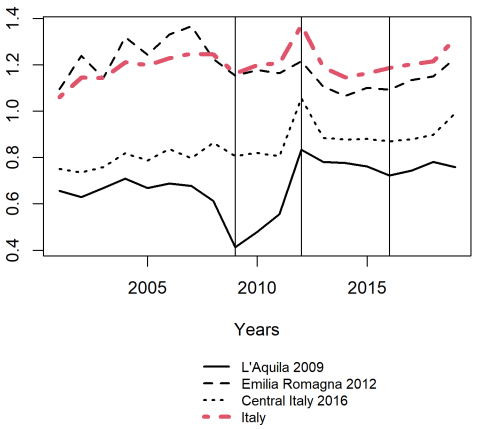
Supplemental material - "Migration responses to earthquakes: evidence from Italy".

A Descriptive analysis on migration rates

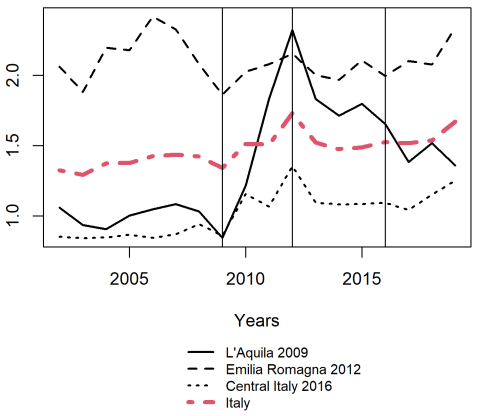
To provide a descriptive analysis of the dynamics of the migration rates, the average values of each outcome variable were calculated for the country as a whole and for each seismic crater (see Figures 1-16). These values correspond to "*weighted*" averages of the out-migration rates of all municipalities within the crater, i.e. $\frac{M^c}{P^c} = \frac{\sum_i m_i^c}{\sum_i p_i^c} = \frac{m_1^c}{p_1^c} \times \frac{p_1^c}{\sum_i p_i^c} + \frac{m_2^c}{p_2^c} \times \frac{p_2^c}{\sum_i p_i^c} + ... + \frac{m_n^c}{p_n^c} \times \frac{p_n^c}{\sum_i p_i^c}$, with m_i^c and p_i^c the migration flow and the population of the municipality $i = 1, 2, ..., n$ belonging to the crater c, respectively.

FIGURE 1
Out-migration flows (per Thousand of Italian population) of Italian citizens to other municipalities, within the same province.



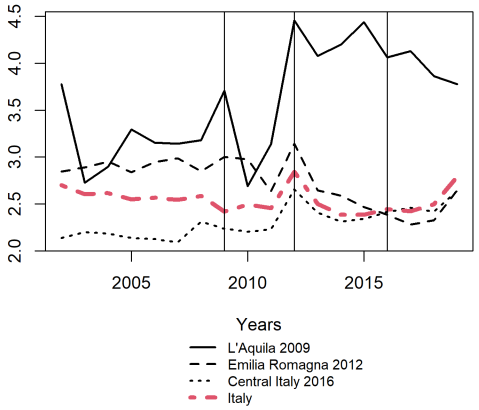
Source: our elaboration on Istat data.

FIGURE 2
Out-migration flows (per Thousand of Italian population) of Italian citizens to other provinces, within the same region.



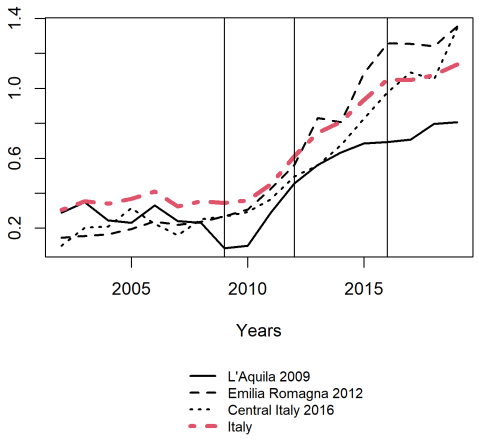
Source: our elaboration on Istat data.

FIGURE 3
Out-migration flows (per Thousand of Italian population) of Italian citizens to other regions.



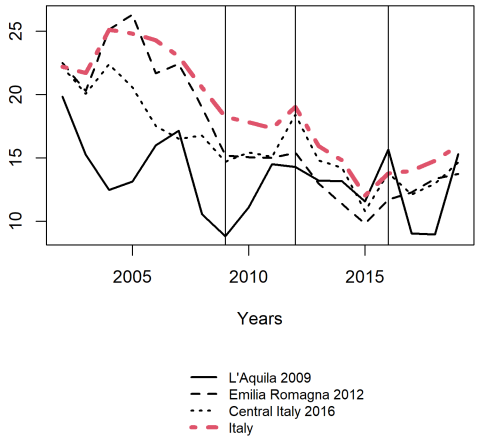
Source: our elaboration on Istat data.

FIGURE 4
Out-migration flows (per Thousand of Italian population) of Italian citizens abroad.



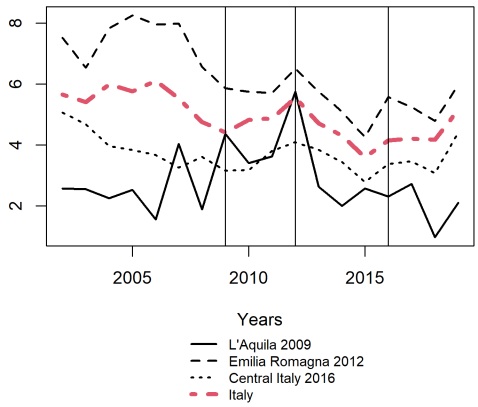
Source: our elaboration on Istat data.

FIGURE 5
Out-migration flows (per Thousand of foreign population) of foreign citizens to other municipalities, within the same province.



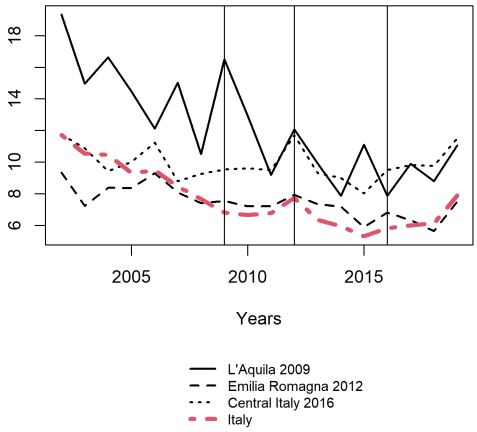
Source: our elaboration on Istat data.

FIGURE 6
Out-migration (per Thousand of foreign population) of foreign citizens to other provinces, within the same region.



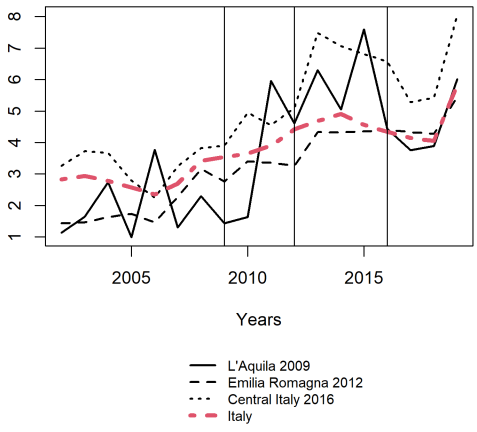
Source: our elaboration on Istat data.

FIGURE 7
Out-migration (per Thousand of foreign population) of foreign citizens to other regions.



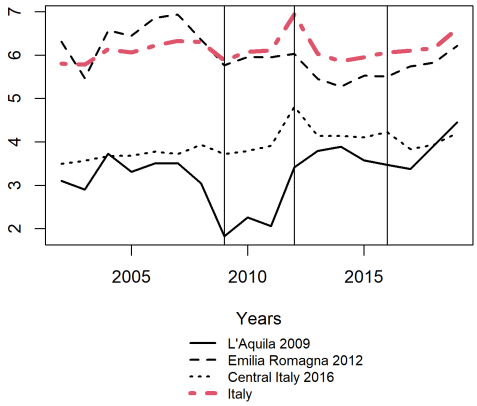
Source: our elaboration on Istat data.

FIGURE 8
Out-migration (per Thousand of foreign population) of foreign citizens abroad.



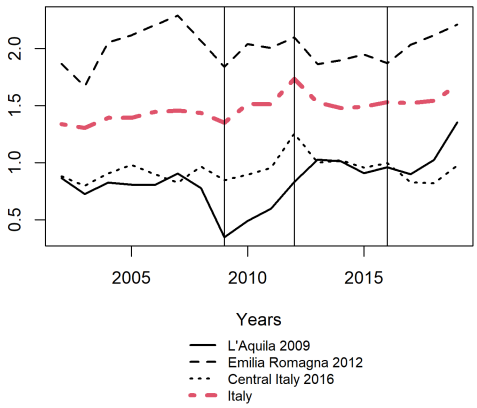
Source: our elaboration on Istat data.

FIGURE 9
In-migration (per Thousand of Italian population) of Italian citizens from other municipalities, within the same province.



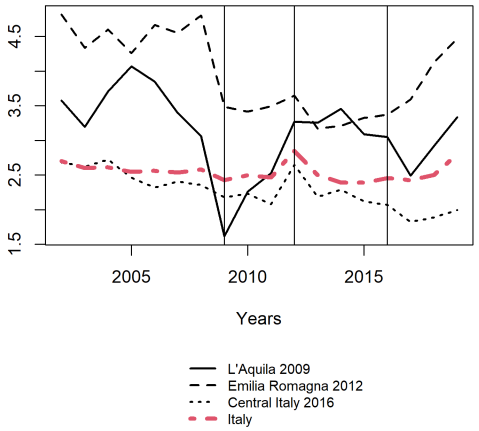
Source: our elaboration on Istat data.

FIGURE 10
In-migration (per Thousand of Italian population) of Italian citizens from other provinces, within the same region.



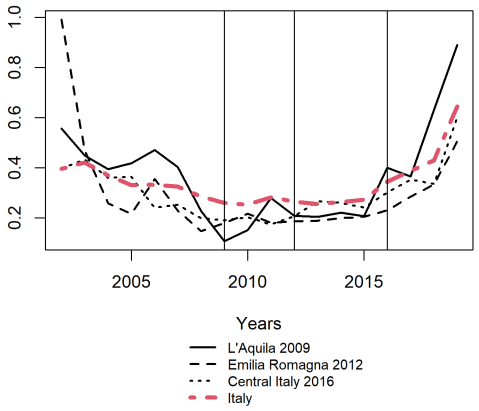
Source: our elaboration on Istat data.

FIGURE 11
In-migration (per Thousand of Italian population) of Italian citizens from other regions.



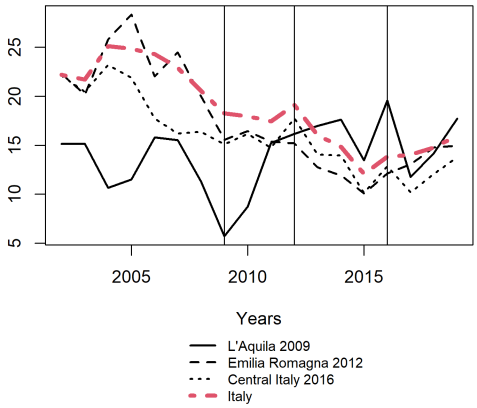
Source: our elaboration on Istat data.

FIGURE 12
In-migration (per Thousand of Italian population) of Italian citizens from abroad.



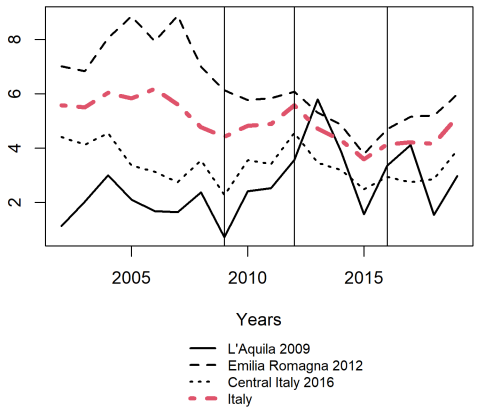
Source: our elaboration on Istat data.

FIGURE 13
In-migration (per Thousand of foreign population) of foreign citizens from other municipalities, within the same province.



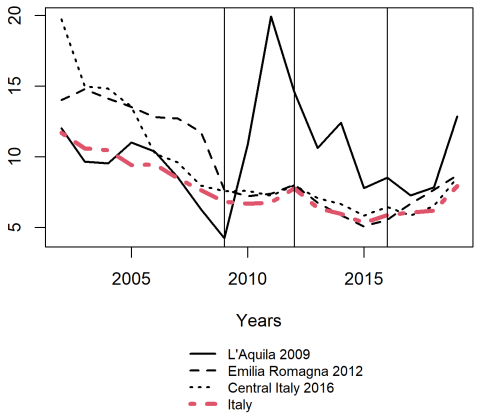
Source: our elaboration on Istat data.

