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## Information Aggregation in Political Decision Making

Francesco Squintani

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### Summary and Keywords

Information is of great value to politicians, who make decisions with uncertain consequences and want to convince the public and their political counterparts of the validity of their proposals. Because of conflicting interests and ideal views, information is not easily shared among political agents. However, information aggregation is collectively valuable, because it leads to better decision-making and facilitates defusing conflicts. Formal theorists investigate some of the institutions used to aggregate information among political agents.

There are several studies on committee decision-making. They establish that rational voters do not make voting choices using only their individual information. This complicates information aggregation, especially when high quorum voting rules are adopted. However, deliberation may restore efficient information aggregation. In the case of homogeneous committees, strategic incentives for information acquisition are optimized by a decision mechanism based on random sequential individual consultations.

The fundamental characteristic of committees is that all decisions are made jointly. An early 21st-century surge of formal studies on information aggregation considers the “opposite case” of information exchange among political entities that make decisions independently of each other. These articles deliver insights on topics as diverse as the optimal organization of meetings, the benefit of cabinet governments, the shape of political and social networks, and the value of engagement of societal groups. The breadth of these results is a testimony to the success and promise of this methodology.

Of great importance for international conflict avoidance is building and maintaining trust among states and non-state entities. Formal analysis of international conflict management institutions such as standard diplomatic communications, peace summits, and third-party intermediation clarifies that, while none of these institutions fully prevent war, they are all useful to aggregate information, build trust, and facilitate peaceful agreements. Even communication through standard diplomatic channels and public announcements may significantly reduce the risk that disputes evolve into conflicts. Third-party intermediation is more effective, even if mediators are not endowed with the power to enforce their settlement proposals.

Keywords: information aggregation, committee decision-making, voting games, information exchange, political networks, mediation, international conflict, political decision making

## Introduction

It is a truism that politicians value information. They make decisions with uncertain consequences, and they want to convince the public and political counterparts of the validity of their proposals. Information may make the difference between success and failure for a single politician, a political party, or a state government. Because of conflicting interests and different ideal views, information transmission among political entities is limited by the incentive to try to win support for one's positions. Attempts at deception and misinformation are also common. But while information hardly flows freely among political entities, information aggregation is collectively valuable. It leads to better proposal portfolios and decision-making and facilitates conflict avoidance.

This article describes formal models of information aggregation among political agents. These models are methodologically based on the theory of non-cooperative games of incomplete information (see Myerson, 1997, for a textbook treatment).<sup>1</sup> In the context of political science, the study of information aggregation took center stage after Arrow's impossibility theorem (Arrow, 1950), which implies that individual information cannot always be efficiently aggregated in collective decision problems. Non-cooperative games of incomplete information have proved useful to study several environments in which some agents do not know something someone else knows and they would like to access such "private information."

A substantial literature has studied information transmission from one or more perfectly informed experts to a single uninformed decision-maker following the seminal papers by Milgrom (1981) for the case of transmission of verifiable information and by Crawford and Sobel (1982) for the case of cheap talk (see, e.g., Battaglini, 2002; Gilligan & Krehbiel, 1989; Morris, 2001). While this circumscribed domain of research has been investigated in depth, the broader question of how different institutional arrangements facilitate information aggregation among political agents involved in decision-making has been only partially explored.

Significant work has focused on the logical implications of quorum voting rules (e.g., simple majority, supermajorities, unanimity) for information aggregation and decision efficiency in committees. A more recent surge of papers considers how individual decision-makers with diverse political preferences exchange information that may be useful to each other. Of great importance for international conflict avoidance is building and maintaining trust among states and non-state entities. Formal theorists engage in the analysis and design of institutions that aggregate and manage information with the objective of brokering peaceful resolution of disputes.

## Information Aggregation and Decision in Committees

The strategic reasoning of individuals in committees plays a role in collective decisions over a set of alternatives. Each agent has private information that is relevant for the committee's decision. Individual preferences over alternatives may also be influenced by idiosyncratic biases, but absent such biases all committee members prefer a decision that is as informed as possible. Canonical examples of this class of problems include committees that evaluate policy proposals at every level of government as well as juries charged to decide whether a defendant is guilty or innocent. All jurors prefer to convict guilty defendants and acquit innocent persons, and they are unsure of the defendant's status. But their personal willingness to risk convicting an innocent person relative to acquitting a guilty defendant may differ.

Formal theoretical works address the question of how well committees aggregate private information, paying attention especially to whether voting rules lead to informed decision, to the role of deliberation prior to voting, and to an individual's incentives for strategic information acquisition.

## Strategic Voting

Unless unanimous consensus is reached with deliberation, decisions in committees almost always are made with a vote. The adopted voting rule may require a different quorum to approve different alternatives. Here we focus on binary choices, such as whether to adopt a proposal that changes the status quo or whether to acquit or convict a defendant. Often a proposal is adopted by simple majority, but a supermajority is required when the status quo should be preserved, as is the case for state constitutions. Jury conviction of a defendant almost always requires unanimity.

