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Language and the cultural markers of COVID-19[1]

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ABSTRACT

Despite its universal nature, the impact of COVID-19 has not been geographically homogeneous. While certain countries and regions have been severely affected, registering record infection rates and excess deaths, others experienced only milder outbreaks. We investigate to what extent human factors, in particular cultural origins reflected in different attitudes and behavioural norms, can explain different degrees of exposure to the virus. Motivated by the linguistic relativity hypothesis, we take language as a proxy for cultural origins and exploit the exogenous variation in the language spoken around the border that divides the French- and German-speaking parts of Switzerland to estimate the impact of culture on exposure to COVID-19. The results obtained using a spatial regression discontinuity design reveal, that within 50- and 25- kilometres bandwidth from the language border, the average COVID-19 exposure levels for individuals in French speaking municipalities was higher. In particular, we find that German speaking municipalities were associated with a reduction of around 40% - 50% in the odds of COVID-19 exposure compared to the French speaking municipalities.

1. Main

After its outbreak in the Chinese province of Hubei in December 2019, COVID-19 rapidly spread across all the world regions and reached the pandemic status in March 2020. Despite its universal diffusion, important differences persist in the spread of the virus and the level of exposure of different communities, both within and across countries. While the first pandemic wave was relatively mild in East Asia and Africa, it had a significant impact on Europe followed by North and South America. Even within these continents important differences emerged in specific regions, for example Lombardia in Italy, the Comunidad de Madrid in Spain or the city of New York, registered infection rates, hospitalisations, and excess deaths several times higher than neighbouring regions. Analogous asymmetries characterised the successive waves of the pandemic.

This heterogeneity has been attributed to different factors. Many of the countries experiencing comparatively lower rates of COVID-19 cases and lower mortality also have comparatively younger populations. Younger individuals usually have stronger immune systems and are also less likely to have pre-existing co-morbidity, which can make them more likely to experience milder cases of COVID-19 (Sudre et al. (2021); Levin et al. (2020)). Together with the age structure, population density is another demographic characteristic typically associated with COVID-19, with denser locations more likely to have an early outbreak (Sy et al. (2021); Carozzi (2020)). Additionally, socio-economic factors matter tremendously and can potentially explain the observed differences across countries and regions. For example, countries that enacted strict social distancing and stay-at-home policies early in their outbreaks experienced milder outbreaks overall (Hsiang et al. (2020)). In a similar vein, inherited attitudes and behaviours, often linked to the culture of origin, may affect the nature of social contact and distancing and have an impact on the spread of the new coronavirus.

This paper investigates whether the language spoken and the cultural origins, reflected in different attitudes and behavioural norms, can contribute to explaining the observed differences in the dynamics of the COVID-19 pandemic. Culture can be defined as "those customary beliefs and values that ethnic, religious, and social groups transmit fairly unchanged from generation to generation" (Guiso et al. (2006)). These ideas and thoughts, in turn, govern the interactions inside social groups and shape individual and social behaviour (Alesina and Giuliano (2015)). As such, cultural origins can expose certain groups/communities to epidemics more than others and influence the way in

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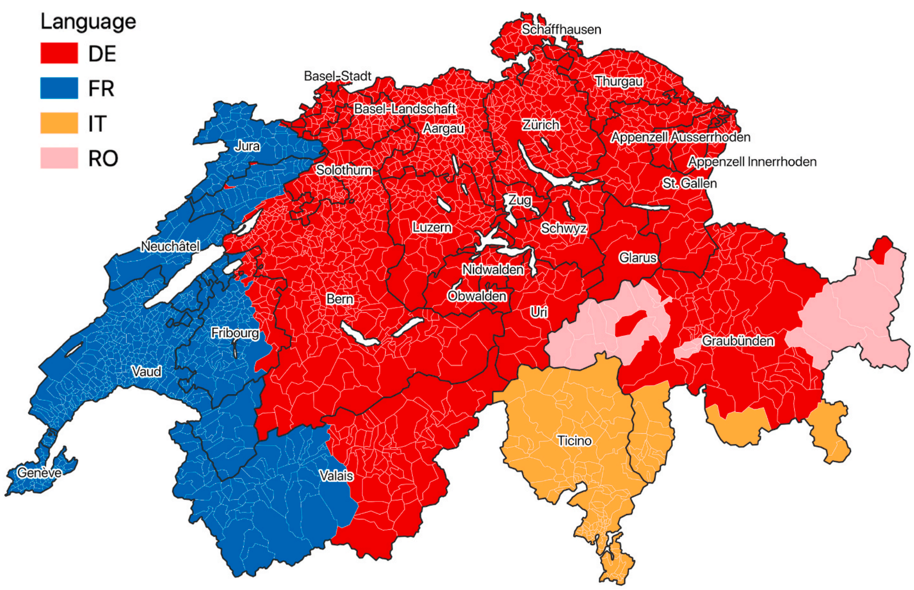
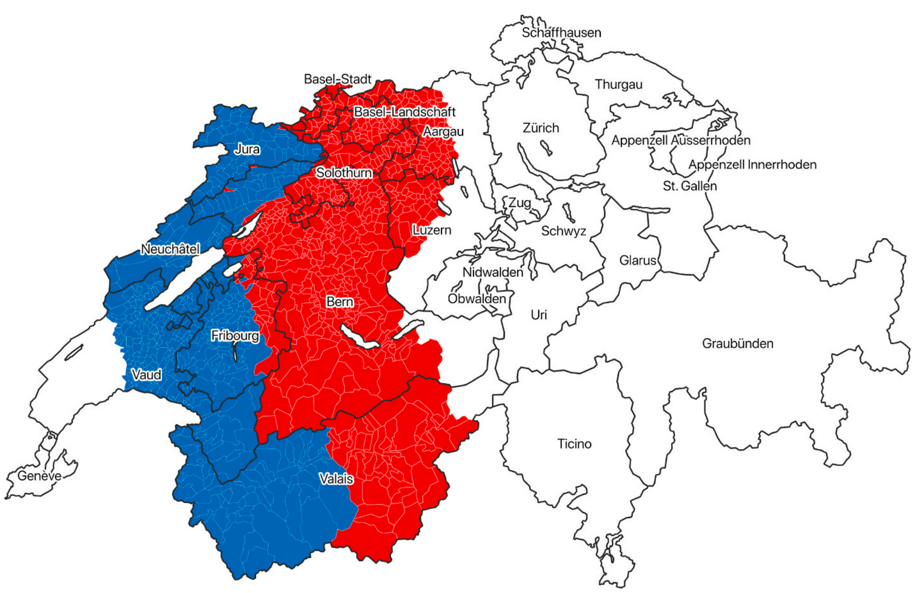
which these groups/communities react to public policy. People in some countries, for example, tend to have fewer social interactions with their family and friends than in others, or keep a bigger interpersonal distance when these interactions take place (Remland et al. (1995); Sorokowska et al. (2017)). Furthermore, the language spoken, which is an important component of any cultural heritage, can have an additional (direct) impact on exposure. This is especially the case when a virus can spread via airborne transmission and therefore when the interaction with affected individuals/communities facilitated by the use of a common language becomes a critical factor. Cultural values and social contact patterns have been shown to be a crucial factor behind the risk of exposure to a disease (Mossong et al. (2008); Dressler (2004)). They have also been shown to shape societal reactions to public interventions designed to contain outbreaks (Deopa and Fortunato (2021); Durante et al. (2021)). Less is known, however, on the way cultural biases may affect the spread of pandemics.

