Leadership Network Structure and Influence Dynamics

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Introduction

Pivotal policy decisions in states or organizations like militant movements are often made by a small group of top leaders (Hermann, 2001). This speaks to the importance of developing systematic methods for improving the ability to understand and anticipate the dynamics of leadership groups. This chapter describes a quantitative methodology for the analysis and modeling of leadership networks which leverages research in complex systems, in particular nonlinear dynamical systems theory (Strogatz, 1994) and network science (Newman, 2010). The nonlinear systems element is the model of social influence dynamics which can exhibit complex phenomena such as large, discontinuous transitions (bifurcations) as a parameter is varied and non-trivial interactions with network structure. Factional and other divisions within leadership networks can induce meaningful structure in them; algorithms developed in complex networks research for analyzing community structure can probe this factional structure and, crucially, relate that structure to policy divisions. Investigation of both the network and issue space, as well as their integration, is a core focus of the methodology and is accomplished statically via structural analysis and dynamically via the nonlinear social influence model which evolves leader positions on issues in response to their mutual influence over their network of ties.

This chapter introduces a recently developed prototype software package, PORTEND, that provides a user interface for the analysis and simulation methods. PORTEND's analytical capabilities are illustrated for an application to Iranian leadership elites regarding seven major issues with a particular focus on whether their nuclear technology capabilities should or should not be constrained and subject to international monitoring. Previous applications of the methodology to Russian and Afghan leadership networks have been reported elsewhere (Gabbay, 2007a, Gabbay, 2013). The factional structure of the Iranian leadership group is analyzed first based on their positions on the issues, then with respect to the network of inter-actor influence relationships, and finally by a synthesis of the issue and network data. Moving from structural analysis to simulation, a qualitative description of the nonlinear social influence model is presented followed by application of the simulation to the nuclear issue and discussion of its implications with respect to Iranian decision making concerning the nuclear negotiations that took place from 2013-15.

PORTEND Software

PORTEND (Political Outcomes Research Tool for Elite Network Dynamics) integrates quantitative techniques from nonlinear systems theory and network science to aid the analysis of policy and factional outcomes with respect to the internal dynamics of a system of political actors. The political actors may be individual leaders or organizations within a government or movement. The outcomes of concern may be policy decisions, winning and losing factions, the positions of individuals, or the potential for issues to cause dissension or factional realignment. Political actors are represented mathematically with respect to their preferences on one or more issues, the saliences of those issues, the network of inter-actor influence, and actor power and susceptibility to influence. The data from which these quantities are calculated is obtained from surveys given to expert analysts. PORTEND imports these surveys and aggregates them to form a composite analyst if desired. It then allows for structural analysis regarding issues and the inter-actor network and for the simulation of social influence and group decision making outcomes. The analyses can be performed for the composite analyst or separately for the individual analysts. An overview of the methodology is shown in Figure 1. PORTEND is currently in a prototype stage of development and is implemented in Matlab.

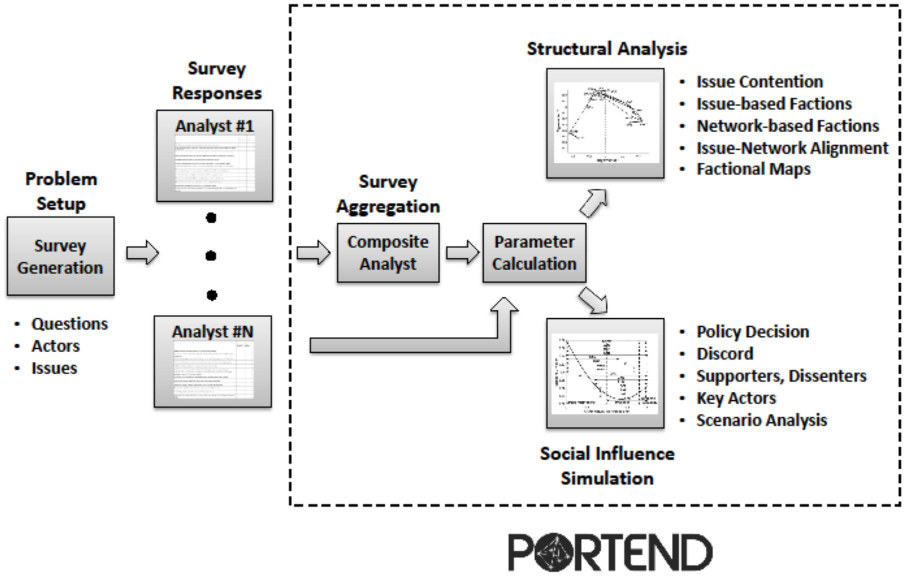


Figure 1. Methodology overview.

Iran Application

This section introduces the Iranian leadership case study which will be used to illustrate the capabilities of the methodology implemented within PORTEND in this chapter. The case study, which was initiated in 2013, considered fifteen top members of the Iranian leadership, as identified by analysts of Iranian politics (Table 1). A survey was developed and then completed by two Iran experts in the autumn of 2013. The elements of the survey will be discussed in the next section. While a major concern of the study involved the Iranian nuclear program, the broader context of Iranian elite politics was also of interest and so the survey included the seven issues below (abbreviations in parentheses):

- Liberalism (LIB): The proper role for Western culture, Islam, media sources, and democratic institutions.
- Economic Reform (ECON): Whether economic policies should benefit the current elites or a wider set of interests.
- Arab States (ARAB): Whether Iran's peers in the Arab world are potential allies or enemies.
- Syrian Regime (SYR): Whether the Assad regime in Syria should be supported.
- US/Israel (USISR): The extent to which Iran should confront the U.S. and Israel.

