Multiplex Network Ties and the Spatial Diffusion of Radical Innovations: Martin Luther’s Leadership in the Early Reformation

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Inclusion of network parameters into regression analysis

In this supplement, we augment our regression analysis by adding measures that characterize a city’s position in the trade network of the HRE. We calculate degree, closeness, betweenness, and eigenvector centrality scores for each city in the trade route network subsample. In Table 4 in the main text, we include these measures in regression analyses predicting adoption of the Reformation (see Table S1 for summary statistics of the network measures).\(^1\)

Table S2 reports the cities with the top centrality scores. Note that many of the most central cities in our sample were on the North Sea or at the mouth of the Rhine, where urban density, trade route intersections, and access to river and seas apparently exerted strong influence on the structure of the network.\(^2\)

| Variable          | Mean | Standard Deviation |
|-------------------|------|--------------------|
| Degree            | 3.30 | 2.06               |
| Closeness (x1000) | .21  | .03                |
| Betweenness (/1000)| .98  | 1.87               |
| Eigenvector       | .05  | .13                |

\(^1\) In network theory, there are various ways of conceptualizing the most important actors in a network. Centrality scores are a common way to estimate the social influence of a node based on its position within the network. A central actor can be thought of as one with many ties to others (degree centrality), closest in path distance to others (closeness), who lies on the shortest path between any two nodes (betweenness), and who has ties to other central actors (eigenvector). For elaboration of these concepts, see Borgatti (2005), Freeman (1979), and Wasserman and Faust (1994: Ch. 5). For application to the study of religious groups, see Everton (2018).

\(^2\) Some places in Table S2 were more important historically than they are today. For instance, Monnikendam is a small fishing town today, but it was an important port in earlier centuries.
Table S2. Top Ten Centralities in the HRE for Each Network Measure

| Degree   | Closeness    | Betweenness | Eigenvector |
|----------|--------------|-------------|-------------|
| Antwerp  | Hamburg      | Hamburg     | Amsterdam   |
| Amsterdam| Lubeck       | Lubeck      | Kampen      |
| Ghent    | Luneburg     | Nuremberg   | Hoorn       |
| Hamburg  | Bruges       | Stettin     | Monnikendam |
| Lubeck   | London       | Frankfurt (am Main) | Edam |
| Bruges   | Antwerp      | Wurzburg    | Naarden     |
| Kampen   | Frankfurt (am Main) | Bruges | Bruges |
| Olmutz   | Stralsund    | Cologne     | Hamburg     |
| Nuremberg| Amsterdam    | Antwerp     | Enkhuizen   |
| Stettin  | Stettin      | Frankfurt (an der Oder) | Antwerp |

HRE road network measures help address an important omitted variable in the previous analysis: the cost of travel. There is reason to believe this cost could have affected both Luther’s network and, independently, the spread of the Reformation. The cost of travel is an omitted variable whose absence likely upwardly biased the coefficients on our previous regressions. Yet, the results reported in Table 4 in the main text reveal that the inclusion of various network parameters does not much affect the results reported in Table 2 of the main text, although it tends to decrease slightly the magnitude of the coefficients.

References

Borgatti, Stephen P. 2005. “Centrality and Network Flow.” Social Networks 27(1):55–71.

Everton, Sean F. 2018. Networks and Religion: Ties that Bind, Loose, Build-Up, and Tear Down. New York: Cambridge University Press.

Freeman, Linton C. 1979. “Centrality in Social Networks: Conceptual Clarification.” Social Networks 1(3):215–39.

Wasserman, Stanley, and Katherine Faust. 1994. Social Network Analysis: Methods and Applications. New York: Cambridge University Press.
### Alternative Specifications

