Private Benefits, Public Vices

Railways and Logrolling in the Nineteenth Century British Parliament

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1 Data Appendix

1.1 MP Investment in Railways

We collected data on how much MPs had invested in railways and which railways they had invested in by drawing on two parliamentary papers: *1845 (317) Railways*, and *1846 (473) Railways*. The papers listed all subscribers to railways for sums above £2,000. Typically, only 5% to 10% of the value of a share had be paid in upfront, thus a £2,000 cutoff implies investments of approximately £100 to £200.

The Parliamentary Papers that reported the investments also listed the profession of the investor, and it is on the basis of MP's identifying themselves as such that we can identify MP investors. All the MPs are then cross-checked with the list of MPs seating in Parliament in 1845 and 1846.

1.2 Data on Railways Crossing MP Constituencies

Our encoding of a 'geographical' interest by MPs in railways required multiple steps: determining the intended routes, geocoding the route information, establishing the boundaries of historical political constituencies, and, finally, checking if a railway crossed an MP constituency.

Since the majority of the railways included in our sample never built any track, ascertaining their proposed route was not trivial. To do so, we drew on *Tuck's Railway Shareholder's*

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Manual, editions 6 through 8, which covered the years 1845 through 1847. The manual listed towns through which the railway intended to pass in detail. Figure 1 shows an example of the way in which the source described the route of a railway projected to connect two towns in Devonshire.

Figure 1: Excerpt from *Tuck's Railway Shareholder's Manual*, 7th Edition

69. BIDEFORD AND TAVISTOCK RAILWAY.—To commence at the port of Bideford, passing through Torrington, Hatherleigh, and Okehampton, terminating in junction with the South Devon Railway at Tavistock. Length, 42 miles Capital	350,000
14,000 *Shares of 25l. each.*	

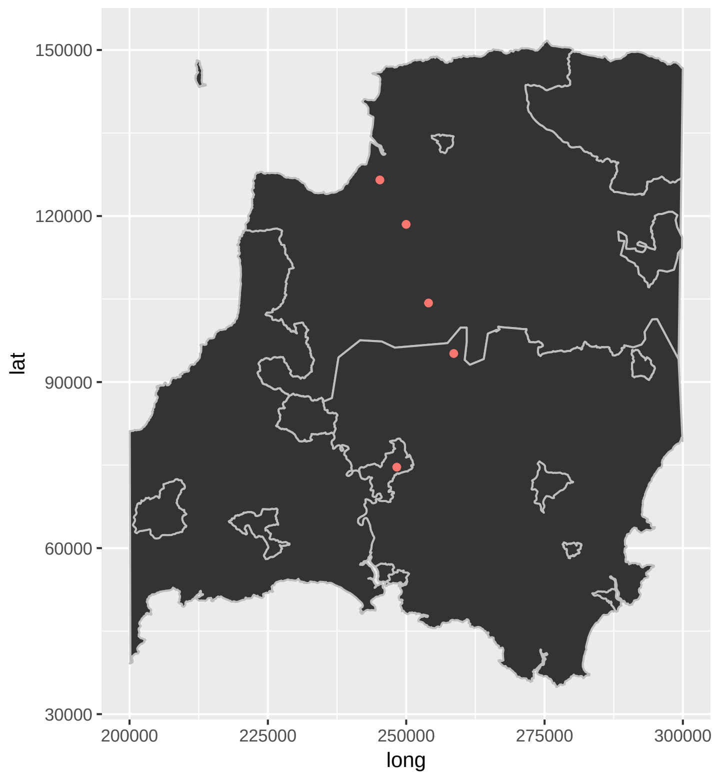
We geocoded the location of all the towns a given railway was intending to pass through using google maps, which yielded a vector of latitude-longitude coordinates associated with each railway line. We then plotted the historic constituency boundaries, using the shapefiles created by the Great Britain Historical GIS Project and the University of Plymouth, and hosted at `www.VisionofBritain.org.uk`. We could then overlay the vector of points that defined a railway's route on the shapefiles of historical constituency boundaries and determine which constituencies were crossed by a railway. Figure 2 shows the map corresponding to the geocoded place names we collected from Figure 1 projected on the historical constituency boundaries.

Since projected railways were typically short, the coding rarely required any judgment calls about which constituencies intersected which railways. Furthermore, we coded which railways crossed which constituencies directly from the stopping points listed in *Tuck's Railway Shareholder's Manual*, rather than by interpolating lines between the points. Our reasoning was that whereas the points were definite, any interpolation could result in the introduction of a link between an MP and a railway when in fact no such link existed. On the basis of our analysis of the behavior of the estimator under measurement error (section 5.2 in the text), we are confident that a failure to record links results in attenuation bias, but the direction of bias as a result of recording links when in fact they did not exist is unclear. Consequently, we chose to default to the more conservative encoding that relied on points.

1.3 MP Oversight of Railways

We determined which MPs oversaw which railways by drawing on Parliamentary Papers that published the allocation of MPs and railways to groups. For 1845 this was easily recorded

Figure 2: Bideford and Tavistock Route Mapped Across Historic Constituency Boundaries



using Parliamentary Paper *1845 (620)*. For 1846 this was done by consulting the report on the Sittings of the House for Private bills and Acts, which were published in paper *1846 (723-II)*.

1.4 MP Covariates and Constituency Covariates

Dependent variable: % Railways Approved: The primary dependent variable of interest in all spatial specifications is the fraction of railway projects that were approved. The numerator in the fraction is the number of railway companies in which a MP had an interest and that were approved by Parliament. Interests are computed from geographical and investment matrices described in the main text. We determined whether or not a railway was approved by collecting data on committee outcomes published in *Parliamentary Papers 1845 (637)* and *1847 (708)*. The denominator in the fraction is simply the number of railways in which an MP has a vested interest as defined by our interest matrices.

Number of Railways Projected in Constituency: This covariate is a count of the number of railways that were projected to cross an MP's constituency. It is computed as the row-sums of the matrix that describes geographical links between MPs and railways.

Number of Railway Investments: This covariate is a count of the number of railways an MP has invested in. It is computed as the row-sums of the matrix that defines MP interests in railways stemming from their investments.

Number of Railways Overseen: This covariate records a count of the number of railways that each MP oversaw. It is computed as the row-sums of the MP oversight matrix.

Liberal Dummy: This covariate is Aydelotte's two-way party breakdown of MPs (variable 173), that classifies them as either conservative or liberal, with the variable taking on a 1 if the MP is classified as liberal.