FIGURE 14
In-migration (per Thousand of foreign population) of foreign citizens from other provinces, within the same region.



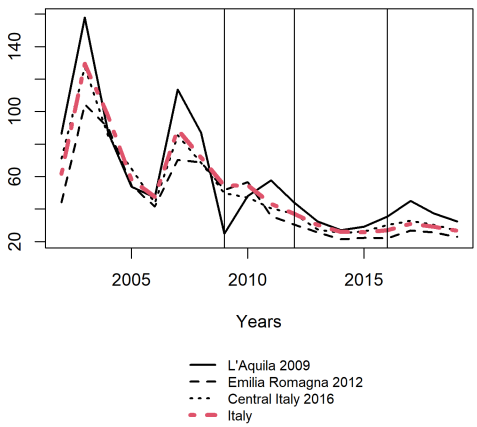
Source: our elaboration on Istat data.

FIGURE 15
In-migration (per Thousand of foreign population) of foreign citizens from other regions.



Source: our elaboration on Istat data.

FIGURE 16
In-migration (per Thousand of foreign population) of foreign citizens from abroad.



Source: our elaboration on Istat data.

B Results of the DID analysis based on weighted observations

As mentioned in the main text, the DID analysis was also carried out using weighted observations, with weights proportional to the population of the municipalities. This robustness check proved particularly important to assess the impact of the 2009 earthquake on the internal emigration rates of Italian citizens. These results are displayed in Tables 1 and 2.

TABLE 1

Earthquakes Treatment Effects on Out-migration. Restricted earthquake zones with contiguous municipalities as control units sample. Dependent variable: emigration rate. Weighted observations.

	To same province	To other provinces within same region	To other regions	Abroad
	Italian citizens			
Simple Weighted Average	-0.073	0.047	-0.248	0.148
	(1.130)	(0.170)	(0.405)	(0.130)
Weighted Avg. of group-specific effects	-0.632	-0.005	-0.423	0.177
	(1.764)	(0.150)	(0.641)	(0.155)
Group specific effect: 2009	0.980	0.929	0.915	-0.490
	(0.522)	(0.737)	(0.653)	(0.265)
Group specific effect: 2012	0.683	-0.054	-0.208	0.239
	(0.320)	(0.130)	(0.188)	(0.127)
Group specific effect: 2016	-2.947	-0.114	-1.026	0.211
	(4.831)	(1.667)	(0.033)	(0.345)
P-value Wald test DID ass.	0.072	0.496	0.113	0.181
	Foreign citizens			
Simple Weighted Average	**5.756**	3.483	0.257	0.422
	(2.164)	(2.152)	(0.727)	(1.735)
Weighted Avg. of group-specific effects	**5.478**	3.075	0.153	-0.025
	(3.077)	(1.992)	(0.793)	(1.701)
Group specific effect: 2009	**10.175**	1.769	5.022	-2.837
	(4.302)	(7.347)	(3.913)	(18.721)
Group specific effect: 2012	**5.657**	4.180	-0.111	1.386
	(1.753)	(2.603)	(0.848)	(1.349)
Group specific effect: 2016	4.171	-0.164	0.052	-3.535
	(11.473)	(1.058)	(2.247)	(4.996)
P-value Wald test DID ass.	0.260	0.280	0.132	0.292

Notes: see Table 1 in the main text.

TABLE 2

Earthquakes Treatment Effect on In-migration. Restricted earthquake zones with contiguous municipalities as control units sample. Dependent variable: immigration rate. Weighted observations.

	From same province	From other provinces within same region	From other regions	From abroad
	Italian citizens			
Simple Weighted Average	-0.261	0.088	0.070	-0.132
	(0.342)	(0.188)	(0.303)	(0.338)
Weighted Avg. of group-specific effects	-0.331	0.094	-0.153	-0.242
	(0.292)	(0.257)	(0.259)	(0.578)
Group specific effect: 2009	0.898	0.470	0.971	-0.061
	(0.492)	(0.375)	(1.117)	(0.177)
Group specific effect: 2012	-0.405	-0.004	0.256	0.040
	(0.480)	(0.161)	(0.340)	(0.062)
Group specific effect: 2016	-0.468	0.181	**-1.024**	-0.767
	(0.285)	(0.688)	**(0.448)**	(1.768)
P-value Wald test DID ass.	0.172	0.121	0.146	0.180
	Foreign citizens			
Simple Weighted Average	**4.975**	0.283	-3.787	0.070
	(1.631)	(1.585)	(1.537)	(0.303)
Weighted Avg. of group-specific effects	**4.095**	-0.462	-5.000	-2.958
	(1.495)	(1.486)	(2.130)	(3.146)
Group specific effect: 2009	**13.297**	-6.503	**8.450**	-19.870
	(4.755)	(3.795)	**(3.108)**	(16.096)
Group specific effect: 2012	**5.334**	1.838	**-3.291**	2.291
	(1.941)	(1.392)	**(1.410)**	(4.052)
Group specific effect: 2016	-0.827	-7.251	-11.921	**-13.947**
	(1.601)	(4.835)	(7.317)	**(5.942)**
P-value Wald test DID ass.	0.180	0.347	0.110	0.069

Notes: see Table 1 in the main text.

C DID analysis of emigration rates of Italian citizens by level of education

A DID analysis was carried out also using emigration rates of Italian citizens aged 24-55 and distinguished by level of education. Specifically, we distinguish individuals with *a*) no formal education or a primary school education, *b*) a lower-secondary school education, *c*) an upper-secondary school education, and *d*) a tertiary-school or higher education level. The DID analysis was also carried out using weighted observations, with weights proportional to the population of the municipalities. The results are reported in Tables 3, 4, 5 and 6.

TABLE 3

Earthquakes Treatment Effects on Out-migration. Italian population (aged 24 to 55) by level of education. Dependent variable: emigration rate. Unweighted observations

	Lower secondary education	Upper secondary education	Tertiary education	No educational qualifications/primary education
	Italian citizens			
Simple Weighted Average	0.766	0.090	-0.371	-0.136
	(0.316)	(0.149)	(0.250)	(0.126)
Weighted Avg. of group-specific effects	0.616	0.054	-0.282	-0.187
	(0.330)	(0.182)	(0.233)	(0.189)
Group specific effect: 2009	1.380	0.173	-1.098	0.136
	(0.757)	(0.371)	(0.705)	(0.103)
Group specific effect: 2012	0.573	0.141	0.138	-0.202
	(0.288)	(0.132)	(0.139)	(0.088)
Group specific effect: 2016	0.389	-0.023	-0.223	-0.273
	(0.539)	(0.302)	(0.356)	(0.380)
P-value Wald test DID ass.	0.017	0.244	0.191	0.304

Notes: see Table 1 in the main text.

TABLE 4

Earthquakes Treatment Effect on In-migration. Italian population (aged 24 to 55) by level of education. Dependent variable: immigration rate. Unweighted observations

	Lower secondary education	Upper secondary education	Tertiary education	No educational qualifications/primary education
	Italian citizens			
Simple Weighted Average	-0.032	0.114	-0.087	-0.117
	(0.291)	(0.204)	(0.427)	(0.095)
Weighted Avg. of group-specific effects	-0.236	-0.091	-0.207	-0.163
	(0.278)	(0.241)	(0.340)	(0.107)
Group specific effect: 2009	1.203	**1.101**	-0.194	0.013
	(0.765)	**(0.393)**	(1.359)	(0.284)
Group specific effect: 2012	-0.685	-0.098	0.408	-0.103
	(0.370)	(0.152)	(0.225)	(0.045)
Group specific effect: 2016	-0.463	-0.478	-0.568	-0.283
	(0.363)	(0.452)	(0.464)	(0.195)
P-value Wald test DID ass.	0.227	0.132	0.168	0.211

Notes: see Table 1 in the main text.

TABLE 5

Earthquakes Treatment Effects on Out-migration. Italian population (aged 24 to 55) by level of education. Dependent variable: emigration rate. Weighted observations

	Lower secondary education	Upper secondary education	Tertiary education	No educational qualifications/primary education
	Italian citizens			
Simple Weighted Average	0.330	0.193	0.078	-0.047
	(0.199)	(0.100)	(0.132)	(0.073)
Weighted Avg. of group-specific effects	0.222	0.144	0.038	-0.052
	(0.187)	(0.083)	(0.116)	(0.060)
Group specific effect: 2009	0.498	0.602	0.397	-0.374
	(0.329)	(0.264)	(0.640)	(0.186)
Group specific effect: 2012	0.486	0.193	0.076	0.034
	(0.256)	(0.117)	(0.120)	(0.066)
Group specific effect: 2016	-0.234	-0.026	-0.095	-0.128
	(0.312)	(0.131)	(0.186)	(0.119)
P-value Wald test DID ass.	0.174	0.115	0.188	0.193

Notes: see Table 1 in the main text.

TABLE 6

Earthquakes Treatment Effect on In-migration. Italian population (aged 24 to 55) by level of education. Dependent variable: immigration rate. Weighted observations

	Lower secondary education	Upper secondary education	Tertiary education	No educational qualifications/primary education
	Italian citizens			
Simple Weighted Average	-0.144	0.003	0.261	0.002
	(0.343)	(0.088)	(0.187)	(0.046)
Weighted Avg. of group-specific effects	-0.166	-0.040	0.170	0.023
	(0.454)	(0.104)	(0.156)	(0.067)
Group specific effect: 2009	0.277	0.278	0.716	-0.108
	(0.276)	(0.211)	(0.511)	(0.117)
Group specific effect: 2012	-0.201	0.019	0.320	-0.012
	(0.367)	(0.114)	(0.255)	(0.031)
Group specific effect: 2016	-0.203	-0.204	-0.184	0.116
	(1.145)	(0.240)	(0.171)	(0.187)
P-value Wald test DID ass.	0.105	0.174	0.003	0.175

Notes: see Table 1 in the main text.

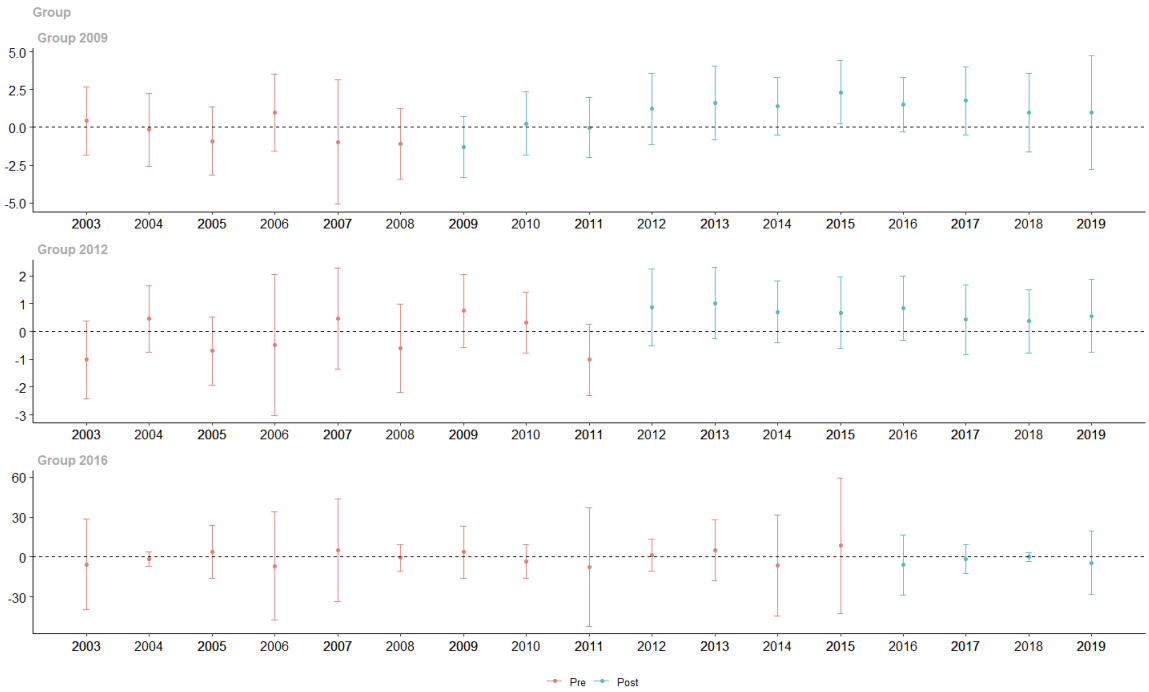
D Plots of group-time average treatment effects

Figures 17-48 contain separate plots of group-time average treatment effects $(ATT(g,t))$ for each group (the first group is labeled "2009", the second "2012", and the third "2016") in all time periods from 2002 to 2019, together with a uniform 90% confidence band. The red dots in the plots are pre-treatment pseudo group-time average treatment effects and are very useful for testing the parallel trends assumption. Blue dots are post-treatment group-time average treatment effects. The confidence bands always include the zero, thus confirming the result of the pre-test of the parallel trends assumption. Under the parallel trends assumption, these can be interpreted as the average effects of earthquakes for units in a particular group at a particular point in time. All inference procedures use clustered bootstrap standard errors at the municipality level.