- Nuclear Issues (NUKE): The extent to which Iran should develop nuclear technology.
- IRGC Influence (IRGC): The appropriate role for the Islamic Revolutionary Guard Corps (IRGC).

Actor (Abbr.)	Role/Notes
Ali Hoseini Khamenei (KHAM)	The supreme leader, the highest political and religious authority in the Islamic Republic of Iran.
Qasem Soleimani (SOL)	Commander of the Quds Force, a unit of the Islamic Revolutionary Guard Corps (IRGC).
Mir Hossein Musavi (MUS)	Prime Minister of Iran from 1981 to 1989. In 2009 he was the reform candidate for president, around whom the Green Movement coalesced. He has been under house arrest since February 2011.
Mohammad Taqi Mesbah Yazdi (YAZ)	A hardline cleric and politician. He is a member of Iran's Assembly of Experts and is seen as the most conservative cleric in Iran.
Ahmad Janati (JAN)	A hardline cleric and chairman of the Guardian Council.
Asadollah Asgaroladi (ASG)	An important businessman with interests in exports, banking, real estate and healthcare. President of several of Iran's international Chambers of Commerce.
Ali Akbar Hashemi-Rafsanjani (RAF)	Served as president of Iran from 1989 to 1997 and chairman of the Expediency Council.
Ali Ardeshir Larijani (LAR)	Current chairman of the Iranian Parliament and former secretary of Iran's Supreme National Security Council.
Yousef Sanei (SAN)	An Iranian scholar and Islamic theologian and philosopher. He serves as a Grand Marja of Shia Islam.
Mohammad Baqr Qalibaf (QAL)	The current mayor of Tehran.
Yahya Rahim Safavi (SAF)	An Iranian military commander and former Chief Commander of the IRGC.
Mahmud Ahmadinejad (AHM)	The former president of Iran.
Seyyed Mohammad Khatami (KHAT)	President of Iran from 1997 to 2005. One of Iran's most prominent reformers.
Saeed Jalili (JAL)	Secretary of Iran's Supreme National Security Council, the equivalent of the U.S. National Security Council.
Hassan Rouhani (ROU)	The current president of Iran.

Table 1. Iranian elites in case study. The abbreviations used in plots are shown in parentheses. Information on roles is as of late 2013.

The analytical questions of interest included:

- Will Iran agree to a nuclear deal that places strong restrictions on enrichment?
- Who might dissent from a nuclear deal and who are possible swing players?
- What are the most controversial issues? Which actor inter-relationships do they stress?
- What issues have the potential to lead to factional realignments?

In November 2013, after the survey had been developed, an interim nuclear deal was announced between Iran and its negotiating counterpart, the P5+1 countries, consisting of the five permanent members of the UN Security Council (China, France, Russia, US, UK) and Germany. This spawned an additional question as to what may have caused the shift in Iran's posture toward nuclear negotiations which will be discussed in the section on simulation results. Space does not allow background on Iranian politics to be provided here – a good discussion of Iranian factional politics can be found in Rieffer-Flanagan (2013).

Analyst Survey

The analyst survey elicits expert judgment on the leadership group under study. The use of a survey methodology allows analysts to complete the survey at their convenience and avoids potential groupthink effects associated with oral elicitation of a group of analysts at one sitting. Only the Actor Opinions and Influence Network components of the survey are discussed here as they are the ones most essential for understanding the results presented below (other components are described in Gabbay (2013)). The surveys can be averaged to form a composite assessment or analyzed individually in order to bring out differences in analyst perspectives.

The Actor Opinions survey section contains a list of statements designed to assess the attitudes of the group members relevant to the policy issues of concern. For each member, analysts are asked to estimate the member's level of agreement/disagreement with a series of statements covering a range of issues, goals, identities, and specific policies. Examples include 'The production, stockpiling, and use of nuclear weapons are all forbidden in Islam' and 'The IRGC should play a guiding role in maintaining Iran as an Islamic republic'. The instructions direct analysts to score the statements on the basis of the private beliefs of the members if thought to be at odds with their public rhetoric. The Actor Opinions section is used to calculate member issue positions known as 'natural preferences,' a key parameter in both structural analysis and the simulation.

The Influence Network section contains a matrix in which analysts estimate the strength of each actor's direct influence upon each of the other members in the group and vice versa. This (directional) dyadic influence strength depends on factors such as the frequency of communications, status within the group, common or rival factional membership, and personal relationships of friendship or animosity. The influence network is used directly in structural analysis and to calculate the 'coupling strengths' which scale the persuasive force of one member on another in the social influence dynamics simulation.

Structural Analysis

Structural analysis involves quantitatively and visually probing the factional composition of the group as a whole and how individuals are situated within the group. Analyst judgments on discrete elements concerning individual actors and actor dyads are synthesized to enable the discovery of broader features and patterns in the group. In addition to being illuminating in its own right, structural analysis can help focus the simulation effort on particular issues such as those which are most polarizing or have the potential to result in new alignments of actor subgroups distinct from the dominant factional configuration. It also allows for insight into dynamics not encompassed by the simulation such as interactions between multiple issues, alliance formation, and succession considerations.

Issue Analysis

The methods for issue analysis utilize only the group member issue positions (natural preferences) calculated from the actor opinions. The analyses can address how contentious an issue is, how similar actor positions are for any given pair of issues, and patterns of actor alignment across the whole set of issues. This section presents examples of these analyses for the Iran case.

