A Sufficient Conditions for Identification of $\Lambda_0$ and $\beta_{1,0}$

**Proposition 1.** Let $\Lambda_0$ and $\beta_{1,0}$ be the true parameter values. Let $\Xi_r$ be a $n_r \times N$ matrix consisting of $R$ horizontally concatenated blocks of size $n_r$, with $I_{n_r}$ in the $r^{th}$ position and zeroes in the other $R-1$ positions. Hence, $\Xi_1 = (I_{n_1}, 0)$, $\Xi_R = (0, I_{n_R})$, and $\Xi_r = (0, I_{n_r}, 0)$ for $r \neq 1, R$, where the 0 matrices are appropriately conformable. Suppressing $t$, let $\Theta_{rk} = \Xi_r G_{rk} S_0^{-1} X_1 \beta_{1,0}$ and $S_0 = I_N - \sum_{r=1}^R \sum_{k=1}^{R} \lambda_{rk} G_{rk}$. Then, the true parameters $\Lambda_0$ and $\beta_{1,0}$ for the system of equation 3 (in the main text) can be identified if the $R$ matrices $[Q_r X_1, Q_r \Theta_r, ..., Q_r \Theta_R]$, $r = 1, ..., R$ have full column rank.

**Proof.** As $S_0^{-1} = I_N + \sum_{r=1}^R \sum_{k=1}^{R} \lambda_{rk} G_{rk} S_0^{-1}$ and $J_Q y = J_Q S_0^{-1} X_1 \beta_{1,0} + J_Q S_0^{-1} u^*$, equation 3 (in the main text) evaluated at the true parameters is written as

$$J_Q y = J_Q X_1 \beta_{1,0} + J_Q \sum_{r=1}^R \sum_{k=1}^{R} \lambda_{rk} G_{rk} S_0^{-1} X_1 \beta_{1,0} + J_Q S_0^{-1} u^*$$

Then, $\Lambda_0$ and $\beta_{1,0}$ in (1) will be identified as long as the $R$ matrices $[Q_r X_1, Q_r \Theta_r, ..., Q_r \Theta_R]$, $r = 1, ..., R$ have full column rank. This condition will be generally satisfied because we have multiple sets of network matrices and exogenous regressors for each group, which produces enough variation to identify $\Lambda_0$ and $\beta_{1,0}$. ■

---

*Corresponding author: Department of Economics, Syracuse University, Syracuse, NY, 13244; whorrace@syr.edu.

†Department of Economics, University of Arkansas, Fayetteville, AR, 72701.

‡Department of Sport Management, Syracuse University, Syracuse, NY, 13244

1Note that $J_Q G_{rk} J_Q = J_Q G_{rk}$ $\forall r,k$ which leads to $J_Q S_0^{-1} J_Q = J_Q S_0^{-1}$
B The Quasi-Maximum Likelihood Function

Suppressing \( t \), the likelihood function for equation 5 (in the main text) is \(^2\)

\[
\ln L(\Lambda, \beta_1, \Sigma) = -\sum_{r=1}^{R} \frac{n_r}{2} \ln(2\pi \sigma_r^2) + \ln |S(\Lambda)| - \sum_{r=1}^{R} \frac{\epsilon_r(\theta_r)'}{2\sigma_r^2},
\]

where \( \Lambda = (\Lambda_1', ..., \Lambda_R')' \) with \( \Lambda_r = (\lambda_1, ..., \lambda_R) \), \( \Sigma = \text{Diag}(\sigma_1^2, ..., \sigma_R^2) \), \( S(\Lambda) = I_N - \sum_{r=1}^{R} \sum_{k=1}^{R} \lambda_{rk} G_{rk} \), and \( \epsilon_r(\theta_r) = y_r - \sum_{k=1}^{R} \lambda_{rk} W_{rk} y_k - X_{1r} \beta_{1r} \) where \( \theta_r = (\Lambda_r, \beta_{1r}) \) and \( \epsilon_r \) is a vector function of \( \theta_r \), and \( \tilde{W}_{rk} \) and \( \tilde{X}_{1r} \) are defined similarly. From Lemma 1 below, we show \( \ln |S(\Lambda)| = -\ln f(\Lambda) + \ln |S(\Lambda)| \) where \( S(\Lambda) = I_N - \sum_{r=1}^{R} \sum_{k=1}^{R} \lambda_{rk} G_{rk} \) and \( f \) is some scalar function of \( \Lambda \). For example, when \( R = 2 \), \( f(\Lambda) = (1 - \lambda_{11})(1 - \lambda_{22}) - \lambda_{12} \lambda_{21} \), and when \( R = 3 \), \( f(\Lambda) = (1 - \lambda_{11})(1 - \lambda_{22})(1 - \lambda_{33}) - (1 - \lambda_{11}) \lambda_{23} \lambda_{32} - (1 - \lambda_{22}) \lambda_{13} \lambda_{31} - (1 - \lambda_{33}) \lambda_{12} \lambda_{21} - 1 \lambda_{13} \lambda_{21} \lambda_{32} \). Using this result, we can evaluate the likelihood without \( P_r \) as

\[
\ln L(\Lambda, \beta_1, \Sigma) = -\sum_{r=1}^{R} \frac{n_r}{2} \ln(2\pi \sigma_r^2) + \ln f(\Lambda) + \ln |S(\Lambda)| - \sum_{r=1}^{R} \frac{\epsilon_r(\theta_r)Q_r \epsilon_r(\theta_r)}{2\sigma_r^2},
\]

where \( \epsilon_r(\theta_r) = y_r - \sum_{k=1}^{R} \lambda_{rk} W_{rk} y_k - X_{1r} \beta_{1r} \). There are two things to note here. First, we may need to further restrict the parameter space of \( \Lambda \) to guarantee that \( f(\Lambda) \) is strictly positive. Second, it may be difficult to evaluate \( |S(\Lambda)| \). The Ord (1975) eigenvalue device may be used to compute the determinant. However, it may only work when the number of networks \( R \) is small, and all the network matrices are sparse. If the number of networks \( R \) is large, then GMM may be preferred to QML, as it avoids the computational difficulties of evaluating the determinant of \( S \).

To simplify estimation, we concentrate out \( \beta_1 \) and \( \Sigma \) in (3). The QML estimate of \( \beta_{1r} \) and \( \sigma_r^2 \), given \( \Lambda_r \), is \( \hat{\beta}_{1r}(\Lambda_r) = (X_{1r}'Q_r X_{1r})^{-1}X_{1r}'Q_r \mu_r(\Lambda_r) \) where \( \mu_r(\Lambda_r) = y_r - \sum_{k=1}^{R} \lambda_{rk} W_{rk} y_k \) is a vector function, and

\[
\hat{\sigma}_r^2(\Lambda_r) = \frac{\epsilon_r'(\theta_r)Q_r \epsilon_r(\theta_r)}{n_r - 1} = \frac{\mu_r(\Lambda_r)'}{n_r - 1} Q_r X_{1r} (X_{1r}'Q_r X_{1r})^{-1} X_{1r}'Q_r |\mu_r(\Lambda_r)|,
\]

is a scalar function. Then the concentrated log-likelihood function in \( \Lambda \) is

\[
\ln L^c(\Lambda) = -\sum_{r=1}^{R} \frac{n_r}{2} \ln(2\pi) + \ln f(\Lambda) + \ln |S(\Lambda)| - \sum_{r=1}^{R} \frac{n_r}{2} \ln \hat{\sigma}_r^2(\Lambda_r).
\]

\(^2\)The likelihood is conditional on the sufficient statistic, the mean of \( y_r \). Lee (2007).
Then the QMLE, \( \hat{\Lambda} \), is the maximizer of the likelihood, and the QMLE of \( \beta_1 \) and \( \Sigma \) are \( \hat{\beta}_{1r}(\hat{\Lambda}_r) \) and \( \text{Diag}(\hat{\sigma}_1^2(\hat{\Lambda}_1), ..., \hat{\sigma}_R^2(\hat{\Lambda}_R)) \), respectively. The asymptotic distribution for these estimators can be derived from Lee et al. (2010, Appendix B). When \( n_r \) is small, the simulation study in section 3 (of the main text) uncovers a sizable finite sample bias for the QML estimator of \( \Lambda \), which persists even as \( T \) increases. To remove the bias, we propose a residual bootstrap finite sample correction in section 3 (of the main text).

\section{Lemma 1}

This generalizes a similar result in Lemma C.1 of Lee et al. (2010) to our setting with multiple networks and heterogeneous network effects.

\textbf{Lemma 1.} Supposing \( t \), let the orthonormal matrix of \( Q_r \) be \( [P_r, t_n_r/\sqrt{n_r}] \). The columns in \( P_r \) are eigenvectors of \( Q_r \) corresponding to the eigenvalue one, such that \( P_r t_n_r = 0 \), \( P_r^T P_r = I_{n_r-1} \) and \( P_r^T Q_r = Q_r \). Denote \( J = \text{Diag}(P_1^T, ..., P_R^T) \) and \( G_{rk} = J P_r G_{rk} J^T \), then, \( \ln |S(A)| = -\ln f(A) + \ln |S(A)| \) where \( S(A) = I_{N-R} - \sum_{r=1}^R \sum_{k=1}^R \lambda_{rk} G_{rk} \), \( S(A) = I_N - \sum_{r=1}^R \sum_{k=1}^R \lambda_{rk} G_{rk} \) and \( f(A) \) is some function of \( A \).