FIGURE 17
The effect of earthquakes on outflows of Italian citizens to other municipalities, within the same province. Conditional. Unweighted observations

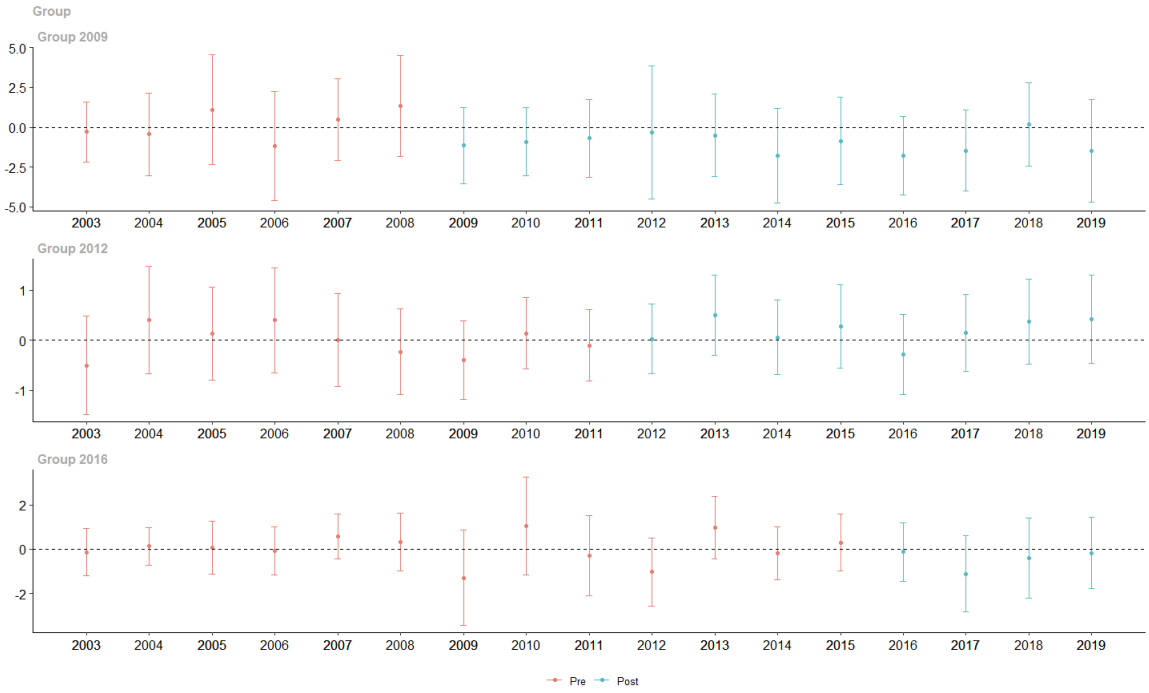
Source: our elaboration on Istat data.

FIGURE 18
The effect of earthquakes on outflows of Italian citizens to other municipalities, within the same province. Conditional. Weighted observations



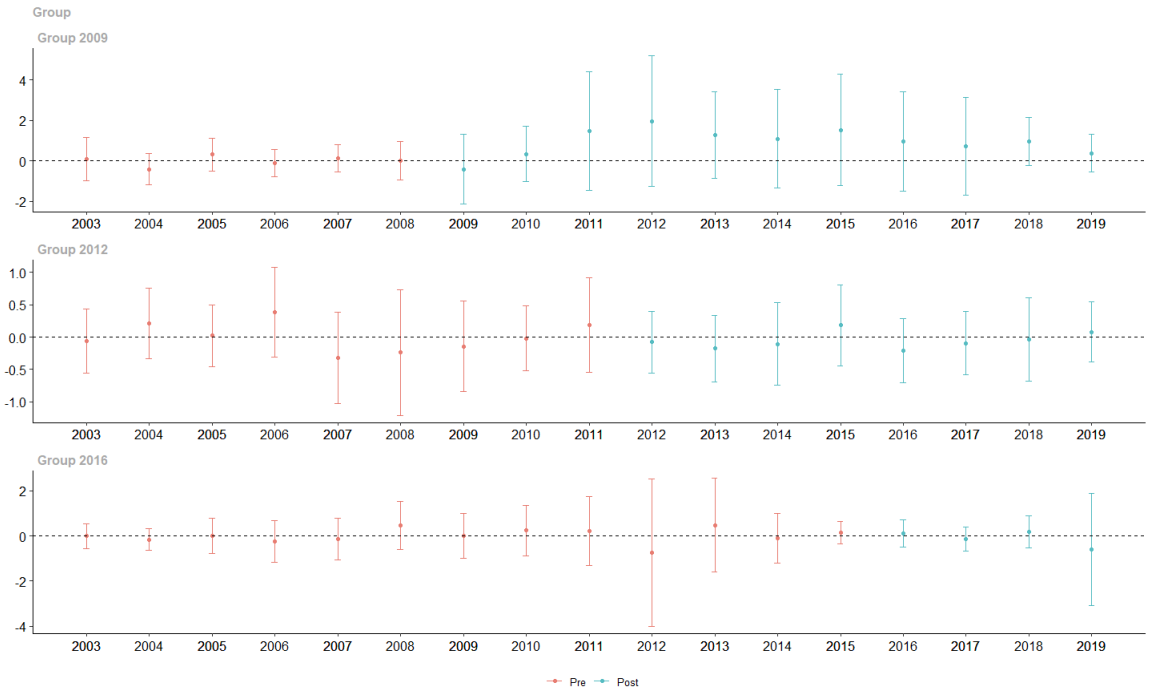
Source: our elaboration on Istat data.

FIGURE 19
The effect of earthquakes on outflows of Italian citizens to other provinces, within the same region. Conditional. Unweighted observations



Source: our elaboration on Istat data.

FIGURE 20
The effect of earthquakes on outflows of Italian citizens to other provinces, within the same region. Conditional. Weighted observations

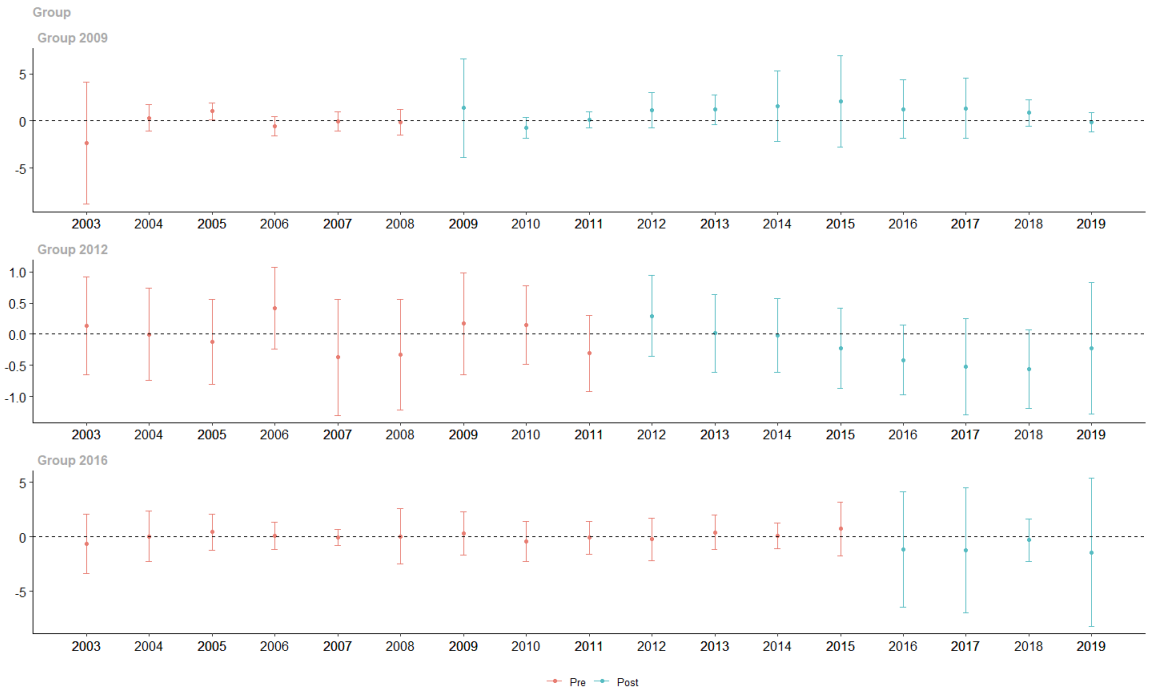


Source: our elaboration on Istat data.

FIGURE 21
The effect of earthquakes on outflows of Italian citizens to other regions. Conditional. Unweighted observations

Source: our elaboration on Istat data.

FIGURE 22
The effect of earthquakes on outflows of Italian citizens to other regions. Conditional. Weighted observations



Source: our elaboration on Istat data.

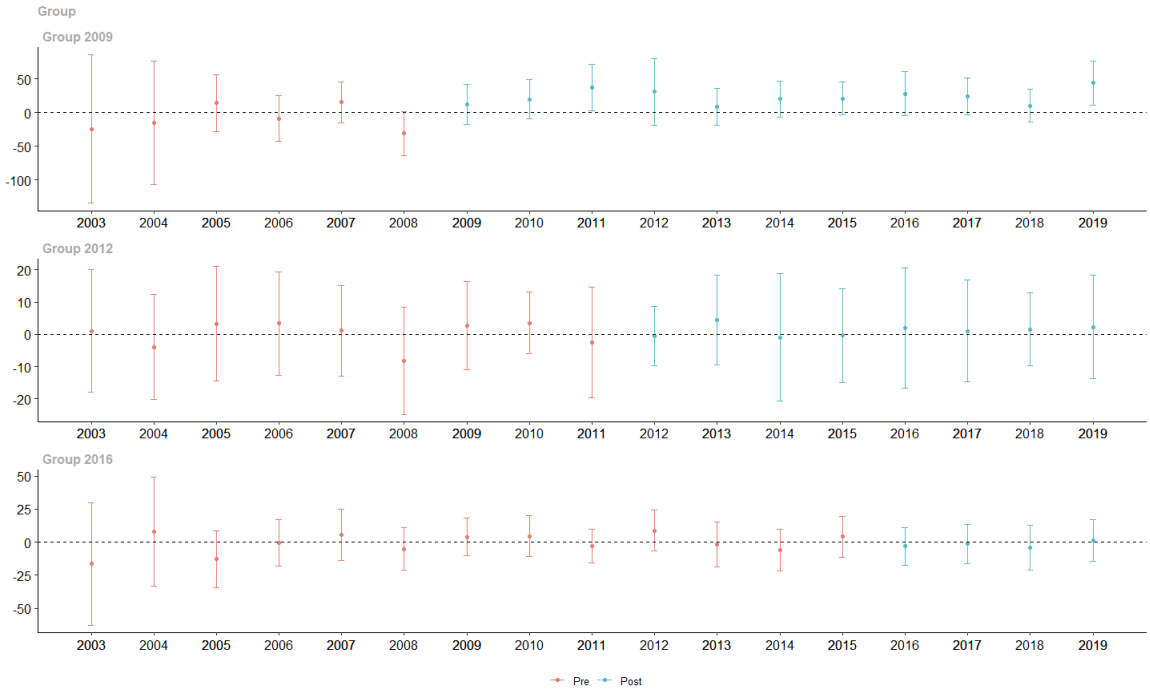
FIGURE 23
The effect of earthquakes on outflows of Italian citizens abroad. Conditional. Unweighted observations

Source: our elaboration on Istat data.

FIGURE 24
The effect of earthquakes on outflows of Italian citizens abroad. Conditional. Unweighted observations

Source: our elaboration on Istat data.

