Simulating Olson's Bandits: An ABM Exploration of Government Decision Dynamics

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***Abstract*— This study employs agent-based modeling (ABM) to simulate Mancur Olson's theory of roving and stationary bandits, with a focus on governance and economic performance. While empirical research has investigated Olson's theory, real-world case studies have not provided the best natural experiments to thoroughly examine it. This research investigates how bandits, under varying initial conditions, parameter values, and environments, govern and maximize their gains. The model, tested through scenario analysis, finds that stationary bandits consistently perform strongly due to their ability to invest in their subjects, giving them a long-term advantage. In contrast, roving bandits exhibit less stability, with varying conditions determining whether they survive, die out, or transition to stationary bandits. Those that transition manage to survive and thrive without investing in their subjects, challenging Olson's assumption that public goods beyond peace and order are essential for societal stability. While these initial results require further validation, they may offer future insights into governance in contexts of weak state capacity.**

Keywords-Agent-Based Modeling (ABM); Olson's Bandits; Complex Adaptive System; Co-Evolution; Government Formation; Decision Dynamics.

I. Introduction

In 1993, Mancur Olson published a paper exploring how bandits could explain variations in governance and economic performance outcomes [12]. Olson posited that roving and stationary bandits are rational agents trying to maximize their gains. He demonstrated how their endowed characteristics and operational context simultaneously reveal the formation of governments and the nature of their decisions. These heterogenous bandits dynamically adapt within complex adaptive systems and co-evolve with their subjects to maximize their fitness function. Over the ensuing decades, scholars have extensively critiqued and engaged in debates spurred by this theory, focusing on the origins and fundamental elements influencing governance.

Building upon Olson's foundational work, subsequent researchers [10][13][19] have further developed the initial theory. These scholarly contributions aim to more precisely articulate the dynamics between rulers and the ruled, as well as the evolution from banditry to established governance and the provisioning of public goods. In 1997, Banks, Olson, and Porter [2] developed an experimental model to investigate how agents' decision-making processes vary with their time horizons and levels of risk aversion. While empirical studies have attempted to explore Olson's theory using natural experiments, these case studies often face limitations due to the gap between theoretical conditions and the real-world cases. This misalignment constrains the ability of researchers to fully test and validate the theory.

We extend the established literature by simulating Olson's concepts of roving and stationary bandits, aiming to assess whether theoretical predictions align with our simulation outcomes. This simulation provides an experimental framework that enables empirical investigation of government decision-making dynamics in ways that real-world natural experiments cannot. In our simulations, roving and stationary bandits compete within a dynamic environment, allowing us to examine the co-evolution of heterogeneous bandit decision-making with their subjects and its impact on macroeconomic outcomes. Our model incorporates a complex adaptive system that facilitates feedback mechanisms, enabling the bandits and subjects to dynamically evolve in pursuit of optimizing their strategic outcomes. This model represents an initial effort to rigorously evaluate Olson's core principles, particularly focusing on the effects of government-subject relationships and government decision-making processes on economic performance.

This research offers significant practical implications, as our simulations underscore the profound impact of government-subject dynamics and decision-making processes on economic outcomes, suggesting avenues for policy intervention and governance reform. Moreover, our model delineates specific scenarios and conditions under which governments emerge and evolve, offering insights into the transition points at which roving bandits opt to become stationary, thus stabilizing their governance.

This model represents a pioneering effort to simulate the dynamic co-evolution of rulers and ruled, unraveling the complexities of ruler decision-making and its impact on the economic performance of both governments and subjects. Central to our model is Olson's insight that rational roving bandits may elect to become stationary to optimize their fitness function, engendering a symbiotic co-evolution with their subjects. Furthermore, our simulations explore how foundational government decisions, such as taxation and investment, influenced by local environmental dynamics, result in varied outcomes across generations. However, this

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model does not address the potential transition to democracy or the problematic tendencies inherent in autocratic successions.