Education Dummy: This is a dummy variable constructed by Aydelotte (variable 17), that takes on a 1 if the MP was university educated.

Athenaeum Member Dummy: This is a dummy variable recorded by Aydelotte (variable 4), that takes on a 1 if the MP is a member of the Athenaeum Club. It is included under the hypothesis that clubs could have functioned as locations in which to broker trades. We selected the Athenaeum (as opposed to other clubs) as it ostensibly selected MPs along dimensions other than party affiliation.

Business MP Dummy: This is a dummy constructed by Aydelotte (variable 118) and that summarizes the data he collected on MP business interests. The measure discretizes MPs into those who were active in business of any sort and those who were not, with active business MPs coded as a 1.

Reform MP Dummy: This is a dummy variable computed from Aydelotte's five-way party breakdown (variable 174). It was included as reforming MPs might have had a different willingness to participate in logrolling. In addition, the reform block constituted a somewhat distinct dimension of British political affiliation that is not well captured by the Liberal Dummy alone.

Canal MP Dummy: This is dummy variable (number 140 in Aydelotte's dataset), which records whether or not an MP had an active business interest in the canal sector. Canal's were reputed to be opposed to the encroachment of railway companies.

Freetrade Club Dummy: This is dummy variable (number 9 in Aydelotte's dataset) and measures whether or not an MP was a member of the Freetrade Club. We included this to capture a political dimension that was not as well captured by the political controls, and because the free-trade lobby constituted an important interest group in this period.

Constituency Population: Total constituency population as measured by Aydelotte's variable number 403.

1.5 Railway Company Share Prices and Covariates

Tobin's Q: Tobin's Q was computed using data from the *Railway Monitor*, which was a supplement published by the *Economist* that compiled share prices of railway companies across the London, Liverpool, Manchester and Leeds exchanges. Since the railway mania burst during our estimation period, the vast majority of companies refrained from calling up the remainder of the par value of the shares until after 1847. Leverage was equally small, as companies had trouble selling tradable long-term debt during this period. New companies approved in 1846 and that were not part of existing railway groups had a median gearing of zero until March 1848.[1] Even though firms borrowed some sums short (probably by accepting bills), we do not have information on how they would be discounted in the short-term market. As a result, we calculated a simplified version of Tobin's Q (ignoring debt) as the ratio between share prices and their par values.

We do have to correct our measure for a different issue. As listed shares were only partly paid, they effectively traded as derivative-like assets (Campbell 2013). For this reason, we compute the shadow price of a fully-paid share (S) from the observed prices of partly-paid shares (P):

$$S = P + Ke^{-(r+q)t}$$

where K is the amount of future capital calls, r is the risk-free rate and q the dividend rate on the share. Because companies did not publish schedules for calling up their capital, we need to make assumptions about the timing of the calls K. Similarly to Campbell (2013), we assume equally distributed calls over a period of 5 years. We used the Bank of England discount rate as a proxy for r and assumed an expected 5% dividend rate. Realised dividends varied a lot across companies, but the overall average dividend/par ratio in railways from 1845 to 1847 was very close to 5% and so we took it as a proxy for the reasonable expectation of railway dividends in the period (Cambell and Turner 2012).[2]

Logroll Dummy Variable: Our primary independent variable of interest is a dummy variable that encoded whether or not a railway could have been the product of logrolling. This was derived by transposing the interest and oversight matrices, and computing a new logrolling

[1] According to the data in *1848 (731) A Return, "Showing the Name of Each Railway for Which Acts Have Been Obtained..."* (1848). Parliamentary Papers. House of Commons.

[2] Experimenting with different dividend rates cannot affect the estimation results since it is equivalent to a level re-scaling of the left-hand side variable. Moreover, OLS estimates in a linear model remain unbiased under general assumptions, even if the left-hand side is measured with error. Efficiency, however, is lower (Hausman 2001).

matrix defined at the company-by-company level. Let O be the $P \times C$ *oversight* matrix and V the $P \times C$ matrix of *vested interests* defined in the main text. We identified which railways had logrolling opportunities by listing the cycles in the following $C \times C$ matrix:

$$M' = O^T \times V$$

Liquidity (% quotes): The measure of liquidity we use is the percentage of days on a given week in which a given railway share was quoted in the *Railway Monitor* tables for Leeds, Liverpool, London or Manchester.

Volatility: This is a time-varying measure of share-price volatility computed by taking the monthly variance of each share's prices.

MP count: This covariate controls for the level of direct political involvement in a company as measured by the number of MPs who had invested in it. The number of MP investors is taken from the *Parliamentary Papers* detailing the size and allocation of MP investments, which we used to calculate the MP investment data (see above).

2 Specification

We aim to model the equilibrium level of vote trading subject to some restrictions on the set of feasible trades. We observe MPs $\{i, j, k, ...\} \in M$, who can trade on the basis of railway projects $\{r, s, t, ...\} \in R$. Only a small set of trades among MPs were feasible in the historical context and our specification needs to reflect this in modelling the equilibrium trading behavior. This also implies that we cannot model each trade independently, as is done in dyadic regressions. The dyadic framing is not ideal as it cannot capture three-way trades, nor can it capture equilibrium behavior when MPs have multiple overlapping trades. In effect, it imposes the assumption that trades between any pairs of MPs are independent.

Nevertheless, for reasons of exposition it is helpful to start by thinking through what our model would look like in the simpler dyadic setting if we could observe everything of interest. In this setting, we would model votes as:

$$\texttt{vote}_{irsj} = \beta \texttt{trade}_{irsj} \texttt{vote}_{jrsi} + \gamma \omega_{irsj} + \epsilon_{irsj}, \tag{1}$$

where $\texttt{vote}_{irsj}$ can be read as MP i receiving a vote for railway project r in exchange for a vote on railway project s from MP j, and ω_{irsj} contains MP and railway specific covariates. Because our information on railways is sparse, we can collapse this large hypothetical structure along one margin (railways) of the two-way MP-Railway network yielding the model:

$$\texttt{votes}_{ij} = \beta \texttt{trade}_{ij} \texttt{votes}_{ji} + \gamma \omega_{ij} + \epsilon_{ij}. \tag{2}$$

Since this is just a sum across pairs of railways, β is preserved.