It is intuitive that voting should lead to informed decisions that account for the views of all committee members.<sup>2</sup> This is easy to see if it is presumed that each agent's vote is based only on her individual information (so-called "sincere voting"), without strategic considerations about how other agents might vote. As shown by Austen-Smith and Banks (1996), however, rational voters usually do not adopt sincere voting strategies. This insight can be envisioned clearly when the decision requires unanimity and is held up by an agent who is opposed because of her private information (Feddersen & Pesendorfer, 1998). Based on their information, all the other agents vote in favor, and such overwhelming evidence that the decision is correct makes the opposing agent change her vote.

In the context of jury decisions, this result questions the presumption that unanimity quorum for conviction is the best rule to prevent conviction of innocent defendants. Feddersen and Pesendorfer (1998) consider situations in which deliberation fails to aggregate information fully and the final decision is made with a vote. If jurors have similar and moderate biases over the two possible mistakes (convicting an innocent vs. acquitting a guilty defendant), there is a significant risk of convicting an innocent person under unanimity rule, even as the size of the jury grows large.<sup>3</sup> Majority and supermajority voting rules lead to a smaller probability of both types of mistake than the unanimity rule, especially in sufficiently large juries, because they make it more likely for individual jurors to vote sincerely in equilibrium.

In general, the reason why a rational agent may prefer to vote contrary to her private information in equilibrium is that she conditions her choice on the event that her vote matters, i.e., it changes the quorum.<sup>4</sup> The fact that the other votes makes her vote matter is informative about the other voters' information, and this may convince the agent to vote disregarding her information. As observed by Dekel and Piccione (2000), it is then irrelevant whether voting is simultaneous or sequential, in the sense that the set of equilibria in which each voter conditions her choice on the event that her vote matters is the same. In other words, each voter disregards how others voted before her and acts as if the final distribution of votes is such that her vote changes the quorum.

Of course, there also exist equilibria in which one or more agents cast their vote with the expectation that it will not make any difference.<sup>5</sup> In the case of simultaneous voting, these equilibria are unreasonable. They require that some agents vote against their preferred alternative only because they expect their vote not to matter. When voting is sequential, instead, there exist equilibria in which voters update their information using earlier votes, vote for their preferred choice based on this information, and yet expect their votes not to matter (Ali & Kartik, 2012). Only early votes are informative in these equilibria. If sufficiently many early votes are in favor of the same alternative, the following voters rationally choose to herd and ignore their own information.

Some of the suggestions raised so far have been tested empirically by Iaryczower and Shum (2012), using data on voting in the U.S. Supreme Court from 1953 to 2008, and the ideology scores of nominees and justices coded by Segal and Cover (1989). The private information aggregation in the Court is quantified as the frequency of cases in which a justice votes differently from what is predicted by her ideology scores (44% of cases). The evidence demonstrated that justices vote strategically, as votes were significantly correlated with the ideology scores of the other justices in the Court. This is contrary to the “sincere voting” hypothesis that votes are based only on justices’ individual information.

Similar results were found in lab experiments by Guarnaschelli, McKelvey, and Palfrey (2000). Subjects were given context-free decision problems analogous to those of a jury with homogeneous biases. Evidence of strategic voting under the unanimity rule was uncovered: a large fraction of subjects voted “conviction” even when their private information suggested “innocence.” However, fewer incorrect “convictions” were recorded under unanimity rule than under majority rule.

## Deliberation

The provocative results described so far presume that not all information has been aggregated in deliberation prior to voting by the committee. Of course, if all voters’ biases over alternatives coincide, they will share all information in deliberation and reach a consensus (Coughlan, 2000). Dorazelski, Gerardi, and Squintani (2003) were the first to consider deliberation and voting when voters’ biases over alternatives are not aligned. They fully characterize equilibrium for the case of two agents uncertain about each other’s preferences, who first run a straw poll (i.e., they simultaneously submit non-binding opinions) and then simultaneously vote on two alternatives. They show that the only case in which one votes according to the other agent’s opinion is when her preferences conflict with her private information.

Beyond the case of two agents, Austen-Smith and Feddersen (2006) prove that the unanimity rule supports full information revelation in straw polls only if all voters’ biases over the alternatives coincide. They show an example in which a straw poll fully aggregates information in a committee with diverse preferences under majority rule.<sup>6</sup> But if the straw poll takes place sequentially instead of simultaneously, Van Weelden (2008) shows that full information aggregation requires that all voters’ biases are sufficiently close, regardless of the quorum rule.

While these papers consider information aggregation in committees with fixed communication protocols and voting rules, Gerardi and Yariv (2007) study unconstrained deliberation. Consider the following decision “mechanism.” First, the committee members simultaneously report their information and biases over alternatives. Then, the alternative is chosen randomly, according to a probability distribution that depends on all individual reports. These distributions are agreed upon in advance so that there is an equilibrium in which every report is “sincere.” Gerardi and Yariv (2007) prove that all equilibrium outcomes obtained with any deliberation protocol and decision rule (including, but not only, quorum voting rules) can also be achieved with the above mechanism together with appropriately chosen report-dependent probability distributions.<sup>7</sup> Suppose now that the decision must be validated with a vote—the question is whether this will limit information aggregation.<sup>8</sup> The answer is no, unless the required quorum is unanimity. For any other quorum rule, the agents can optimally decide the best alternative with deliberation (possibly, but not necessarily, using the above mechanism) and then unanimously vote for it. Assuming optimal deliberation, all such quorum rules are equivalent.

