

Financing Dilemma in Project Management [1]

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Abstract. The concept of an intelligent decision-making core for coalition formation becomes increasingly pertinent, especially in contexts where, e.g., diverse "stake-shareholders" must collaborate to achieve common goals. Take, for example, a multinational corporation aiming to launch a new product line. The company relies on contributions from various departments, each with its own goals and priorities. The decision core, in this case, must navigate through competing interests, ensuring that all stakeholders are motivated to contribute to the project's success. However, in practice, securing the necessary funding often falls short of initial expectations. Despite commitments from stakeholders, financial constraints or unforeseen circumstances can lead to incomplete funding, requiring the decision core to adapt and recalibrate strategies to meet the project's objectives. Thus, the concept of forming coalitions extends beyond theoretical frameworks, finding practical application in complex organizational dynamics where the alignment of interests is crucial for success.

Keywords: coalition; game; contribution; donation; monotonic; project

1. INTRODUCTION

Project management is often perceived as a structured approach to planning, executing, and controlling projects to achieve specific goals. However, real-world project management is far from a purely rational and deterministic process. Instead, it operates within a complex web of interactions, where individuals

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and groups make decisions under constraints of limited information, cognitive biases, and personal incentives—an idea well captured by the concept of bounded rationality. Bounded rationality, introduced by Simon (1955), suggests that human decision-making is not perfectly rational but is instead constrained by the cognitive limitations of individuals, the information available to them, and the time they have to make decisions. This is particularly relevant in the context of project management, where multiple stakeholders must form temporary alliances, negotiate resources, and adapt to unforeseen challenges.

One way to interpret project management in this light is through the lens of coalition games, a branch of game theory that examines how groups of individuals form coalitions to achieve collective benefits. In multi-person games (Owen, 1971, 1982), a coalition is a subset of participants who come together to maximize their shared interests. Rational coalitions, in particular, are of interest because they ensure that all members derive individual benefits, regardless of the actions of non-coalition members. In the context of project management, coalitions emerge when stakeholders—such as project managers, team members, sponsors, and external partners—align their interests to achieve project objectives. However, the formation and stability of these coalitions are not dictated purely by rational calculations; they are also shaped by the bounded rationality of the participants, leading to suboptimal or unexpected outcomes.

The interplay between coalition formation and bounded rationality introduces a new perspective on project management. Participants do not always act in ways that align with classical rationality; they may overestimate the benefits of collaboration, underestimate risks, or make decisions based on heuristics rather than systematic analysis. This introduces an element of unpredictability into coalition games within projects. The approach presented here builds upon prior research on monotonic systems (Mullat, 1971-1977, 1979), where the formation of coalitions follows certain structured conditions. While no prior knowledge of these formal models is required to engage with the discussion, it is important to recognize that the formation of coalitions in project management can be analyzed through a similar theoretical lens, particularly in terms of decision interdependence and incentive structures.

A crucial implication of this approach is that rational coalitions can still emerge within projects, even when participants exhibit bounded rationality. This aligns with the principle of independence of irrelevant alternatives (Nash, 1950), which suggests that rational choices should remain stable regardless of external factors that do not directly affect the outcome. However, in practical project management scenarios, rejected alternatives and unforeseen contingencies often influence decision-making in unexpected ways. Understanding project management as a coalition game thus provides a richer framework for analyzing how teams navigate uncertainty, allocate resources, and resolve conflicts while operating within cognitive and informational limitations.

To illustrate these concepts more concretely, the following layout for further reading scenario will provide an intuitive example of how coalition formation in project management can be shaped by bounded rationality, ultimately challenging conventional assumptions about rational decision-making in team dynamics.

The layout for further reading:

Section 1. Introduction, presents an overview of project management within a bounded rationality framework, the role of coalition games in decision-making, and the connection between coalition formation and rationality constraints.

Section 2 contains an extended pedagogical scenario of coalition games and bounded rationality in project financing. Particularly, it emphasizes negotiation and coalition formation, decision-making processes shaped by social and psychological factors, connected to our monotonic game (Mullat, 1979) kernel solution and equilibrium contribution, and the definition of kernel-based stability in coalition games. Beyond these points, it emphasizes ensuring fairness and independence in contributions, the psychological and social influences on funding decisions, and implications for project management in adaptive financing strategies for project managers. It also highlights the monotonic game kernel solution and the principle of independence, which ensure stability of contributions without external dependency.

