

Money, Ties, and Roll Calls: Integrating Regression and Network Methods to Trace Oil & Gas PAC Effects on Legislative Decisions

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Abstract: *This research introduces a novel convergent methodology integrating case-based observational analysis with traditional variable-based analysis. The study examines how lawful political contributions influence legislative decisions and voting behavior in the U.S. Senate, utilizing data on Political Action Committee (PAC) contributions and roll-call votes. First, correlation and regression analyses test whether PAC funding significantly associates with senators' voting patterns. Subsequently, a network analysis compares the network of PAC contributions among senators with their voting alignments based on legislative decisions. Findings indicate a positive association between PAC contributions and voting behavior: the amount of oil and gas PAC money a senator received is moderately correlated with the senator's pro-industry voting proportion (Pearson $r = 0.48$). At the network level, the similarity between the PAC contribution network and the voting network is slightly above random expectation but does not reach conventional statistical significance. Overall, the results suggest that PAC contributions associate with legislative voting at the individual level. The relational patterns among senators provide a complementary, albeit statistically inconclusive, perspective. This underscores the multi-layered nature of political influence in legislative processes and the value of examining contribution dynamics through senatorial interactions.*

Keywords: PAC Contribution; Legislative Voting Decision; Regression Analysis; Network Analysis; Methodological Integration

1. Introduction

The relationship between political funding and legislative action has long been a pivotal area of research in political science. This paper focuses on a critical example of such influence: the effect of Political Action Committee (PAC) contributions on legislators' voting behavior. Although previous studies have identified monetary contributions as significant factors influencing voting behavior (see Table 1), many of these works face methodological constraints, particularly in providing contextual explanations for the varying degrees of influence observed.

To address this gap, it is essential to consider the networks among legislators. These interpersonal networks act as intermediaries between the input of PAC contributions and the resulting voting behaviors, offering a richer context for analysis. Thus, employing network analysis methodologies is crucial for a more comprehensive understanding of legislative voting dynamics.

This study aims to uncover the dynamic relational patterns underlying legislative decision-making, emphasizing the interplay between legislative voting behavior, relevant variables, and interpersonal relationships among legislators. The primary focus is on the correlation between U.S. senators' roll-call votes and their receipt of PAC contributions. By contrasting the network of PAC contributions with the network of voting alignments among senators, the analysis delineates how financial inputs correlate with legislative outputs.

To investigate these relationships, a theoretical framework and analytical model were developed, incorporating traditional variable-based techniques (such as correlation and regression) for detailed, systematic

examination. These methods are vital for assessing interconnections among variables and their impact on legislative voting. Furthermore, the integration of network analysis enables the examination of personal connections among senators—both visually and statistically—thereby revealing interaction patterns that may elucidate how PAC contributions influence voting behavior.

It should be noted that while regression and correlation analyses are effective for identifying associations, they cannot by themselves establish causality. However, combining network analysis with traditional approaches allows a deeper exploration of potential causal dynamics linking PAC contributions and voting behavior. This holistic approach enriches our understanding of the multifaceted factors influencing legislators' votes by illuminating both direct effects and contextual forces that shape legislative outcomes.

The remainder of this paper is organized as follows: **Section 2** reviews the relevant literature and discusses the methodological convergence of traditional statistical analysis and network analysis. **Section 3** describes the data collection and analytical methods used to explore the relationships between PAC contributions, senators' voting behavior, and the personal connections among senators. **Section 4** presents the results of the analysis. Finally, **Section 5** offers the conclusions, discussing the study's implications and suggesting directions for future research.

2. Literature review

2.1 Political Action Committee (PAC) contributions

A PAC is an organization in the United States designed to raise and spend money to elect or defeat political candidates, influence elections, and affect legislation and government decision-making. PACs are typically formed by businesses, labor unions, trade associations, or other interest groups to channel contributions from members and supporters directly to political campaigns or causes they support. Several types of PACs exist, including connected PACs (established by corporations, unions, or trade associations and funded by stakeholders within those organizations), non-connected PACs (which advocate for ideological or single-issue agendas and raise funds from the general public), and leadership PACs (created by elected officials or political figures) [1].