\textbf{Proof.} Here, we show that the Lemma holds for two networks. From this, we can easily see that the Lemma holds generally. Define \( H = \begin{bmatrix} [P_1, \frac{t_{n_1}}{\sqrt{n_1}}] & 0 \\ 0 & [P_2, \frac{t_{n_2}}{\sqrt{n_2}}] \end{bmatrix} \). Then, we can show that

\[ |H^T (I - \sum_{r=1}^2 \sum_{k=1}^2 \lambda_{rk} G_{rk}) H| = |H^T H||I - \sum_{r=1}^2 \sum_{k=1}^2 \lambda_{rk} G_{rk}| = |I_N - \sum_{r=1}^2 \sum_{k=1}^2 \lambda_{rk} G_{rk}| \text{ as } |H^T H| = 1. \]

Next, we show

\[ H^T (I_N - \sum_{r=1}^2 \sum_{k=1}^2 \lambda_{rk} G_{rk}) H = \begin{bmatrix} [P_1, \frac{t_{n_1}}{\sqrt{n_1}}] & 0 \\ 0 & [P_2, \frac{t_{n_2}}{\sqrt{n_2}}] \end{bmatrix} \begin{bmatrix} I_{n_1} - \lambda_{11} W_{11} & -\lambda_{12} W_{12} \\ -\lambda_{21} W_{21} & I_{n_2} - \lambda_{22} W_{22} \end{bmatrix} \begin{bmatrix} [P_1, \frac{t_{n_1}}{\sqrt{n_1}}] & 0 \\ 0 & [P_2, \frac{t_{n_2}}{\sqrt{n_2}}] \end{bmatrix}. \]

Now, \( P_r^T W_{rk} t_{nk} = 0 \) and \( t_{n_r}^T W_{rk} t_{nk} = n_r \). Hence,

\[ H^T (I_N - \sum_{r=1}^2 \sum_{k=1}^2 \lambda_{rk} G_{rk}) H = \begin{bmatrix} P_1^T (I_{n_1} - \lambda_{11} W_{11}) P_1 & 0 & -\lambda_{12} P_1^T W_{12} P_2 & 0 \\ \frac{t_{n_1}^T}{\sqrt{n_1}} (I_{n_1} - \lambda_{11} W_{11}) P_1 & 1 - \lambda_{11} & \frac{t_{n_1}^T}{\sqrt{n_1}} (-\lambda_{12} W_{12}) P_2 & -\frac{t_{n_1}^T}{\sqrt{n_1}} \lambda_{12} \\ -\lambda_{21} P_2^T W_{21} P_1 & 0 & P_2 (I_{n_2} - \lambda_{22} W_{22}) P_2 & 0 \\ \frac{t_{n_2}^T}{\sqrt{n_2}} (-\lambda_{21} W_{21}) P_1 & -\frac{t_{n_2}^T}{\sqrt{n_2}} \lambda_{21} & \frac{t_{n_2}^T}{\sqrt{n_2}} (I_{n_2} - \lambda_{22} W_{22}) P_2 & 1 - \lambda_{22} \end{bmatrix}. \]
Then, from Laplace’s formula,

\[
|H(I_N - \sum_{r=1}^{2} \sum_{k=1}^{2} \lambda_{rk} G_{rk})H| \\
= (1 - \lambda_{11}) \begin{vmatrix}
P_1'(I_{n_1} - \lambda_{11} W_{11}) & -\lambda_{12}P_1'W_{12}P_2 \\
-\lambda_{21}P_2'W_{21}P_1 & P_2'(I_{n_2} - \lambda_{22} W_{22})P_2 \\
\frac{\lambda_{12}}{\sqrt{n_2}}(-\lambda_{21} W_{21}P_1) & \frac{\lambda_{21}}{\sqrt{n_2}}(-\lambda_{22} W_{22}P_2) \\
\end{vmatrix} \\
+ (-1)^{n_2} \frac{\lambda_{12}}{\sqrt{n_1}} \begin{vmatrix}
P_1'(I_{n_1} - \lambda_{11} W_{11}) & -\lambda_{12}P_1'W_{12}P_2 \\
-\lambda_{21}P_2'W_{21}P_1 & P_2'(I_{n_2} - \lambda_{22} W_{22})P_2 \\
\frac{\lambda_{12}}{\sqrt{n_1}}(I_{n_1} - \lambda_{11} W_{11})P_1 & \frac{\lambda_{21}}{\sqrt{n_1}}(-\lambda_{12} W_{12}P_2) \\
\end{vmatrix} \\
- \lambda_{12}\lambda_{21} \begin{vmatrix}
P_1'(I_{n_1} - \lambda_{11} W_{11}) & -\lambda_{12}P_1'W_{12}P_2 \\
-\lambda_{21}P_2'W_{21}P_1 & P_2'(I_{n_2} - \lambda_{22} W_{22})P_2 \\
\end{vmatrix} \\
= \left((1 - \lambda_{11})(1 - \lambda_{22}) - \lambda_{12}\lambda_{21}\right) \begin{vmatrix}
P_1'(I_{n_1} - \lambda_{11} W_{11}) & -\lambda_{12}P_1'W_{12}P_2 \\
-\lambda_{21}P_2'W_{21}P_1 & P_2'(I_{n_2} - \lambda_{22} W_{22})P_2 \\
\end{vmatrix} \\
= \# \\
\]

Now, the determinant \# is equal to \(|J_{f}\) \(|I_N - \sum_{r=1}^{2} \sum_{k=1}^{2} \lambda_{rk} G_{rk}\)J_{f}|| = \(|I_{N-2} - \sum_{r=1}^{2} \sum_{k=1}^{2} \lambda_{rk} G_{rk}|\), implying that \(|I_{N} - \sum_{r=1}^{2} \sum_{k=1}^{2} \lambda_{rk} G_{rk}| = \left((1 - \lambda_{11})(1 - \lambda_{22}) - \lambda_{12}\lambda_{21}\right)\) \(|I_{N-2} - \sum_{r=1}^{2} \sum_{k=1}^{2} \lambda_{rk} G_{rk}|\). Therefore, the Lemma holds for the \(R = 2\) case. From this, we can easily see that the Lemma holds for any number of networks. For example, when there are \(R = 3\) networks, \(f(\Lambda) = (1 - \lambda_{11})(1 - \lambda_{22})(1 - \lambda_{33}) - (1 - \lambda_{11})\lambda_{23}\lambda_{32} - (1 - \lambda_{22})\lambda_{13}\lambda_{31} - (1 - \lambda_{33})\lambda_{21}\lambda_{12} - \lambda_{13}\lambda_{21}\lambda_{32} \). \(\blacksquare\)

### D Additional Simulation Results

To save space Table 2 (in the main text) contains selected results for the four DGPs defined in section 3 of the main text. In particular, Table 2 provides simulation results for estimation of network-level coefficients for only two sample sizes: \(\{n_r, T\} = \{5, 500\} \) and \(\{5, 1000\}\), using two ways to estimate
the selection probabilities: Multinomial Logit (MLN) and 5-fold cross-validated Random Forest (RF). Here, we provide additional results for intermediate sample size, \( \{n_r, T\} = \{10, 500\} \), and an additional estimator of the selection probabilities: out-of-bag tuned RF. Table 4 provides the results for all three sample sizes for MNL estimation of the probabilities. Table 5 provides the results for both the 5-fold cross-validated and out-of-bag tuned RF (described below). Therefore, Table 2 (in the main text) provides a subset of the results in Tables 4 and 5 below. For comparison purposes, Table 6 provides the results for RF with no tuning.

We consider two ways of tuning the maximum number of splits in a tree. The first method is based on the out-of-bag (OOB) classification error. RF is a bagging method which grows trees on bootstrapped subsets of the observations. On average, around two-thirds of the observations are used to fit a tree, so the remaining observations can be used to calculate an out-of-sample classification error by excluding the trees grown on bootstraps that include observation \( i \) when computing the \( i^{th} \) observation’s prediction. This is computationally easiest but may be subject to overfitting because the OOB error is similar to a leave-one-out cross-validation error when the number of trees grown is large (James et al., 2017). The second method uses five-fold cross-validation in which the data are divided into five subsets of similar size. This method is computationally more intensive, but may be less subject to overfitting, as each possible subset is used as a test set in alternation and is validated against the complement of the subset. For comparison, we consider RF without tuning where we grow 1,000 trees with a maximum number of splits = \( T - 1 \).

In almost all cases, Tables 4 and 5 show that RF with five-fold cross-validation performs best in terms of both bias and variance of the estimates. When it is not tuned (Table 6), the bias of RF is as large as that of MNL, even in DGP 3 and 4 (Table 4). This result aligns well with the findings in Scornet et al. (2015) and Wager and Walther (2015) that the depth of the trees (i.e. the number of splits in a tree) should be controlled to eliminate bias from the inherent data-dependent procedures in growing trees. Wager and Athey (2018, Appendix B) explain that the bias may be due to the fact that RF tends to push outliers into corners of features space. Minimizing this sort of bias by a proper tuning of the number of splits may be important in our context as selection bias can only be corrected when outliers are correctly identified. The result may provide practical guidance on the selection of the maximum number of splits that satisfies the theoretical condition on depth of a decision tree for the consistency of random forest in Scornet et al. (2015) and Wager and Walther (2015).
E NBA Data and Additional Empirical Results

Descriptive statistics for the variables in the outcome and selection equations are in Tables 7 and 8. The first columns contain the abbreviated names of the 30 NBA teams, which are partitioned by division (e.g., Atlantic Division of the Eastern Conference) and ranked within division by the mean of our outcome variable, Wins (second column), which is measured as Wins Produced per minute. For example, in the 2015-16 season Cleveland (CLE) had an average Wins Produced per minute of 0.0066 (second column) with a standard deviation of 0.0264 (third column). Cleveland played in 1,883 sampled time periods (column heading Periods) with an average duration of 1.7611 minutes per period (column heading ADP = average duration per period). Over short time intervals player-time level Wins Produced can be highly variable and sometimes quite small (non-pivotal) due to many zeros in the box score. During this season, the Golden State Warriors (GSW) had the highest Wins Produced per minute (0.0081) and Philadelphia (PHI) had the lowest (0.0051). Not surprisingly, the Warriors won the most games that season (72) and Philadelphia the fewest (10). Therefore, if the goal is to win games, then our outcome measure seems appropriate for these data.