Concluding Remarks provide a summary of insights from a coalition game theory point of view in project management, stressing practical applications beyond project financing.

2. EXTENDED PEDAGOGICAL SCENARIO: *Coalition Games and Bounded Rationality in Project Financing*

In this scenario, we consider a group of participants who intend to fund a developing project through donations. Each participant, indexed as $j = \overline{1,n}$ is initially willing to contribute a specific donation amount p_j, which may take any form—monetary, in-kind support, or intellectual resources. The donations p_j are assumed to follow a probabilistic distribution, modeled by an **exponential density function:**

$$f(x,\beta) = \begin{cases} \frac{1}{\beta} \cdot \exp(-x/\beta) \text{ for } x \geq 0, \\ 0 \text{ for } x < 0. \end{cases}$$

This function captures the reality that smaller contributions are more frequent, while larger contributions become increasingly rare. The expectation is to accumulate a sufficient total fund to finance the project. However, the final outcome is not merely the sum of individual donations but rather the result of a **dynamic negotiation process** shaped by bounded rationality and coalition formation.

2.1 Negotiation and Coalition Formation

As participants deliberate on the feasibility and relevance of the project, **their initial willingness to contribute undergoes transformation.** Instead of a deterministic and static allocation of donations, a reorientation of preferences takes place as individuals interact with like-minded participants. This dynamic process is governed by a coalition game, adhering to a **monotonic game scheme** (Mullat, 1979), where contributions are revised based on perceived benefits, risks, and social influences.

From a bounded rationality perspective, participants do not merely assess the project on strict cost-benefit calculations; instead, they rely on **heuristics, biases, and social cues** to refine their decisions. For example, some contributors may overestimate the collective enthusiasm and pledge more than they can sustain, while others may **underestimate** the urgency of the project and hesitate. As negotiations progress, these biases are gradually corrected through feedback loops, social comparisons, and strategic adjustments in coalition commitments.

2.2 The Kernel Solution and Equilibrium Contribution

The concept of a **kernel** (Mullat, 1979) provides a structured solution to this negotiation game. The kernel represents a **stable coalition of contributors**—a subset of participants who agree to finance the project under adjusted conditions. However, these contributions do not necessarily align with their original pledges. Instead, they converge toward a **reasonable equilibrium**, determined through the coalition game's internal dynamics.

The kernel ensures that:

1. **Fairness in Contribution Adjustments** – No participant is left feeling excessively burdened or exploited. If someone initially pledged disproportionately high compared to others, adjustments occur to balance perceived fairness.
2. **Independence from Non-Coalition Participants** – The agreement remains stable regardless of external influences or participants who choose not to contribute.
3. **Monotonicity in Commitment** – Contributions may be **reduced but not arbitrarily revoked**, ensuring that once a reasonable threshold is reached, the project remains viable.

2.3 Bounded Rationality and the Definition of a "Reasonable" Scenario

Crucially, the final agreed-upon contributions are **not the absolute optimal ones** in a classical rational sense, but rather the **most reasonable among all possible financing options**. This reasonableness arises from a balance between individual participant preferences, negotiation constraints, and bounded rationality factors such as:

- **Cognitive limitations:** Participants do not possess perfect information or computational capacity to determine the ideal funding structure.
- **Social influence and peer effects:** Individuals may adjust their pledges based on the visible commitments of others.
- **Loss aversion and sunk cost fallacy:** Those who have already contributed may be reluctant to withdraw their support entirely, even if their initial enthusiasm has waned.

In this context, the **reasonable scenario** refers to a financing arrangement where each participant provides a guaranteed contribution that satisfies the collective funding requirement **without excessive burden on any single individual**. The final funding state is **not necessarily the optimal solution from a purely rational standpoint**, but it is **the most stable and socially acceptable**—the best that can be achieved given the constraints of human decision-making and coalition dynamics.

2.4 Implications for Project Management

This extended scenario demonstrates that **project financing can be understood as a coalition game**, where contributions are not static but evolve dynamically based on negotiation and bounded rationality. Successful project management requires recognizing that:

- Funding commitments are **subject to change** based on evolving coalitions.
- Decisions are not always made rationally; they are influenced by **psychological, social, and strategic factors**.
- Stability in funding is achieved **not by enforcing rigid contribution rules** but by fostering **a fair and self-sustaining coalition** of committed participants.

By incorporating these insights, project managers can better navigate the complexities of stakeholder negotiations, anticipate shifts in commitment, and design adaptive financing strategies that maximize both feasibility and fairness.