FIGURE 25
The effect of earthquakes on outflows of foreign citizens to other municipalities, within the same province. Conditional. Unweighted observations

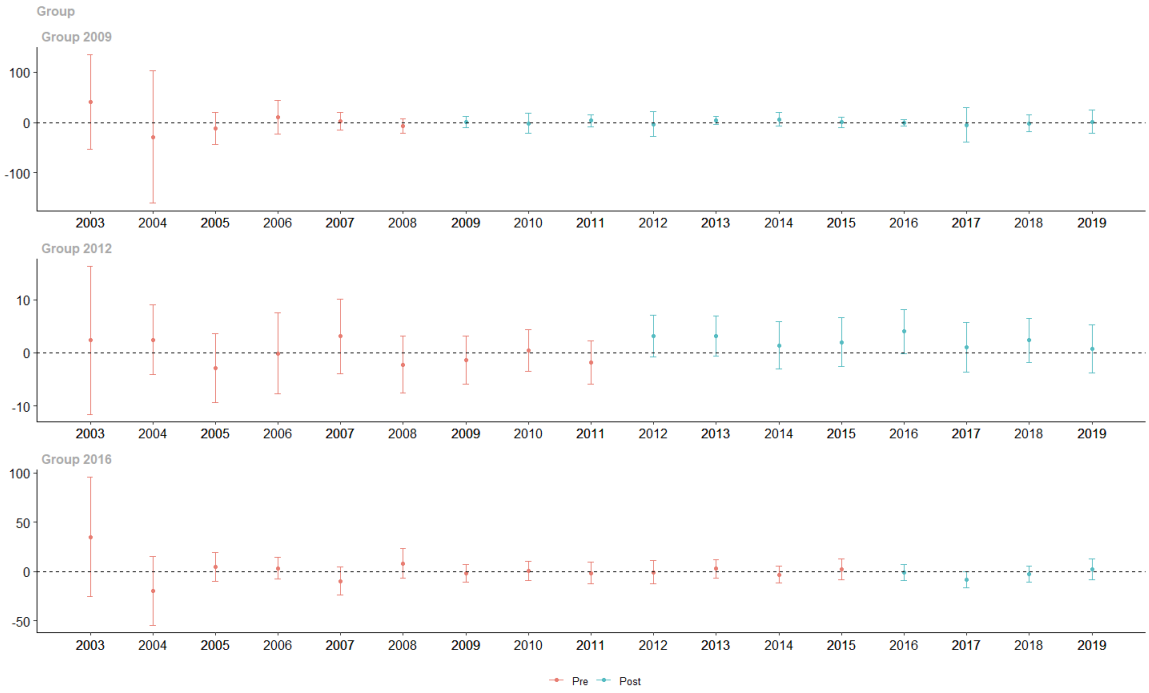


Source: our elaboration on Istat data.

FIGURE 26
The effect of earthquakes on outflows of foreign citizens to other municipalities, within the same province. Conditional. Weighted observations

Source: our elaboration on Istat data.

FIGURE 27
The effect of earthquakes on outflows of foreign citizens to other provinces, within the same region. Conditional. Unweighted observations

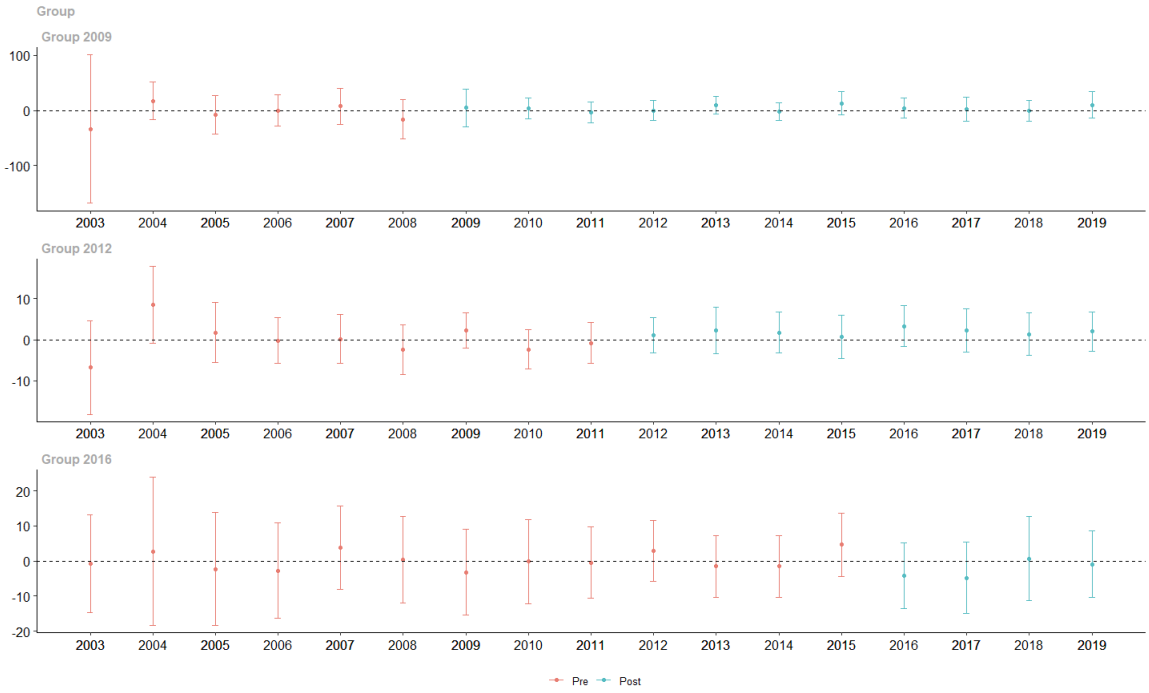


Source: our elaboration on Istat data.

FIGURE 28
The effect of earthquakes on outflows of foreign citizens to other provinces, within the same region. Conditional. Weighted observations

Source: our elaboration on Istat data.

FIGURE 29
The effect of earthquakes on outflows of foreign citizens to other regions. Conditional. Unweighted observations



Source: our elaboration on Istat data.

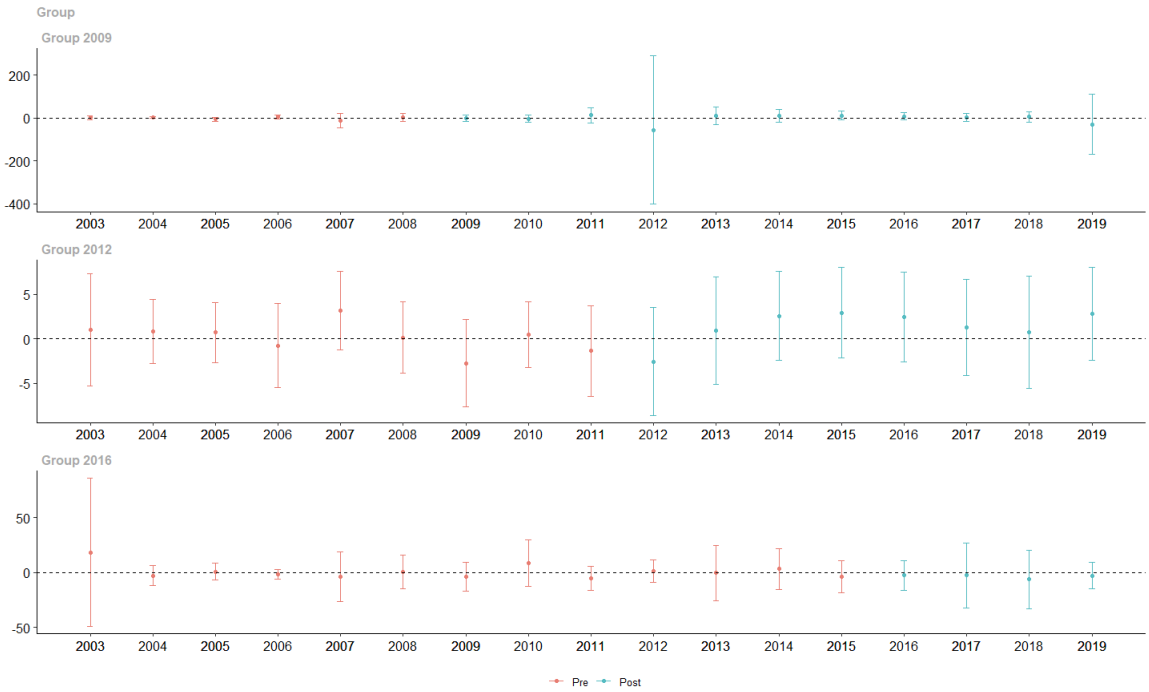
FIGURE 30
The effect of earthquakes on outflows of foreign citizens to other regions. Conditional. Weighted observations

Source: our elaboration on Istat data.

FIGURE 31
The effect of earthquakes on outflows of foreign citizens abroad. Conditional. Unweighted observations

Source: our elaboration on Istat data.

FIGURE 32
The effect of earthquakes on outflows of foreign citizens abroad. Conditional. Weighted observations

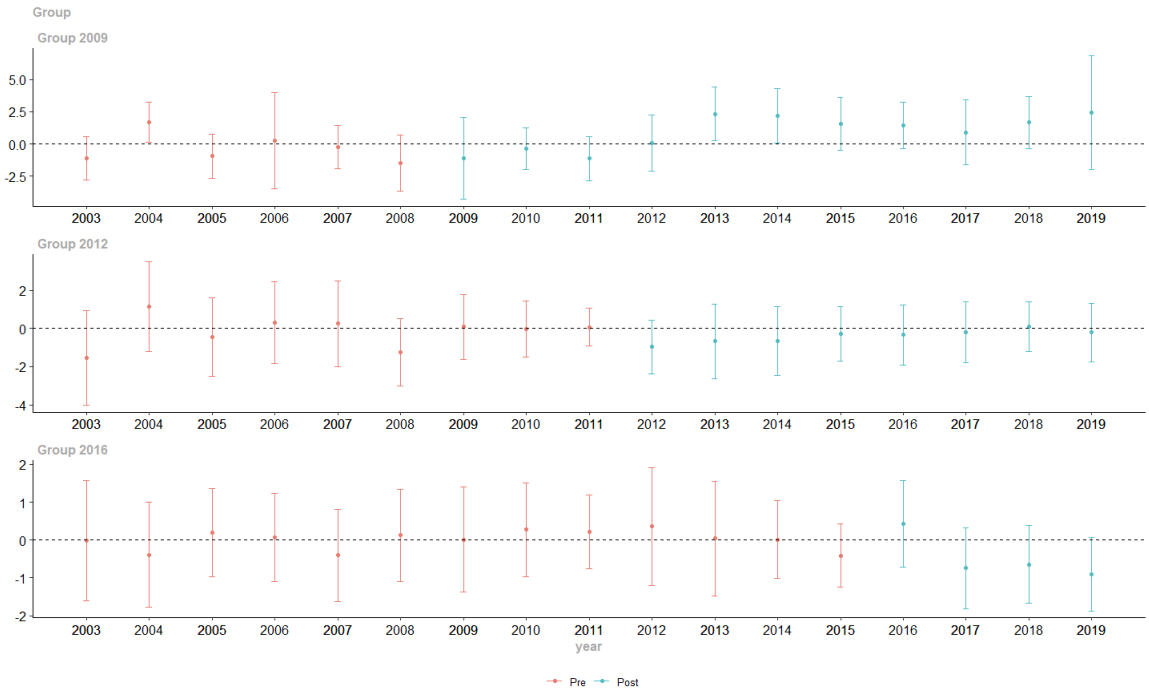


Source: our elaboration on Istat data.

FIGURE 33
The effect of earthquakes on inflows of Italian citizens from other municipalities, within the same province. Conditional. Unweighted observations

Source: our elaboration on Istat data.