PACs play a significant role in American politics by providing a means for groups and individuals to exert financial influence over elections and policy debates. They contribute funds both to candidates who support their interests and to campaigns opposing those who do not. While PACs are intended to facilitate democratic participation, they are often criticized for enabling a disproportionate influence of wealthy donors and special interest groups on policy. Such criticisms have led to calls for campaign finance reform and greater transparency in political funding [2].

PAC contributions are subject to federal regulation. Under current Federal Election Commission (FEC) rules, a traditional PAC can contribute up to \$5,000 per election (primary, general, or special) to a candidate's campaign committee. PACs may also give up to \$15,000 per year to a national party committee and \$5,000 per year to another PAC. A recent development in campaign finance is the emergence of Super PACs, which are allowed to raise unlimited sums from corporations, unions, associations, and individuals and spend unlimited amounts to advocate for or against political candidates. Unlike traditional PACs, however, Super PACs are prohibited from coordinating their spending directly with the candidates or campaigns they support [3].

2.2 Existing studies on the relationship between PAC contributions and legislative voting behaviors

Research on the influence of PAC contributions on congressional voting began in the late 1970s. Existing research extensively examines the relationship between Political Action Committee (PAC) contributions and legislative voting behaviors, employing a diverse array of statistical methodologies such as Ordinary Least Squares (OLS), probit and logit regression analyses, along with more sophisticated techniques like Two-Stage Least Squares (2SLS) and multilevel modeling. These studies collectively indicate that PAC contributions exert a notable influence on legislative voting, though the magnitude and implications of this influence vary significantly based on factors such as timing, legislative context, and specific issues at hand.

For example, studies by Witko (2011) and Fleisher (1993) demonstrate a statistically significant impact of PAC contributions on voting behaviors, highlighting that this influence is subject to variations driven by ideological predispositions and other controlled variables [4, 5]. Conversely, research conducted by Liu (2004) and Ansolabehere et al. (2000) suggests that the relationship between PAC contributions and voting is not

always direct and may be moderated by elements like party ideology, district interests, and the particular circumstances of the vote [6, 7].

The methodological diversity reflected in the literature, ranging from meta-analyses to logistic regression and complex multilevel and Tobit models, underscores the intricacies and multidimensional nature of analyzing the effects of PAC contributions. Additionally, findings from Stratmann (1995) suggest that PAC contributions made closer to the time of voting have a more substantial impact on legislative decisions than those made earlier [8].

Despite the variance in methodologies and specific focal points of these studies, a prevailing theme emerges: PAC contributions do indeed influence legislative voting, but the extent and nature of this influence are heavily dependent on a multitude of contextual factors, both external and internal to the legislative environment. This body of research points to the nuanced and conditional nature of PAC contributions' impact on legislative outcomes, necessitating a comprehensive consideration of various influencing factors when assessing this complex relationship.

Table 1. Existing studies on the relationship between PAC contributions and legislative voting

Author	Method	Findings
Witko (2011) [4]	OLS, Probit regression analysis	PAC contributions can influence legislative behavior in various settings, though the mechanisms of influence differ depending on the issue context.
Liu (2004) [5]	Logit regression	No direct link found between oil industry PAC contributions and congressional votes; party affiliation, ideology, and district interests were the strongest predictors of voting behavior.
Ansolabehere et al. (2000) [6]	OLS regression analysis	Identified a significantly stronger link between lobbying efforts and campaign contributions than most prior studies had suggested. (Implication: financial contributions are closely tied to lobbying outcomes.)
Stratmann (1995) [7]	Tobit and probit model	Contributions made close to the time of the vote have a greater influence on voting behavior than those received by the legislator a year or two before the vote.
Fleisher (1993) [8]	OLS, 2SLS	Even after controlling for legislators' ideological leanings, PAC contributions have a statistically significant but small effect on their voting decisions.
Wright (1990) [9]	OLS, 2SLS	Campaign contributions were good predictors of which interest groups engaged in lobbying; however, once lobbying activity was accounted for, there was little evidence of a direct effect of contributions on roll-call votes.
Grenzke (1989) [10]	2SLS regression model	Found minimal evidence that campaign contributions influenced congressional voting patterns.
Chappell (1982) [11]	Probit-Tobit model	The effect of campaign contributions on voting outcomes is less significant than a single-equation probit model would suggest (indicating that simpler models may overstate contribution effects).

