Appendix 3: Micro-level interpretation of coefficient

Tables A3.1 and A3.2 show the coefficients and standard errors for every term in 5 different Philadelphia models and A3.3 and A3.4 for New York. Model 5 is the one presented in the full paper, and the terms are presented in the same order as the terms in the figures in the main text. We ran multiple additive models to look at whether these terms improved model fit and also to ensure that we were not over-fitting the data. We use these terms to look at the probability of two organizations collaborating in each city.

	Term Name	Model 1	Model 2	Model 3	Model 4	Model 5
Network Terms	Ties	−5.22 (0.08)***	−3.53 (0.19)***	−3.99 (0.42)***	−4.50 (0.43)***	−4.43 (0.47)***
	Mutual	3.50 (0.25)***	3.18 (0.27)***	3.14 (0.27)***	3.09 (0.28)***	3.19 (0.30)***
	Anti-InDegree Cent.	1.13 (0.16)***	1.54 (0.17)***	1.57 (0.17)***	2.36 (0.20)***	2.60 (0.21)***
	Anti-OutDegree Cent.	−1.86 (0.32)***	−0.98 (0.36)**	−0.30 (0.40)	−0.13 (0.40)	−0.04 (0.40)
Spatial Terms	Receiver: Medium Turf Size		−1.21 (0.26)***	−1.29 (0.27)***	−1.79 (0.31)***	−1.83 (0.32)***
	Receiver: Large Turf Size		1.11 (0.17)***	1.05 (0.17)***	0.28 (0.23)	0.23 (0.24)
	Sender: Medium Turf Size		0.03 (0.09)	0.14 (0.10)	0.10 (0.11)	0.10 (0.11)
	Sender: Large Turf Size		0.58 (0.09)***	0.55 (0.10)***	0.54 (0.10)***	0.50 (0.10)***
	Homophily: Medium Turf Size		0.64 (0.35)	0.59 (0.36)	0.57 (0.37)	0.56 (0.36)
	Homophily: Large Turf Size		−0.64 (0.21)**	−0.67 (0.22)**	−0.62 (0.23)**	−0.60 (0.23)**
	Turf Overlap		0.14 (0.45)	0.01 (0.46)	−0.04 (0.45)	−0.13 (0.47)
	Dist. Bet. Home Offices		−0.34 (0.03)***	−0.33 (0.03)***	−0.31 (0.03)***	−0.35 (0.03)***
Organizational Characteristic Terms	Receiver: 501(c)(3)			−0.43 (0.23)	−0.52 (0.24)*	−0.63 (0.25)**
	Sender: 501(c)(3)			−0.41 (0.17)*	−0.47 (0.17)**	−0.41 (0.18)*
	Homophily: Not 501(c)(3)			−0.59 (0.20)**	−0.67 (0.21)**	−0.69 (0.21)***
	Homophily: 501(c)(3)			0.71 (0.22)**	0.82 (0.22)***	0.84 (0.23)***
	Receiver: Paid Staff			−0.27 (0.20)	−0.11 (0.21)	−0.09 (0.21)
	Sender: Paid Staff			0.51 (0.17)**	0.52 (0.17)**	0.55 (0.17)**
	Homophily: No Paid Staff			0.29 (0.19)	0.21 (0.19)	0.18 (0.19)
	Homophily: Paid Staff			0.35 (0.20)	0.37 (0.20)	0.41 (0.20)*
	Receiver: Volunteers			−0.00 (0.40)	−0.14 (0.41)	−0.21 (0.41)
	Sender: Volunteers			0.40 (0.34)	0.39 (0.34)	0.35 (0.34)
	Homophily: No Volunteers			0.13 (0.67)	0.12 (0.68)	0.12 (0.69)
	Homophily: Volunteers			0.06 (0.40)	0.01 (0.40)	0.01 (0.40)
Organizational Focus Terms	Receiver: Arts				−1.58 (0.24)***	−1.58 (0.25)***
	Homophily: Arts				1.22 (0.27)***	1.23 (0.27)***
	Receiver: Community Imp.				0.32 (0.15)*	0.25 (0.16)
	Homophily: Community Imp.				0.32 (0.13)*	0.38 (0.13)**
	Receiver: Development				0.76 (0.18)***	0.84 (0.19)***
	Homophily: Development				−0.12 (0.21)	−0.20 (0.21)
	Receiver: Education				0.39 (0.17)*	0.39 (0.18)*
	Homophily: Education				−0.14 (0.18)	−0.10 (0.18)
	Receiver: Environment				−0.61 (0.21)**	−0.57 (0.22)**
	Homophily: Environment				1.11 (0.19)***	1.11 (0.19)***
	Receiver: Housing				−2.40 (0.45)***	−2.25 (0.45)***
	Homophily: Housing				0.38 (0.77)	0.21 (0.77)
	Receiver: Human Services				−0.02 (0.23)	0.05 (0.24)
	Homophily: Human Services				0.39 (0.43)	0.30 (0.44)
	Receiver: Public Health				1.40 (0.20)***	1.30 (0.21)***
	Homophily: Public Health				−0.48 (0.45)	−0.58 (0.47)
	Receiver: Recreation				−0.06 (0.21)	−0.11 (0.22)
	Homophily: Recreation				−0.09 (0.25)	−0.03 (0.25)
	Receiver: Religion				−1.55 (0.34)***	−1.54 (0.34)***
	Homophily: Religion				1.71 (0.48)***	1.71 (0.47)***
	Receiver: Seniors				0.79 (0.24)***	0.73 (0.24)**
	Homophily: Seniors				−0.07 (0.31)	−0.04 (0.33)
	Receiver: Youth				0.03 (0.19)	0.03 (0.20)
	Homophily: Youth				−0.09 (0.21)	0.01 (0.21)

