Effects of prolonged lockdown on domestic violence. Evidence from Italy.

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Abstract

According to the anecdotal evidence, local lockdowns and other non-medical measures aimed at mitigating the Covid-19 pandemic contributed to a significant increase in domestic violence worldwide. Although the Italian data from a descriptive point of view seem to confirm this trend, the complex relationships between mitigation measures and domestic violence require a more refined study. In fact, domestic violence might have surged because of various reasons, including the augmented time women had to spend restricted at home (*Exposure Theory*) and the negative economic consequences of anti-pandemic mitigation measures (*Bargaining Power Theory* vs. *Male Backlash*). All these phenomena may have also been exacerbated by the increased domestic consumption of alcohol and drugs. The aim of this study is to disentangle the complex relations between Covid-19 mitigation measures and domestic violence, particularly concentrating on the *Exposure Theory*. Trends in domestic violence are measured using text-mining techniques applied to the platform Google Trends, looking at the day-by-day records for domestic violence related terms. Non-medical Covid-19 mitigation measures are proxied by either air pollution generated by road traffic and heating at local level, or by the Stringency Index calculated by The Oxford Coronavirus Government Response Tracker (OxCGRT) project. The empirical analysis confirm the positive relationship between exposure time and frequency of domestic violence.

Keywords: Air pollution; Domestic violence; Female activity rate; Covid-19 mitigation measures.
JEL Classification: G2, K2, K4.

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Introduction

Local lockdowns and other non-medical measures aimed at mitigating the Covid-19 pandemic contributed to a significant increase in domestic violence everywhere, and Italy was not different.

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1. Literature

Domestic violence (DV) is a complex and multifaced phenomenon. Various theories have been developed in the field of economic literature aimed at motivating its drivers. Each one originates from a different subject. The most obvious and the only one that is *directly* related to some specific lockdown measures, is the augmented time women had to spend *restricted* at home and thus potentially exposed to DV, according to the theory of "exposure". Some other theories claim that a reduction of partner's and/or family's wage because of the labor market worsened conditions might have affected DV: the economic *Bargaining Theory* states that increases in the pay gap between partners might trigger more violent episodes, while the sociological theory of *Male Backlash* suggests that violence is a response to women's empowerment, because men feel their position of "heads" of the family threatened by job loss. Other explanations ground on the changes in alcohol and drugs abuse; evidence supports the idea that domestic alcohol consumption, increased during lockdowns, could have exacerbated DV.

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2. Data collection and empirical hypotheses

The response variable is collected through Google Trends. We use a text-mining algorithm designed to consider all the relevant couples and triplets of words on the topic of DV, in order to have an objective and strong proxy variable for the intensity of domestic violence in Italy. The data is on a daily basis for each region in Italy.[1]

Google Trends returns two types of values: a unique national historical series for the selected period and a set of regional indices showing interest for a given topic in each region in the selected period. To obtain a panel-type response variable, we calculated the products of the two to have a value for each week and for each region. In our study, we constructed two response variables: the first using the "Search by Topic" function (*GT-Topic*) which considers misspellings, acronyms and translations into other languages of a certain string, in our case "Domestic Violence" (Figure 1).

[Figure 1 about here - Google Trends: "Search by Topic" (*GT-Topic*)]

[1] Data is missing for Basilicata, Molise and Valle d'Aosta.

Unfortunately, the "Search by Topic" function is not available for all strings. Hence, to overcome this deficiency we also considered a variable where we selected several strings related to DV (i.e., "1522"[2], "abuse", "rape", "domestic violence" and "violence sexual") (*GT-RStrings*) (Figure 2).

[Figure 2 about here - Google Trends: "Search by strings" (*GT-RStrings*)

In both search by topic and search by strings, we performed variable smoothing techniques to reduce the seasonal effect close to November 25th, the International Day for the Elimination of Violence against Women, via a moving average of 4 weekly observations.

Data is indexed and normalized: indexed because it is extracted from an unbiased sample of Google searches and indexed in a range of values from 0 to 100, where 0 indicates that there were not enough searches to build the index, while 100 indicates the moment of greatest interest in that area and in that period; normalized because the values are compared to all searches carried out in that area and in that period; the values returned by Google Trends (*GT*) are obtained with the following formula:

$$GT_{d,i} = \frac{100}{\max(S_{d,i})} S_{d,i} \quad (1)$$

where *d* and *i* indicate the day and the geographical area, respectively, while *S* is the ratio between searches containing the keywords and total searches on a given day in a given area. The frequency depends on the selected time horizon: below 90 days it is daily, up to 5 years it is weekly, beyond that it is monthly.

As proxies of the intensity of the Covid-19 lockdown, various molecules that measure air pollution are considered. In fact, during the lockdowns imposed by the authorities to contain the spread of the virus, people were forced to stay at home for a variable number of hours. In that period, the use of cars, motorcycles, and public transport like buses and airplanes dropped dramatically in the most intense phases of the lockdown.

The air pollution is measured with 6 polluting elements (Source: ISPRA elaborations on SNPA data, 2022)[3]:

- NO_2 i.e. nitrogen dioxide;
- Nox i.e., the sum of NO_2 and NO (i.e., nitrogen monoxide);
- CO i.e., carbon monoxide;
- C_6H_6 i.e., benzene;
- PM2.5 i.e., all the particles (the so called "fine dust") with a diameter less than 2.5 micron (μm);
- PM10 like PM2.5 but with diameter less than 10 micron.

All the 6 polluting elements follow a strictly correlated pattern, we choose NO2 as the representative pollutant,[4] which likely follows the time pattern of the lockdown at national level. Figure 3 reports the monthly NO2 trend

[2] 1522 is the Italian toll-free number for reporting cases of violence by victims.
[3] Not publicly available.
[4] The reason why we chose NO2 as representative of all the other pollutants will be clear in the next paragraph dedicated to the regression analysis.

for the provinces of Lombardy, which was the Italian region most affected by the Covid-19 virus in terms of number of deaths.

[Figure 3 about here -- Monthly NO2 trend in Lombardy

The reduction of the pollution in the air is assumed to reflect a longer permanence of family members within the house (a proxy of the *Exposure* time). Accordingly, we formulate the following hypothesis:

H1: *A lower concentration of air pollution is associated with an increase of the episodes of Domestic Violence.*

We have also considered an alternative index to measure the severity of the lockdown, namely the Stringency Index, calculated by The Oxford Coronavirus Government Response Tracker (OxCGRT) project. The index is made up of 9 metrics, including the closure of schools, work environments and public transport, the limitation of gatherings and restrictions on internal travel. The index ranges from 0 to 100, with the latter indicating the maximum intensity of the lockdown in the reference period. As part of the OxCGRT project, two versions of the index were calculated, one for vaccinated people and one for unvaccinated people; we considered the weighted average of the two. The frequency of the measurements was daily but given that the government measures did not change frequently, the values remained the same for several days (54 unique values); therefore, we inserted the actual value at the beginning of each week without carrying out transformations of the original index. The data is national and therefore the same for each region. We expect that an increase of the index reflects a longer *Exposure* time. Accordingly, we formulate the following hypothesis:

[Figure 4 about here -- Monthly NO2 trend in Lombardy

H2: *Higher values of the Stringency Index are associated with an increase the episodes of Domestic Violence.*

3. Methodology

To test H1 and H2, we performed a regression analysis. The dependent variable is the Google Trend Index, while the explanatory variable is the *Exposure* time, measured either air pollution or the Stringency Index. The specification of the estimated equation is as follows:

$$GT_{i,t} = \beta_1 I_{i,t} + \beta_2 X_{i,t} + \mu_i + \varepsilon_{i,t} \quad (2)$$

where *i* refers to the region, and *t* to the week in which the DV event occurred. $GT_{i,t}$ is the response variable from Google Trends, $I_{i,t}$ is the *Exposure* time, measured either by air polluting elements or the Stringency

Index, $X_{i,t}$ is a set of covariates illustrated in the next paragraph, μ_i are regional Fixed Effects, and $\varepsilon_{i,t}$ is a zero mean error term.

In the empirical analysis, we considered 5 time windows (from 1 to 5 weeks), and "integrated" covariates, i.e. moving sums for 2, 3, 4, and 5 consecutive weeks previous to the event.

We performed different regression models with both response indexes constructed by "Search by Topic" (*GT-Topic*) and *GT-RStrings*. As model selection criteria we used AIC, BIC and log-likelihood. Four baseline models have been specified, according to the set of covariates / regional Fixed Effects, namely: (i) Pollutants + Regional Fixed Effects; (ii) Pollutants + covariates; (iii) Stringency Index + Regional Fixed Effects; and (iv) Stringency Index + covariates.

3.1 Covariates

Covariates are drawn from a large dataset provided by the Italian National Statistics Institute (ISTAT). The initial database was composed of 174 variables (4160 observations) with variable frequency and territorial disaggregation. Following a parsimony approach, we adopted statistically rigorous selection criteria aimed at reducing the number of covariates included in the regression model, in order:

- Backward stepwise selection (81 selected variables);
- Obs. report unique / obs. total > 2% (64 selected variables);
- Correlation with response variable < -0.1 and > 0.1 (42 selected variables);
- Elimination of high correlation between covariates (22 selected variables).

Among those selected, some covariates are linked to the theories on DV exposed previously. Specifically, the selection criteria preserve variables related to education, which may represent Male Backlash phenomena; wages by gender, which reflect both different degrees of Bargaining Power and Male Backlash; the IPAB index, which mainly captures Bargaining Power.

Finally, since the air polluting variables have the problem that when rainfalls occurred the air was cleaned up, but these reductions are not linked with the lockdowns. Hence, we use rainfalls as covariate to make sure that we do not account this kind of reduction in air pollution in our analysis.

Summary statistics on the covariates are reported in Table 1.[5]

[NEARING COMPLETION]

[Table 1 about here - Summary statistics for the covariates]

3.2 Correlation analysis

INSERT CORRELATION ANALYSIS BTW DV Indexes and (various definitions of) DV HERE

Correlation table among covariates, 1 table. Short paragraph, all the details in appendix.

[5] Further details are reported in Appendix 1.

[NEARING COMPLETION]

[Table 2 about here - Correlation matrix]

4. Results

In this section we present the results obtained through the estimation of equation (2) in its variants with response variable *GT-Topic* or *GT-RStrings*, including either regional fixed effects or regional-level covariates.

We start with the response variable *GT-Topic*. Given that the pattern of the six pollutants is strictly correlated through time, as a preliminary step we ran six regressions to identify the pollutant which better explains the observed variation in the data, while avoiding overfitting. Table 3 illustrates the outcome of six models with regional Fixed Effects, one per each pollutant. In the table, we report the estimated coefficients, the standard errors, t-values, and p-values, along with AIC, Log Likelihood, R squared, and F-Statistics.

[Table 3 about here - Effects of individual pollutants on Google Trends records (*GT-Topic*), Regional Fixed Effects, 1 week]

From Table 3, one can note that model with CO does not pass the F test for zero slopes, while those with PM10, PM25, and C6H6 exceed it but not for the standard significance thresholds (10% or better); NOX and NO2, instead, exceed it for all thresholds. Nonetheless, the AIC criterion for NO2 is the lowest, therefore we will use this pollutant as a benchmark measure to observe the trend of DV crimes over time intervals longer than a week.

[Table 4 about here - Effects of NO2 on Google Trends records (*GT-Topic*), Regional Fixed Effects, 2-5 weeks]

As can be seen from Tables 3 and 4, the significance of the parameter associated with NO2 for all 5 weeks preceding the DV event is negative and statistically significant. Furthermore, the size of the parameter decreases as we move away from the event (i.e. the parameter of the first week before the event is greater than in the previous weeks, the absolute smallest value is recorded in the 5th week before the event).