**Table S3. Determinants of Reformation Adoption by 1530, de facto HRE**

|                        | (1)  | (2)  | (3)  | (4)  | (5)  | (6)  | (7)  | (8)  | (9)  |
|------------------------|------|------|------|------|------|------|------|------|------|
| Dependent Variable: Protestant by 1530 |      |      |      |      |      |      |      |      |      |
| Luther letter dummy    |  .167* |      |      |      |      |      |      |      |      |
|                        | (.078) |      |      |      |      |      |      |      |      |
| Number of Luther letters | .032** |      |      |      |      |      |      |      |      |
|                        | (.010) |      |      |      |      |      |      |      |      |
| Luther visit by 1522 dummy | .230** |      |      |      |      |      |      |      |      |
|                        | (.077) |      |      |      |      |      |      |      |      |
| Number of Luther visits | .114** |      |      |      |      |      |      |      |      |
|                        | (.035) |      |      |      |      |      |      |      |      |
| Luther students dummy  | .115*  |      |      |      |      |      |      |      |      |
|                        | (.058) |      |      |      |      |      |      |      |      |
| Number of Luther students | .009** |      |      |      |      |      |      |      |      |
|                        | (.003) |      |      |      |      |      |      |      |      |
| Any connection to Luther dummy | .140*  |      |      |      |      |      |      |      |      |
|                        | (.069) |      |      |      |      |      |      |      |      |
| First principal component of Luther variables (dichotomous) | .072** |      |      |      |      |      |      |      |      |
|                        | (.018) |      |      |      |      |      |      |      |      |
| First principal component of Luther variables (count) | .067** |      |      |      |      |      |      |      |      |
|                        | (.019) |      |      |      |      |      |      |      |      |
| City-level controls    | YES  | YES  | YES  | YES  | YES  | YES  | YES  | YES  | YES  |
| Observations           | 225  | 225  | 225  | 225  | 225  | 225  | 225  | 225  | 225  |
| No. of clusters        | 112  | 112  | 112  | 112  | 112  | 112  | 112  | 112  | 112  |
| Pseudo R-squared       | .300 | .305 | .332 | .330 | .294 | .289 | .299 | .345 | .332 |

**Note:** Robust standard errors clustered by territory are in parentheses. Average marginal effects of probit coefficients reported for all regressions. City-level controls include dummies for the printing press, whether a city printed a work by Luther (in columns 1, 3, 5, 7, and 8), the number of printed works by Luther (in columns 2, 4, 6, and 9), independent city, university, bishop, lay magnate, on water, Hanseatic league, log of population in 1500, market potential in 1500, log distance to Wittenberg, log distance to Zürich, latitude, longitude, and the interaction of the city’s coordinates. All regressions include a constant term (not reported). Distance to Wittenberg and Zürich are in km. Wittenberg and Erfurt, Luther’s two places of residence, are not included.

* *p < .05; **p < .01 (two-tailed tests).
Table S4. Determinants of Reformation Adoption by 1530, Alternative Letter and Student Variables

|                      | (1)   | (2)   | (3)   | (4)   | (5)   | (6)   | (7)   | (8)   |
|----------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Dependent Variable: Protestant by 1530 |       |       |       |       |       |       |       |       |
| Any letter dummy    | .122  |       |       |       |       |       |       |       |
|(incoming or outgoing)|       | (.067)|       |       |       |       |       |       |
| Total letters       |       | .019**|       |       |       |       |       |       |
|(incoming + outgoing)|       | (.007)|       |       |       |       |       |       |
| Incoming letter dummy |       | .054  |       |       |       |       |       |       |
|                      |       | (.059)|       |       |       |       |       |       |
| Number of incoming letters | .032* |       |       |       |       |       |       |       |
|                      |       | (.014)|       |       |       |       |       |       |
| Luther students dummy |       | .057  |       |       |       |       |       |       |
|(1512–1516)          |       | (.048)|       |       |       |       |       |       |
| Number of Luther students | .006  |       |       |       |       |       |       |       |
|(1512–1516)          |       | (.004)|       |       |       |       |       |       |
| Luther students dummy |       | .048  |       |       |       |       |       |       |
|(1512–1522)          |       | (.045)|       |       |       |       |       |       |
| Number of Luther students | .004* |       |       |       |       |       |       |       |
|(1512–1522)          |       | (.002)|       |       |       |       |       |       |
| City-level controls  | YES   | YES   | YES   | YES   | YES   | YES   | YES   | YES   |
| Observations         | 300   | 300   | 300   | 300   | 300   | 300   | 300   | 300   |
| No. of clusters      | 138   | 138   | 138   | 138   | 138   | 138   | 138   | 138   |
| Pseudo $R$-squared   | .363  | .366  | .346  | .350  | .349  | .344  | .347  | .352  |

Note: Robust standard errors clustered by territory are in parentheses. Average marginal effects of probit coefficients reported for all regressions. City-level controls include dummies for the printing press, whether a city printed a work by Luther (in columns 1, 3, 5, and 7), the number of printed works by Luther (in columns 2, 4, 6, and 8), independent city, university, bishop, lay magnate, on water, Hanseatic league, log of population in 1500, market potential in 1500, log distance to Wittenberg, log distance to Zürich, latitude, longitude, and the interaction of the city’s coordinates. All regressions include a constant term (not reported). Distance to Wittenberg and Zürich are in km. Wittenberg and Erfurt, Luther’s two places of residence, are not included.