2.3 Methodological convergence of traditional statistical analysis and network analysis

In data-driven research, two fundamental analytical perspectives can be distinguished (see Figure 1). Traditional statistical analysis focuses on relationships among attribute variables of the cases or subjects under observation (for instance, examining how a legislator's characteristics relate to their voting behavior). In contrast, network analysis examines the relationships between the subjects themselves (e.g., relationships or interactions among legislators), based on those attributes or other relational data. Historically, these two approaches have been pursued separately in the study of legislative behavior, each providing different insights.

		Traditional Statistical Analysis : analysis of variables themselves or relationships between variables (i.e., frequency analysis, crosstab analysis, average analysis(t-test), variance analysis(F-test), correlation, regression, SEM, etc.)				
		Var1	Var2	Var3	• • •	Var.M
Network Analysis: analysis of the relationship between cases (i.e., network visualization analysis, centrality analysis, degree analysis, density analysis, sub-network analysis, QAP correlation, MR-QAP, etc.)	Case 1					
	Case 2					
	Case 3					
	• • •					
	Case N					

Figure 1. Comparison between traditional statistical analysis and network analysis on data frame table

Traditional statistical analyses rely on several key assumptions, such as independence of observations, normality of data distributions, and homogeneity of variance. Independence means that data points (e.g., individual legislators' voting records) are assumed not to influence each other. Normality implies that variables are expected to follow an approximately normal (bell-curve) distribution, which is often tested before applying statistical models. Equal variance (homoscedasticity) assumes that different groups or samples have similar variance; many statistical procedures (like ANOVA and OLS regression) require that variance across groups or conditions be equal. Violations of these assumptions can affect the validity of traditional statistical inferences [12].

Network analysis, on the other hand, is a sophisticated methodology that diverges from these traditional approaches by explicitly focusing on relationships and interdependencies. In network analysis, the fundamental units are nodes (e.g., individual actors such as senators) and links (the connections or relationships between nodes). Unlike traditional methods, which treat observations as independent, network analysis is designed to explore complex interdependencies among actors, often employing concepts from graph theory and relying on non-parametric statistics or simulation techniques (such as Markov Chain Monte Carlo) to analyze data that violate independence assumptions [13].

Within a network, nodes can be categorized as actors (active participants in interactions) or non-actors (entities that influence the network indirectly or passively). Network analysis goes beyond assessing individual attributes of nodes; it examines the structure of the connections between nodes. This includes identifying which nodes are connected, the strength or frequency of their ties, and the overall patterns these connections form. Such analysis provides insights into structural dynamics—revealing, for example, clusters of tightly interconnected actors or influential brokers who connect otherwise disparate groups [14].

The network approach offers a comprehensive framework for understanding multifaceted interactions within complex systems. By analyzing relational patterns, network analysis can uncover how connections among actors influence behaviors and outcomes in ways that may be invisible to traditional variable-centered analysis. This richness has made network analysis an indispensable tool in fields like sociology, economics, and political science, where the interconnectedness of actors fundamentally shapes phenomena. In the context of legislative studies, network analysis allows researchers to visualize and quantify how senators' relationships (e.g. shared committee memberships, social ties, or common donors) might affect their voting alliances, thereby bridging the gap between individual-level factors and collective behavior [15].

3. Data and methods

3.1 Data

This study utilizes data on members of the 116th U.S. Senate, covering the period 2019–2021. As summarized in Table 2, the dataset includes each senator's personal attributes (such as age, party, and committee memberships) alongside details of their roll-call voting behavior. These personal attributes serve primarily as independent variables in the analysis. The dataset also incorporates information on PAC contributions made to each senator, with a particular focus on contributions from the oil and gas industry (a sector chosen due to its substantial level of political donations and policy interest).