This paper is structured in the following format. First, we review the empirical paradigm to frame the research in context. Next, we present a detailed overview of the agent-based model articulating the different agents and their capabilities. Third, we explore the model through baseline and scenario analyses to identify initial results. Finally, we articulate the conclusions and outline the next steps for future research to build upon.

II. RELATED WORKS

To contextualize the problem, we review the literature on both Olson's theory and agent-based modeling (ABM) to illustrate the challenges faced by previous research and the benefits provided by agent-based simulations.

A. *Olson's Bandits and Government-Subject Dynamics*

In his 1993 theory [12], Olson posited that within a competitive landscape of roving bandits, rational actors would opt to become stationary bandits, recognizing the potential for greater wealth accumulation as autocrats compared to the transient gains from roving banditry. Stationary bandits impose lower taxes than their roving counterparts and establish a peace and order, as well as contributing to the provision of public goods. This arrangement incentivizes subjects to invest in the future, promising them greater long-term rewards under a new equilibrium where both parties benefit from a symbiotic relationship. Thus, Olson's theory offers a pivotal explanation for government formation, addressing and overcoming the fundamental issue of collective action problems, and governance impact on economic development.

Following Olson's seminal postulation, numerous scholars have expanded upon his theoretical framework [8][19], delving into the nuanced decision-making of rulers and their balancing act between extracting resources from society and providing public goods [7][10][13]. Alternatively, Moselle and Polak [11] present a critical viewpoint, arguing that the provision of public goods by rulers, while potentially enhancing economic performance, may not necessarily translate to better outcomes for subjects. While these models elucidate theoretical principles, they often fall short in empirical testing. Addressing this gap, Banks, Olson, and Porter [2] developed an experimental model to investigate the decision making postulated by Olson, offering empirical support to his theoretical assertions. While this model tests key elements of Olson's theory, our research goes a step further by rigorously examining the intricate dynamics between rulers and subjects within a constantly evolving landscape of roving and stationary bandits.

Empirical research has investigated Olson's theory using natural experiments, yielding some valuable insights. However, these studies often face challenges in aligning real-world cases with the theoretical constructs, as the complexities of natural settings frequently deviate from the controlled assumptions of the theory. As a result, the empirical evidence supporting Olson's framework remains incomplete.

B. *Simulating Dyadic Decision Making in Evolving Landscapes*

Recent decades have witnessed a significant paradigm shift in social sciences through the proliferation of agent-based simulations, facilitating bottom-up analyses. The 1996 release of "Growing Artificial Societies" by Epstein & Axtell [4] showcased the profound potential of simple, iteratively modified models to yield insightful and paradigm-shifting results. In their simulation, heterogeneous agents, with distinct endowments of skill and resources engage, in competition within a dynamic landscape to secure resources. This model laid significant groundwork for employing agent-based modeling in simulating complex social science processes, opening new avenues for research and theory development.

Researchers have utilized this technique to model key scenarios and theories, contributing to empirical research by creating heterogeneous agents endowed with specific capabilities and initial conditions, which adapt within a dynamic, uncertain landscape to maximize their fitness functions [1][15][18]. The Wolf-Sheep predation model, significantly explored in studies by Wilensky et al. [16] [17], Marucco et al. [9], and Husnain [6], simulates the evolution of population dynamics based on simple decision-making within a dynamic landscape, offering insights into the dynamic co-evolution of species and the sensitive dependence on initial conditions.

The foundational simulations in the field provide a rich background that underpins our simulation efforts. Our bandit-subject relationship's population dynamics parallel those observed in the wolf-sheep predation model [6][16][17]. We also adopt Epstein and Axtell's [4] simple observation and decision-making rules to construct the decision tree for our roving bandits. Lastly, by incorporating Olson's core decision-making dynamics through a simplified set of rules and equations, we effectively simulate the evolving landscape and the behavior of self-maximizing bandits as theorized by Olson.