Assessing the impact of culture on exposure to COVID-19 is made difficult by the presence of several country specific characteristics that might have had an impact on the dynamics of the pandemic beyond cultural origins. The factors described above are of course highly



(a)



(b)

Fig. 1. Panel (a) shows the language borders within Switzerland. DE: German FR: French IT: Italian RO: Romansh. The black lines represent cantonal boundaries and the white lines represent the municipality boundaries. Panel (b) focuses on the municipalities within 50 km of the *Rösti* border.

country specific as has been the timing of exposure to COVID-19. Furthermore, institutional set-ups are not homogeneous, and the severity and time-span of policies enacted to contain the diffusion of the virus, like social distancing and shut down orders, have varied largely across and even within individual countries (typically in federal states). Estimates of the impact of culture based on cross-country data would therefore be strongly biased.

In this paper we circumvent these difficulties by investigating exposure to COVID-19 within Switzerland. Looking at Fig. 1, we observe that Switzerland has distinct linguistic regions and the French and German speaking areas are divided by a sharp geographical border colloquially referred to as the *Rösti* border. Rösti refers to a hashed potato dish which originated in the canton of Bern and is typical of Swiss German cuisine. These language divisions have deep historical roots and with the exception of few minor movements, the early historical development of the German-French boundaries have been relatively stable since AD 1100 (Büchi (2001)). By focusing on the Swiss population living at close distance from the *Rösti* border, the individuals in our study sample reside, therefore, in the same cantons (subject to analogous policy restrictions) and in neighbouring municipalities (with analogous geographical and demographic characteristics), but speak different languages.

Language is the principal means by which individuals conduct and engage in social interactions. Language embodies and expresses cultural relativity (Kramsch and Widdowson (1998)). The theory of linguistic relativity, also known as Sapir-Whorf hypothesis, posits that the language spoken influences the interpretation of reality and consequently shapes behavioural responses (Whorf (1956); Sapir (1968)). Building on this, we take language as a proxy for different cultural origins and exploit the exogenous variation in the language spoken on the two sides of the language border to estimate the impact of culture on exposure to COVID-19.

In Switzerland the linguistic differences are indeed both a reflection and the best proxy of cultural differences (Egger and Lassmann (2015); Ritz and Brewer (2013); Deopa and Fortunato (2021); Watts (1988); Büchi (2001)). In fact the language border often demonstrates the general cultural divide within the country, as the direct-democratic political system of Switzerland has repeatedly revealed striking differences in attitudes and preferences across these linguistic groups. The French speakers have traditionally been more supportive in matters of welfare state provisions and social spending (Eugster et al. (2017); Theiler (2004)).

2. Data

We use two primary sources of data. Our first source is the Swiss Household Panel (SHP) which is a longitudinal survey of a random sample of private households whose members represent the non-institutional population resident in Switzerland (Voorpostel et al. (2020)). The principal aim of SHP is to observe social change, dynamics of living conditions and social representations in the population. The survey is conducted annually, we use the latest wave (22) for the year 2020: which refers to the period September 2020 to February 2021.

In order to capture the geographical distribution of COVID-19 exposure we analyse the response of individuals who are geo-referenced to their respective municipality of residence. The survey asks “Do you know anyone who has been infected with the new Coronavirus?“. The respondent has six options: 1) No 2) Yes, someone else in my circle of friends and acquaintances 3) Yes, a work colleague 4) Yes, a family member or close friend 5) Yes, a household member and 6) Yes, myself. Using this sequentially ordered response allows us to measure the individual’s perceived COVID-19 exposure level within his/her social network from a scale of 0–5. Within this scale, 0 represents no exposure at all and 5 represents the highest level of exposure i.e. being infected yourself.

Our second source is the Swiss Federal Statistical Office (FSO) which provides us with demographic (population, population density, population aged 65 and above), economic (population employed, population of foreign cross border workers) and geographic (land usage - lakes and urban settlement) characteristics of the municipalities which may influence the diffusion of COVID-19 beyond culture. For each of these characteristics we utilise the data from 2020, however, for foreign cross border workers FSO provides quarterly data and we include data from 2020Q1 - 2021Q1. Table 1 provides summary statistics for our variables of interest.

3. Methods

Utilising the historically occurring spatial discontinuity as seen in the *Rösti* border, allows for an empirical design that facilitates studying the role of culture in a causal context. There are two important features of relevance: first that the primary language spoken in the municipalities changes sharply at the language border as seen in Fig. 2; and second that segments of this border do not overlap with the administrative canton (state) borders, therefore, many confounding factors such as institutional differences in law, transport, health services and public infrastructure are not a concern. The presence of this language border which forms a two-dimensional discontinuity in longitude–latitude space, suggests exploiting differences in culture and estimating its impact by employing a spatial regression discontinuity (RD) design. This allows us to compare the perceived COVID-19 exposure levels for individuals in municipalities within a close distance from the boundary formed between German speaking and French speaking areas. Within this setup, the causal effect of culture is identified using the variation at the

Table 1
Summary statistics.

Variable	Mean	Median	Std. Dev.	Min	Max
COVID-19 exposure	7952	1.206	1.325	0	5
log (Population aged 65+)	1275	6.301	1.114	3.135	11.035
log (Population employed)	1275	7.016	1.408	2.773	13.105
log (Population)	1275	7.984	1.085	5.011	12.949
log (Population density)	1275	5.687	1.274	0.642	9.458
asinh (Population of foreign cross-border workers 2020 Q1)	1275	3.300	2.357	0	11
asinh (Population of foreign cross-border workers 2020 Q2)	1275	3.308	2.355	0	11
asinh (Population of foreign cross-border workers 2020 Q3)	1275	3.322	2.352	0	11
asinh (Population of foreign cross-border workers 2020 Q4)	1275	3.321	2.353	0	11
asinh (Population of foreign cross-border workers 2021 Q1)	1275	3.319	2.361	0	11
asinh (land usage - lakes)	1275	0.832	1.325	0	6.607
log (land usage - urban settlement)	1275	4.864	0.828	1.946	8.602

The unit of observation for COVID-19 exposure is at the individual level, taken from the Swiss Household Panel (SHP), wave 22. The unit of observation for the demographic, economic and geographic variables is at the municipality level. They have been obtained from the Swiss Federal Statistical Office’s website. Due to the presence of zeroes, for variables - population of foreign cross-border workers and land usage for lakes (in hectares), we use the inverse hyperbolic sine *(asinh)* transformation.