The roll-call voting data are focused on energy-related legislation, especially issues pertinent to the oil and gas sector. The compiled data are conceptually divided into two segments. The first segment contains the 100

senators' personal information and background characteristics. The second segment captures each senator's voting behavior on energy issues—specifically, whether their votes aligned for or against oil and gas industry interests. We identified 61 relevant energy-related roll-call votes in the 116th Congress (including votes on renewable energy policies and offshore oil drilling measures). For each senator, a voting proportion (VP) was calculated as the number of pro-oil/gas industry votes divided by the total number of these 61 votes. This proportion ranges from 0 to 1, where values closer to 1 indicate a more consistently pro-industry voting record. In our analysis, this VP metric serves as the dependent variable, reflecting each senator's tendency to support oil and gas interests.

All data were collected from publicly available sources. Senatorial attributes and voting records were obtained from official sources such as the United States Senate website and congressional vote databases. Information on PAC contributions was gathered from reputable public databases including The Washington Post, OpenSecrets.org, and NationalJournal.com. These sources ensured that the dataset is comprehensive and reliable for analyzing the influence of PAC contributions on legislative behavior in an industry-specific context.

Table 2. Description of variables

Variable	Description
VP	<i>Voting proportion</i> of each senator on oil & gas issues (value from 0 to 1). A higher value indicates a more pro-industry voting record. Note: Calculated as the number of pro-oil/gas votes divided by the total number of relevant energy votes (61 votes in the 116th Congress).
sex	= 1 if male, = 0 if female
age	Age in years (calculated as 2021 minus birth year).
seniority	Length of service in the Senate (number of years, as of the 116th Congress).
party	Party affiliation: =1 if Republican Party; =0 if Democratic Party.
state	U.S. state that the senator represents.
region	Geographic region of the senator's state (Midwest, Northeast, South, or West).
midwest	Regional dummy: =1 if state is in the Midwest; =0 otherwise.
northeast	Regional dummy: =1 if state is in the Northeast; =0 otherwise.
south	Regional dummy: =1 if state is in the South; =0 otherwise
west	Regional dummy: =1 if state is in the West; =0 otherwise.
conservatism	Ideology score (0–100) from National Journal's 2019–2021 congressional ratings, where higher scores indicate a more conservative voting record. (<i>These ratings rank lawmakers on a conservative-liberal scale based on their votes on economic, social, and foreign policy issues.</i>)
enrcom	Membership in the Senate Energy and Natural Resources Committee: =1 if the senator was a member of this committee; =0 otherwise.
moilgas	Total amount of PAC money (USD) the senator received from the oil & gas sector (2019–2021).

3.2 Methods

In this study, two complementary methodological approaches are applied: traditional statistical analysis and network analysis. The traditional approach provides a baseline understanding of variable relationships, while the network approach offers insight into structural relationships among senators. Below, we outline each method in detail.

3.2.1 Method1: Traditional statistical analysis

We first conduct a correlation analysis to explore bivariate relationships among key variables: the voting proportion (VP), oil/gas industry PAC contributions received (moilgas), party affiliation, ideological conservatism score, seniority, and Energy Committee membership (enrcom). Pearson correlation coefficients are calculated for each pair of variables to assess the strength and direction of their linear relationships. This step identifies significant associations (at the $p < 0.05$ or $p < 0.01$ levels) that could inform hypotheses about how PAC money and other factors relate to legislative voting.

Next, we perform a multivariate regression analysis with the voting proportion (VP) as the dependent variable. The regression model includes multiple independent variables concurrently: party affiliation,

ideological conservatism, membership on the Energy and Natural Resources Committee (enrcom), and regional indicators (the four region dummy variables). PAC contributions (moilgas) are also included as a key independent variable. By examining the regression coefficients, we can quantify the influence of each factor on a senator's pro-industry voting score while controlling for the others. In particular, this allows us to assess whether PAC money has an effect on voting behavior above and beyond ideology, party, and other characteristics. The regression analysis also reports adjusted R-squared values for each model specification, indicating the proportion of variance in the voting behavior explained by the included variables. Comparing these values across models helps evaluate the added explanatory power of variables like PAC contributions.

