale. The dashed red line represents the incidence of new deaths attributed to the virus 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)[2].

Since Italy was the first European nation to experience COVID-19, it was also the one that reacted earlier, soon implementing an almost two-month period of generalized lockdown. Whilst the rigid constraints started to be relaxed in May 2020, together with the end of the first wave of the pandemic, they have never been completely abandoned, with COVID-related regulations that have remained in place

[2] 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.

also between the various waves, as shown in figure 1 by the background grey area representing the stringency of non-pharmaceutical interventions.

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



Source: Ritchie *et al.* (2020) for the incidence of cases and deaths, and Hale *et al.* (2021) for the policy index.

The increase in infections of the second wave was sudden and dramatic. In a couple of weeks, it surpassed the maximum incidence of the first wave, peaking at the end of November 2020 with a number of new daily registered cases per population which was six times higher than the one previously recorded. 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, as is immediately evident on comparing the solid blue line and the dashed red line in the graph in correspondence to the first two waves. 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 assessment based on 21 indices[3]. This more nuanced strategy is reflected in the relatively 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. Also shown in the plot is the third wave of the pandemic, whose conclusion also defines the end date of the analysis that I perform in the next sections.

The new approach was introduced by a government decree that defined four different scenarios (prime ministerial decree – in Italian *Decreto del Presidente del Consiglio dei Ministri*, thereafter DPCM – November 3, 2020), 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[4]. In the former case, any unnecessary 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 (see also 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, until eventually having been cancelled at the end of March 2022 (decree-law no. 24 of March 24, 2022), in spite of the umpteenth resurgence of the number of infections during the spring of that same year.

[3] The indicators had been previously identified by a decree of the Health minister, signed on April 30, 2020, following the monitoring activity envisaged by the government a few days earlier (DPCM April 26, 2020). They comprised 6 process indices regarding the evolution of the disease and the monitoring capacity, 6 process indices regarding diagnostic assessment and contact tracing, and 9 performance indices regarding the dynamic of the pandemic and the endurance of the health system. For the general normative framework in which the new system was implemented, see the report of Senato della Repubblica (2020).

[4] 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.

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 exact procedure followed for any reclassification was changed numerous times. Regions asked to be regularly consulted, questioning the transparency of the whole process, while they were themselves accused of (voluntarily or inadvertently) manipulating some epidemiological data to remain in lighter-shaded areas[5]. Moreover, on a more micro-level, 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 another 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 may also have 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

[5] On these issues see, for example, the newsletter of the Conference of the Regions and Autonomous provinces, «Le Regioni», n. 3952 17.11.2020; «Pagella Politica», *Il sistema a colori delle regioni è sempre più disordinato*, 6.10.2021, «Le Scienze», *I dati della discordia sulla pandemia in Italia*, 19.11.2020; «Il Post», *Com'è andata la complicata vicenda dei dati sbagliati della Lombardia*, 25.1.2021; *Perché la Sicilia non passerà in zona gialla*, 20.8.2021, «Il Messaggero», *Covid, la procura di Genova indaga sui paramentri della raccolta dati, nel mirino la gestione della seconda ondata*, 9.11.2020; «La Stampa», *Dossier: La pandemia dei numeri. Che cosa non funziona nei dati che ci stanno cambiando la vita*, 3.12.2020.

compared to a baseline period before the start of the pandemic – the median of the same weekday during 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[6].

Aggregated anonymized mobility flows have been validated in numerous research projects as reliable information in the study of the pandemic dynamics. For example, within the broad field of the social sciences, they have been used to test the compliance with stay-at-home orders (Brodeur *et al.* 2021), to investigate the conditional impact of political trust on the efficiency of restrictive policies (Bargain and Aminjonov 2020), to verify the risk connected to outdoor recreation activities (Venter *et al.* 2021), and to trace the economic consequences of containment policies in Europe (Spelta and Pagnottoni 2021) and in the United States (Goolsbee and Syverson 2021). Between the first submission and the revised version of this work, I have also found several interesting studies that apply mobility data to the Italian case, some of them with a research aim similar to mine (Gaeta *et al.* 2021; Manica *et al.* 2021; Panarello and Tassinari 2021).