Rounding out Table 7 are the explanatory variables in the outcome equation. As previously stated, Experience is the cumulative minutes played by a player from the beginning of the game to the end of period \( t - 1 \). The Fatigue variable is total minutes continuously played by the player at the end of period \( t - 1 \). For example, Milwaukee (MIL) had values of Experience and Fatigue of 14.3271 and 5.5877 minutes, respectively. The Milwaukee players play many minutes (on average), and many of these minutes are continuous, compared to other teams in the league. Philadelphia (PHI) had the lowest values for the experience variable, while Atlanta (ATL) had the lowest fatigue variable. It is likely that these coaches substitute many players more frequently than the rest of the league. This is reflected in their relatively low values for “Average Duration per Period” (ADP) of 1.6193 minutes (PHI) and 1.6391 minutes (ATL). The RPI variable is “Ratings Percentage Index” and is a measure of the opposing team’s power rating at the end of the previous season. Higher ratings reflect tougher opposing teams, so Phoenix (PHX) faced the toughest schedule (RPI = 0.5028) during the 2015-16 season, based on power ratings at the end of the 2014-15 season.

Table 8 contains means and standard deviations for the variables in the selection equation. The second column contains dependent variable (Nguard), and we see that the Portland coach (POR) uses on average the most guards (2.5), while Chicago (CHI) uses the fewest (1.44). This is not surprising.

---

3The RPI for each opposing team is obtained from ESPN: http://www.espn.com/nba/stats/rpi/year/2015.
given that Portland averaged the most guards on their roster ($NguradR = 4.98$) in any game and Chicago had the fewest ($NguradR = 3.14$). The Golden State Warriors (GSW) had the largest positive cumulative score differential $CumscoreDiff = 6.62$, while Philadelphia (PHI) had the largest negative score differential (-6.03). Golden State tended to be leading in points over the season, while Philadelphia was often losing. This is also not surprising given their best and worst (respectively) records at the end of the season. Boston (BOS) had the largest number of cumulative fouls over a game ($CumFoul = 11.20$) and the San Antonio Spurs (SAS) had the fewest (8.54 fouls).

The reduced form of equation 15 (in the main text) provides insight onto the overall network effects in the production process. Suppressing subscripts, the matrix form of equation 15 is,

$$y = M \cdot y + XB + u,$$

where $y = [y_{rfg}, y_{kfg}]$, a $10 \times 1$ vector, and $M = \begin{bmatrix} \lambda_{rr}W_{rfg}W_{fg} & \lambda_{rk}W_{rfg}W_{kfg} \\ \lambda_{kr}W_{kfg}W_{rfg} & \lambda_{kk}W_{kfg}W_{kfg} \end{bmatrix}$, a $10 \times 10$ network matrix. Solving for the reduced form and taking expectations conditional on $X$ yields

$$E(y|X) = (I_{10} - M)^{-1}XB.$$  \hfill (9)

This implies that the reduced-form peer- and competitor-effects are polynomial functions of the structural peer- and competitor-effects of any head-to-head match-up. For example, the second-order network term, $M^2$, is given by

$$M^2 = \begin{bmatrix} \lambda_{rr}W_{rfg}W_{rfg} & \lambda_{rk}W_{rfg}W_{kfg} \\ \lambda_{kr}W_{kfg}W_{rfg} & \lambda_{kk}W_{kfg}W_{kfg} \end{bmatrix} \begin{bmatrix} \lambda_{rr}W_{rfg}W_{rfg} & \lambda_{rk}W_{rfg}W_{kfg} \\ \lambda_{kr}W_{kfg}W_{rfg} & \lambda_{kk}W_{kfg}W_{kfg} \end{bmatrix} = \begin{bmatrix} m_1 & m_2 \\ m_3 & m_4 \end{bmatrix}$$

where

$$m_1 = (\lambda_{rr}W_{rfg})^2 + \lambda_{rk}\lambda_{kr}W_{rfg}W_{kfg}$$
$$m_2 = \lambda_{rr}\lambda_{rk}W_{rfg}W_{kfg} + \lambda_{kk}\lambda_{kr}W_{kfg}W_{rfg}$$
$$m_3 = \lambda_{rr}\lambda_{kr}W_{rfg}W_{kfg} + \lambda_{kk}\lambda_{kr}W_{kfg}W_{rfg}$$
$$m_4 = (\lambda_{kk}W_{kfg})^2 + \lambda_{rk}\lambda_{kr}W_{rfg}W_{kfg}$$

The first component of $m_1$ represents the second-order, pure peer-effect of team $r$ on itself ($r \rightarrow r \rightarrow r$). The second component of $m_1$ represents the competitor-effect that arises from the fact
that r’s performance affects k’s performance but it feeds back to r through the competitor network (r \rightarrow k \rightarrow r). The first component of m_2 represents a mixed effect that arises from the fact that k affects r’s performance which, in turn, affects r again through its own peer network (k \rightarrow r \rightarrow r). The second component of m_2 represents a mixed effect that arises from the network effect of team k that is affecting team r’s performance through the competition network (k \rightarrow k \rightarrow r). Terms m_3 and m_4 can be similarly understood, but from the perspective of team k.

We calculate the 10 \times 10 reduced-form matrix (I_{10} - M)^{-1} in (9) for every network in each period t for every r vs. k match-up over the season. Since the elements of the upper, right-hand 5 \times 5 submatrix of (I_{10} - M)^{-1} capture the competitor-effect from k to r for each of the 5 players on team r, we report the average of the row-sums of the submatrices for every period for every match-up of team r vs. k over the season. This average embodies a reduced-form “indirect competitor-effect” from k to r.\footnote{This is similar to the direct and indirect reduced-form spatial effects discussed in LeSage and Pace (2009) and Elhorst (2014). See Glass et al. (2016), Table 5 for an example.} We also report the same for the lower left-hand 5 \times 5 submatrix, which captures the competitor-effect from r to k. These two reduced-form average effects corresponded in sign and magnitude to the structural competitor-effects \lambda_{rk} and \lambda_{kr} within a division. Therefore, it appears that for these data the first-order structural competitor-effects are an excellent proxy for the reduced-form competitor-effects.\footnote{In fact, we find that any row sum of the upper, right-hand 5 \times 5 submatrix approximately equals the competitor coefficient, \lambda_{rk}, which we believe is due to the topology of the competition matrix.}

Table 9 contains the reduced-form indirect competitor-effects. We do not include t-statistics for the indirect competitor-effects, but the point of this table is to show the similarity between these results and those of Table 3 in the main text. For example, in Table 9 the average indirect competitor-effect of Boston (BOS) on Toronto (TOR) is -0.220, while the corresponding structural parameter in Table 3 is -0.229. In Table 9 the average indirect competitor-effect of New York (NYK) on Boston (BOC) is -0.508, while the corresponding structural parameter in Table 3 is -0.569. Results are similar for other match-ups, as well. Apparently, the reduced-form competitor-effects are largely determined by the first-order effect, which consists solely of the structural parameter, \lambda_{rk}, so we would not be making a grave error if we interpreted the structural competitor-effects in Table 3 as reduced-form indirect competitor-effects. We also experimented with a “direct” and “indirect own network effect” by calculating the average of the diagonal elements and the row-sums, but without the diagonal elements, respectively, of the 5 \times 5 upper left-hand corner submatrix of the matrix (I_{10} - M)^{-1} over all time periods for the games played between teams r and k within a division. We found that this average was affected by the relative signs of \lambda_{rk} and \lambda_{kr}. If the signs were the same, then it increased the...
average effect, but if the signs were different, then this effect was smaller. The point is that without accounting for the competitor-effects (which the literature has often overlooked) the within network effects may not be accurately measured.

In Table 3 (of the main text) the sign of the estimated \( \lambda_{rk} \) is almost always the opposite of the sign of the estimated \( \lambda_{kr} \), which makes sense from a competitive standpoint, but the 120 intra-divisional estimates are numerous and difficult to interpret on their own. Therefore, we also report the 60 products, \( \lambda_{rk} \lambda_{kr} \), which appears in both \( m_1 \) and \( m_4 \) of the second-order network effect, of the reduced-form matrix \((I_{10} - M)^{-1}\). This is only a partial structural effect, but it provides an easier way to simultaneously summarize the competitor-effects for both teams in any match-up between \( r \) and \( k \) than the individual competitor-effects alone. It is a single statistic that captures (in some sense) the intensity of the rivalry between \( r \) and \( k \) (and vice versa) after controlling for individual performance, within-team chemistry and coaching. These statistics should be particularly relevant for quantifying intensity of intra-divisional rivalry. These are tabulated in Table 10. For example, consider the Toronto Raptors (TOR) in the first row. The signs and the relative magnitudes of the competitor-effect products suggest that the New York Knicks (NYK) are a much tougher opponent for Toronto \((-0.141)\) than is Boston \((-0.064)\). The “toughest” match-up in the Atlantic division in terms of competitor-effects is New York vs. Boston, where the product of the competitor-effects is largest in magnitude in the division \((-0.319)\). Looking down the rows of the table, the toughest match-ups in each division in terms of competitor-effects are: CLE-MIL \((-0.575)\) in the Central Division, CHA-ORL \((-0.468)\) in the Southeast, UTA-DEN \((-0.320)\) in the Northwest, PHX-LAL \((-0.206)\) in the Pacific, and HOU-NOP \((-0.199)\) in the Southwest.

