**Supplementary Information Appendix**
**For manuscript:**

# Do All Roads Lead to Sapporo? The Role of Linking and Bridging Ties in Evacuation Decisions

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**Appendix 1: Descriptive Statistics and Models**
**Figure A1.1: Short Distance Evacuation**

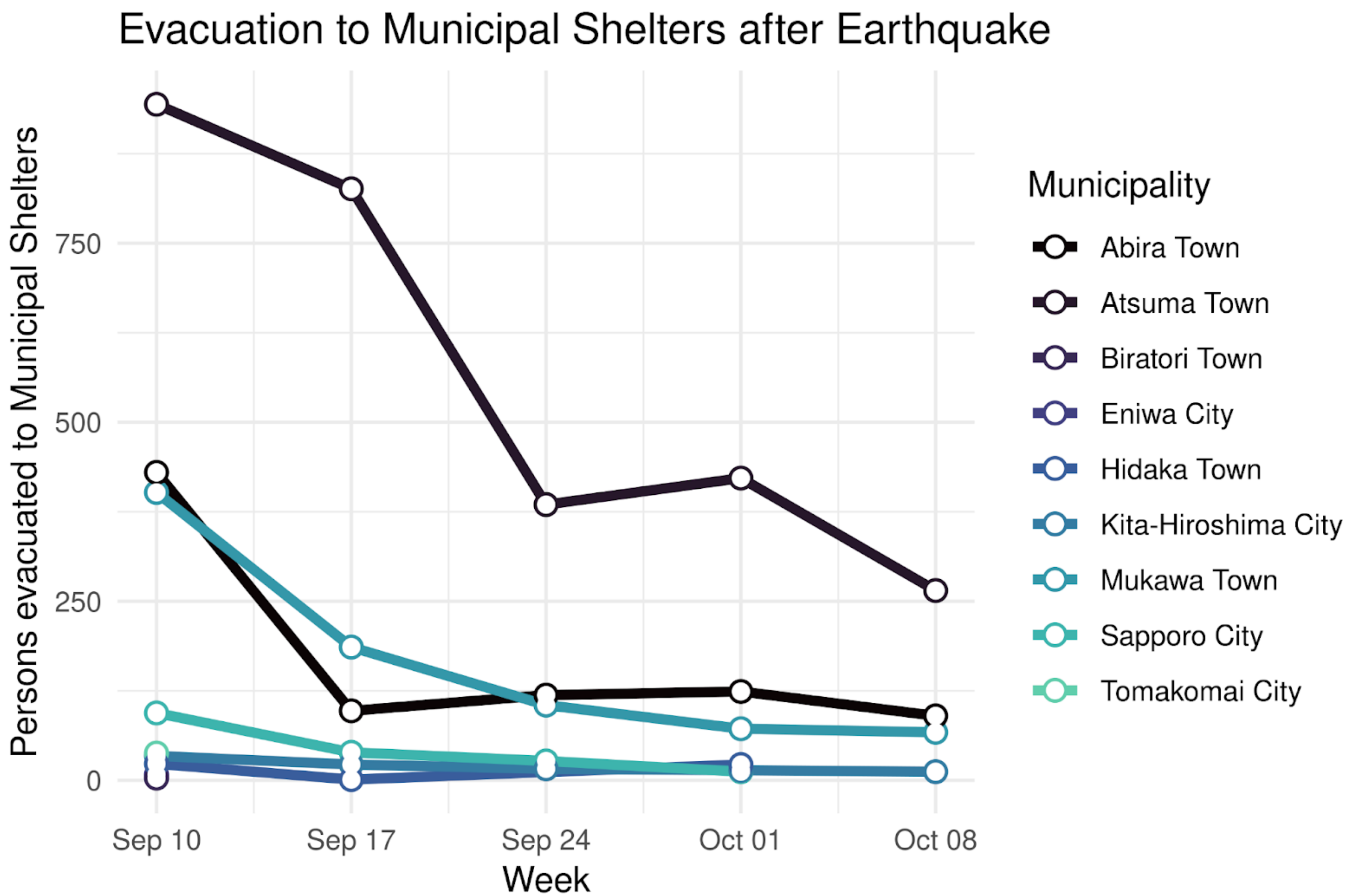


**Table A1.1: Descriptive Statistics**

Descriptive Statistics

| | Mean | Median | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Rate of Evacuees | 16.83 | 8.87 | 25.28 | 0.79 | 169.52 |
| Bonding Social Capital | 0.71 | 0.72 | 0.05 | 0.58 | 0.78 |
| Bridging Social Capital | 0.31 | 0.3 | 0.01 | 0.28 | 0.33 |
| Linking Social Capital | 0.24 | 0.24 | 0.02 | 0.19 | 0.27 |
| Social Vulnerability | 0.74 | 0.74 | 0.02 | 0.68 | 0.79 |
| Revenues to Expenditures Ratio | 4.21 | 3.58 | 3.41 | 0.1 | 19.6 |
| Emergency Services Spending | 35.73 | 26.71 | 26.99 | 9.64 | 126.5 |
| Public Works Spending | 112.23 | 83.61 | 66.6 | 43.52 | 316.95 |
| Rate of Shelters Opened | 0.2 | 0.1 | 0.28 | 0 | 0.96 |
| Distance from Epicenter | 72.51 | 76.1 | 23.76 | 26.27 | 115.19 |
| Rate of Buildings Damaged | 1.74 | 0.09 | 6.02 | 0 | 35.44 |
| Rate of Evacuees to Local Shelters | 0.03 | 0 | 0.16 | 0 | 1.47 |
| Days of Water Outages | 0.86 | 0 | 1.48 | 0 | 6 |

Note: Rates calculated per 1000 residents.