These results have been tested by Goeree and Yariv (2011) in lab experiments where subjects were given context-free problems analogous to jury vote. Without deliberation, a higher quorum voting rule led to a lower probability

to “convict the innocent,” as in earlier experiments. Deliberation that took the form of unconstrained communication before the vote significantly reduced such differences and improved efficiency. Subjects mostly communicated with public messages, revealing private information. Such messages were a good predictor for final group choices.

According to the empirical estimations by Iaryczower, Shi, and Shum (2018), however, deliberation may hurt decision-making because it may lead agents to coordinate on suboptimal equilibria. Using the 1925–1996 U.S. appellate court vote records, they calibrate the justices’ individual information and biases in the model by Gerardi and Yariv (2007) without assuming optimal information aggregation in equilibrium. The calibrated information and biases were used to calculate the counterfactual voting outcomes without deliberation, as specified in the equilibrium of the majority voting model by Feddersen and Pesendorfer (1998). In this comparison, deliberation is beneficial only when the justices have divergent biases or their private information is sufficiently imprecise.

## Information Acquisition and Learning

As well as aggregating private information, committee decision rules should encourage individual members to first gather information. Researching facts is costly, and because information is a public good, it is underprovided relative to the social optimum. Persico (2003) studies the case of decision-making by quorum voting rule without deliberation and voters with homogeneous biases. He shows that simple majority optimizes incentives for individual information acquisition, provided that the committee is not too small.<sup>9</sup> The optimal committee size increases as the prior assessments of the alternatives become closer.

Moving beyond the case of voting rules (with or without deliberation), Gershkov and Szentes (2009) fully characterize optimal information acquisition and decision in committees with homogeneous biases. An optimal class of mechanisms is as follows. One random agent at a time is chosen by a referee to gather and report information without being informed of her position in the sequence or of previous reports. After each additional report, the referee either continues calling agents or stops and chooses an alternative. The possibly random decision rule ensures that it is an equilibrium that agents exert effort when called (because their biases are homogeneous, they also report truthfully).<sup>10</sup> Gershkov and Szentes (2009) characterize more precisely the optimal mechanism under the additional constraint that the decision is also optimal given any sequence of reports (i.e., the referee cannot pre-commit to arbitrary decision rules that may better incentivize information acquisition, at the cost of sometimes choosing suboptimally). A decision is made when the assessment based on the reports favors one alternative with sufficient precision and the required precision decreases with each additional report.<sup>11</sup>

Information acquisition in committees where voters have diverse biases over alternatives is mostly an open question. In one interesting case studied by Strulovici (2010), the agents know the value of the status quo and may collectively choose to experiment with an alternative. With experimentation, each agent may learn whether the alternative or the status quo is better for her. Voting rules are shown to not achieve efficiency because voters do not vote “sincerely.” When experimentation is about a costly innovation with uncertain rewards such that “no news is bad news,” a simple majority leads to insufficient experimentation.

Several insights into the main themes of formal theories on information aggregation in committees can be gleaned. Rational voters do not cast votes based only on individual information. This complicates information aggregation, and this distortion is compounded by voting rules with a high quorum (such as unanimity, in the extreme). Nevertheless, committees efficiently aggregate private information through deliberation, and it may be that the optimal decision rule is not a quorum voting rule. Assessing the individual strategic incentives for information

acquisition in committees is a fundamental question that is not yet fully answered. In the case where all voters' biases over alternatives coincide, the optimal mechanism takes the form of random sequential individual consultations. The fundamental characteristic of committees that shapes formal analysis is that all decisions are made jointly, leading to the investigation of information aggregation properties of different decision rules. The next section considers the "opposite case" of information aggregation among political agents making individual decisions independently of each other.

## Information Exchange Among Political Decision-Makers

Some models of information exchange and aggregation assess political agents who make decisions independently of each other. The main obstacle to information exchange is that politicians hold diverse ideal views and possibly conflicting prerogatives. They may want to lie and try to win support for their own positions. For example, let us consider policymakers in different jurisdictions. They face similar policy challenges and would gain from the experience gathered by their peers. Information may be exchanged in official meetings or in one-to-one conversations. Because of externalities across jurisdictions, each agent's payoff is influenced by the decisions of others, and she has an incentive to try and convince them to act in line with her own interest.

The formal analysis of information exchange among independent decision-makers is carried out within the framework of communication games based on Crawford and Sobel (1982). They consider communication from a fully informed sender to an uninformed decision-maker. This formulation is developed into a multi-player communication model by Galeotti, Ghiglini, and Squintani (2013), the workhorse game used by formal political theorists to study information exchange. They consider communication among players with different preferences about the decisions each one of them makes. Each player holds private information useful for all decisions and can be a sender or a receiver of information. No single individual player is fully informed.

Galeotti et al. (2013) prove that a player is capable of communicating credible information to an audience of players in equilibrium only if her preferences are sufficiently close to (a weighted average of) the players' preferences in the audience. This constraint becomes tighter when audience members receive more information from other players. Equilibrium welfare depends not only on the number of truthful messages sent in equilibrium but also on how evenly these messages are distributed across decision-makers.

