

Faessler, Lisa; Lalive, Rafael; Efferson, Charles

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## How Culture Shapes Choices Related to Fertility and Mortality: Causal Evidence at the Swiss Language Border

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*Lisa Faessler, Rafael Lalive, Charles Efferson*

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Telephone +49 (0)89 2180-2740, Telefax +49 (0)89 2180-17845, email [office@cesifo.de](mailto:office@cesifo.de)

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# How Culture Shapes Choices Related to Fertility and Mortality: Causal Evidence at the Swiss Language Border

## Abstract

Results from cultural evolutionary theory often suggest that social learning can lead cultural groups to differ markedly in the same environment. Put differently, cultural evolutionary processes can in principle stabilise behavioural differences between groups, which in turn could lead selection pressures to vary across cultural groups. Separating the effects of culture from other confounds, however, is often a daunting, sometimes intractable challenge for the working empiricist. To meet this challenge, we exploit a cultural border dividing Switzerland in ways that are independent of institutional, environmental, and genetic variation. Using a regression discontinuity design, we estimate discontinuities at the border in terms of preferences related to fertility and mortality, the two basic components of genetic fitness. We specifically select six referenda related to health and fertility and analyse differences in the proportion of yes votes across municipalities on the two sides of the border. Our results show multiple discontinuities and thus indicate a potential role of culture to shape preferences and choices related to individual health and fertility. These findings further suggest that at least one of the two groups, in order to uphold its cultural values, has supported policies that could impose fitness costs on individuals in the group.

JEL-Codes: Z100, Z130, D720, I180.

Keywords: gene-culture coevolution, cultural evolution, social learning, cultural variation, fitness, cultural border, regression discontinuity design.

*Lisa Faessler*  
*Faculty of Business and Economics*  
*University of Lausanne / Switzerland*  
*lisa.faessler@unil.ch*

*Rafael Lalive*  
*Faculty of Business and Economics*  
*University of Lausanne / Switzerland*  
*rafael.lalive@unil.ch*

*Charles Efferson*  
*Faculty of Business and Economics*  
*University of Lausanne / Switzerland*  
*charles.efferson@uni.ch*

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# 1 Introduction

2 Gene-culture coevolutionary theory argues that human populations are subject to two evolutionary  
3 processes, genetic and cultural (Laland 2008). Genetic variants influence the development and  
4 spread of cultural traits, while cultural practices affect selection on genes. As a result, genes and  
5 culture coevolve as linked dynamical processes. As a kind of corollary hypothesis, an especially  
6 controversial claim is that social learning stabilises cultural differences at the group level, which  
7 in turn introduces the possibility of selection at the level of the cultural group (Henrich 2004,  
8 Richerson et al. 2016).

9 We examine a kind of proof of concept for these ideas. Specifically, we do not directly consider  
10 culture's influence on genetic fitness, but we do insist on an attempt to identify cleanly the  
11 causal influence of culture on decisions affecting health and fertility. Identifying cultural variation  
12 as a group-level phenomenon is often a difficult empirical challenge because culture typically  
13 covaries with many other variables related to institutions, the environment, and possibly even  
14 genes. To meet this challenge, we exploit a distinctive feature of Switzerland's geography, a  
15 linguistic and cultural border that separates the German-speaking part of the country from the  
16 French-speaking part. Right at the border, the environments for French speakers and German  
17 speakers are necessarily identical. Moreover, the French- and German-speaking parts of the  
18 country are genetically similar in general (Buhler et al. 2012). Finally, in some regions, the border  
19 does not match any institutional boundary. Thus, right at the border, we have the possibility  
20 of observing variation in preferences and norms that we can say is cultural in the precise sense  
21 that it cannot be institutional, environmental, or genetic. This situation represents an unusual  
22 opportunity because cultures often covary with one or more of these variables.

23 Consider two examples that illustrate the challenges of isolating culture in domains that could  
24 influence selection on genes. First, lactase persistence is a classic example. In most mammals,  
25 including humans, lactase production declines after weaning, but some populations have evolved  
26 the ability to produce lactase throughout adulthood, a condition known as lactase persistence.  
27 This adaptation is thought to have arisen in response to the cultural practice of dairy farming,  
28 which allowed people to consume milk and dairy products as a significant part of their diet.  
29 Nonetheless, recent evidence suggests that multiple factors, including different environmental  
30 conditions, have contributed to lactase persistence, and that dairying alone is probably insufficient  
31 to explain the spread of the trait. In particular, exposure to famine and diseases has played a

32 crucial role in the evolution of lactase persistence (Evershed et al. 2022). Second, the cultural  
33 practice of cooking and its influence on human gut size is another classic example. Cooking  
34 allows us to pre-digest our food over the campfire or on the stove, which improves the biological  
35 availability of the nutrients in the food. Cooking as a cultural innovation likely allowed our  
36 ancestors to evolve smaller guts because they were able to extract more energy from their food  
37 for a given metabolic cost. Thus, energetic resources within the body became available for other  
38 functions such as brain growth and development. This shift in energy allocation is thought to  
39 have played a key role in the evolution of larger brains and shorter digestive tracts in humans  
40 compared to our primate relatives. Stories of this sort are interesting and compelling, and they  
41 may very well be correct. They are not, however, causal explanations. Valid comparisons that  
42 we could rely on to represent the counterfactual state are not available to us and probably never  
43 will be.

## 44 1.1 Identifying Culture

45 Identifying the causal influence of culture on gene selection is a challenge. Comparing the  
46 average behaviours of two populations often cannot provide evidence for cultural variation (Bell  
47 et al. 2009). If environmental conditions, institutions, and other socioeconomic variables covary  
48 with culture, isolating the extent to which group-level variation is specifically cultural can be  
49 exceedingly difficult. Lamba & Mace (2011), for example, compared groups within the same  
50 culture but living in different locations, and they found substantial variation across the groups.  
51 This kind of result suggests that large differences among groups can be environmental just as  
52 surely as they can be cultural, and indeed recent evidence suggests that ecology can explain a  
53 substantial amount of human population diversity (Wormley et al. 2022).

54 That said, a number of new tools have been developed to allow the identification of causal  
55 effects without randomised experiments, and these tools can potentially help us identify culture.  
56 These quasi-experimental methods include the regression discontinuity design (RDD). The basic  
57 idea of the regression discontinuity design is to compare the outcomes of individuals just above  
58 and below some threshold. Intuitively, researchers estimate two regression lines, one on each  
59 side of the threshold, and doing so identifies any discontinuities in the response variable that  
60 occur right at the threshold (Lee & Lemieux 2010, Cattaneo et al. 2019). A few studies have  
61 used a variant of this method, the spatial regression discontinuity design, to identify cultural  
62 discontinuities and the Swiss language border. We adopt the same basic approach here.