The most fundamental element of issue analysis is simply the actor natural preferences themselves as is shown in the plots of Figure 2. The positive end of the scale indicates support or a favorable attitude with respect to the issue and has a maximum value of 2. Similarly, the negative axis signifies opposition or an unfavorable attitude. These plots are useful for visual inspection of individual actor positions and their distribution within an issue as well as examining clustering across issues. To better highlight clustering patterns and deviations from them, conservatives are identified as those actors having negative scores on the Liberalism plot and marked by solid gray circles; reformers have positive Liberalism scores and are marked by open squares. The Liberalism plot shows a bloc consisting of KHAM (the Supreme Leader), SOL, SAF, JAN, YAZ and JAL at the far negative end of the axis indicating strong opposition to political and cultural liberalization whereas ROU (the president), KHAT, MUS and SAN are found oppositely at the pro-liberalization side. This pattern of opposed clustering is repeated for other issues as well thereby leading to the interpretation of the former subgroup as a core conservative or hardline faction and the latter one as a core reformist or moderate (from a US/Western viewpoint) faction. Note that RAF is usually aligned with the reformists except on the Economic Reform issue towards which he is most opposed. A subgroup composed of LAR, QAL and ASG typically forms a conservative-leaning centrist bloc with Economic Reform again a notable exception. The level of disagreement over an issue is indicated by the amount of spread in the actor positions as can be quantified by standard deviation (see Table 2 below). Nuclear Weapons, in which the actor positions appear most compressed, is the least contentious issue by this measure.

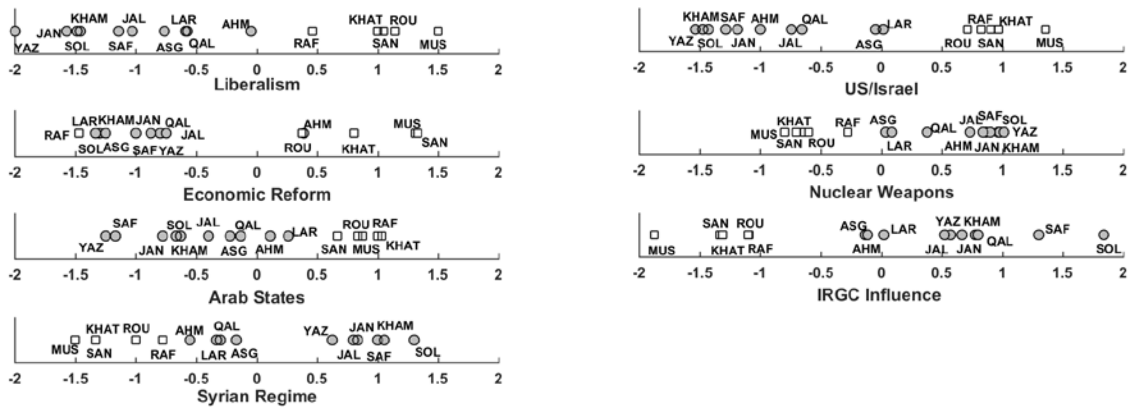


Figure 2. Actor natural preferences for the seven issues. Conservatives are gray circles, reformers are open squares.

To get a sense of the relationship between issues, Figure 3 shows plots of actor natural preferences on two pairs of issues. Observe in Figure 3(a) that the actor positions in the joint US/Israel and Nuclear Weapons space fall essentially on a line as is indicated by the almost perfect (anti-) correlation of -0.98. This implies that, although the issues are plotted on a two-dimensional plane, the system is essentially one-dimensional in the sense that if given the actor positions on one issue, then their positions on the second can be inferred with high accuracy. In Figure 3(b), Economic Reform appears on the vertical axis: there is now more scatter of actor positions and the correlation is lower in magnitude (although still highly statistically significant) indicating a less one-dimensional aspect. The core conservative and reform factions are still effectively at the opposite ends of the main axis (PC 1) but RAF and AHM are significantly off axis as are, to a lesser extent, ASG and LAR. The two plots have different implications with respect to potential coalitions if the two issues interact so that changing position on one issue affects an actor’s position on the other. In Figure 3(b), RAF is nearer the conservatives and could side with them increasing his support for a more robust nuclear capability and bolstering their opposition to economic reforms. An analogous implication holds for AHM with respect to the reformist faction. Such realignment would not be possible if the two issues in play were US/Israel and Nuclear Weapons as in Figure 3(a): RAF would remain close to the reformers and AHM to the conservatives. However, it could be possible for ASG and LAR to be forced to side with one of the main factions if maintaining their centrist positions were to become untenable.