[Table 5 about here - Effects of NO2 on Google Trends records (*GT-Topic*), Covariates, 1-5 weeks]

As anticipated, we repeated the analysis conducted previously by adopting the Stringency Index calculated by the OxCGRT project as a proxy for Exposure, as an alternative to pollutants. The results corresponding to the specification of equation (2) with regional fixed effects are reported in Table 6.

[Table 6 about here - Effects of the Stringency Index on Google Trends records (*GT-Topic*), Regional Fixed Effects, 1-5 weeks]

As can be seen in Table 6, the Stringency Index also appears to significantly influence the DV phenomenon. The estimated parameter is positive, indicating that a greater intensity of the lockdown is associated with a higher incidence of DV cases. As previously observed for the representative pollutant NO2, also the parameter associated with the Stringency Index decreases as we move away from the week immediately preceding the event.
The results using the covariates insted of the Fixed Effects (Table 7) confirm the previous analysis.

[Table 7 about here - Effects of the Stringency Index on Google Trends records (*GT-Topic*), Covariates, 1-5 weeks]

[Table 8 about here - Effects of individual pollutants on Google Trends Strings (*GT-RStrings*), Regional Fixed Effects, 1 week]

Unlike the case with the dependent variable *GT-Topic*, the best performing pollutants according to the AIC criterion are both C6H6 and NO2 (Table 8). Given the closeness between the two AIC values, we decided to perform the regression analysis including both. Table 9 reports the estimates of both NO2 and C6H6 on Google Trends Strings (*GT-RStrings*), with Regional Fixed Effects. Both parameters show the expected (negative) sign for all the five weeks previous to the event, and like in the previous analysis the parameters decrease as we move away from the DV event over time.

[Table 9 about here - Effects of NO2 and C6H6 on Google Trends Strings (*GT-RStrings*), Regional Fixed Effects, 1-5 weeks]

[Table 10 about here - Effects of NO2 and C6H6 on Google Trends Strings (*GT-RStrings*), Covariates, 1-5 weeks]

[Table 11 about here - Effects of the Stringency Index on Google Trends Strings (*GT-RStrings*), Regional Fixed Effects, 1-5 weeks]

Table 11 shows the estimated parameters for the Stringency Index on *GT-RStrings* in the Fixed Effects model. Also in this case the parameters show the expected (positive) sign and are always significant at 1 per cent level for all the five weeks previous to the event. Again, the parameters decrease as we move away from the DV event over time. Table 12, using covariates instead of the Fixed Effects confirms the results of the previous analysis.

[Table 12 about here - Effects of the Stringency Index on Google Trends Strings (*GT-RStrings*), Covariates, 1-5 weeks]

4.1 Robustness

5. Conclusions

In this paper, …….

The outcomes of our analysis are extremely important for policy makers worldwide to prevent the increase of violent episodes during pandemic crises or other phenomena which require prolonged lockdown periods.

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FIGURES AND TABLES

Figure 1 - Google Trends: "Search by Topic" (*GT-Topic*)

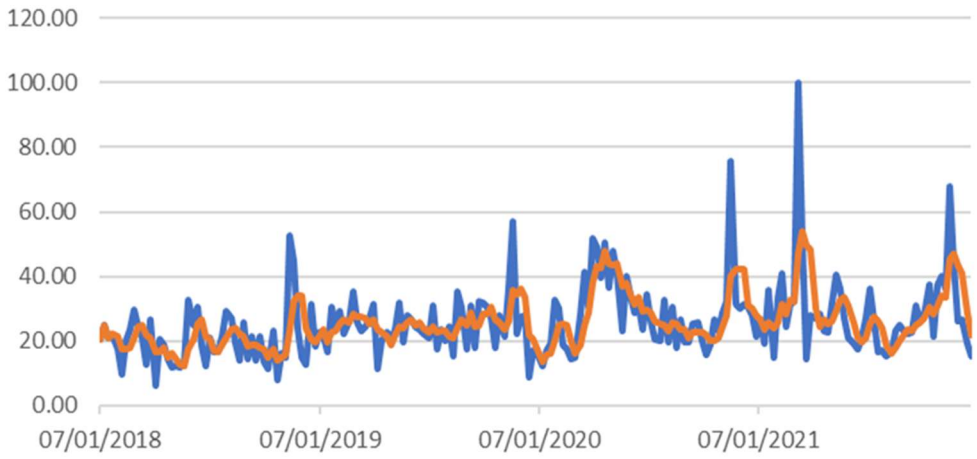


Figure 2 - Google Trends: "Search by strings" (*GT-RStrings*)

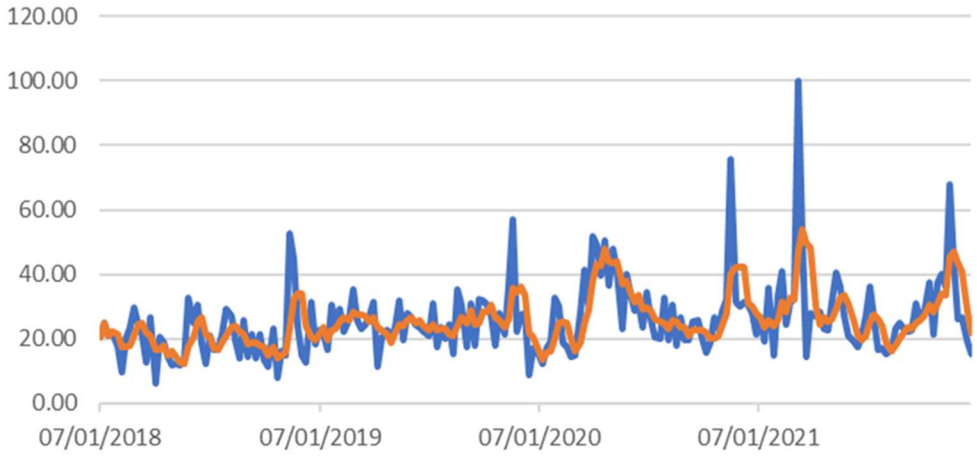


Figure 3 - Monthly NO2 trend in Lombardy

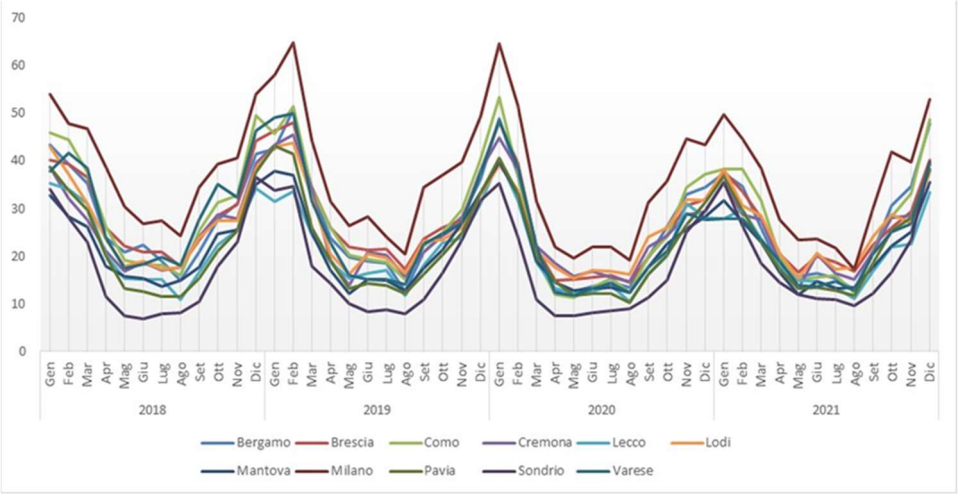
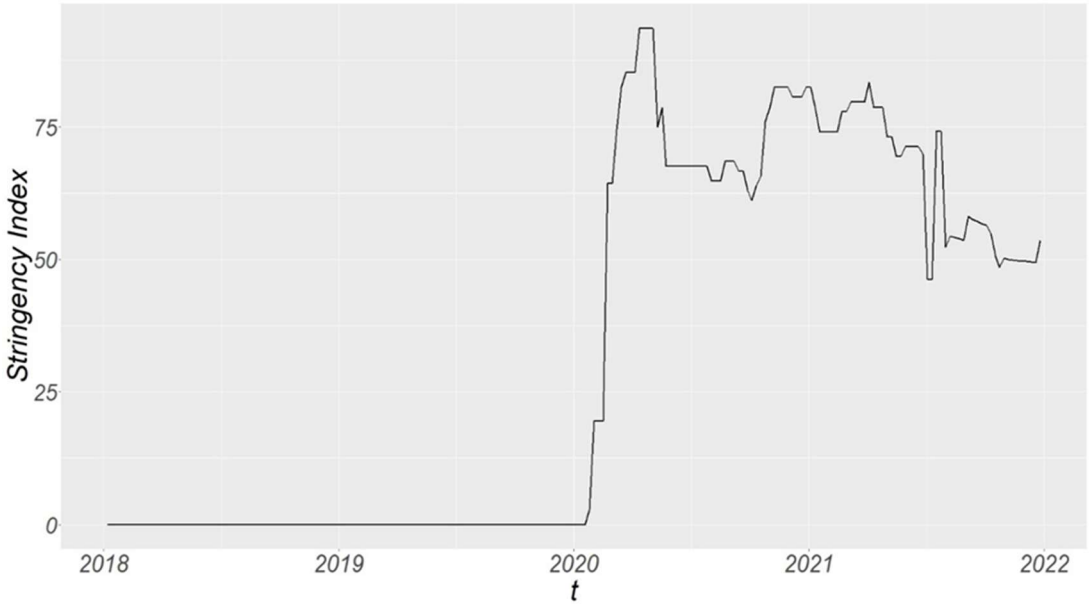


Figure 4 - Stringency Index, The Oxford Coronavirus Government Response Tracker (OxCGRT) project



The Index is Composed of 9 metrics: Closure of schools; Closure of working environments; Cancellation of public events; Limitation to gatherings; Closure of public transport; Indications "stay at home"; Public information campaigns; Restrictions on internal travel; Checks on international travel. Value between 0 and 100, national. Weighted average of the index for vaccinated and unvaccinated.