63 These studies are known as “Röstigraben studies”, a type of spatial regression discontinuity  
64 design that examines cultural differences in behaviour in Switzerland. The term “Röstigraben” –  
65 German for “hash brown trench” – refers to a linguistic and cultural border within Switzerland.  
66 The border separates the German-speaking part from the French-speaking part of the country, and  
67 in some regions it does not match any institutional boundary. With appropriate data, researchers  
68 could in principle check for discontinuities in any variable of interest right at the language border,  
69 and by doing so the researcher would effectively isolate cultural differences, as a group-level  
70 phenomenon, in identical institutional and ecological settings. Using this technique, Eugster et al.  
71 (2011) document a persistent difference in the demand for social insurance at the border, and  
72 Eugster et al. (2017) also found a significant discontinuity in unemployment duration. Focusing  
73 on the bilingual canton of Fribourg, Brown et al. (2018) discovered a systematic difference in  
74 the financial literacy of students across the border, and their analyses suggest that the effect is  
75 driven by cultural differences rather than unobserved heterogeneity in policies.

## 76 1.2 Switzerland’s Linguistic and Cultural Landscape

77 Switzerland is a multilingual country with four official languages: German, French, Italian, and  
78 Romansh. German is the most widely spoken language at home (62%), while French is second  
79 (22.8%). Switzerland’s linguistic diversity is a unique feature that has played a significant role  
80 in shaping its culture and society. Multilingualism is a common characteristic among Swiss  
81 people. However, the historical border between the French- and the German-speaking regions  
82 has remained clear-cut. A sharp change in the main language spoken at home persists when  
83 switching from one side of the border to the other (OFS 2022a). Because the language border is  
84 clear and well-defined in space, we can meaningfully isolate discontinuous differences that occur  
85 right at the border.

86 Beyond language, conventional wisdom posits that this linguistic border also captures dif-  
87 ferences in values, norms, and preferences. Swiss media and citizens often view it as a cultural  
88 divide that marks contrasting attitudes. During federal elections, when voting on shared issues,  
89 these differences become especially apparent (Etter et al. 2014). Furthermore, the French- and  
90 German-speaking regions show distinct patterns of health-related behaviours *on average*. For  
91 instance, French speakers typically consume more red meat but less butter, milk, and coffee than  
92 their German-speaking counterparts (Chatelan et al. 2017, Rochat et al. 2019). These compar-  
93 isons of group averages do not provide causal evidence, but they do fit with the conventional

94 wisdom within Switzerland. When you cross the Röstigraben, it's not just the language that  
95 changes; culture more broadly changes, too. That said, we can check to see if this is the case  
96 with a spatial regression discontinuity design. The basic idea is to code variables of interest  
97 as a function of distance from the language border, and then use the method to estimate any  
98 discontinuities in the variables right at the border. Doing so is effectively like comparing what  
99 happens one meter to the east of the border to what happens one meter west of the border.

### 100 **1.3 The Cultural Components of Fitness**

101 Having explained our strategy to isolate culture's causal effect, we now turn to the second  
102 consideration. Namely, what kinds of available data connect possible cultural differences within  
103 Switzerland to fertility and mortality, the two basic components of genetic fitness? In our study,  
104 we focus on the tendency of people to vote for or against policies that should impact either  
105 the survival or reproduction of individuals. In Switzerland, the leading causes of death are  
106 predominantly disease. In 2018, cardiovascular diseases contributed to 31% of the deaths, while  
107 cancer accounted for 26%. Dementia is third at 10%. Because the majority of deaths are related  
108 to (the absence of) health, we focus on choices related to health to understand how culture could  
109 influence survival rate. Specifically, we investigate choices related to the healthcare system and  
110 the management of pandemics.

111 Shifting to fertility and drawing on Hrdy's work on the evolutionary basis of parenthood  
112 (1999), we focus on women's freedom of choice regarding investments in offspring. Human infants  
113 are highly resource-intensive, and raising a human child requires cooperation among multiple  
114 caregivers. Humans are cooperative breeders, and presumably women have long been subject  
115 to selection for the ability to assess the social support available for raising a child. If adequate  
116 support is lacking, women may choose not to invest in the child and prioritise potential future  
117 offspring instead. In terms of genetic fitness, women need the freedom to manage trade-offs  
118 between investing in current offspring versus conserving resources for potential future offspring.  
119 In that sense, cultural practices that limit women's autonomy could be viewed as imposing a  
120 detrimental effect on the fitness of women who have not completed reproduction and on the  
121 inclusive fitness of any genetic relatives. We investigate potential differences in support for three  
122 types of policy that should influence women's freedom of choice and degree of social support  
123 during and after pregnancy. These three types of policy pertain to abortion access, assisted  
124 reproduction, and paid parental leave.



125 In sum, our study aims to investigate the causal influence of culture on health- and fertility-  
126 related choices and to discuss how any differences might relate to genetic fitness. To meet this  
127 goal, we use a quasi-experimental design based on distance from the Röstigraben, a linguistic and  
128 cultural border in Switzerland. We are looking for discontinuities in choices at the border. Any  
129 discontinuities at the border would suggest a cleanly identified cultural difference that shapes  
130 preferences and behaviour. We will then discuss, somewhat speculatively, how these cultural  
131 differences could affect the relative fitness of individuals in the two cultural groups.

## 132 **2 Methods**

### 133 **2.1 Referanda Data**

134 To explore potential cultural differences in decision-making domains related to fertility and  
135 mortality, we use data from referenda in Switzerland. Because we are using a regression  
136 discontinuity design, we need a substantial amount of geographically precise data, which the  
137 referenda data provide. We focus on referenda at the Swiss level and thus common to all cantons.  
138 Finally, referenda occur multiple times a year and encompass a wide range of topics, including  
139 health, the healthcare system, and fertility. However, the sample represents only the voting  
140 population and excludes the opinions of non-voters on both sides of the border. Nonetheless, the  
141 laws are based on the decisions of voters. As such, even though our data are not representative  
142 of the Swiss population, they can be helpful in identifying cultural differences in the voting  
143 population. We use the percentage of “yes” votes in referenda as our response variables, and we  
144 estimate discontinuities in referenda results across municipalities on both sides of the border.  
145 Namely, we focus on a preregistered list of referenda related to health or fertility in the past  
146 decade (Faessler et al. 2022). The data are provided by the Federal Statistical Office and include  
147 referenda results across municipalities, with our unit of analysis being the municipality. We  
148 selected municipalities within 100 km of the language border, totalling 1,409 municipalities.

### 149 **2.2 Regression Discontinuity Design**

150 A regression discontinuity design has three essential elements: a threshold, a running variable,  
151 and a treatment. In our case, the threshold is the cultural border, the continuous variable is  
152 the distance from this border, and the treatment is the culture. Starting from these elements,  
153 we estimate two regression lines on each side of the border to examine whether voting results

154 are discontinuous at the border. As such, we study the effect of moving from one side of the  
155 language and cultural boundary to the other on referenda outcomes and the distribution of policy  
156 preferences these outcomes represent.

The generic regression model for these regression discontinuity designs can be represented as follows.

$$y_m = \beta_0 + \beta_1 German_m + \beta_2 f_0(Distance_m) + \beta_3 German_m * f_1(Distance_m) + controls + \epsilon_m \quad (1)$$

157 In detail,  $y_m$  denotes the outcome of interest for municipality  $m$ , which is the proportion of  
158 “yes” votes for a referendum.  $German_m$  is a dummy variable that takes the value of 1 if the  
159 municipality is on the German side of the border and 0 otherwise. In that sense,  $\beta_1$  captures  
160 the discontinuity of interest, the cultural discontinuity at the border. A significant  $\beta_1$  value  
161 indicates a causal effect of culture on voting decisions at the border.  $Distance_m$  is the running  
162 variable that measures the distance from the border.  $f_0()$  and  $f_1()$  are functions of distance  
163 to the border that will be estimated. Both  $Distance_m$  and its interaction with  $German_m$  take  
164 care of controlling for effects that happen away from the border and that could be driven by  
165 environmental differences. Throughout the study, we will estimate different versions of this  
166 generic regression discontinuity model, each of which will focus on a distinct referendum.