*p < .05; **p < .01 (two-tailed tests).
Table S5. Determinants of Reformation Adoption by 1530, Alternative Variables

|                        | (1)   | (2)   | (3)   | (4)   | (5)   |
|------------------------|-------|-------|-------|-------|-------|
| **Dependent Variable:**| Protestant by 1530 |       |       |       |       |
| Number of distinct letter recipients | .074** |       |       |       |       |
|                        | (.025) |       |       |       |       |
| Luther letters in Latin dummy | .195** | (.041) |       |       |       |
| Luther letters in German dummy | - .051 | (.085) |       |       |       |
| Number of Luther letters in Latin | .033** | (.007) |       |       |       |
| Number of Luther letters in German | .019 | (.033) |       |       |       |
| First principal component of Luther variables (dichotomous) | .059** | (.014) |       |       |       |
| Second principal component of Luther variables (dichotomous) | -.004 | (.022) |       |       |       |
| First principal component of Luther variables (count) | .050** | (.013) |       |       |       |
| Second principal component of Luther variables (count) | .019 | (.021) |       |       |       |
| City-level controls | YES   | YES   | YES   | YES   | YES   |
| Observations | 300   | 300   | 300   | 300   | 300   |
| No. of clusters | 138   | 138   | 138   | 138   | 138   |
| Pseudo R-squared | .368  | .377  | .368  | .401  | .392  |

**Note:** Robust standard errors clustered by territory are in parentheses. Average marginal effects of probit coefficients reported for all regressions. City-level controls include dummies for the printing press, whether a city printed a work by Luther (in columns 2 and 4), the number of printed works by Luther (in columns 1, 3, and 5), independent city, university, bishop, lay magnate, on water, Hanseatic league, log of population in 1500, market potential in 1500, log distance to Wittenberg, log distance to Zürich, latitude, longitude, and the interaction of the city’s coordinates. All regressions include a constant term (not reported). Distance to Wittenberg and Zürich are in km. Wittenberg and Erfurt, Luther’s two places of residence, are not included. *p < .05; **p < .01 (two-tailed tests).
### Table S6. Determinants of Reformation Adoption by 1530, Linear Probability Model

|                          | (1)     | (2)     | (3)     | (4)     | (5)     | (6)     | (7)     | (8)     | (9)     |
|--------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Dependent Variable: Protestant by 1530 |          |         |         |         |         |         |         |         |         |
| Luther letter dummy      | .216    | (1.17)  |         |         |         |         |         |         |         |
| Number of Luther letters | .034**  | (.010)  |         |         |         |         |         |         |         |
| Luther visit by 1522 dummy | .287*   | (1.37)  |         |         |         |         |         |         |         |
| Number of Luther visits  | .152**  | (.051)  |         |         |         |         |         |         |         |
| Luther students dummy    | .129*   | (0.59)  |         |         |         |         |         |         |         |
| Number of Luther students| .013**  | (0.05)  |         |         |         |         |         |         |         |
| Any connection to Luther dummy | .159*   | (0.64)  |         |         |         |         |         |         |         |
| First principal component of Luther variables (dichotomous) | .090**  | (0.029) |         |         |         |         |         |         |         |
| First principal component of Luther variables (count) | .068**  | (0.021) |         |         |         |         |         |         |         |
| City-level controls      | YES     | YES     | YES     | YES     | YES     | YES     | YES     | YES     | YES     |
| Observations             | 300     | 300     | 300     | 300     | 300     | 300     | 300     | 300     | 300     |
| No. of clusters          | 138     | 138     | 138     | 138     | 138     | 138     | 138     | 138     | 138     |
| R-squared                | 269     | 272     | 289     | 294     | 265     | 267     | 272     | 304     | 293     |