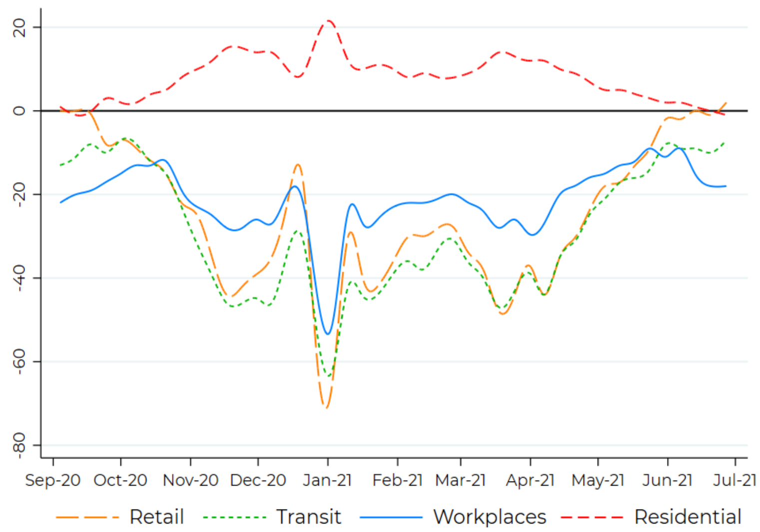
I retrieved Google mobility data for all Italian provinces from the beginning of September 2020, that is before the introduction of the color-coding system, in a period of relative stasis in the pandemic, to the end of June 2021, when all the regions were classified as white, i.e. the lowest risk scenario.

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

[6] 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.

vacation period at the end of 2020, for which the Italian government ordered a nation-wide red zone for most of the holidays.

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



Source: (Google LLC 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 the introduction of the new policy and June 2021, some of them, like Campania and the Aosta Valley, were under those constraints for more than 30% of the time. Cumulating 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[7].

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.

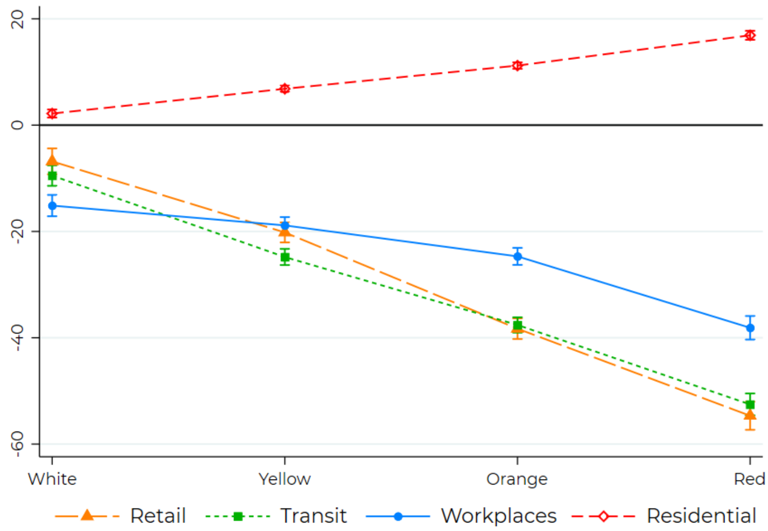
A white-coded policy had almost no effect on mobility in retail and residential areas: that is, in the absence of any significant restrictions, citizens visited or remained in those places as they had done before the pandemic, confirming the validity of the baseline period used by Google. In fact, white 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 time since November 2020, mostly just before the summer of 2021[8]. 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, in white-coded provinces/periods there was a slightly bigger decrease in attendance at transit stations (-9%), and even more so in workplaces (-15%). Both these larger systematic declines in mobility 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.

[7] More specifically, given the panel structure of the data, with the number of time periods (303) 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.