$^{***}p < 0.001, ^{**}p < 0.01, ^{*}p < 0.05$

Table A3.1: Philadelphia Models Part 1

	Term Name	Model 1	Model 2	Model 3	Model 4	Model 5
ACS Census Block Data Terms	Receiver: Later than Median Year Moved					0.60 (0.19)**
	Sender: Later than Median Year Moved					−0.46 (0.17)**
	Homophily: Earlier than Median Year Moved					0.16 (0.18)
	Homophily: Later than Median Year Moved					0.02 (0.21)
	Receiver: Higher than Median Household Income					0.22 (0.17)
	Sender: Higher than Median Household Income					−0.12 (0.14)
	Homophily: Lower than Median Household Income					−0.25 (0.17)
	Homophily: Higher than Median Household Income					−0.10 (0.17)
	Receiver: Higher than Median Pop Density					−0.23 (0.20)
	Sender: Higher than Median Pop Density					−0.21 (0.16)
	Homophily: Lower than Median Pop Density					0.03 (0.18)
	Homophily: Higher than Median Pop Density					0.29 (0.18)
Census Block Land Use Terms	Receiver: Industrial					−0.09 (0.32)
	Receiver: Parks and Rec					0.16 (0.25)
	Receiver: Public Facilities					−0.47 (0.31)
	Receiver: Residential					0.30 (0.18)
	Receiver: Transportation					−0.87 (0.48)
	Sender: Industrial					−0.68 (0.48)
	Sender: Parks and Rec					−0.66 (0.22)**
	Sender: Public Facilities					−0.07 (0.26)
	Sender: Residential					0.24 (0.14)
	Sender: Transportation					−0.72 (0.73)
	Homophily: Commercial					−0.75 (0.46)
	Homophily: Parks and Rec					−0.19 (0.68)
	Homophily: Public Facilities					0.07 (1.00)
	Homophily: Residential					−0.17 (0.16)
	AIC	-111147.86	-111490.29	-111578.45	-111859.35	-111904.05
	BIC	-111104.94	-111361.51	-111320.91	-111344.25	-111109.94
	Log Likelihood	55577.93	55757.14	55813.23	55977.67	56026.02