FIGURE 34
The effect of earthquakes on inflows of Italian citizens from other municipalities, within the same province. Conditional. Weighted observations

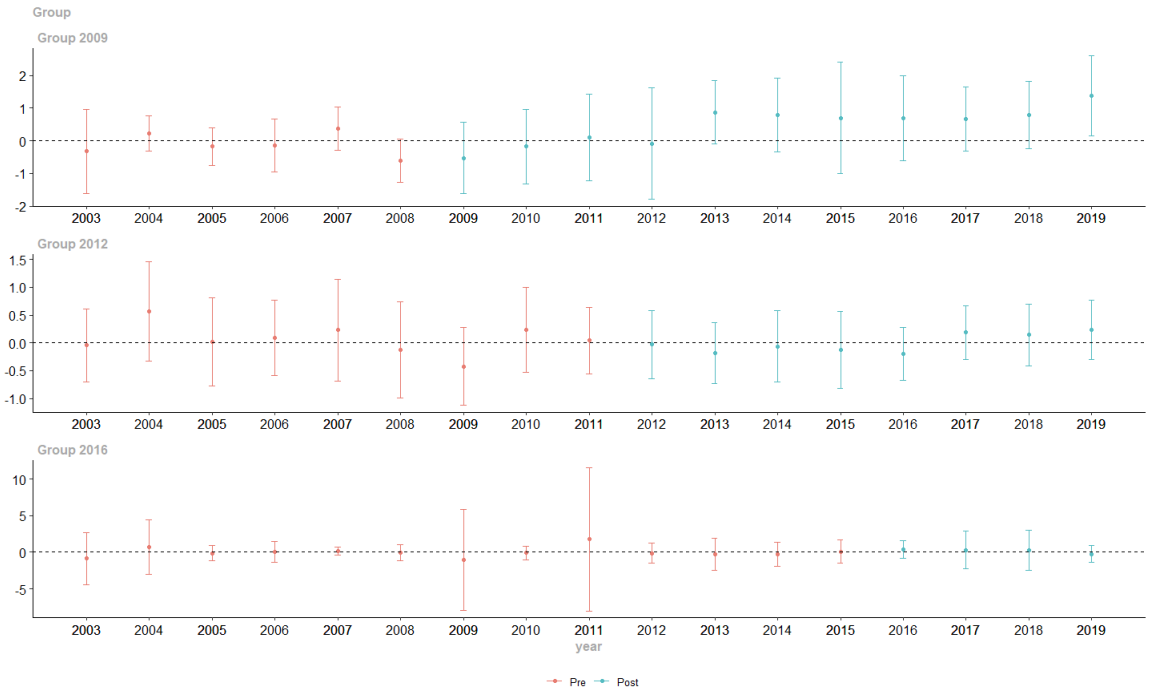


Source: our elaboration on Istat data.

FIGURE 35
The effect of earthquakes on inflows of Italian citizens from other provinces, within the same region. Conditional. Unweighted observations

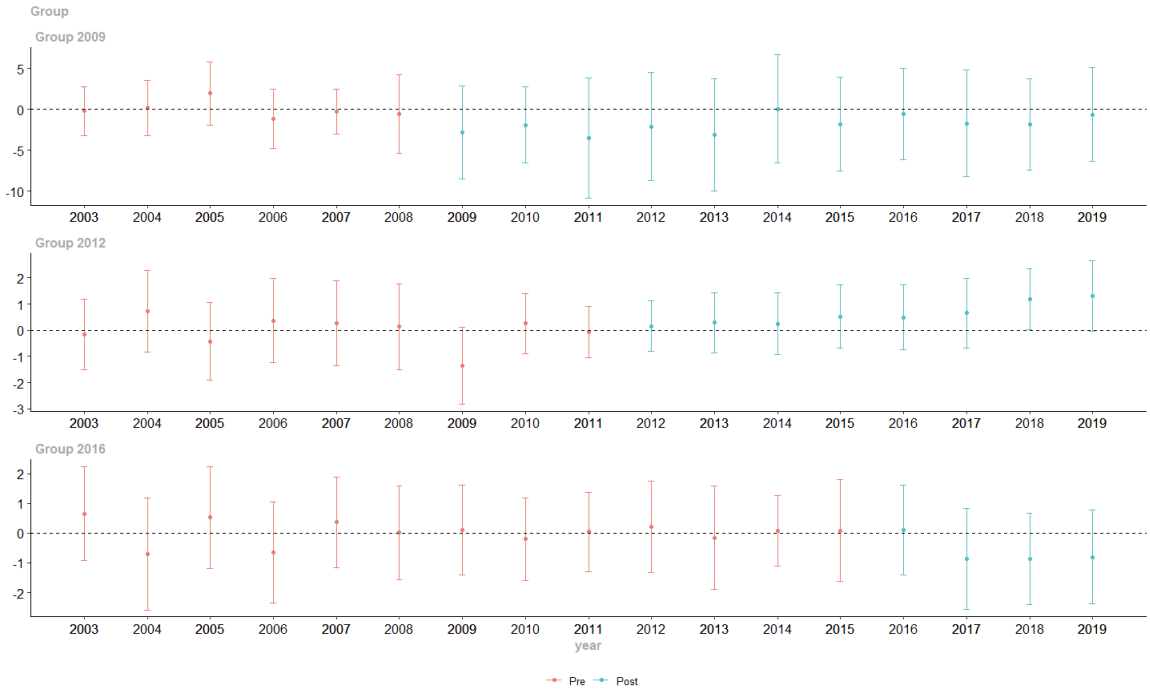
Source: our elaboration on Istat data.

FIGURE 36
The effect of earthquakes on inflows of Italian citizens from other provinces, within the same region. Conditional. Weighted observations



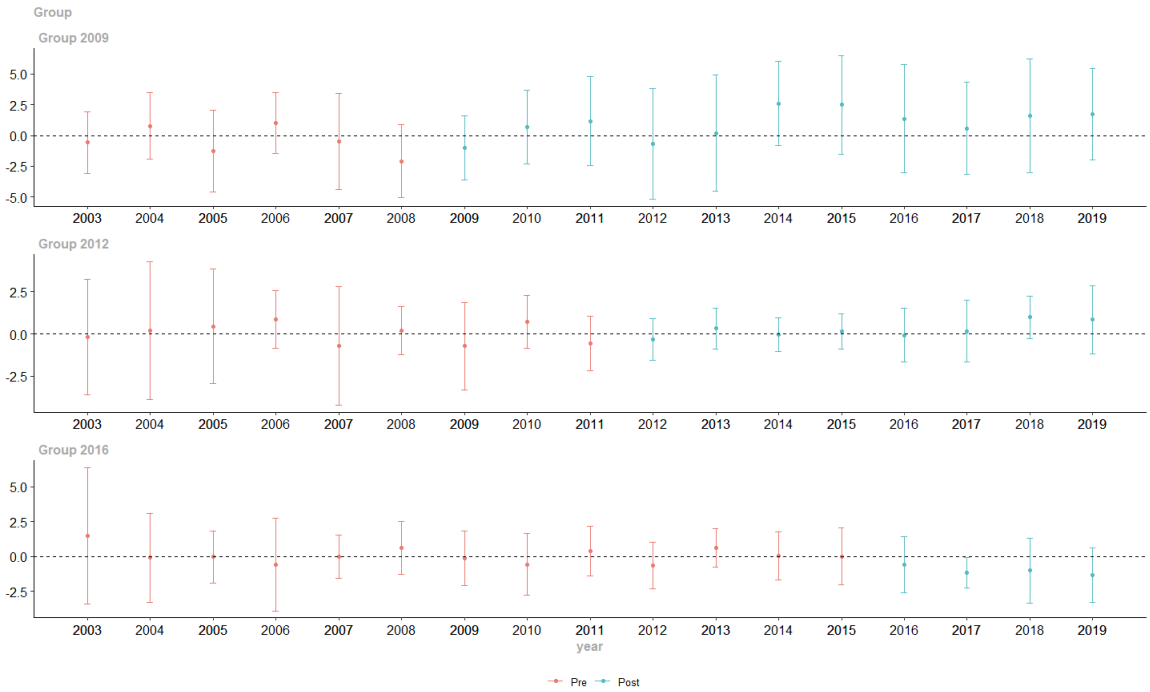
Source: our elaboration on Istat data.

FIGURE 37
The effect of earthquakes on inflows of Italian citizens from other regions. Conditional. Unweighted observations



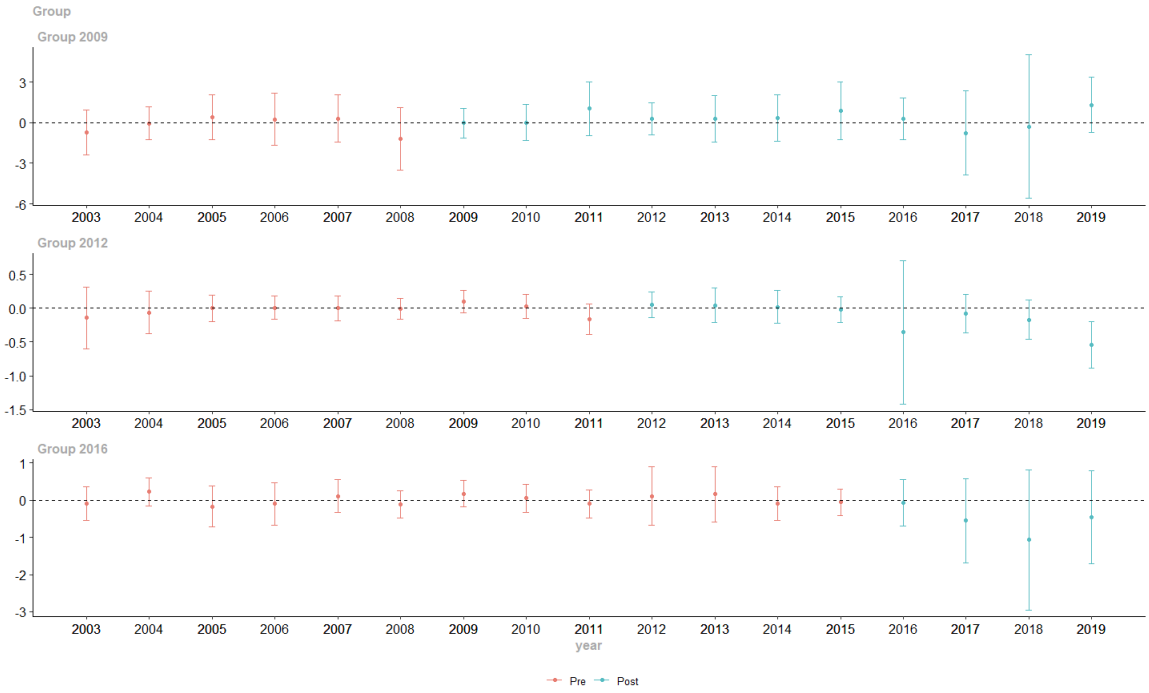
Source: our elaboration on Istat data.

FIGURE 38
The effect of earthquakes on inflows of Italian citizens from other regions. Conditional. Weighted observations



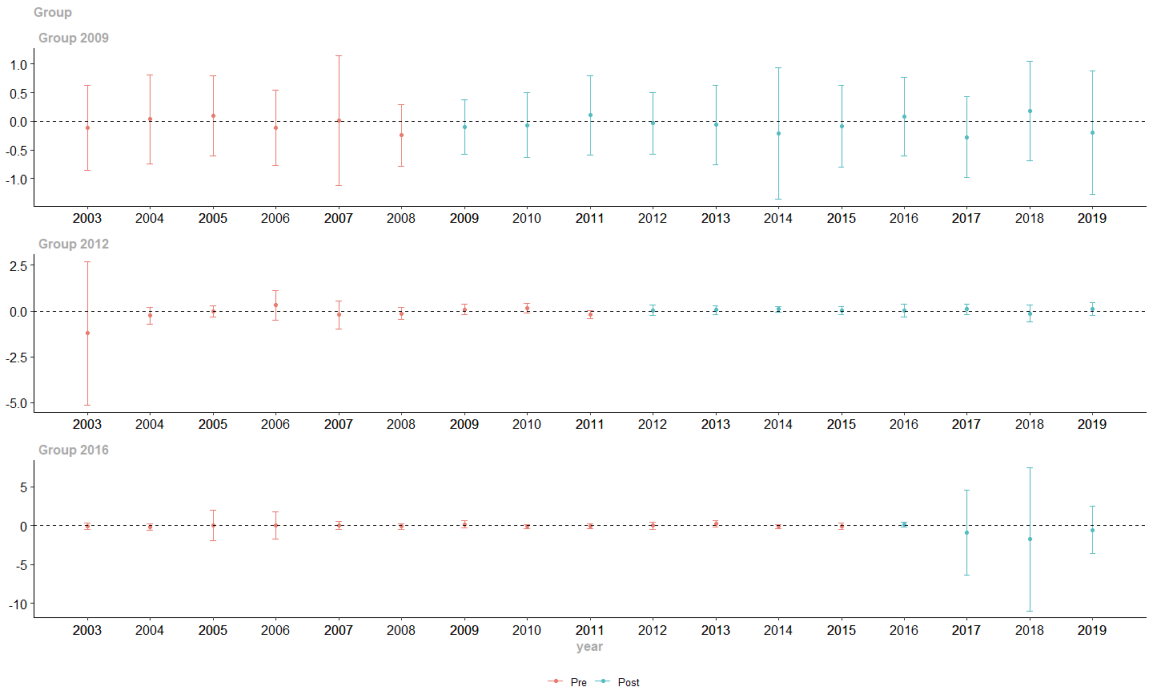
Source: our elaboration on Istat data.