Table 3 - Effects of individual pollutants on Google Trends records (*GT-Topic*), Regional Fixed Effects, 1 week

	Estimate	Std. Error	t value	Pr(>|t|)	Signif.
nox - 1 week	-3.51E-02	9.00E-03	-3.896	9.92E-05	***
Residual standard error: 8.545 on 4159 degrees of freedom					
Multiple R-squared: 0.003638, Adjusted R-squared: 0.003398					
F-statistic: 15.18 on 1 and 4159 DF, p-value: 9.905e-05					
AIC: 29658.23					
Log Lik: -14827.12					
no2 - 1 week	-1.28E-01	2.02E-02	-6.335	2.63E-10	***
Residual standard error: 8.52 on 4159 degrees of freedom					
Multiple R-squared: 0.009557, Adjusted R-squared: 0.009319					
F-statistic: 40.13 on 1 and 4159 DF, p-value: 2.625e-10					
AIC: 29633.44					
Log Lik: -14814.72					
co - 1 week	-3.11E-01	4.78E-01	-0.65	5.16E-01	
Residual standard error: 8.561 on 4159 degrees of freedom					
Multiple R-squared: 0.0001015, Adjusted R-squared: -0.0001389					
F-statistic: 0.4223 on 1 and 4159 DF, p-value: 0.5158					
AIC: 29672					
Log Lik: -14834.49					
pm10 - 1 week	-4.78E-02	1.47E-02	-3.24	1.17E-03	**
Residual standard error: 8.55 on 4159 degrees of freedom					
Multiple R-squared: 0.002529, Adjusted R-squared: 0.002289					
F-statistic: 10.55 on 1 and 4159 DF, p-value: 0.001174					
AIC: 29662.86					
Log Lik: -14829.43					
pm25 - 1 week	-4.22E-02	1.97E-02	-2.147	3.18E-02	*
Residual standard error: 8.556 on 4159 degrees of freedom					
Multiple R-squared: 0.001107, Adjusted R-squared: 0.0008672					
F-statistic: 4.611 on 1 and 4159 DF, p-value: 0.03183					
AIC: 29668.79					
Log Lik: -14832.39					
c6h6 - 1 week	-4.47E-01	2.43E-01	-1.837	6.63E-02	.
Residual standard error: 8.558 on 4159 degrees of freedom					
Multiple R-squared: 0.0008105, Adjusted R-squared: 0.0005702					
F-statistic: 3.374 on 1 and 4159 DF, p-value: 0.06632					
AIC: 29670.2					
Log Lik: -14833.01					
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					

Table 4 - Effects of NO2 on Google Trends records (*GT-Topic*), Regional Fixed Effects, 2-5 weeks

	Estimate	Std. Error	t value	Pr(>|t|)	Signif.
no2 - 2 weeks	-5.78E-02	1.05E-02	-5.499	4.04E-08	***
Residual standard error: 8.53 on 4159 degrees of freedom					
Multiple R-squared: 0.007219, Adjusted R-squared: 0.006981					
F-statistic: 30.24 on 1 and 4159 DF, p-value: 4.039e-08					
AIC: 29643.25					
Log Lik: -14819.63					
no2- 3 weeks	-3.64E-02	7.18E-03	-5.078	3.98E-07	***
Residual standard error: 8.535 on 4159 degrees of freedom					
Multiple R-squared: 0.006162, Adjusted R-squared: 0.005923					
F-statistic: 25.79 on 1 and 4159 DF, p-value: 3.977e-07					
AIC: 29647.68					
Log Lik: -14821.84					
no2- 4 weeks	-2.38E-02	5.48E-03	-4.347	1.41E-05	***
Residual standard error: 8.542 on 4159 degrees of freedom					
Multiple R-squared: 0.004524, Adjusted R-squared: 0.004284					
F-statistic: 18.9 on 1 and 4159 DF, p-value: 1.411e-05					
AIC: 29654.53					
Log Lik: -14825.27					
no2 - 5 weeks	-1.93E-02	4.45E-03	-4.334	1.50E-05	***
Residual standard error: 8.542 on 4159 degrees of freedom					
Multiple R-squared: 0.004524, Adjusted R-squared: 0.004284					
F-statistic: 18.87 on 1 and 4159 DF, p-value: 1.498e-05					
AIC: 29654.65					
Log Lik: -14825.32					

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table 5 - Effects of NO2 on Google Trends records (GT-Topic), Covariates, 1-5 weeks

	Estimate	Std. Error	t value	Pr(>|t|)	Signif.
no2 - 1 week	-0.1462	0.02507	-5.829	6,00E-09	***
Residual standard error: 9.682 on 4137 degrees of freedom					
Multiple R-squared: 0.3038, Adjusted R-squared: 0.3001					
F-statistic: 82.06 on 22 and 4137 DF, p-value: <2.2e-16					
AIC: 30718.82					
Log Lik: -15335.41					
no2 - 2 weeks	-7.46E-02	1.33E-02	-5.629	1.94E-08	***
Residual standard error: 9.675 on 4137 degrees of freedom					
Multiple R-squared: 0.3048, Adjusted R-squared: 0.3011					
F-statistic: 82.44 on 22 and 4137 DF, p-value: <2.2e-16					
AIC: 30712.98					
Log Lik: -15332.49					
no2 - 3 weeks	-4.98E-02	9.15E-03	-5.443	5.56E-08	***
Residual standard error: 9.677 on 4137 degrees of freedom					
Multiple R-squared: 0.3045, Adjusted R-squared: 0.3008					
F-statistic: 82.32 on 22 and 4137 DF, p-value: <2.2e-16					
AIC: 30714.91					
Log Lik: -15333.45					
no2 - 4 weeks	-3.47E-02	7.05E-03	-4.917	9.11E-07	***
Residual standard error: 9.686 on 4137 degrees of freedom					
Multiple R-squared: 0.3033, Adjusted R-squared: 0.2995					
F-statistic: 81.84 on 22 and 4137 DF, p-value: <2.2e-16					
AIC: 30722.2					
Log Lik: -15337.1					
no2 - 5 weeks	-3.04E-02	5.77E-03	-5.273	1.41E-07	***
Residual standard error: 9.684 on 4137 degrees of freedom					
Multiple R-squared: 0.3035, Adjusted R-squared: 0.2998					
F-statistic: 81.94 on 22 and 4137 DF, p-value: <2.2e-16					
AIC: 30720.77					
Log Lik: -15336.39					

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table 6 - Effects of the Stringency Index on Google Trends records (GT-Topic), Regional Fixed Effects, 1-5 weeks

	Estimate	Std. Error	t value	Pr(>|t|)	Signif.
stringency_idx- 1 week	0.077431	0.003568	21.7	<2e-16	***
Residual standard error: 8.114 on 4159 degrees of freedom					
Multiple R-squared: 0.1017, Adjusted R-squared: 0.1015					
F-statistic: 470.8 on 1 and 4159 DF, p-value: <2.2e-16					
AIC: 29227.25					
Log Lik: -14611.63					
stringency_idx- 2 weeks	0.03912	0.00179	21.86	<2e-16	***
Residual standard error: 8.108 on 4159 degrees of freedom					
Multiple R-squared: 0.103, Adjusted R-squared: 0.1028					
F-statistic: 477.7 on 1 and 4159 DF, p-value: <2.2e-16					
AIC: 29221.08					
Log Lik: -14608.54					
stringency_idx- 3 weeks	0.026505	0.001195	22.18	<2e-16	***
Residual standard error: 8.096 on 4159 degrees of freedom					
Multiple R-squared: 0.1058, Adjusted R-squared: 0.1055					
F-statistic: 491.9 on 1 and 4159 DF, p-value: <2.2e-16					
AIC: 29208.4					
Log Lik: -14602.2					
stringency_idx- 4 weeks	0.0200457	0.0008982	22.32	<2e-16	***
Residual standard error: 8.09 on 4159 degrees of freedom					
Multiple R-squared: 0.107, Adjusted R-squared: 0.1067					
F-statistic: 498.1 on 1 and 4159 DF, p-value: <2.2e-16					
AIC: 29202.8					
Log Lik: -14599.4					
stringency_idx- 5 weeks	0.0160762	0.0007205	22.31	<2e-16	***
Residual standard error: 8.09 on 4159 degrees of freedom					
Multiple R-squared: 0.1069, Adjusted R-squared: 0.1067					
F-statistic: 497.8 on 1 and 4159 DF, p-value: <2.2e-16					
AIC: 29203.08					
Log Lik: -14599.54					

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table 7 - Effects of the Stringency Index on Google Trends records (GT-Topic), Covariates, 1-5 weeks

	Estimate	Std. Error	t value	Pr(>|t|)	Signif.
Stringency_Index - 1 week	3.99E-02	6.36E-03	6.281	3.72E-10	***
Residual standard error: 9.675 on 4137 degrees of freedom					
Multiple R-squared: 0.3047, Adjusted R-squared: 0.301					
F-statistic: 82.42 on 22 and 4137 DF, p-value: <2.2e-16					
AIC: 30713.38					
Log Lik: -15332.69					
Stringency_Index - 2 weeks	2.12E-02	3.20E-03	6.615	4.20E-11	***
Residual standard error: 9.661 on 4137 degrees of freedom					
Multiple R-squared: 0.3068, Adjusted R-squared: 0.3031					
F-statistic: 83.23 on 22 and 4137 DF, p-value: <2.2e-16					
AIC: 30700.95					
Log Lik: -15326.48					
Stringency_Index - 3 weeks	1.54E-02	2.14E-03	7.19	7.63E-13	***
Residual standard error: 9.665 on 4137 degrees of freedom					
Multiple R-squared: 0.3081, Adjusted R-squared: 0.3045					
F-statistic: 83.75 on 22 and 4137 DF, p-value: <2.2e-16					
AIC: 30692.92					
Log Lik: -15322.46					
Stringency_Index - 4 weeks	1.21E-02	1.62E-03	7.468	9.91E-14	***
Residual standard error: 9.649 on 4137 degrees of freedom					
Multiple R-squared: 0.3085, Adjusted R-squared: 0.3048					
F-statistic: 83.89 on 22 and 4137 DF, p-value: <2.2e-16					
AIC: 30690.4					
Log Lik: -15321.37					
Stringency_Index - 5 weeks	9.96E-03	1.30E-03	7.64	2.69E-14	***
Residual standard error: 9.649 on 4137 degrees of freedom					
Multiple R-squared: 0.3086, Adjusted R-squared: 0.3049					
F-statistic: 83.92 on 22 and 4137 DF, p-value: <2.2e-16					
AIC: 30690.36					
Log Lik: -15321.18					

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table 8 - Effects of individual pollutants on Google Trends Strings (GT-RStrings), Regional Fixed Effects, 1 week

	Estimate	Std. Error	t value	Pr(>|t|)	Signif.
nox - 1 week	-0.069033	0.006847	-10.08	<2e-16	***
Residual standard error: 6.503 on 4159 degrees of freedom					
Multiple R-squared: 0.02385, Adjusted R-squared: 0.02362					
F-statistic: 101.6 on 1 and 4159 DF, p-value: <2.2e-16					
AIC: 27386.03					
Log Lik: -13691.02					
no2 - 1 week	-0.23953	0.01515	-15.81	<2e-16	***
Residual standard error: 6.393 on 4159 degrees of freedom					
Multiple R-squared: 0.05667, Adjusted R-squared: 0.05645					
F-statistic: 249.9 on 1 and 4159 DF, p-value: <2.2e-16					
AIC: 27243.77					
Log Lik: -13619.89					
co - 1 week	-40.672	0.3622	-11.23	<2e-16	***
Residual standard error: 6.485 on 4159 degrees of freedom					
Multiple R-squared: 0.02943, Adjusted R-squared: 0.02919					
F-statistic: 126.1 on 1 and 4159 DF, p-value: <2.2e-16					
AIC: 27362.22					
Log Lik: -13679.11					
pm10 - 1 week	-0.11337	0.01119	-10.13	<2e-16	***
Residual standard error: 6.502 on 4159 degrees of freedom					
Multiple R-squared: 0.02407, Adjusted R-squared: 0.02384					
F-statistic: 102.6 on 1 and 4159 DF, p-value: <2.2e-16					
AIC: 27385.11					
Log Lik: -13690.56					
pm25 - 1 week	-0.19232	0.01482	-12.98	<2e-16	***
Residual standard error: 6.502 on 4159 degrees of freedom					
Multiple R-squared: 0.02407, Adjusted R-squared: 0.02384					
F-statistic: 102.6 on 1 and 4159 DF, p-value: <2.2e-16					
AIC: 27385.11					
Log Lik: -13690.56					
c6h6 - 1 week	-28.889	0.1815	-15.91	<2e-16	***
Residual standard error: 6.39 on 4159 degrees of freedom					
Multiple R-squared: 0.05741, Adjusted R-squared: 0.05718					
F-statistic: 253.3 on 1 and 4159 DF, p-value: <2.2e-16					
AIC: 27240.53					
Log Lik: -13618.26					

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table 9 Effects of NO2 and C6H6 on Google Trends Strings (GT-RStrings), Regional Fixed Effects, 1-5 weeks