167 In this analysis, municipality language  $German_m$  and distance from the language border  
168  $Distance_m$  are our main independent variables. Distance from the border, in particular, plays  
169 a crucial role, and we explain in detail how the measure is constructed. First, using the same  
170 distance data as Eugster et al. (2011), each municipality is assigned a language according to  
171 the language spoken by most of its population. Second, the distance to the language border is  
172 calculated by determining the shortest road distance between the focal municipality and the  
173 nearest municipality where the other language is spoken. Further, the distance is set as negative  
174 for French-speaking municipalities and positive for German-speaking municipalities.

175 Our statistical model controlled for municipality type because rural and urban areas could  
176 exhibit different voting patterns. We control for this possibility by including a dummy for  
177 municipality type, i.e. whether the municipality is located in an urban or rural area. We also  
178 include canton fixed effects. In Switzerland, a federal system divides power between the state  
179 and the cantons. Cantons are administrative subdivisions of the country and have authority  
180 over education, health care, policing, and taxation. In particular, institutions related to health

181 and fertility may vary across cantons. We include a canton fixed effect to account for this  
 182 variation. Nevertheless, the language border crosses some cantons and does not correspond to an  
 183 institutional boundary.

184 A fundamental assumption of regression discontinuity design is that at the threshold, the  
 185 treated and control groups differ only by treatment. Because our unit of analysis is the mu-  
 186 nicipality, we necessarily move from one municipality to another at the threshold. However,  
 187 while municipalities have a certain degree of autonomy, their powers are limited by cantonal  
 188 and federal laws. Municipalities are mainly responsible for local governance, including waste  
 189 management, water supply, social welfare and public transport. Thus, even though institutions  
 190 change from one municipality to another, the institutional changes are limited and not directly  
 191 related to health and fertility.

	Mean all	French l.	German l.	Difference	At the border
Population size	3163.38	2609.39	3576.18	966.79	-121.512
Population variation (%)	8.83	13.36	5.45	-7.91***	-6.307***
Density	323.73	203.00	413.69	210.69***	102.682
Immigrants (%)	14.19	16.14	12.74	-3.40***	-5.280***
Household size	2.31	2.37	2.27	-0.10***	0.023
0-19 years (%)	20.45	21.97	19.32	-2.65***	-1.704***
20-64 years (%)	59.74	59.75	59.73	-0.02	0.331
+65 years %	19.81	18.28	20.95	2.67***	1.373***
Young dependency ratio	34.52	36.81	32.81	-4.00***	-2.839***
Mean taxable revenue	69,762	66,617	72,275	5,658***	10,257**
Tax rate for families	5.30	4.94	5.57	0.63***	-0.145***
Tax rate for singles	15.40	15.33	15.45	0.12	-0.284***
Social assistance (%)	2.69	2.80	2.61	-0.19	-1.213***

Table 1: Municipalities and population characteristics around the border. Notes: “Mean all” refers to the mean of municipalities within 50 km of the language border. “French language” includes only the municipalities where most of the population speaks French, within a 50km range. “German language”, the municipalities where most of the population speaks German, within a 50km range. “Difference” shows the mean difference between French-language municipalities and German-language municipalities. “At the border” shows the difference estimated at the language border using regression discontinuity design and controlling for population, canton, and whether the municipality is urban or rural. \* $p < 0.1$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.01$ . Source: Swiss Federal Statistical Office (SFO). Distances from search.ch.

192 Aside from institutions, population characteristics may also vary at the border. Table 1  
 193 provide the statistics for a selection of population and municipality variables likely to influence  
 194 choices related to health and fertility. The variables include population size and characteristics,  
 195 age structure within the population, and a series of wealth indicators. Most of the variables are  
 196 not perfectly balanced at the border, but regions are more balanced at the border than overall  
 197 (column "Difference" has larger differences than "At the border"). In particular, the age structure  
 198 and wealth seem to differ on the border’s two sides. The municipalities on the German-speaking

199 side count more older individuals and fewer younger individuals while having higher revenues and  
200 smaller tax ratios. These differences could suggest that the population on the German-speaking  
201 side of the border is more preoccupied with health, but it also benefits from higher revenues to  
202 prevent disease or provide medical care.

203 Importantly, our setting cannot exclude that some individuals decide to move to the other  
204 side of the border. If so, people would self-select their treatments, which would undermine to  
205 some extent our identification strategy. While people could decide to live in the region that best  
206 matches their values, the language border is sharp. Our data indicate that the mean proportion of  
207 French speakers shifts from 74% to 12% within a distance of only 6 km. Similarly, the proportion  
208 of German speakers shifts from 24% to 86%. Moving to another linguistic region would require  
209 the individual to learn the other language, which necessarily constitutes a barrier. Further, the  
210 average moving distance is 13 km, and most of the moves (58%) happen within a distance of  
211 5km (OFS 2022*b*). Although we cannot exclude that some individuals self-select in treatments,  
212 we suspect this mechanism has limited effects.

### 213 **3 Results**

214 Our results show multiple discontinuities in voting behaviours at the language border. Before  
215 turning to these results, we would like to explain the generic argument for why discontinuities  
216 are interesting from a gene-culture coevolutionary perspective. First, assume that policies related  
217 to health and reproduction vary in terms of how they affect mortality and fertility. Some policies  
218 might favour more children and other policies fewer children. This would mean, in turn, that  
219 policies, if enacted, would vary in terms of how they incentivise individuals to manage the  
220 trade-offs between the quantity and quality of their offspring. Analogously, some policies might  
221 augment the scope for individuals to rely on social support when raising offspring, while other  
222 policies might do the opposite. In this way, if enacted policies would vary in terms of how they  
223 incentivise individuals to manage the trade-offs between current and future offspring. Lastly,  
224 policies related to pandemics should affect the risk of infectious disease and by extension the  
225 risk of mortality. Policies related to healthcare more broadly should affect the extent to which  
226 individuals invest in their health and in turn survival. For example, one of the referenda below  
227 concerned how to organise health insurance. Even if we imagine that the alternatives would  
228 have no consequences in terms of the quality of healthcare supplied we can easily imagine that

229 different insurance schemes would affect behaviour on the demand side. Some schemes might  
230 incentivise healthy lifestyles and preventative treatments, while other schemes might tip the  
231 balance in favour of treating people after they get sick.