**Note:** Robust standard errors clustered by territory are in parentheses. Regression coefficients reported for all regressions. City-level controls include dummies for the printing press, whether a city printed a work by Luther (in columns 1, 3, 5, 7, and 8), the number of printed works by Luther (in columns 2, 4, 6, and 9), independent city, university, bishop, lay magnate, on water, Hanseatic league, log of population in 1500, market potential in 1500, log distance to Wittenberg, log distance to Zürich, latitude, longitude, and the interaction of the city’s coordinates. All regressions include a constant term (not reported). Distance to Wittenberg and Zürich are in km. Wittenberg and Erfurt, Luther’s two places of residence, are not included.

*p < .05; **p < .01 (two-tailed tests).*
### Table S7. Determinants of Reformation Adoption by 1530, Using Only Observations with Network Data

|                                | (1)        | (2)        | (3)        | (4)        | (5)        | (6)        | (7)        | (8)        | (9)        |
|--------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| **Dependent Variable:**        | Protestant by 1530 | Protestant by 1530 | Protestant by 1530 | Protestant by 1530 | Protestant by 1530 | Protestant by 1530 | Protestant by 1530 | Protestant by 1530 | Protestant by 1530 |
| Luther letter dummy            | .115 (.070) | .115 (.070) | .115 (.070) | .115 (.070) | .115 (.070) | .115 (.070) | .115 (.070) | .115 (.070) | .115 (.070) |
| Number of Luther letters       | .026** (.009) | .026** (.009) | .026** (.009) | .026** (.009) | .026** (.009) | .026** (.009) | .026** (.009) | .026** (.009) | .026** (.009) |
| Luther visit by 1522 dummy     | .163* (.072) | .163* (.072) | .163* (.072) | .163* (.072) | .163* (.072) | .163* (.072) | .163* (.072) | .163* (.072) | .163* (.072) |
| Number of Luther visits        | .080** (.030) | .080** (.030) | .080** (.030) | .080** (.030) | .080** (.030) | .080** (.030) | .080** (.030) | .080** (.030) | .080** (.030) |
| Luther students dummy          | .135** (.052) | .135** (.052) | .135** (.052) | .135** (.052) | .135** (.052) | .135** (.052) | .135** (.052) | .135** (.052) | .135** (.052) |
| Number of Luther students      | .010* (.004) | .010* (.004) | .010* (.004) | .010* (.004) | .010* (.004) | .010* (.004) | .010* (.004) | .010* (.004) | .010* (.004) |
| Any connection to Luther dummy | .144** (.053) | .144** (.053) | .144** (.053) | .144** (.053) | .144** (.053) | .144** (.053) | .144** (.053) | .144** (.053) | .144** (.053) |
| First principal component of Luther variables (dichotomous) | .058** (.017) | .058** (.017) | .058** (.017) | .058** (.017) | .058** (.017) | .058** (.017) | .058** (.017) | .058** (.017) | .058** (.017) |
| First principal component of Luther variables (count) | .052** (.017) | .052** (.017) | .052** (.017) | .052** (.017) | .052** (.017) | .052** (.017) | .052** (.017) | .052** (.017) | .052** (.017) |
| City-level controls            | YES        | YES        | YES        | YES        | YES        | YES        | YES        | YES        | YES        |
| Observations                   | 263        | 263        | 263        | 263        | 263        | 263        | 263        | 263        | 263        |
| No. of clusters                | 129        | 129        | 129        | 129        | 129        | 129        | 129        | 129        | 129        |
| Pseudo R-squared               | 376.87     | 392.39     | 394.39     | 393.38     | 393.39     | 413.41     | 406.40     | 406.40     | 406.40     |