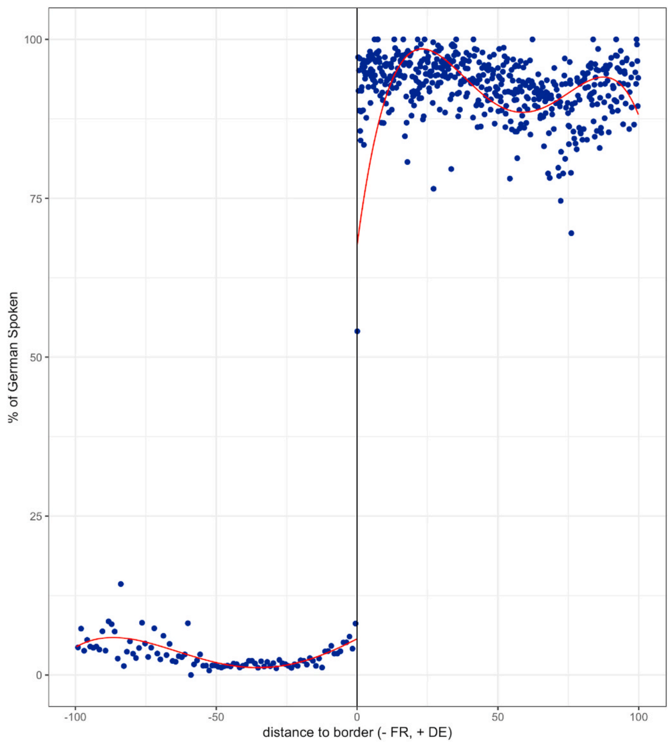


Fig. 2. Percentage of Germans speakers, by distance to language border. The x axis represents distance from the language border where negative distance = French (FR) speaking; positive distance = German (DE) speaking. Data driven binned sample means mimicking the underlying variability of the data. Bins were selected by an optimal evenly-spaced method for a bandwidth of 100 km.

discontinuity. We use a semi-parametric RD approach that limits the sample to municipalities within a bandwidth of 50 and 25 km of the language border and the main regression takes the following specification:

$$\text{cov}_{imc} = \alpha + \beta\,\text{Language}_m + f(\text{geographic location}_m) + \boldsymbol{\tau}_c + \varepsilon_{imc} \quad (1)$$

where cov_{imc} is the outcome variable: COVID-19 exposure for individual i in municipality m in canton c along the language border, and Language_m is an indicator equal to 1 if the municipality speaks German and equal to 0 if French. f (geographic location_m) is the RD polynomial, which controls for smooth functions of geographic location. Following Gelman and Imbens (2019), for our baseline specification we use local linear and quadratic RD polynomials. Finally, $\boldsymbol{\tau}_c$ is a set of canton fixed effects, which ensures that we are comparing municipalities across the same cantons and that there are no underlying institutional differences.

An additional identifying assumption for spatial RD requires that all relevant factors besides language must vary smoothly at the boundary, so that individuals located right next to the border in the French speaking municipalities can be an appropriate counterfactual for those in the German municipalities. To assess the plausibility of this assumption, we examine the following characteristics that may potentially vary across the border and drive the difference in COVID-19 exposure levels: population, population density, population aged 65 +, population employed, quarterly population of foreign cross border workers and land use statistics for urban settlement and lakes (in hectares). In Fig. 3 we report the estimates of the difference between the German and French municipalities for these demographic, economic and geographic characteristics. The regressions uses equation (1) but using the relevant covariates as the outcome to test if there exists any discontinuity at the boundary. We find these to be statistically insignificant, implying they are smooth (balanced) at the threshold and confirming the validity of the design.

The bandwidth or the distance of a municipality to the language border is an important concept for spatial RD. To construct this distance, first, we allocate every municipality to a language region based on the language spoken by the majority of its residents - this information is made publicly available by FSO. Then using the projected coordinate system for Switzerland (EPSG: 21781, CH1903/LV03) we calculate the Euclidean distance between municipalities and the language border utilising the function st_distance from the Simple Features package in R.

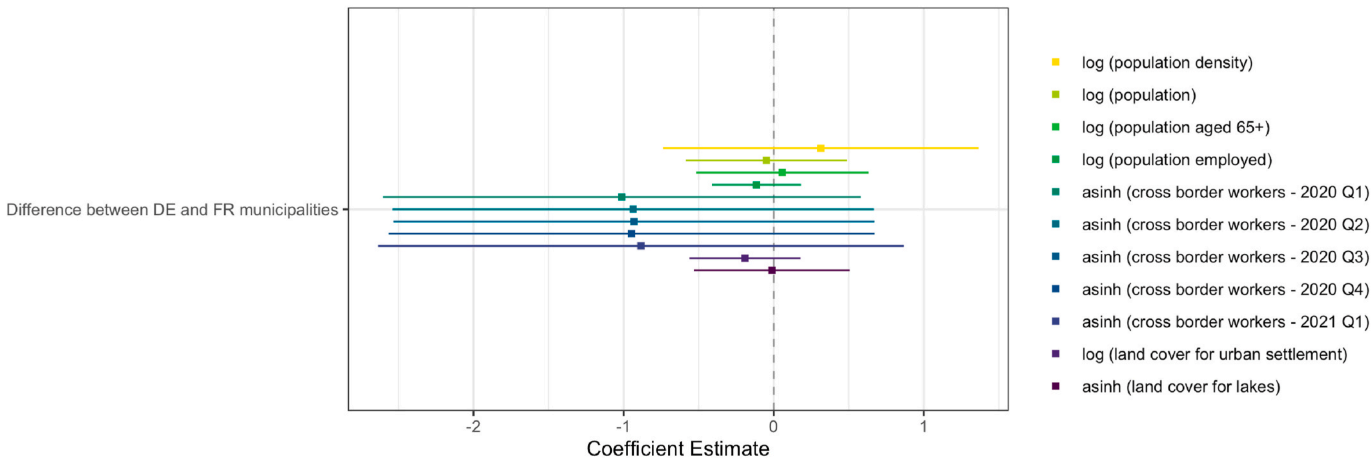
4. Results

We begin by graphically analysing the relationship between the outcome variable COVID-19 exposure and culture proxied by language, using a one dimensional RD plot i.e. by using the distance to the language border. Positive values of distance indicate individuals in German speaking area. In Fig. 4, the trend line gives the predicted values from regressing the outcome variable on a second-degree polynomial in distance to the border, weighted using a uniform kernel. Bins were selected by an optimal evenly-spaced method and a bandwidth of 100 km. The RD plot shows that there is a clear drop in the levels of COVID-19 exposure for individuals living in German speaking municipalities.