[8] The percentage rises to 26.7% including the two months covered by the analysis before the introduction of the color-coding system.

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



What is most important is that the predicted mobility under each of the increasingly stringent color coding was exactly in line with expectations[9]. 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

[9] Notwithstanding their simplicity, the four bivariate models have a non-trivial explained variance: 57% for the retail and recreational areas, 38% for transit stations, 30% for workplaces, and 56% for residential places. The complete set of coefficients is included in table A.1 in the supplementary material.

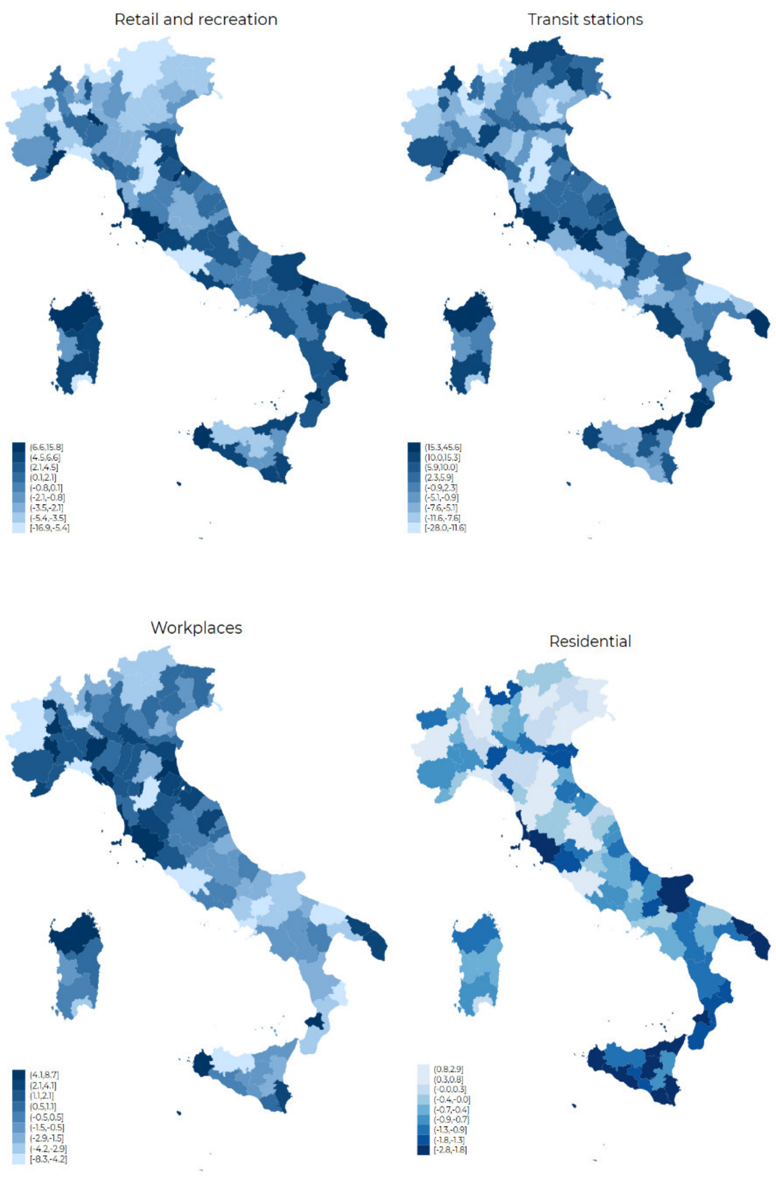
different color-coding in diverse areas. The smallest difference in mobility between white and red policies is the one regarding residential areas, for the reasons already stated above, i.e. that it is a measure of duration and people always spend a great deal of time at home also in normal times. The 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 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 that can exceed 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[10].

The inclusion of provincial fixed effects does not modify the systematic impact of the color-coding system (see table A.2 in the supplementary material), but yields a very interesting and differentiated map of local behaviors. 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.