232 Second, assume that for a given referendum one of the policies under consideration is best in  
233 terms of expected fitness, and right at the border the best policy is the same on both sides of  
234 the border. This assumption does not mean that the best policy is the same throughout the  
235 French- and German-speaking regions. It simply means that the best policy is the same right at  
236 the border. We do not know which policy is better, nor does the answer to this question matter  
237 for present purposes. We simply assume that one is better than the other. If this is true, then  
238 a discontinuity implies that one of the two groups favours the sub-optimal policy for cultural  
239 reasons, where cultural reasons by this account must be separate from institutions, genes, and  
240 environment. This sub-optimal policy, if enacted, would bring an expected fitness cost, however  
241 small, relative to the other policy under consideration. For each of the referenda we examine, we  
242 speculate about such possibilities in greater detail below.

### 243 **3.1 Health-related referanda**

#### 244 **28 September 2014, the referendum for a single public health insurance company.**

245 First, we analysed the results of the referendum on creating a single public health insurance  
246 company, which took place on 28 September 2014. Under the proposed single-payer system, a  
247 public insurance company would have replaced the current private insurance companies, and  
248 all residents would have been required to enrol in the public plan. Supporters argued that the  
249 single-payer system would reduce administrative costs and improve access to healthcare. At the  
250 same time, opponents claimed that it would lead to longer waiting times and lower quality of  
251 care.

252 Figure 1 shows a strong discontinuity at the border in the pattern of “yes” votes proportions  
253 across municipalities. The left-hand side of the graph displays French-speaking municipalities,  
254 while the right-hand side shows German-speaking municipalities. In almost all municipalities  
255 on the French-speaking side of the border, the proportion of “yes” votes is higher than in  
256 municipalities on the German-speaking side. The red lines represent linear regression lines.  
257 Linear regression results in Table 2 confirm the presence of a discontinuity in voting results at  
258 the border. The German language estimate is not sensitive to controlling for canton fixed effects  
259 and whether the municipality is urban or rural (estimate  $\in \{-0.199; -0.219; -0.221\}$ ,  $p < 0.01$ ).

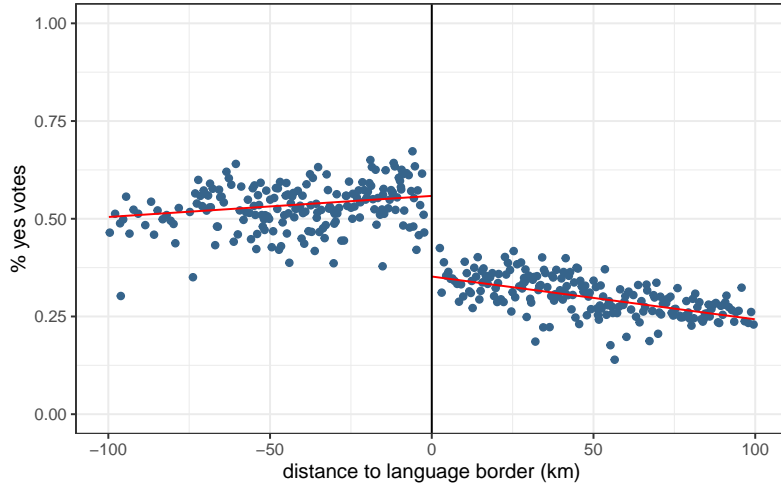


Figure 1: Average proportion of “yes” votes to the referendum for a single public health insurance, by distance to the language border. Notes: The left-hand side of the graph displays French-speaking municipalities; the right-hand side, German-speaking municipalities. The red lines are the linear regression lines. Source: Federal Statistical Office. Distances from search.ch.

	(1)	(2)	(3)
German Language	-0.199*** (0.009)	-0.219*** (0.009)	-0.221*** (0.009)
German*Distance	-0.002*** (0.0002)	-0.002*** (0.0002)	-0.002*** (0.0002)
Distance	0.001*** (0.0001)	0.001*** (0.0001)	0.001*** (0.0002)
Urban			0.022*** (0.004)
Constant	0.558*** (0.007)	0.574*** (0.016)	0.554*** (0.016)
Cantons FE	No	Yes	Yes
Observations	1,409	1,409	1,353
Adjusted R <sup>2</sup>	0.662	0.804	0.807

Table 2: Referenda for a single public health insurance company: regression analysis at the language border. Notes: The regression analysis shows the impact of switching from the French-speaking side of the border to the German-speaking side on voting results, that is, the proportion of “yes” votes in a municipality. “German language” indicates that the primary language of a municipality is German and is our variable of interest. “Distance” is the road distance to the language border. “Distance” and its interaction with “German language” control for effects that happen away from the border and environmental differences. We restrict our analysis to municipalities within 100km of the language border. Models (2) and (3) include controls for the canton. Model (3) includes a control variable for municipality characteristics, whether the municipality is located in a rural or urban area. Robust standard errors are in parenthesis. \*p<0.1; \*\*p<0.05; \*\*\*p<0.01. Source: Federal Statistical Office. Distances from search.ch.

260 The referendum on a single health insurance company highlights an interesting example  
 261 of the potential influence of culture on fitness. Swiss citizens were asked if they would like

262 a single public health insurance system or multiple private health insurance companies. To  
263 illustrate the significance of this choice, imagine two extremes. At one extreme, a single insurance  
264 company would pool risk over the entire Swiss population. At the other extreme, each individual  
265 would self-insure and be responsible for her own healthcare and associated costs. Whatever  
266 the details, the optimal system in terms of an individual's health, survival, and fitness must lie  
267 between these two extremes. We observed that the two groups supported different policies at  
268 the border. If, however, the distribution of optimal strategies was the same right at the border,  
269 the discontinuity in preferences right at the border means that at least one of the two cultures  
270 supported a sub-optimal policy for cultural reasons. To maintain cultural beliefs or preferences,  
271 one group was prepared to support a fitness cost relative to the optimal policy.

272 **22 September 2013, revision of the law on epidemics and 13 June 2021, Covid law.**

273 The second example comes from two referenda related to the management of epidemics. The  
274 two referenda are 8 years apart. On 22 September 2013, Switzerland held a first referendum  
275 on revising the law on epidemics, and the proposed changes aimed to enhance the country's  
276 response to any future pandemics. The revised law would have expanded the government's  
277 powers to contain outbreaks, require vaccinations, and collect health data for public health  
278 reasons. However, groups such as anti-vaxxers and privacy advocates were concerned about the  
279 increased surveillance and data collection that could follow. Eight years later, on 13 June 2021,  
280 Swiss citizens voted on a related question, namely the Covid law. The proposal was to give the  
281 government extraordinary powers to manage the Covid-19 pandemic, powers such as imposing  
282 restrictions on public life and providing financial aid to those affected. However, the law faced  
283 opposition from groups who believed it gave the government too much power and infringed on  
284 individual freedoms. Both laws were approved by a majority vote of around 60%.

285 Figure 2 plots the average proportion of "yes" votes for these two referenda across municipal-  
286 ities on the two sides of the language border. The two figures present similar patterns, namely a  
287 negative slope on both sides and a steeper slope on the French side. However, these two graphs  
288 by themselves do not allow us to confirm or disconfirm the presence of discontinuities at the  
289 border.