	Estimate	Std. Error	t value	Pr(>|t|)	Signif.
no2 - 1 week	-0.13698	0.02171	-6.308	3.11E-10	***
c6h6 - 1 week	-170.767	0.2602	-6.563	5.92E-11	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					
Residual standard error: 6.361 on 4158 degrees of freedom					
Multiple R-squared: 0.06634, Adjusted R-squared: 0.06589					
F-statistic: 147.7 on 2 and 4158 DF, p-value: <2.2e-16					
AIC: 27202.9					
Log Lik: -13598.45					
	Estimate	Std. Error	t value	Pr(>|t|)	
no2 - 2 weeks	-0.08009	0.0114	-7.024	2.51E-12	***
c6h6 - 2 weeks	-0.92274	0.13631	-6.77	1.47E-11	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					
Residual standard error: 6.321 on 4158 degrees of freedom					
Multiple R-squared: 0.07813, Adjusted R-squared: 0.07769					
F-statistic: 176.2 on 2 and 4158 DF, p-value: <2.2e-16					
AIC: 27150.03					
Log Lik: -13572.02					
	Estimate	Std. Error	t value	Pr(>|t|)	
no2 - 3 weeks	-0.058318	0.007834	-7.444	1.18E-13	***
c6h6 - 3 weeks	-0.658279	0.093607	-7.032	2.36E-12	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					
Residual standard error: 6.288 on 4158 degrees of freedom					
Multiple R-squared: 0.08774, Adjusted R-squared: 0.0873					
F-statistic: 200 on 2 and 4158 DF, p-value: <2.2e-16					
AIC: 27106.45					
Log Lik: -13550.23					
	Estimate	Std. Error	t value	Pr(>|t|)	
no2 - 4 weeks	-0.046924	0.006015	-7.802	7.67E-15	***
c6h6 - 4 weeks	-0.509057	0.071879	-7.082	1.66E-12	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					
Residual standard error: 6.265 on 4158 degrees of freedom					
Multiple R-squared: 0.09438, Adjusted R-squared: 0.09394					
F-statistic: 216.7 on 2 and 4158 DF, p-value: <2.2e-16					
AIC: 27076.09					
Log Lik: -13535.04					
	Estimate	Std. Error	t value	Pr(>|t|)	
no2 - 5 weeks	-0.039851	0.004906	-8.123	5.94E-16	***

c6h6 - 5 weeks	-0.417645	0.05865	-7.121	1.26E-12	***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 6.244 on 4158 degrees of freedom

Multiple R-squared: 0.1003, Adjusted R-squared: 0.09986

F-statistic: 231.7 on 2 and 4158 DF, p-value: <2.2e-16

AIC: 27048.83

Log Lik: -13521.42

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table 10 - Effects of NO2 and C6H6 on Google Trends Strings (GT-RStrings), Covariates, 1-5 weeks

	Estimate	Std. Error	t value	Pr(>|t|)	Signif.
no2 - 1 week	-1.42E-01	1.84E-02	-7.729	1.35E-14	***
c6h6 - 1 week	-5.63E-01	2.24E-01	-2.521	0.011753	*
Residual standard error: 5.888 on 4136 degrees of freedom					
Multiple R-squared: 0.3135, Adjusted R-squared: 0.3097					
F-statistic: 82.12 on 23 and 4136 DF, p-value: <2.2e-16					
AIC: 26582.11					
Log Lik: -13266.05					
no2 - 2 weeks	-7.81E-02	9.59E-03	-8.153	4.67E-16	***
c6h6 - 2 weeks	-3.36E-01	1.16E-01	-2.903	0.003719	**
Residual standard error: 5.872 on 4136 degrees of freedom					
Multiple R-squared: 0.3173, Adjusted R-squared: 0.3135					
F-statistic: 83.56 on 23 and 4136 DF, p-value: <2.2e-16					
AIC: 26559.25					
Log Lik: -13254.62					
no2 - 3 weeks	-5.11E-02	6.52E-03	-7.846	5.44E-15	***
c6h6 - 3 weeks	-2.72E-01	7.85E-02	-3.464	0.000537	***
Residual standard error: 5.85 on 4136 degrees of freedom					
Multiple R-squared: 0.3222, Adjusted R-squared: 0.3185					
F-statistic: 85.5 on 23 and 4136 DF, p-value: <2.2e-16					
AIC: 26528.76					
Log Lik: -13239.38					
no2 - 4 weeks	-3.89E-02	4.97E-03	-7.839	5.74E-15	***
c6h6 - 4 weeks	-2.01E-01	5.98E-02	-3.363	0.000779	***
Residual standard error: 5.829 on 4136 degrees of freedom					
Multiple R-squared: 0.3272, Adjusted R-squared: 0.3235					
F-statistic: 87.47 on 23 and 4136 DF, p-value: <2.2e-16					
AIC: 26498.06					
Log Lik: -13224.03					
no2 - 5 weeks	-3.23E-02	4.03E-03	-8.012	1.45E-15	***
c6h6 - 5 weeks	-1.57E-01	4.86E-02	-3.224	0.001273	**
Residual standard error: 5.81 on 4136 degrees of freedom					
Multiple R-squared: 0.3315, Adjusted R-squared: 0.3278					
F-statistic: 89.18 on 23 and 4136 DF, p-value: <2.2e-16					
AIC: 26471.42					
Log Lik: -13210.71					

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table 11 - Effects of the Stringency Index on Google Trends Strings (GT-RStrings), Regional Fixed Effects, 1-5 weeks

	Estimate	Std. Error	t value	Pr(>|t|)	Signif.
stringency_idx - 1 week	0.102363	0.002421	42.28	<2e-16	***
Residual standard error: 5.504 on 4159 degrees of freedom					
Multiple R-squared: 0.3007, Adjusted R-squared: 0.3005					
F-statistic: 1788 on 1 and 4159 DF, p-value: <2.2e-16					
AIC: 25998.8					
Log Lik: -12997.4					
stringency_idx - 2 weeks	0.05146	0.001214	42.38	<2e-16	***
Residual standard error: 5.501 on 4159 degrees of freedom					
Multiple R-squared: 0.3016, Adjusted R-squared: 0.3014					
F-statistic: 1796 on 1 and 4159 DF, p-value: <2.2e-16					
AIC: 25993.4					
Log Lik: -12994.7					
stringency_idx - 3 weeks	0.0347218	0.0008089	42.93	<2e-16	***
Residual standard error: 5.479 on 4159 degrees of freedom					
Multiple R-squared: 0.307, Adjusted R-squared: 0.3069					
F-statistic: 1843 on 1 and 4159 DF, p-value: <2.2e-16					
AIC: 25960.73					
Log Lik: -12978.36					
stringency_idx - 4 weeks	0.026233	0.000607	43.21	<2e-16	***
Residual standard error: 5.468 on 4159 degrees of freedom					
Multiple R-squared: 0.3099, Adjusted R-squared: 0.3067					
F-statistic: 1867 on 1 and 4159 DF, p-value: <2.2e-16					
AIC: 25943.58					
Log Lik: -12969.79					
stringency_idx - 5 weeks	0.0211143	0.0004862	43.42	<2e-16	***
Residual standard error: 5.46 on 4159 degrees of freedom					
Multiple R-squared: 0.3119, Adjusted R-squared: 0.3118					
F-statistic: 1886 on 1 and 4159 DF, p-value: <2.2e-16					
AIC: 25931.1					
Log Lik: -12963.55					

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table 12 Effects of the Stringency Index on Google Trends Strings (GT-RStrings), Covariates, 1-5 weeks

	Estimate	Std. Error	t value	Pr(>|t|)	Signif.
Stringency_Index - 1 week	1,07E-01	3,56E-03	30,153	< 2e-16	***
Residual standard error: 5.413 on 4137 degrees of freedom					
Multiple R-squared: 0.4198, Adjusted R-squared: 0.4167					
F-statistic: 136 on 22 and 4137 DF, p-value: <2.2e-16					
AIC: 25880.6					
Log Lik: -12916.3					
Stringency_Index - 2 weeks	5,48E-02	1,78E-03	30,725	< 2e-16	***
Residual standard error: 5.388 on 4137 degrees of freedom					
Multiple R-squared: 0.4249, Adjusted R-squared: 0.4218					
F-statistic: 138.9 on 22 and 4137 DF, p-value: <2.2e-16					
AIC: 25843.54					
Log Lik: -12897.77					
Stringency_Index - 3 weeks	3,77E-02	1,18E-03	31,816	< 2e-16	***
Residual standard error: 5.333 on 4137 degrees of freedom					
Multiple R-squared: 0.4368, Adjusted R-squared: 0.4338					
F-statistic: 145.8 on 22 and 4137 DF, p-value: <2.2e-16					
AIC: 25756.82					
Log Lik: -12854.41					
Stringency_Index - 4 weeks	2,87E-02	8,87E-04	32,364	< 2e-16	***
Residual standard error: 5.292 on 4137 degrees of freedom					
Multiple R-squared: 0.4453, Adjusted R-squared: 0.4424					
F-statistic: 151 on 22 and 4137 DF, p-value: <2.2e-16					
AIC: 25693.02					
Log Lik: -12822.51					
Stringency_Index - 5 weeks	2,33E-02	7,12E-04	32,677	< 2e-16	***
Residual standard error: 5.265 on 4137 degrees of freedom					
Multiple R-squared: 0.4511, Adjusted R-squared: 0.4481					
F-statistic: 154.5 on 22 and 4137 DF, p-value: <2.2e-16					
AIC: 25649.93					
Log Lik: -12800.97					

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

APPENDIX 1- Covariates

Covariates (see Section 4.1) can be summarized into three main subcategories:

Variables closely related to DV:

1. Calls to 1522
2. Mistreatment against family members and cohabitants
3. Persecutory acts, stalking

Social variables:

4. Marriages with at least one foreign spouse
5. Marriages with both Italian spouses
6. Male resident population
7. Education, male, age 25-64
8. Education, female, age 25-64
9. Single parents, male
10. Single parents, female
11. Single parents %
12. People over 11 years of age who consume alcohol

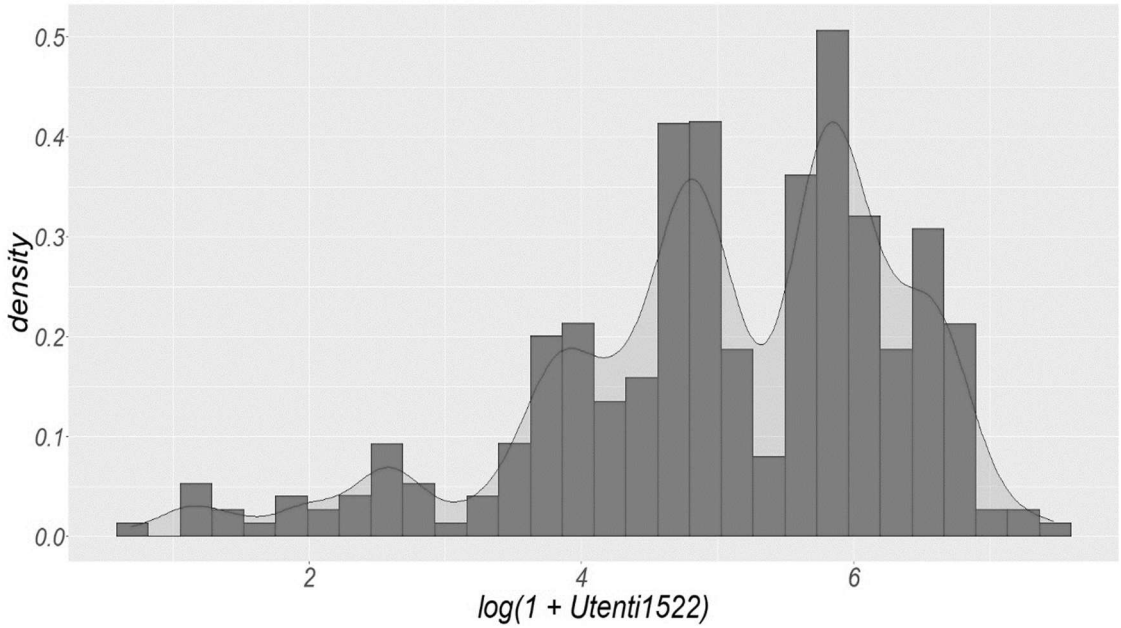
Economic variables:

13. Gross hourly wages, male
14. Gross hourly wages, female
15. Gross hourly wages, young population
16. Total final consumption expenditure
17. IPAB (Housing Price Index), all items
18. IPAB (Housing Price Index), new houses
19. IPAB (Housing Price Index), existing houses
20. IPAB (Housing Price Index), trend changes, all items

Variables closely related to DV

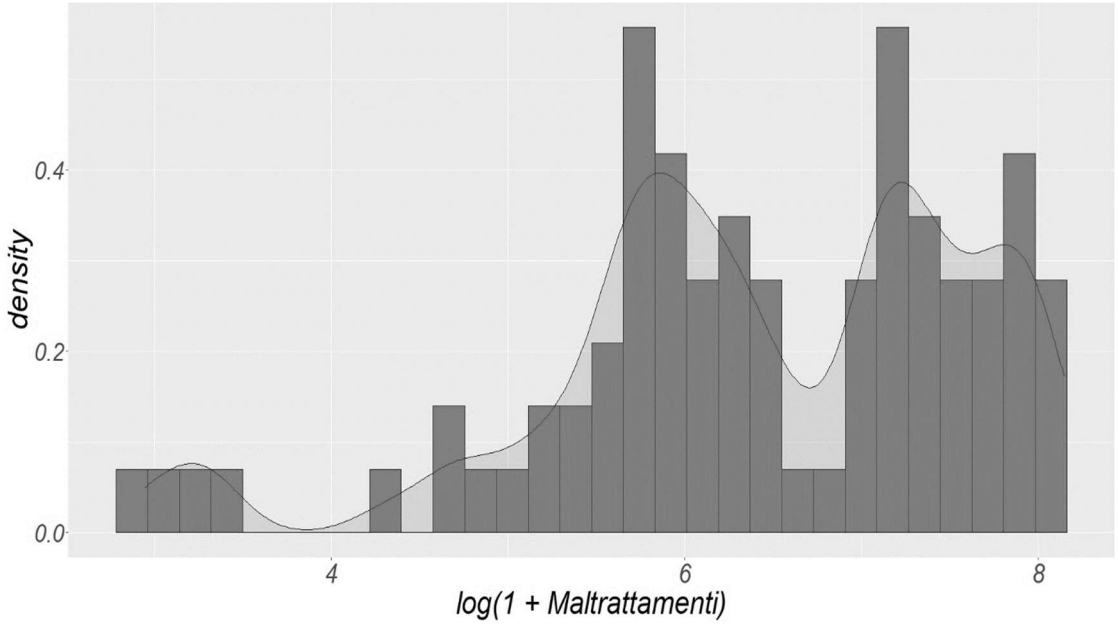
1. Calls to 1522. 1522 is the anti-violence and anti-stalking number in Italy; this variable reports the number of users who called the number requesting help for themselves or someone they knew. The original data had a quarterly frequency and provincial breakdown, the provincial values were summed up to obtain the regional values.

Figure A1 - Distribution/density of the log transformed variable Calls to 1522



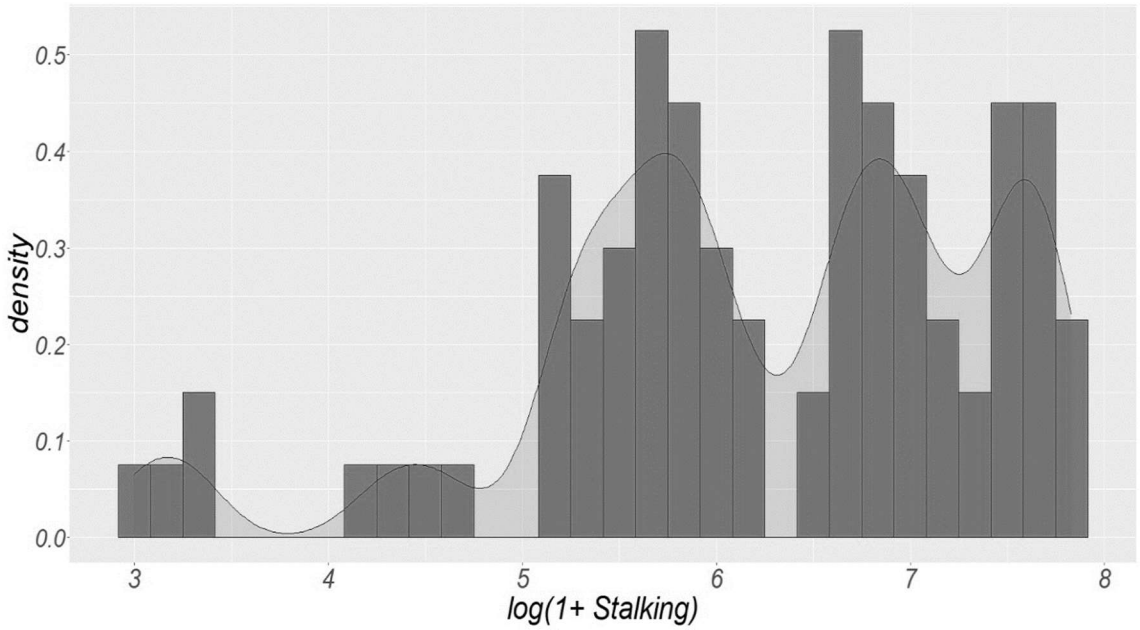
2. Mistreatment against family members and cohabitants. The variable reports the absolute number of crimes reported by the police force to the judicial authority; the original data had annual frequency and provincial breakdown; the regional were calculated by summing up the provincial values.

Figure A2 - Distribution/density of the log transformed variable Mistreatment against family members and cohabitants



3. Persecutory acts, stalking. The same premise as the previous variable applies.

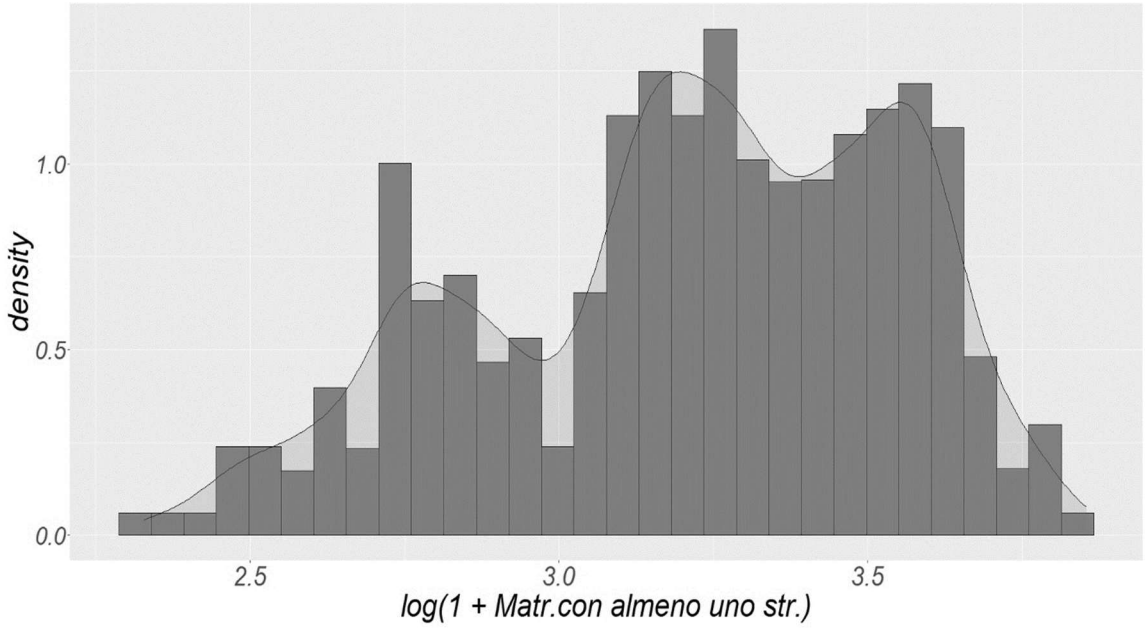
Figure A3 - Distribution/density of the log transformed variable Persecutory acts, stalking



Social variables

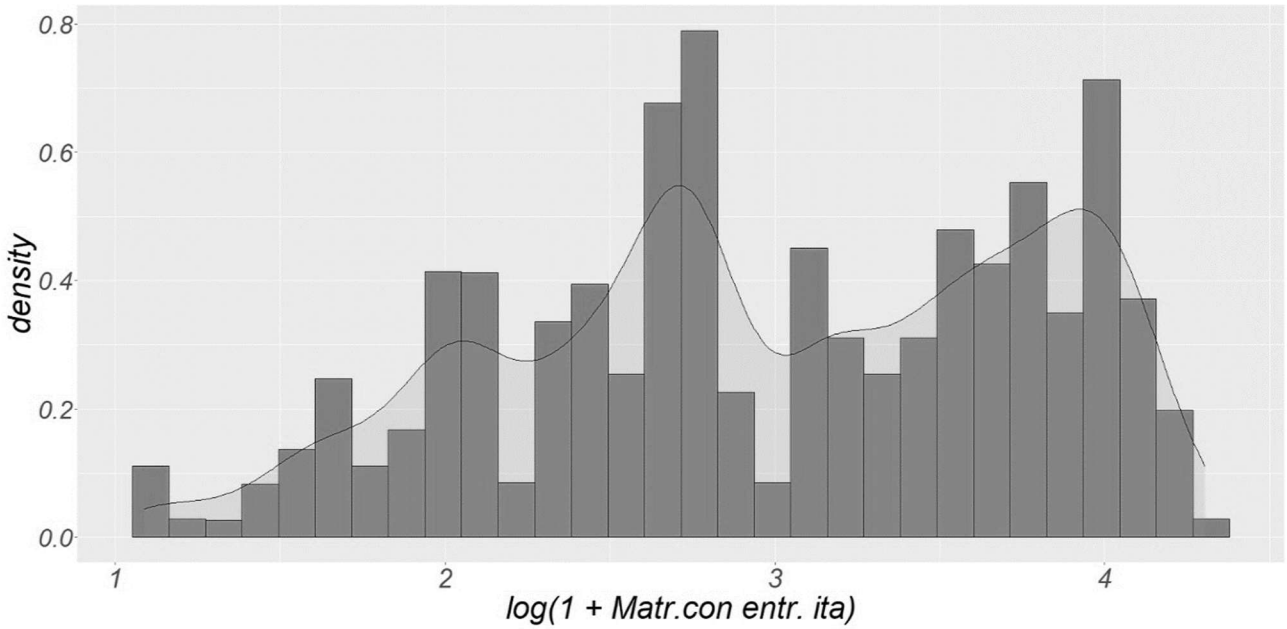
4. Marriages with at least one foreign spouse. The original data were yearly percentages over total weddings at a quarterly frequency and provincial breakdown; the provincial values were summed up to obtain regional values.