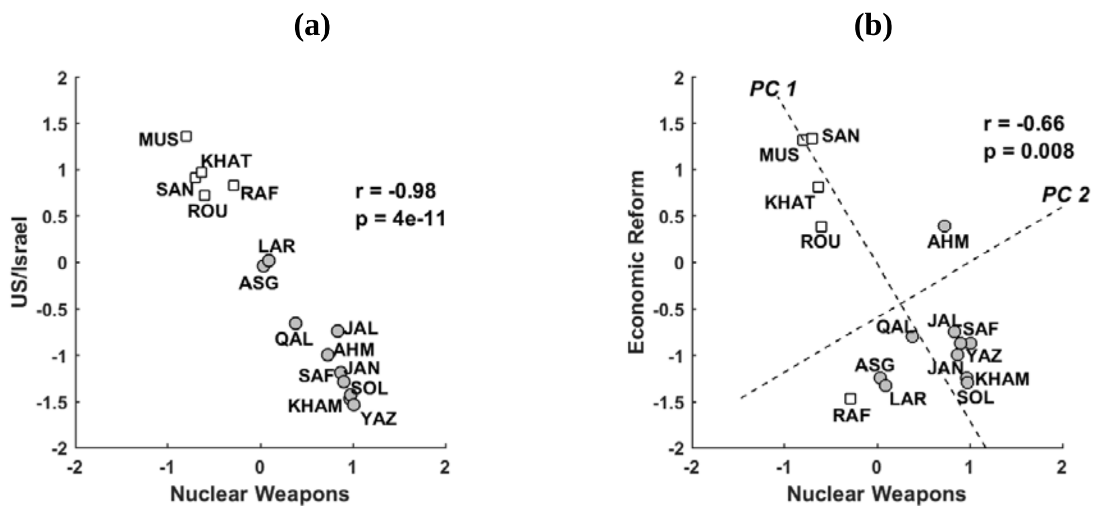
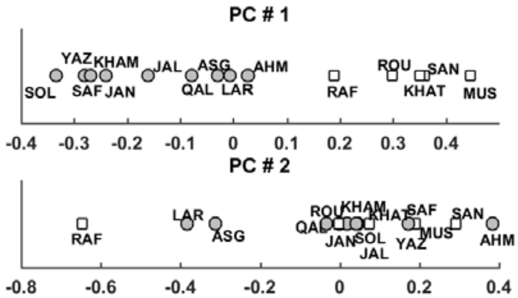


Figure 3. Two-dimensional issue plots: (a) US/Israel and (b) Economic Reform plotted vs Nuclear Weapons. The numbers in the upper right-hand corner are: the correlation between the actor positions on the two issues (*r*); and the p-value measure of statistical significance (*p*) which indicates the probability that the observed correlation could have occurred by chance given no underlying relationship – lower p-values imply stronger statistical significance. The dashed lines in (b) correspond to principal component axes.

While the discussion of factional alignments so far has involved visual inspection across issues, numerical methods exist for automatically revealing patterns of alignment. One such technique is Principal Components Analysis (PCA) which seeks to represent a data matrix by a series of coordinate vectors, known as principal components (PCs), each of which corresponds to a pattern of covariation in the data (Webb and Copsey, 2011). The PCs are ranked in descending order of importance as determined by how much of the variance (the data scatter around the mean) they carry which is given by their 'eigenvalues'. Each PC is uncorrelated with the others so that they run as perpendicular directions through the data; in fact, they correspond to an alternative set of coordinate axes to the direct data variables.

For example, we can interpret Figure 3(b) as measurements of the two issue variables, Nuclear Weapons and Economic Reform, with each actor's natural preference pair as a data point. The first PC then points in a direction along the dashed line running from upper left to lower right and the second is the line perpendicular to that. In essence, PCA has rotated the standard coordinate system, wherein each axis corresponds to one issue, to the dashed system where each PC is a weighted combination of the two issues (the weights can be negative). The origin is the intersection of the two PCs located at the point given by the mean along each issue. An actor's coordinate on each PC is the (signed) distance between this origin and where he falls on the PC axis (the nearest point on that axis to him). The variance in the actor coordinates on PC 1 is given by its eigenvalue of 4.22 whereas PC 2's eigenvalue is 1.75 so we see that PC 1's share of the total variance (71 percent) is much larger than that of PC 2 (29 percent) indicating that PC 1 is more important in approximating the data. (The disparity between the two PCs would be even greater for Figure 3(a) given that it is much more one-dimensional.)



PC 1 Eigen-value	PC 1 Issue	PC 1 Issue Value	PC 2 Eigen-value	PC 2 Issue	PC 2 Issue Value
0.57	LIB	0.46	0.17	ECON	0.89
	IRGC	-0.44		USISR	-0.34
	USISR	0.41		ARAB	-0.26
	SYR	-0.39		NUKE	0.16
	ECON	0.32		IRGC	0.09
	ARAB	0.30		LIB	0.06
	NUKE	-0.28		SYR	0.03

Figure 4. First two principal components of actor natural preferences. Left: Actor coordinates. Right: Eigenvalues and issue values. Eigenvalues are expressed as the fraction of the total sum of eigenvalues. Issue values are listed in descending magnitude.

Turning to the complete set of issues, Figure 4 shows the first two (out of seven) principal components obtained from the data matrix formed by the natural preferences of each of the fifteen actors on all seven issues. The top plot on the left side shows the actor coordinates for the first principal component. This corresponds well to the dominant factional alignment identified in our discussion of the issue plots of Figure 2. The core conservative bloc of KHAM, SOL, SAF, JAN, YAZ and JAL is on the extreme negative end; the conservative-leaning centrists QAL, LAR and ASG are just left of zero and the core reform bloc of ROU, KHAT, MUS and SAN is on the far positive side. Rafsanjani is aligned with the reformers on PC 1 as is the case on six of the issue plots. Ahmadinejad's location as a centrist may be surprising given his international reputation as a hardliner during his presidency but is supported by his position near the center or on the reform side for four of the issues. The eigenvalues in the corresponding table show that PC 1 carries 57 percent of the total variance, much larger than PC 2's 17 percent share. This supports the interpretation of PC 1 as the dominant factional alignment. The PC 1 Issue Value column shows that there is no single primary issue whose magnitude is much larger than the others, again suggesting that PC 1 represents the most common pattern across the set of issues. This is not the case, however, for PC 2 where the Economic Reform component of 0.89 is by far the strongest. The plot of the PC 2 coordinates shows RAF and AHM at opposite ends reflecting the fact that, while the majority of the actors preserve the standard factional composition for Economic Reform, RAF and AHM make large against-the-grain shifts in the conservative and reformist directions respectively as observed in Figure 2 (RAF and AHM also appear at opposite ends of the second PC for the two-issue example of Figure 3(b)).