# Table A1.2: Models

**OLS Models of logged Evacuees per 1000 residents in Municipalities with any Documented Evacuation Between Cities (n = 34)** [1]

*Coefficient with Std. Errors in parentheses* [2] *with Fixed Effects by Week (n = 5)*

| | **Model 1: Model with Direct Effects** *(All cities)* | | **Model 2: Model with Interaction Effect** *(All cities)* | | **Model 3: Model with Direct Effects** *(Excluding Outliers[3])* | | **Model 4: Model with Interaction Effect** *(Excluding Outliers)* | |
|---|---|---|---|---|---|---|---|---|
| | **Model 1A: Basic Model** | **Model 1B: Full Controls** | **Model 2A: Basic Model** | **Model 2B: Full Controls** | **Model 3A: Basic Model** | **Model 3B: Full Controls** | **Model 4A: Basic Model** | **Model 4B: Full Controls** |
| **Social Capital** | | | | | | | | |
| Bonding | -0.07 (0.05) | **-0.08** (0.05)$^{.}$ | -0.07 (0.05) | **-0.12** (0.05)$^{*}$ | 0.04 (0.05) | **-0.10** (0.05)$^{.}$ | 0.04 (0.05) | **-0.10** (0.05)$^{.}$ |
| Bridging | **0.09** (0.04)$^{*}$ | -0.02 (0.04) | **0.23** (0.12)$^{.}$ | **0.32** (0.12)$^{**}$ | 0.03 (0.04) | 0.02 (0.04) | 0.04 (0.11) | **0.31** (0.11)$^{**}$ |
| Linking | **-0.09** (0.03)$^{**}$ | **-0.07** (0.03)$^{*}$ | 0.04 (0.11) | **0.25** (0.11)$^{*}$ | **-0.07** (0.03)$^{*}$ | -0.04 (0.03) | -0.05 (0.10) | **0.27** (0.11)$^{*}$ |
| **Vulnerability** | | | | | | | | |
| Social Vulnerability Index | **-0.18** (0.06)$^{**}$ | **-0.13** (0.05)$^{*}$ | **-0.19** (0.06)$^{**}$ | **-0.20** (0.06)$^{***}$ | 0.03 (0.04) | -0.07 (0.04) | 0.02 (0.04) | **-0.10** (0.04)$^{*}$ |
| **Interactions** | | | | | | | | |
| Bridging x Linking | | | -0.02 (0.02) | **-0.05** (0.02)$^{**}$ | | | -0.00 (0.02) | **-0.05** (0.02)$^{**}$ |
| **Public Goods** | | | | | | | | |
| Revenues to Expenditures Ratio | | 0.05 (0.04) | | 0.06 (0.04) | | 0.01 (0.04) | | 0.01 (0.04) |
| Emergency Services Spending | | **0.22** (0.05)$^{***}$ | | **0.18** (0.05)$^{**}$ | | 0.01 (0.05) | | 0.03 (0.05) |
| Public Works Spending | | -0.01 (0.04) | | 0.03 (0.04) | | 0.08 (0.05) | | **0.12** (0.05)$^{*}$ |
| Shelters Opened per capita | | **-0.15** (0.03)$^{***}$ | | **-0.16** (0.03)$^{***}$ | | **-0.16** (0.03)$^{***}$ | | **-0.17** (0.03)$^{***}$ |
| **Controls** | | | | | | | | |
| Distance from Epicenter | 0.00 (0.03) | **-0.06** (0.03)$^{*}$ | 0.02 (0.04) | -0.04 (0.03) | 0.01 (0.03) | **-0.09** (0.03)$^{**}$ | 0.02 (0.03) | **-0.06** (0.03)$^{*}$ |
| Buildings Damaged per capita | | **-0.15** (0.06)$^{**}$ | | **-0.20** (0.06)$^{***}$ | | **-0.12** (0.06)$^{*}$ | | **-0.19** (0.06)$^{**}$ |
| Evacuees to Local Shelters per capita | | -0.01 (0.06) | | 0.01 (0.06) | | -0.02 (0.06) | | 0.00 (0.06) |
| Days of Water Outages | | 0.02 (0.03) | | **0.09** (0.04)$^{*}$ | | 0.02 (0.03) | | **0.09** (0.04)$^{*}$ |
| **Fixed Effects** | | | | | | | | |
| Week 2 | 0.29 (0.21) | **0.29** (0.15)$^{.}$ | 0.29 (0.21) | **0.29** (0.15)$^{*}$ | 0.28 (0.19) | **0.27** (0.16)$^{.}$ | 0.28 (0.19) | **0.28** (0.15)$^{.}$ |
| Week 3 | **0.36** (0.21)$^{.}$ | **0.35** (0.15)$^{*}$ | **0.36** (0.21)$^{.}$ | **0.36** (0.15)$^{*}$ | **0.35** (0.19)$^{.}$ | **0.35** (0.16)$^{*}$ | **0.35** (0.19)$^{.}$ | **0.35** (0.15)$^{*}$ |
| Week 4 | 0.32 (0.21) | **0.32** (0.15)$^{*}$ | 0.32 (0.21) | **0.32** (0.15)$^{*}$ | 0.31 (0.19) | **0.31** (0.15)$^{*}$ | 0.31 (0.19) | **0.31** (0.15)$^{*}$ |
| Week 5 | 0.34 (0.21) | **0.34** (0.15)$^{*}$ | 0.34 (0.21) | **0.34** (0.15)$^{*}$ | **0.32** (0.19)$^{.}$ | **0.31** (0.16)$^{*}$ | **0.32** (0.19)$^{.}$ | **0.32** (0.15)$^{*}$ |
| Constant | **3.65** (0.83)$^{***}$ | **4.10** (0.78)$^{***}$ | **2.81** (1.10)$^{*}$ | **2.43** (0.94)$^{*}$ | **1.70** (0.67)$^{*}$ | **3.84** (0.64)$^{***}$ | 1.60 (0.97) | **1.69** (0.98)$^{.}$ |
| Mean VIF | 1.69 | 2.91 | 10.98 | 11.73 | 1.93 | 3.17 | 10.64 | 11.99 |
| $R^2$ | 0.19 | 0.63 | 0.20 | 0.65 | 0.07 | 0.44 | 0.07 | 0.47 |
| Adj. $R^2$ | 0.15 | 0.59 | 0.15 | 0.61 | 0.01 | 0.37 | 0.01 | 0.40 |
| Num. obs. | 170 | 170 | 170 | 170 | 160 | 160 | 160 | 160 |