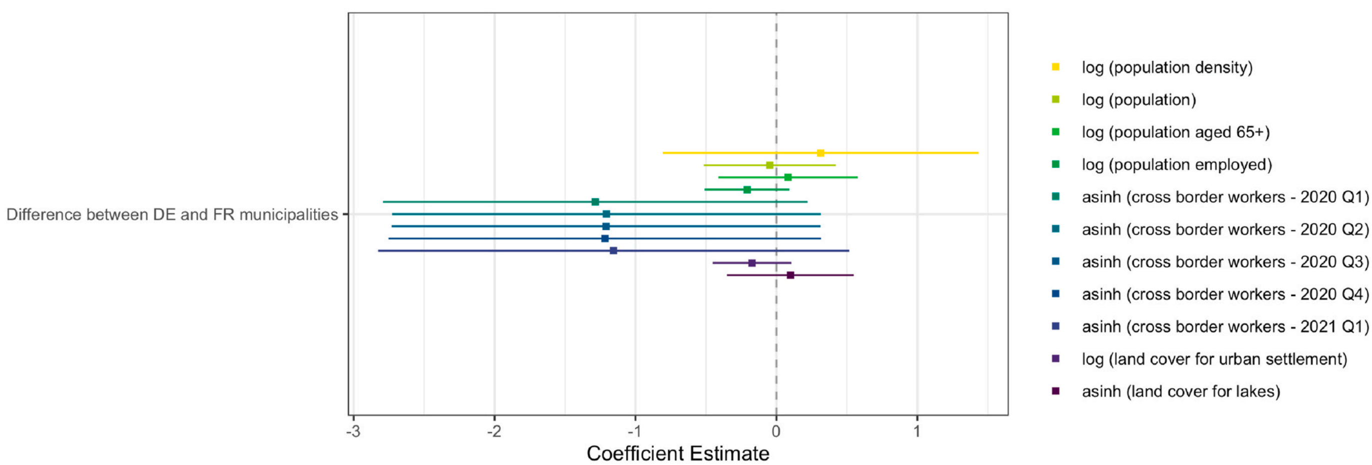
Table 2 presents our estimates of the causal impact of culture on the perceived COVID-19 exposure within one's social network, using equation (1). Here we treat the dependent variables as continuous and estimate using ordinary least squares with fixed effects. This allows us to interpret the coefficients as the average difference in exposure between the two linguistic groups. Panel A reports estimation utilising the two dimensions of the language border: latitude and longitude; and Panel B reports estimation using the distance to the boundary (one dimensional). Limiting the sample to municipalities within a bandwidth of 50 and 25 km of the language boundary, columns (1) and (3) use a local linear RD polynomial and columns (2) and (4) use a quadratic RD polynomial. In combination with the inclusion of canton fixed effects, this ensures that we are comparing observations in close geographic proximity. Our estimates from the multidimensional RD indicate that the COVID-19 exposure levels for individuals in the German speaking municipalities was between 0.4 and 0.5 points lower compared to the French side. Therefore, we find the average COVID-19 exposure level to be higher for individuals in French speaking municipalities. Coherently, in Panel B we find the results to be consistent and stable across specifications. In the appendix, Table A1 and A2, we re-estimate our main specification including all controls used for the balance checks. We find our results continue to hold and are consistent with those in Table 2, thus confirming the validity of the continuity assumption for all other observable covariates.

Similar to Dell et al. (2018), we present Table 2 Panel A results graphically in Fig. 5. This is the three-dimensional counterpart to the standard two-dimensional RD plots, with each municipality's longitude on the x axis and latitude on the y axis. Data at the individual level have been aggregated to the municipality level. The background shows predicted values, for a finely spaced grid of longitude-latitude coordinates, using equation (1). In classic regression discontinuity, the predicted value plot is a two-dimensional curve, as seen in Fig. 4, however here we introduce a third dimension indicated by the colour gradient. In the figure COVID-19 exposure illustrates the predicted jump across the language boundary.

As there is no widely accepted optimal bandwidth for a multidimensional RD, to check the robustness of our estimates we plots our results using equation (1) for different bandwidth values between 10 and 50 km, as shown in Fig. 6. The bandwidth under consideration is denoted on the x-axis and the error bars show 95% confidence intervals. Each sub-figure employs different functional forms for the RD polynomial: linear latitude-longitude (Fig. 6a), quadratic latitude-longitude (Fig. 6b), linear distance to the language border (Fig. 6c) and quadratic distance to the language border (Fig. 6d). We find our results to be remarkably robust to alternative bandwidth choices.



(a) Sample within < 50 km



(b) Sample within < 25 km

Fig. 3. Balance checks for demographic, economic and geographic characteristics. The x-axis presents the estimates for the difference in the relevant characteristics between the DE (German) and FR (French) areas. Due to the presence of zeroes, for variables - population of foreign cross-border workers and land usage for lakes (in hectares), we use the inverse hyperbolic sine *(asinh)* transformation. Results use equation (1). The unit of observation is the municipality. All regressions include a linear RD polynomial in latitude and longitude, and canton fixed effects. Robust standard errors, clustered at canton level. 95% Confidence intervals.

Switzerland's economy relies heavily on cross-border workers – known as frontaliers in French, Grenzgänger in German and frontalieri in Italian. They make up about 6% of the country's total workforce. Therefore, an additional concern in our specification is that the difference in COVID-19 exposure may not be a result of only cultural differences but due to the fact that the French-speaking municipalities were more exposed to COVID-19 simply because of their geographical proximity to France. To address this, first we control for potentially varying transmission of information between language regions due to different degrees of exposure to neighbouring countries by including the number of cross-border workers per municipality. And second, we drop all municipalities that border neighbouring countries of France, Italy and Germany. Table 3 presents these results and we find them to be robust to these changes.

In Table 4, we take into account the ordinal nature of the COVID-19 exposure variable and use an ordered logistic regression with fixed effects. We show results (odd ratio) for fixed effects ordered logit using the Blow-Up and Cluster (BUC) estimator discussed by Baetschmann et al. (2015). Panel A reports estimation utilising the two dimensions of the language border: latitude and longitude; and Panel B reports estimation using the distance to the boundary (one dimensional). Similar to previous estimation, we limit the sample to municipalities within a bandwidth of 50 and 25 km of the language boundary, columns (1) and (3) use a local linear RD polynomial and columns (2) and (4) use a quadratic RD polynomial. Our results show that being in the German speaking municipalities is associated with a reduction of around 40% - 50% in the odds of COVID-19 exposure levels compared to individuals in the French speaking area.

5. Discussion

The heterogeneous impact of COVID-19, both across and within countries, in terms of infections, hospitalisations and excess deaths has drawn scholar attention on understanding the characteristics that have made certain communities more vulnerable than others to the pandemic. Understanding these characteristics could serve as a guide to build resilience in the face of potential new shocks of an analogous nature. Recent research has highlighted geographical and demographic factors that can inhibit/favour the spread of the virus or limit/enhance its effects. Additionally, social factors such as the timing and stringency of non-pharmaceutical interventions enacted after the outbreak have also been examined. The evidence presented in this paper complement these results showing that the severity of the pandemic can be partly attributed also to cultural attitudes and behavioural norms transmitted from generation to generation.