Estimates of \( \beta_{1r} \), estimates of \( \beta_{2r} \) and the coefficient on the selection bias based on Lee’s approach, and those based on Dahl’s approach are in Table 11, 12 and 13, respectively. An interesting result in Table 12 is that the coefficient on the selection bias term in the final-step estimates is almost always insignificant, using Lee’s approach. Therefore, either the selection model is poorly specified or NBA coaches had little strategic effect on player productivity after accounting for peer- and competitor-effects in the 2015-16 season. Only the LA Clippers (LAC in the MNL model) and the LA Lakers (LAL in the RF model) had significant coach selection effects at the 95% significance level.
| \(\{n_c, T\}\) | No Bias Term | MNL | Dahl |
|---|---|---|---|
| \(\beta_2(0)\) | \(\beta_2(1)\) | \(\beta_2(2)\) | \(\beta_2(1)\) | \(\beta_2(2)\) |
| Bias | -1.40 | -0.32 | 0.51 | -0.01 | -0.01 | -0.00 | 0.01 | -0.10 | 0.12 |
| SD | 0.20 | 0.27 | 0.29 | 0.23 | 0.25 | 0.25 | 0.16 | 0.43 | 0.46 |
| Avg. Bootstrap SE | 0.19 | 0.27 | 0.28 | 0.23 | 0.25 | 0.25 | 0.16 | 0.44 | 0.47 |
| RMSE | 1.42 | 0.42 | 0.59 | 0.23 | 0.25 | 0.25 | 0.17 | 0.57 | 0.58 |
| 95% Coverage Rate | 0.00 | 0.78 | 0.54 | 0.95 | 0.95 | 0.95 | 0.97 | 0.99 | 0.99 |
| Bias | -1.10 | -0.33 | -0.51 | -0.03 | -0.01 | -0.02 | -0.02 | -0.08 | 0.11 |
| SD | 0.19 | 0.27 | 0.26 | 0.22 | 0.24 | 0.24 | 0.16 | 0.43 | 0.43 |
| Avg. Bootstrap SE | 0.19 | 0.27 | 0.27 | 0.22 | 0.24 | 0.24 | 0.16 | 0.43 | 0.45 |
| RMSE | 1.41 | 0.43 | 0.57 | 0.23 | 0.24 | 0.24 | 0.17 | 0.57 | 0.55 |
| 95% Coverage Rate | 0.00 | 0.76 | 0.54 | 0.95 | 0.96 | 0.96 | 0.95 | 0.99 | 0.99 |
| Bias | -1.10 | -0.34 | -0.50 | -0.04 | -0.00 | -0.00 | -0.00 | -0.07 | 0.09 |
| SD | 0.15 | 0.20 | 0.22 | 0.16 | 0.18 | 0.18 | 0.11 | 0.36 | 0.34 |
| Avg. Bootstrap SE | 0.14 | 0.19 | 0.20 | 0.17 | 0.18 | 0.18 | 0.13 | 0.40 | 0.39 |
| RMSE | 1.41 | 0.39 | 0.55 | 0.16 | 0.18 | 0.18 | 0.11 | 0.37 | 0.35 |
| 95% Coverage Rate | 0.00 | 0.59 | 0.26 | 0.95 | 0.94 | 0.94 | 0.96 | 0.97 | 0.98 |

**DGP1: Lee + Linear Utility Function**

**Bias**

**DGP2: Dahl + Linear Utility Function**

**Bias**

**DGP3: Lee + Nonlinear Utility Function**

**Bias**

**DGP4: Dahl + Nonlinear Utility Function**

**Bias**
| \( n_r T \) | \( \beta_2(0) \) | \( \beta_2(1) \) | \( \beta_2(2) \) | \( \beta_2(0) \) | \( \beta_2(1) \) | \( \beta_2(2) \) | \( \rho \) | \( \beta_2(0) \) | \( \beta_2(1) \) | \( \beta_2(2) \) | \( \rho \) | \( \beta_2(0) \) | \( \beta_2(1) \) | \( \beta_2(2) \) |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Bias | -0.12 | -0.07 | 0.10 | 0.11 | -0.14 | 0.20 | -0.08 | -0.06 | 0.07 | 0.04 | -0.14 | 0.18 | -0.11 | 0.07 |
| SD   | 0.31  | 0.27  | 0.29  | 0.26  | 0.32  | 0.36  | 0.25  | 0.26  | 0.26  | 0.19  | 0.32  | 0.34  | 0.32  | 0.34  |
| Avg. Bootstrap SE | 0.28  | 0.26  | 0.27  | 0.25  | 0.34  | 0.36  | 0.25  | 0.27  | 0.28  | 0.19  | 0.36  | 0.38  | 0.35  | 0.38  |
| RMSE | 0.33  | 0.28  | 0.31  | 0.29  | 0.35  | 0.41  | 0.26  | 0.27  | 0.27  | 0.19  | 0.35  | 0.38  | 0.35  | 0.38  |
| 95% Coverage Rate | 0.89  | 0.93  | 0.90  | 0.89  | 0.94  | 0.91  | 0.93  | 0.95  | 0.95  | 0.94  | 0.96  | 0.96  | 0.95  | 0.96  |
| Bias | -0.11 | -0.06 | -0.09 | -0.10 | -0.10 | -0.20 | -0.10 | -0.06 | -0.09 | -0.06 | -0.14 | -0.18 | -0.14 | -0.18 |
| SD   | 0.27  | 0.26  | 0.27  | 0.23  | 0.31  | 0.32  | 0.24  | 0.24  | 0.25  | 0.18  | 0.31  | 0.31  | 0.31  | 0.31  |
| Avg. Bootstrap SE | 0.27  | 0.25  | 0.26  | 0.25  | 0.34  | 0.35  | 0.24  | 0.26  | 0.27  | 0.18  | 0.36  | 0.37  | 0.36  | 0.37  |
| RMSE | 0.29  | 0.26  | 0.28  | 0.25  | 0.35  | 0.38  | 0.26  | 0.27  | 0.27  | 0.19  | 0.34  | 0.36  | 0.34  | 0.36  |
| 95% Coverage Rate | 0.90  | 0.94  | 0.92  | 0.91  | 0.95  | 0.93  | 0.93  | 0.95  | 0.95  | 0.93  | 0.96  | 0.96  | 0.95  | 0.96  |
| Bias | -0.07 | -0.07 | -0.07 | -0.08 | -0.15 | 0.19 | -0.06 | -0.04 | -0.06 | -0.04 | -0.14 | -0.17 | -0.14 | -0.17 |
| SD   | 0.23  | 0.21  | 0.21  | 0.23  | 0.25  | 0.25  | 0.18  | 0.19  | 0.19  | 0.13  | 0.24  | 0.25  | 0.24  | 0.25  |
| Avg. Bootstrap SE | 0.20  | 0.19  | 0.19  | 0.19  | 0.25  | 0.26  | 0.18  | 0.19  | 0.20  | 0.14  | 0.26  | 0.28  | 0.26  | 0.28  |
| RMSE | 0.24  | 0.22  | 0.22  | 0.24  | 0.29  | 0.31  | 0.19  | 0.20  | 0.20  | 0.14  | 0.28  | 0.30  | 0.28  | 0.30  |
| 95% Coverage Rate | 0.90  | 0.92  | 0.91  | 0.89  | 0.91  | 0.91  | 0.93  | 0.95  | 0.95  | 0.94  | 0.94  | 0.94  | 0.94  | 0.94  |

Table 2: Simulation Results on Network-Level Coefficients: Random Forest
Table 3: Simulation Results on Network-Level Coefficients: RF (No Tuning)

| \{n, T\} | \(\beta(0)\) | \(\beta(1)\) | \(\beta(2)\) | \(\rho\) | Lee | Dahl |
|---|---|---|---|---|---|---|
| **DGP1: Lee + Linear Utility Function** | | | | | | |
| Bias | -0.43 | -0.04 | 0.12 | -1.45 | -0.18 | 0.27 |
| {5, 500} | SD | 0.24 | 0.27 | 0.27 | 0.40 | 0.27 | 0.28 |
| RMSE | 0.49 | 0.27 | 0.30 | 1.50 | 0.32 | 0.39 |
| Bias | -0.42 | -0.05 | 0.11 | -1.45 | -0.19 | 0.26 |
| {10, 500} | SD | 0.22 | 0.24 | 0.26 | 0.39 | 0.25 | 0.26 |
| RMSE | 0.47 | 0.25 | 0.28 | 1.51 | 0.31 | 0.36 |
| Bias | -0.40 | -0.05 | 0.10 | -1.52 | -0.19 | 0.26 |
| {5, 1000} | SD | 0.16 | 0.19 | 0.19 | 0.30 | 0.19 | 0.20 |
| RMSE | 0.43 | 0.19 | 0.22 | 1.55 | 0.27 | 0.33 |
| **DGP2: Dahl + Linear Utility Function** | | | | | | |
| Bias | -0.70 | -0.23 | 0.39 | -0.83 | -0.31 | 0.47 |
| {5, 500} | SD | 0.23 | 0.27 | 0.27 | 0.40 | 0.28 | 0.28 |
| RMSE | 0.74 | 0.36 | 0.48 | 0.92 | 0.42 | 0.55 |
| Bias | -0.71 | -0.23 | 0.36 | -0.81 | -0.30 | 0.44 |
| {10, 500} | SD | 0.22 | 0.28 | 0.27 | 0.40 | 0.29 | 0.28 |
| RMSE | 0.74 | 0.36 | 0.45 | 0.90 | 0.42 | 0.52 |
| Bias | -0.68 | -0.23 | 0.36 | -0.80 | -0.31 | 0.45 |
| {5, 1000} | SD | 0.17 | 0.20 | 0.20 | 0.30 | 0.21 | 0.21 |
| RMSE | 0.70 | 0.30 | 0.41 | 0.94 | 0.38 | 0.50 |
| **DGP3: Lee + Nonlinear Utility Function** | | | | | | |
| Bias | -0.59 | 0.21 | 0.22 | -1.51 | 0.23 | 0.24 |
| {5, 500} | SD | 0.26 | 0.29 | 0.30 | 0.44 | 0.29 | 0.30 |
| RMSE | 0.65 | 0.35 | 0.37 | 1.57 | 0.37 | 0.39 |
| Bias | -0.60 | 0.20 | 0.21 | -1.45 | 0.27 | 0.27 |
| {10, 500} | SD | 0.24 | 0.27 | 0.26 | 0.40 | 0.28 | 0.27 |
| RMSE | 0.65 | 0.34 | 0.33 | 1.53 | 0.36 | 0.35 |
| Bias | -0.57 | 0.19 | 0.20 | -1.55 | 0.22 | 0.23 |
| {5, 1000} | SD | 0.17 | 0.20 | 0.18 | 0.29 | 0.20 | 0.19 |
| RMSE | 0.60 | 0.27 | 0.27 | 1.58 | 0.30 | 0.29 |
| **DGP4: Dahl + Nonlinear Utility Function** | | | | | | |
| Bias | -1.13 | 0.54 | 0.55 | -1.23 | 0.53 | 0.54 |
| {5, 500} | SD | 0.24 | 0.28 | 0.28 | 0.40 | 0.29 | 0.28 |
| RMSE | 1.16 | 0.61 | 0.61 | 1.29 | 0.61 | 0.61 |
| Bias | -1.13 | 0.55 | 0.56 | -1.25 | 0.53 | 0.54 |
| {10, 500} | SD | 0.22 | 0.27 | 0.27 | 0.37 | 0.28 | 0.28 |
| RMSE | 1.15 | 0.61 | 0.62 | 1.31 | 0.60 | 0.61 |
| Bias | -1.11 | 0.53 | 0.55 | -1.30 | 0.51 | 0.53 |
| {5, 1000} | SD | 0.16 | 0.19 | 0.20 | 0.27 | 0.20 | 0.21 |
| RMSE | 1.12 | 0.56 | 0.58 | 1.33 | 0.55 | 0.57 |
Table 4: NBA 2015-16 Descriptive Statistics: Outcome Function