Figure A4 - Distribution/density of the log transformed variable Marriages with at least one foreign spouse



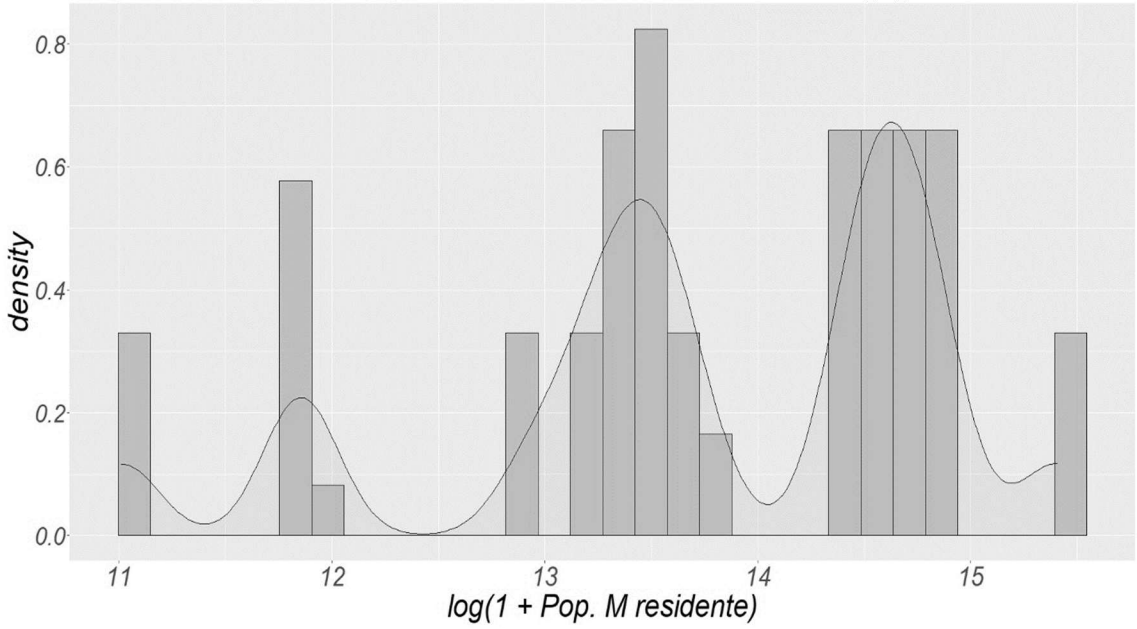
5. Marriages with both Italian spouses. The same premise as the previous variable applies.

Figure A5 - Distribution/density of the log transformed variable Marriages with both Italian spouses



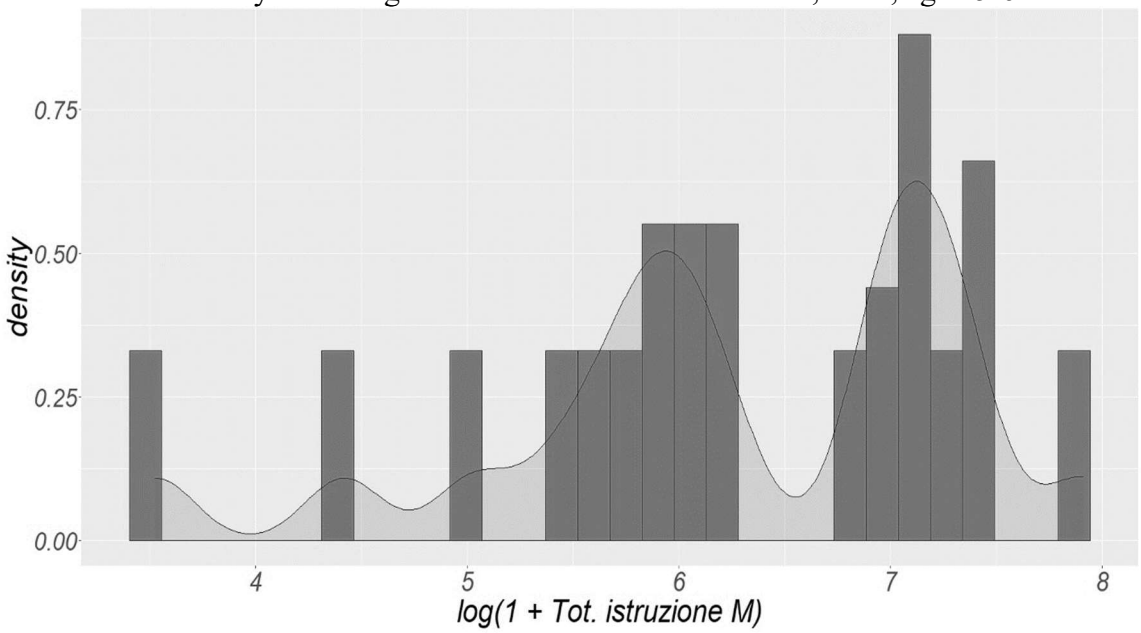
6. Male resident population. The original data was at annual frequency and provincial breakdown, the regional values were obtained by adding the values of the individual provinces.

Figure A6 - Distribution/density of the log transformed variable Male resident population



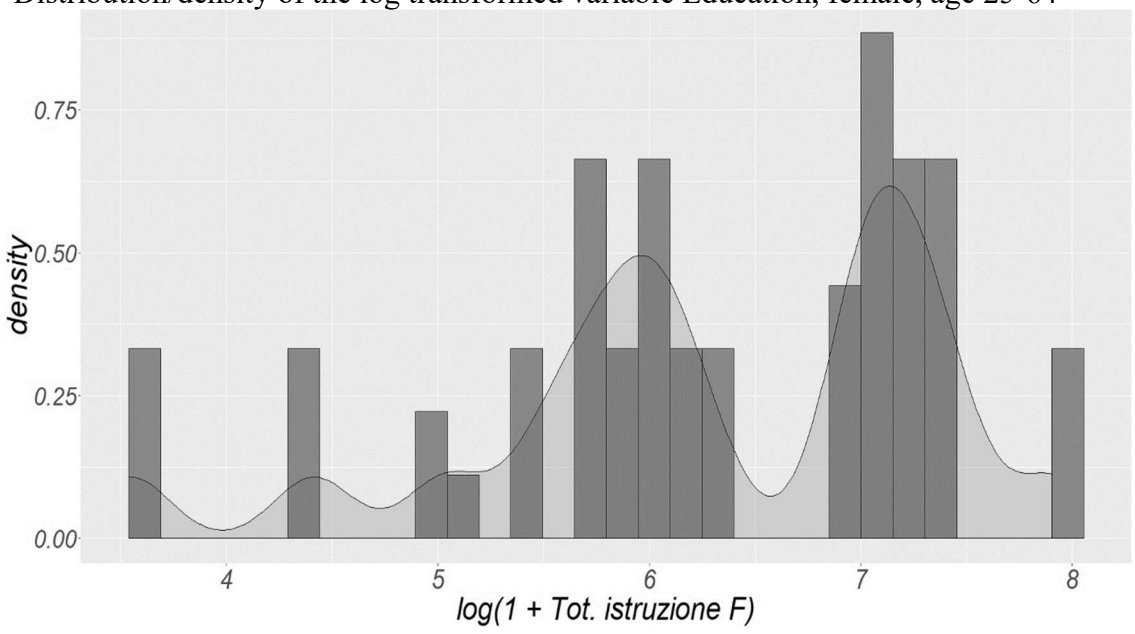
7. Education, male, age 25-64
   ISTAT collects data regarding education dividing it into 5 categories (per thousands of people):
   • Primary school diploma or no qualifications
   • Middle school diploma
   • 2/3 year diploma (professional qualification)
   • 4/5 year diploma (high school)
   • Undergraduate and postgraduate degree
   The variable is the sum of the 5 categories, the data was regionally broken down at an annual frequency.

Figure A7 - Distribution/density of the log transformed variable Education, male, age 25-64



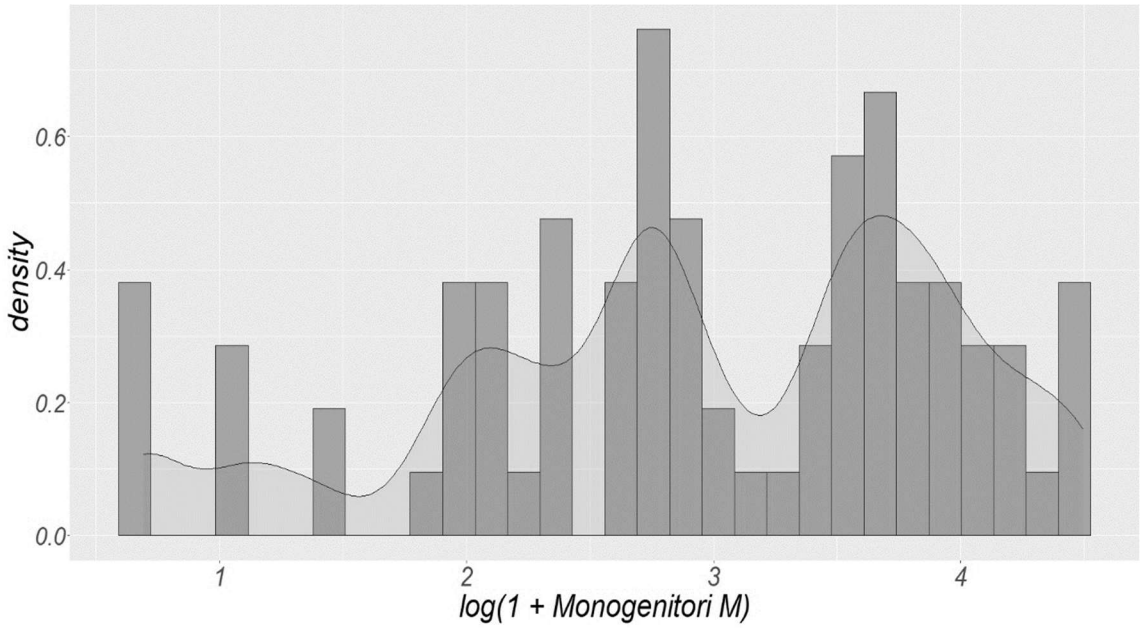
8. Education, female, age 25-64 . The same premise as the previous variable applies.

Figure A8 - Distribution/density of the log transformed variable Education, female, age 25-64



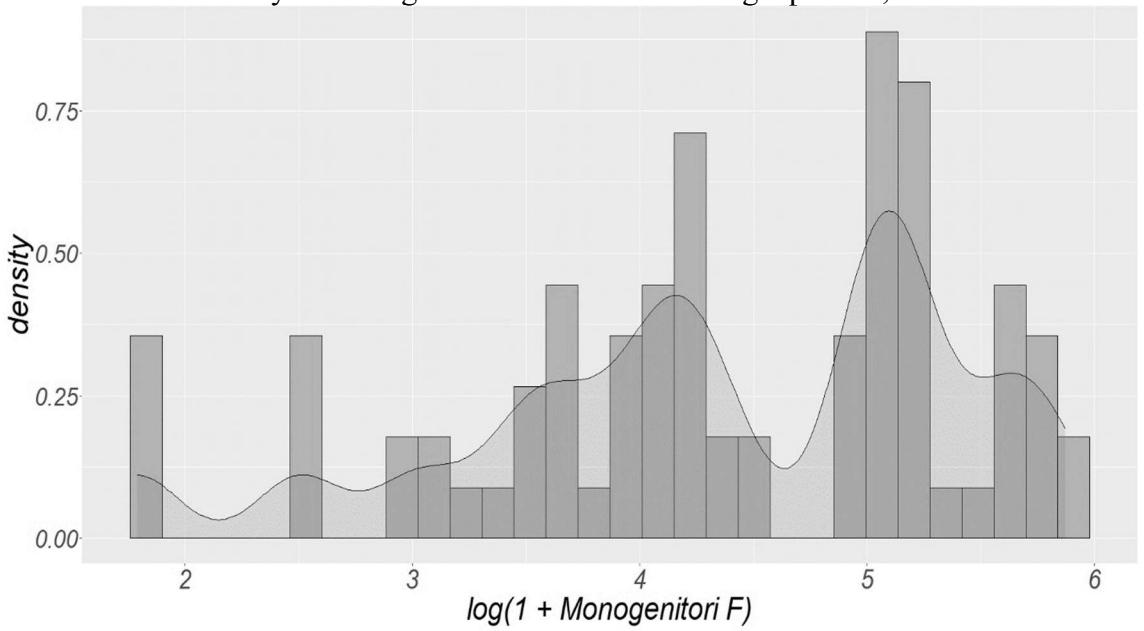
9. Single parents, male. Annual frequency and annual disaggregation. The values are a two-year average (calculated compared to the previous year).

