2023

Modeling Wealth Distribution in a Society

Dylan Berns
Old Dominion University

Peihsien Sun
Old Dominion University

Adrian V. Gheorghe
Old Dominion University

Original Publication Citation

Berns, D., Sun, P., & Gheorghe, A. V. (2023). Modeling wealth distribution in a society. *International Conference of Management and Industrial Engineering, 11*, 409-416. https://doi.org/10.56177/11icmie2023.41

11th International Conference of
Management and Industrial Engineering
2023, Bucharest

ISSN 2344-0937
ISSN-L 2344-0937
Volume 11
Website: https://icmie-faima-upb.ro

MODELING WEALTH DISTRIBUTION IN A SOCIETY

Dylan BERNS, Peihsien SUN, Adrian V. GHEORGHE
Engineering Management and Systems Engineering Department, Old Dominion University, Norfolk, Virginia

Adrian V. GHEORGHE: 0000-0003-2830-675X
dbern007@odu.edu, psun002@odu.edu, agheorgh@odu.edu

Abstract: *The interconnectedness of social mood, changing dynamics, income inequality, and wealth distribution underscores the complexity of understanding and addressing these issues. This complexity inspires researchers to develop models and conduct further research to gain insights into the mechanisms driving income inequality and wealth distribution. By studying these phenomena more comprehensively, one can aim to develop strategies and policies that promote a more equitable distribution of wealth and opportunities, thereby fostering social stability and economic prosperity. In the present paper, there was build a model on wealth distribution and income inequality to help people understand the complexities of wealth inequality and how economic policies can influence the distribution of resources within a society. By stimulating economic activities and implementing policy interventions, the model provides insights into the factors that contribute to wealth disparities and explores potential solutions for more equitable wealth distribution.*

Keywords: *NetLogo, modelling, agent-based modeling (ABM), complexity.*

INTRODUCTION

Traditional approaches to analyzing data for wealth distribution can be limited. For example, traditional inequality of opportunity (IOp) approaches suffer from the challenge of discretizing the highly skewed continuous variable of inheritances, leading to non-robust and arbitrary measures of IOp. Salas-Rojo, P. and Rodríguez, J. G. employs Machine Learning (ML) methods [1], specifically the 'random forest' algorithm to optimize the choice of cut-offs and generate statistically meaningful types based on inheritances, to examine the relationship between inherited wealth and the distribution of wealth (financial, non-financial, and total) in four developed countries: the United States, Canada, Italy, and Spain. The ML approach aims to let the data speak, reducing potential biases introduced by researchers in the discretization process. The result showed that even when considering parental education as an additional circumstance, inheritances remain the primary contributor to wealth inequality. The effect of inheritances is most prominent in the middle of the wealth distribution, while parental education is more relevant for asset-poor households. When focusing on financial wealth, inheritances play a significant role in explaining wealth disparities, particularly in countries where housing prices make homeownership less affordable, like Spain and Italy. In the US, the effect of inheritances is more pronounced, reflecting the impact of private initiative in wealth accumulation. Additionally, the study finds that parental education, which is correlated with higher income and saving levels, also contributes to wealth disparities. The findings reveal the significance of inheritances in shaping wealth disparities in developed countries, and the application of ML techniques offers more robust and meaningful insights into the relationship between inheritances and wealth distribution. However, further research is needed to understand the factors contributing to cross-country differences in wealth IOp. Even though in this paper the authors are mainly focusing on the Wealth distribution of the United States, their research gave us an idea of where our research can expand to and the possibility of adopting new techniques including ML and Artificial Intelligence (AI).

MODEL DESCRIPTION

The research aims to model economic classes and their interactions to understand wealth inequality and policy impacts in the United States. The current complex system of wealth distribution and income inequality is characterized by widening gaps between the wealthy and the rest of the population. This situation hinders social mobility and exacerbates socio-economic divisions. By developing a comprehensive model, the authors seek to identify the drivers of wealth

disparities, including factors like technological advancements, tax policies, access to education, and historical injustices. Future research in the field of wealth distribution and income inequality holds great potential for advancing our understanding of the complex dynamics within the economic system. Building upon the existing literature, there are several areas that warrant further investigation. Firstly, exploring the interplay between technological advancements and wealth disparities can provide valuable insights into how automation and digitalization impact job opportunities and income levels across different economic classes. Additionally, understanding the role of social policies, such as progressive taxation and wealth redistribution, in mitigating wealth inequality remains crucial for shaping effective policy interventions.