We now want to overcome the limitations of the dyadic framing so as to allow an MP's trading decisions with all of his trading partners to be simultaneously determined. This requires a parameterization of how an MP's trading partners affect his outcome. We follow the approach in the social networks literature of aggregating outcomes across trading partners:

$$\begin{aligned} \texttt{votes}_i &= \rho \sum_j \left(\texttt{trade}_{ij} \texttt{votes}_{ji} + \gamma \omega_{ij} + \epsilon_{ij} \right) \\ \texttt{votes} &= \rho \Lambda \texttt{votes} + \gamma X + \epsilon \end{aligned} \tag{3}$$

Written in this way it is clear that the trade indicator in the above regression is the 'long' form of our logrolling matrix Λ – it is Λ with each row-column combination placed in a vector rather than in an $M \times M$ matrix. Since in aggregating in this way we lose covariates that are indexed by j, it is sensible to insert covariates that are functions of the characteristics of j. In our specification this takes the form of the controls $M^T X$, which capture the characteristics of other MPs who could influence MP i's outcome.

Thus, taking into account dependence across logrolls and between multiple trading partners, while seeking to model the effects of the identity of those trading partners, we arrive at the specification

$$\texttt{votes} = \alpha\iota + \rho\Lambda\texttt{votes} + \beta X + \delta M^T X + \epsilon. \tag{4}$$

which would be our empirical specification if we observed individual voting. Since we do not perfectly observe voting, we substitute committee approvals for `votes`. We consider the ramifications of this substitution in the next section.

Table 1: Estimates of Peer-effects Model for 1845, Logroll Length Two

	Model 1	Model 2	Model 3	Model 4
ρ	0.47 (0.20)*	0.43 (0.20)*	0.42 (0.19)*	0.68 (0.26)**
Intercept	0.17 (0.03)***	0.12 (0.05)*	0.12 (0.06)*	0.17 (0.06)**
Num RW Projected in Constituency	0.00 (0.00)	0.00 (0.00)	0.00 (0.01)	−0.00 (0.01)
Num RW Investments	0.00 (0.02)	−0.00 (0.03)	0.00 (0.02)	0.01 (0.03)
Num RW Overseen	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Lag RW Proj. in Const.	0.00 (0.04)	−0.00 (0.04)	−0.01 (0.04)	−0.03 (0.04)
Lag Num RW Invest.	0.03 (0.13)	0.02 (0.14)	0.03 (0.14)	0.05 (0.14)
Lag Num RW Overseen	−0.01 (0.01)	0.01 (0.02)	0.00 (0.02)	0.00 (0.02)
Liberal Dummy		0.07 (0.05)	0.08 (0.05)	0.06 (0.05)
Education Dummy		0.03 (0.05)	0.03 (0.05)	0.02 (0.04)
Reform MP Dummy		−0.15 (0.05)**	−0.15 (0.05)**	−0.16 (0.05)**
Canal MP Dummy		−0.27 (0.08)***	−0.27 (0.09)**	−0.24 (0.09)**
Business MP Dummy		0.14 (0.06)*	0.15 (0.06)*	0.12 (0.06)*
Borough Dummy		−0.05 (0.04)	−0.06 (0.05)	−0.07 (0.05)
Lag Liberal		0.07 (0.15)	0.12 (0.16)	0.17 (0.17)
Lag Education		−0.11 (0.12)	−0.16 (0.13)	−0.06 (0.18)
Lag Reform MP		0.05 (0.26)	0.15 (0.26)	0.17 (0.31)
Lag Canal MP		−0.61 (0.88)	−1.17 (0.95)	−1.06 (0.95)
Lag Business MP		−0.18 (0.25)	−0.16 (0.25)	−0.09 (0.30)
Lag Borough Dummy		−0.01 (0.21)	−0.01 (0.21)	−0.01 (0.24)
Atheneum Memb. Dummy			−0.03 (0.05)	−0.01 (0.04)
Constituency Pop.			−0.00 (0.00)	−0.00 (0.00)
Lag Atheneum Memb.			0.17 (0.20)	0.09 (0.20)
Lag Const. Pop.			0.00 (0.00)	0.00 (0.00)
Freetrade Club Dummy				0.21 (0.05)***
Re-Elected in '47				−0.06 (0.04)
Lag Freetrade MP				−0.30 (0.40)
Lag Re-Elected in '47				−0.12 (0.18)
Num. obs.	200.00	200.00	200.00	200.00
R^2	0.05	0.12	0.13	0.20
MC Moran's I	−0.04	−0.03	−0.04	−0.04
MC Moran P-Value	0.92	0.81	0.85	0.86

Notes: Dependent variable = share of each MP's railway interests approved. See text for definition of dependent variables. Estimation by GS2SLS. Robust standard errors in parentheses.
$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$.