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$; $.\ p < 0.10$.

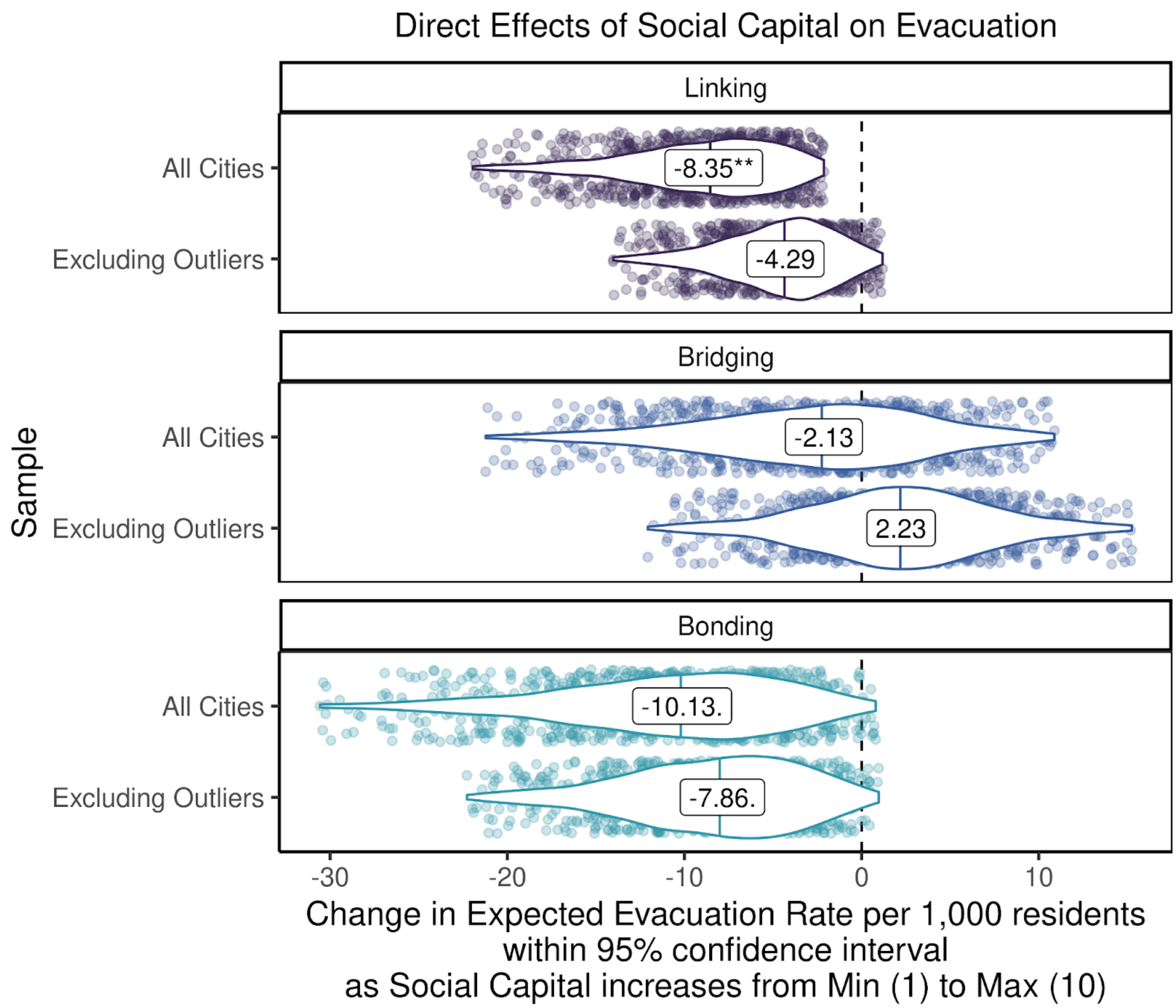
[1] 4 city-weeks saw no documented evacuation, but zero could not be log-transformed. To include these cases *and* respect the original distribution, these cases were assigned a small-but-realistic value: 0.7913, half the size of the smallest non-zero observation. Results were consistent when excluding these cases.

[2] Coefficient depicts log-odds of evacuation given an increase in the predictor by 1 unit on a scale from 1 to 10.

[3] Repeated models excluding 10 observations from outlier cities Isoya-gun and Shimukappu-mura as robustness checks. Models in **blue font** show best fitting models. Models in **grey font** show early models.