The model focuses on understanding wealth inequality in the United States by demonstrating the respective wealth among economic classes and analyzing how they are influenced by policies and the overall economic environment. The factors utilized in the model can be manipulated to incorporate influences such as technological advancements, tax policies, access to education, and historical disparities; the model will shed light on the complex interactions that shape wealth distribution. Through data-driven insights, the authors seek to inform policymakers about evidence-based strategies to promote social mobility, reduce economic disparities, and foster a more inclusive and equitable economic system that benefits all segments of society.

2.1 Agents

Individuals: Members of a society, each with their own wealth level. the authors included four economic classes in this paper, Very Wealthy, Upper Class, Middle Class, and Lower Class.
Economic System: The overall economic structure that influences wealth distribution.
Government: The governing body that can implement economic policies.

2.2 Environment

Society: A simulated society with a diverse population and economic activities. The society exists within the government that collects taxes.
Economic Opportunities: Simulate various income-generating activities like jobs, investments, and business ventures

2.3 Behaviors

Wealth Accumulation: Individuals engage in economic activities, leading to the accumulation or loss of wealth.
Economic Mobility: Economic mobility is a key aspect when studying wealth distribution and income inequality, encompassing factors such as education, skills, and social influences that impact an individual's potential to ascend or descend the socioeconomic ladder. However, a critical flaw in the concept lies in the assumption that individuals are capable of freely moving between economic classes. In reality, economic mobility is constrained by numerous structural barriers, resulting in many individuals being trapped within their respective class positions with limited prospects for advancement. The population size remains fixed, while the proportion of individuals within each economic class fluctuates. As a result, any shift in membership between classes is a zero-sum game, with one person's advancement entailing another's decline. This highlights the entrenched nature of wealth disparities and the challenge of achieving genuine social mobility. To address these limitations, future research should delve deeper into the systemic inequalities that hinder economic mobility and explore policy interventions aimed at fostering a more fluid and equitable socioeconomic (combined influence of social and economic factors that shape and determine the overall well-being and status of individuals or communities) landscape, wherein individuals have genuine opportunities to improve their economic standing regardless of their initial class position. Due to the above reasons, in our model, the authors did not implement this factor.
Government Policies: The government can implement policies like taxes, welfare programs, and regulations that influence wealth distribution.

2.4 Features of the Model

Income Generation Algorithms: The authors aim to simulate income generation for individuals based on their economic activities and success rates, with each simulation year represented by a tick. During each tick, all economic classes are subject to tax payments and generate income based on the median incomes for their respective economic class. Further, based on current mean value of stock holdings per economic class and average stock market returns, each class earned investment income. Additionally, individuals engage in spending activities, reflecting their living costs, such as housing, transportation, and groceries. The amount of money spent each year is based on the average percent of income spent annually by each economic class as a proportion of annual income. the authors do not, however, consider passive forms of investing, such as real estate ownership, in the spending equation. The model aims to explore how spending patterns affect wealth distribution, highlighting that individuals in lower economic classes are required to spend a higher percentage of their income annually, rather than saving and capitalizing on investment opportunities. This modeling approach allows us to better understand how economic interactions and spending behaviors influence wealth

disparities between different economic classes in the society.
Wealth Distribution Analysis: Analyze and visualize wealth distribution in the society to identify patterns and inequalities.
Policy Impact Simulation: Test the impact of various government policies on wealth distribution and economic mobility.

IMPLEMENTATION

For the Societal Wealth Distribution Model, as shown in Fig. 1, it was chosen to leverage the power of NetLogo [2] as a vital tool to construct and analyze complex simulations. NetLogo is a pioneering open-source multi-agent programmable modeling environment that enables us to explore and simulate intricate natural and social phenomena. It is developed by Uri Wilensky at the esteemed Center for Connected Learning and Computer-Based Modeling, Northwestern University. NetLogo provides a versatile platform for studying diverse real-world scenarios.