3 Logrolls of varying length

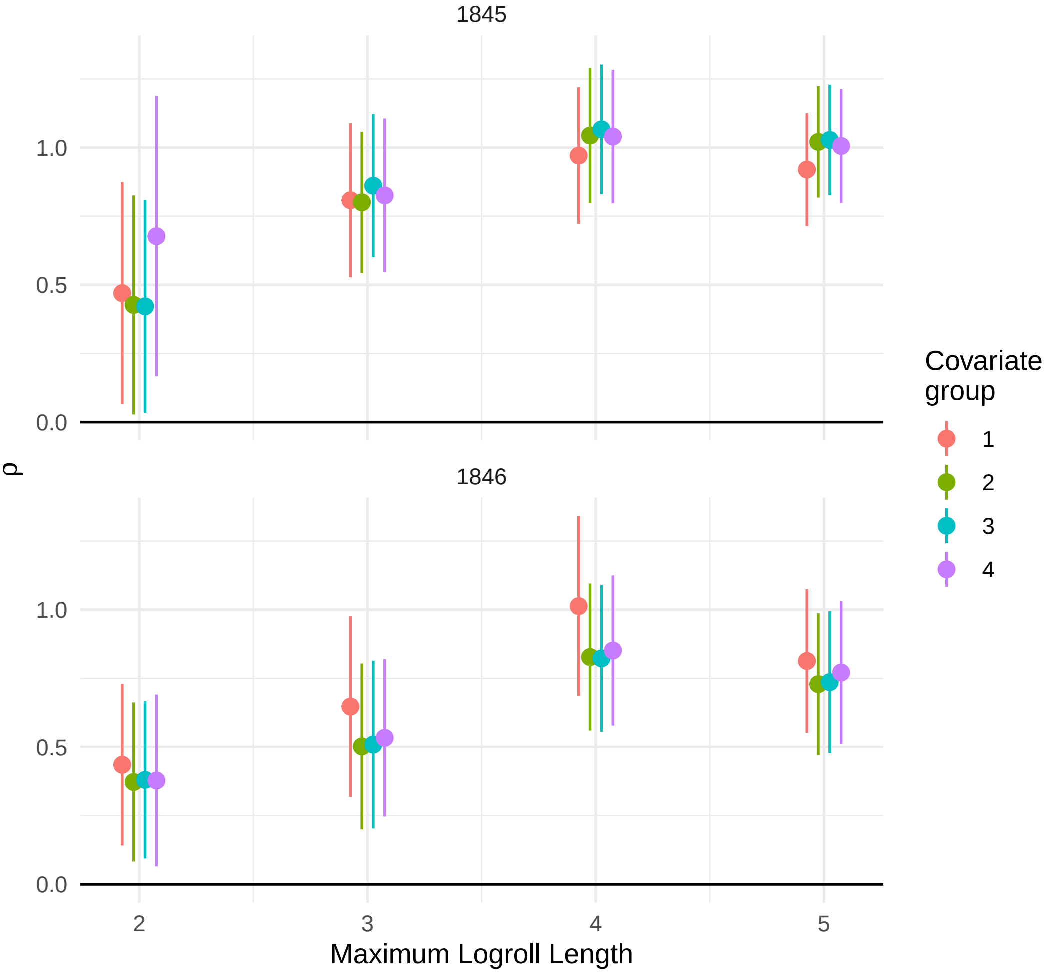
In this section we consider what happens if MPs either trade over logrolls of shorter length (length-2 only), or logrolls of longer length. Tables 1 and 2 recreate the regressions from the main text but using only logrolls of length-2. In Figure 3, we consider logrolling length more broadly by estimating the regressions in the main text using logrolls of lengths 2 through 5. The colors in the Figure correspond to the models included in columns 1 through 4 of Tables 1 and 2. The figure shows that as the length of logrolls rise the coefficient becomes larger and the standard error of the coefficients decrease.

Table 2: Estimates of Peer-effects Model for 1846, Logroll Length Two

	Model 1	Model 2	Model 3	Model 4
ρ	0.44 (0.15)**	0.37 (0.14)*	0.38 (0.14)**	0.38 (0.16)*
Intercept	0.13 (0.03)***	0.06 (0.03)*	0.08 (0.03)**	0.08 (0.04)*
Num RW Projected in Constituency	−0.00 (0.00)**	−0.00 (0.00)$^{\cdot}$	−0.00 (0.00)	−0.00 (0.00)
Num RW Investments	0.03 (0.01)**	0.03 (0.01)**	0.03 (0.01)**	0.03 (0.01)**
Num RW Overseen	−0.00 (0.00)	−0.00 (0.00)	−0.00 (0.00)	−0.00 (0.00)
Lag RW Proj. in Const.	−0.00 (0.01)	−0.00 (0.01)	−0.00 (0.01)	0.00 (0.01)
Lag Num RW Invest.	−0.00 (0.02)	0.01 (0.02)	0.03 (0.03)	0.03 (0.03)
Lag Num RW Overseen	−0.00 (0.00)	0.00 (0.01)	−0.00 (0.01)	−0.00 (0.01)
Liberal Dummy		0.01 (0.03)	0.01 (0.03)	0.01 (0.03)
Education Dummy		0.05 (0.02)$^{\cdot}$	0.05 (0.02)$^{\cdot}$	0.04 (0.02)$^{\cdot}$
Reform MP Dummy		−0.07 (0.04)$^{\cdot}$	−0.07 (0.04)$^{\cdot}$	−0.08 (0.04)*
Canal MP Dummy		−0.04 (0.11)	−0.05 (0.11)	−0.05 (0.12)
Business MP Dummy		0.10 (0.04)*	0.09 (0.04)*	0.10 (0.04)*
Borough Dummy		0.04 (0.02)$^{\cdot}$	0.02 (0.03)	0.02 (0.03)
Lag Liberal		0.09 (0.09)	0.09 (0.09)	0.10 (0.10)
Lag Education		−0.01 (0.07)	0.06 (0.08)	0.10 (0.11)
Lag Reform MP		0.08 (0.12)	0.09 (0.13)	0.13 (0.13)
Lag Canal MP		0.09 (0.30)	0.06 (0.30)	0.02 (0.30)
Lag Business MP		−0.05 (0.09)	0.00 (0.09)	0.03 (0.10)
Lag Borough Dummy		−0.10 (0.06)$^{\cdot}$	−0.18 (0.09)*	−0.20 (0.09)*
Atheneum Memb. Dummy			0.01 (0.03)	0.01 (0.03)
Constituency Pop.			−0.00 (0.00)$^{\cdot}$	−0.00 (0.00)
Lag Atheneum Memb.			0.19 (0.12)	0.21 (0.13)$^{\cdot}$
Lag Const. Pop.			−0.00 (0.00)	−0.00 (0.00)
Freetrade Club Dummy				−0.05 (0.06)
Re-Elected in '47				0.00 (0.02)
Lag Freetrade MP				0.03 (0.25)
Lag Re-Elected in '47				−0.06 (0.09)
Num. obs.	285.00	285.00	285.00	285.00
R^2	0.17	0.20	0.21	0.21
MC Moran's I	−0.16	−0.11	−0.11	−0.11
MC Moran P-Value	1.00	1.00	1.00	1.00

Notes: Dependent variable = share of each MP's railway interests approved. See text for definition of dependent variables. Estimation by GS2SLS. Robust standard errors in parentheses.
$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$.

Figure 3: Estimates of the coefficient ρ using logrolls of lengths 2 through 5



Points represent the estimated coefficient and the lines show +/- two standard errors. The top panel depicts 1845 and the bottom panel 1846

4 Further Robustness Tests using Board of Trade Data

We estimate here models that test the hypothesis that the pattern of approval of railways in 1845 was not affected by logrolling, but simply mirrored the suggestions of the Board of Trade (BoT), which in that year made recommendations about which railways should be approved.

We adopt two alternative approaches here. In the first, we substitute in the BoT recommendations as our dependent variable in the model. Thus we are testing whether logrolling is detectable in a situation in which logrolling could not be occuring, namely, if MPs purely voted according to the recommendations of the BoT. In the second, we try including BoT recommendations as a control variable in the model. In this setting, we test whether MPs' decisions were swayed by the recommendations.