To define a donation framework, we introduce an index representing the intensity $\pi(p_j, H)$ of a participant's $j \in H$ contribution. This intensity characterizes the coalition H, ensuring that all members contribute at least $\mathcal{P}(H) = \arg\min_{p_j \in H} \pi(p_j, H)$. The function $\mathcal{P}(H)$ represents an individual guaranteed donation of all participants in the coalition H.

For each individual participant $j \in H$ within the group H or coalition—who share similar interests—their donation intensity $\pi(p_j, H)$ will be at least equal to $F(H) = \pi(p_j, H) = p_j \cdot |H|$. The kernel coalition is defined as the coalition $H^* = \arg\max_{X \subseteq W} F(H)$ where guaranteed donation intensity among all possible coalitions organized inside so-called grandcoalition W is maximized. This kernel is particularly important because it guarantees a total contribution $\mathcal{P}(H^*) \cdot |H^*|$ granted to the project.

Let determine the preferences or momentums π of participants in the coalition H. Suppose that each participant's $j \in H$ contribution intensity, in collaboration with others in H, equals $\pi(p_j, H)$. If a participant cannot find a suitable partner for the project, their momentum to contribute will default to an individual baseline level, denoted as $\pi(p_j, \{j\}) = p_j \cdot |\{p_j\}|$, $|\{p_j\}| = 1$. Conversely, if all participants contribute and are in a well-matched grandcoalition W, the total (guarnteed) contribution will be at least $\mathcal{P}(W) \cdot |W|$, $|W| = n$.

1. First Statement: Exit Decreases Momentum

- We state that if a participant $j \in H$ leaves the group to work alone, the remaining participants $i \in H - \{j\}$ will experience a decrease in their intention momentum to contribute: $\pi(p_i, X - \{j\}) \leq \pi(p_i, X)$
- This is reasonable under the assumption that collaboration within H generates synergistic effects or mutual reinforcement, so removing j reduces the overall collective drive.

2. Second Statement: Entry Increases Momentum

- If an independent participant $j \notin H$ joins H, forming a new coalition $H + \{j\}$, we assert that the contribution momentum for the original members increases: $\pi(p_i, H + \{j\}) \geq \pi(p_i, H)$ for all $i \in H$.

3. Clarifying the Function π

- Is $\pi(p_j, H)$ a strictly increasing function of group size? If so, it might be helpful to explicitly state assumptions about the structure of π, such as monotonicity or superadditivity.

4. Potential Edge Cases

- There could be cases where adding j does not strictly increase momentum (e.g., if j is a free-rider or disrupts harmony). You may consider whether the inequality should be strict (i.e., $>$ instead of $\geq$).

A natural question arises: Can a larger group with lower individual donation momentums p_j fund the project more? While possible in theory, such contributions aren't guaranteed—this is the key issue. We will focus only on guaranteed payments from participants in the kernel H^* .

2.4.1 The Kernel and the Principle of Independence

The **global maximum for project funding by kernel participants** is the foundation of independence, aligning with the **principle of rejected alternatives**. This means the funding stability of H^* remains unaffected by the preferences of non-kernel participants. Even if outsiders wish to join, their inclusion should not significantly impact the funding outcome.

However, relying on non-kernel participants introduces **uncertainty**, as their commitments may be unreliable. They could strategically adjust their preferences, potentially destabilizing the project. To ensure stability, H^* must be robust enough to sustain funding without external support.

Our assumption is that the refusal of non-kernel participants to engage does not influence kernel members' decisions. This aligns with **bounded rationality** and Nash's (1950) **principle of independence from rejected alternatives**, ensuring that kernel participants remain committed regardless of external factors. Formally, this stability mirrors the **idempotent principle**—once a decision is made under stable conditions, it remains unchanged, preserving its original validity.