**Figure A1.2: Simulations both including and excluding outliers**

**Figure A1.2-1: Simulated Direct Effects on Evacuation,**
*Repeating Figure 4 while including Outliers (Model 1B) and Excluding Outliers (Model 3B)*




As described in the main text, we see in the top panel under "Excluding Outliers" that when excluding 10 observations from outlier cities Isoya-gun and Shimukappu-mura, the 95% confidence interval for the significant effect of linking social capital dips ever so slightly below 0. This reflects how though the effect of linking social capital was statistically significant with all observations (and when removing just Isoya-gun), removing Shimukappu-mura as well deflates the effect just slightly. Linking social capital's effect is still somewhat statistically significant when performing a one-tailed hypothesis test, since 93% of expected changes are still greater than zero ($p < 0.07$). However, this study uses two-tailed hypothesis tests.

**Figure A1.2-2: Simulated Direct Effects on Evacuation,**
*Repeating Figure 3 while including Outliers (Model 1B) and Excluding Outliers (Model 3B)*

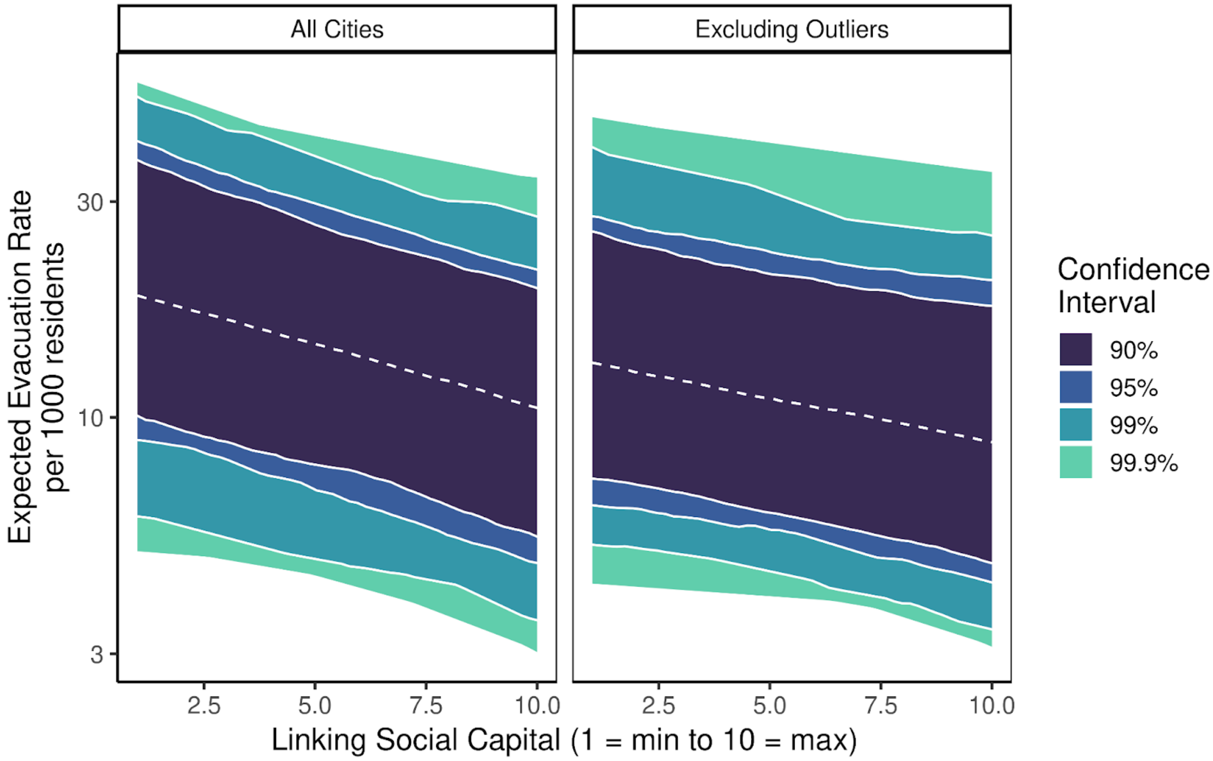
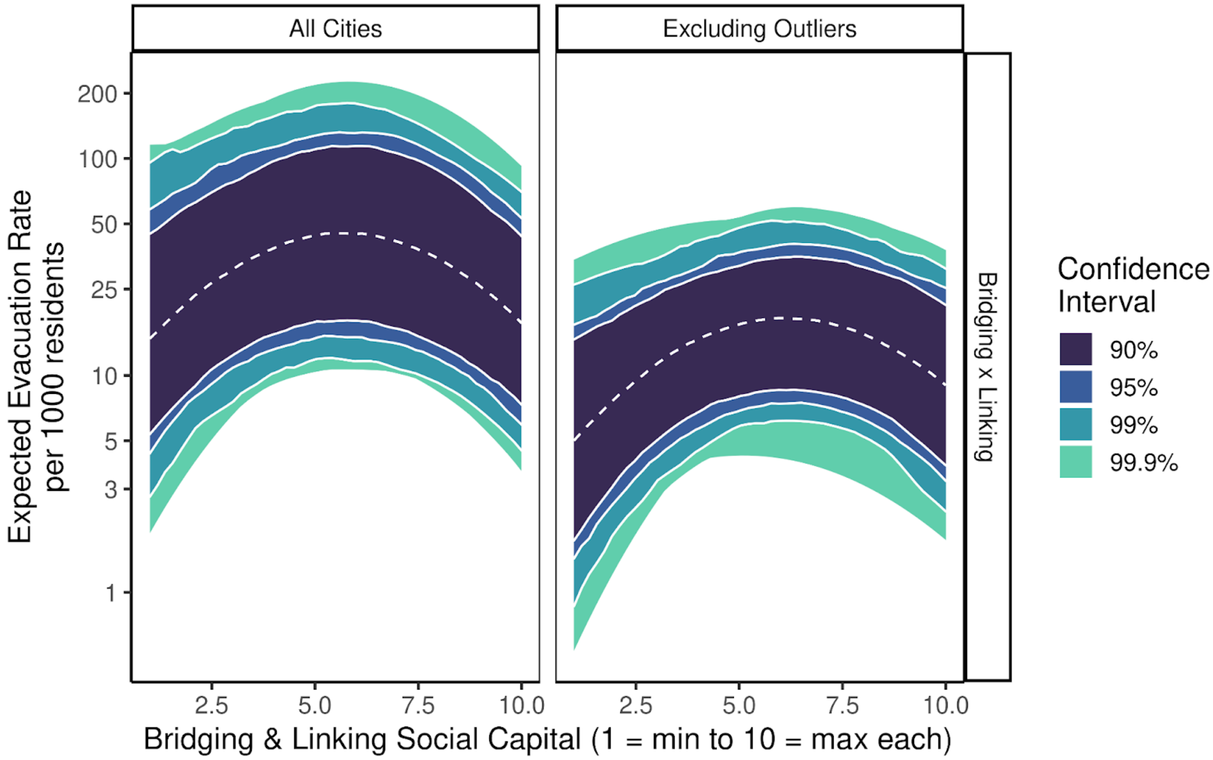