$^{***}p < 0.001, ^{**}p < 0.01, ^{*}p < 0.05$

Table A3.2: Philadelphia Models Part 2

	Term Name	Model 1	Model 2	Model 3	Model 4	Model 5
Network Terms	Ties	−5.79 (0.07)***	−1.63 (0.18)***	−1.37 (0.24)***	−1.39 (0.25)***	−0.46 (0.29)
	Mutual	2.89 (0.33)***	2.35 (0.37)***	2.33 (0.36)***	2.33 (0.37)***	2.26 (0.38)***
	Anti-InDegree Cent.	−0.43 (0.12)***	0.02 (0.13)	0.06 (0.12)	0.21 (0.13)	0.26 (0.13)
	Anti-OutDegree Cent.	1.86 (0.38)***	2.89 (0.44)***	2.95 (0.46)***	2.94 (0.46)***	2.81 (0.45)***
Spatial Terms	Receiver: Medium Turf Size		−1.11 (0.21)***	−1.10 (0.21)***	−1.14 (0.21)***	−1.12 (0.22)***
	Receiver: Large Turf Size		−0.01 (0.13)	−0.01 (0.13)	−0.01 (0.14)	−0.02 (0.14)
	Sender: Medium Turf Size		0.26 (0.11)*	0.25 (0.11)*	0.26 (0.11)*	0.26 (0.11)*
	Sender: Large Turf Size		−0.25 (0.13)	−0.25 (0.14)	−0.26 (0.14)	−0.33 (0.15)*
	Homophily: Small Turf Size		−1.14 (0.17)***	−1.13 (0.17)***	−1.11 (0.17)***	−1.06 (0.18)***
	Homophily: Medium Turf Size		0.11 (0.39)	0.11 (0.40)	0.09 (0.40)	0.09 (0.40)
	Homophily: Large Turf Size		0.35 (0.27)	0.34 (0.28)	0.31 (0.28)	0.28 (0.28)
	Turf Overlap		0.33 (0.06)***	0.34 (0.06)***	0.34 (0.06)***	0.37 (0.06)***
	Dist. Bet. Home Offices		−0.70 (0.03)***	−0.71 (0.03)***	−0.71 (0.03)***	−0.76 (0.03)***
Organizational Characteristic Terms	Receiver: 501(c)(3)			−0.15 (0.16)	−0.22 (0.17)	−0.23 (0.17)
	Sender: 501(c)(3)			−0.24 (0.18)	−0.26 (0.18)	−0.28 (0.18)
	Homophily: Not 501(c)(3)			−0.21 (0.18)	−0.24 (0.18)	−0.25 (0.19)
	Homophily: 501(c)(3)			0.24 (0.18)	0.26 (0.19)	0.28 (0.19)
	Receiver: Paid Staff			−0.14 (0.12)	−0.17 (0.13)	−0.18 (0.13)
	Sender: Paid Staff			0.22 (0.13)	0.24 (0.14)	0.24 (0.14)
	Homophily: No Paid Staff			−0.35 (0.16)*	−0.31 (0.16)	−0.31 (0.16)*
	Homophily: Paid Staff			−0.17 (0.15)	−0.19 (0.16)	−0.19 (0.16)
	Receiver: Volunteers			−0.28 (0.14)*	−0.33 (0.15)*	−0.35 (0.15)*
	Sender: Volunteers			−0.04 (0.15)	−0.05 (0.15)	−0.12 (0.15)
	Homophily: No Volunteers			−0.09 (0.19)	−0.09 (0.20)	−0.09 (0.20)
	Homophily: Volunteers			0.29 (0.16)	0.29 (0.16)	0.30 (0.17)
Organizational Focus Terms	Receiver: Arts				0.12 (0.10)	0.14 (0.10)
	Homophily: Arts				−0.28 (0.21)	−0.31 (0.21)
	Receiver: Community Imp.				0.09 (0.09)	0.09 (0.09)
	Homophily: Community Imp.				−0.04 (0.12)	−0.03 (0.13)
	Receiver: Development				−0.13 (0.15)	−0.09 (0.15)
	Homophily: Development				−0.09 (0.53)	−0.11 (0.54)
	Receiver: Education				0.43 (0.10)***	0.41 (0.10)***
	Homophily: Education				0.15 (0.14)	0.10 (0.15)
	Receiver: Environment				−0.30 (0.10)**	−0.34 (0.10)**
	Homophily: Environment				0.08 (0.12)	0.12 (0.12)
	Receiver: Housing				−0.12 (0.16)	−0.10 (0.16)
	Homophily: Housing				0.50 (0.38)	0.45 (0.39)
	Receiver: Human Services				0.07 (0.16)	0.03 (0.16)
	Homophily: Human Services				0.10 (0.53)	0.05 (0.52)
	Receiver: Public Health				−0.31 (0.14)*	−0.35 (0.15)*
	Homophily: Public Health				−0.21 (0.33)	−0.25 (0.33)
	Receiver: Recreation				0.29 (0.11)*	0.30 (0.11)**
	Homophily: Recreation				−0.05 (0.25)	−0.06 (0.25)
	Receiver: Religion				−0.09 (0.20)	−0.10 (0.21)
	Receiver: Seniors				0.08 (0.14)	0.07 (0.14)
	Homophily: Seniors				−0.20 (0.31)	−0.14 (0.32)
	Receiver: Youth				−0.03 (0.11)	−0.04 (0.11)
	Homophily: Youth				0.16 (0.16)	0.15 (0.16)

