Web Appendix for: "A Hierarchy of Preferences: A Longitudinal Network Analysis Approach to PTA Formation"

Mark S. Manger (corresponding author)
Lecturer, Department of International Relations
London School of Economics and Political Science
m.s.manger@lse.ac.uk

Mark A. Pickup
Lecturer, School of Politics and International Relations
University of Nottingham
mark.pickup@nottingham.ac.uk

Tom Snijders
Professor
Department of Statistics, University of Oxford
tom.snijders@nuffield.ox.ac.uk

Web Appendix

Notes on Interpretation

Conditional on actor i being allowed to make a change, the probability that a change to x_{ij} is proposed by actor i is:

$$P(x) = \frac{\exp\big(f_i(\beta, \boldsymbol{x_{ij}})\big)}{\sum_{h=1}^{n} \exp\big(f_i^X(\beta, \boldsymbol{x_{ih}})\big)} \tag{1}$$

where $\boldsymbol{x_{ij}}$ is the network with tie x_{ij} toggled from 0 to 1 or 1 to 0; and $\boldsymbol{x_{ih}}$ is the network with tie x_{ih} toggled from 0 to 1 or 1 to 0. Conditional on the formation of tie x_{ij} being proposed, the probability of it being confirmed by country j is:

$$P(x) = \frac{\exp\big(f_i(\beta, \boldsymbol{x_{ij}})\big)}{\exp\big(f_i(\beta, \boldsymbol{x'_{ij}})\big) + \exp\big(f_i(\beta, \boldsymbol{x_{ij}})\big)} \tag{2}$$

where $\boldsymbol{x'_{ij}}$ is the network with tie x_{ij} not toggled from 0 to 1 or 1 to 0. These are the multinomial logit expressions.

In addition, a random element with a Gumbel distribution is incorporated into the actors' assessment of their situation to capture considerations not modeled explicitly. Actors make changes such as to optimize the evaluation function plus this random disturbance. In the language of econometric random utility modeling, this is stochastic optimization.

The variable of interest may be monadic, dyadic or structural. The usual *ceteris paribus* condition extends beyond the characteristics of the countries and country dyads to the network structure. Not only do countries j and h have the same values on the other included covariates, and not only do countries i and j have the same values on the other included dyadic covariates as i and h, but country i would be left in the same network position by a tie with j as it would by a tie with h.

1

We can also show the difference in the estimated ratios of tie formation probability conditional on all other covariates in the initial network of all pre-existing ties to the unconditional probabilities calculated straight from their prevalence in the network. This is shown in table 1: The probability of two middle-income countries forming a tie seems relatively high given its prevalence in the network, while the probability of high-middle and middle-low income pairs appears to range in the middle, and high-low and low-low ties as least probable.

Once covariates such as transitive closure and other controls are taken into account, these probabilities change considerably, making the hierarchical character of the network obvious: high-middle income ties become more likely, middle-middle income ties less so, and middle-low income ties are now in the least probable category.

	Unconditional	Conditional on: Transitivity, Trade, Distance, etc.
High probability ties	H-H, M-M	H-H, H-M
Intermediate probability ties	M-L, H-M	M-M
Low probability ties	H-L, L-L	H-L, L-L, M-L

Table 1: Interpretation of Dyadic Covariates

Results for earlier time periods

Table 2 presents the results of the estimation of our network model for the time period 1962-1993, and can be compared with the estimation results from the 1994-2004 period presented in the paper.In the 1962-1993 period, alliances and democracy are important predictors of PTA formation. Their effects are in line with theoretical expectations. This differs from the subsequent 1994-2004 period, in which these effects were not significant. The effects of indirect ties and distance are similar in both periods. As for the income

	Log Odds		S.E.
Degree (density)	-2.921	**	0.164
Indirect ties	-0.909	**	0.111
Distance	-0.035	**	0.001
Alliance	1.498	**	0.158
Low × Low	0.702	**	0.243
High × High	0.505		0.330
Mid × High	0.749	**	0.161
Mid × Low	-0.892	**	0.082
Low × High	1.107	**	0.082
Democracy	0.174	**	0.015
Democracy ego × Democracy alter	-0.003		0.003
Trade	0.027	**	0.011
inverse GDP	0.333		0.204
Trade × inverse GDP	0.013		0.034

*** Significant at the 0.1%, ** 1% level, * at 5% level.

Table 2: Parameter Estimates: 1962-1993.

interactions, the effects are generally muted in the 1962-1993 period compared to the 1994-2004 period. Relatively speaking, the probabilities of Low × High and Low × Low ties are greater than we would have expected. However, given the extreme rarity of PTAs in the earlier time period, the importance of these estimates should not be overstated. In 1962-1993, there are only five Low × High ties to influence the results: the EC's agreement with Morocco, Egypt, and Tunisia, and the inclusion of the Solomon Islands into the SPARTECA agreement with Australia and New Zealand. These countries shortly thereafter achieved middle-income status. We would not want to put too much emphasis on estimates driven by such a small number of observations. We also note that trade has a positive and significant effect on PTA formation in the 1962-1993 period. This effect is insignificant for the 1994-2004 period. However like this latter period, the interaction of trade with GDP remains insignificant in the earlier period.