Together, the correlation and regression analyses provide a robust statistical foundation for understanding the interdependencies among variables. The correlation analysis highlights pairwise associations, and the regression analysis identifies the strongest predictors of pro-industry voting when factors are considered simultaneously. This dual approach not only reaffirms the relevance of traditional statistical methods in this context, but also sets the stage for the subsequent network analysis, which will probe beyond these variable-level relationships to examine the structural connections among senators.

3.2.2 Method2: Network analysis

We employ two main techniques in the network analysis: network visualization and network correlation analysis. Firstly, network visualization analysis entails the graphical depiction of the structural relationships between nodes, which represent unobservable elements, within a two-dimensional or three-dimensional space [16]. In this research, we employ the Spring map visualization method from among various network visualization techniques to visually explore the relational structures between nodes, specifically individuals. The Spring map method utilizes a layout algorithm that embeds virtual springs between nodes, organizing them based on mutual forces of attraction and repulsion. A key advantage of this method is that it arranges adjacent nodes at regular intervals, minimizing overlap between nodes and intersections of links. This facilitates an easier visual inspection of node locations. To optimally position each node, calculations are iteratively performed approximately 5 to 10 times the total number of nodes. For this study, we apply a factor of 10 iterations per node.

Secondly, the correlation analysis between networks is conducted utilizing the Quadratic Assignment Procedure (QAP), a premier method in network statistical analysis. This technique is pivotal for significance testing or hypothesis testing within network data contexts, as discussed in seminal works by Krackhardt (1987) and Martin (1999). Network data, inherently relational and dependent, does not lend itself to conventional statistical methods which typically presuppose data independence. Therefore, QAP, which involves the randomization of network data matrixes comprising rows and columns, is employed. Specifically, the QAP correlation analysis method calculates the degree of correlation and p-value by fixing one network while randomly rearranging the row and column information of another, allowing for robust analysis of inter-network relationships [17, 18].

4. Results

4.1 Traditional statistical analysis

The correlation analysis reveals several noteworthy associations among the variables (see Table 3). Most importantly, the amount of oil and gas PAC money a senator received (moilgas) is positively and significantly correlated with their pro-industry voting proportion (VP). The Pearson correlation between moilgas and VP is 0.48, indicating a moderate positive relationship (significant at the 0.01 level). In other words, senators who received more campaign contributions from the oil and gas sector tended to vote more in line with oil and gas industry interests. Additionally, there is a very strong correlation between a senator's party affiliation and their conservatism score (approximately 0.90, $p < 0.01$), reflecting the well-known alignment between party (Republican vs. Democrat) and ideological stance in contemporary U.S. politics. By contrast, most other pairwise correlations are weak or not statistically significant. For example, variables like seniority and committee membership (enrcom) show little correlation with the voting proportion or with PAC funding. This suggests that, apart from the overlap between partisanship and ideology, no other two variables in our dataset are highly collinear or tightly coupled.

Table 3. Correlation analysis

	VP	moilgas	party	conservatism	seniority	enrcom
VP	1					
moilgas	0.48**	1				
party	0.32**	0.24*	1			
conservatism	0.35**	0.32**	0.9*	1		
seniority	0.19	0.05	0.02	-0.03	1	
enrcom	0.21	-0.02	0.05	0.04	0.14	1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In the regression analysis as seen in Table 4, the dependent variable, denoted as VP, represents the voting proportion of each senator on ‘oil and gas’ issues, scaled from 0 to 1. A value approaching 1 signifies a voting pattern that is more pro-industry. The analysis reveals that Political Action Committee (PAC) contributions, specifically those from oil and gas interest groups (referred to as ‘moilgas’), are significantly and positively associated with Senators’ voting behaviors. The explanatory contribution of PAC money is particularly pronounced in terms of the model’s explanatory power, as evidenced by comparisons of the adjusted R-squared values across different models. This indicates that PAC contributions are a strong predictor of Senators’ pro-industry voting tendencies on oil and gas issues.