290 Tables 3 and 4 present the results of the regression analyses. Both results show quantitatively  
291 small estimates whose significance varies across models. These results should be interpreted with  
292 caution. We focus on model 3 results, where this model is the most demanding specification

	(1)	(2)	(3)
German Language	-0.050*** (0.009)	-0.014 (0.010)	-0.016* (0.010)
German*Distance	0.001*** (0.0002)	-0.0003 (0.0002)	-0.0004* (0.0002)
Distance	-0.001*** (0.0001)	-0.001*** (0.0002)	-0.001*** (0.0002)
Urban			0.062*** (0.004)
Constant	0.592*** (0.007)	0.695*** (0.018)	0.639*** (0.018)
Cantons FE	No	Yes	Yes
Observations	1,409	1,409	1,353
Adjusted R <sup>2</sup>	0.382	0.525	0.594

Table 3: Revision of the epidemics law: regression analysis at the language border. Notes: The regression analysis shows the impact of switching from the French-speaking side of the border to the German-speaking side on voting results, that is, the proportion of “yes” votes in a municipality. “German language” indicates that the primary language of a municipality is German and is our variable of interest. “Distance” is the road distance to the language border. “Distance” and its interaction with “German language” control for effects that happen away from the border and environmental differences. We restrict our analysis to municipalities within 100km of the language border. Models (2) and (3) include controls for the canton. Model (3) includes a control variable for municipality characteristics, whether the municipality is located in a rural or urban area. Robust standard errors are in parenthesis. \* $p < 0.1$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.01$ . Source: Federal Statistical Office. Distances from search.ch.

	(1)	(2)	(3)
German Language	-0.0005 (0.010)	0.029** (0.012)	0.027** (0.011)
German*Distance	0.001*** (0.0002)	-0.0003 (0.0003)	-0.0004* (0.0002)
Distance	-0.002*** (0.0002)	-0.0002 (0.0002)	-0.0002 (0.0002)
Urban			0.094*** (0.005)
Constant	0.541*** (0.008)	0.617*** (0.022)	0.528*** (0.020)
Cantons FE	No	Yes	Yes
Observations	1,409	1,409	1,353
Adjusted R <sup>2</sup>	0.186	0.272	0.440

Table 4: Revision of the Covid law: regression analysis at the language border. Notes: The regression analysis shows the impact of switching from the French-speaking side of the border to the German-speaking side on voting results, that is, the proportion of “yes” votes in a municipality. “German language” indicates that the primary language of a municipality is German and is our variable of interest. “Distance” is the road distance to the language border. “Distance” and its interaction with “German language” control for effects that happen away from the border and environmental differences. We restrict our analysis to municipalities within 100km of the language border. Models (2) and (3) include controls for the canton. Model (3) includes a control variable for municipality characteristics, whether the municipality is located in a rural or urban area. Robust standard errors are in parenthesis. \* $p < 0.1$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.01$ . Source: Federal Statistical Office. Distances from search.ch.



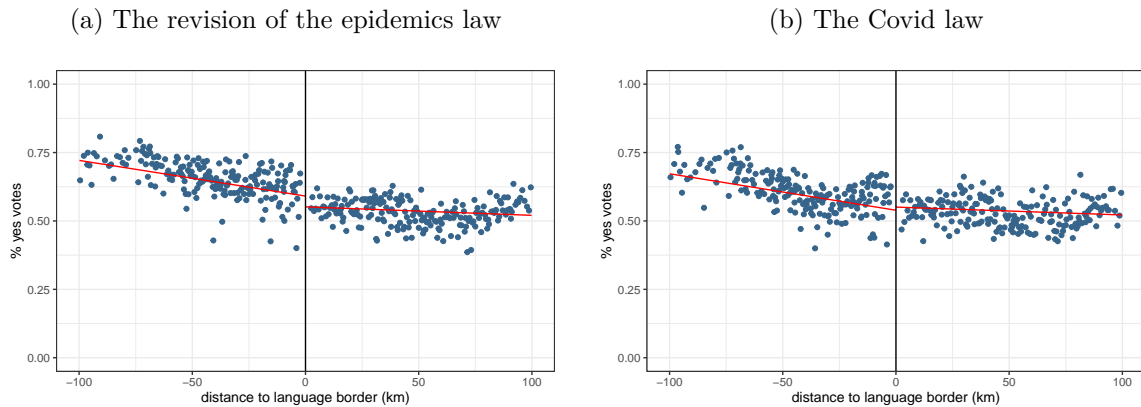


Figure 2: Average proportion of “yes” votes to the two referenda on epidemics management across municipalities, by distance to the language border. Notes: The left-hand side of the graph displays French-speaking municipalities; the right-hand side, German-speaking municipalities. The red lines are the linear regression lines. Source: Federal Statistical Office. Distances from search.ch.

293 in terms of causality because it includes controls for cantons and whether the municipality is  
 294 urban. The two estimates are significant and suggest a discontinuity in voting behaviours at  
 295 the border. In 2013, the municipalities on the German-speaking side of the border were less  
 296 likely to accept the law (estimate =  $-0.016$ ,  $p < 0.1$ ). In 2021, the effect goes in the opposite  
 297 direction. Municipalities on the German-speaking side of the border are more likely to vote “yes”  
 298 (estimate =  $0.027$ ,  $p < 0.05$ ). Even though we should treat these results as provisional, we can  
 299 also discuss possible reasons for such a change. In 2013, the threat of an actual epidemic was  
 300 very abstract. In 2021, Covid-19 had appeared and made the consequences of a pandemic very  
 301 concrete. Observing the consequences of the Covid-19 pandemic could have caused a shift in  
 302 opinions in both directions. Being confronted with the reality of the Covid-19 pandemic and  
 303 the number of deaths, individuals previously sceptical about the necessity of strict widespread  
 304 measures could have changed their minds. On the other hand, previously cautious individuals  
 305 could have come to the conclusion that the treatment was worse than the disease, particularly if  
 306 they belonged to a category of the population spared from the worst forms of the disease.

307 Disease outbreaks and pandemics can have substantial impacts on individual fitness. Therefore,  
 308 the revised law on epidemics and Covid law could potentially have affected the fitness of Swiss  
 309 citizens. During pandemics, large-scale actions are more effective, as highly infectious diseases  
 310 spread on a large scale. Approving these laws could thus have improved fitness by reducing the  
 311 risk of disease transmission and ensuring access to healthcare and financial support. Voting  
 312 against these laws would have meant supporting a potential individual fitness cost. However, a  
 313 *laissez-faire* approach could have benefited individual fitness in some situations. For example, we

314 know that Covid-19 was less severe for younger people. The costs of shutdowns, for example,  
315 might have loomed relatively largely for them, while the risks from the disease would have been  
316 minimal. In such cases, voting for the laws might have imposed a fitness cost. Regardless, a  
317 discontinuity at the border implies that one group showed relatively strong support for a policy  
318 that would have imposed fitness costs when compared to the other policy.

### 319 3.2 Fertility-related referenda

320 **9 February 2014, referendum prohibiting the reimbursement of abortion.** We now  
321 provide three examples related to fertility. We start with the referendum on the reimbursement  
322 of abortion. On 9 February 2014, Swiss citizens voted on the prohibition of the reimbursement of  
323 abortion by health insurance companies. Proponents of the proposal argued that taxpayers should  
324 not be forced to pay for a procedure they consider morally objectionable. Conversely, opponents  
325 argued that women should have access to safe and affordable abortion services, regardless of  
326 their financial situation.