In tables 3 and 4 we show the results of the first exercise. Data on the decisions of the BoT were taken from Casson (2009 , Appendix A), and the dependent variable was computed as the fraction of projects an MP was interested in that was recommended for approval by the BoT. As we can see, the estimates are consistently lower than those obtained with the true committee outcomes and insignificant.

For the second test, rather than considering the recommendations as an alternative dependent variable, we simply include them as a covariate and check whether we continue to find a peer-effect.

We can see that for log-rolls of length-3, as shown in Table 5, the inclusion of the BoT control reduces the size of ρ marginally, while the coefficient remains positive and significant. The coefficient on the measure of BoT approval itself is also positive and significant, as we would expect, and its lagged value is not significant, which is also reasonable.

For log-rolls of length-2 (Table 6), ρ remains significant only in the shortest regression. For longer specifications the coefficient is either no longer significant – and is typically only about one standard error larger than zero – or else appears to be unstable (recall that ρ should fall between -1 and 1). One simple way to interpret this is that the length-2 logroll specifications omit a large fraction of the vote trading activity, as they capture only a fraction of the connections between MPs. This is, in fact, consistent with what we see for the length-2 logrolling coefficients in all specifications across both years, namely that they are smaller and less-precisely estimated than the length-3 logrolls.

We also note that it is consistent with our investigation of the way in which missing connections bias the estimated effect towards zero. This likely accounts for the difference between the two specifications (length-2 vs. length-3). Finally, as we describe in text, the BoT did not produce any recommendation for the railways examined in the 1846 session so that the evidence of outcomes' affiliation there could not have been created by this mechanism. All in all, we feel the weight of evidence points towards logrolling occurring.

5 Misclassification Error

The fact that we do not observe individual votes on projects creates a misclassification error where committee approval $A_{ir} \in \{0, 1\}$ is an imperfect measure of voting. A_{ir} is the result of

Table 3: Placebo of Peer-effects Model for 1845 with Logrolls up to Length Three

	Model 1	Model 2	Model 3	Model 4
ρ	0.19 (0.17)	0.11 (0.19)	0.20 (0.19)	0.08 (0.17)
Intercept	0.04 (0.03)	−0.00 (0.06)	0.07 (0.07)	0.06 (0.08)
Num RW Projected in Constituency	0.03 (0.01)*	0.03 (0.01)*	0.03 (0.01)**	0.03 (0.01)**
Num RW Investments	0.09 (0.05)$^{\cdot}$	0.09 (0.04)*	0.08 (0.04)*	0.09 (0.04)*
Num RW Overseen	0.01 (0.01)	0.00 (0.01)	0.01 (0.01)	0.01 (0.01)
Lag RW Proj. in Const.	0.01 (0.03)	0.04 (0.03)	0.06 (0.03)*	0.06 (0.03)$^{\cdot}$
Lag Num RW Invest.	0.13 (0.16)	0.12 (0.17)	0.15 (0.17)	0.02 (0.17)
Lag Num RW Overseen	−0.01 (0.01)	0.07 (0.02)**	0.08 (0.03)**	0.09 (0.03)**
Liberal Dummy		0.10 (0.05)$^{\cdot}$	0.11 (0.05)*	0.10 (0.05)*
Education Dummy		0.01 (0.05)	−0.01 (0.05)	−0.01 (0.05)
Reform MP Dummy		−0.00 (0.06)	−0.01 (0.06)	−0.02 (0.06)
Canal MP Dummy		−0.39 (0.19)*	−0.47 (0.19)*	−0.46 (0.18)*
Business MP Dummy		−0.02 (0.07)	−0.06 (0.07)	−0.05 (0.07)
Borough Dummy		−0.04 (0.05)	−0.12 (0.05)*	−0.11 (0.05)*
Lag Liberal		0.06 (0.23)	−0.11 (0.22)	−0.08 (0.23)
Lag Education		−0.08 (0.16)	−0.14 (0.17)	−0.23 (0.20)
Lag Reform MP		−0.21 (0.32)	−0.28 (0.30)	−0.00 (0.32)
Lag Canal MP		−1.57 (1.03)	−0.72 (0.99)	−0.98 (1.03)
Lag Business MP		−0.26 (0.32)	−0.08 (0.31)	−0.10 (0.34)
Lag Borough Dummy		−0.32 (0.28)	−0.30 (0.26)	−0.58 (0.27)*
Atheneum Memb. Dummy			−0.09 (0.04)*	−0.09 (0.04)*
Constituency Pop.			−0.00 (0.00)$^{\cdot}$	−0.00 (0.00)
Lag Atheneum Memb.			0.35 (0.20)$^{\cdot}$	0.37 (0.19)*
Lag Const. Pop.			−0.00 (0.00)*	−0.00 (0.00)**
Freetrade Club Dummy				0.08 (0.14)
Re-Elected in '47				0.01 (0.04)
Lag Freetrade MP				−0.07 (0.38)
Lag Re-Elected in '47				0.37 (0.18)*
Num. obs.	200.00	200.00	200.00	200.00
R^2	0.13	0.23	0.28	0.29
MC Moran's I	-0.01	0.01	-0.04	0.01
MC Moran P-Value	0.54	0.35	0.84	0.31

Notes: Dependent variable = share of each MP's railway interests approved. See text for definition of dependent variables. Estimation by GS2SLS. Robust standard errors in parentheses.
$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$.