$^{***}p < 0.001, ^{**}p < 0.01, ^{*}p < 0.05$

Table A3.3: New York City Models Part 1

	Term Name	Model 1	Model 2	Model 3	Model 4	Model 5
ACS Census Block Data Terms	Receiver: Later than Median Year Moved					0.07 (0.13)
	Sender: Later than Median Year Moved					−0.15 (0.14)
	Homophily: Earlier than Median Year Moved					0.00 (0.16)
	Homophily: Later than Median Year Moved					0.34 (0.17)*
	Receiver: Higher than Median Household Income					−0.11 (0.13)
	Sender: Higher than Median Household Income					−0.17 (0.14)
	Homophily: Lower than Median Household Income					0.14 (0.16)
	Homophily: Higher than Median Household Income					0.39 (0.16)*
	Receiver: Higher than Median Pop Density					−0.17 (0.14)
	Sender: Higher than Median Pop Density					−0.39 (0.15)*
	Homophily: Lower than Median Pop Density					−0.14 (0.15)
	Homophily: Higher than Median Pop Density					0.43 (0.17)*
Census Block Land Use Terms	Receiver: Industrial					−0.51 (0.28)
	Receiver: Parks and Rec					0.40 (0.16)*
	Receiver: Public Facilities					0.01 (0.19)
	Receiver: Residential					−0.34 (0.14)*
	Receiver: Transportation					−0.29 (0.22)
	Sender: Industrial					0.21 (0.29)
	Sender: Parks and Rec					−0.36 (0.24)
	Sender: Public Facilities					0.28 (0.26)
	Sender: Residential					0.01 (0.15)
	Sender: Transportation					0.40 (0.20)*
	Homophily: Commercial					−0.57 (0.37)
	Homophily: Parks and Rec					0.70 (0.40)
	Homophily: Residential					0.07 (0.16)
	AIC	-336221.09	-337038.79	-337076.79	-336976.80	-337183.47
	BIC	-336175.87	-336891.83	-336794.18	-336434.19	-336358.25
	Log Likelihood	168114.54	168532.40	168563.40	168536.40	168664.74

$^{***}p < 0.001, ^{**}p < 0.01, ^{*}p < 0.05$

Table A3.4: New York City Models Part 2

Consider two organizations, A and B. B sends a tie to A, and we will consider whether A also sends a tie to B. Both organizations are 501(c)(3) organizations, both have paid staff, but only A has volunteers. Both of their turfs are of medium size, and do overlap. Their home offices are at a distance of 10 kilometers (approximately 6 miles) from each other which works out to -4.71 in logged degrees (the units reported), and both are based in Residential areas with more recently moved residents than the median, higher than the median household income, and a larger population density. Organization A is focused on the Environment and Education, and organization B is focused on the Environment and Recreation. Neither organization has any other ties. For both cities we add up all of the significant coefficients that apply. These are the coefficients in Tables S1 and S2. If we use the standard significance cuttoff of p=.05, then these are the relevant terms with a single star (or more) next to them. In Philadelphia, the significant network terms are *Ties* (-4.43), *Mutual* (3.19), and *Anti-InDegree Centralization* (2.60). The last term is a geometrically weighted term, but as adding a tie from A to B increases the in-degree centralization only of B from 0 to 1, we do not need to include the weighting (see Levy 2016 for more information). All of these terms are relevant to the tie from A to B as this will be a mutual tie given that B already says they collaborate with A.