The transmission of culture involves not only behavioural practices

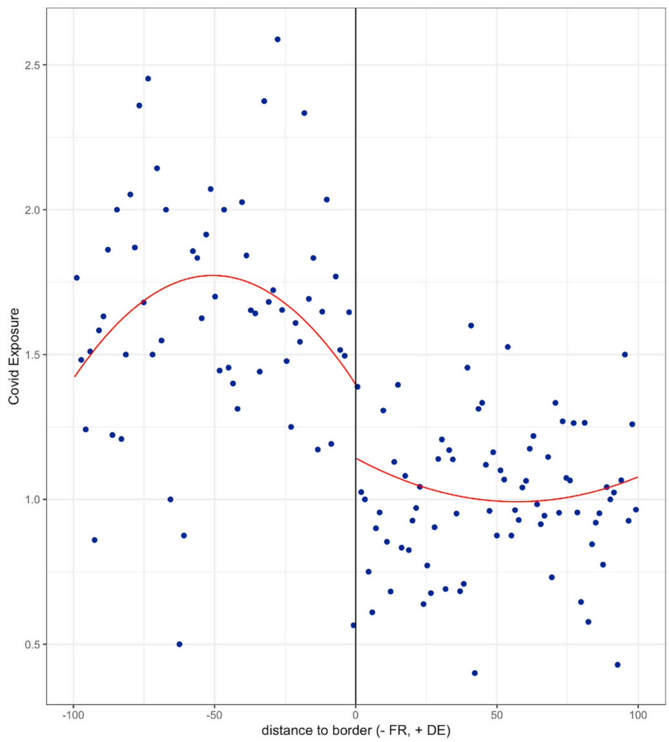


Fig. 4. Binned average for COVID-19 exposure (One dimensional RD plot). The x axis represents distance to the language border where negative distance = French (FR) speaking; positive distance = German (DE) speaking. Second-degree polynomial in distance from the border, weighted using a uniform kernel. Bins were selected by an optimal evenly-spaced method and a bandwidth of 100 km.

and material artefacts, but also the representation of these practices and artefacts in the human mind, which is mediated by language (Gelman and Roberts (2017)). Therefore, we use language as a proxy for cultural inheritance and examine differential exposure to COVID-19 of the Swiss population living on the two sides of the French-German linguistic border. We find that individuals residing in German speaking municipalities within 50- and 25- kilometres bandwidth from the language border experienced a significantly lower perceived exposure to COVID-19 than individuals living on the French side, within the same bandwidth. Given the demographic, geographic and administrative continuity around our cutoff (i.e., the language border), we interpret these results as first evidence of the role that cultural markers have played during the COVID-19 pandemic.

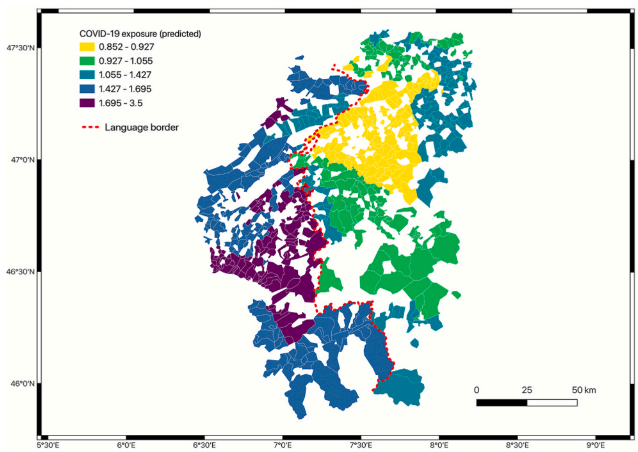
Looking beyond Switzerland, we find trends supporting our results in other countries and regions. For example, in Belgium despite the French-speaking region of Wallonia having a shared border with France, the spread of COVID-19 affected several Dutch-speaking provinces in Flanders more acutely (Desson et al. (2020); Peeters et al. (2021)). In general, culture has influenced the diffusion of communicable diseases and responses to epidemics well before (and beyond) the COVID-19 outbreak. Buckee et al. (2021) emphasises that human societies are structured by cultural forces that define social relations, especially amongst kin, and the spread of infection reflects these social structures. They highlight the example of Dengue, a mosquito borne disease, for which the transmission is often driven by social connections as routine movements among the usual places, such as the homes of family and friends, are often similar for the infected individual and their contacts (Stoddard et al. (2013)).

The next step is to examine what are the specific cultural attitudes and behavioural norms that expose (or insulate) social groups from pandemics. At this stage, we can formulate some hypotheses on the cultural differences between German- and French-speaking Swiss citizens that might explain our results. First, language is a very peculiar cultural trait that can, in itself, exert an effect on contagion especially when, as in the case of COVID-19, transmission takes place through small particles suspended in the air. In fact, sharing the same language affects relational patters and facilitates physical interaction through conversation. It can therefore expose certain linguistic communities more than others to contagion. In the specific case of COVID-19 in Switzerland, the different spread of the virus in Germany and France during the 2020 might contribute explaining a higher exposure of the French speaking population because of their close connections with France (facilitated by speaking a common language). Second, generalised trust towards others, the belief held about others' trustworthiness, is one of the most commonly defined cultural trait and is generally higher in German speaking cantons than in French speaking ones (Deopa and Fortunato (2021)). Generalised trust also represents a widely used measure of civism and social capital and has been found to be associated with cooperative and altruistic behaviour (Brehm and Rahn (1997); Uslaner (2002)). In the context of the pandemic, trustworthiness might be reflected in responsible behaviour and respect of hygienic rules and

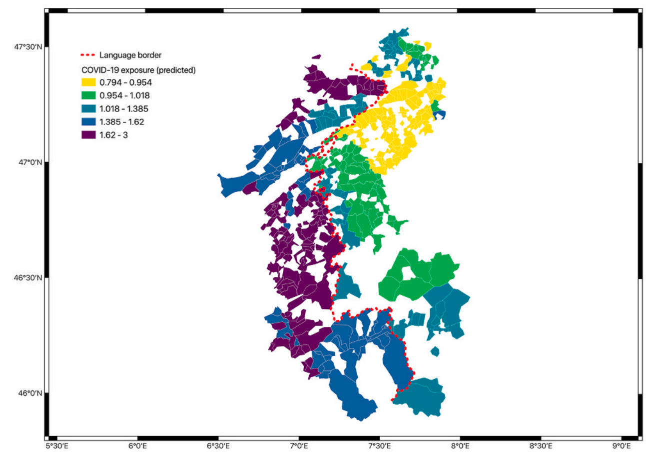
Table 2
Effect of culture on COVID-19 exposure.