[10] More in detail, the overall national changes in mobility in retail areas, transit stations, workplaces and residential areas were respectively, -26.0%, -28.0%, -22.1% and +8.1%. In the province of Ancona they were -25.0%, -28.1%, -21-3% and +8.3%.

FIG. 4. *Excess and lack of provincial mobility compared to the average predicted level according to the policy.*



The maps of these local effects, representing the coefficients of the dummy provincial variables relative to Ancona, are presented in figure 4. For retail areas, transit stations and workplaces, darker shades of blue represent different degrees of excess of mobility in comparison to that province, while lighter ones denote a relative lack of mobility. The shades 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 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[11]. 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 the different color intensities are not similarly distributed in the various maps, so that each one of them most likely would require specific explanation.

Once I have mapped the geography of excesses/lacks of mobility, there are two main research avenues that can be followed: treating those maps as dependent or independent variables, as *explanandum* or as *explanans*. The former option, looking for ex-ante correlates of mobility, reflects more a sociological interest, whereas the latter reflects more a policy perspective, searching for the ex-post associations[12]. In this section I provide a couple of examples of the types of research questions which Google's mobility data can help answer.

[11] 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.

[12] As pointed out by a referee, this kind of exploration cannot support causal explanations, and for this reason I tried to avoid any strong expression of causality. At the same time, I followed a straightforward logic of temporal priority to distinguish ex-ante and ex-post correlates of mobility and compliance.

4. Ex-ante Correlates of Provincial Variation in Mobility and Compliance

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[13]. Some of them varied across provinces, some across time, and others simultaneously across both dimensions.

The first group is composed of epidemiological variables such as the positivity rate and the share of fully vaccinated population. The former is expected to reduce extra-residential mobility by inducing greater respect for the severity of the health situation (Goolsbee and Syverson 2021). The latter quantity represents an index of adherence to the wider policy recommendations, but also, on the contrary, could promote a sense of immunity and lower risk.

The second group comprises 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. I then opted to include two macroeconomic indicators provided by Eurostat for the provincial level, namely the GDP per capita and the employment rate. Wealthier provinces may behave differently from poorer ones, while the larger the share of employed population, the more certain behaviors – e.g. presence in workplaces – may be affected or difficult to modify.

The third group of indices includes the important sociological notion of civicness (Putnam 1993), which is supposed to contribute to compliance through a collective sense of responsibility. To measure this concept, I used an updated and simplified version of the aggregate index of social capital developed by (Cartocci 2007). This consists of three equally weighted components: the turnout level in national elections; the presence of non-profit organizations; and the circulation of newspapers. These factors have often been found to be associated with different institutional capacities of local governments,

[13] In the supplementary material I detail the exact definition of each index and the sources used to collect all the data.

so that they can also be considered proxies for different monitoring and enforcement capabilities (Cartocci and Vanelli 2008). A more straightforward way to take into account the variegated institutional capacities is to directly use measures of the quality of regional government such as those developed at the University of Gothenburg, which have recently been also found to be associated with subjective and objective indicators of COVID dynamics (Charron *et al.* 2021). I thus opted to include their most recent European Quality of Government (EQI) index, estimated on the basis of the three components of quality, impartiality, and corruption of the regional government.

Finally, the fourth group introduced into the model some standard demographic variables, such as the size of the population (logged), its density, and the percentage of the population aged over 65. While larger and less urbanized provinces are supposedly more difficult to control, the size of the older population should moderate the effect of the restrictive policies, either because older people are less affected by some of the mobility restrictions (in workplaces and transit stations, for instance), or because of habits that tend not to change (in retail places and residential areas). As control variable, I also included the day of the week, since weekends, and especially Sundays, may be characterized by different activities compared to working days, being less or more affected by the policy constraints.

Table 1 reports the coefficients of a series of multivariate regressions with panel corrected standard errors having daily provincial mobility in the four areas as dependent variables and all the covariates mentioned above, plus the different color codes, as independent ones. In this exploration, I preferred to keep in the models all the potential ex-ante factors associated with mobility and compliance in order to avoid the risk of spurious relationships, even at the cost of possible collinearity. The coefficients of a series of bivariate relationships with those factors, controlling only for the stringency of the policy and the day of the week, are presented in the supplementary material in table A.1.