Table 4: Placebo of Peer-effects Model for 1845 with Logrolls up to Length Two

	Model 1	Model 2	Model 3	Model 4
ρ	−0.45 (0.47)	0.00 (0.18)	0.03 (0.18)	−0.06 (0.18)
Intercept	0.06 (0.04)	0.00 (0.06)	0.09 (0.07)	0.07 (0.08)
Num RW Projected in Constituency	0.03 (0.01)*	0.03 (0.01)*	0.03 (0.01)**	0.03 (0.01)**
Num RW Investments	0.10 (0.05)$^{\cdot}$	0.09 (0.04)*	0.09 (0.04)*	0.09 (0.04)*
Num RW Overseen	0.01 (0.01)	0.00 (0.01)	0.01 (0.01)	0.01 (0.01)
Lag RW Proj. in Const.	0.02 (0.03)	0.04 (0.03)	0.07 (0.03)*	0.07 (0.03)*
Lag Num RW Invest.	0.10 (0.17)	0.11 (0.17)	0.14 (0.17)	0.02 (0.17)
Lag Num RW Overseen	−0.00 (0.01)	0.07 (0.02)**	0.09 (0.03)**	0.09 (0.03)**
Liberal Dummy		0.10 (0.05)$^{\cdot}$	0.11 (0.05)*	0.10 (0.05)*
Education Dummy		0.00 (0.05)	−0.02 (0.05)	−0.01 (0.05)
Reform MP Dummy		−0.01 (0.06)	−0.01 (0.06)	−0.02 (0.06)
Canal MP Dummy		−0.39 (0.19)*	−0.48 (0.19)*	−0.47 (0.18)*
Business MP Dummy		−0.02 (0.06)	−0.06 (0.07)	−0.05 (0.07)
Borough Dummy		−0.04 (0.05)	−0.12 (0.05)*	−0.10 (0.05)*
Lag Liberal		0.12 (0.21)	−0.03 (0.20)	−0.05 (0.22)
Lag Education		−0.06 (0.16)	−0.12 (0.17)	−0.24 (0.20)
Lag Reform MP		−0.18 (0.31)	−0.26 (0.29)	−0.01 (0.31)
Lag Canal MP		−1.59 (1.03)	−0.61 (1.01)	−0.91 (1.05)
Lag Business MP		−0.27 (0.31)	−0.08 (0.31)	−0.15 (0.34)
Lag Borough Dummy		−0.37 (0.27)	−0.39 (0.25)	−0.60 (0.27)*
Atheneum Memb. Dummy			−0.09 (0.04)*	−0.09 (0.04)*
Constituency Pop.			−0.00 (0.00)$^{\cdot}$	−0.00 (0.00)
Lag Atheneum Memb.			0.38 (0.20)$^{\cdot}$	0.38 (0.19)*
Lag Const. Pop.			−0.00 (0.00)*	−0.00 (0.00)**
Freetrade Club Dummy				0.07 (0.14)
Re-Elected in '47				0.00 (0.04)
Lag Freetrade MP				0.03 (0.35)
Lag Re-Elected in '47				0.36 (0.17)*
Num. obs.	200.00	200.00	200.00	200.00
R^2	0.15	0.22	0.27	0.29
MC Moran's I	0.23	-0.01	-0.01	0.03
MC Moran P-Value	0.00	0.58	0.66	0.16

Notes: Dependent variable = share of each MP's railway interests approved. See text for definition of dependent variables. Estimation by GS2SLS. Robust standard errors in parentheses.
$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$.

Table 5: Peer-effects Model for 1845 with Logrolls up to Length Three and with BoT Control

	Model 1	Model 2	Model 3	Model 4
ρ	$0.68\ (0.14)^{***}$	$0.67\ (0.13)^{***}$	$0.70\ (0.14)^{***}$	$0.70\ (0.15)^{***}$
Intercept	$0.13\ (0.03)^{***}$	$0.10\ (0.04)^{*}$	$0.06\ (0.05)$	$0.13\ (0.05)^{*}$
Num RW Projected in Constituency	$-0.01\ (0.00)$	$-0.01\ (0.00)^{**}$	$-0.01\ (0.00)^{**}$	$-0.01\ (0.00)^{*}$
Num RW Investments	$-0.02\ (0.03)$	$-0.03\ (0.04)$	$-0.02\ (0.04)$	$-0.01\ (0.03)$
Num RW Overseen	$0.00\ (0.01)$	$0.01\ (0.01)$	$0.00\ (0.01)$	$0.00\ (0.01)$
BoT Approves	$0.18\ (0.06)^{**}$	$0.17\ (0.06)^{**}$	$0.18\ (0.06)^{**}$	$0.18\ (0.06)^{**}$
Lag RW Proj. in Const.	$0.01\ (0.03)$	$-0.00\ (0.03)$	$-0.02\ (0.03)$	$-0.03\ (0.04)$
Lag Num RW Invest.	$-0.03\ (0.10)$	$-0.04\ (0.12)$	$-0.03\ (0.11)$	$-0.00\ (0.12)$
Lag Num RW Overseen	$-0.01\ (0.01)^{*}$	$-0.01\ (0.02)$	$-0.04\ (0.02)^{\cdot}$	$-0.04\ (0.02)^{*}$
Liberal Dummy		$0.06\ (0.04)$	$0.07\ (0.05)$	$0.06\ (0.05)$
Education Dummy		$0.05\ (0.04)$	$0.06\ (0.04)$	$0.05\ (0.04)$
Reform MP Dummy		$-0.13\ (0.05)^{**}$	$-0.13\ (0.05)^{**}$	$-0.15\ (0.04)^{***}$
Canal MP Dummy		$-0.24\ (0.09)^{**}$	$-0.20\ (0.10)^{*}$	$-0.16\ (0.10)$
Business MP Dummy		$0.16\ (0.05)^{**}$	$0.19\ (0.05)^{***}$	$0.16\ (0.05)^{***}$
Borough Dummy		$-0.06\ (0.04)$	$-0.05\ (0.05)$	$-0.06\ (0.05)$
Lag Liberal		$-0.12\ (0.17)$	$-0.01\ (0.17)$	$0.09\ (0.18)$
Lag Education		$-0.10\ (0.11)$	$-0.16\ (0.12)$	$0.03\ (0.16)$
Lag Reform MP		$0.18\ (0.25)$	$0.34\ (0.25)$	$0.49\ (0.28)^{\cdot}$
Lag Canal MP		$0.09\ (0.73)$	$-0.99\ (0.79)$	$-0.65\ (0.77)$
Lag Business MP		$-0.26\ (0.23)$	$-0.30\ (0.23)$	$-0.10\ (0.27)$
Lag Borough Dummy		$0.20\ (0.20)$	$0.22\ (0.20)$	$0.12\ (0.23)$
Atheneum Memb. Dummy			$0.00\ (0.04)$	$0.02\ (0.04)$
Constituency Pop.			$0.00\ (0.00)$	$-0.00\ (0.00)$
Lag Atheneum Memb.			$0.14\ (0.17)$	$0.15\ (0.16)$
Lag Const. Pop.			$0.00\ (0.00)^{**}$	$0.00\ (0.00)^{**}$
Freetrade Club Dummy				$0.15\ (0.05)^{**}$
Re-Elected in '47				$-0.07\ (0.03)^{*}$
Lag Freetrade MP				$-0.46\ (0.36)$
Lag Re-Elected in '47				$-0.12\ (0.16)$
Num. obs.	200.00	200.00	200.00	200.00
R^2	0.22	0.26	0.29	0.32
MC Moran's I	-0.10	-0.07	-0.07	-0.07
MC Moran P-Value	1.00	0.97	0.98	0.98

Notes: Dependent variable = share of each MP's railway interests approved. See text for definition of dependent variables. Estimation by GS2SLS. Robust standard errors in parentheses.
$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$.