Network Analysis

Parallel to the investigation of issue-based factions described above, the factional structure which arises from the network of inter-actor influence relationships is also of concern.

Network science has developed many algorithms for detecting community structure in networks. Intuitively, the goal is to find subgroups of nodes which have more links among them than they do with other subgroups. Community structure may reflect similarities in preferences among network members via: the homophily principle (also known as assortative mixing), a formal construct for the commonplace that 'birds of a feather flock together' (Newman, 2010); or the mechanism of social influence which assumes that people who interact more often tend to become more similar (Friedkin and Johnsen, 2011). This section presents the application of a community structure algorithm which is then extended to illustrate how community structure and actor natural preferences can be integrated to address joint issue-network alignment.

The algorithm employed in PORTEND seeks to divide a network into two communities so that the network 'modularity' is maximized (Newman, 2006). The contribution to the total modularity from a given pair of nodes is proportional to the difference between their observed tie strength and that which would be expected if their interactions were solely due to chance; these contributions for all the dyads form the elements of the modularity matrix. The total modularity expresses the extent to which a putative division of the network into two communities exhibits a level of intra-community linking exceeding the level expected if the division were, in fact, arbitrary with no correspondence to behaviorally meaningful subgroups. The maximization is done in an approximate but efficient way by calculating the first eigenvector of the modularity matrix (eigenvectors are ranked in order of descending eigenvalue) and then assigning all nodes whose components in the first eigenvector are positive to one community and the nodes with negative components to the other. As an example, Newman (2006) presents an application to a network of 62 dolphins and finds that the two communities identified by the first eigenvector matched to high accuracy the two groups into which the network actually split after a key dolphin died (only three dolphins were misclassified).

The application of the community detection algorithm to the Iranian influence network is shown in Figure 5 which plots the actor coordinates obtained from the first two eigenvectors of the modularity matrix (using the symmetrized network in which tie strengths are the same in both directions in a dyad). We refer to the eigenvectors as 'factional dimensions'. The initial discussion of Figure 5 will center on the meaning of Factional Dimension (FD) 1 but, as will be seen below, FD 2 also has a significant interpretation regarding the Economic Reform issue. The dashed line corresponds to the division formed by separately grouping nodes with positive and negative signs in Eigenvector 1. The left and right sides correspond to conservative and reformer classifications respectively. The correspondence with the issue-based factions is immediately apparent because, as in PC 1 in Figure 4, all the gray circles are on one side and the white squares on the other. All members of the core conservative and reform blocs as identified by the issue analysis above are correctly classified. Only ASG can be considered to be misclassified as a reformer, perhaps understandable given that he is more of a centrist than a hardline conservative (and in fact he appears in the middle of FD 1).

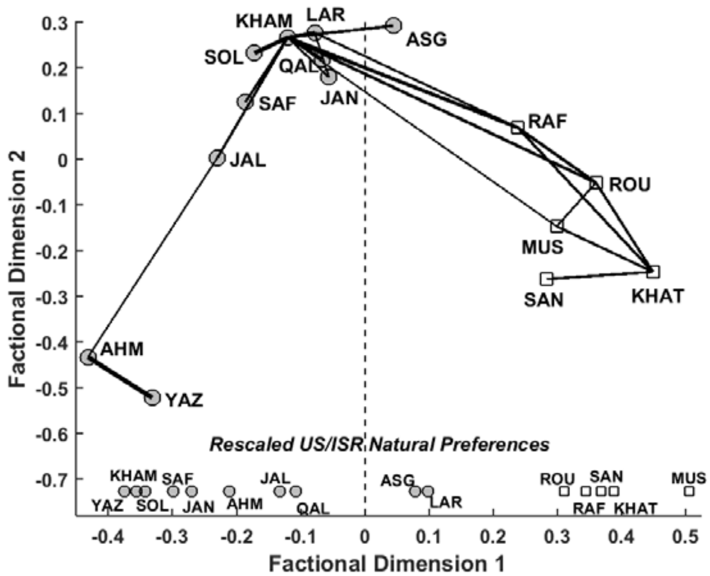


Figure 5. Community structure in the Iran influence network. Dashed line partitions network into conservative (left) and reformist (right) communities. Link thickness between actors is proportional to relationship strength (weak links have been thresholded). Points at bottom of plots are actor natural preferences for the US/Israel issue rescaled to fit inside the horizontal axis.

It is also possible to combine issue and network data for purposes of addressing polarization and factional realignment. As used here, polarization refers to the extent to which disagreement over an issue reinforces divisions present in the network. Hence, polarization is not simply the level of disagreement over an issue as might be gauged from the standard deviation of actor issue positions. Quantitatively, the contribution of an actor dyad to the polarization for a given issue is found by multiplying the corresponding modularity matrix element – network-derived data – by the product of the two actor natural preferences – issue data (which makes the polarization equivalent to the covariance between natural preferences over all the ties in the network (Newman, 2010)). The polarization value for each issue is shown in Table 2. For comparison purposes, the standard deviation of actor natural preferences is shown in the last column. The US/Israel issue is most polarizing even though Liberalism has the highest standard deviation. Nuclear Weapons and Economic Reform have very nearly the same polarization whereas the latter has a substantially larger standard deviation. Consequently, we see that the integration of network and issue data gives a different and perhaps more significant picture of issue divisiveness than issue data alone.