Table 1. *Ex-ante correlates of mobility and compliance.*

	Retail	Transit	Workplaces	Residential
Policy				
Yellow	-13.63***	-15.43***	-3.45***	4.45***
	(1.02)	(0.99)	(1.18)	(0.35)
Orange	-28.52***	-24.19***	-7.86***	7.56***
	(1.06)	(1.03)	(1.23)	(0.37)
Red	-42.15***	-36.38***	-20.02***	12.17***
	(1.26)	(1.23)	(1.47)	(0.44)
Positivity	-45.04***	-59.63***	-34.75***	29.14***
	(7.07)	(6.90)	(8.30)	(2.48)
Vaccinations	0.63***	0.71***	0.19***	-0.20***
	(0.06)	(0.06)	(0.07)	(0.02)
Service sector	0.03**	0.04**	-0.06***	0.00
	(0.02)	(0.02)	(0.01)	(0.00)
Employees pct	-0.32***	-0.17***	-0.17***	0.03***
	(0.02)	(0.02)	(0.01)	(0.00)
GDP per capita	-0.78***	-1.33***	-0.43***	0.12***
	(0.04)	(0.05)	(0.03)	(0.01)
Employment rate	0.42***	0.76***	0.25***	-0.06***
	(0.04)	(0.04)	(0.03)	(0.01)
Social capital	-0.25**	4.89***	0.80***	0.08*
	(0.12)	(0.18)	(0.11)	(0.05)
Government quality	2.22***	-2.04***	3.37***	0.00
	(0.24)	(0.26)	(0.18)	(0.08)
Log population	1.27***	-0.09	0.31***	0.04**
	(0.06)	(0.14)	(0.07)	(0.02)
Density	0.10***	0.03**	-0.04***	0.07***
	(0.01)	(0.02)	(0.01)	(0.00)
Old population	-0.05**	0.69***	-0.08***	0.10***
	(0.03)	(0.03)	(0.03)	(0.01)
Day of week				
Monday	17.47***	1.45	-9.27***	1.35**
	(1.63)	(1.56)	(1.88)	(0.55)
Tuesday	18.10***	1.82	-9.51***	1.92***
	(1.62)	(1.55)	(1.87)	(0.55)
Wednesday	17.13***	2.33	-9.71***	1.97***
	(1.62)	(1.55)	(1.87)	(0.55)
Thursday	16.94***	3.12**	-7.93***	1.75***
	(1.63)	(1.56)	(1.87)	(0.55)
Friday	13.64***	2.04	-9.44***	2.49***
	(1.62)	(1.56)	(1.87)	(0.55)
Saturday	8.01***	1.70	-7.19***	1.17**
	(1.62)	(1.56)	(1.87)	(0.55)
Constant	-11.28***	-15.37***	8.61***	-5.04***
	(1.90)	(2.54)	(2.46)	(0.69)
Observations	32356	31687	32388	32401
Provinces	107	107	107	107
R squared	0.76	0.55	0.42	0.74

Note: Panel corrected standard errors *** $p<0.01$ ** $p<0.05$ * $p<0.10$.

Including the new set of explanatory factors did not affect the influence of the color-coding policy, whose monotonically increasing association with mobility changes is still highlighted by the data. 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 relationship with the main covariates of interest are also confirmed, but some of them show inconsistent coefficients depending on the different places identified by Google mobility data[14].

Epidemiological variables show the same consistent results in both the multivariate and the bivariate models. Positivity rates, signaling the epidemiological risk, were expected to be associated with a reduction in extra-residential mobility and an increased permanence at home. The relationships are highly significant and confirmed across places, as are those regarding vaccination rates. All other things being equal, provinces that strictly follow the vaccination plans are also those that allow themselves to reduce their extra-residential mobility to a lesser extent. The coefficients for both variables are larger, in absolute terms, for transit stations and retail areas, and relatively smaller for workplaces and residential places. For the latter, the effects are less elastic, being probably already consequent on other socio-economic factors. It should also be noted that, longitudinally speaking, vaccination rates are rough proxies of a time variable, which means that the overall level of compliance diminished systematically week 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.