**Figure A1.2-2** shows this effect directly, repeating the analysis from **Figure 3** in the main text for a model of all cities (Model 1B), in the left panel, vs. the model excluding outliers (Model 3B), represented by the right panel. This reveals that though the level of statistical significance differs officially, substantively, the effect of linking social capital is still quite considerable.

To summarize, this minor difference in statistical significance means that the effect of linking social capital remains quite large even when removing outliers, but every outlier removed decreases the significance of the effect somewhat. This suggested to the authors that perhaps we should investigate interactions as well; indeed, our interaction models produce statistically significant beta coefficients both when including and excluding outliers.

**Figure A1.2-3: Simulated Interaction Effects on Evacuation,**

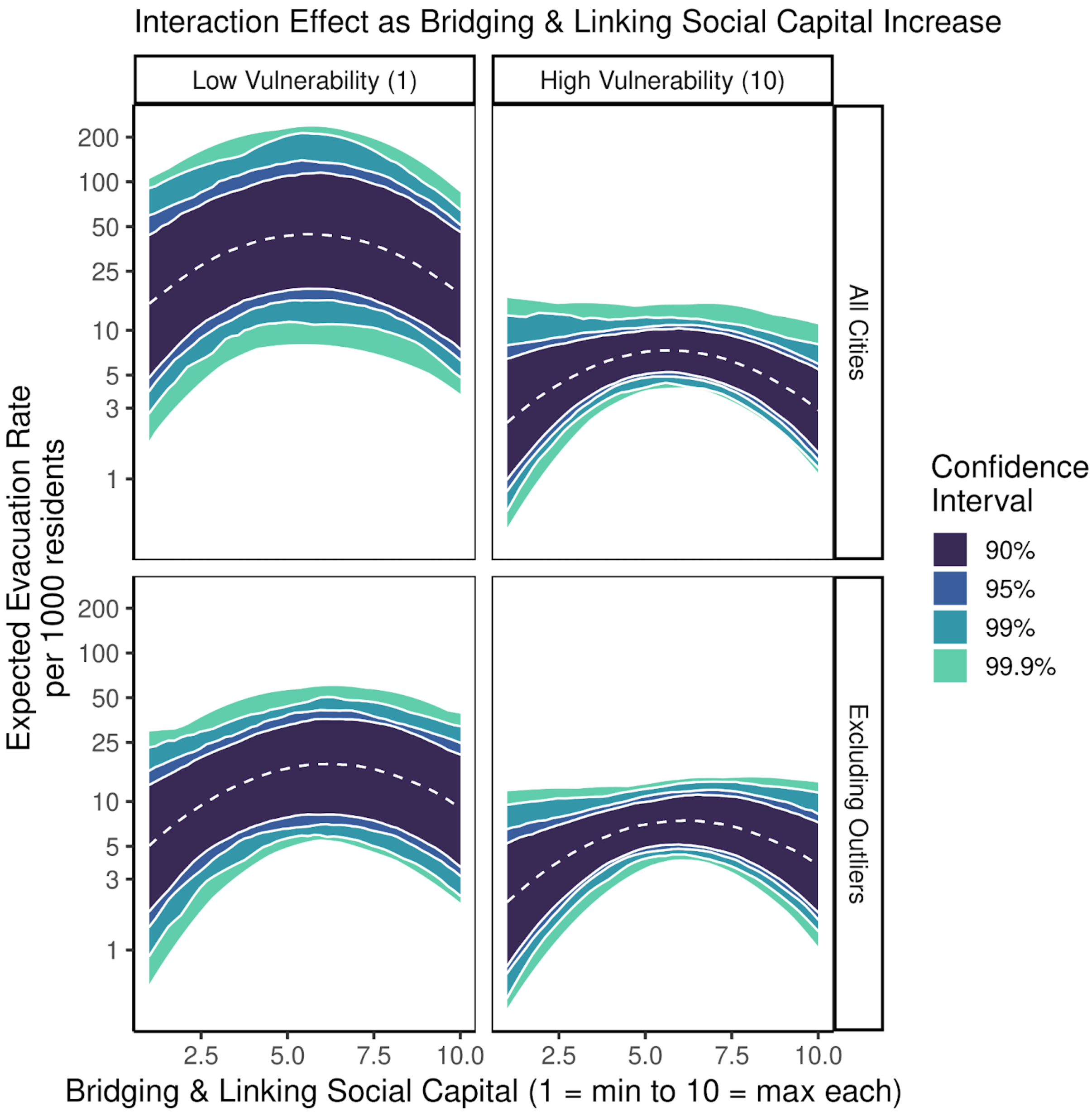
*Repeating Figure 5 while including Outliers (Model 2B) and Excluding Outliers (Model 4B)*




As seen above, the general curvilinear trend of our interaction effect in Figure 5 remains the same both when including outliers (left panel, same as Figure 5 in main text) and when removing outliers (right panel, based on Model 4B). The trend deflates somewhat, which makes sense, because we have removed outlier observations, but it shows the same pattern as before.