0.1 Comparisons with Dyadic Analysis

To facilitate the comparison with earlier results in the literature, we also estimate a traditional logit model in which the unit of observation is the country-year dyad drawn from our longitudinal network dataset, although the actual sample differs since dyads drop out once a PTA has been formed between the two countries. The results are shown in table 3. In line with much of the literature, we include cubic splines (not shown) to account for duration dependence in a time-series cross-section model (Beck, Katz and Tucker 1998). We only include undirected dyads (i.e. it does not matter which country is first in the dyad) and cluster over the dyad, since different years of the same dyad are not independent (Froot 1989).[1] Strictly speaking, monadic terms such as DEMOCRACY cannot be interpreted in a dyadic logit model if each dyad is only included once. On the other hand, if it is included twice, i.e. once for each direction as in a directed dyad model, events (i.e. PTA formation) are double-counted and the estimation is overconfident. A partial solution to this problem is to use a directed-dyad dataset, but to only include the smaller or larger of the monadic attribute as a "limiting process."[2]

For a related reason, it is unfortunately not possible to include a variable to capture "indirect ties." The number of indirect ties is a monadic attribute that may change in different directions with a tie: Forming a tie can reduce the number of indirect ties for one actor but leave the number unchanged for the other actor. This would increase the probability of tie formation in the logit model because parameters influence the probability of tie formation in the dyad, even though one country gains zero utility from such a tie. By contrast, since the relative difference in indirect ties enters the objective function in our model, we can estimate and interpret the coefficients for individual countries.

---

[1] We follow standard practice and use STATA's built-in `cluster` option and the custom `btscs` command.

[2] Estimating such a model using our dataset yields substantially identical results that are available upon request. We thank our anonymous reviewers for this suggestion.

4

		S.E.	
Time period:	1994-2004		
Distance	-0.042	***	0.001
Alliance	0.597	***	0.121
Low × Low	0.657	**	0.206
High × High	0.761	**	0.242
Mid × High	0.259	*	0.120
Mid × Low	-0.171		0.127
Low × High	-2.263	***	0.299
Democracy$_i$	-0.106	***	0.011
Democracy$_j$	-0.094	***	0.011
DemocracyBoth	0.008	***	0.000
Trade	-0.279	***	0.076
inverse GDP$_i$	-24.018	***	0.045
inverse GDP$_j$	-11.271	*	0.043
Trade × inv. GDP$_i$	0.921	**	0.005
Trade × inv. GDP$_j$	1.746	***	0.004
Observations	97966		
Pseudo R^2	0.24		

*** Significant at the 0.1%, ** 1% level, * at 5% level.

S.E.: Robust standard errors clustered over dyads. Cubic spline coefficients and constant not shown.

Table 3: Logit Estimates: PTA Formation

A comparison with the results of the logit model show that in a traditional dyadic approach, the estimated effect of democratic governance is likewise at best small and negative for the 1994-2004 time period. Likewise, the aggregate measure of trade in the network analysis appears positive but insignificant, while it is negative and significant in the logit model, again echoing existing work (Mansfield, Milner and Pevehouse 2007, 422). The logit model also shows an estimated negative and significant coefficient of the inverse of GDP. While the lack of significance of the coefficient estimates of our controls is unexpected, the results of the traditional logit model are much harder to bring into harmony with basic economic incentives: It suggests that while it matters how much a country trades with a

particular partner in relation to its GDP, the more it trades and the smaller its economy, the less likely it will form PTAs. We cannot square this result with intuition or economic theory.

The comparison of network and logit model estimates for the relative income class dummies reveals further pronounced differences: The income interaction parameter estimates are all significant except for MID × LOW TIES, but the sign for LOW × LOW ties is reversed. Again, the findings of the network model are a better fit with theory, as political economy models predict that high-income countries should be reluctant to pursue trade liberalization with low-income partners (Kono 2008), and accord better with the empirical evidence of tariff barriers found by other studies. For example, Laird, Vanzetti and Fernández de Córdoba (2006, 15) calculate that exports between least-developed countries face a weighted average tariff of 8 percent, exports between developed countries only incur a tariff of 2.1 percent, and exports from least-developed to developed countries the highest barriers at 11 percent. Since these figures take preferential rates into account, they are fully consonant with our findings. In both logit and network model, the coefficient on DEMOCRACY is negative, but significant only in the logit model. This is likely specific to the post-Cold War analysis period. We leave further investigation of the unexpected signs of the control variable coefficients for future work.

References

Beck, Nathaniel, Jonathan N. Katz and Richard Tucker. 1998. "Taking time seriously: Time-series-cross-section analysis with a binary dependent variable." *American Journal of Political Science* 42(4):1260–1288.

Froot, Kenneth A. 1989. "Consistent Covariance Matrix Estimation with Cross-Sectional Dependence and Heteroskedasticity in Financial Data." *Journal of Financial and Quantitative Analysis* 24(3):333–355.

Kono, Daniel Yuichi. 2008. "Democracy and Trade Discrimination." *Journal of Politics* 70(4):942–955.

Laird, Sam, David Vanzetti and Santiago Fernández de Córdoba. 2006. Smoke and Mirrors: Making Sense of the WTO Industrial Tariff Negotiations. Policy Issues in International Trade and Commodities Study Series 30 UNCTAD Trade Analysis Branch, Division on International Trade in Goods and Services and Commodities New York and Geneva: .

Mansfield, Edward D., Helen V. Milner and Jon C. Pevehouse. 2007. "Vetoing co-operation: The impact of veto players on preferential trading arrangements." *British Journal Of Political Science* 37:403–432.