*Note:* Robust standard errors clustered by territory are in parentheses. Average marginal effects of probit coefficients reported for all regressions. City-level controls include dummies for the printing press, whether a city printed a work by Luther (in columns 1, 3, 5, 7, and 8), the number of printed works by Luther (in columns 2, 4, 6, and 9), independent city, university, bishop, lay magnate, on water, Hanseatic league, log of population in 1500, market potential in 1500, log distance to Wittenberg, log distance to Zürich, latitude, longitude, and the interaction of the city’s coordinates. All regressions include a constant term (not reported). Distance to Wittenberg and Zürich are in km. Wittenberg and Erfurt, Luther’s two places of residence, are not included. *p < .05; **p < .01 (two-tailed tests).
**Table S8.** Determinants of Reformation Adoption by 1530, with Imperial Circle Fixed Effects

|                          | (1)          | (2)          | (3)          | (4)          | (5)          | (6)          | (7)          | (8)          | (9)          |
|--------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| **Dependent Variable:**  | Protestant by 1530 | Protestant by 1530 | Protestant by 1530 | Protestant by 1530 | Protestant by 1530 | Protestant by 1530 | Protestant by 1530 | Protestant by 1530 | Protestant by 1530 |
| Luther letter dummy      | .201*        | .041**       | .326**       | .147**       | .125+        | .008         | .172*        | .091**       | .077**       |
|                          | (.094)       | (.013)       | (.097)       | (.038)       | (.066)       | (.004)       | (.076)       | (.022)       | (.021)       |
| Number of Luther letters | .041**       | .326**       | .147**       | .125+        | .008         | .172*        | .091**       | .077**       |              |
|                          | (.013)       | (.013)       | (.038)       | (.066)       | (.004)       | (.076)       | (.022)       | (.021)       |              |
| Luther visit by 1522 dummy | .326**     |              |              |              |              |              |              |              |              |
|                          | (.097)       |              |              |              |              |              |              |              |              |
| Number of Luther visits  | .147**       |              |              |              |              |              |              |              |              |
|                          | (.038)       |              |              |              |              |              |              |              |              |
| Luther students dummy    | .125+        |              |              |              |              |              |              |              |              |
|                          | (.066)       |              |              |              |              |              |              |              |              |
| Number of Luther students | .008        |              |              |              |              |              |              |              |              |
|                          | (.004)       |              |              |              |              |              |              |              |              |
| Any connection to Luther dummy | .172*     |              |              |              |              |              |              |              |              |
|                          | (.076)       |              |              |              |              |              |              |              |              |
| First principal component of Luther variables (dichotomous) | .091** |              |              |              |              |              |              |              |              |
|                          | (.022)       |              |              |              |              |              |              |              |              |
| First principal component of Luther variables (count) | .077** |              |              |              |              |              |              |              |              |
|                          | (.021)       |              |              |              |              |              |              |              |              |
| City-level controls      | YES          | YES          | YES          | YES          | YES          | YES          | YES          | YES          | YES          |
| Imperial Circle fixed effects | YES      | YES          | YES          | YES          | YES          | YES          | YES          | YES          | YES          |
| Observations             | 193          | 193          | 193          | 193          | 193          | 193          | 193          | 193          | 193          |
| No. of clusters          | 103          | 103          | 103          | 103          | 103          | 103          | 103          | 103          | 103          |
| Pseudo R-squared         | .285         | .293         | .328         | .321         | .276         | .266         | .286         | .333         | .313         |

**Note:** Robust standard errors clustered by territory are in parentheses. Average marginal effects of probit coefficients reported for all regressions. City-level controls include dummies for the printing press, whether a city printed a work by Luther (in columns 1, 3, 5, 7, and 8), the number of printed works by Luther (in columns 2, 4, 6, and 9), independent city, university, bishop, lay magnate, on water, Hanseatic league, log of population in 1500, market potential in 1500, log distance to Wittenberg, log distance to Zürich, latitude, longitude, and the interaction of the city’s coordinates. All regressions include a constant term (not reported). Distance to Wittenberg and Zürich are in km. Wittenberg and Erfurt, Luther’s two places of residence, not included. Imperial Circle fixed effects include Austria, Bavaria, Bohemia, Burgundy, Electorate, Franconia, the Italian States, Lower Saxon, Swabia, Upper Rhenish, and Westphalia.

*p < .05; **p < .01 (two-tailed tests).
Robustness checks on simulations using consistent cities between regressions and simulations

As noted in the main text, the simulations consisted of a larger population of cities than the regression analyses, as we wanted to capture the potential flows between all cities and thus accurately map the trade relationships. Still, one may be interested in a simulation analysis that only considers the cities in the regressions. Note that this approach of “listwise deletion” may create problems in network analyses. For example, if the network is A—B—C and B is not in the data in the regression, then removing B would falsely assume that A and C are not connected. However, we also ran the simulations using the reduced sample of 264 cities that removed 36 cities that are not in the HRE de jure and 27 cities for which we do not have population data. This yields a target of 55 cities that adopted the Reformation.