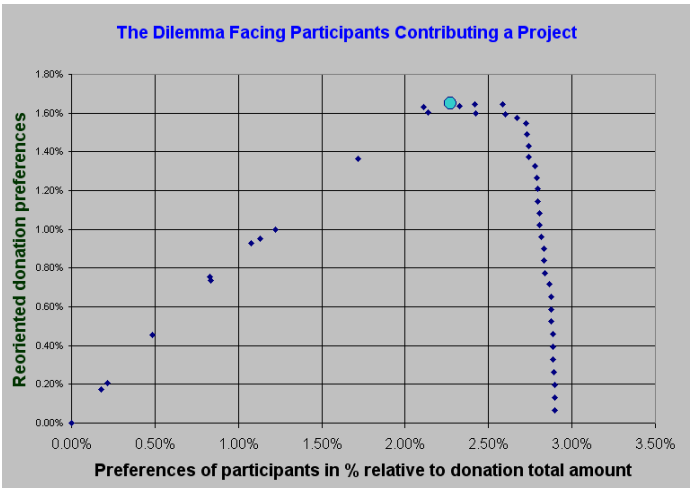


Figure 1 illustrates the relationship between participants' initial donation momentums and their adjusted contributions to the project. The X-axis represents participants' preferences as a percentage of the total donation amount, while the Y-axis shows the reoriented donation preferences, reflecting adjustments made during the **bargaining process**.

Let we introduce in accord with exponential distribution function $f(x,\beta)$ the preferences p_j, of participants' $W = \{j = \overline{1,n}\}$. We can designate as H, all participants who prefer to participate in the project together with their like-minded people, while $\overline{H}$ prefer to reject the project or have other reasons for participating in the project.

In this context, funding is not merely a passive process but a **bargaining game**, where participants strategically adjust their contributions to collectively manage the project in the most efficient way. A key observation from the figure is that kernel participants contribute at least **52.8% of their initial intended amount**, highlighting their adaptability and commitment to ensuring the project's feasibility. Through simulation, we find that these kernel members consistently allocate approximately **50% of their initial donation momentums**, demonstrating their readiness to sustain the project while navigating the bargaining dynamics.

The **blue dot** in the graph represents the **largest guaranteed contribution level**, meaning it is the highest point at which participants continue to agree to participate in the project. This point is critical in the bargaining process, marking the threshold where contributions remain stable and collectively accepted.

The kernel selection method:

1. All expected donations p_1, p_2,…, p_n, initially annonced for participants $j = \overline{1,n}$, will be reordered in descending order along the X-axis.
2. A new sequence, denoted as descending sequence, $\vec{p}_1 \geq \vec{p}_2 \geq,...,\geq \vec{p}_n$, is then constructed. This sequence lead to so-called defining momentums or intentions $\pi(\vec{p}_j, H_j) = \vec{p}_j \cdot |H_j|$, $|H_j| = j$, $j = \overline{1,n}$, is then plotted on the Y-axis representing single-peaked preferences of initial donations, where $H_{j+1} = H_j \cup \{j\}$, $j = \overline{1,n-1}$, $H_1 = \{1\}$.
3. The local maximum within this defining sequence is identified as the kernel of Mullat's monotonic game, which is visually marked by the blue dot in Figure 1.

This method efficiently determines the kernel, capturing the most stable level of collective contributions in the bargaining game among participants. By strategically adjusting their donation commitments, participants navigate a complex decision-making process to optimize the project's success.

3. CONCLUDING REMARKS

In conclusion, the application of coalition game theory to project management provides a nuanced perspective on decision-making under constraints. While traditional project management frameworks assume rational and predict-

able behavior, the integration of bounded rationality highlights the dynamic nature of stakeholder commitments. The kernel solution offers a structured yet adaptable approach to coalition formation, ensuring stability even when individual contributions fluctuate due to cognitive biases, social influences, and negotiation dynamics. Importantly, this method extends beyond project financing, offering insights into resource allocation, team coordination, and strategic planning in various collaborative environments.

By acknowledging the limitations of purely rational models and embracing a more flexible, behaviorally informed perspective, project managers can better anticipate shifts in stakeholder engagement and proactively design strategies that accommodate evolving commitments. This approach underscores the importance of fostering cooperation through fair and self-sustaining coalitions rather than relying on rigid contractual obligations. Furthermore, the principle of independence from rejected alternatives ensures that coalition stability is preserved despite external fluctuations, reinforcing the resilience of project structures.

Beyond project financing, these insights can be applied to broader domains where collective action and strategic alignment are critical, such as public policy initiatives, organizational change management, and cross-sector collaborations. The ability to model and predict coalition behavior under bounded rationality conditions provides a powerful tool for decision-makers seeking to balance efficiency with fairness. Ultimately, the methodological approach presented here contributes to a deeper understanding of how projects can be successfully managed in complex, uncertain, and resource-constrained environments, equipping practitioners with a more adaptive and pragmatic framework for navigating the realities of collaborative work.

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