Table 6: Peer-effects Model for 1845 with Logrolls up to Length Two and with BoT Control

	Model 1	Model 2	Model 3	Model 4
ρ	0.47 (0.20)*	0.25 (0.20)	0.30 (0.22)	0.23 (0.21)
Intercept	0.15 (0.03)***	0.12 (0.05)*	0.10 (0.05)$^{\cdot}$	0.16 (0.06)*
Num RW Projected in Constituency	−0.00 (0.00)	−0.00 (0.00)	−0.01 (0.01)	−0.01 (0.01)
Num RW Investments	−0.02 (0.03)	−0.02 (0.03)	−0.01 (0.03)	−0.01 (0.03)
Num RW Overseen	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
BoT Approves	0.22 (0.07)***	0.21 (0.07)**	0.21 (0.07)**	0.22 (0.07)***
Lag RW Proj. in Const.	−0.00 (0.03)	−0.01 (0.04)	−0.02 (0.04)	−0.03 (0.04)
Lag Num RW Invest.	0.01 (0.12)	−0.01 (0.13)	−0.00 (0.13)	0.05 (0.13)
Lag Num RW Overseen	−0.01 (0.01)	−0.00 (0.02)	−0.02 (0.02)	−0.02 (0.02)
Liberal Dummy		0.05 (0.05)	0.06 (0.05)	0.05 (0.05)
Education Dummy		0.03 (0.04)	0.04 (0.04)	0.03 (0.04)
Reform MP Dummy		−0.15 (0.05)**	−0.15 (0.05)**	−0.17 (0.05)***
Canal MP Dummy		−0.19 (0.07)*	−0.16 (0.08)*	−0.13 (0.08)$^{\cdot}$
Business MP Dummy		0.15 (0.06)**	0.17 (0.06)**	0.14 (0.06)*
Borough Dummy		−0.04 (0.05)	−0.04 (0.05)	−0.04 (0.05)
Lag Liberal		0.06 (0.15)	0.14 (0.15)	0.21 (0.16)
Lag Education		−0.06 (0.12)	−0.11 (0.12)	0.03 (0.17)
Lag Reform MP		0.12 (0.25)	0.22 (0.26)	0.20 (0.29)
Lag Canal MP		−0.22 (0.81)	−0.99 (0.92)	−0.70 (0.91)
Lag Business MP		−0.09 (0.24)	−0.11 (0.24)	0.01 (0.28)
Lag Borough Dummy		0.03 (0.20)	0.04 (0.21)	0.07 (0.24)
Atheneum Memb. Dummy			−0.01 (0.05)	0.00 (0.04)
Constituency Pop.			0.00 (0.00)	−0.00 (0.00)
Lag Atheneum Memb.			0.12 (0.20)	0.10 (0.19)
Lag Const. Pop.			0.00 (0.00)$^{\cdot}$	0.00 (0.00)$^{\cdot}$
Freetrade Club Dummy				0.20 (0.06)***
Re-Elected in '47				−0.06 (0.04)$^{\cdot}$
Lag Freetrade MP				−0.15 (0.37)
Lag Re-Elected in '47				−0.20 (0.18)
Num. obs.	200.00	200.00	200.00	200.00
R^2	0.11	0.15	0.17	0.20
MC Moran's I	-0.03	-0.01	-0.02	-0.02
MC Moran P-Value	0.85	0.55	0.76	0.68

Notes: Dependent variable = share of each MP's railway interests approved. See text for definition of dependent variables. Estimation by GS2SLS. Robust standard errors in parentheses.
$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$.

aggregating the 5 votes with a majority rule:

$$A_{ir} = \mathbb{1}\Big[\sum_j V_{jr} \geq 3\Big], \tag{5}$$

where $\mathbb{1}[.]$ is the indicator function.

Suppose that we are interested in the vote of one MP i on a project r, call it V_{ir}. We can then characterize a misclassification error M_{ir} into the two possible errors:

$$M_{ir} = P(A_{ir} \neq V_{ir}) = FP_{ir} + FN_{ir}$$

where FP_{ir} and FN_{ir} are the false positives and negatives, respectively. These quantities are defined by the joint probability of what we observe and what we don't:

$$FP_{ir} = P(A_{ir} = 1, V_{ir} = 0) = P(A_{ir} = 1|V_{ir} = 0)P(V_{ir} = 0) \tag{6}$$

$$FN_{ir} = P(A_{ir} = 0, V_{ir} = 1) = P(A_{ir} = 0|V_{ir} = 1)P(V_{ir} = 1) \tag{7}$$

It is easy to unpack the conditional probabilities in these expressions. Let X be the sum of the votes of the other 4 committee members and its cdf $F_X(x) = P(X \leq x)$. For instance, conditional on $V_{ir} = 1$, the probability of rejection by the committee is just $F_X(1)$. The reason being that if only one or fewer members of the committee vote for the project it will fail to pass even if the specific MP i votes for it.