Social science simulations offer a controlled environment where researchers can systematically model complex phenomena, such as government decision-making, allowing for a level of precision and experimentation that is not feasible in real-world settings. These simulations enable the exploration of theoretical scenarios in ways that natural experiments cannot.

By integrating both empirical insights from natural experiments and the rigorous control provided by agent-based simulations, this study bridges the gap between theoretical predictions and real-world complexities, offering a more comprehensive understanding of Olson's bandit theory in evolving governance structures.

III. MODELING OLSONS BANDITS

To support reproducibility and demonstrate validity, we outline the fundamental components of our ABM simulating

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Olson's bandits, explaining the key assumptions, characteristics, and decision-making elements.

A. *Bandit Decision Making*

Figure 1 presents a detailed overview of the capabilities and decision-making methods of our heterogeneous bandits, highlighting their distinct strategies. We begin with the assumption that bandit fitness—defined as the change in a bandit's resources—is the most effective indicator of success. This assumption is rooted in Olson's theory, where bandits, or government agents, are rational and self-maximizing actors who prioritize their own well-being. Although both types of bandits possess the ability to tax their subjects, they are distinguished by unique capabilities that allow for a broad exploration of behaviors. Roving bandits, represented in blue, utilize a decision tree to strategically determine their movements. In contrast, stationary bandits, depicted in red, can invest in their territories to offer public goods beyond mere peace, enhancing the well-being of their subjects.

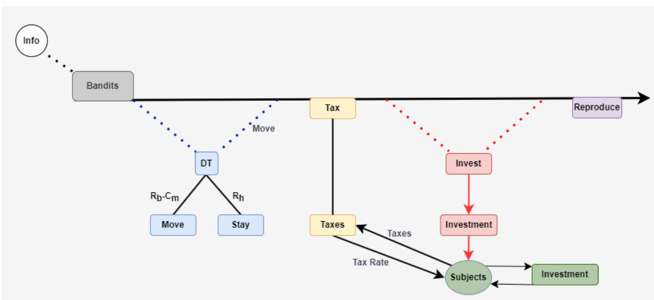

Figure 1: Bandit Decision Making Model

B. *Movement*

Initially, both types of bandits assess the local environment, gathering information on available resources to inform their strategies. Utilizing this information, roving bandits determine the optimal location for their next move, integrating this into their decision tree. The best location is characterized by the most abundant resources and the absence of stationary bandit control. Having assessed the optimal move and its associated costs, roving bandits consult their decision tree to choose between moving or remaining at their current position. Should multiple roving bandits converge on the same location, a conflict ensues, resulting in all but one bandit flee to a randomly selected nearby space.

C. *Taxation*

Following the conclusion of all movements, both roving and stationary bandits levy taxes on their subjects at predetermined rates, subsequently collecting the resulting income. The imposed tax rate directly influences the subjects' investment rate, dictating the proportion of their resources they allocate to development. In this model, the subjects' investment rate inversely correlates with rate at which they are taxed, reflecting the delicate balance that stationary bandits must navigate between taxation and potential returns on investment. Rooted in Olson's core assumption, our model posits that subjects are motivated to invest in their domains primarily when they are assured a share of the investment's returns. Subjects' investment rates are calculated using the following equation:

$$I_s = 1 - T_b - 0.4 \quad (1)$$

Is represents the investment rate of the subject, and Tb denotes the tax rate imposed by the bandit.

We establish a base saving rate of 0.4, representing the minimum threshold that subjects must achieve before considering future investments. In scenarios where taxation is absent, the investment rate gradually increases, reflecting the subjects' growing optimism about future prospects. Thus, the interplay between the base rate and taxation critically influences the subjects' willingness to invest.