This framework has been used by Patty (2013) to study how meetings of policymakers should be organized optimally. Communication during the meeting is shared among all participants, and one-to-one information transmission is discouraged. Invited agents may improve information aggregation and welfare even if they do not communicate truthfully. This is so when they change the composition of agents' preferences at the meeting, making it closer to the preferences of a larger set of speakers. Excluding agents with large decision-making power may also be optimal, because it changes the composition of preferences more significantly than excluding agents with less authority.

Instead of holding decision-making power fixed and asking how to organize information transmission, Dewan and Squintani (2018) ask how authority should be granted within a political group. In their model, leadership is shaped by the availability of trustworthy advisers. Truthful advice requires ideological proximity to the leader, potentially countering the desirability of ideologically moderated leaders. A relatively extreme leader with a large ideological base may be better for the whole group. This insight extends to the case of electoral competition between two

separate groups. Party cohesion and the size of a leader's base within the party are possibly more important to electoral success than proximity of the leader's position to the median voter. The logic is intuitive. Although close to the median voter, a leader isolated within her own party will not be effective. Voters anticipate this and do not vote her into power.

The logic of these results on optimal allocation of authority is taken one step further by Dewan, Galeotti, Ghiglino, and Squintani (2015), who study executives in parliamentary democracies. Two aspects are modeled: decision-making authority is assigned to individuals, and private information is aggregated through communication. By comparing different institutional arrangements, Dewan et al. (2015) prove that cabinet government maximizes information aggregation and executive efficiency. Because cabinet communication involves all decision-makers, individual ministers' information disclosure incentives are optimized. Power within the cabinet should not be fully centralized, they show, nor fully decentralized, irrespective of whether the considered policies require individual ministers' policy-specific expertise or a more generalized knowledge.

Now take a step back and consider the information aggregation problem at the intraparty deliberations stage that shapes party platforms. In the model by Dewan and Squintani (2016), each politician may either bargain individually or join a faction and delegate bargaining power to the faction leader. Factionalization is shown to allow the transfer of power to moderate politicians and to improve information aggregation. Ideological factions benefit the party when they provide a means to tie uninformed or extremist politicians to more moderate and informed faction leaders.

The idea of voluntary association and communication leads to the exemplary study by Penn (2016) on engagement and disengagement of societal groups. Modern societies comprise subcultures whose identity is shaped by ethnicity, religion, class, sexual orientation, and geographic location. These groups may choose to associate and communicate with others, or they may disengage. They face a trade-off between the informational benefits of engagement and the externality costs imposed by the decisions of others. Penn (2016) demonstrates that policies of inclusion by extremist subcultures can be beneficial even when extremists choose to not actively communicate. Institutional mechanisms for incentivizing cultural interchange across societal groups are also identified.<sup>12</sup>

These studies of information exchange among political agents naturally lead to the consideration of political networks. Despite many empirical studies on the subject, formal modeling is very recent. The earliest contribution is by Patty and Penn (2014), who extend the framework by Galeotti et al. (2013) to study sequential communication in networks of three agents, with heterogeneous policy preferences and discretionary authority. By means of examples, they show that permuting the position of agents in the same networks may change information transmission incentives.

Beyond the case of three players, the study of communication on networks in the form of cheap talk is an unexplored territory. Squintani (2018) considers transmission of verifiable information on networks. Each agent's strategic decision is whether to disclose information or withhold it. As an example, policymakers who have access to policy experiments conducted in their own jurisdiction may disclose results to a network of peers in other constituencies or conceal them in the abundance of bureaucratic documents, but they cannot falsify results.

When all agents are ideologically distant from each other, Squintani (2018) shows that the optimal and (pairwise) stable network is the line in which agents are ordered according to their ideological biases. This is in sharp contrast with earlier results that identified the star as the optimal and stable network for information transmission in the absence of biases (Bala & Goyal, 2000; Jackson & Wolinsky, 1996). When agents are clustered in ideologically

cohesive groups, it is optimal for all agents that each cluster organizes as a faction: a star whose only link with the other stars is through the star centers (the faction leaders). These results suggest positive and normative rationales for horizontal links between like-minded agents in political networks as opposed to hierarchical networks such as the star that prevails in institutions where agents' preferences are closely aligned.

While Squintani (2018) considers optimal network transmission of multi-agent verifiable information, Bloch, Demange, and Kranton (2018) study the spreading of possibly false information originating from a single agent. Their model comprises biased agents, who prefer a specific action regardless of what is best for the society, and unbiased agents, who wish correct decisions to be made. One agent may learn which action is best and choose whether to send a true or false message to her network neighbors, who may then transmit it further. A social network is found to serve as a filter when unbiased agents block messages from parts of the network where many agents are biased so that sufficiently credible information spreads.

The formal studies of information exchange discussed in this section deliver insights spanning the optimal organization of meetings, the benefits of cabinet governments, the shape of political and social networks, and the value of engagement of societal groups. The value of these results lies in consequent suggestions for the design of institutions and policies that facilitate information exchange among agents with diverse preferences. The next section is set in the context of international relations. Formal studies of the information aggregation and trust-building properties of peace-brokering institutions are presented. The results derived in these studies can serve as inspiration for intergovernmental institution design.