FIGURE 39
The effect of earthquakes on inflows of Italian citizens from abroad. Conditional. Unweighted observations



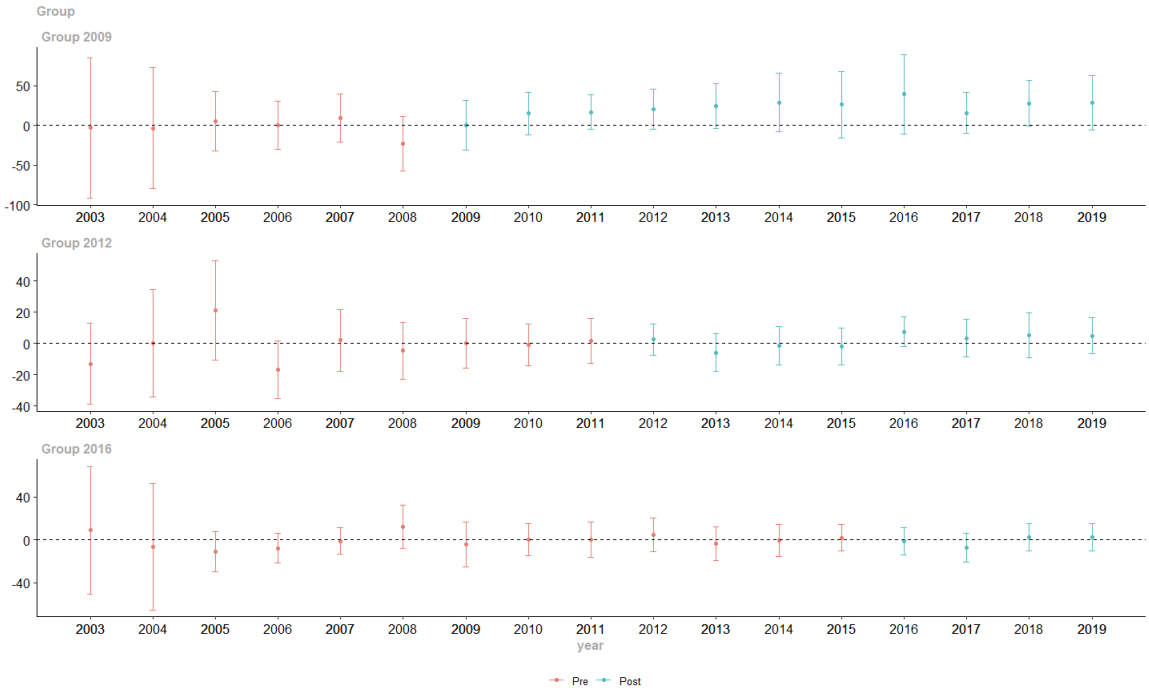
Source: our elaboration on Istat data.

FIGURE 40
The effect of earthquakes on inflows of Italian citizens from abroad. Conditional. Weighted observations



Source: our elaboration on Istat data.

FIGURE 41
The effect of earthquakes on inflows of foreign citizens from other municipalities, within the same province. Conditional. Unweighted observations

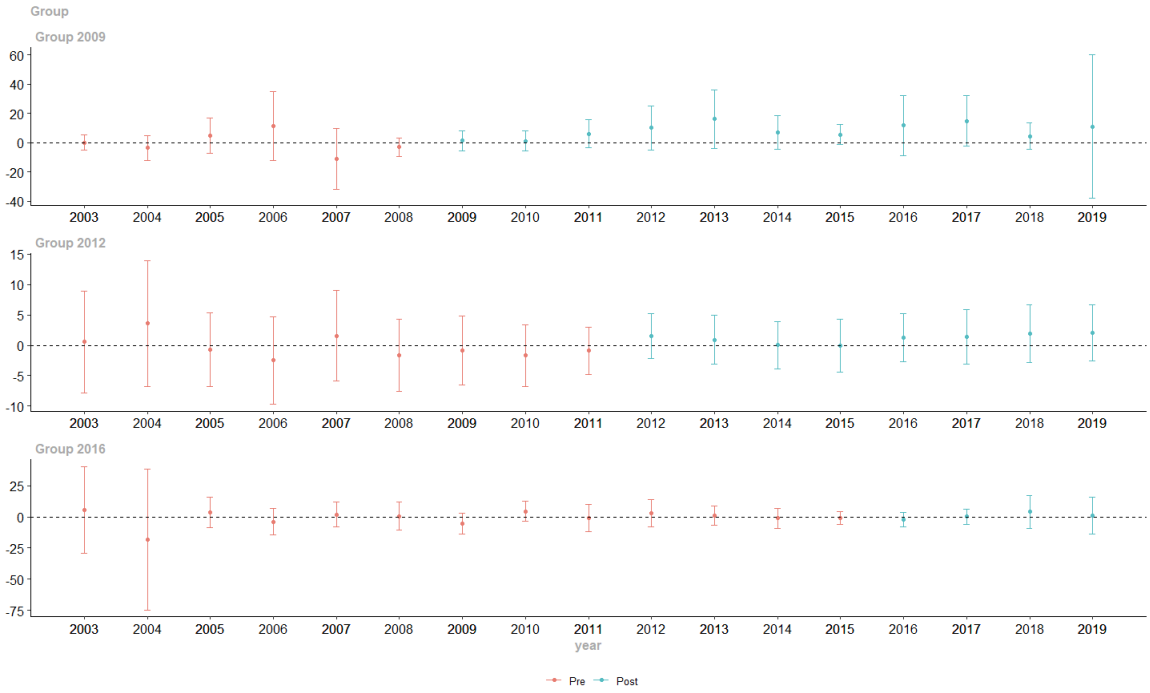


Source: our elaboration on Istat data.

FIGURE 42
The effect of earthquakes on inflows of foreign citizens from other municipalities, within the same province. Conditional. Weighted observations

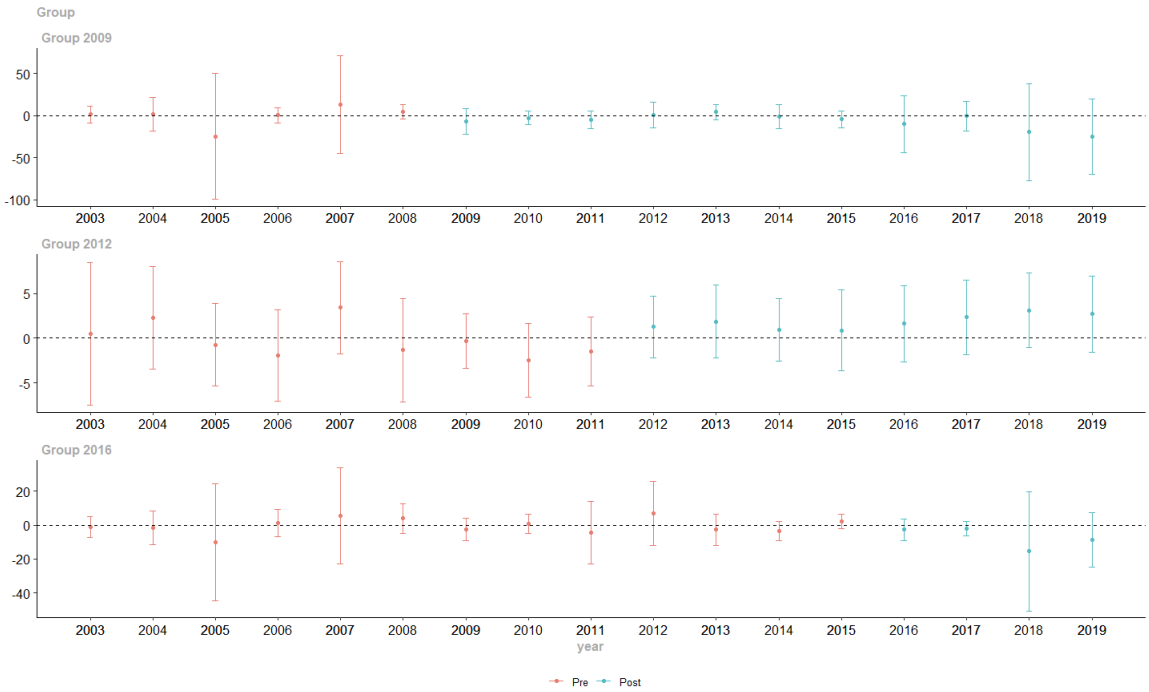
Source: our elaboration on Istat data.

FIGURE 43
The effect of earthquakes on inflows of foreign citizens from other provinces, within the same region. Conditional. Unweighted observations



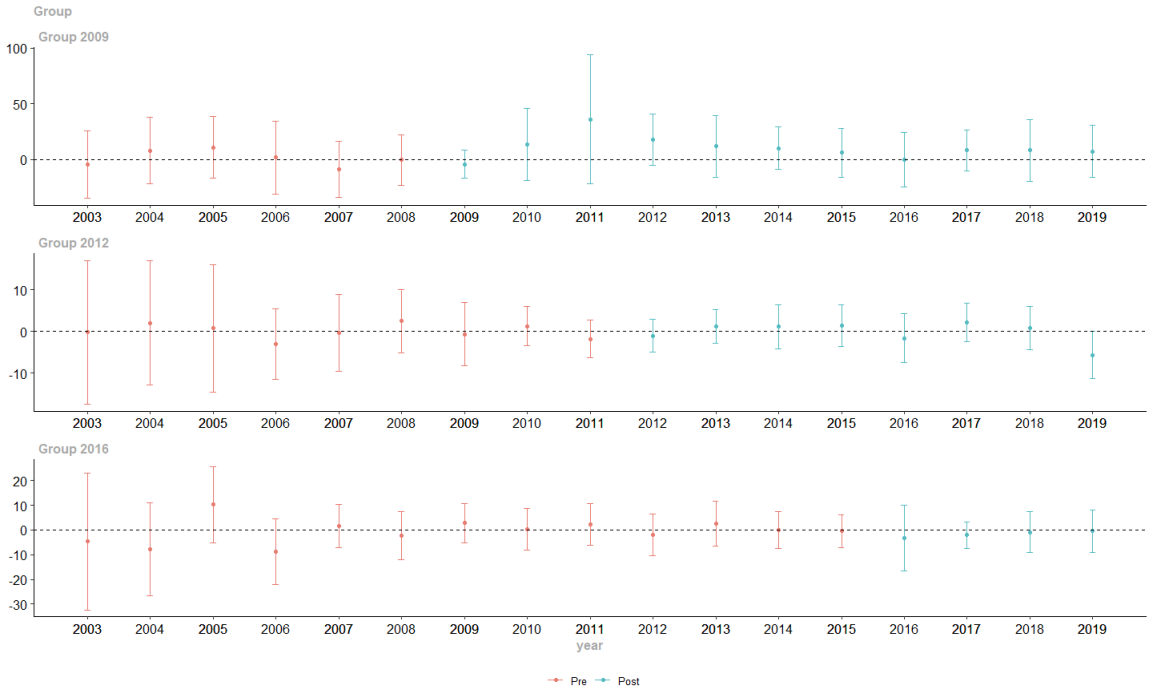
Source: our elaboration on Istat data.

FIGURE 44
The effect of earthquakes on inflows of foreign citizens from other provinces, within the same region. Conditional. Weighted observations



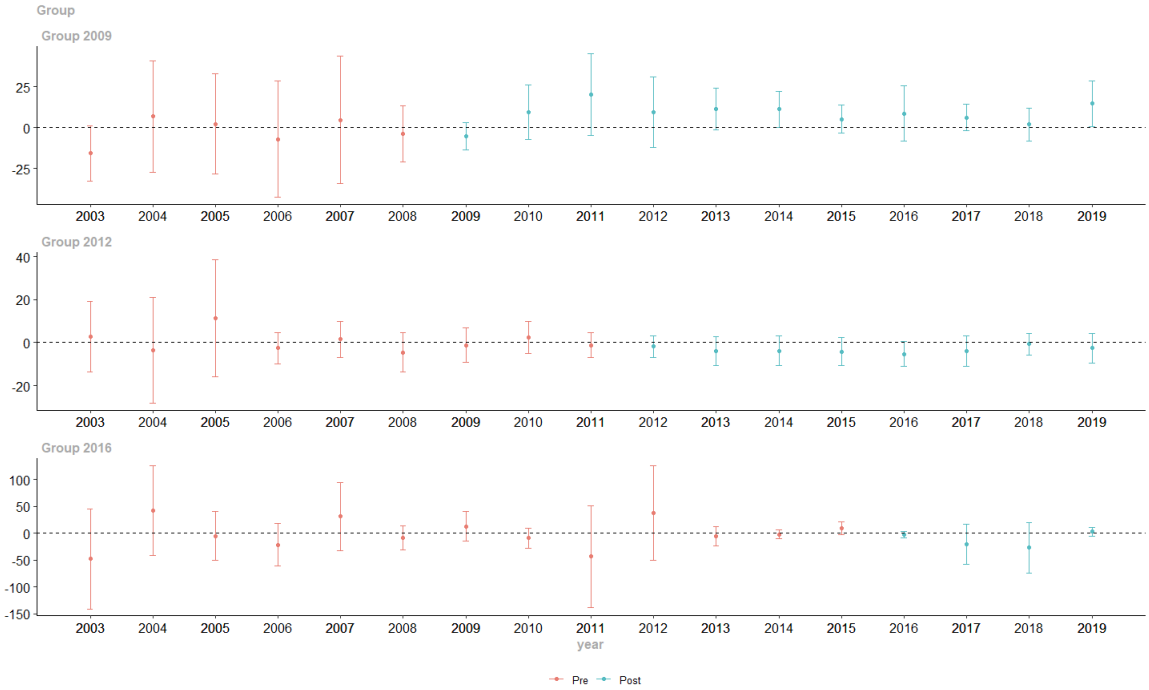
Source: our elaboration on Istat data.