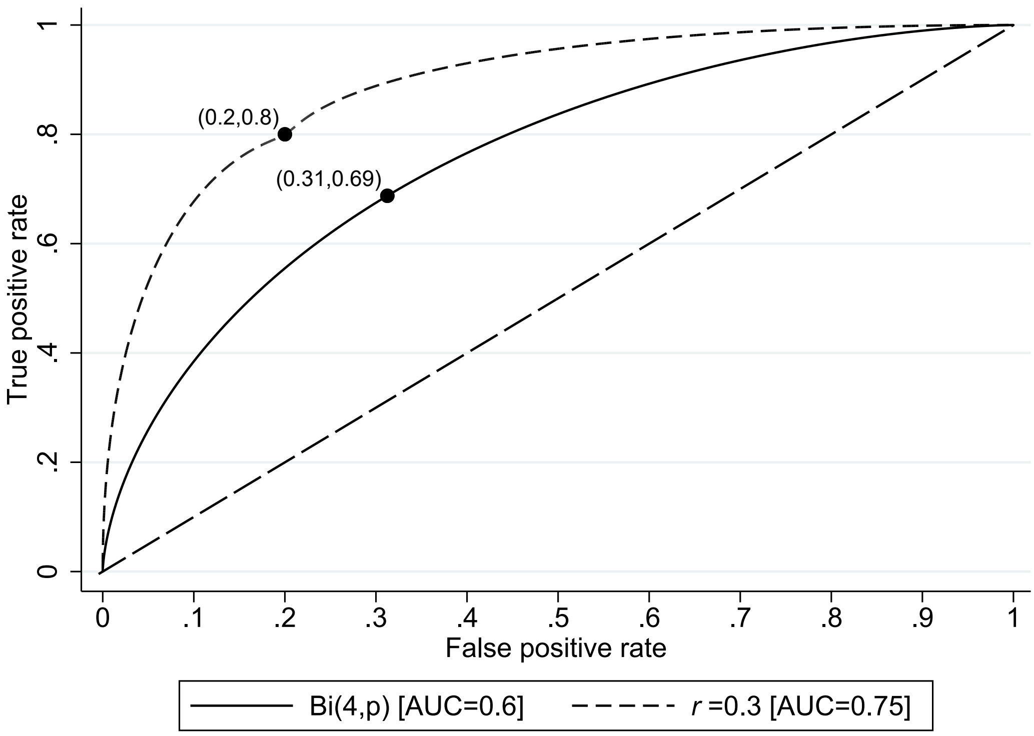
With this notation in place we can write the total misclassification rate as:

$$M_{ir} = FP_{ir} + FN_{ir} \tag{8}$$

$$= [1 - F_X(1)]P(V_{ir} = 0) + F_X(1)P(V_{ir} = 1), \tag{9}$$

We do not know the cdf of X, but if we assume that MP votes are i.i.d. Bernoulli trials, it follows that $X \sim Bi(4, p)$. In this case we can solve for the error rates by anchoring p to the observed approval rates. Across the two parliamentary sessions, a little under half of railway projects submitted to Parliament were approved. If we pick $p = 0.5$ the binomial tells us that $F_X(1) = 0.3125$. We also ignore the prior for V_{ir}, but our starting assumption that all votes are generated with probability p implies, somewhat circularly, that the prior should also be p, which results in $FN_{ir} = FP_{ir} = 0.15625$. Generalizing this logic for all values of $p \in [0, 1]$, we can summarize the misclassification errors with a receiver operating characteristic in Figure 4. The solid line represents the ROC with a $Bi(4, p)$ distribution and we marked the point corresponding to $p = 0.5$ which has false positive and true positive rates of 0.31 and 0.69, respectively. The area under the curve (AUC) for this case is of only 0.6, indicating that committee decisions are a poor discriminant for individual votes. However, this result follows under the dubious assumption that all votes are independent draws from an identical distribution.

Figure 4: Receiver Operating Characteristic for Misclassification Error.



A more realistic formulation of the cdf of X lets each vote be generated with probability p_{ir}. We can decompose p_{ir}s into three factors:

$$p_{ir} = \eta_r + \xi_i + \epsilon_{ir}, \tag{10}$$

where η_r, is a project component common to all MPs in the committee, ξ_i an MP specific component, and ϵ_{ir} an idiosyncratic component – reflecting things like having a logrolling opportunity on this particular railway. This implies $Cov(p_{ir}, p_{jr}) > 0$ because of the common railway project term. Expressed in words, this is the sensible intuition that the votes of MPs sitting on the same sub-committee on a particular project are likely to be correlated for reasons having to do with that project.[3]

Since the p_{ir} are correlated, the binomial model is not a good candidate for the cdf of X. There are variants of the binomial distribution that allow for correlated draws (Witt 2014; Kadane 2016; Kupper and Haseman 1978). Intuitively, the larger the correlation of votes, the lower will be the misclassification risk since each MP will be more likely to vote with the majority on each project. In Figure 4 we represent the case of an additive binomial distribution with correlation $r = 0.3$ among votes. The false positive rate in the previous example with $p_{ir} = 0.5, \forall i$ is now only 0.2 and the AUC also improves considerably.

Nevertheless, we may still worry that while the misclassification error is fine in the general case, it could be less accurate for the specific MPs logrolling, who could potentially be more prone to being outvoted. This echoes concerns in the literature that politicians trading votes may not always have a vote that matters, i.e. they may not cast the marginal vote (Stratmann 1995; Stratmann 1992; Guerrero and Matter 2017). This conflates a question of measurement error with a question about whether the mechanism is operative: if MPs are not marginal then they cannot logroll. Still, the fact that committees were so small, relative to votes in plenary, suggests that an MP's vote would often be worth buying for the effect it might have within a committee. In other words, the logrolling MP could do more than simply vote on his own, namely, by persuading other MPs and treating the railway in question favorably during questioning. Nevertheless, there is clearly some misclassification risk in mapping votes to approvals.

However, as previously discussed, we are not working directly with approvals at the railroad level but aggregated across railroads. This has the desirable property of converting binary measurement error (misclassification error) into continuous measurement error. Summing across railroads we get:

$$V_i = \sum_r V_{ir} = \#TP_i + \#FN_i$$

$$A_i = \sum_r A_{ir} = \#TP_i + \#FP_i$$

where $\#TP_i$ is the number of true positives across all of i's railway interests. Therefore, $A_i = V_i + \#FP_i - \#FN_i$. So unless misclassifications are lopsided for some reason, the error is 0 in expectation, for the usual reasons.

Moreover, we can see that in summing we obtain the desired true measure plus a nuisance

[3] If the votes were independent, the cdf of X would simply be Poisson binomial.

term, so we can write it as $A_i = \#TP_i + f(p_j)$ where the p_j's are the parameters indexing the willingness of the other MPs to vote in favor of i's interests. Thus, the deviation of what we observe from the true measure is some function of who the other MPs were. For a given MP i this is the MPs who oversee his projects, which in the terminology of our specification is determined by the ith row of the contextual effects matrix M'.

For example, if the MPs of a given political party tend to systematically reject more railways, and this results in the number of approvals MP i receives being lower than they would otherwise be, we already control for this in our main specification that includes the mean number of MPs *overseeing the projects of MP i* who belong to that political party in the ith row of M'. Thus, insofar as the propensities of MPs to approve projects can be captured by their observable characteristics, the contextual effects in our peer-effect model should pick up some of the measurement error induced by working with company approvals rather than individual votes for companies.

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