**Figure A1.2-4: Simulated Interaction Effects on Evacuation,**

*Repeating Figure 6 while including Outliers (Model 2B) and Excluding Outliers (Model 4B)*

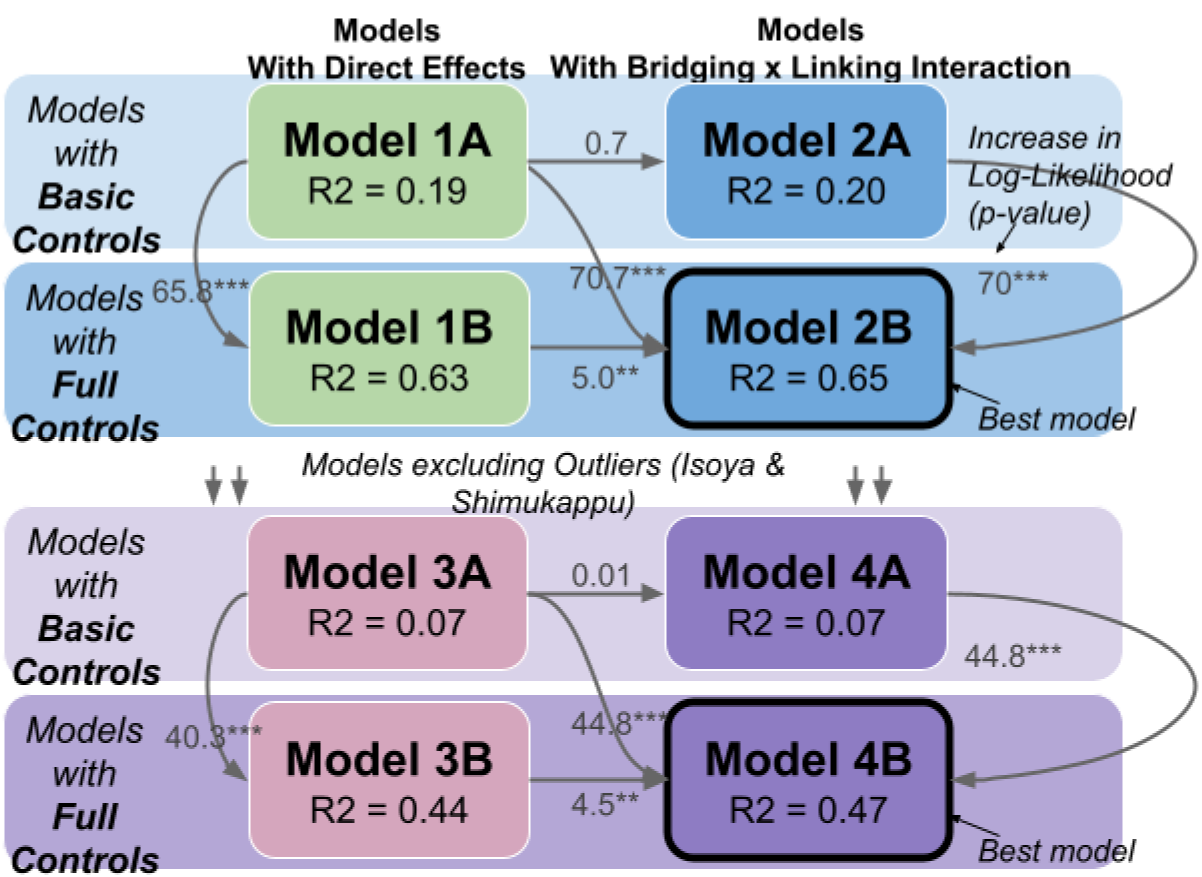



Finally, we replicated our findings from **Figure 6** from the main text above in **Figure A1.2-4.** This shows in the top two panels the interaction effect between bridging and linking social capital for our models of all cities (Model 2B), split by level of social vulnerability, as shown in the main text. Then, in the bottom two panels, we compare this against same visuals, but produced from Model 4B, our fully specified models of cities excluding outliers Isoya-gun and Shimukappu-mura. This shows similarly that the curvilinear trend persists in both. Similar to in the overall sample of cities, we project lower overall evacuation curves for highly vulnerable cities (right lower panel), and greater overall evacuation curves for less vulnerable cities (left lower panel). This shows that excluding outliers does not affect the veracity of our results.

## Likelihood Ratio Tests

We used a series of likelihood ratio tests in the *lmtest* package in R to analyze which of our models from **Table A1.2** fit best. Likelihood ratio tests are a common technique for comparing ordinary least squares regression models. Likelihood ratio tests allow us to analyze whether a model with an extra term (eg. additional controls or an interaction effect) sees an improvement in log-likelihood, compared to a model without that extra term. The value added of likelihood ratio tests is that it produces a chi-squared statistic and p-value we can use to identify whether the improvement in log-likelihood from our second model was statistically significant enough to know that increase was definitely not due to chance. Likelihood ratio tests are a more robust test than comparing R2 statistics alone, because it takes into consideration the number of covariates and quantifies how statistically significant that improvement in model fit is - how confident we are that this improvement was not just due to chance.