Network Terms contribution in Philadelphia:
-4.43 + 3.19 + 2.60 = 1.36

We can examine the same terms in New York. As adding a term from A to B will increase the out-degree of A from 0 to 1, we similarly can include the *Anti-OutDegree Centralization* term for New York just as we treated *Anti-InDegree Centralization* for Philadelphia. Also

note that here the *ties* term is not signficant. Thus, the Network terms contribution for New York City is given below.

Network Terms contribution in New York:
2.26 + 2.81 = 5.07

We cannot directly compare these numbers until we add up everything else relevant to the particular organizations. These numbers would be appropriate only for organizations where no other terms applied. Turning to the Spatial Terms, since both organizations have medium sized turfs, the negative and significant *Sender* and *Receiver: Medium Turf Size* terms in both cities apply. The homophily term is not significant in either city, so it is not included. *Turf Overlap* is significant for New York, so we include that coefficient (0.99) for New York. The term *Distance Between Home Offices* is significant in both cities so it will be included. The coefficient for this term is multiplied by the log of the actual distance (in geographic degrees) between the home offices. Thus, the Spatial Terms contribution for each city is:

Spatial Terms contribution in Philadelphia:
-1.83 + 0.50 + (-4.71)*(-0.35)= 0.32
Spatial Terms contribution in New York:
-1.12 + 0.26 + 0.37 + (-4.71)*(-0.76) = 3.09

For the Organizational Characteristics Terms, we see a lot of difference between significance in Philadelphia and New York. In Philadelphia the *Sender* and *Receiver: 501(c)(3)* and *Homophily: 501(c)(3)* terms apply as well as *Sender: Paid Staff* and *Homophily: Paid Staff*. For New York, only *Receiver: Volunteers* applies.

Organizational Characteristics Terms contribution in Philadelphia:
-0.63 + (-0.41) + (0.69) +0.55 +0.41 =0.61
Organizational Characteristics Terms contribution in New York:
-0.35

Organization A is focused on the Environment and Education, and organization B is focused on the Environment and Recreation. In Philadelphia, *Receiver: Environment*, and *Homophily: Environment* are all significant terms. In New York, *Receiver: Environment* and *Receiver: Recreation* are also significant. Thus the Organizational Focus Terms contribution is:

Organizational Focus Terms contribution in Philadelphia:
(-0.57) +1.11 =0.54
Organizational Focus Terms contribution in New York:
(-0.34) + 0.30 = -0.04

There are no contributions form the ACS data terms for Philadelphia. In New York City, the significant effects are*Homophily: Later than Median Year Moved*, *Homophily: Higher than Median Household Income*, *Sender: Higher than Median Pop Density*, and *Homophily: Higher than Median Pop Density*.

ACS Census Block contribution in Philadelphia:
0

ACS Census Block contribution in New York:
$0.34 + 0.39 + (-0.39) + (0.43) = 0.77$

Finally, there are no significant terms for having home office locations in Residential areas in the model for Philadelphia, whereas *Receiver: Residential* is significant in New York. Thus,

Census Block Land Use contribution in Philadelphia:
0
Census Block Land Use contribution in New York:
-0.34

Adding up all these contributions for each city gives an overall log-odds of the tie from Organization A to B in Philadelphia of 2.83. Taking the inverse logit, we find the overall probability of this tie occurring to be roughly 94%. In New York, the total log-odds is 8.2 yielding a probability of 99.97%. Because we selected for different types of homophily in each city combined with the centralization effects we get a huge chance of each tie, but for different reasons. We therefore see differences in how these coefficients play out when combined appropriately in the two different cities.

References:

Levy, M. A. 2016. gwdegree: Improving interpretation of geometrically-weighted degree estimates in exponential random graph models. *Journal of Open Source Software* 1(3): 36.