Overall, the results are largely similar to the main analysis. The results for Scenario 1 indicate that only six cities adopt the Reformation (due to deleting one city).

The results for Scenario 2 are presented in Table S9. Compared to the main analyses, the number of adopted cities for each parameter decreases slightly, but nonetheless an unreasonably high infectious probability is needed to reach the target number.

| \( P_{infect} \) | Number of Adopted Cities |
|-----------------|--------------------------|
| .1              | 14.80                    |
| .2              | 25.00                    |
| .3              | 38.60                    |
| .4              | 47.00                    |
| .5              | 58.60                    |
| .6              | 66.46                    |
| .7              | 76.63                    |

The results for Scenario 3 are presented in Table S10. Compared to the main analyses, the number of adopted cities for each parameter decreases slightly. Yet, because we are searching for a lower number of target cities, the infectious probability required to attain the target number is about the same as in the main text (.30 versus .32).

| \( P_{infect} \) | Number of Adopted Cities |
|-----------------|--------------------------|
| .1              | 20.78                    |
| .2              | 39.68                    |
| .3              | 55.07                    |
| .4              | 68.67                    |
| .5              | 80.30                    |

Overall, the robustness checks indicate that even in an alternative specification of the data, the implications for the main analysis are similar.
**Pseudo-code for Simulations**

**For Scenario 1**

1. Set adoption status of all cities as not adopted
2. Set adoption status of Wittenberg as adopted
3. For each of Wittenberg’s trade neighbors:
   - Set adoption status as adopted
4. For each of the trade neighbors of the adopted cities:
   - Set adoption status as adopted (this achieves the “Wittenberg seven as the initial adopters”)
5. Set threshold parameter
6. For each iteration $i$:
   - While adoption status of all cities $\neq$ adoption status of all cities in iteration $i-1$:
     - For each focal city $c$:
       - Set $x =$ number of trade neighbors that adopted in iteration $i-1$
       - If $x \geq$ threshold:
         - Set adoption status of city $c$ as adopted
       - Else:
         - Set adoption status of city $c$ as not adopted
7. Calculate number of adopted cities
8. Rerun steps 1-6 for 500 replications and calculate the average number of adopted cities

**For Scenario 2**

1. Set adoption status of all cities as not adopted
2. Set adoption status of Wittenberg as adopted
3. For each of Wittenberg’s trade neighbors:
   - Set adoption status as adopted
4. For each of the trade neighbors of the adopted cities:
   - Set adoption status as adopted (this achieves the “Wittenberg seven as the initial adopters”)
5. Set P_infect parameter

6. For each focal city $c$:
   
   if city $c$ is connected to Luther:
   
   if random number between $[0, 1] \leq P_{infect}$:
   
   set adoption status of city $c$ as adopted
   
   else:
   
   set adoption status of city $c$ as not adopted

7. Calculate number of adopted cities

8. Rerun steps 1-6 for 500 replications and calculate the average number of adopted cities

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For Scenario 3

1. Set adoption status of all cities as not adopted

2. Set adoption status of Wittenberg as adopted

3. For each of Wittenberg’s trade neighbors:
   
   Set adoption status as adopted

4. For each of the trade neighbors of the adopted cities:
   
   Set adoption status as adopted (this achieves the “Wittenberg seven as the initial adopters”)

5. Set threshold parameter and P_infect parameter

6. For each focal city $c$:
   
   if city $c$ is connected to Luther:
   
   if random number between $[0, 1] \leq P_{infect}$:
   
   set adoption status of city $c$ as adopted
   
   else:
   
   set adoption status of city $c$ as not adopted

7. For each iteration $i$:
   
   while adoption status of all cities $\neq$ adoption status of all cities in iteration $i-1$:

   for each focal city $c$:

   set $x =$ number of trade neighbors that adopted in iteration $i-1$
if x >= threshold:
    set adoption status of city c as adopted
else:
    set adoption status of city c as not adopted

8. Calculate number of adopted cities

9. Rerun steps 1-7 for 500 replications and calculate the average number of adopted cities