**Figure A1.3: Visual Summary of Likelihood Ratio Tests**




*Note: Lines depict likelihood ratio tests between two models, where the direction of the arrow depicts the model that fit better according to the likelihood ratio test. Each arrow is accompanied by the difference in log-likelihood, with the statistical significance of that statistic marked by asterisks. Statistical significance is represented where *** = p < 0.001, ** = p < 0.01, and * = p < 0.05.*

In **Figure A1.3** (above)**,** we visualize likelihood ratio tests pertaining to our 8 models. The first 4 models (in **blue**) are our main models 1A to 2B from **Table A1.2**; the second 4 models (in **purple**) represent our models with outliers removed, from **Table A1.2 Models 3A** to **4B**. Each model displays its name and R2 statistic (percentage of variation in log-evacuation explained). In each case, we performed 5 likelihood ratio tests (represented by the 5 arrows between our 4 squares above in **Figure A1.3**).

As described below, we used these tests to measure the value added of 1) control variables and 2) interaction effects, and 3) confirm that excluding outliers did not impact these tests. Please see the visual above, followed by a description of this visual below.

***1. Value of Controls?***

To test the value of adding controls, we compared our basic model Model 1A to our fully specified model Model 1B; the arrow connecting them indicates that Model 1B fit better, seeing an improvement in log-likelihood of 65.8 ($p < 0.001$) compared to Model 1A. Similarly, Model 2B fit better than 2A, seeing an improvement in log-likelihood of 70.0 ($p < 0.001$).

***2. Value of Interaction Effect?***

Then, to compare the value added from our interaction effect *and* fully specified controls, we compared Model 2B to previous models. It turns out Model 2B fitted better than models 1A (+70.7, $p < 0.001$), 1B (+5.0, $p < 0.01$), or 2A (+70, $p < 0.001$). This Figure indicates that the model which fit best was **Model 2B,** as it was preferred to all other models when compared systematically. It also had the highest R2 statistic, at 0.65.

***3. Not due to Outliers?***

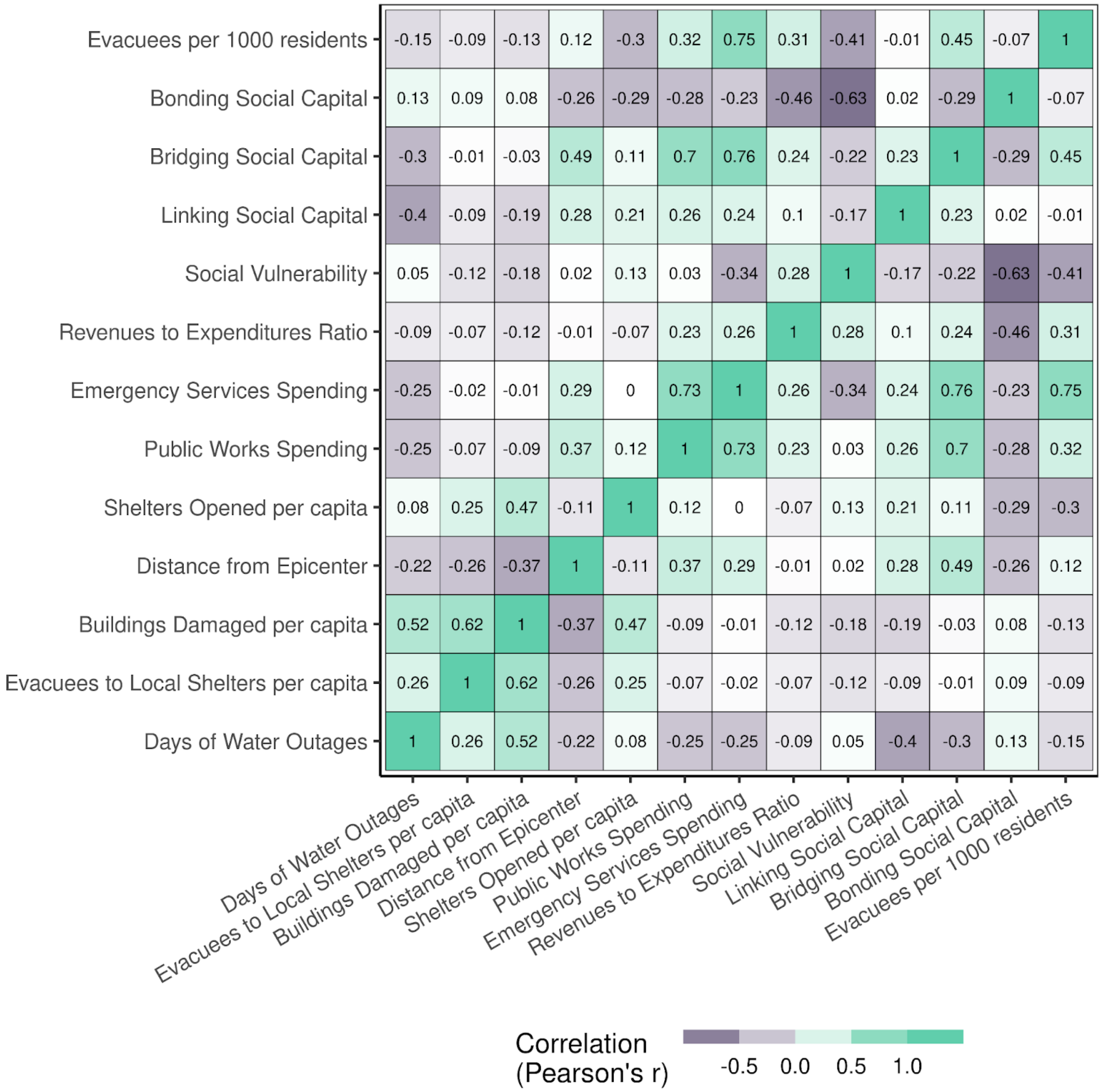
In the bottom of Figure A1.6, we repeated this same process for models 3A, 3B, 4A, and 4B, namely our models with outliers removed. We found the same consistent improvements in log-likelihood, with similar levels of statistical significance. Model 4B, our fully specified interaction model, saw significant improvements in model fit compared to all other models. This shows that our results are consistent even after excluding outliers. This Figure indicates that the model (excluding outliers) which fit best was **Model 4B,** as it was preferred to all other models when compared systematically. It also had the highest R2 statistic, at 0.47.