Economic variables were expected to be correlated with mobility mostly in workplaces and residential areas, and their effects are confirmed by the multivariate and bivariate models, and sometimes extend to mobility in other places. More specifically, it is easier to adopt smart working technologies in the service sector compared to manufacturing and agriculture, reducing the permanence in office. Complying with the mobility limitations has fewer income consequences in provinces relying more on dependent workers compared to self-

[14] 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.

employed, contract workers and independent entrepreneurs. Safety concerns prevail in richer provinces, but at the same time the larger amount of people with work obligations seems to reduce their margin of freedom and counterbalance that wealth effect[15].

Social capital was expected to boost the change in mobility in the various areas due to restrictive policies. However, together with the direct measure of government quality, it is the variable showing the most unexpected behaviors[16]. Social capital is negatively associated with mobility in retail areas and positively in residential places, as I supposed, but also positively with transit stations and workplace attendance, contrary to my expectations. The measure of the quality of local governments, based on the three indices of impartiality, quality and corruption, shows a similar uneven association. Contrary to the economic variables, comparing multivariate and bivariate models does not solve the puzzle of the odd results, which most likely depends on some spurious relationship that makes the two variables act as proxies for something not included in the regressions.

Demography also seems to play a role; but larger provinces are also the more densely populated ones and with relatively younger populations, which makes the multivariate coefficients harder to interpret. Moreover, their association with mobility and compliance most likely depends on the type of area, it not being possible to imagine a homogenous effect of those three factors combined across all places. Individually taken, from the analyses reported in the supplementary material, size and density seem to magnify the mobility consequences of policies, while the age structure of the province moderates them.

All the above relationships have been controlled for the day of the week, having Sundays as reference category. Interestingly, the change in mobility in transit stations is not associated with the precise day of the week, whereas the attendance of other places is. For example, whilst going or not going to work on Sundays has not been affected by the pandemic and its restraining policies, the comparative reduction in workplace mobility is evident on all the other days. People

[15] The two quantities are closely correlated, and the bivariate models in the supplementary material reveal that they are in fact both negatively associated with extra-residential mobility. In table 1, the two variables compete for similar quantities of the explained variance, and their opposite effects highlight how, keeping the GDP per capita constant, different work duties oppose the general trend shown by the wealthiest provinces.

[16] 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).

already stayed at home on Sundays, so that the positive relative association is now evident on all the remaining weekdays.

Finally, to be noted is that, in spite of their imperfections and possibly under-specifications, 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 0.42 and 0.76, with an additional explanatory power of 19% for mobility in retail and recreational areas, of 17% for transit stations, 12% for workplaces, and 18% for residential areas. They also improve their overall fit against most of the models with simple provincial fixed effects, adding a supplementary explained variance that ranges between 6% (for workplace mobility) and 15% (for permanence in residential areas). The only circumstance in which our covariates performed worse compared to provincial fixed effects was in respect to mobility in transit stations, which would have probably required some very specific variable related to infrastructures like airports, harbors, railway and underground stations, motorway service areas, etc.

5. Ex-post Correlates of Provincial Variation in Mobility and Compliance

The preceding 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 ex-post epidemiological correlates. 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 origins.

The dependent variable used to estimate those consequences is the incidence of new certified COVID cases, which is primarily a function of that same quantity one week before[17]. 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

[17] 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.

positivity rate, which is mostly a measure of the trend of the pandemic, with high and increasing values in the ascending phase of a wave, and lower values during more stable and less problematic phases. Finally, given the well-known up and downs showed by the registration of epidemiological data, all models include the day of the week as control variable.