D. *Investment*

Subsequently, stationary bandits invest in their subjects. This action embodies Olson's fundamental assumption: for society to thrive, governments must ensure peace, property rights, and contract enforcement. Although our published results utilize a simple interest equation, the model is also compatible with compound and exponential interest calculations. The simple interest calculation involves the bandits' investment amount (Ib), their investment time horizon (Hb), and an assumed interest rate of 0.05.

$$Y = I_b * r * H_b \quad (2)$$

Once stationary bandits have invested in their subjects, they are precluded from making further investments until the initial investment has matured. Subjects have the ability to invest in themselves by applying their investment rate, as determined by (1), to the simple interest formula.

At the end of each tick in the simulation, bandits undergo base attrition, reflecting the necessity to sustain themselves to avoid extinction. Wealthy bandits, having sufficiently accumulated resources, possess the ability to reproduce, thereby generating new bandits of their respective type—either roving or stationary.

Validating this model poses challenges due to the lack of directly comparable real-world data. Therefore, we employ face validity, ensuring that the model's behavior aligns with the theoretical expectations of Olson's bandit theory. Specifically, we assess whether the decision-making processes and outcomes in the simulation are consistent with the core principles of rational, self-maximizing agents and the dynamics observed in other related theoretical work. This approach provides a foundational level of validation, though future work could explore additional validation techniques as more empirical data becomes available.

IV. RESULTS

Here we analyze the model's performance across different scenarios, evaluating how roving and stationary bandits behave under a range of initial conditions, parameter settings, and environmental contexts.

A. *Baseline*

To begin, we establish a benchmark to gauge the baseline performance of bandits within the simulation, serving as a foundational comparison point for assessing outcomes across various scenarios. Based on initial testing to explore the

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performance of the model under a variety of initial conditions and parameter values, we established two key conclusions. First, we set the model to stop after 250 ticks, during which time the system undergoes phase shifts and unstable equilibrium changes before reaching a stable state. This duration allows us to capture both short-term and long-term dynamics. Second, we identified key variables that significantly impact model performance, which led us to fix certain parameters (e.g., population) while varying others (e.g., tax rate) to better understand their effects. Table 1 outlines the values of key variables, including bandits' operational parameters and subjects' behavioral tendencies, essential for understanding the simulation dynamics. Normal distributions are applied to model variables such as the bandits' observation range, tax rate, investment rate, investment time, and the subjects' optimism, ensuring variation in these parameters. This approach creates a dynamic and realistic simulation landscape, presenting bandits and subjects with a nuanced environment characterized by variable costs and opportunities.

TABLE 1. BASELINE INITIAL CONDITIONS AND PARAMETER VALUES

Parameters	*Description*	*Base value*
Population	Total number of Bandits	50
Stationary Population	The initial number of stationary Bandits	25
Observation Range	How far the Bandits can see around them (mean & standard deviation)	3:1.5
Move Cost	The cost for Bandits to move one step.	2
Spawn Rate	The rate new Bandits spawn from the fit bandits	1
Attrition Rate	The rate Bandits lose wealth each tick	0.25
Tax Rate	The Bandits tax rate for their subjects	0.4:0.2
Investment Rate	The Stationary Bandit investment rate into their subjects	0.25:0.125
Investment Time	The Stationary Bandit time of investments	1.5:0.75
Optimism	The Optimism of subjects that the future will get better.	0.025:0.012