| Team | Wins (wins/min) | Experience (mins) | Fatigue (mins) | RPI | Games | Periods | Obs. | ADP |
|------|-----------------|------------------|---------------|-----|-------|--------|------|-----|
|      | Mean            | SD               | Mean          | SD  | Mean  | SD     | Mean | SD  |
| **East Conference** |                 |                  |               |     |       |        |      |     |
| **Atlantic Division** |                 |                  |               |     |       |        |      |     |
| TOR  | 0.0068          | 0.0254           | 13.9906       | 8.952 | 4.8002 | 4.2214 | 0.4975 | 0.0402 |
| BOS  | 0.0061          | 0.0266           | 13.5679       | 8.7688 | 4.5319 | 4.1359 | 0.4970 | 0.0414 |
| NYK  | 0.0058          | 0.0251           | 13.2521       | 8.9107 | 4.4921 | 4.3276 | 0.5001 | 0.0409 |
| BKN  | 0.0053          | 0.0252           | 13.5829       | 8.9497 | 4.5742 | 4.2478 | 0.5008 | 0.0399 |
| PHI  | 0.0051          | 0.0265           | 13.1285       | 8.5196 | 3.6186 | 3.5643 | 0.5030 | 0.0402 |
| **Central Division** |                 |                  |               |     |       |        |      |     |
| CLE  | 0.0066          | 0.0264           | 13.7307       | 9.0387 | 5.8030 | 4.2359 | 0.4984 | 0.0402 |
| IND  | 0.0061          | 0.0251           | 13.9000       | 8.9143 | 4.6639 | 4.1757 | 0.5003 | 0.0401 |
| DET  | 0.0059          | 0.0257           | 14.6659       | 9.4099 | 4.8601 | 4.5260 | 0.4981 | 0.0419 |
| CHI  | 0.0059          | 0.0249           | 13.4434       | 8.8153 | 4.6841 | 4.4133 | 0.4996 | 0.0418 |
| MIL  | 0.0055          | 0.0242           | 14.3271       | 9.5646 | 5.5877 | 5.3570 | 0.5006 | 0.0394 |
| **Southeast Division** |                 |                  |               |     |       |        |      |     |
| MIA  | 0.0065          | 0.0253           | 14.4091       | 8.7387 | 4.7797 | 4.2856 | 0.4982 | 0.0397 |
| ATL  | 0.0063          | 0.0264           | 13.1450       | 8.6175 | 3.3534 | 3.3129 | 0.4996 | 0.0384 |
| CHA  | 0.0068          | 0.0254           | 13.5900       | 8.9516 | 4.9244 | 4.5149 | 0.4972 | 0.0406 |
| WAS  | 0.0061          | 0.0257           | 13.7136       | 9.0765 | 4.7863 | 4.4908 | 0.4996 | 0.0414 |
| ORL  | 0.0060          | 0.0249           | 13.3663       | 9.1810 | 5.1182 | 4.9035 | 0.4984 | 0.0415 |
| **West Conference** |                 |                  |               |     |       |        |      |     |
| **Northwest Division** |                 |                  |               |     |       |        |      |     |
| OKC  | 0.0073          | 0.0265           | 13.5447       | 8.9972 | 4.5932 | 4.3073 | 0.4994 | 0.0413 |
| POR  | 0.0066          | 0.0261           | 13.4148       | 8.7288 | 4.6371 | 4.1711 | 0.5018 | 0.0416 |
| UTA  | 0.0050          | 0.0256           | 13.5649       | 8.9888 | 3.8109 | 3.7618 | 0.5001 | 0.0446 |
| DEN  | 0.0058          | 0.0257           | 13.4496       | 8.7122 | 5.0957 | 4.6100 | 0.5029 | 0.0438 |
| MIN  | 0.0058          | 0.0253           | 13.1619       | 8.9522 | 4.8360 | 4.3706 | 0.5012 | 0.0406 |
| **Pacific Division** |                 |                  |               |     |       |        |      |     |
| GSW  | 0.0081          | 0.0268           | 13.1567       | 9.1074 | 4.2704 | 4.0395 | 0.4968 | 0.0372 |
| LAC  | 0.0065          | 0.0263           | 13.0637       | 8.7264 | 4.6467 | 4.2978 | 0.4997 | 0.0422 |
| SAC  | 0.0064          | 0.0261           | 14.1710       | 9.0768 | 4.8797 | 4.5854 | 0.5018 | 0.0431 |
| PHX  | 0.0053          | 0.0261           | 13.9407       | 9.4149 | 5.2119 | 5.0957 | 0.5028 | 0.0416 |
| LAL  | 0.0056          | 0.0252           | 12.7579       | 9.3083 | 4.9857 | 4.4327 | 0.5042 | 0.0403 |
| **Southwest Division** |                 |                  |               |     |       |        |      |     |
| SAS  | 0.0072          | 0.0253           | 12.2602       | 8.2964 | 3.8246 | 3.6986 | 0.4980 | 0.0398 |
| DAL  | 0.0058          | 0.0257           | 13.4748       | 8.8809 | 4.0182 | 3.9327 | 0.5012 | 0.0434 |
| MEM  | 0.0056          | 0.0252           | 13.5685       | 8.8102 | 4.8904 | 4.4279 | 0.4992 | 0.0439 |
| HOU  | 0.0063          | 0.0269           | 13.8216       | 9.4650 | 4.4653 | 4.7234 | 0.5012 | 0.0419 |
| NOP  | 0.0060          | 0.0252           | 14.2266       | 9.1684 | 5.0658 | 4.5300 | 0.5015 | 0.0408 |

30 NBA teams are partitioned by division and ranked within division by the mean of the outcome variable, **Wins Produced** per minute. **SD**: Standard Deviation; **ADP**: Average Duration per Period; **RPI**: Ratings Percentage Index (a power measure of the opposing team).
Table 5: NBA 2015-16 Descriptive Statistics: Selection Equation

| Team          | N_{guard\_t} | CumScoreDiff_{t\_t} | CurScoreDiff_{t\_t} | CumFoul_{t\_t} | CurFoul_{t\_t} | CurTime_{t\_t} | Duration_{t\_t} | N_{guardR\_t} | N_{guardOPP\_t} |
|---------------|--------------|----------------------|----------------------|---------------|---------------|---------------|---------------|---------------|----------------|
| **East Conference** |             |                      |                      |               |               |               |               |               |                |
| Atlantic Division |             |                      |                      |               |               |               |               |               |                |
| TOR           | 2.17         | 0.54                 | 1.92                 | 8.99          | 0.17          | 6.24          | 0.69          | 0.87          | 25.11          |
| BOS           | 1.89         | 0.59                 | 1.59                 | 10.07         | 0.06          | 7.02          | 0.71          | 0.95          | 25.64          |
| NYK           | 2.18         | 0.42                 | -0.37                | 10.60         | -0.13         | 3.05          | 9.75          | 0.67          | 25.15          |
| BKN           | 1.87         | 0.66                 | -3.85                | 9.96          | -0.32         | 3.04          | 9.30          | 0.61          | 25.58          |
| PHI           | 1.97         | 0.58                 | -6.03                | 10.54         | -0.30         | 3.02          | 10.76         | 0.64          | 24.72          |
| **Central Division** |             |                      |                      |               |               |               |               |               |                |
| CLE           | 2.15         | 0.55                 | 3.31                 | 11.19         | 0.23          | 3.01          | 9.64          | 0.67          | 24.84          |
| IND           | 1.90         | 0.40                 | 1.09                 | 9.26          | 0.11          | 3.01          | 9.88          | 0.67          | 25.54          |
| DET           | 1.68         | 0.47                 | 0.41                 | 10.80         | 0.02          | 3.17          | 9.39          | 0.67          | 25.63          |
| CHI           | 1.44         | 0.52                 | -0.78                | 9.28          | -0.10         | 3.09          | 9.08          | 0.65          | 25.24          |
| MIL           | 1.74         | 0.62                 | -1.96                | 9.56          | -0.19         | 3.08          | 10.22         | 0.71          | 24.82          |
| **Southeast Division** |     |                      |                      |               |               |               |               |               |                |
| MIA           | 1.83         | 0.46                 | 1.23                 | 9.92          | 0.09          | 3.02          | 9.14          | 0.62          | 24.99          |
| ATL           | 1.89         | 0.52                 | 1.23                 | 9.91          | 0.09          | 2.95          | 9.38          | 0.57          | 25.50          |
| CHA           | 2.10         | 0.61                 | 1.17                 | 10.88         | 0.15          | 3.21          | 9.63          | 0.66          | 25.04          |
| WAS           | 2.32         | 0.64                 | 0.19                 | 10.54         | 0.03          | 3.06          | 10.32         | 0.68          | 25.11          |
| ORL           | 1.60         | 0.54                 | 0.01                 | 10.27         | -0.04         | 3.08          | 10.38         | 0.74          | 25.00          |
| **West Conference** |     |                      |                      |               |               |               |               |               |                |
| OKC           | 2.36         | 0.56                 | 4.60                 | 10.05         | 0.29          | 3.08          | 10.32         | 0.68          | 25.36          |
| POR           | 2.50         | 0.55                 | 0.80                 | 11.29         | 0.02          | 3.09          | 10.84         | 0.73          | 25.22          |
| UTA           | 1.76         | 0.53                 | 1.39                 | 11.04         | 0.12          | 2.81          | 9.77          | 0.59          | 25.15          |
| DEN           | 1.83         | 0.52                 | -2.06                | 9.31          | -0.10         | 3.09          | 10.57         | 0.68          | 25.27          |
| MIL           | 1.58         | 0.51                 | -1.62                | 9.37          | -0.15         | 3.05          | 10.14         | 0.67          | 24.56          |
| **Pacific Division** |     |                      |                      |               |               |               |               |               |                |
| GSW           | 2.19         | 0.46                 | 6.62                 | 10.55         | 0.41          | 3.20          | 10.34         | 0.72          | 24.89          |
| LAC           | 2.36         | 0.54                 | 2.22                 | 10.00         | 0.14          | 2.99          | 10.67         | 0.69          | 25.00          |
| SAC           | 1.73         | 0.55                 | -1.90                | 10.37         | -0.12         | 2.97          | 10.12         | 0.63          | 24.87          |
| PHX           | 2.03         | 0.50                 | -4.06                | 10.85         | -0.18         | 3.17          | 11.59         | 0.77          | 25.09          |
| LAL           | 1.91         | 0.30                 | -6.61                | 10.43         | -0.36         | 3.34          | 10.13         | 0.73          | 24.81          |
| **Southwest Division** |     |                      |                      |               |               |               |               |               |                |
| SAS           | 1.51         | 0.51                 | 5.56                 | 10.28         | 0.35          | 2.90          | 8.54          | 0.66          | 25.10          |
| DAL           | 1.98         | 0.57                 | -0.78                | 9.82          | -0.07         | 3.01          | 9.60          | 0.60          | 25.15          |
| MEM           | 1.48         | 0.52                 | -0.77                | 10.22         | -0.08         | 2.94          | 10.68         | 0.73          | 24.97          |
| Hou           | 1.92         | 0.45                 | -0.61                | 10.19         | -0.01         | 3.16          | 10.74         | 0.70          | 24.52          |
| NOP           | 1.90         | 0.55                 | -1.99                | 9.75          | -0.15         | 3.14          | 10.55         | 0.69          | 25.07          |