The Aligned Dimension column in Table 2 is the number of the factional dimension with which the issue has the highest magnitude correlation. The larger value of polarization of US/Israel as compared with Liberalism, despite the latter's higher standard deviation, is a reflection of the greater alignment that US/Israel has with FD 1 as seen by its better correlation in Table 2. A visual sense of this alignment can be gleaned from Figure 5 by comparing the actor network positions along the horizontal axis with their (rescaled) US/Israel natural preferences at the bottom. Whether or not the correlation represents a genuine relationship between the eigenvector and the actor natural preferences can be assessed from the p-value column with lower values indicating greater significance. All of the correlations in Table 2 are highly significant. Six of the seven issues best correlate with FD 1 reinforcing the conclusion that it represents the dominant factional division in the network. Consequently, these issues stress the major faultline in the group but are not likely to cause a fundamental factional realignment (although centrists may be forced to side with one camp or another as noted in connection with Figure 3(a)). However, Economic Reform is seen to align best with FD 2 (the vertical axis in Figure 5) and, therefore, if it were to become more salient, a factional realignment could be induced in which RAF allies more strongly with the conservatives and AHM does likewise with the reformers.

Issue	**Polarization**	**Aligned Dimension**	**Correlation Magnitude**	**Standard Deviation**
US/Israel	0.395	1	0.885***	1.036 (3)
IRGC Influence	0.393	1	0.779**	1.095 (2)
Liberalism	0.358	1	0.799**	1.142 (1)
Syrian Regime	0.248	1	0.731*	0.974 (5)
Economic Reform	0.198	2	0.645*	0.998 (4)
Nuclear Weapons	0.195	1	0.907***	0.701 (7)
Arab States	0.158	1	0.796**	0.786 (6)

Table 2. Integrated issue-network analysis metrics. Issues are listed in descending order of polarization. Statistical significance levels of correlations: * $p<.01$, ** $p<.001$, *** $p<.0001$. The last column shows the standard deviation of the actor natural preferences (rank in parentheses).

Nonlinear Social Influence Simulation

Model Description

The nonlinear model of social influence simulates the evolution of group member positions along the policy axis due to their mutual interactions. The social science underpinnings of the model derive primarily from social psychology theories of attitude change and small group dynamics and theories of foreign policy decision making (Eagly and Chaiken, 1993, Hermann et al., 2001). A brief summary of the model is presented in this section; fuller descriptions can be found in Gabbay (2007c, 2007b). It should be noted that since the model is focused on group dynamics, it does not involve a representation of the decision making calculus associated with particular policy choices (see Davis and O'Mahony (2013) for an example of a computational model that does so in the context of insurgent groups). With respect to other models of group dynamics, on a mathematical level, the nonlinear model is most similar to that of social influence network theory (Friedkin and Johnsen, 2011) to which the model can be made equivalent in the (linear) limit of low disagreement. The most prominent formal model of decision making applied to real-world political contexts is that of Bueno de Mesquita (1997, 2009) which however has received some criticism regarding lack of transparency (Scholz et al., 2011). While Bueno de Mesquita's model uses analyst input and a one-dimensional issue axis as does the present model, it is based on expected utility theory whereas PORTEND is rooted in nonlinear dynamical systems theory and network science, cornerstones of complex systems research.

In the model, an actor's position changes under the influence of two separate forces: the 'self-bias force' and the 'group influence force'. Considering the self-bias force first, each actor is assumed to come to the debate with an initial issue position given by his natural preference (also called the natural bias) which reflects the actor's underlying beliefs, attitudes, and worldview pertinent to the issue. If an actor's position is shifted from his natural preference due to group pressures, he will experience a cognitive dissonance that resists this change and strives to move the actor's position back toward the natural preference.

The group influence force is the total force acting to change an actor's position due to the persuasive efforts of the other actors in the group. It is assumed to operate in a pairwise manner so that an actor – the message receiver – experiences a persuasive 'coupling force' from another actor – the message sender – to whom he is connected (and vice versa). The functional form of the coupling force is nonlinear in the difference between the sender and receiver positions: if the difference is small, the force increases roughly linearly; the force then reaches a peak at a difference known as the 'latitude of acceptance', beyond which it begins to wane towards zero. This form is motivated by social judgment theory which posits that the amount of opinion change in a person receiving a persuasive message follows an inverted U-curve as a function of the difference between the opinion advocated in the message and that of the receiver (Eagly and Chaiken, 1993) (however, the coupling force in the model has a long tail rather than ending abruptly as in an inverted-U). The coupling force that actor *j* exerts on actor *i* also depends on the 'coupling strength' from *j* to *i*, which is obtained from the influence network. The 'coupling scale' is the mean of the incoming coupling strengths (in-degree).

The model description above governs how actors change their positions under their mutual influence but does not yield the decision itself. In order to do so, the appropriate decision rule – leader choice, weighted majority, or consensus – must be applied. Typically, this is done after the simulation reaches equilibrium so that the actor positions reach steady-state values that no longer change perceptibly. For purposes of determining whether an actor supports or dissents from a policy decision, an actor is considered to support a policy if it lies within a specified maximum distance, usually taken to be the latitude of acceptance, from the actor's final position. Similarly, actors are taken to dissent from a policy if it lies beyond this distance.