## Information Aggregation and Trust Building in International Relations

Private information is a quintessential feature of international relations. Confidentiality and secrecy are the standard rule when military and foreign policy are concerned. State entities and militant groups devote large resources to espionage and counterespionage activities to achieve strategic advantages. The resulting widespread uncertainty and incomplete information are collectively detrimental to the international community. As identified in the classical work by Fearon (1995), the main rationalistic cause for arms races and conflict is incomplete information about opponents' military strength and willingness to fight. Blainey (1973) famously argued that wars begin when states disagree about their relative power and end when they agree again.

Of course, if two disputants know each other's opportunity costs of war and agree on the chances that either of them wins, then there is a deal involving net transfers that they both prefer to conflict. In a bargaining model where a dominant entity makes an ultimatum offer to a revisionist who wants to change the status quo, Fearon (1995) shows that war breaks out with positive probability when the revisionist's willingness to fight is private information. This result generalizes to more complex bargaining models that include multiple rounds of offers (see, e.g., Powell, 1999). It holds a fortiori when both disputants' willingness to fight is private information and when they disagree over the probability of victory because their military strength is private information.

These results are further generalized by Meirowitz and Sartori (2008), who include militarization choices in the analysis. They prove that conflict cannot be avoided with probability one unless both military strength and war preferences are perfectly observable. This result holds for any bargaining protocol satisfying two minimal

requirements. The first one is that if the parties were to know each other's military strengths, then they would reach a deal and avoid war in equilibrium. The second one is that it is possible for either party to initiate war without the consent of the other disputant.<sup>13</sup>

Bringing private information about willingness to fight into the picture, Kydd (1997) considers a dispute between two entities, each of which is either greedy and strictly prefers to fight or a security seeker who fights only if attacked. Disputants have imperfect information on the opponents' types. First, they simultaneously choose whether to attack or not, and war breaks out unless neither attacks. Then, they choose whether to arm or not, and this choice is assumed observable. Finally, they choose again whether to attack or not. The analysis formalizes the intuitive idea that arms races and conflict may be driven by mistrust of opponents' motives, in so-called "spirals of greed and fear" (Jervis, 1978). Security seekers build weapons in equilibrium unless their information is that the opponent is also a security seeker. Greedy types arm and trigger war in the final period.<sup>14</sup>

Given that private information is the main cause of arms races and conflict, it is important to assess how well peace-brokering institutions aggregate information among disputants and build mutual trust. The role taken by formal theorists is to determine the logical consequences of different institutional arrangements, such as communication through standard diplomatic channels, public announcements, the organization of summits or peace talks, information transmission through mediators, third-party inspections, and other forms of third-party intermediation.

It is intuitive that communication helps smoothe out differences. Baliga and Sjöström (2004) show that even communication through standard diplomatic channels may significantly reduce the risk of arms races and conflict. In their model, two disputants are uncertain about each other's motives. In an extreme form of spiral of greed and fear, a small probability that they are greedy is sufficient for arms races and conflict to escalate with probability one in equilibrium. Communication dramatically improves this situation. If parties can exchange messages before they choose their strategies, then there is an equilibrium in which the dispute subsides with large probability.<sup>15</sup>

The logic that communication helps to avoid conflict is used by Levy and Razin (2004) to explain the established fact that democracies rarely fight one another. Democratic governments face higher costs than non-democracies when lying about their motives through public announcements because their statements are subject to public scrutiny. As they are less likely engage in bluffing, their opponents are less inclined to fear unannounced aggressive behavior. This leads to the unraveling of spirals of greed and fear between democracies.<sup>16</sup>

This explanation of "democratic peace" has been provided empirical support by Schultz (1999), who tested it against the competing explanation that democratic leaders face higher political costs for waging war. Using data on militarized disputes from 1816 to 1980, he estimated the probability that a revisionist backs down when served an ultimatum by a stronger state and found it significantly lower when the latter is a democracy. This is consistent with an explanation of democratic peace based on credibility of communication.

Although communication usually helps in avoiding conflict, a word of caution comes from the study by Baliga and Sjöström (2012) on provocations by extremists who wish to derail peaceful resolution of disputes. In their model, one of the two sides in a dispute comprises a leading group whose propensity to fight is unknown to the opponent and the other an extremist group who wants to trigger war. If the extremists are informed about the leading group's willingness to fight, they can increase the chances of a spiral of fear just by making cheap talk statements. When the leading group's willingness to fight is sufficiently high, the extremists provoke the opponent. This coordinates the equilibrium into conflict, unless the opponents' propensity to fight is very low.<sup>17</sup>

Besides communication through standard diplomatic channels, recent work investigates more complex institutional arrangements, such as peace talks, summits, and various forms of intermediation. In addition to providing a forum in which enemy leaders establish personal relations and focus communication, further benefits of peace summits are reported by Meirowitz, Morelli, Ramsay, and Squintani (2019). In their model, disputants uncertain of each other's military strength bargain with the Nash protocol. They simultaneously make demands and fight if the demands are incompatible. Suppose a summit is organized where the enemy leaders share information and attempt to coordinate demands to avoid war. Every equilibrium is proved to take the following form: with some probability, the summit is "successful" and an agreement is reached. If not, the summit fails and the dispute precipitates into conflict. The probability that the summit is a success depends on the enemy leaders' conversations. Meirowitz et al. (2019) show that the possibility that the summit will fail provides better incentives to communicate truthfully and reach an agreement than communication through standard diplomatic channels.<sup>18</sup> While conflict still occurs with positive probability, its chances are reduced.