SD: Standard Deviation; CumScoreDiff_{t\_t} (CurScoreDiff_{t\_t}): Cumulative (Current) Score Difference between the two teams at the end of period t − 1 (in period t − 1); CumFoul_{t\_t} (CurFoul_{t\_t}): Cumulative (Current) number of Fouls committed at the end of period t − 1 (in period t − 1); CurTime_{t\_t} ∈ [0, 48]: game time at the start of period t in minutes; Duration_{t\_t}: Duration of period t − 1; N_{guardR\_t}, N_{guardOPP\_t}, and N_{guardOPP\_t}: Number of Guards on the Roster of the game, of the Period t − 1 and of the OPPosing team of the period t − 1, respectively.
|                  | East Conference          |             | Atlantic Division |             |             |             |             |             |             |             |             |             |
|------------------|--------------------------|-------------|-------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|                  | TOR                      | BOS         | NYK               | BKN         | PHI         |             |             |             |             |             |             |             |
| TOR              | -                        | -0.220      | 0.507             | -0.167      | -0.040      |             |             |             |             |             |             |             |
| BOS              | -0.231                   | 0.384       | -                  | -0.312      | 0.193       |             |             |             |             |             |             |             |
| NYK              | -0.007                   | -0.415      | 0.344             | -           | -0.290      |             |             |             |             |             |             |             |
| BKN              | 0.060                    | 0.215       | -0.183            | 0.388       | -           |             |             |             |             |             |             |             |
| PHI              | -                        |             |                    |             |             |             |             |             |             |             |             |             |

|                  | Central Division         |             |                   |             |             |             |             |             |             |             |             |             |
|                  | CLE                      | IND         | DET               | CHI         | MIL         |             |             |             |             |             |             |             |
| CLE              | -                        | 0.251       | -0.408            | -0.331      | 0.541       |             |             |             |             |             |             |             |
| IND              | -0.319                   | -           | 0.288             | -0.238      | 0.129       |             |             |             |             |             |             |             |
| DET              | 0.424                    | -0.453      | -                  | -0.364      | -0.542      |             |             |             |             |             |             |             |
| CHI              | 0.459                    | 0.197       | 0.180             | -           | -0.483      |             |             |             |             |             |             |             |
| MIL              | -0.470                   | -0.233      | 0.452             | 0.356       | -           |             |             |             |             |             |             |             |

|                  | Southeast Division       |             |                   |             |             |             |             |             |             |             |             |             |
|                  | MIA                      | ATL         | CHA               | WAS         | ORL         |             |             |             |             |             |             |             |
| MIA              | -                        | -0.016      | 0.098             | -0.190      | -0.088      |             |             |             |             |             |             |             |
| ATL              | -0.096                   | -           | 0.325             | 0.470       | -0.273      |             |             |             |             |             |             |             |
| CHA              | -0.061                   | -0.563      | -                  | -0.034      | 0.587       |             |             |             |             |             |             |             |
| WAS              | 0.144                    | -0.316      | 0.059             | -           | -0.180      |             |             |             |             |             |             |             |
| ORL              | 0.419                    | 0.327       | -0.398            | 0.262       | -           |             |             |             |             |             |             |             |

|                  | West Conference          |             |                   |             |             |             |             |             |             |             |             |             |             |
|                  | Northwest Division       |             |                   |             |             |             |             |             |             |             |             |             |             |
|                  | OKC                      | POR         | UTA               | DEN         | MIN         |             |             |             |             |             |             |             |
| OKC              | -                        | 0.068       | 0.348             | -0.423      | 0.123       |             |             |             |             |             |             |             |
| POR              | 0.035                    | -           | 0.243             | -0.234      | -0.349      |             |             |             |             |             |             |             |
| UTA              | -0.280                   | -0.182      | -                  | 0.446       | 0.018       |             |             |             |             |             |             |             |
| DEN              | 0.148                    | 0.134       | -0.409            | -           | -0.181      |             |             |             |             |             |             |             |
| MIN              | -0.140                   | 0.326       | 0.180             | 0.072       | -           |             |             |             |             |             |             |             |
|                  | Pacific Division         |             |                   |             |             |             |             |             |             |             |             |             |             |
|                  | GSW                      | LAC         | SAC               | PHX         | LAL         |             |             |             |             |             |             |             |
| GSW              | -                        | 0.025       | -0.195            | -0.494      | -0.268      |             |             |             |             |             |             |             |
| LAC              | 0.036                    | -           | 0.156             | 0.064       | -0.214      |             |             |             |             |             |             |             |
| SAC              | -0.006                   | -0.210      | -                  | -0.414      | 0.387       |             |             |             |             |             |             |             |
| PHX              | 0.292                    | -0.109      | 0.422             | -           | 0.489       |             |             |             |             |             |             |             |
| LAL              | 0.297                    | 0.208       | -0.271            | -0.305      | -           |             |             |             |             |             |             |             |

|                  | Southwest Division       |             |                   |             |             |             |             |             |             |             |             |             |             |
|                  | SAS                      | DAL         | MEM               | HOU         | NOP         |             |             |             |             |             |             |             |
| SAS              | -                        | 0.288       | 0.067             | -0.134      | 0.370       |             |             |             |             |             |             |             |
| DAL              | -0.370                   | -           | 0.115             | 0.386       | -0.362      |             |             |             |             |             |             |             |
| MEM              | -0.038                   | -0.055      | -                  | 0.031       | 0.070       |             |             |             |             |             |             |             |
| HOU              | 0.266                    | -0.304      | 0.160             | -           | 0.374       |             |             |             |             |             |             |             |
| NOP              | -0.254                   | 0.282       | 0.016             | -0.375      | -           |             |             |             |             |             |             |             |

Average indirect effect from a competitor is the average of row sum of the right-hand corner $5 \times 5$ submatrix of the $10 \times 10$ network matrix over all time periods for a given team and opposing team.
Table 7: Product Competitor Effect Estimates, $\lambda_{rk}\lambda_{kr}$, within Division

### East Conference

| Atlantic Division | tor | bos | nyk | bkn | phi | tor | bos | nyk | bkn | phi |
|-------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| TOR               | -0.064 | -0.141 | -0.319 | -0.298 | -0.121 | -0.002 | -0.773 | -2.516 | -2.939 | -1.187 |
| BOS               | -0.319 | -0.298 | -0.121 | -0.038 | -0.147 | -0.002 | -0.773 | -2.516 | -2.939 | -1.187 |
| NYK               | -0.319 | -0.298 | -0.121 | -0.038 | -0.147 | -0.002 | -0.773 | -2.516 | -2.939 | -1.187 |
| BKN               | -0.319 | -0.298 | -0.121 | -0.038 | -0.147 | -0.002 | -0.773 | -2.516 | -2.939 | -1.187 |
| PHI               | -0.319 | -0.298 | -0.121 | -0.038 | -0.147 | -0.002 | -0.773 | -2.516 | -2.939 | -1.187 |

| Central Division | cle | ind | det | chi | mil | cle | ind | det | chi | mil |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| TOR              | -0.094 | -0.239 | -0.264 | -0.575 |
| BOS              | -0.174 | -0.052 | -0.030 | -0.483 | -0.239 |
| NYK              | -0.121 | -0.038 | -1.187 | -0.681 |
| BKN              | -0.147 | -1.717 |
| PHI              | -0.165 |

| Southeast Division | mia | atl | cha | was | orl | mia | atl | cha | was | orl |
|-------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| TOR               | -0.006 | -0.302 | -0.002 | -0.468 | -0.049 |
| BOS               | -0.319 | -0.298 | -0.121 | -0.038 | -0.147 |
| NYK               | -0.121 | -0.038 | -1.187 | -0.681 |
| BKN               | -0.147 | -1.717 |
| PHI               | -0.165 |