To repercussions of the introduction of the restrictive policies can be assessed by comparing the respective coefficients of the mobility variables in the next two tables. In the first one, the covariates of interest are the 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 provincial color-policy in the different days and weeks, the successive table shifts the attention towards the excesses/lacks of mobility in the four places, making it possible to test the statistical significance and magnitude of non-compliance.

Table 2 confirms that extra-residential mobility is positively related with the likelihood of new contagions, whereas staying at home is inversely related to infections. Judging directly from their outcomes, mobility constraints are associated with a more limited circulation 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 almost 50 more new daily COVID cases in Italy, corresponding to 0.8 new cases per million persons. The impact of increased mobility is slightly lower for transit stations (0.6 more cases per million persons), and higher for workplaces (1 more case per million). Staying at home, plausibly cumulating the effects of multiple changes in mobility in other areas, has the largest effect, decreasing the incidence of new cases by more than 3 persons per million.

All the control variables manifest the expected highly significant associations. The incidence of new cases is for large part determined by the same values in the previous week, and it is positively related to the number of COVID tests. All other things being equal, the percentage of fully vaccinated people consistently reduces the chances for new infections, while the positivity rate increases them. Weekdays do not show regular patterns compared to Sundays, except for Mondays (aside from model 3), on which the cases of the preceding rest day are usually registered, and which in fact show mostly negative and significant coefficients beyond those due to the usually lower number of COVID tests. The overall explained variance is very high, with an R-squared of 0.87.

Table 2. *Mobility trends and the incidence of new COVID cases.*

	(1)	(2)	(3)	(4)
Lag incidence	0.57***	0.56***	0.55***	0.58***
	(0.01)	(0.01)	(0.01)	(0.01)
Retail	0.08***			
	(0.01)			
Transit		0.06***		
		(0.01)		
Workplaces			0.10***	
			(0.02)	
Residential				-0.31***
				(0.04)
Tests	1.72***	1.64***	1.59***	1.66***
	(0.07)	(0.07)	(0.07)	(0.07)
Vaccinations	-0.11***	-0.10***	-0.09**	-0.11***
	(0.03)	(0.04)	(0.04)	(0.03)
Positivity	150.90***	152.78***	151.86***	154.51***
	(4.67)	(4.75)	(4.75)	(4.62)
Day of week				
Monday	-3.23***	-2.06**	-1.09	-1.38*
	(0.84)	(0.84)	(0.86)	(0.81)
Tuesday	-1.23	0.16	1.29	0.89
	(0.84)	(0.83)	(0.85)	(0.80)
Wednesday	-0.74	0.62	1.84**	1.32*
	(0.85)	(0.83)	(0.85)	(0.80)
Thursday	-0.16	1.14	2.22***	1.80**
	(0.85)	(0.84)	(0.85)	(0.81)
Friday	-0.16	0.95	2.13**	1.77**
	(0.84)	(0.83)	(0.85)	(0.81)
Saturday	-0.14	0.50	1.44*	0.93
	(0.83)	(0.83)	(0.85)	(0.80)
Constant	-3.32***	-4.36***	-4.60***	-4.70***
	(0.82)	(0.77)	(0.77)	(0.74)
Observations	31607	30953	31639	31652
Provinces	107	107	107	107
R squared	0.87	0.87	0.87	0.87

Note: Panel corrected standard errors *** p<0.01 ** p<0.05 * p<0.10.

By adding the color measures, table 3 simultaneously serves two purposes: testing if the policies somehow contributed to contain the circulation of the virus, and verifying if the residual unconstrained mobility is still systematically associated with the new infections. If this were the case, non-compliance would have favored a further spread of the pandemic.