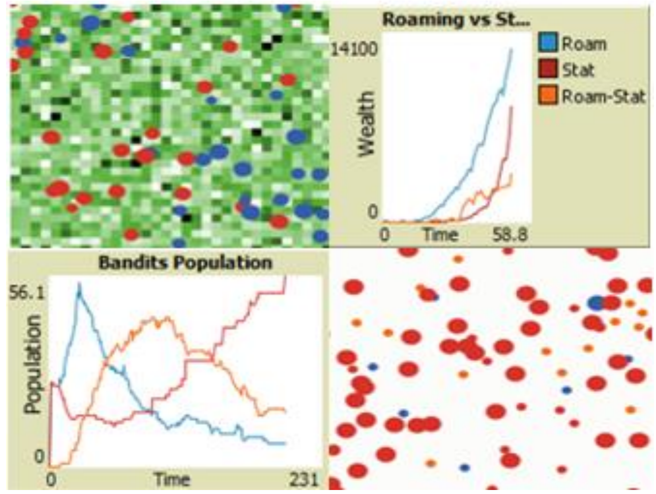

Figure 2: Baseline Environment, Time Series Wealth and Population Plots

In the baseline scenario, visualized in Figure 2, roving bandits initially outperform stationary bandits, swiftly accumulating resources and expanding in population as illustrated by the first 25 ticks on the time series wealth plot. However, this dominance is short-lived; stationary bandits gradually surpass roving bandits as their investments mature. The intensifying competition among roving bandits diminishes their returns significantly, especially as available subjects become scarce and less inclined to invest in themselves due to frequent raids. Consequently, the landscape undergoes a dramatic transformation, from a normal distribution, resource-rich environment to one starkly barren except for the wealth now concentrated within the domains of stationary bandits.

Interestingly, the simulation reveals a bifurcation among roving bandits driven by their tax rate, leading to distinct paths in their evolution. Roving bandits that adopt lower tax rates transition to roving-stationary status, signified by turning orange, after remaining immobile for 10 consecutive ticks. These newly stationary bandits often outnumber their roving counterparts and maintain their fitness by assuming a leadership role over their subjects, taxing them minimally without offering public goods. This minimal taxation strategy ensures that their subjects remain incentivized to invest, showcasing how rational bandits sustain their autocratic position without providing public goods, demonstrating a new equilibrium strategy. In contrast, true roving bandits, maintaining their nomadic nature, levy nearly maximum taxation rates above 90 percent.

Ultimately, true stationary bandits—those who are both capable and willing to invest in their subjects—outperform both roving bandits and converted stationary bandits. This outcome provides strong empirical support for Olson's theory, illustrating that rational bandits opt for a stationary lifestyle and, by investing in their subjects, achieve superior long-term performance compared to their counterparts.

B. *Resource Rich Environment*

In this scenario illustrated in Figure 3, we introduce our bandits to a resource-rich environment. The primary objective is to examine the evolution of roving bandits'

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decision-making processes in response to an environment abundant in resources from the outset. Additionally, this scenario investigates whether a higher resource starting environment empowers stationary bandits to further dominate the landscape and outperform their roving counterparts.

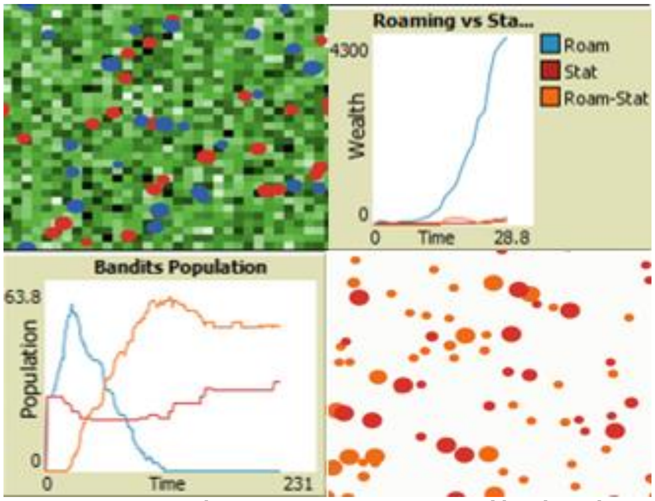

Figure 3: Resource Rich Environment, Time Series Wealth and Population Plots

The bandit population time series plot reveals that roving bandits almost invariably face extinction. Further investigation reveals a significant population explosion among roving bandits, exacerbating the competition for resources. This intense competition for an initially abundant resource pool rapidly depletes the landscape, precipitating a population collapse reminiscent of dynamics observed in Wolf-Sheep predation models.