The above correlation result shows PAC money (here, moilgas which means money from interest groups for oil and gas) is significantly correlated with Senators’ voting decisions (Pearson $r = 0.48$). It should be noted that this correlation coefficient indicates the strength of an association, not a causal effect of PAC money on voting behavior.

Table 4. Regression analysis predicting senators’ pro-industry voting proportion (VP)

Independent variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
moilgas	0.0110***	0.0095***	0.0097***	0.0096***	0.0096***	0.0098***
party		0.1863*		0.1912*		0.0859
conservatism			0.0034*		0.0035*	0.0023
enrcom				0.2363*	0.2401*	0.2381*
midwest				0.0597	0.0732	0.0504
northeast				-0.0219	-0.0171	-0.0304
south				0.0651	0.0617	0.0622
_cons	0.4481***	0.3630***	0.2910***	0.2782**	0.2034	0.2211
adj. R2	0.226	0.265	0.262	0.291	0.284	0.286

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4.2 Network analysis results

The network analysis provides a multidimensional perspective on how PAC funding ties relate to voting alliances. Figure 2 presents a side-by-side comparison of the two network graphs: the PAC contribution network (left), where links connect senators who received contributions from the same oil & gas interest groups, and the voting similarity network (right), where links connect senators who have very similar voting records on oil & gas legislation. (In these diagrams, each red circle represents a Democratic senator and each blue rectangle a Republican senator.) Analysis of the graphs and corresponding network measures indicates a noticeable, though statistically non-significant, overlap between the two networks. In particular, many pairs of senators who are closely linked in the PAC contribution network (meaning they share common donors in the oil & gas sector) also appear as closely linked in the voting network (meaning they voted similarly on oil/gas issues). We quantify this overlap in two ways. First, we calculate the percentage of senator-pairs that are aligned in both networks. We find approximately a 47% overlap: nearly half of all pairs of senators that form a connection (or cluster together) in one network show a similar connection in the other network. In other words, senators who share funding sources tend to also share voting alignments about 47% of the time.

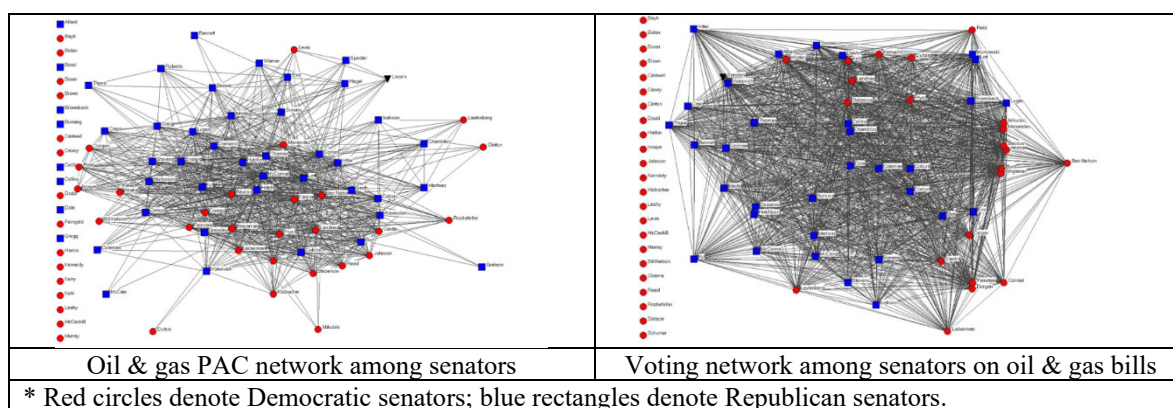


Figure 2. Comparison of networks: (Left) Oil & gas PAC contribution network among senators; (Right) Voting alignment network among senators on oil & gas bills

Second, we compute a simple matching coefficient to formally measure similarity between the two adjacency matrices (Table 5, row 1). The simple matching coefficient is 0.466, which indeed corresponds to a 46.6% similarity between the two binary networks. To put this in perspective, we compare it against what might occur by chance. Given the density of connections in each matrix, randomly permuting the network ties yields an average matching of 0.457 (45.7%) with a standard deviation of 0.015. Thus, the observed 46.6% alignment is slightly higher than the random expectation (by roughly 0.9 percentage points). While this difference is modest, it suggests a non-random correspondence between PAC-based ties and voting-based ties among senators.