Complexity enters into the model via the nonlinear form of the influence between actors and its interaction with the network formed by the inter-actor coupling strengths. The model can be considered to have two regimes of behavior: a 'linear' one, in which the behaviors typically correspond to initial intuition, and a 'nonlinear' regime corresponding to high disagreement (roughly, position differences exceeding twice the latitude of acceptance) in which behaviors can run counter to initial intuition. The linear regime is always characterized by gradual changes in outcomes as parameters such as the level of disagreement or coupling scale are varied whereas the nonlinear regime can exhibit discontinuous transitions, referred to as bifurcations, between states such as deadlock, majority rule, and consensus (Gabbay and Das, 2014). With respect to the interaction of nonlinearity and network structure, at high disagreement levels networks with lower tie density (for example, a chain) can be more effective at reducing group discord and yielding consensus than ones with higher density (for example, a complete network) in contrast with the 'linear' expectation that a higher number of ties is better for consensus formation (Gabbay, 2007b).

Simulation Results

All seven issues were simulated. Here only the Nuclear Weapons results are discussed as that issue was of primary analytical concern. The simulation using the set of parameter values calculated directly from the composite analyst is shown in Figure 6(a). The latitude of acceptance is taken to be one unit along the issue axis as that corresponds to a step along the attitude survey scale, say from ‘neutral’ to ‘weak agreement’ or from ‘weak agreement’ to ‘strong agreement’. Actors start out at their natural preferences and the time units are essentially arbitrary given that the equilibrium is of concern.

The policy labels and corresponding intervals in Figure 6(a) are calculated from the Actor Opinions section of the survey (they can also be set manually) and are intended to be rough guides to assist in interpretation of simulation results rather than hard and fast boundaries. The Weapons Capability policy corresponds to an actor believing that a nuclear weapons capability is critical to ensuring the survival of the Iranian regime. Breakout signifies that the actor prefers that Iran should have the ability to develop nuclear weapons without building or testing them. Strong Restrictions signifies that the actor is willing to accept more forceful constraints on Iran’s nuclear enrichment program such as intrusive monitoring of nuclear facilities in exchange for the removal of economic sanctions (a fourth policy of No Enrichment was not preferred by any actor).

The decision rule is leader choice and the open diamond indicates the final policy, coincident with KHAM’s final position. We see that the policy choice is located in the Weapons Capability zone, justly slightly less hardline than KHAM’s initial natural preference. This is not surprising given the outsize influence that KHAM has on the group; his network out-degree – the sum of all his outgoing influence network values on the rest of the group is more than three times the second highest actor. Rafsanjani does move sufficiently towards a harder line so that he can support the policy. However, the core reformers, most notably ROU, dissent as they end up greater than one unit (the latitude of acceptance) from the policy.

The above result, however, is inconsistent with the more conciliatory posture that Iran took in reaching the interim nuclear agreement in November 2013. It is not tenable that the Iranian president Rouhani, a savvy political insider, would have been vigorously pursuing a nuclear deal with the United States completely at odds with the Supreme Leader’s policy, thereby setting himself up for failure. This leads to the inference that the Iranian policy may have shifted to a softer line than represented in the original analyst data. Possible scenarios underlying this shift can be investigated by changing the simulation parameters. Simulations of scenarios involving increased group cohesion or increased reformer status due to Rouhani’s election in June 2013 could not produce a significant enough policy shift. But another potential explanation is that Khamenei himself softened his position, which can be modeled by shifting his natural preference in the negative direction along the Nuclear Weapons issue axis. This can indeed account for the softer line policy: given the leader choice decision rule and his great influence, the policy essentially follows his natural preference; a shift of -0.2 brings the policy into the Breakout range and a shift of -1 moves it into the Strong Restrictions range.

(a) **(b)**

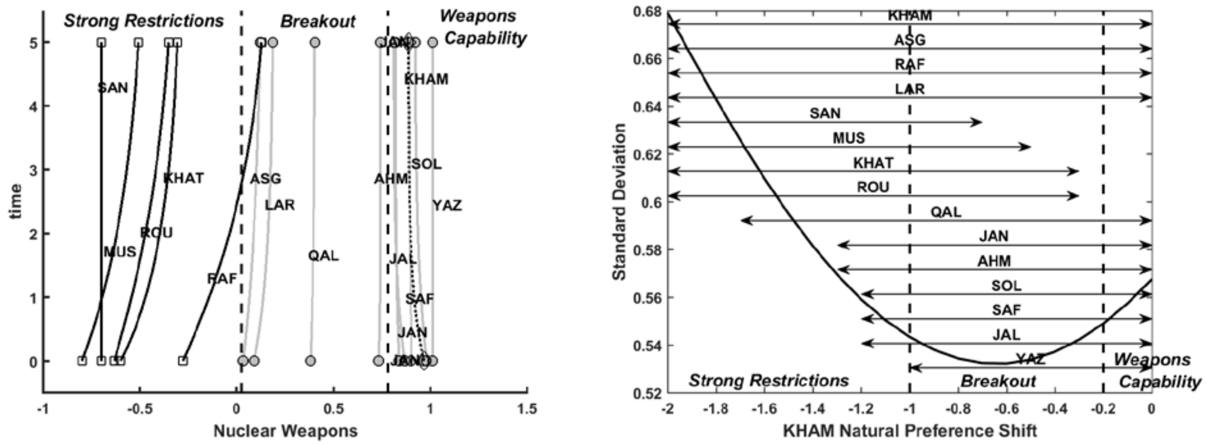


Figure 6. Nuclear Weapons issue simulation. (a) Actor trajectories using composite analyst values (first letter of actor abbreviation intersects with trajectory curve). Dashed lines demarcate boundaries between different policy labels. Dotted line is policy value (same as KHAM trajectory due to leader choice rule) and open diamond at top is policy decision. (b) Effect of Khamenei softening his natural preference: standard deviation of actor final positions (solid curve) and actor concurrence intervals (double-headed arrows, actor listed above). Horizontal axis is shift from KHAM original natural preference from composite analyst.