FIGURE 45
The effect of earthquakes on inflows of foreign citizens from other regions. Conditional. Unweighted observations



Source: our elaboration on Istat data.

FIGURE 46
The effect of earthquakes on inflows of foreign citizens from other regions. Conditional. Weighted observations



Source: our elaboration on Istat data.

FIGURE 47
The effect of earthquakes on inflows of foreign citizens from abroad. Conditional. Unweighted observations

Source: our elaboration on Istat data.

FIGURE 48
The effect of earthquakes on inflows of foreign citizens from abroad. Conditional. Weighted observations

Source: our elaboration on Istat data.

E Robustness checks

The analysis was carried out using the migration rates as outcomes variables and restricting the control group of never treated units to those municipalities belonging to one of the five regions affected by an earthquake during the sample period plus a few contiguous municipalities. For robustness check, the analysis was repeated using the whole national sample. The results of this robustness check are reported in Tables 7 and 8. Overall, they confirm the main evidence discussed above. Therefore, our conclusions are not driven by the choice of the geographical scope (selected regions or all Italy).

The analysis was also repeated using a wider selection of municipalities for the treated group, following an enlarged definition of the earthquake zones for the events in 2009 and 2012. The results are reported in Tables 9 and 10. The enlarged version of the craters does not seem to reflect the intensity of either the seismic events or, consequently, of the reconstruction work. In fact, we did not find evidence on the in-migration of both Italian and foreign citizens. The absence of significant effects on the emigration of both Italian and foreign citizens, on the other hand, confirms the evidence that earthquakes had an impact only on very short-distance movements, towards areas near the narrow definition of the earthquake zones and less affected by the quakes.

TABLE 7

Earthquakes Treatment Effects on Out-migration. Restricted craters with Italy as control units sample. Dependent variable: emigration rate

	To same province	To other provinces within same region	To other regions	Abroad
	Italian citizens			
Simple Weighted Average	**1.182**	-0.373	-0.624	-0.029
	(0.616)	(0.255)	(0.415)	(0.165)
Weighted Avg. of group-specific effects	0.639	-0.358	-0.539	-0.105
	(0.554)	(0.292)	(0.403)	(0.250)
Group specific effect: 2009	3.097	-0.986	-1.781	-0.025
	(1.635)	(0.617)	(1.145)	(0.231)
Group specific effect: 2012	0.918	0.189	0.254	0.209
	(0.401)	(0.203)	0.222	(0.147)
Group specific effect: 2016	-0.247	-0.455	-0.497	-0.314
	(0.772)	(0.484)	(0.559)	(0.444)
P-value Wald test DID ass.	0.001	0.270	0.318	0.245
	Foreign citizens			
Simple Weighted Average	**9.087**	0.590	2.536	-1.703
	(4.063)	(1.117)	(2.247)	(2.018)
Weighted Avg. of group-specific effects	6.484	-0.123	-0.053	-0.539
	(3.206)	(1.245)	(2.036)	(0.403)
Group specific effect: 2009	19.920	0.276	**17.756**	-1.781
	(12.733)	(3.195)	**(7.586)**	(1.145)
Group specific effect: 2012	**7.073**	2.238	-0.681	0.254
	(2.771)	(1.238)	(1.058)	(0.222)
Group specific effect: 2016	2.074	-2.336	-4.307	-0.497
	(5.393)	(2.490)	(3.062)	(0.559)
P-value Wald test DID ass.	0.184	0.104	0.228	0.513

Notes: The table reports aggregated treatment effect parameters under the conditional parallel trends assumption and with clustering at the municipality level. The row 'Simple Weighted Average' reports the weighted average (by group size) of all available group-time average treatment effects (ATT_W^O). The row 'Weighted Average of group-specific effects' reports the weighted average of the three group-specific average treatment effects (ATT_W^{Sel}). The row 'Group-specific Effects' summarizes average treatment effects by the the timing of the earthquake. Standard errors in parenthesis. ATT in bold means that the confidence band at 95% significance level does not cover the zero.

TABLE 8

Earthquakes Treatment Effect on In-migration. Restricted craters with Italy as control units sample. Dependent variable: immigration rate

	From same province	From other provinces within same region	From other regions	From abroad
	Italian citizens			
Simple Weighted Average	0.631	-0.289	-0.355	-0.153
	(0.786)	(0.388)	(0.711)	(0.194)
Weighted Avg. of group-specific effects	0.783	-0.213	-0.475	-0.333
	(1.055)	(0.459)	(0.441)	(0.207)
Group specific effect: 2009	0.397	-0.838	-0.415	0.373
	(1.476)	(1.126)	(2.199)	(0.482)
Group specific effect: 2012	0.319	-0.026	0.167	-0.109
	(0.682)	(0.225)	(0.321)	(0.067)
Group specific effect: 2016	1.108	-0.127	-0.814	**-0.767**
	(1.822)	(0.843)	(0.401)	**(0.368)**
P-value Wald test DID ass.	0.180	0.476	0.163	0.309
	Foreign citizens			
Simple Weighted Average	**6.059**	1.377	1.366	7.929
	2.507	(1.221)	(1.879)	(7.878)
Weighted Avg. of group-specific effects	3.146	1.012	0.906	2.120
	(2.334)	(1.664)	(1.602)	(5.861)
Group specific effect: 2009	**21.589**	**6.868**	5.542	33.276
	(6.665)	**(2.876)**	(7.069)	(23.603)
Group specific effect: 2012	2.836	0.907	0.138	3.538
	(2.646)	(1.313)	(1.365)	(2.928)
Group specific effect: 2016	-1.346	0.358	0.365	-7.322
	(3.687)	(2.992)	(2.032)	(7.506)
P-value Wald test DID ass.	0.236	0.742	0.124	0.003

Notes: see Table 7.

TABLE 9

Earthquakes Treatment Effects on Out-migration. Enlarged craters with contiguous municipalities as control units sample. Dependent variable: emigration rate

	To same province	To other provinces within same region	To other regions	Abroad
	Italian citizens			
Simple Weighted Average	-0.103	-0.100	-0.001	0.042
	(0.412)	(0.337)	(0.238)	(0.134)
Weighted Avg. of group-specific effects	-0.032	-0.050	-0.084	-0.052
	(0.425)	(0.299)	(0.198)	(0.171)
Group specific effect: 2009	-0.468	-0.176	0.159	0.189
	(0.652)	(0.660)	(0.381)	(0.226)
Group specific effect: 2012	0.500	-0.106	-0.079	0.050
	(0.375)	(0.164)	(0.178)	(0.120)
Group specific effect: 2016	0.010	0.127	-0.348	-0.432
	(0.882)	(0.571)	(0.392)	(0.450)
P-value Wald test DID ass.	0.083	0.123	0.524	0.178
	Foreign citizens			
Simple Weighted Average	-1.491	-2.057	0.669	-1.797
	(4.973)	(1.692)	(0.772)	(1.732)
Weighted Avg. of group-specific effects	-1.079	-1.347	-0.080	-1.225
	(3.496)	(1.239)	(1.509)	(1.563)
Group specific effect: 2009	-5.794	-6.677	2.009	-2.453
	(9.556)	(3.971)	(3.025)	(3.626)
Group specific effect: 2012	5.112	1.670	0.617	-2.406
	(2.469)	(0.979)	(1.877)	(1.409)
Group specific effect: 2016	-2.236	-0.571	-3.025	1.283
	(4.949)	(1.846)	(2.976)	(2.955)
P-value Wald test DID ass.	0.107	0.199	0.181	0.225

Notes: The table reports aggregated treatment effect parameters under the conditional parallel trends assumption and with clustering at the municipality level. The row 'Simple Weighted Average' reports the weighted average (by group size) of all available group-time average treatment effects (ATT_W^O). The row 'Weighted Average of group-specific effects' reports the weighted average of the three group-specific average treatment effects (ATT_W^{Sel}). The row 'Group-specific Effects' summarizes average treatment effects by the the timing of the earthquake. Standard errors in parenthesis. ATT in bold means that the confidence band at 95% significance level does not cover the zero.

TABLE 10

Earthquakes Treatment Effect on In-migration. Enlarged craters with contiguous municipalities as control units sample. Dependent variable: immigration rate

	From same province	From other provinces within same region	From other regions	From abroad
	Italian citizens			
Simple Weighted Average	-0.769	0.040	0.498	-0.010
	(0.488)	(0.287)	(1.155)	(0.120)
Weighted Avg. of group-specific effects	-0.333	-0.054	0.156	-0.046
	(0.828)	(0.236)	(0.818)	(0.104)
Group specific effect: 2009	-1.636	0.394	1.412	0.056
	(0.840)	(0.608)	(2.375)	(0.200)
Group specific effect: 2012	-0.307	-0.341	-0.298	-0.040
	(0.558)	(0.184)	(0.308)	(0.063)
Group specific effect: 2016	1.001	-0.252	-0.787	-0.195
	(2.433)	(0.611)	(0.441)	(0.191)
P-value Wald test DID ass.	0.203	0.159	0.267	0.216
	Foreign citizens			
Simple Weighted Average	-0.784	2.955	-0.893	-0.450
	(2.536)	(1.938)	(1.374)	(17.260)
Weighted Avg. of group-specific effects	-0.894	2.519	-0.908	-1.058
	(2.096)	(1.674)	(1.325)	(11.850)
Group specific effect: 2009	-1.911	6.670	0.746	-0.985
	(4.696)	(5.191)	(2.383)	(31.966)
Group specific effect: 2012	1.549	0.519	-3.250	2.620
	(2.941)	(1.268)	(1.953)	(3.941)
Group specific effect: 2016	-2.204	2.277	0.112	-4.363
	(3.677)	(3.297)	(2.265)	(7.754)
P-value Wald test DID ass.	0.154	0.544	0.083	0.110

Notes: see Table 9.

F Standard DID results

We have also adopted a standard DID approach based on the estimation of a TWFE equation, in order to assess the bias in the estimated treatment effects with respect to those computed through the method provided by Callaway and Sant'Anna (2021). In particular, following Spitzer, Tortorici, and Zimran (2022), we have estimated a DID equation with non-parametric province-specific time trends:

$$\ln m_{it} = \alpha_{pt} + \alpha_i + \beta_{09}(D_{09,i} \times q_t) + \beta_{12}(D_{12,i} \times q_t) + \beta_{16}(D_{16,i} \times q_t) + v_{it} \tag{1}$$

where $\ln m_{it}$ is the logarithm of the migration rate of municipality i at time t (i.e. one of the sixteen outcome variables used in our analysis), α_{pt} are province-year fixed effects capturing province-specific year-to-year variations, and α_i are municipalities fixed effects capturing time-invariant differences in migration rates across municipalities. The three β_k coefficients on the interaction between the treated unit ($s_{k,i}$, with k indicating one of the three earthquakes) and an indicator for years 2009 (2012, 2016, alternatively) and later (q_t) are our coefficients of interest. As usual, we cluster standard errors at the municipality level to mitigate the effect of spatial autocorrelation between the errors of nearby municipalities, even across different years. Identification is based on the degree to which severely damaged municipalities deviated in the post-treatment period from the trend of other municipalities in the same province. The results of the estimated βs are then compared to those of the group-specific ATT reported in tables 1 and 2 in the paper. Finally, to provide a test of the parallel trends assumption inherent in equation (1), we also adapt equation (1) into the following event study specification:

$$\ln m_{it} = \alpha_{pt} + \alpha_i + \beta_{09,t} D_{09,i} + \beta_{12,t} D_{12,i} + \beta_{16,t} D_{16,i} + \varepsilon_{it} \tag{2}$$

where the β_t coefficients for the three groups are permitted to vary over time.