To further interpret these similarities, we also consider other binary similarity measures. The Jaccard coefficient (Table 5, row 2) is 0.170, which focuses only on the cases where a connection exists in at least one network (ignoring joint absences). This indicates that about 17% of all connections that exist in either the PAC network or the voting network are present in both. Finally, the Hamming distance (Table 5, row 3) between the two networks is 5,288, which counts the number of disagreeing cells (0 vs. 1 mismatches) between the two 100×100 binary adjacency matrices. This value was computed over all 9,900 off-diagonal cells of the matrices (self-ties on the diagonal are excluded). Because both networks are undirected, each senator pair appears twice in the matrix (once in cell ij and once in cell ji), so the 9,900 off-diagonal cells correspond to the 4,950 distinct unordered senator pairs counted twice. The Hamming distance of 5,288 therefore corresponds to 2,644 distinct senator pairs ($5,288 \div 2$), out of 4,950 possible pairs, for which a tie is present in one network but absent in the other. This counting rule is consistent with the simple matching coefficient reported above, since $(9,900 - 5,288) / 9,900 = 0.466$.

Overall, these network comparisons show a noteworthy pattern: there is a measurable, though not overwhelming, correspondence between who funds whom and who votes with whom. Senators receiving money from similar interest groups often find themselves voting in similar ways. However, the similarity is far from perfect, which is expected given the multitude of other factors (party loyalty, constituency pressures, ideological values) that also drive voting behavior. The QAP correlation analysis indicates that although the observed PAC–voting network overlap is slightly higher than the random expectation, it does not reach conventional levels of statistical significance (the observed similarities have p-values around 0.25, see Table 5). This implies that the alignment, while suggestive, should be interpreted with caution. It highlights a tendency rather than a deterministic rule: PAC networks tend to mirror voting alliances to some degree, suggesting a possible, though statistically unconfirmed, role of shared financial backers in legislative coalitions.

In interpreting these results, it is useful to understand the metrics used. In network analysis of binary relations (presence or absence of a tie), the simple matching coefficient and Jaccard coefficient are common measures of similarity, whereas Hamming distance is a measure of dissimilarity. The simple matching coefficient calculates the proportion of all entries (possible senator-pairs) that are identical in the two adjacency matrices – counting both connected pairs (1/1 matches) and unconnected pairs (0/0 matches). For example, a coefficient of 0.466 means that 46.6% of all senator-pairs are either connected in both networks or not connected in both. The Jaccard coefficient, on the other hand, looks only at positive connections: it is the ratio of the number of senator-pairs connected in both networks to the number of senator-pairs connected in at least one network. Our Jaccard coefficient of 0.170 indicates that 17.0% of all ties that exist in either the PAC network or the voting network are common to both. Lastly, the Hamming distance (5288) essentially counts the number of mismatched ties between the two networks (each mismatch is a pair that is connected in one network but not

the other). These metrics together provide a nuanced view of the overlap: while nearly half of all possible pairwise relationships match exactly (mostly because many pairs of senators are unrelated in either context), a smaller fraction of actual alliances coincide in both funding and voting, and there is a substantial number of divergences as well. This underscores the idea that PAC influence is one layer of a complex set of forces driving voting behavior, which the network perspective helps illuminate.

Table 5. Association between PAC and voting networks by QAP correlation

		Value	Sig	Avg	SD	P(Large)	P(Small)
1	Simple Matching:	0.466	0.255	0.457	0.015	0.255	0.750
2	Jaccard Coefficient:	0.170	0.280	0.156	0.024	0.280	0.727
3	Hamming Distance:	5288.000	0.255	5367.474	161.629	0.750	0.255

Note: Value = observed value of the similarity/distance measure between networks. Mean (random) and SD (random) = the average and standard deviation of that measure under 1,000 random permutations (from QAP). Significance (Sig) and P(Large)/P(Small) = the proportion of random permutations yielding a value as extreme as the observed (for one-tailed tests in the “large” or “small” direction). In these results, none of the observed similarities are significant at conventional levels (e.g., the simple matching’s P(Large) = 0.255 suggests a 25.5% chance of seeing as high a similarity under randomness).