**4. Choosing the right Interaction Effect**

Finally, we selected the interaction effect between bridging and linking social capital from Models 2B and 4B, because it consistently improved the log-likelihood of the models. Separate from **Figure A1.3**, we also compared other specifications instead, including an interaction effect between linking social capital and vulnerability, or an interaction between linking social capital, bridging social capital, and vulnerability, but neither of these interactions produced statistically significant improvements in the log-likelihood for both the original model and the models with outliers removed. This means neither of these interactions consistently improved the explanatory power of the model to a significant degree. (See our replication code for demonstrations of these alternative specifications and their lack of explanatory power.)

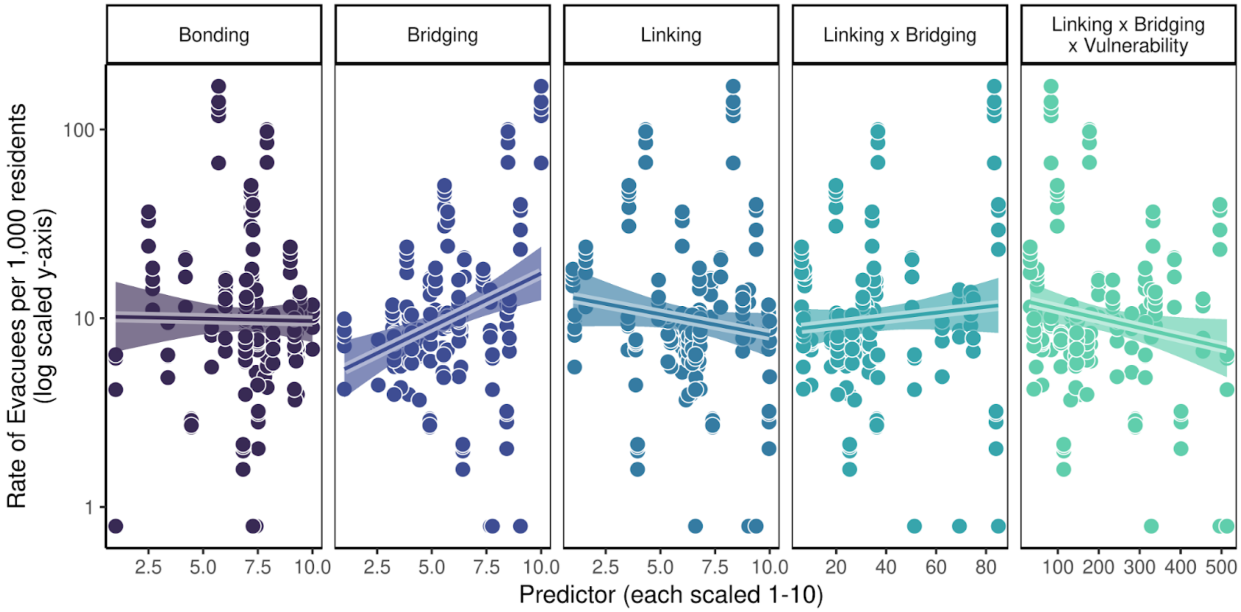
As a result, we present results in this manuscript for just the direct effect of linking social capital (Models 1A-B) and the interaction effect between bridging and linking social capital (Models 2A-B) in this paper.

**Figure A1.4: Correlation Matrix**




*Caption: Cell labels and shading reflect the strength of association between each pair of variables based on the Pearson's r correlation coefficient, where -1 indicates strong negative association, 0 indicates no association, and 1 indicates strong positive association.*

**Figure A1.5: Bivariate Scatterplots of Evacuation, Social Capital, and Key Interactions**




Caption: Points depict raw data, jittered for effect, with simple bivariate OLS regression lines of best fit to approximate the association between each predictor and the outcome.

Bonding social capital displays no particular association, as expected, while bridging ties are positively associated with evacuation. In keeping with our models, linking ties are *negatively* associated with evacuation, as expected. The furthest right panels multiple two or more predictors together, to approximate the interactions studied in our models.

Cities with stronger linking *and* bridging ties descriptively see more evacuees. This matches the left and right panels in **Figure 5**, and may be strongly influenced by the strong bivariate effect of bridging ties described above in **Figure A1.5**. However, the bivariate trend for the interaction between linking and bridging ties with evacuation rates contrasts somewhat with the center panel of Figure 5. According to that panel, after adjusting for covariates, our interaction model (**Table A1.2**, column 4) projected *fewer* evacuees given more bridging *and* linking ties (with an interesting curvilinear trend in **Figure 5**). In contrast, the furthest right panel in **Figure A1.5** descriptively reflects the trends of our model better. showing that vulnerable cities with stronger linking and bridging social capital tended to see fewer evacuees. We found in **Figure 6** and our interaction model the same trend (albeit with an interesting curvilinear shape). It is compelling that this general negative trend appears descriptively in **Figure A1.5.**