	Sample falls within < 50 km		Sample falls within < 25 km	
	Linear	Quadratic	Linear	Quadratic
	(1)	(2)	(3)	(4)
Panel A: Latitude & longitude				
German speaking	−0.451***	−0.471***	−0.413***	−0.490***
	[− 0.717, −0.185]	[− 0.735, −0.208]	[− 0.694, −0.132]	[− 0.766, −0.213]
Panel B: Distance to border				
German speaking	−0.446***	−0.448***	−0.442***	−0.433***
	[− 0.661, −0.232]	[− 0.663, −0.233]	[− 0.666, −0.218]	[− 0.653, −0.212]
Observations	3903	3903	2512	2512
Canton fixed effects	Yes	Yes	Yes	Yes

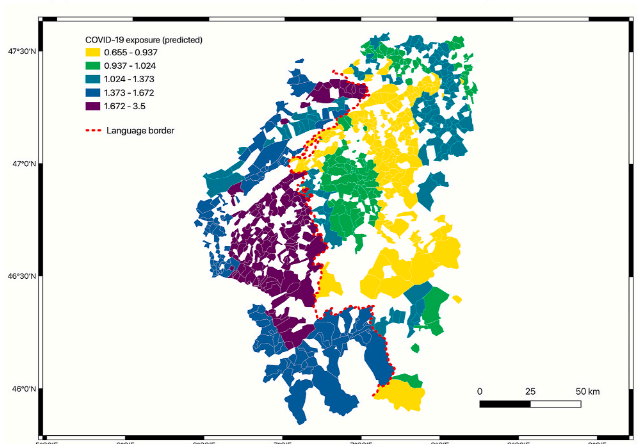
Results use equation (1). The unit of observation is the individual. Robust standard errors, clustered at municipality level. 95% confidence intervals are reported in parenthesis. Panel A presents results using latitude and longitude and Panel B presents results using distance to the border. Columns (1) and (2) include a linear and quadratic RD polynomial for a bandwidth of 50 km. Columns (3) and (4) include a linear and quadratic RD polynomial for a bandwidth of 25 km *p<0.1; **p<0.05; ***p<0.01.



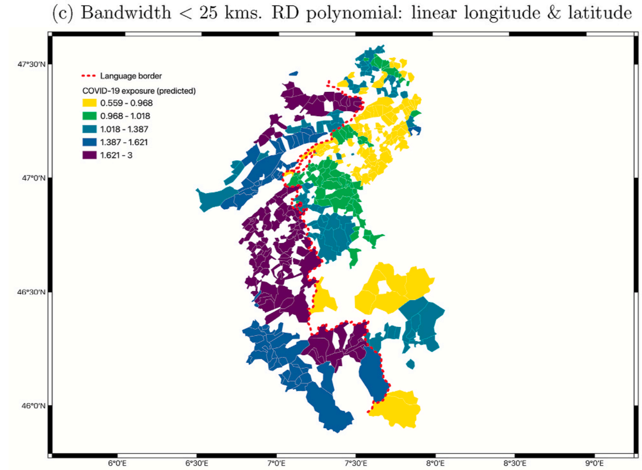
(a) Bandwidth < 50 kms. RD polynomial: linear longitude & latitude



(c) Bandwidth < 25 kms. RD polynomial: linear longitude & latitude

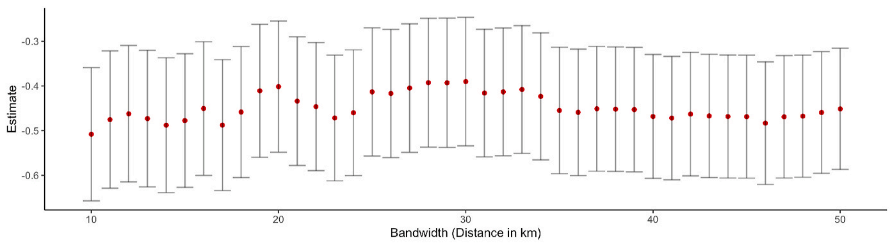


(b) Bandwidth < 50 kms. RD polynomial: quadratic longitude & latitude

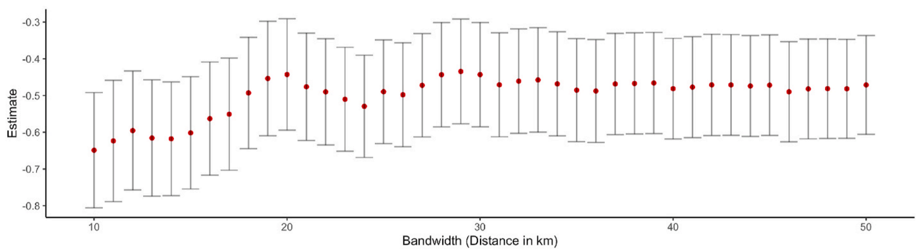


(d) Bandwidth < 25 kms. RD polynomial: quadratic longitude & latitude

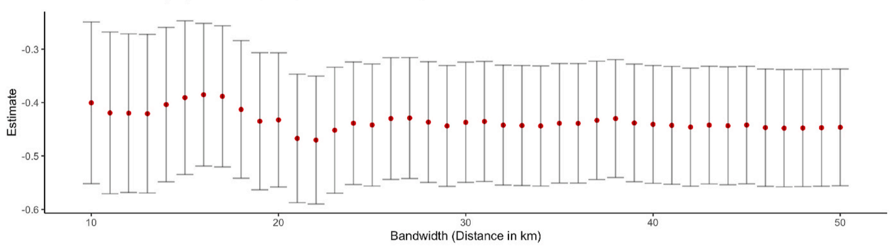
Fig. 5. RD graphs. Longitude is on the x-axis, latitude is on the y-axis. The background shows predicted values, for a finely spaced grid of longitude-latitude co-ordinates, from a regression of the COVID-19 exposure using equation (1).



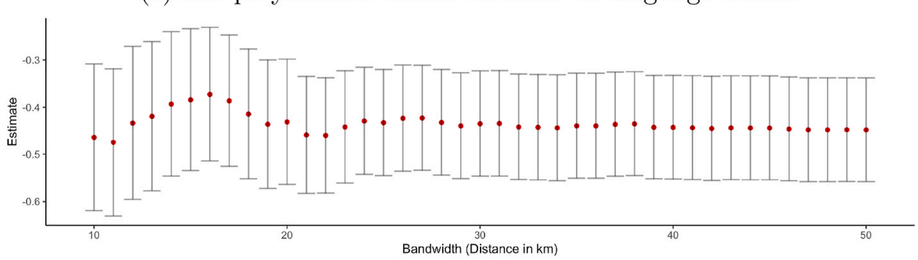
(a) RD polynomial: linear longitude & latitude



(b) RD polynomial: quadratic longitude & latitude



(c) RD polynomial: linear distance to language border



(d) RD polynomial: quadratic distance to language border

Fig. 6. Robustness of estimates from baseline specification. Each sub-figure plots the estimates from equation (1), as used in Table 2, for different bandwidth values between 10 and 50 km in 1 km increments (horizontal axis). The error bars from the point estimates show 95% confidence intervals, and robust standard errors are clustered at the level of municipalities. Sub-figures (a) and (b) correspond to a linear and quadratic RD polynomial in latitude and longitude space. Sub-figures (c) and (d) correspond to a linear and quadratic RD polynomial for distance to language border.

infection prevention and control (IPC) norms that, in turn, reduce exposure to contagion. A relatively high frequency of in-person contacts with family members and friends is another cultural characteristic that might have facilitated the spread of the virus in French speaking areas. Indeed, a recent study conducted in Luxembourg shows how, even in the middle of the health emergency, the mean number of contacts was significantly higher between French speaking individuals than between Germanophones living in the Grand-Duchy (Latsuzbaia et al. (2020)).