Figure A9 - Distribution/density of the log transformed variable Single parents, male



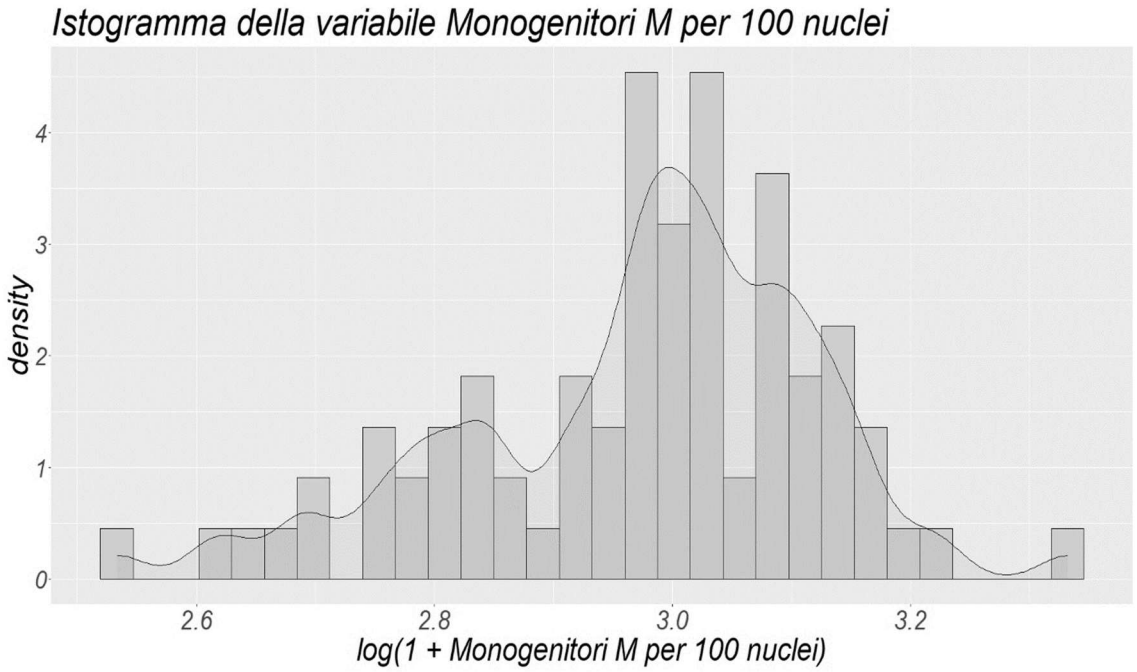
10. Single parents, female. The same premise as the previous variable applies.

Figure A10 - Distribution/density of the log transformed variable Single parents, female



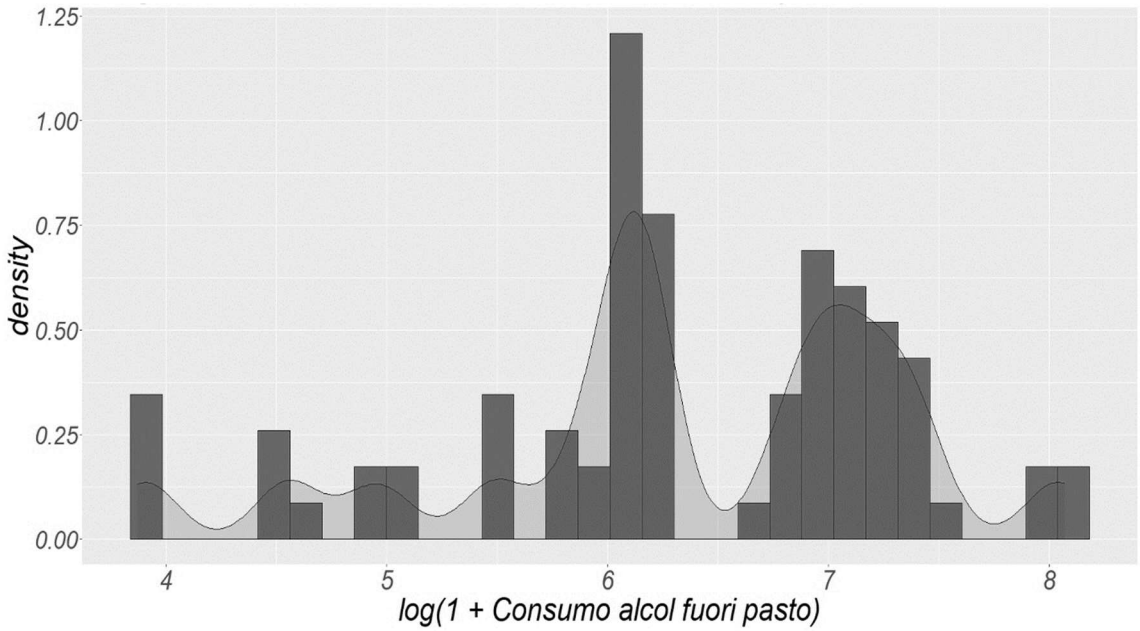
11. Single parents %. The variable is for 100 households.

Figure A11 - Distribution/density of the log transformed variable Single parents %



12. People over 11 years of age who consume alcohol. The variable is for thousands inhabitants.

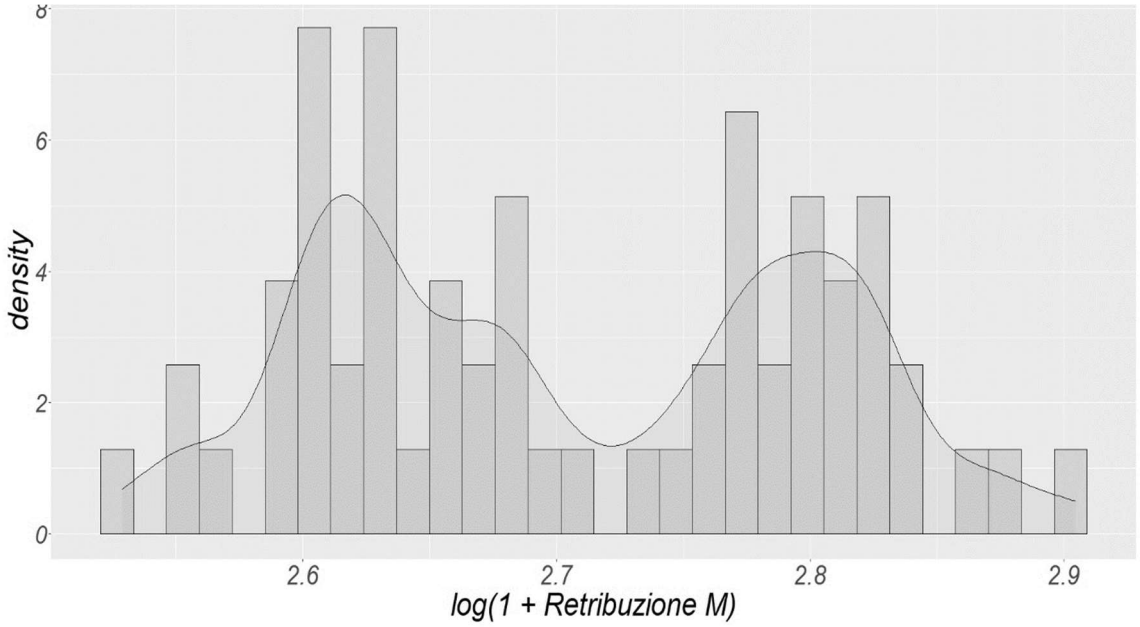
Figure A12 - Distribution/density of the log transformed variable People over 11 years of age who consume alcohol



Economic variables

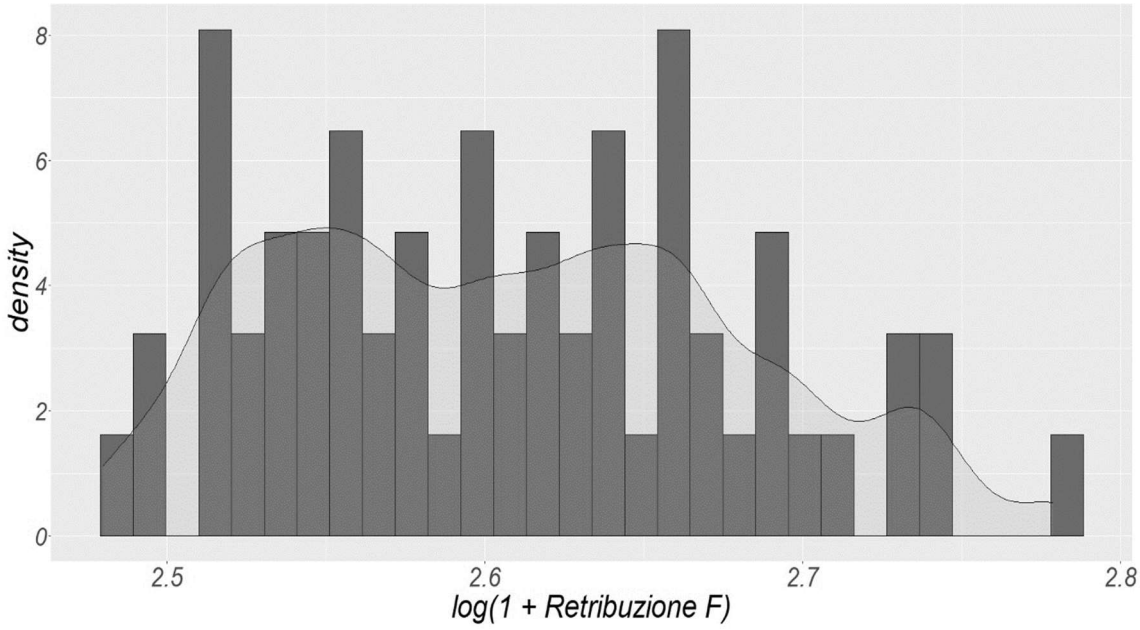
13. Gross hourly wages, male. Average values per hour paid (euros), calculated with respect to employed positions, annual frequency and provincial breakdown.