5. Conclusions

This research is the first to examine the interplay between Political Action Committee contributions and senatorial voting behavior using a combined variable-based and network-based framework. While prior studies have primarily analyzed the associations among individual variables (such as personal attributes, PAC contributions, and roll-call votes), our study expands the scope to include the relationships among the legislators themselves, incorporating network dynamics into the analysis. By utilizing network analysis, we are able to detect patterns of alignment and influence that are not immediately evident from traditional regression analysis alone. Methodologically, we performed a comprehensive analysis of roll-call votes and PAC contributions (focusing on the oil & gas industry) for the 116th U.S. Congress. We began by mapping the network of PAC contributions among senators, then conducted a regression analysis to quantify the relationship between PAC money and voting behavior. Subsequently, we analyzed the network of voting alignments among those senators and compared it to the PAC network, looking for correspondence between financial ties and voting alliances.

Our findings reveal a strong positive association between PAC contributions and legislative voting decisions at the individual level, alongside suggestive—though statistically non-significant—parallels between the PAC contribution network and the voting network of senators. In practical terms, senators who are linked by common sources of PAC funding often display similar voting patterns. These results suggest a link between the financial networks in Congress and legislative voting behavior. At the same time, the analysis indicates that this association, while statistically significant at the individual level, is just one part of a multifaceted landscape. Other forces (partisanship, ideology, constituency interests) concurrently shape legislative outcomes. Moreover, because this study relies on cross-sectional observational data, the findings should be interpreted as associations rather than causal effects; unobserved confounders and reverse causality (e.g., PACs donating to senators who already support their positions) cannot be ruled out. This insight suggests that further case studies and analyses are warranted to determine how broadly our findings apply across different policy areas and legislative sessions. We recommend that future legislative studies incorporate network analysis as a valuable complement to traditional approaches, in order to capture these relational dynamics and provide a more nuanced understanding of voting behavior.

Key findings of the study can be summarized as follows. (1) Limitations of variable-based analysis: Traditional variable-by-variable analysis offers important baseline insights into factors affecting voting decisions, but it does not fully capture the complex interconnections and peer influences among senators. This underscores the inherent limitations of an approach that looks at legislators in isolation. (2) Network alignments in voting behavior: Network diagrams reveal clusters of senators with closely aligned voting behaviors, and these clusters often correspond to similarities in the senators’ PAC funding sources. In other words, there are suggestive relational ties – senators linked through common donors or associations – that tend to correspond with coordinated voting, patterns not fully discernible through standard regression analysis alone, although this network-level similarity did not reach statistical significance in the QAP test. (3) Value of network analysis in legislative research: The observed patterns highlight the importance of incorporating network analysis into the study of legislative voting behavior. By accounting for the relationships and social context surrounding

legislators, researchers can gain deeper insight into how individual characteristics (like party or ideology) interact with structural factors (like caucus memberships or funding networks) to shape outcomes. (4) Need for broader case studies: To improve the generalizability of these insights, further research should examine additional cases and contexts. Expanding the analysis to different time periods, other industries, or other legislative bodies will help determine which patterns observed here are consistent features of legislative politics and which may be unique to the specific context of energy policy in the 116th Senate.

In summary, network analysis not only complements traditional variable-based analysis but also bridges the gap between examining discrete factors and understanding broader relational contexts in legislative behavior. By integrating these approaches, this study provides a richer and more dynamic picture of the policy-making process. The combined perspective significantly enhances our interpretation of how political influence operates within legislative bodies, shedding light on the intricate web of interactions that ultimately shape policy decisions.

Conflicts of Interest: The author declares no conflict of interest.

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