Finally, culture also influences preferences regarding the physical distance that people keep when interacting with others, and recent literature suggests that individuals with Southern European cultural origins are accustomed to relatively closer interactions (Sorokowska et al. (2017)). Bayeh et al. (2021) discusses how individual differences shaped by cultural context, for example, intolerance of uncertainty, optimism, conspiratorial thinking, or collectivist orientation have implications for behaviours that are relevant to the spread and impact of COVID-19, such as mask-wearing and social distancing. Note that despite being one of the wealthiest countries in the world, Switzerland has one of the lowest COVID-19 vaccination rates in Europe. Interestingly, this anomaly is mainly due to the scarce success of the campaign in German-speaking eastern cantons, where the uptake is often lower than in the country's French-speaking west and Italian-speaking south (Jones and Chazan (2021)). The milder exposure to the pandemic perceived in German-speaking communities, revealed by our results, can in part explain a skeptical attitude towards the federal vaccination program.

As with all regression discontinuity design analyses, it needs to be acknowledged that, while our results have a strong internal validity,

Table 3
Robustness check.

Panel A: Latitude & longitude				
	Sample falls within < 50 km		Sample falls within < 25 km	
	Linear	Quadratic	Linear	Quadratic
	(1)	(2)	(3)	(4)
German speaking	−0.451***	−0.524***	−0.353**	−0.529***
	[− 0.722, −0.180]	[− 0.781, −0.267]	[− 0.653, −0.053]	[− 0.807, −0.251]
asinh (Pop. of cross border workers 2020Q1)	0.025	0.006	0.251	0.229
	[− 0.462, 0.512]	[− 0.480, 0.493]	[− 0.366, 0.867]	[− 0.377, 0.835]
asinh (Pop. of cross border workers 2020Q2)	0.026	0.034	−0.078	−0.078
	[− 0.525, 0.578]	[− 0.509, 0.577]	[− 0.793, 0.638]	[− 0.767, 0.612]
asinh (Pop. of cross border workers 2020Q3)	−0.163	−0.146	−0.404*	−0.356
	[− 0.594, 0.268]	[− 0.561, 0.269]	[− 0.866, 0.059]	[− 0.799, 0.088]
asinh (Pop. of cross border workers 2020Q4)	0.151	0.133	0.281	0.244
	[− 0.299, 0.601]	[− 0.309, 0.574]	[− 0.285, 0.848]	[− 0.287, 0.776]
asinh (Pop. of cross border workers 2021Q1)	−0.037	−0.021	−0.040	−0.026
	[− 0.317, 0.242]	[− 0.286, 0.245]	[− 0.376, 0.295]	[− 0.323, 0.270]
Panel B: Distance to border				
German speaking	−0.490***	−0.493***	−0.445***	−0.429***
	[− 0.724, −0.256]	[− 0.727, −0.259]	[− 0.689, −0.201]	[− 0.668, −0.190]
asinh (Pop. of cross border workers 2020Q1)	0.016	0.014	0.229	0.258
	[− 0.477, 0.508]	[− 0.477, 0.505]	[− 0.395, 0.853]	[− 0.340, 0.856]
asinh (Pop. of cross border workers 2020Q2)	0.037	0.043	−0.066	−0.075
	[− 0.518, 0.591]	[− 0.509, 0.594]	[− 0.785, 0.652]	[− 0.761, 0.611]
asinh (Pop. of cross border workers 2020Q3)	−0.153	−0.158	−0.372	−0.411*
	[− 0.579, 0.272]	[− 0.585, 0.268]	[− 0.840, 0.096]	[− 0.871, 0.050]
asinh (Pop. of cross border workers 2020Q4)	0.145	0.147	0.254	0.306
	[− 0.304, 0.594]	[− 0.301, 0.596]	[− 0.319, 0.827]	[− 0.261, 0.872]
asinh (Pop. of cross border workers 2021Q1)	−0.041	−0.042	−0.036	−0.071
	[− 0.313, 0.231]	[− 0.315, 0.230]	[− 0.365, 0.293]	[− 0.405, 0.263]
Observations	3421	3421	2109	2109
Canton fixed effects	Yes	Yes	Yes	Yes
Drop border municipalities	Yes	Yes	Yes	Yes

Results use equation (1) while controlling for the population of cross border workers. The unit of observation for the dependent variable: COVID-19 exposure, is the individual. The unit of observation for cross border workers is at the municipality level. Robust standard errors, clustered at municipality level. 95% confidence intervals are reported in parenthesis. Panel A presents results using latitude and longitude and Panel B presents results using distance to the border. Columns (1) and (2) include a linear and quadratic RD polynomial for a bandwidth of 50 km. Columns (3) and (4) include a linear and quadratic RD polynomial for a bandwidth of 25 km *p<0.1; **p<0.05; ***p<0.01.

Table 4
Fixed effects ordered logit (Odds Ratio).

Panel A: Latitude & longitude				
	Sample falls within < 50 km		Sample falls within < 25 km	
	Linear	Quadratic	Linear	Quadratic
	(1)	(2)	(3)	(4)
German speaking	0.529***	0.519***	0.563***	0.512***
	[0.378,0.740]	[0.387,0.697]	[0.399,0.794]	[0.412,0.638]
Panel B: Distance to border				
German speaking	0.532***	0.531***	0.539***	0.546***
	[0.428,0.662]	[0.431,0.654]	[0.421,0.690]	[0.425,0.702]
Observations	3901	3901	2511	2511
Canton fixed effects	Yes	Yes	Yes	Yes

The results presented are the odds ratio. The unit of observation for the dependent variable: COVID-19 exposure, is the individual. Robust standard errors, clustered at canton level and 95% confidence intervals are reported in parentheses. Panel A presents results using latitude and longitude and Panel B presents results using distance to the border. Columns (1) and (2) include a linear and quadratic RD polynomial for a bandwidth of 50 km. Columns (3) and (4) include a linear and quadratic RD polynomial for a bandwidth of 25 km *p<0.1; **p<0.05; ***p<0.01.

their generalisability might me contested as our estimates are obtained using observations very close to the (spatial) cutoff. However, the fact that even looking at individuals with relatively close cultural origins as the Swiss French- and German-speaking citizens we find significant differences in perceived exposure to COVID-19 attributable to culture suggests that cultural markers might have played a significant role along the different waves of the pandemic. Recognising the importance of culture on the contagion dynamics may also have significant policy implications. There is broad consensus that some non-pharmaceutical interventions (NPIs) are indispensable to limit the diffusion of the virus, but valuations differ as to which measures are most effective or to what duration and severity is needed. In this respect, our results suggest that there is no one size fits all solution. Optimal measures, as their duration and severity, shall be evaluated accordingly to how individuals normally behave and how they will adjust their behaviour in response to the policy enacted. But these are inherent cultural characteristics that vary significantly between and as shown in this paper in some cases even within countries.

Credit author statement

All authors discussed the results, contributed analysis tools, and performed writing – original draft preparation, reviewing and editing.