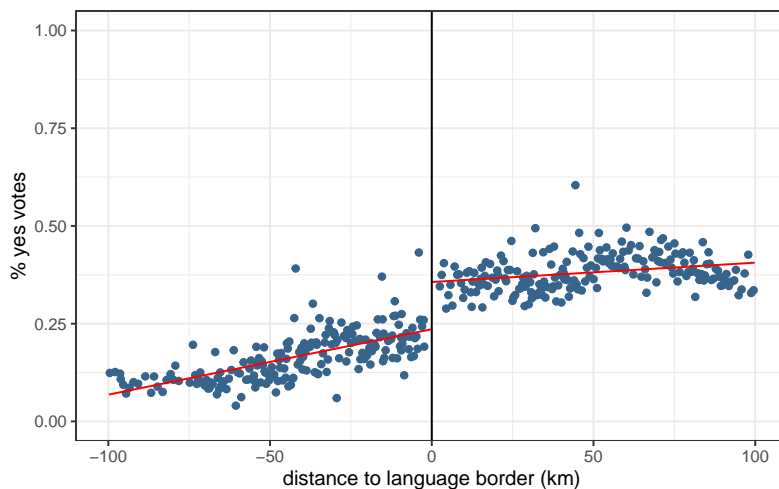


Figure 3: Average proportion of “yes” votes to referendum prohibiting the reimbursement of abortion across municipalities, by distance to the language border. Notes: The left-hand side of the graph displays French-speaking municipalities; the right-hand side, German-speaking municipalities. The red lines are the linear regression lines. Source: Federal Statistical Office. Distances from search.ch.

327 Figure 3 presents the percentage of votes in favour of the initiative across municipalities at  
328 different distances of the language border. The data show an evident discontinuity at the border.  
329 Municipalities on the French-speaking side of the border were less likely to vote in favour of  
330 modifying the law than municipalities on the German-speaking side. Regression analysis results  
331 in Table 5 confirm these descriptive results. The German language estimate is significant in the

332 three models, and adding controls does not change this in any way (estimate  $\in \{0.122; 0.125;$   
 333  $0.127\}$ ,  $p < 0.01$ ).

	(1)	(2)	(3)
German Language	0.122*** (0.008)	0.125*** (0.009)	0.127*** (0.009)
German*Distance	-0.001*** (0.0002)	0.0003 (0.0002)	0.0003* (0.0002)
Distance	0.002*** (0.0001)	0.0005*** (0.0002)	0.0005*** (0.0002)
Urban			-0.041*** (0.004)
Constant	0.236*** (0.006)	0.133*** (0.017)	0.174*** (0.017)
Cantons FE	No	Yes	Yes
Observations	1,409	1,409	1,353
Adjusted R <sup>2</sup>	0.676	0.756	0.770

Table 5: Referendum prohibiting the reimbursement of abortion: regression analysis at the language border. Notes: The regression analysis shows the impact of switching from the French-speaking side of the border to the German-speaking side on voting results, that is, the proportion of “yes” votes in a municipality. “German language” indicates that the primary language of a municipality is German and is our variable of interest. “Distance” is the road distance to the language border. “Distance” and its interaction with “German language” control for effects that happen away from the border and environmental differences. We restrict our analysis to municipalities within 100km of the language border. Models (2) and (3) include controls for the canton. Model (3) includes a control variable for municipality characteristics, whether the municipality is located in a rural or urban area. Robust standard errors are in parenthesis. \* $p < 0.1$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.01$ . Source: Federal Statistical Office. Distances from search.ch.

334 Restricting women’s access to abortion could have considerable genetic fitness implications,  
 335 particularly for women. As cooperative breeders, mothers require social support to raise their  
 336 children. They must balance investment in their current offspring with investment in potential  
 337 future offspring (Hrdy 1999). In that sense, any restrictions on access to abortion would limit  
 338 women’s ability to manage this trade-off and impose a fitness cost on women. The 2014 referendum  
 339 prohibiting the reimbursement of abortion in Switzerland could have resulted in such a cost for  
 340 women, given the potential restrictions on access that the initiative could have imposed. The  
 341 discontinuity in the voting results at the border suggests that one group was more willing to  
 342 support a sub-optimal policy in terms of fitness. In particular, to preserve moral values, the  
 343 German-speaking group was willing to pay the expected fitness cost related to the sub-optimal  
 344 policy compared to the other policy under consideration.

345 **5 June 2016, referendum on assisted reproduction.** On 5 June 2016, Swiss citizens voted  
 346 to modify the medically assisted reproduction law. The proposed amendment aimed to legalize,  
 347 under certain conditions, the genetic diagnosis of embryos derived from in vitro fertilization before  
 348 implanting the embryos. The amended law would have allowed pre-implementation diagnosis  
 349 only for carriers of alleles associated with severe hereditary disease or those who cannot have a  
 350 child naturally. Supporters argued that the law was necessary to provide couples with the same  
 351 reproductive options already available in neighbouring countries. On the other hand, opponents  
 352 feared that the revision would have lead to an ethically unacceptable expansion of genetic testing  
 353 on human embryos and undermined the traditional family structure.

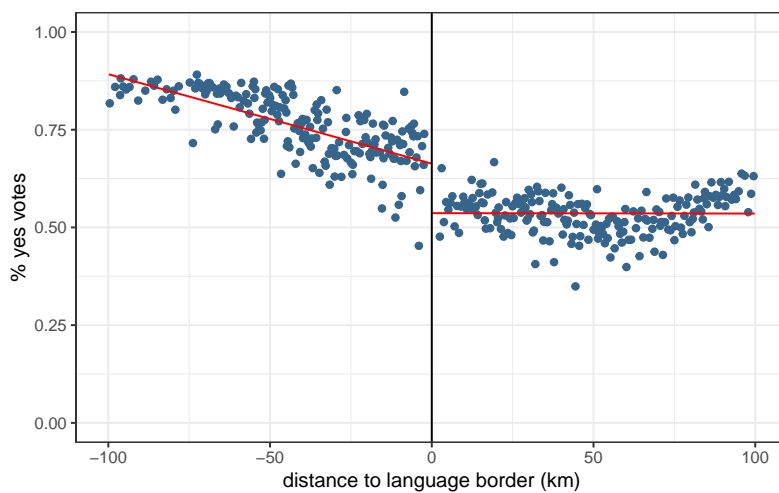


Figure 4: Average proportion of “yes” votes to referendum allowing genetic diagnosis of embryos, across municipalities, by distance to the language border. Notes: The left-hand side of the graph displays French-speaking municipalities; the right-hand side, German-speaking municipalities. The red lines are the linear regression lines. Source: Federal Statistical Office. Distances from search.ch.

354 Figure 4 shows the average proportion of “yes” votes across municipalities at various distances  
 355 from the language border. Data present a clear discontinuity at the border. Further, most data  
 356 points on the French-speaking side of the border are above the data points on the German-  
 357 speaking side. At the border, the French-speaking group is more likely to be in favour of amending  
 358 the law than the German-speaking group. These results are confirmed by the regression analysis  
 359 results presented in Table 6. The German language estimate is significant (estimate  $\in \{-0.131;$   
 360  $-0.099; -0.097\}$ ,  $p < 0.01$ ).