Table 3. *Policy constraints, extra-mobility and the incidence of new COVID cases.*

	(1)	(2)	(3)	(4)
Lag incidence	0.60***	0.59***	0.60***	0.60***
	(0.01)	(0.01)	(0.01)	(0.01)
Policy				
Yellow	-4.19***	-3.92***	-3.89***	-3.83***
	(0.55)	(80.53)	(0.52)	(0.56)
Orange	-5.26***	-4.75***	-4.70***	-4.63***
	(0.64)	(0.56)	(0.56)	(0.64)
Red	-7.55***	-6.83***	-6.50***	-6.55***
	(0.84)	(0.70)	(0.73)	(0.86)
Retail	-0.01			
	(0.01)			
Transit		0.01		
		(0.01)		
Workplaces			0.03	
			(0.02)	
Residential				-0.04
				(0.05)
Tests	1.68***	1.69***	1.69***	1.70***
	(0.07)	(0.07)	(0.07)	(0.07)
Vaccinations	-0.00	-0.02	-0.02	-0.02
	(0.03)	(0.03)	(0.03)	(0.03)
Positivity	147.79***	149.44***	149.08***	149.05***
	(4.37)	(4.44)	(4.38)	(4.36)
Day of week				
Monday	-1.57**	-1.82**	-1.52*	-1.67**
	(0.79)	(0.77)	(0.77)	(0.76)
Tuesday	0.53	0.27	0.57	0.41
	(0.79)	(0.77)	(0.77)	(0.75)
Wednesday	0.85	0.62	0.91	0.73
	(0.79)	(0.77)	(0.77)	(0.75)
Thursday	1.42**	1.19	1.43*	1.28*
	(0.79)	(0.77)	(0.77)	(0.76)
Friday	1.09	0.90	1.17	1.02
	(0.78)	(0.77)	(0.77)	(0.76)
Saturday	0.62	0.48	0.71	0.56
	(0.77)	(0.77)	(0.76)	(0.75)
Constant	-3.90***	-3.57***	-3.50***	-3.68***
	(0.77)	(0.74)	(0.72	(0.72
Observations	31607	30953	31639	31652
Provinces	107	107	107	107
R squared	0.88	0.88	0.88	0.88

Note: Panel corrected standard errors *** $p<0.01$ ** $p<0.05$ * $p<0.10$.

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, although the latter variable loses its statistical significance. The introduction of more stringent policies is systematically associated, at a week's distance, with a reduction in the contagions, with consequences whose magnitudes increase moving from yellow, to orange, to red constraints. Mondays are again the only days on which a systematically lower number of new cases is registered, confirming the pattern already shown in the preceding table.

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 systematic association between mobility and incidence of new cases registered in the previous table 2 is entirely absorbed by the reductive effects due to the different policies. The coefficients for transit stations, workplaces, and residential areas have the same signs as before, but lose their statistical significance, while the one for retail areas even changes sign, remaining very small and most of all without any systematic association with the spread of the virus.

6. Conclusion

In this research note, the analysis has proceeded step by step.

First, it has been shown that the color-coding system has contributed to reducing mobility in several different areas, as well as 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 reported in figure 4.

There are numerous potential explanations for the outlined patterns of extra-mobility; and the third step of the analysis explored some evidence regarding several epidemiological, socio-economic, institutional, and demographic variables associated with citizens' movements during the pandemic. These ex-ante correlates provided some explanation of the fact that certain provinces exhibit higher or lower mobility than do other provinces characterized by similar policy constraints, tempering their interpretation as direct proxies for compliance with the policies. At the same time, a complete explanation of the cross-country and longitudinal variation in people's habits would fall outside the scope of this research note, and would require differentiating the models according to the different types of place in which Google measured those mobility trends.

In the fourth step, a series of regression models checked the relationship between mobility and the incidence of new COVID cases, and then assessed if that relationship remained systematic even when controlling for the mobility declines induced by the more stringent policies. To synthesize: Mobility, with its inevitable social interactions, contributed to the persistence and spread of the pandemic. The color-coding system promoted a mobility reduction that, in turn, contributed to limit the spread of the virus. The good news is that the level of compliance was sufficiently large to ensure that any physiological residual extra-mobility was not enough to further contribute to the pandemic. Alternatively, but no less positively, any excess of mobility was sufficiently justified by factors such as those explored in the third step of my analysis, so that it was 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.

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