Table A1
Main specification including controls - latitude & longitude space

	Sample falls within < 50 km		Sample falls within < 25 km	
	Linear	Quadratic	Linear	Quadratic
	(1)	(2)	(3)	(4)
German speaking	−0.481***	−0.520***	−0.432***	−0.525***
	[− 0.733, −0.229]	[− 0.771, −0.269]	[− 0.703, −0.162]	[− 0.797, −0.253]
log (Pop. density)	0.063	0.073	0.029	0.062
	[− 0.040, 0.167]	[− 0.035, 0.182]	[− 0.092, 0.150]	[− 0.071, 0.195]
log (Population)	−0.027	0.041	−0.105	−0.018
	[− 0.455, 0.402]	[− 0.394, 0.476]	[− 0.672, 0.462]	[− 0.606, 0.570]
log (Pop. employed)	0.045	0.026	0.085	0.033
	[− 0.099, 0.190]	[− 0.121, 0.173]	[− 0.095, 0.265]	[− 0.148, 0.215]
log (Pop. aged 65+)	−0.093	−0.165	−0.034	−0.150
	[− 0.468, 0.282]	[− 0.557, 0.227]	[− 0.544, 0.477]	[− 0.697, 0.397]
log (land usage - urban settlement)	0.094	0.106	0.145	0.230
	[− 0.196, 0.384]	[− 0.191, 0.402]	[− 0.174, 0.464]	[− 0.104, 0.564]
asinh (land usage - lakes)	0.037	0.035	0.040	0.036
	[− 0.018, 0.092]	[− 0.018, 0.089]	[− 0.018, 0.099]	[− 0.021, 0.093]
asinh (Pop. of cross border workers 2020Q1)	−0.023	−0.046	0.202	0.196
	[− 0.514, 0.467]	[− 0.534, 0.443]	[− 0.412, 0.816]	[− 0.401, 0.793]
asinh (Pop. of cross border workers 2020Q2)	0.083	0.108	−0.046	−0.024
	[− 0.463, 0.629]	[− 0.429, 0.645]	[− 0.747, 0.654]	[− 0.698, 0.651]
asinh (Pop. of cross border workers 2020Q3)	−0.196	−0.200	−0.448**	−0.459**
	[− 0.606, 0.214]	[− 0.594, 0.194]	[− 0.888, −0.007]	[− 0.876, −0.042]
asinh (Pop. of cross border workers 2020Q4)	0.169	0.180	0.276	0.294
	[− 0.283, 0.621]	[− 0.264, 0.624]	[− 0.293, 0.845]	[− 0.237, 0.825]
asinh (Pop. of cross border workers 2021Q1)	−0.062	−0.063	−0.037	−0.052
	[− 0.337, 0.212]	[− 0.328, 0.202]	[− 0.363, 0.289]	[− 0.352, 0.248]
Observations	3747	3747	2364	2364
Canton fixed effects	Yes	Yes	Yes	Yes

Results estimated use equation (1) including controls used for balance test. The unit of observation for the dependent variable: COVID-19 exposure, is the individual. The unit of observation for the demographic, economic and geographic variables is at the municipality level. Due to the presence of zeroes, for variables - population of foreign cross-border workers and land usage for lakes (in hectares), we use the inverse hyperbolic sine *(asinh)* transformation. Robust standard errors, clustered at municipality level. 95% confidence intervals are reported in parenthesis. Columns (1) and (2) include a linear and quadratic RD polynomial for a bandwidth of 50 km. Columns (3) and (4) include a linear and quadratic RD polynomial for a bandwidth of 25 km *.p<0.1; **p<0.05; ***p<0.01.

Table A2
Main specification including controls - distance to language border

	Sample falls within < 50 km		Sample falls within < 25 km	
	Linear	Quadratic	Linear	Quadratic
	(1)	(2)	(3)	(4)
German speaking	−0.477***	−0.479***	−0.490***	−0.482***
	[− 0.702, −0.251]	[− 0.706, −0.253]	[− 0.723, −0.256]	[− 0.715, −0.250]
log (Pop. density)	0.068	0.068	0.044	0.055
	[− 0.033, 0.169]	[− 0.033, 0.169]	[− 0.073, 0.161]	[− 0.062, 0.172]
log (Population)	−0.003	−0.002	−0.070	−0.119
	[− 0.434, 0.428]	[− 0.433, 0.429]	[− 0.636, 0.496]	[− 0.657, 0.418]
log (Pop. employed)	0.032	0.035	0.047	0.050
	[− 0.105, 0.170]	[− 0.103, 0.174]	[− 0.127, 0.220]	[− 0.118, 0.217]
log (Pop. aged 65+)	−0.119	−0.121	−0.073	−0.024
	[− 0.498, 0.260]	[− 0.500, 0.258]	[− 0.584, 0.437]	[− 0.507, 0.460]
log (land usage – urban settlement)	0.097	0.093	0.170	0.151
	[− 0.190, 0.383]	[− 0.193, 0.379]	[− 0.149, 0.490]	[− 0.164, 0.465]
asinh (land usage - lakes)	0.034	0.035	0.037	0.042
	[− 0.020, 0.089]	[− 0.020, 0.090]	[− 0.022, 0.097]	[− 0.014, 0.098]
asinh (Pop. of cross border workers 2020Q1)	−0.022	−0.025	0.192	0.220
	[− 0.515, 0.472]	[− 0.517, 0.468]	[− 0.424, 0.808]	[− 0.377, 0.818]
asinh (Pop. of cross border workers 2020Q2)	0.089	0.097	−0.016	−0.032
	[− 0.459, 0.636]	[− 0.448, 0.643]	[− 0.721, 0.688]	[− 0.708, 0.644]
asinh (Pop. of cross border workers 2020Q3)	−0.194	−0.201	−0.437*	−0.465**
	[− 0.601, 0.213]	[− 0.609, 0.208]	[− 0.892, 0.017]	[− 0.915, −0.014]
asinh (Pop. of cross border workers 2020Q4)	0.167	0.169	0.259	0.300
	[− 0.287, 0.621]	[− 0.285, 0.623]	[− 0.320, 0.838]	[− 0.276, 0.876]
asinh (Pop. of cross border workers 2021Q1)	−0.061	−0.064	−0.034	−0.062
	[− 0.335, 0.212]	[− 0.338, 0.211]	[− 0.363, 0.294]	[− 0.394, 0.269]
Observations	3747	3747	2364	2364
Canton fixed effects	Yes	Yes	Yes	Yes

Results estimated use equation (1) including controls used for balance test. The unit of observation for the dependent variable: COVID-19 exposure, is the individual. The unit of observation for the demographic, economic and geographic variables is at the municipality level. Due to the presence of zeroes, for variables - population of foreign cross-border workers and land usage for lakes (in hectares), we use the inverse hyperbolic sine *(asinh)* transformation. Robust standard errors, clustered at municipality level. 95% confidence intervals are reported in parenthesis. Columns (1) and (2) include a linear and quadratic RD polynomial for a bandwidth of 50 km. Columns (3) and (4) include a linear and quadratic RD polynomial for a bandwidth of 25 km *p<0.1; **p<0.05; ***p<0.01.

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