361 The outcome of the 5 June 2016’s referendum on pre-implantation genetic diagnosis could  
 362 have had fitness consequences at the individual level. By allowing couples with serious hereditary  
 363 diseases to implant healthy embryos selectively, the legalisations of pre-implantation diagnosis

	(1)	(2)	(3)
German Language	-0.131*** (0.010)	-0.099*** (0.010)	-0.097*** (0.010)
German*Distance	0.002*** (0.0002)	-0.001** (0.0002)	-0.001*** (0.0002)
Distance	-0.002*** (0.0002)	-0.0004** (0.0002)	-0.0003** (0.0002)
Urban			0.050*** (0.004)
Constant	0.664*** (0.007)	0.809*** (0.018)	0.758*** (0.018)
Cantons FE	No	Yes	Yes
Observations	1,409	1,409	1,353
Adjusted R <sup>2</sup>	0.638	0.772	0.792

Table 6: Referendum on assisted reproduction: regression analysis at the language border.

Notes: The regression analysis shows the impact of switching from the French-speaking side of the border to the German-speaking side on voting results, that is, the proportion of “yes” votes in a municipality. “German language” indicates that the primary language of a municipality is German and is our variable of interest. “Distance” is the road distance to the language border. “Distance” and its interaction with “German language” control for effects that happen away from the border and environmental differences. We restrict our analysis to municipalities within 100km of the language border. Models (2) and (3) include controls for the canton. Model (3) includes a control variable for municipality characteristics, whether the municipality is located in a rural or urban area. Robust standard errors are in parenthesis. \* $p < 0.1$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.01$ . Source: Federal Statistical Office. Distances from search.ch.

364 could have increased their offspring’s chances of survival and reproduction, ultimately leading  
365 to a positive impact on individual fitness. However, genetic screening implies an opportunity  
366 cost. Using genetic screening for non-medical reasons, such as selecting specific traits such as eye  
367 colour or height, could result in a waste of resources. Unnecessary screening might divert limited  
368 resources away from other procedures that could matter more in terms of health. We do not know  
369 what screening level maximised individual fitness in that particular environment. Nonetheless,  
370 we observed that at the border, the two groups had different preferences and associated voting  
371 behaviours, where one policy would presumably impose a fitness cost on individuals relative to  
372 the other policy.

373 **27 September 2020, referendum on paternity leave.** Our last example focuses on paternity  
374 leave. On 27 September 2020, Swiss citizens had to decide whether fathers should be granted two  
375 weeks of paid paternity leave. The proposed amendment to the Swiss Federal Constitution aimed  
376 to give fathers the right to take two weeks off work after the birth of a child. This leave would  
377 have been financed by the government. Proponents of the amendment argued that paternity

378 leave would have provided fathers with the opportunity to bond with their newborns and help  
379 reduce gender inequality in the workplace and society. On the other hand, opponents claimed  
380 that the proposed paternity leave policy would have increased costs for employers and should  
381 not be legislated at the federal level.

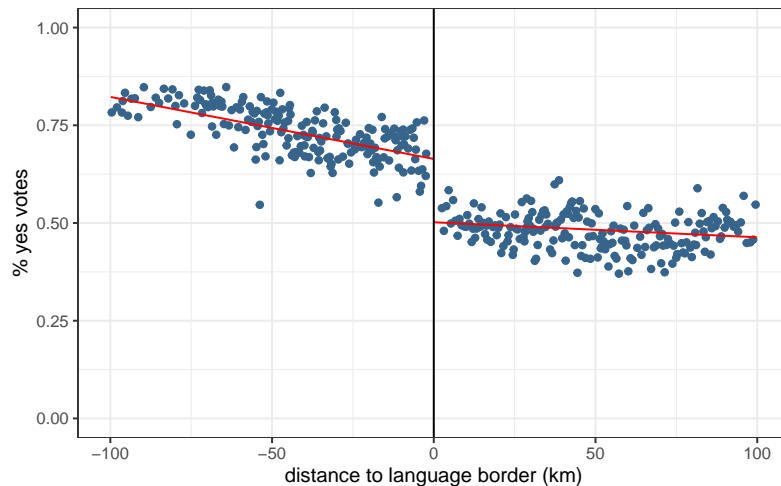


Figure 5: Average proportion of “yes” votes to referendum on paternity leave across municipalities, by distance to language border. Notes: The left-hand side of the graph displays French-speaking municipalities; the right-hand side, German-speaking municipalities. The red lines are the linear regression lines. Source: Federal Statistical Office. Distances from search.ch.

382 Figure 5 presents the average proportion of “yes” votes for the referendum on paid paternity  
383 leave across municipalities at different distances from the language border. We observe a clear  
384 discontinuity at the language border. Municipalities on the French-speaking side of the border  
385 were more likely to approve a paid paternity leave than those on the German-speaking side.  
386 Table 7 presents the regression analysis. The results confirm the descriptive evidence from the  
387 graph. The German language estimate is significant and not sensitive to additional controls for  
388 cantons and whether the municipality is urban or rural ( model (3) estimate =  $-0.160$ ,  $p < 0.01$ ).

389 Paternity leave may have had positive fitness consequences. Paternity leave allows fathers  
390 to spend more time with their newborn children. The more the father invests, the better  
391 the outcomes should tend to be for the current offspring. However, we could also imagine a  
392 countervailing effect for men. By investing time and resources in current offspring, fathers  
393 are potentially hindering their careers, which could make them less attractive in the future.  
394 Consequently, fathers are potentially hindering their ability to identify opportunities to mate  
395 with other women. In this sense, paternity leave could partially harm fathers’ fitness. We observe  
396 that the two groups adopted different voting behaviours at the border. Assuming the acceptance

	(1)	(2)	(3)
German Language	-0.171*** (0.009)	-0.155*** (0.010)	-0.160*** (0.009)
German*Distance	0.001*** (0.0002)	-0.0003 (0.0002)	-0.0003 (0.0002)
Distance	-0.002*** (0.0001)	-0.001*** (0.0002)	-0.001*** (0.0002)
Urban			0.067*** (0.004)
Constant	0.665*** (0.007)	0.769*** (0.019)	0.704*** (0.018)
Cantons FE	No	Yes	Yes
Observations	1,409	1,409	1,353
Adjusted R <sup>2</sup>	0.715	0.773	0.811

Table 7: Referendum on paternity leave: regression analysis at the language border. Notes: The regression analysis shows the impact of switching from the French-speaking side of the border to the German-speaking side on voting results, that is, the proportion of “yes” votes in a municipality. “German language” indicates that the primary language of a municipality is German and is our variable of interest. “Distance” is the road distance to the language border. “Distance” and its interaction with “German language” control for effects that happen away from the border and environmental differences. We restrict our analysis to municipalities within 100km of the language border. Models (2) and (3) include controls for the canton. Model (3) includes a control variable for municipality characteristics, whether the municipality is located in a rural or urban area. Robust standard errors are in parenthesis. \* $p < 0.1$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.01$ . Source: Federal Statistical Office. Distances from search.ch.