The primary objective of our Societal Wealth Distribution Model is to gain insights into the distribution of wealth across different segments of the population. To achieve this, the authors have meticulously gathered and incorporated a wide array of data resources to ensure the accuracy and comprehensiveness of our simulations. Drawing from current economic statistics, the authors have acquired essential inputs that allow us to forecast potential outcomes within the socioeconomic landscape. This data serves as a foundation upon which the authors can build a dynamic and realistic model, capable of reflecting the complexities of wealth distribution in a society. To create a comprehensive representation of the economy, the authors have included estimates for various economic classes, net worth, incomes, and tax brackets [3],[4],[5]. By incorporating these diverse elements, our model can account for the varying degrees of financial well-being among individuals and different social strata. To capture the intricacies of spending and investment habits, the authors have delved into research on people's consumer behaviors and investment patterns[6],[7]. Understanding the percentage of the population that owns stocks and the proportion of income spent in the economy provides crucial insights into the flow of money and its impact on wealth distribution.

Through the synergistic integration of NetLogo and our carefully curated data resources, our Societal Wealth Distribution Model aims to shed light on the mechanisms and factors that influence the allocation of wealth in society. By running simulations and analyzing the outcomes, the authors aspire to glean valuable insights that can inform policymakers, economists, and social scientists alike. [8].

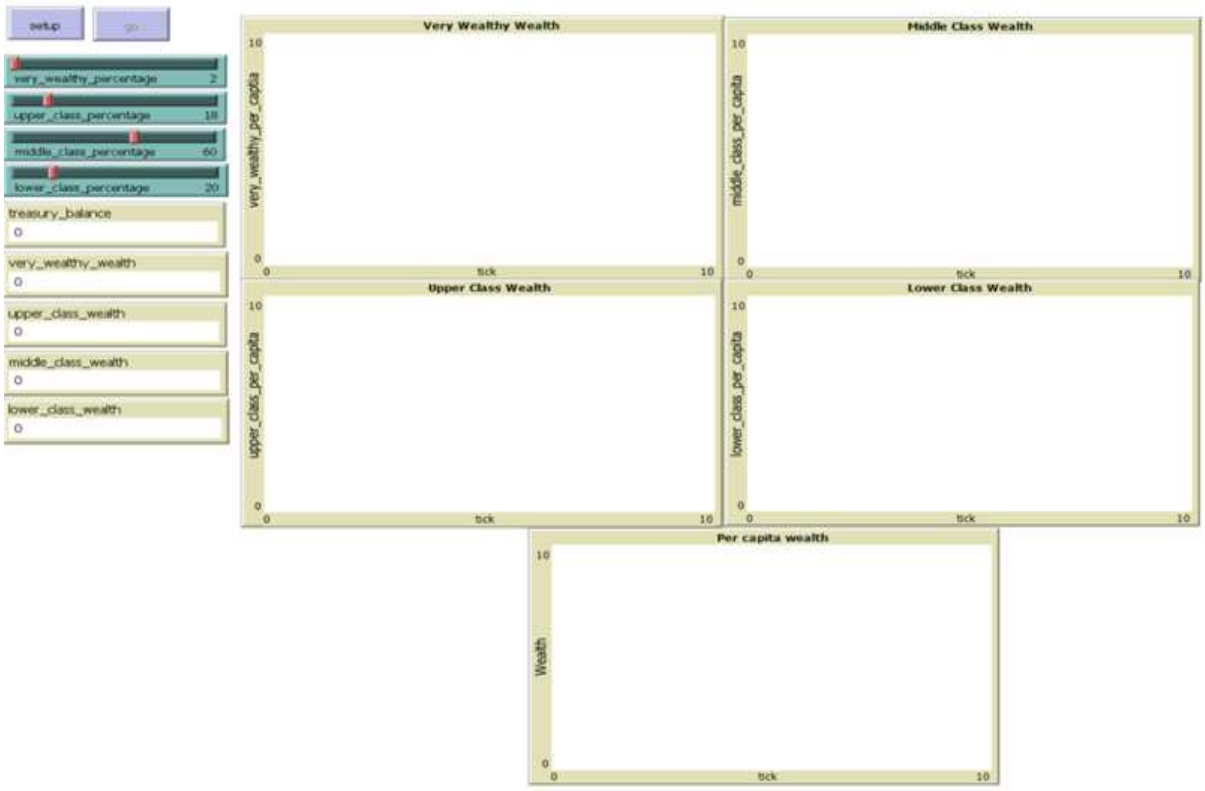

Figure 1: Societal Wealth Distribution Model Interface

RESULTS

the authors ran the Societal Wealth Distribution Model across three distinct scenarios to gain valuable insights into the dynamics of wealth distribution.