Roving bandits that strategically transition to stationary status often become the most populous agents. This suggests that, in the medium term, transitioning roving bandits capture more resources and exhibit superior fitness, resulting in faster population growth compared to original stationary bandits. Both transitioning roving bandits and original stationary bandits reach an equilibrium stabilizing of their populations. Despite population stability, original stationary bandits maintain a long-term advantage over their transitioning counterparts, attributed to their investments in public goods that bolster the economic performance of their subjects.

C. *Resource Rich and Low Tax Environment*

Figure 4 shows this how we expand on scenario one's resource-rich landscape, this evolution introduces lower tax rates for bandits, now ranging from 0 to 0.4, a reduction from the original range of 0 to 0.8. This adjustment aims to more precisely assess the tax rate's influence on both roving and stationary bandits' strategies and outcomes. The key questions are whether lower tax rates disproportionately impact roving bandits over stationary ones, and if such rates enable roving bandits to secure gains without deterring subjects' investments—thereby maintaining a fertile landscape and averting the population bubble and collapse observed previously.

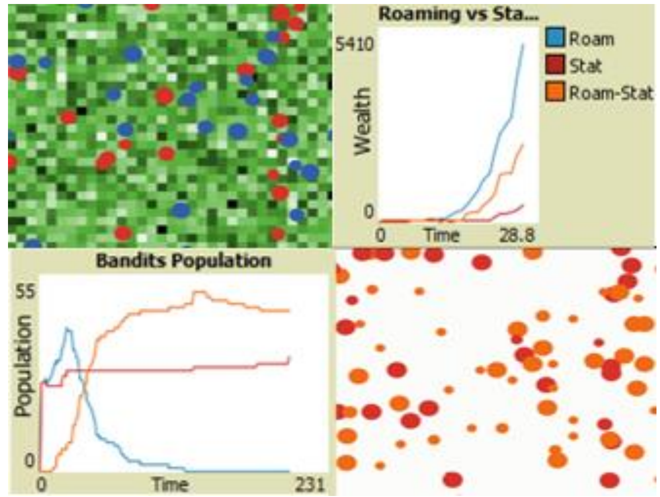

Figure 4: Resource Rich and Low Tax Environment, Time Series Wealth and Population Plots

Roving bandits face rapid decline; however, the majority transition to stationary status, adopting it as the dominant strategy for survival. This adaptation underscores an equilibrium where low tax rates enable former roving bandits to not only survive but thrive, effectively becoming successful roving-stationary bandits.

Stationary bandits that invest in their subjects maintain the upper hand in the model, excelling in resource capture through their strategic investments. The mutual benefits arising from bandits' investments and subjects' self-investment create a symbiotic relationship, enabling both parties to thrive. Roving-Stationary bandits adopt a nuanced strategy, levying lower taxes to incentivize subjects' self-investment, thereby benefiting from a more laissez-faire approach

D. *Resource Rich and High Tax Environment*

Figure 5 examines the impact of high taxes on governance decision-making, contrasting with Scenario 2's focus on low taxes. This scenario aims to further unravel the dynamic equilibria among roving, roving-stationary, and stationary bandits, dictated by their differing tax strategies. Here bandits are given high tax rates ranging from 0.2 to 1, a significant increase from Scenario 2's 0 to 0.5 range and the baseline's 0 to 0.8.

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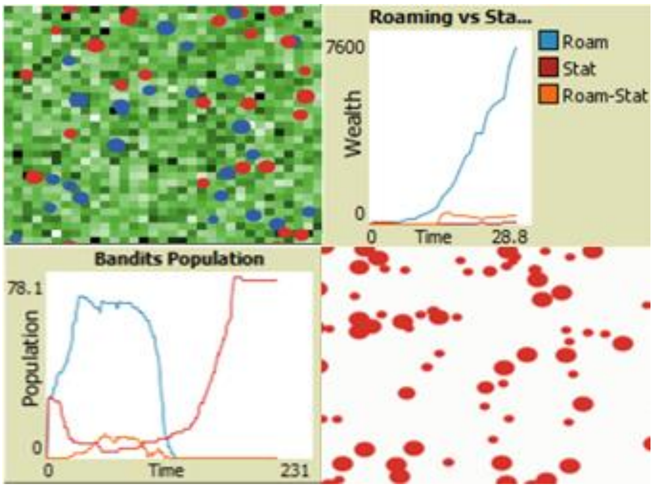