Consider the involvement of mediators who lay the groundwork for the summit by meeting the disputants separately. They collect information under the expectation of confidentiality and use it to compose the agenda of the summit and formulate proposals to resolve the dispute.<sup>19</sup> The question is whether this form of third-party mediation improves information aggregation and further reduces the risk of conflict. Fey and Ramsay (2010) provide a negative answer when the disputants' private information concerns willingness to fight. The answer by Hörner, Morelli, and Squintani (2015) is positive when private information concerns military strength. The difference hinges on the role of the mediator's confidentiality within peace talks. Because of confidentiality, enemy leaders have better incentives to disclose information to a mediator than directly to each other. By judiciously using this information at and before the summit, the mediator optimizes each disputant's equilibrium beliefs about the opponent's strength, thus encouraging them to make concessions and reach an agreement. If disputants know each other's strengths, private information on willingness to fight does not directly influence expected payoffs in the case of war, and the mediator's ability to shape equilibrium belief does not discourage conflict.

We have concluded that mediation is useful in dispute management even without the capability of creating external incentives, such as sanctions or military intervention. The next question is whether it would be even more effective if mediators were endowed with the power to enforce decisions, i.e., whether arbitration would be more effective than mediation. Hörner et al. (2015) show that this distinction need not be consequential. The optimal mediator's strategies make enemy leaders so wary of conflict in equilibrium that they accept peaceful settlements as often as they would be imposed under arbitration, in expectation.<sup>20</sup> What an arbitrator achieves by imposing peaceful dispute settlements is achieved by a mediator in equilibrium by convincing enemy leaders to accept negotiated proposals.

The observation that none of these institutions fully ensures peaceful resolution of disputes leads to an intriguing question. War can be understood as the "punishment" for starting and escalating a dispute. Institutions that reduce the chance that disputes evolve into conflicts make such a punishment less severe and may paradoxically incentivize disputes. Meirowitz et al. (2019) investigate whether this may potentially offset the benefits of peace-brokering institutions. They find that the perspective of dealing with disputes with unmediated communication may incentivize militarization and dispute escalation, ultimately leading to higher conflict incidence. Instead, the form of mediation studied in Hörner et al. (2015) is not subject to this drawback.<sup>21</sup>

Another feature of this form of mediation is that the only source of information is voluntary communications by disputants. In some instances, third parties may acquire information in different ways. Baliga and Sjöström (2008)

study the effectiveness of weapon inspections in conflict avoidance in a setting where a disputant's military strength is uncertain. The disputant can refuse weapon inspections, which may lead to pre-emptive attack by the opponent. However, the possibility of hiding military strength also has the positive effect of reducing the incentive to arm. Communication through standard diplomatic channels complements the possibility of weapon inspections by reducing the risk of pre-emptive wars. Kydd (2003) considers the role of an intermediary who has privileged information about one disputant's willingness to fight and may report it to the other.<sup>22</sup> He shows that if the intermediary's objective is just to minimize the risk of conflict, communication will not be credible and intermediation will be ineffective.

By reviewing formal studies on some of the main institutions used to foster peaceful dispute resolutions, this section uncovered surprisingly positive insights. While none of the considered institutional arrangements succeeds in fully preventing war, they are all effective to some degree in aggregating information, building trust among disputants, and facilitating peaceful agreements. Even communication through standard diplomatic channels and public announcements may significantly reduce the risk of spirals of greed and fear and of ensuing conflicts. Third-party intermediation is more effective, even if mediators are not given the power to enforce their settlement proposals. Third-party military intervention (even in the most benign forms of interposition or peacekeeping) need not be a necessary ingredient of dispute management and conflict limitation.

## Conclusion

This article presented formal studies of information aggregation in politics, distinguishing among the main topics considered in the literature. After presenting the main themes of the analysis of information aggregation through voting and deliberation in committees, it described works on information exchange among political decision-makers and concluded with studies of how international conflict resolution institutions aggregate information and build trust among disputants. The main lessons drawn can be summarized as follows:

1. Formal studies on committee decision-making establish that rational voters do not choose their votes using only their individual information. This complicates information aggregation, especially with high quorum voting rules. Efficient information aggregation may be restored with deliberation. In the case of homogeneous committees, strategic incentives for information acquisition are optimized by a mechanism with random sequential individual consultations.
2. Recent studies on information exchange among political agents making decisions independently of each other provide insights into diverse topics. These include the optimal organization of meetings, the benefit of cabinet governments, the shape of political and social networks, and the value of engagement of societal groups. The breadth of these results is a testimony to the success and promise of this methodology.
3. Formal analysis of international conflict-avoidance institutions such as communication through standard channels, peace summits, and third-party intermediation clarifies that, while no such institutions can fully prevent war, they are all effective to some degree at aggregating information, building trust among disputants, and facilitating peaceful agreements.