397 of paternity leave has fitness consequences and that at the border the optimal policy was the  
398 same, then one group showed relatively strong support for a policy that would have imposed  
399 individual fitness costs compared to the other policy. If we assume paternity leave is beneficial  
400 for fitness, then the group on the German-speaking side of the border showed relatively strong  
401 support for a policy that would have yielded a fitness cost relative to the other policy, a policy  
402 that enjoyed more support on the French-speaking side.

## 403 4 Discussion

404 We have investigated the causal influence of culture on health- and fertility-related choices  
405 using a spatial regression discontinuity design and Swiss referenda data. Our results show  
406 multiple discontinuities at the language border. Such discontinuities isolate cultural variation  
407 in preferences for policies that, if enacted, would have presumably affected health and fertility  
408 choices at the individual level. We have also speculated about connections between possible  
409 referenda outcomes and downstream effects on genetic fitness. Although the details of these  
410 speculations differ, the generic logic is always the same. For a given referendum, assume that

411 one policy was optimal in the sense that it would have promoted choices and created incentives  
412 that would have been better – in terms of individual expected fitness – than the other policy.  
413 We do not know which policy was optimal in this sense, but we assume that one was better,  
414 and the other was worse. If, in addition, the optimal policy right at the border was the same  
415 on both sides of the border, then any discontinuity in voting at the border implies that one of  
416 the two groups supported the sub-optimal policy for cultural reasons. More to the point, one  
417 of the two groups supported a policy that would have negatively affected health, survival, and  
418 fertility relative to the other policy. By extension, the individuals in this group were ready to  
419 pay an opportunity cost in terms of fitness, and they were willing to impose this fitness cost  
420 on their Swiss fellows who would have been subject to the policy if enacted. We can view this  
421 opportunity cost in two ways. First, it would have represented an opportunity cost relative to  
422 the other policy under consideration. Second, it would have represented an opportunity cost in  
423 the form of reduced fitness relative to other societies, for example other countries in continental  
424 Europe.

425 While our findings emphasise cultural differences in health- and fertility-related voting  
426 decisions at the language border, our study comes with several limitations. First, individuals  
427 could have, in principle, self-selected into treatments. People born on the French-speaking side of  
428 the border could have moved to the German-speaking region in search of a cultural environment  
429 more aligned with their personal values and vice versa. Although we suspect associated effects  
430 are trivial, we cannot definitively dismiss the potential impact of endogenous sorting into location  
431 at the border. Future research, equipped with more extensive data regarding the place of birth  
432 in lieu of the place of residence, would be better poised to control for any possible selection bias  
433 of this sort. Second, our sample consists solely of voters and is thus unrepresentative of the Swiss  
434 population. That said, laws and policies are enacted precisely on the basis of the preferences and  
435 decisions of voters, and in this sense our sample represents the politically engaged part of the  
436 population. As such, our data demonstrate how culture can shape voting decisions and policy  
437 outcomes.

438 Third, we do not know how cultural variation in voting translates into cultural variation in  
439 behaviour. For instance, we found clear distinctions in voting about paternity leave. Yet, we  
440 do not know how these kinds of differences might relate to the time fathers spend with their  
441 children, and we do not know how people on both sides of the border might react to one policy  
442 versus another. In general, we can imagine that the two groups might often support different



443 policies, but they might also react differently to the policy that prevails after all the votes are  
444 tallied. Future research could examine these kinds of questions by exploring cultural differences  
445 in behavioural responses to political outcomes.

446 Finally, the data only pertain to referenda results and do not distinguish between the different  
447 reasons people vote one way or another. Our task was to isolate, as much as possible, the effects  
448 of culture from the effects of environments, institutions, and even genes. Our approach separates  
449 the influence of culture on voting in this way, but it cannot identify which components of culture  
450 drive results. Observed variation at the border could be driven by differences in cultural domains  
451 related to religion, political affiliation, media consumption, or secular values. Future studies  
452 could unpack the discontinuities by investigating these kinds of underlying mechanisms.

453 Within the boundaries of these limitations, we have attempted to add a crucial element to  
454 the discussion of gene-culture processes by pushing for the clean identification of culture as a  
455 distinct cause of health- and fertility-related choices. In particular, genetic evolutionary processes  
456 do not favour stable differences between groups. Minimal gene flow between groups is enough  
457 to render groups nearly identical genetically (Frankham et al. 2002, Bell et al. 2009), and this  
458 seems to be the state of affairs at the Röstigraben in Switzerland (Buhler et al. 2012). This is  
459 crucial because, if groups are genetically similar, selection at the group level is irrelevant. If  
460 groups are different, in contrast, selection at the group level could easily matter. In this latter  
461 case, group selection can shape evolutionary dynamics in addition to selection at the individual  
462 level, and the result can be entirely new evolutionary regimes that would not otherwise be  
463 possible. Although the workaday evolutionary ecologist generally ignores such possibilities in  
464 strictly genetic systems, cultural evolutionary processes may be completely different (Mesoudi &  
465 Danielson 2008, Richerson et al. 2016). Our results show that cultural evolution can stabilise  
466 differences between groups, even amid ongoing contact, and it can do so in decision-making  
467 domains that should have a relatively close link to genetic fitness.

468 In particular, under the assumption that fitness effects are equivalent right at the border  
469 on both sides of the border, our results suggests that voters on one side or another routinely  
470 support a sub-optimal policy. The policy is sub-optimal in the sense that it should impose a cost  
471 in terms of expected fitness on individuals subject to the policy, but support for the policy is  
472 to some extent a group-level cultural phenomenon. This suggests the potential for cultures to  
473 maintain preferences detrimental to fitness when compared to some relevant benchmark.

474 These results are especially surprising because they hold in contemporary Switzerland.

475 Switzerland is one of the easiest places in the world to get from one place to another. The  
476 distances are short, and the trains are clean, pleasant, frequent, extremely long, and exceedingly  
477 reliable. Moreover, this has been the state of affairs for a long time. The flow of cultural  
478 information across the border on a daily basis must be extreme, and thus one might naively  
479 expect the Röstigraben to be a cute vestige of former times. Our results, however, show that the  
480 reality is quite the opposite.

481 Altogether, given the limitations of our approach, our contribution is twofold. First, we  
482 highlight the value of using a quasi-experimental design to isolate the causal influence of culture on  
483 decision making. Strangely, many of us are probably comfortable with the notion that somehow  
484 cultural differences exist. However, from a strict empirical perspective, cultures routinely covary  
485 with other confounds, and separating the effects of culture from these confounds can often be  
486 difficult or impossible. Our approach does so by essentially identifying systematic group-level  
487 differences that cannot be genetic, environmental, or institutional. Second, we specifically isolate  
488 cultural effects of this sort in decision-making domains related to health and fertility. In this  
489 way, although we do not examine genetic fitness directly, we do lean in this direction by focusing  
490 on cultural variation in support for policies that should influence fertility, health, and survival.  
491 The variation in question is a group-level phenomenon based on cultural evolutionary processes,  
492 but it should have consequences for individual reproduction and by extension fitness.

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## 498 **Author Contributions**

499 LF, RL, and CE designed the study. RL provided the distance data. LF analysed the data with  
500 feedback from CE and RL. LF wrote the article with input from CE.

501 **Research Transparency and Reproducibility**

502 The data used in this study is publicly available at <https://www.bfs.admin.ch/> . Distance data  
503 and code for data analysis will be made available after publication.

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