We have estimated equations (1) and (2) selecting only the municipalities in the region(s) in

which the affected spatial units are located. The estimation results of equation (1) are reported in Table 11. The estimates of the event-study specification (equation 2) are reported in Figures 49-64.[1]

Generally speaking, we observe that the estimated β parameters from equation 1 are lower than the group-specific ATT estimated with the method proposed by Callaway and Sant'Anna (2021),[2] confirming that the traditional DID approach based on a two-way-fixed-effect estimation method can generate downward-biased results in the presence of multiple groups and multiple periods of treatment. This negative bias may also help explain the paradox emphasized by Beine and Jeusette (2018) in their meta-analysis of the literature on climate change and migration: in several studies, the occurrence of adverse climatic developments reduces rather than enhances the mobility of the affected population. However, the profile of the year-specific effects obtained with the two methods are very similar. For example, the comparing Figures 53 and 25, we note that the time profile of the ATT estimated with the two methods is very similar although the year-specific effects in Figure 53 are systematically lower, thus contributing to generate a non-significant overall effect.

[1] The figures present year-specific treatment effect from the event-study specification of equation 2). First, this specification provides a clear test of the parallel trends assumption underlying the DID analysis. They also show how any effect of the earthquakes in the post-earthquake period evolved over time.

[2] A lower value of the ATT parameter estimated with the traditional method is observed in 9 out 12 cases when the outcome variable is the log of emigration rate of Italian citizens, in 8 out 12 cases when the outcome variable is the log of emigration rate of foreign citizens, in 6 out 12 cases when the outcome variable is the log of immigration rate of Italian citizens, and in 10 out 12 cases when the outcome variable is the log of immigration rate of foreign citizens.

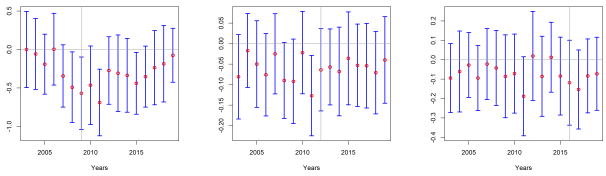
TABLE 11

Earthquakes Treatment Effects in Out-migration and In-migration. Standard DID results

	Out-migration				In-migration			
	same province	same region	other regions	abroad	same province	same region	other regions	abroad
	Italian citizens							
2009	-0.202***	-0.038	-0.189*	-0.079	-0.162*	-0.022	-0.238**	-0.047
	(0.048)	(0.079)	(0.080)	(0.082)	(0.084)	(0.092)	(0.095)	(0.068)
2012	0.003	-0.002	0.025	0.101***	-0.056*	0.018	-0.003	-0.049**
	(0.019)	(0.025)	(0.026)	(0.035)	(0.029)	(0.029)	(0.031)	(0.023)
2016	-0.055	-0.065*	-0.104*	-0.107**	-0.089**	-0.033	-0.017	-0.012
	(0.036)	(0.039)	(0.035)	(0.048)	(0.042)	(0.062)	(0.051)	(0.043)
	Foreign citizens							
2009	0.090	-0.117	-0.136	-0.055	0.203	0.300*	0.381	-0.269
	(0.200)	(0.240)	(0.197)	(0.242)	(0.219)	(0.172)	(0.248)	(0.230)
2012	0.076*	0.037	-0.066	-0.163	-0.070	-0.030	-0.097	0.044
	(0.039)	(0.065)	(0.060)	(0.112)	(0.044)	(0.079)	(0.060)	(0.048)
2016	-0.043	-0.095	0.053	0.194*	0.058	-0.129	0.105	-0.037
	(0.108)	(0.092)	(0.092)	(0.111)	(0.092)	(0.127)	(0.108)	(0.125)

Notes: The table reports aggregated treatment effect parameters computed using equation (1). Standard errors clustered on the municipality level are in parentheses. *, **, and *** mean that the parameter is significant at 10%, 5%, and 1% significant level, respectively. The sample includes only municipalities in the regions of Abruzzo, Emilia Romagna, Marche, Lazio and Umbria. Sample period: 2002-2019.

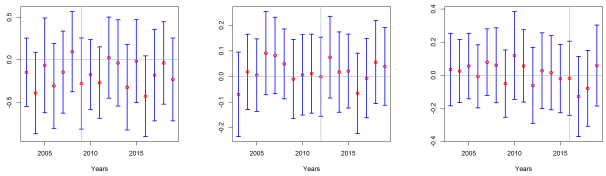
FIGURE 49
The effect of the earthquakes on outflows of Italian citizens to other municipalities, within the same province. Event study specification



(a) 2009 (b) 2012 (c) 2016

Source: Our elaboration on Istat data.

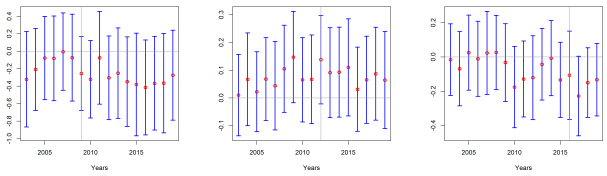
FIGURE 50
The effect of the earthquakes on outflows of Italian citizens to other provinces, within the same region. Event study specification



(a) 2009 (b) 2012 (c) 2016

Source: Our elaboration on Istat data.

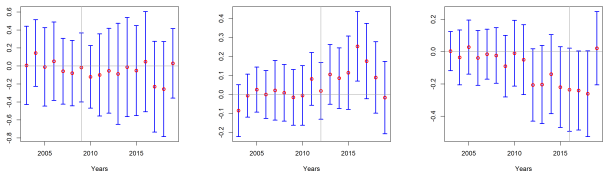
FIGURE 51
The effect of the earthquakes on outflows of Italian citizens to other regions. Event study specification



(a) 2009 (b) 2012 (c) 2016

Source: Our elaboration on Istat data.

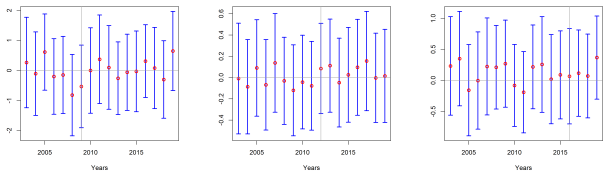
FIGURE 52
The effect of the earthquakes on outflows of Italian citizens abroad. Event study specification



(a) 2009 (b) 2012 (c) 2016

Source: Our elaboration on Istat data.

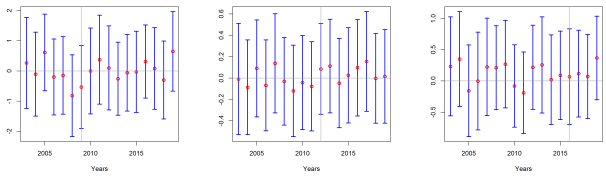
FIGURE 53
The effect of the earthquakes on outflows of foreign citizens to other municipalities, within the same province. Event study specification



(a) 2009 (b) 2012 (c) 2016

Source: Our elaboration on Istat data.

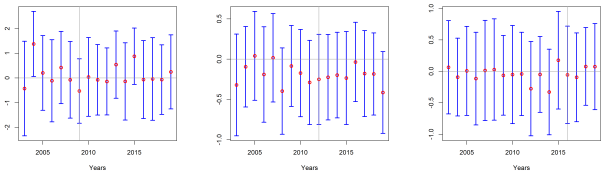
FIGURE 54
The effect of the earthquakes on outflows of foreign citizens to other provinces, within the same region. Event study specification



(a) 2009 (b) 2012 (c) 2016

Source: Our elaboration on Istat data.

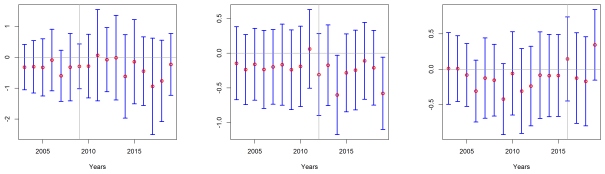
FIGURE 55
The effect of the earthquakes on outflows of foreign citizens to other regions. Event study specification



(a) 2009 (b) 2012 (c) 2016

Source: Our elaboration on Istat data.

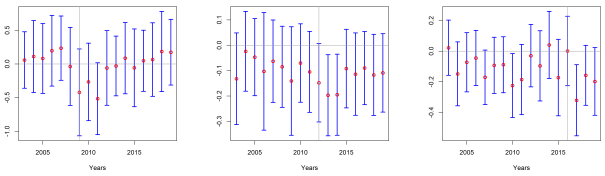
FIGURE 56
The effect of the earthquakes on outflows of foreign citizens abroad. Event study specification



(a) 2009 (b) 2012 (c) 2016

Source: Our elaboration on Istat data.

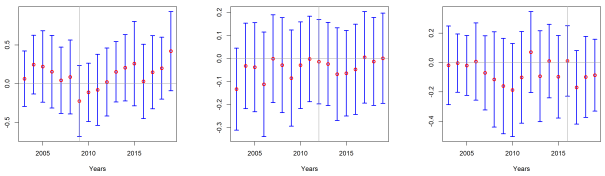
FIGURE 57
The effect of the earthquakes on inflows of Italian citizens from other municipalities, within the same province. Event study specification



(a) 2009 (b) 2012 (c) 2016

Source: Our elaboration on Istat data.

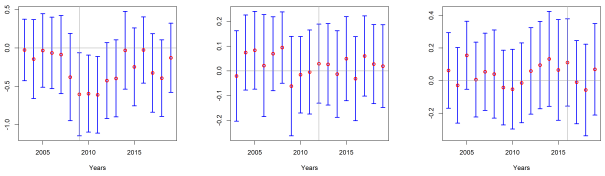
FIGURE 58
The effect of the earthquakes on inflows of Italian citizens from other provinces, within the same region. Event study specification



(a) 2009 (b) 2012 (c) 2016

Source: Our elaboration on Istat data.

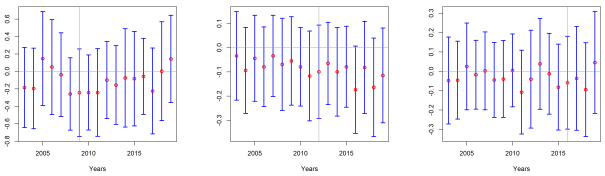
FIGURE 59
The effect of the earthquakes on inflows of Italian citizens from other regions. Event study specification



(a) 2009 (b) 2012 (c) 2016

Source: Our elaboration on Istat data.

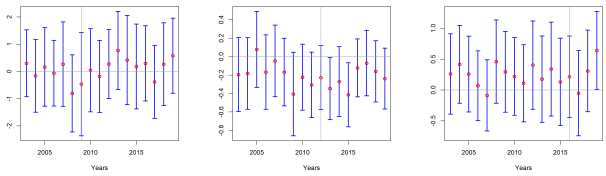
FIGURE 60
The effect of the earthquakes on inflows of Italian citizens from abroad. Event study specification



(a) 2009 (b) 2012 (c) 2016

Source: Our elaboration on Istat data.

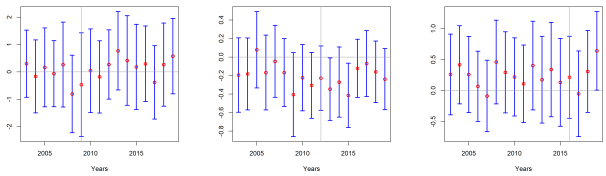
FIGURE 61
The effect of the earthquakes on inflows of foreign citizens from other municipalities, within the same province. Event study specification



(a) 2009 (b) 2012 (c) 2016

Source: Our elaboration on Istat data.

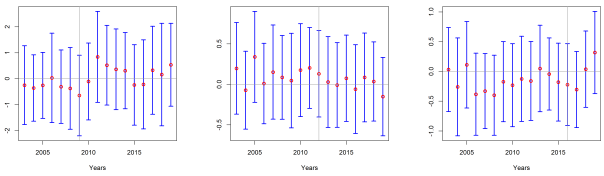
FIGURE 62
The effect of the earthquakes on inflows of foreign citizens from other provinces, within the same region. Event study specification



(a) 2009 (b) 2012 (c) 2016

Source: Our elaboration on Istat data.

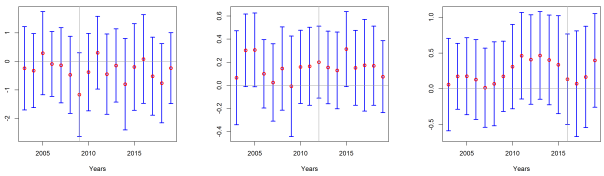
FIGURE 63
The effect of the earthquakes on inflows of foreign citizens from other regions. Event study specification



(a) 2009 (b) 2012 (c) 2016

Source: Our elaboration on Istat data.

FIGURE 64
The effect of the earthquakes on inflows of foreign citizens from abroad. Event study specification



(a) 2009 (b) 2012 (c) 2016

Source: Our elaboration on Istat data.

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