Some themes are important for the general question of information aggregation in politics, but the extant formal investigation of these so far is insufficient. Political institutions that aggregate information often deal with multiple issues simultaneously. While a single issue may be the pretext for an international dispute, it is rarely the case that

disputants cannot accommodate along several dimensions. One main task of negotiators is often to figure out how much one side is willing to yield in one area of bargaining in exchange for concessions on a different issue of contention. Information exchange among political decision-makers is also often about different policy dimensions. An individual actor may have a specific expertise in a policy area and may want to trade her advice in exchange for information on other policy matters. Committees decide on several issues, and individual members often trade support for a decision they do not care much about in exchange for support for their own initiatives. This practice of “log-rolling” is considered quintessential to the working of political committees. A fundamental question is whether the consideration of multiple issues leads to better or worse information aggregation and decisions than predicted by the single-issue theories discussed in this article.

Related to these comments on aggregation of information about multiple issues is the question of the extent to which game repetition and reputation concerns may shape the strategies of political agents engaged in information aggregation. Log-rolling in committees often takes the form of intertemporal trade of favors. An agent’s incentive to support a decision lies in the expectation that she will be reciprocated in the future, and one’s reputation as a “team player” is a most valuable asset. Similar considerations apply to the case of information exchange among officeholders in different constituencies.

Of course, political decision-makers also care about their reputation vis-à-vis their voters and supporters. Progress on this question is made by Levy (2007), who studies the effect of voting transparency in a committee whose individual members’ only motivation is establishing a reputation of voting what is best for the society. If each vote is public, she proves that agents vote against presumption (i.e., against the alternative deemed superior *ex ante*) more often than it is optimal for the society. This negative effect is mitigated when individual votes are secret and only the final decision is public.<sup>23</sup> The effect of reputational motives on deliberation is studied by Visser and Swank (2007) in a committee where members have diverse biases over alternatives and each member is either perfectly informed or fully uninformed. They confirm the result that agents vote against presumption and predict that committees vote unanimously. However, the quorum rule matters as it determines the informed agent’s preference with whom the committee vote conforms.

Despite this work on committee members’ concerns for their reputation outside the committee, the question of how concerns for reputation within different institutions (including, but not only, committees) influence information aggregation is almost entirely unexplored. And it is important that this question is within reach of formal political theory, because it can be tackled with the standard methodology of repeated games of incomplete information.

Finally, it is worth exploring the determinants of preferences and biases of political agents engaged in information aggregation. The studies presented in this article take such preferences as the starting point of the analysis and argue that preference divergence is the main obstacle to information aggregation. In many contexts, the preferences of political agents are not exogenous. For example, they can reflect the preferences of the median voters in the different constituencies that elect them or the balance of powers within the state/entity they represent in a dispute. If it were possible to smooth out preference divergences, information aggregation would be easier to achieve and welfare would improve. In the context of international relations, for example, the empirical regularity that democracies do not fight each other epitomizes the conflict-avoidance role of institutions that align preferences of disputants. Similarly, different electoral rules may lead to more effective parliamentary debate and legislative production by keeping in check polarization among elected representatives. And it is well known that a wise selection of agents into committees is one of the main ingredients toward their effective functioning. It is not only

their preferences over outcomes that matters, their attitude toward cooperation and intertemporal deals determines whether they will be willing to act as team players in the interest of the whole committee.

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## Notes:

(1.) Just as in any non-cooperative game, decisional entities (players) choose strategies to maximize individual “utilities” (that need not coincide with monetary payoffs but may include ideological preferences over outcomes, for example), given their beliefs about the strategies of all the other players in the game. Strategies are “in equilibrium” when all players’ beliefs are correct. In a game of incomplete information, the players’ utilities may depend on an unknown “state of nature,” and players may be unsure about their opponents’ motives and hence about how they choose strategies in the game. Such uncertainty is modeled by stipulating that each player may take different types with different preferences, and each type chooses a (possibly different) strategy to maximize expected utility given her probabilistic beliefs about the state and opponents’ types and her beliefs about each opponent type’s strategy. Strategies are in “Bayesian equilibrium” when strategy beliefs are correct and beliefs over opponents’ types and states conform with a “prior” distribution, common to all players, over the states of nature and all players’ types.

(2.) This supposition goes back to the suggestions by Condorcet (1785).

(3.) The intuitive conclusion that large juries rarely rule for conviction under the unanimity rule is restored by Gerardi (2000), who studies the case where jurors do not know each other’s biases, and there is even a small chance that the jury includes “extremists” who would never convict a defendant.

(4.) In the simple majority case, for example, an individual vote matters if it breaks a tie in favor of one alternative or the other, or if it creates a tie.

(5.) For example, in the simple majority case, it is an equilibrium for each voter to vote for the same alternative regardless of her information, in the expectation that all other voters will do the same.

(6.) Full information aggregation via straw poll requires that the voters be unsure about each other's biases. Otherwise, the agents with the least moderate biases in the committee would not reveal information.