### West Conference

| Northwest Division | okc | por | uta | den | min | okc | por | uta | den | min |
|--------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| TOR               | 0.002 | -0.045 | -0.033 | -0.320 | -0.002 | -0.001 | -0.001 | -0.034 | -0.007 | -0.005 |
| BOS               | -0.045 | -0.033 | -0.320 | -0.002 | -0.001 | -0.001 | -0.034 | -0.007 | -0.005 | -0.005 |
| NYK               | -0.045 | -0.033 | -0.320 | -0.002 | -0.001 | -0.001 | -0.034 | -0.007 | -0.005 | -0.005 |
| BKN               | -0.045 | -0.033 | -0.320 | -0.002 | -0.001 | -0.001 | -0.034 | -0.007 | -0.005 | -0.005 |
| PHI               | -0.045 | -0.033 | -0.320 | -0.002 | -0.001 | -0.001 | -0.034 | -0.007 | -0.005 | -0.005 |

| Pacific Division | gsw | lac | sac | phx | lal | gsw | lac | sac | phx | lal |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| TOR               | -0.116 | -0.072 | -0.017 | 0.384 | -1.196 | -0.906 | -0.535 | -2.585 | 0.121 | -0.228 |
| BOS               | -0.045 | -0.033 | -0.320 | 0.003 | -0.103 |
| NYK               | -0.045 | -0.033 | -0.320 | 0.003 | -0.103 |
| BKN               | -0.045 | -0.033 | -0.320 | 0.003 | -0.103 |
| PHI               | -0.045 | -0.033 | -0.320 | 0.003 | -0.103 |

| Southwest Division | sas | dal | mem | hou | nop | sas | dal | mem | hou | nop |
|--------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| TOR               | -0.140 | -0.006 | -0.155 | -0.118 | -0.098 | -0.655 | -1.100 |
| BOS               | -0.006 | -0.155 | -0.118 | -0.098 | -0.655 | -1.100 |
| NYK               | -0.140 | -0.006 | -0.155 | -0.118 | -0.098 | -0.655 | -1.100 |
| BKN               | -0.006 | -0.155 | -0.118 | -0.098 | -0.655 | -1.100 |
| PHI               | -0.140 | -0.006 | -0.155 | -0.118 | -0.098 | -0.655 | -1.100 |

The standard errors are computed using the Delta method.
Table 8: Other Parameter Estimates from First-Stage Estimation

| Team | Parameter Estimate | t-statistics |
|------|--------------------|--------------|
|      | Exper. | Fatigue | $\sigma^2$ | Exper. | Fatigue | $\sigma^2$ |
| TOR  | 0.0000 | 0.0002 | 0.0007 | 0.4322 | 2.1627 | 60.0333 |
| BOS  | 0.0002 | 0.0000 | 0.0007 | 1.9461 | 0.1305 | 61.5467 |
| NYK  | 0.0001 | 0.0001 | 0.0007 | 1.0801 | 1.5110 | 60.7783 |
| BKN  | 0.0001 | -0.0001 | 0.0007 | 0.7985 | -1.3967 | 60.6300 |
| PHI  | 0.0001 | 0.0001 | 0.0007 | 0.7050 | 1.3797 | 64.2028 |
| CLE  | -0.0002 | 0.0004 | 0.0007 | -2.1448 | 3.9403 | 61.3677 |
| IND  | 0.0001 | 0.0001 | 0.0007 | 0.7459 | 0.8906 | 60.6465 |
| DET  | -0.0001 | 0.0002 | 0.0007 | -0.8755 | 2.6751 | 59.2284 |
| CHI  | 0.0001 | 0.0001 | 0.0006 | 0.7086 | 1.1942 | 59.8832 |
| MIL  | 0.0001 | 0.0000 | 0.0006 | 1.290 | -0.3539 | 59.7662 |
| MIA  | 0.0000 | 0.0001 | 0.0006 | 0.0699 | 1.2007 | 60.7783 |
| ATL  | 0.0003 | -0.0001 | 0.0007 | 2.9096 | -0.7113 | 63.5767 |
| CHA  | 0.0000 | 0.0001 | 0.0007 | 0.2671 | 1.3312 | 59.0085 |
| WAS  | 0.0000 | 0.0000 | 0.0007 | -0.1675 | 0.4690 | 61.8708 |
| ORL  | 0.0001 | 0.0000 | 0.0007 | 0.9473 | -0.4786 | 60.2495 |
| OKC  | -0.0001 | 0.0002 | 0.0007 | -0.9113 | 2.2144 | 60.9426 |
| POR  | 0.0001 | 0.0001 | 0.0007 | 0.5428 | 1.0831 | 60.6465 |
| UTA  | 0.0001 | 0.0003 | 0.0007 | 1.0949 | 2.9773 | 63.7966 |
| DEN  | 0.0001 | 0.0001 | 0.0007 | 1.4732 | 1.1264 | 60.7124 |
| MIN  | 0.0000 | 0.0001 | 0.0007 | 0.4925 | 1.4218 | 61.4980 |
| GSW  | 0.0001 | 0.0000 | 0.0007 | 0.9378 | 0.4554 | 61.5042 |
| LAC  | -0.0002 | 0.0003 | 0.0007 | -2.0434 | 2.8251 | 61.0246 |
| SAC  | 0.0000 | 0.0001 | 0.0007 | 0.0606 | 0.8664 | 62.5620 |
| PHX  | -0.0001 | 0.0000 | 0.0007 | -1.0618 | 0.0162 | 60.3490 |
| LAL  | 0.0000 | 0.0001 | 0.0007 | 0.3291 | 1.5397 | 59.1946 |
| SAS  | -0.0001 | 0.0002 | 0.0007 | -0.6380 | 2.3176 | 61.2862 |
| DAL  | 0.0001 | -0.0001 | 0.0007 | 1.6625 | -0.8558 | 62.7375 |
| MEM  | 0.0000 | 0.0001 | 0.0007 | -0.4087 | 0.9881 | 60.9098 |
| HOU  | 0.0000 | 0.0002 | 0.0007 | 0.5125 | 2.2838 | 62.6738 |
| NOP  | 0.0001 | 0.0001 | 0.0006 | 1.2368 | 1.7580 | 61.2372 |

Exper. is Experience. Standard errors are computed using the asymptotic results of Lee et al. (2010).
| Team | Home | Half | RPI | SB | Home | Half | RPI | SB |
|------|------|------|-----|----|------|------|-----|----|
| TOR  | 0.0000 | -0.0002 | -0.0016 | 0.0005 | 0.0938 | -0.4976 | -0.1799 | 0.3155 |
| BOS  | 0.0000 | -0.0045 | -0.0076 | 0.0000 | 0.5481 | -4.4823 | -1.7804 | -0.6415 |
| NYK  | -0.0003 | -0.0021 | -0.0020 | 0.0001 | -0.4591 | -3.7866 | -0.1946 | 0.0905 |
| BKN  | 0.0009 | -0.0005 | -0.0013 | -0.0014 | 1.4976 | -0.8976 | -1.3412 | -1.7153 |
| PHI  | 0.0001 | -0.0004 | -0.0012 | 0.0003 | 0.1985 | -0.7865 | -0.8640 | 0.3908 |
| CLE  | 0.0002 | -0.0022 | -0.0015 | 0.0010 | 0.3476 | 3.6505 | -1.5563 | 1.2754 |
| IND  | 0.0004 | -0.0011 | -0.0049 | -0.0012 | 0.6670 | -1.9592 | -0.5085 | -0.5567 |
| DET  | 0.0011 | 0.0011 | -0.0226 | 0.0001 | 2.1510 | 1.7195 | -2.3251 | 0.0921 |
| CHI  | 0.0003 | -0.0007 | -0.0030 | 0.0012 | 0.5459 | -1.1011 | -2.8896 | 1.1375 |
| MIN  | 0.0012 | 0.0001 | -0.0003 | 0.0000 | 0.6604 | 0.5793 | -1.2921 | 0.0906 |
| MIA  | 0.0005 | -0.0002 | -0.0021 | 0.0004 | 0.8208 | -0.3501 | -2.0987 | 0.1721 |
| ATL  | 0.0001 | -0.0027 | -0.0361 | -0.0018 | 0.9024 | -6.4545 | -3.8706 | -1.1457 |
| CHA  | 0.0012 | -0.0005 | -0.0075 | -0.0009 | 2.0826 | -0.8465 | -0.9330 | -0.4459 |
| WAS  | 0.0007 | 0.0001 | -0.0213 | -0.0009 | 1.1842 | 0.1053 | -1.8594 | -1.5900 |
| ORL  | 0.0001 | -0.0016 | -0.0011 | -0.0002 | 0.2044 | -2.7118 | -0.0998 | -0.2885 |
| OKC  | 0.0002 | -0.0006 | 0.0019 | -0.0005 | 0.3707 | 0.9853 | -1.1714 | -0.3338 |
| POR  | 0.0007 | -0.0008 | 0.0018 | -0.0002 | 1.4196 | -1.4578 | 0.1697 | -0.1983 |
| UTA  | 0.0009 | -0.0009 | -0.0052 | -0.0003 | 1.6589 | -1.6497 | -0.6611 | -0.3410 |
| DEN  | 0.0005 | -0.0024 | -0.0036 | 0.0012 | 0.8774 | -4.2105 | -0.3757 | 1.4980 |
| MIN  | 0.0000 | -0.0011 | 0.0009 | -0.0002 | -0.0496 | -1.9122 | 0.6609 | -0.2508 |
| GSW  | 0.0008 | -0.0015 | -0.0030 | -0.0007 | 1.3449 | -2.5837 | -0.2933 | -0.9381 |
| LAC  | 0.0002 | -0.0023 | -0.0064 | 0.0020 | 0.3681 | 3.8951 | -0.5227 | 2.3539 |
| SAC  | 0.0004 | -0.0004 | -0.0019 | -0.0004 | 0.8405 | -0.7953 | -1.1531 | -0.3442 |
| PHX  | 0.0007 | -0.0007 | -0.0034 | -0.0008 | 1.0747 | 3.3409 | -0.2891 | 0.3144 |
| LAL  | 0.0007 | -0.0002 | -0.0024 | -0.0027 | 1.0083 | 0.3828 | -2.1520 | -2.3189 |
| SAS  | 0.0006 | 0.0009 | -0.0342 | -0.0013 | 1.0194 | 1.6524 | -3.9568 | -0.6966 |
| DAL  | 0.0007 | -0.0015 | -0.0096 | -0.0005 | 1.3417 | -2.9593 | -1.0208 | -0.2442 |
| MEM  | 0.0008 | -0.0004 | -0.0017 | -0.0008 | 1.4729 | -0.8841 | -1.7251 | -0.9201 |
| HOU  | 0.0010 | 0.0004 | -0.0030 | 0.0005 | 1.5626 | 0.5905 | -1.2372 | 0.2069 |
| NOP  | 0.0011 | -0.0004 | -0.0222 | -0.0002 | 2.6907 | -0.8260 | -2.4852 | -0.2451 |