While it is clear that Khamenei can shift the policy if desired, considerations of minimizing discord within the leadership as a whole and, in particular, maintaining the support of key hardliners – the IRGC members Soleimani and Safavi, and Janati, the chairman of the Guardian Council – are doubtlessly important in his decision making calculus. These factors can be assessed using Figure 6(b) which plots the standard deviation of the final positions and the concurrence interval for each actor – the range of KHAM's natural preference shift over which the actor supports the policy decision. Observe that there is a minimum in the standard deviation at a shift of about -0.6 approximately in the middle of the Breakout interval. Furthermore, there is a range from about -0.7 to -1 for which all actors concur with a policy in the Breakout zone. These observations imply that a Breakout policy would minimize discord within the group. Indeed, as KHAM moves into the Strong Restrictions zone, he rapidly begins to lose conservative support: first YAZ, then crucially at -1.2 the IRGC members SOL and SAF, followed shortly thereafter by JAN.

The above analysis leads to the conclusion that the Khamenei softening scenario is a plausible explanation for Iran's shift to a posture more amenable to reaching a deal on the nuclear issue; he can maintain consensus while pursuing a Breakout policy, which is consistent with trying to reach a nuclear agreement, albeit one which would be very weak from the perspective of the United States. The fact that there were secret meetings between US and Iranian officials on the nuclear issue starting in 2012, a year prior to Rouhani's election (Associated Press, 2014), suggests that Khamenei may very well have shifted towards a more flexible position than the original hardline Weapons Capability ascribed to him from the analyst surveys. With respect to the prospects of reaching a final deal, his original analyst-derived position would imply that a deal would be extremely unlikely. The analysis of the softening scenario indicates that Khamenei's room for maneuver is limited so that he can only move a small amount into the Strong Restrictions zone before losing the support of key conservatives.

This suggests that a deal which provides robust provisions against an Iranian breakout capability – in particular, the US stated that it sought a minimum breakout time of one year – would indeed be possible but very difficult to reach. A deal between Iran and the P5+1 was in fact announced in July 2015. An assessment as to the strength of the deal from the P5+1 perspective – whether the monitoring and other restrictions on Iranian nuclear activities are sufficiently robust as to prevent a rapid breakout capability or a covert program – cannot be made here. However, the fact that the negotiations took twenty months from when the interim deal was announced to reach a final agreement, including two six-month extensions of the interim deal, attests to the difficulty in consummating the negotiations.

Conclusion

Relationships among leadership elites and their preferences on important issues are essential elements in determining the outcomes of policy debates. This chapter has presented a methodology, implemented with the PORTEND software package, for the analysis of the factional structure of leadership elites and the simulation of their group decision making via the nonlinear social influence model. Methods for investigating factional structure based on issue data alone range from simple standard deviations and plots of actor natural preferences to more sophisticated pattern extraction using Principal Components Analysis, which revealed meaningful dominant and subordinate factional alignments among the set of Iranian leaders; the first corresponding to the primary conservative-reformer divide over most of the issues and the second reflecting key departures from this alignment with respect to economic reform. Complementary to the issue analysis, the application of a community structure algorithm to the inter-actor influence network also yielded similar dominant and subordinate structures via the first two eigenvectors. The uncovering of the parallel structure in the issue and network data illustrates the power of applying methods from research in complex networks. This research also forms the basis for the polarization metric which quantifies the extent to which differences in actor issue positions also stress network faultlines, thereby providing an integrated measure of how divisive an issue is.

The social influence model entails complexity via its nonlinear coupling of actors over their influence network and was applied to Iranian nuclear decision making. Simulation of the original analyst values yielded a policy decision that was so hardline as to be inconsistent with apparent Iranian moves towards more negotiating flexibility in late 2013. The model's capability for scenario analysis was illustrated to address this inconsistency. Khamenei's shift towards a more moderate natural preference was found to be the most plausible explanation. Sweeping over his natural preference shift, the simulation indicated that he had sufficient room to maneuver before losing the support of key hardliners so as to make negotiations tenable. However, his ability to enter the Strong Restrictions zone, which presumably would have considerable overlap with the goals of the P5+1 countries, was found to be quite limited implying that achieving an agreement would be quite difficult – a conclusion perhaps supported by the long period of time required to reach a deal.

Finally, addressing further research, one area could involve the investigation of whether automated content analysis of actor rhetoric could be a viable input source for either the structural analysis or the simulation. Another area could be extending the social influence model to a multidimensional issue space in order to allow issues to trade off against each other. Additionally, complexity research on adaptive networks could be used to develop an issue-network coevolution model in which both issue positions and network ties would interact and change dynamically, thereby explicitly modeling alliance formation processes, a capability not present in the current model.

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