Figure 5: Resource Rich and High Tax Environment, Time Series Wealth and Population Plots

Stationary bandits subject to high tax rates face rapid extinction, while those imposing low to medium tax rates not only survive but flourish. Likewise, roving-stationary bandits only survive under low tax rates, mirroring the survival condition of their stationary counterparts.

Initially, roving bandits seem to adopt the dominant strategy, with very few opting to transition into a roving-stationary status. The roving bandits' population experiences growth, stabilizes for a brief period, and then undergoes a sudden collapse. Ultimately, this scenario proves unsustainable for roving bandits, leading to their complete extinction.

E. Comparison of Scenario Performances

In this section, we systematically compare the performance of bandits across the scenarios to highlight key differences and similarities in behavior and outcomes. Despite being an initial exploration of Olson's bandits with a relatively simple ruleset, our simulation yields significant conclusions. Firstly, rational roving bandits strategically adapt to their environments by transitioning into stationary bandits. Secondly, despite their adaptation, these roving-stationary bandits abstain from providing public goods or making investments in their subjects. This reveals a previously unidentified equilibrium for autocrats, challenging Olson's assumption that societal thriving requires both peace and public goods. Thirdly, although roving-stationary bandits find a niche to survive and flourish, stationary bandits offering additional public goods emerge as the model's fittest agents, in alignment with Olson's theory.

Across all scenarios, roving bandits are significantly affected by changes in initial conditions, parameters values, and environment. Their survivability is highly contingent on favorable conditions. In certain contexts, roving bandits experience strong initial performance, leading to a population explosion. However, this rapid growth depletes local resources, often resulting in an eventual extinction event, mimicking patterns observed in predator-prey models. Under less favorable conditions, a bifurcation occurs where roving bandits with lower tax rates are able to successfully transition into roving-stationary bandits, adopting a more sustainable strategy.

In contrast, stationary bandits exhibit more stable performance across a wide range of conditions. Whether in low-resource or high-resource environments, and regardless of tax rates, stationary bandits manage to survive and eventually thrive. Their ability to invest in their local environment provides them with a significant long-term advantage. However, under extreme conditions—such as high tax rates—stationary bandits can face early extinction if their investments do not mature in time.

For both roving and stationary bandits, excessively high taxes appear to be a burden rather than a benefit. While high taxes can support long-term performance if the bandits survive the initial phases, they often lead to early decline. Overall, the key patterns across scenarios suggest that resource availability and taxation strategies are critical determinants of bandit survival and success.

V. CONCLUSIONS

This study contributes to the literature by providing a systematic agent-based simulation of Olson's bandit theory, revealing how varying conditions affect the evolution of governance structures. Unlike empirical studies constrained by real-world complexities, this simulation allows for controlled exploration of bandit decision-making dynamics across a variety of scenarios. Our findings both support and challenge aspects of Olson's theory.

The strong performance of stationary bandits investing in their subjects aligns with Olson's theory. However, the actions of roving bandits suggest that the pathway from banditry to stable governance may not always require heavy investment in public goods. Several scenarios illustrated that bandits can thrive without investing in their subjects, revealing this new equilibrium. This challenges the assumption that provision of additional public goods, beyond peace, is essential for societal stability. While we hold back from drawing definitive practical implications until the model can be further validated, the initial results indicate potential relevance for situations characterized by weak state capacity.

Future models can build on these foundations and improve alignment with Olson's theory by incorporating learning mechanics that enable bandits to adapt, optimizing their tax and investment strategies. Moreover, stronger calibration and validation with real-world data can enhance its accuracy and practical relevance.

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