SB: Selection Bias coefficient (i.e. $\sigma_{12r}$ in equation 10 of the main text). Bootstrap standard errors.
### Table 10: Outcome Function Estimates (Network-Level): Dahl (2002) Semi-Parametric Approach

| Team | Random Forest | Multinomial Logit |
|------|---------------|-------------------|
|      | Parameter Estimates | t-statistics | Parameter Estimates | t-statistics |
|      | Home Half RPI | Home Half RPI | Home Half RPI | Home Half RPI |
| TOR  | 0.0001 -0.0003 -0.0016 0.0952 -0.4881 -0.1691 |               | 0.0001 -0.0003 -0.0016 0.1144 -0.4697 -0.1651 |
| BOS  | 0.0003 -0.0025 -0.0176 0.5516 -4.0062 -1.7817 |               | 0.0003 -0.0025 -0.0175 0.5388 -3.9773 -1.7589 |
| NYK  | -0.0003 -0.0021 -0.0220 -0.4599 -3.5814 -0.1941 |               | -0.0003 -0.0020 -0.0199 -0.4724 -2.5579 -0.1902 |
| BKN  | 0.0009 -0.0005 -0.0134 1.4782 -0.8570 -1.3371 |               | 0.0009 -0.0005 -0.0134 1.4738 -0.8823 -1.3204 |
| PHI  | 0.0002 -0.0004 -0.0114 0.2669 -0.6814 -0.1941 |               | 0.0002 -0.0004 -0.0118 0.2674 -0.6757 -0.1864 |
| CLE  | 0.0002 0.0023 -0.0143 3.5593 -1.6480 -0.1448 |               | 0.0002 0.0020 -0.0155 0.3178 2.8157 -1.5774 |
| IND  | 0.0003 -0.0012 -0.0050 0.6166 -2.1052 -0.5114 |               | 0.0005 -0.0011 -0.0047 0.8011 -1.7782 -0.4850 |
| DET  | 0.0011 0.0011 -0.228 2.0616 -1.7453 -1.3415 |               | 0.0011 0.0009 -0.0224 2.0278 1.4673 -2.3043 |
| CHI  | 0.0003 -0.0007 -0.0371 0.5362 -1.1239 -2.8910 |               | 0.0004 -0.0007 -0.0359 0.7090 -1.0655 -2.7865 |
| MIL  | 0.0011 -0.0011 0.0044 1.7108 -1.7047 0.4268 |               | 0.0011 -0.0011 0.0044 1.6884 -1.6991 0.4319 |
| MIA  | 0.0005 -0.0002 -0.0214 0.8189 -0.3470 -2.0953 |               | 0.0005 -0.0002 -0.0214 0.7845 -0.2801 -2.1017 |
| ATL  | 0.0001 -0.0026 -0.0355 0.9811 -4.3300 -3.7971 |               | 0.0000 -0.0027 -0.0361 0.0819 4.5066 -3.8924 |
| CHA  | 0.0012 -0.0005 -0.0075 2.0737 -0.8479 -0.9379 |               | 0.0012 -0.0005 -0.0074 2.0724 -0.7985 -0.9334 |
| WAS  | 0.0007 0.0001 -0.213 1.1771 0.1255 -1.8571 |               | 0.0007 0.0003 -0.0197 1.2687 0.4984 -1.7179 |
| ORL  | 0.0001 -0.0017 -0.0009 0.1996 -2.7319 -0.0823 |               | 0.0001 -0.0016 -0.0011 0.1987 -2.6877 -0.0923 |
| OKC  | 0.0003 0.0006 -0.0122 0.4932 0.8934 -1.1982 |               | 0.0002 0.0006 -0.0119 0.3711 0.9487 -1.1716 |
| POR  | 0.0007 -0.0009 0.0027 1.3850 -1.6555 0.2512 |               | 0.0007 -0.0008 0.0018 1.4068 1.4104 0.1693 |
| UTA  | 0.0009 -0.0009 -0.0053 1.6466 -1.6512 -0.6665 |               | 0.0009 -0.0009 -0.0052 1.6601 1.6156 -0.6601 |
| DEN  | 0.0005 -0.0024 -0.0036 0.8727 -4.0382 -0.3739 |               | 0.0005 -0.0023 -0.0036 0.8582 -4.1444 -0.3715 |
| MIN  | 0.0000 -0.0011 0.0069 -0.0493 -1.8248 0.6582 |               | 0.0000 -0.0011 0.0069 -0.0530 -1.8358 0.6690 |
| GSW  | 0.0008 -0.0015 -0.0031 1.3672 -2.4139 -0.2950 |               | 0.0008 -0.0015 -0.0031 1.3179 -2.3322 -0.2942 |
| LAC  | 0.0002 0.0023 -0.0065 0.3680 3.6931 -0.5288 |               | 0.0002 0.0023 -0.0062 0.3838 3.7818 -0.5078 |
| SAC  | 0.0004 -0.0005 -0.0010 0.8699 -0.8803 -1.1506 |               | 0.0003 -0.0009 -0.0015 0.6069 -1.5301 -1.1918 |
| PHX  | 0.0007 0.0001 -0.0034 1.0887 3.3329 -0.2909 |               | 0.0006 0.0016 -0.0013 0.9074 2.5161 -0.1132 |
| LAL  | 0.0007 0.0002 -0.0020 0.9952 0.3652 -2.1370 |               | 0.0006 0.0022 -0.0251 0.9509 0.3316 -2.1368 |
| SAS  | 0.0006 0.0009 -0.0034 1.0150 1.6469 -3.9480 |               | 0.0006 0.0009 -0.0034 1.0275 1.5818 -3.9721 |
| DAL  | 0.0007 -0.0015 -0.0006 1.3436 -2.9338 -1.0233 |               | 0.0007 -0.0015 -0.0007 1.3232 -2.8085 -1.0123 |
| MEM  | 0.0008 -0.0004 -0.0175 1.4848 -0.8341 -1.7207 |               | 0.0008 -0.0004 -0.0175 1.4825 -0.8136 -1.7272 |
| HOU  | 0.0010 0.0004 -0.0130 1.5623 0.5864 -1.2369 |               | 0.0010 0.0004 -0.0130 1.5495 0.5763 -1.2314 |
| NOP  | 0.0011 -0.0003 -0.0226 2.1017 -0.6382 -2.5118 |               | 0.0011 -0.0004 -0.0223 2.1106 -0.7952 -2.4880 |

Bootstrap standard errors.
References

[1] Breiman, L. 2001. Random Forests. Machine Learning, 45, 5–32.

[2] Elhost, J. P., 2014. Spatial Econometrics: From Cross-Sectional Data to Spatial Panels. Springer.

[3] Glass, A. J., Kenjegalieva, K., and Sickles, R. C., 2016. A spatial autoregressive stochastic frontier model for panel data with asymmetric efficiency spillovers, Journal of Econometrics, Volume 190, Issue 2, 289-300.

[4] James, G., Witten, D., Hastie, T. and Tibshirani, R. 2017. An introduction to statistical learning. Springer.

[5] Lee, B., Lessler, J., and Stuart, E., 2010. Improving propensity score weighting using machine learning. Stat Med. 2010 February 10; 29(3): 337-346.

[6] Lee, L.F., 2007. Identification and estimation of econometric models with group interactions, contextual factors and fixed effects. J. Econometrics 140, 333-374.

[7] Lee, L.F., Liu, X. and Lin, X., 2010. Specification and estimation of social interaction models with network structures. The Econometrics Journal, 13(2), 145-176.

[8] Lesage, J. and Pace, R., 2009. Introduction to Spatial Econometrics. Chapman and Hall/CRC.

[9] Mentch, L., and Hooker, G. 2016. Quantifying Uncertainty in Random Forests via Confidence Intervals and Hypothesis Tests. Journal of Machine Learning Research, 17, 1-41.

[10] Ord, J.K., 1975. Estimation methods for models of spatial interaction. J. the American Statistical Association 70, 120-297.

[11] Scornet, E., Biau, G., and Vert, J. P. 2015. Consistency of Random Forests. The Annals of Statistics, 43, 1716–1741.

[12] Wager, S. and Athey, S. 2018 Estimation and Inference of Heterogeneous Treatment Effects using Random Forests, Journal of the American Statistical Association, 113:523, 1228-1242.

[13] Wager, S. and Walther, G. 2015. Adaptive Concentration of Regression Trees with Application to Random Forests. arXiv:1503.06388.