Figure A13 - Distribution/density of the log transformed variable Gross hourly wages, male



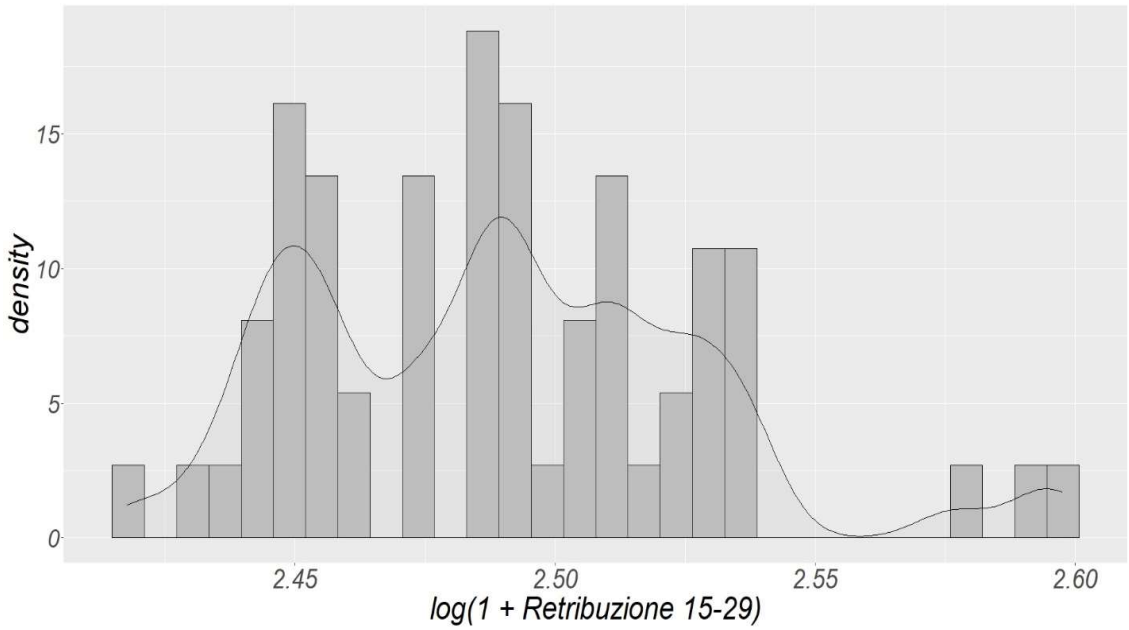
14. Gross hourly wages, female. The same premise as the previous variable applies.

Figure A14 - Distribution/density of the log transformed variable Gross hourly wages, female



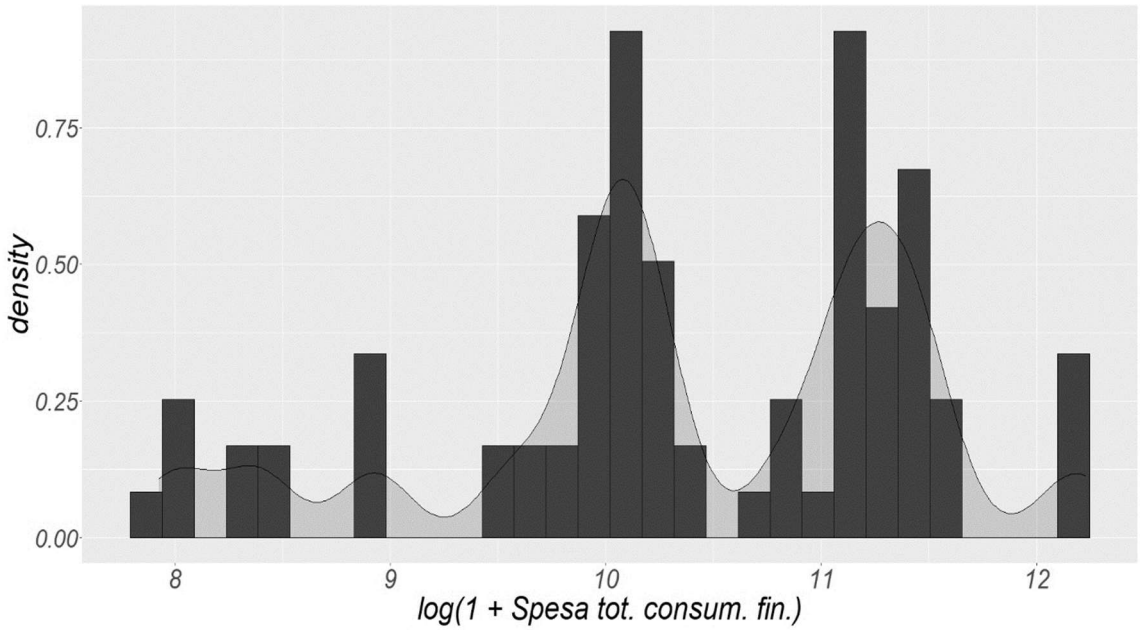
15. Gross hourly wages, young population. Age range 15-29. The same premise as the previous variable applies.

Figure A15 - Distribution/density of the log transformed variable Gross hourly wages, young population



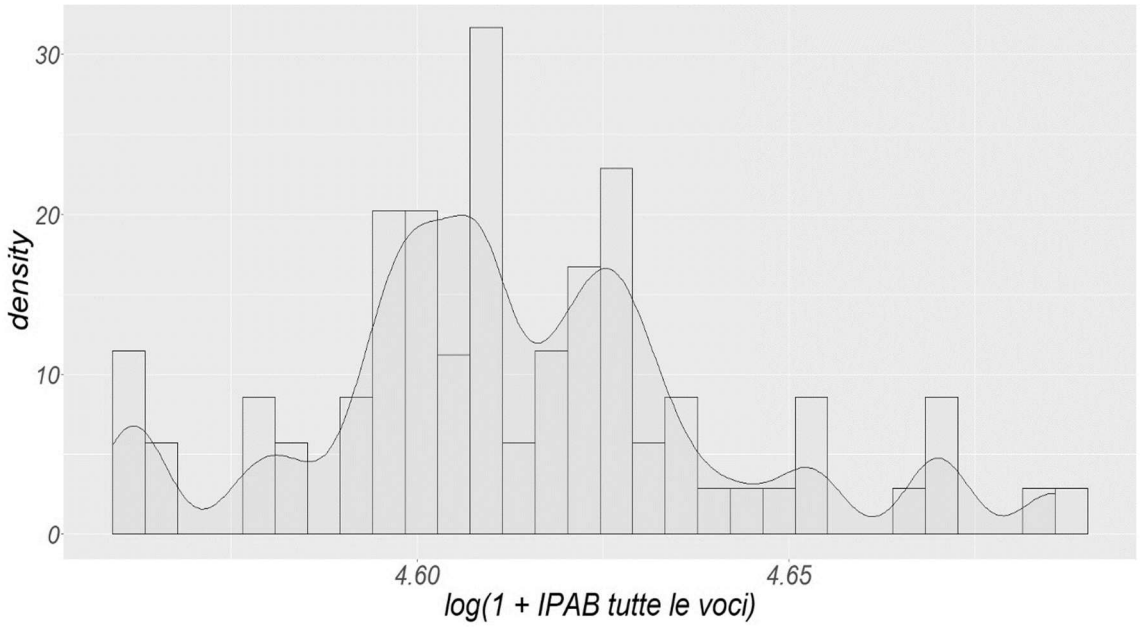
16. Total final consumption expenditure. Chained values (reference year 2015).

Figure A16 - Distribution/density of the log transformed variable Total final consumption expenditure



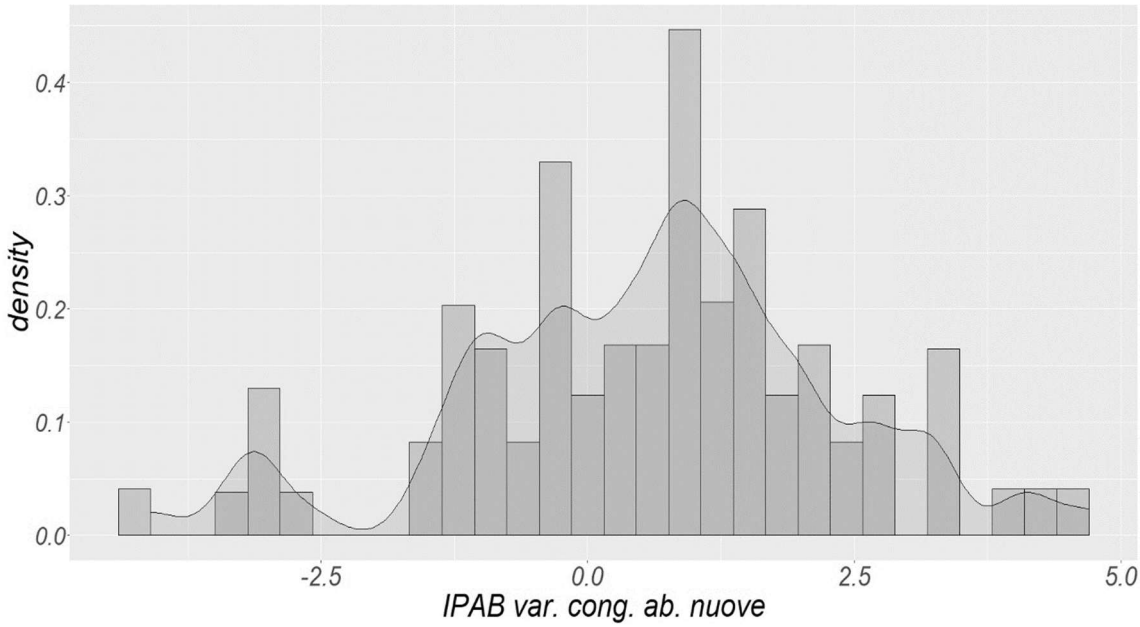
17. IPAB (Housing Price Index), all houses. House price index, Laspeyres-type index with reference to the year 2015 (base year) which measures the change in house prices over time.

Figure A17 - Distribution/density of the log transformed variable IPAB, all items



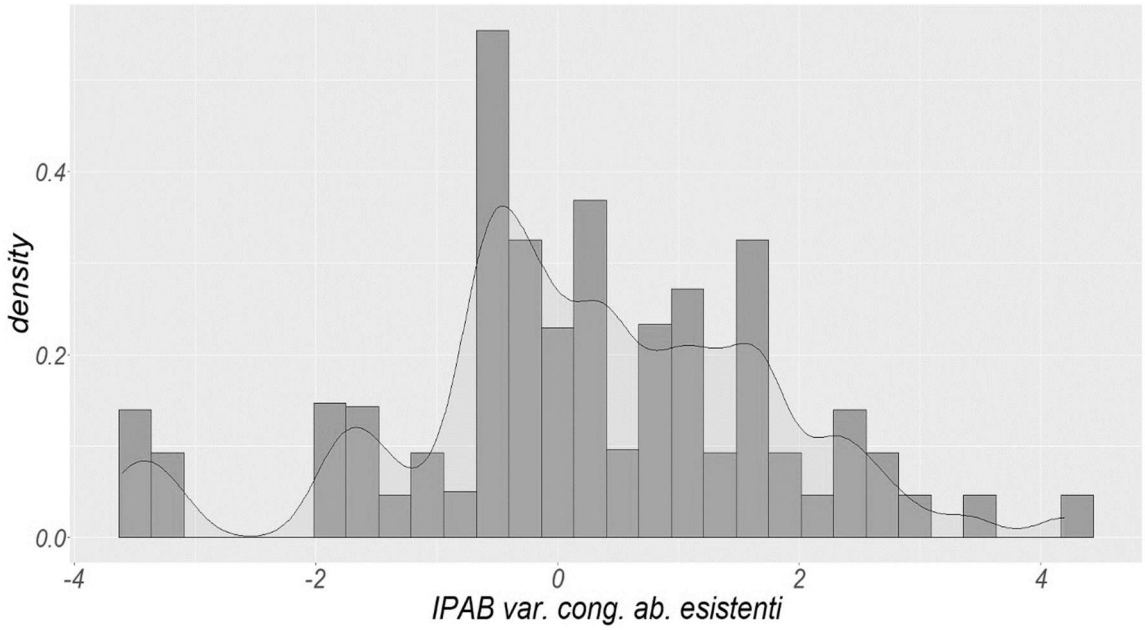
18. IPAB (Housing Price Index), new houses. Cyclical changes in percentage.

Figure A18 - Distribution/density of the log transformed variable IPAB, new houses



19. IPAB (Housing Price Index), existing houses. The same premise as the previous variable applies.

Figure A19 - Distribution/density of the log transformed variable IPAB, existing houses



20. IPAB (Housing Price Index), trend changes, all houses. Data in percentage.

Figure A20 - Distribution/density of the log transformed variable IPAB trend changes, all houses