(7.) This result is based on the "revelation principle" by Myerson (1979), which states that any equilibrium of a game in which players have private information and communicate according to any protocol can be achieved with a "mechanism" in which each player confidentially reports her information to an impartial mediator, who then makes individual recommendations to each player, randomizing with report-dependent distributions that ensure that the players report truthfully and obey recommendations in equilibrium. In the case of committee decisions, there is no use for individual recommendations and confidential reports and hence no need for such a mediator. The same outcomes can be achieved with reports addressed to the whole committee.

(8.) This naturally begs the question of why committees decide with voting, given that appropriately randomized decision rules would lead to efficiency. It is possible that even simple random mechanisms require excessive cognitive effort by the committee members. Further, the calculation of the report-based randomization probabilities that achieve optimality requires a precise probabilistic assessment of preferences in the committee, and this may not always be available.

(9.) Plurality rules are suboptimal for two reasons. First, the committee size required to support equilibria in which all agents vote sincerely grows with the quorum rule. And when agents expect to not reveal information, their information-acquisition incentives are weaker than if anticipating that they will vote sincerely. Second, the equilibrium probability that each agent's vote matters is smaller, the larger the quorum rule.

(10.) This result is a generalization of Myerson's revelation principle. Because agents called to acquire information are not informed of their place in the sequence, nor of the previous reports, their strategic decision is as if they communicated confidentially to a mediator, whose report-dependent decision rule ensures that agents acquire information when called. The reason why agents are called in sequence, instead of simultaneously, is to allow the mediator to economize on the overall information-acquisition costs.

(11.) Lowering the required precision as reports pile up is the optimal way to simultaneously incentivize information acquisition (which requires that the decision is "noisy," so that each report matters with sufficient probability) and minimize the probability of choosing the wrong alternative. With high probability, the decision is made early and it is precise, but upon being called, an agent believes her report likely matters.

(12.) Such mechanisms act either by mixing individuals of different subcultures in institutional places such as schools and offices or by raising the cost of within-group engagement (e.g., by banning tax relief and subsidies to associations and clubs that are not sufficiently diverse).

(13.) Suppose by contradiction that there existed an equilibrium in which militarized disputants avoided war by agreeing on settlements based on their relative strengths. Absent conflict, military strength is not fully observable, nor can it be perfectly demonstrated. Each disputant would have an incentive to reduce military spending. This would undo the basis for agreement they are supposed to reach and upset the equilibrium. But of course, if neither disputant militarized, both would have a unilateral incentive to arm and gain better terms, possibly by triggering war.

(14.) In the more sophisticated model by Chassang and Padrò (2010), arms races may facilitate peace by deterrence, when they reduce the first strike advantage and hence stifle offensive behavior. In the extreme case of mutually assured destruction, the first-strike advantage is eliminated. Instead, militarization that builds up a military advantage makes opponents fearful and increases the chance of pre-emptive conflict. It is further shown that military asymmetry can facilitate peace if the status quo is sufficiently favorable to the stronger entity, as it reduces the chances of a spiral of fear.

(15.) Security seekers differentiate their equilibrium messages depending on their propensity to fight. A “dovish” message is sent by those who fight only if they believe the probability the opponent fights is high, whereas those who fight unless they believe such a probability is low send a “hawkish” message. Doves do not escalate conflict, whereas hawks fight only against self-reported hawks. Greedy types send the same message as doves, but then act aggressively.

(16.) However, these results do not fully extend to the case where the modal best response to aggressive behavior is not to reciprocate but to acquiesce.

(17.) In situations where the modal best response to aggressive behavior is to acquiesce, a mirror-like manipulation strategy is available to pacifists who want to avoid war at all costs. By signaling that the leading group’s propensity to fight is low, pacifists encourage the opponent to act hawkish and force the leading group into submission.

(18.) In more formal terms, the summit provides the disputants a joint randomization device to coordinate on different equilibria of the Nash bargaining game. Joint randomization enlarges the set of outcomes possible after communication and thus yields better information transmission incentives.

(19.) This mediation practice is often called “shuttle diplomacy” and has become popular since Henry Kissinger’s efforts in the Middle East in the early 1970s and the Camp David negotiations mediated by Jimmy Carter (see, e.g., Fey & Ramsay, 2010, for a detailed discussion).

(20.) As proved by Bester and Wärneryd (2006) and Fey and Ramsay (2009), even an arbitrator could not avoid war with probability one. If she tried, either strong disputants would not agree to arbitration (if the arbitrator’s decisions were independent of the information she collected from enemy leaders) or weak disputants would pretend to be stronger (if settlements depended on leaders’ messages to the arbitrator). In either case, arbitration would be ineffective.

(21.) The reason lies again in the optimal mediator’s use of confidential information. As well as minimizing the incentives for weak disputants to exaggerate strength, optimal mediation strategies also minimize the incentive to acquire military strength and escalate disputes. Unmediated communication is a less sharp mechanism. It generates negotiated outcomes that favor stronger entities and hence incentive militarization.

(22.) The source of such information is not modeled, e.g., it could be based on espionage or be obtained as part of a broader deal with the disputant.

(23.) When individual votes are public, agents chance voting against presumption because if their choice is confirmed correct, this is a strong signal of competence, and such an expected benefit more than balances out the expected loss of being proven wrong. This distortion is mitigated by secret voting, because the voting outcome is only an imprecise signal of individual votes.

**Francesco Squintani**

Department of Economics, University of Warwick

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