In the first scenario, the authors initiated the simulation using the most recent economic data available, spanning a period of five years. The results of this simulation, shown in Fig 2., highlighted several noteworthy trends. Notably, the wealthy and upper-class segments of the population experienced rapid growth in their wealth accumulation. In contrast, the middle-class remained relatively stagnant, struggling to see significant progress in their financial standing. The lower class showed a gradual decline in wealth, indicating a concerning trend of worsening financial conditions for this segment of society.

For the second scenario, the authors introduced a policy adjustment aimed at improving the economic situation of the lower class. This adjustment involved a substantial increase in the minimum wage, raising it to $15 per hour. The immediate consequence of this policy was a significant boost to the income of the lower class, as shown in Fig. 3, effectively doubling their earnings. However, it is important to acknowledge that this simulation simplifies certain real-world complexities by ignoring the effects of inflation and assuming that all individuals in the lower class equally benefit from the wage increase while expenses remain unaffected. In this isolated scenario, the authors observed a positive outcome where the lower class began to accumulate wealth at a notable pace, bridging the wealth gap. In contrast, the middle and upper classes saw little change in their wealth status, largely maintaining their existing positions.

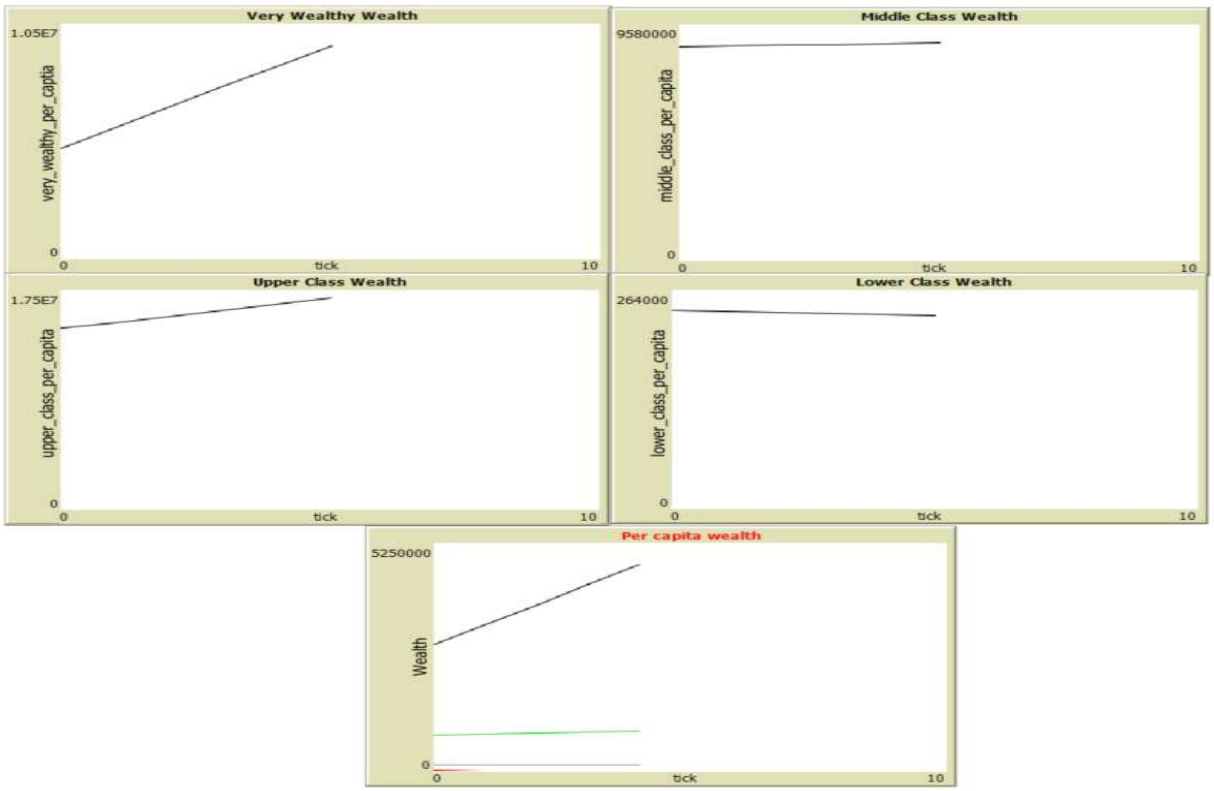

Figure 2. Scenario One

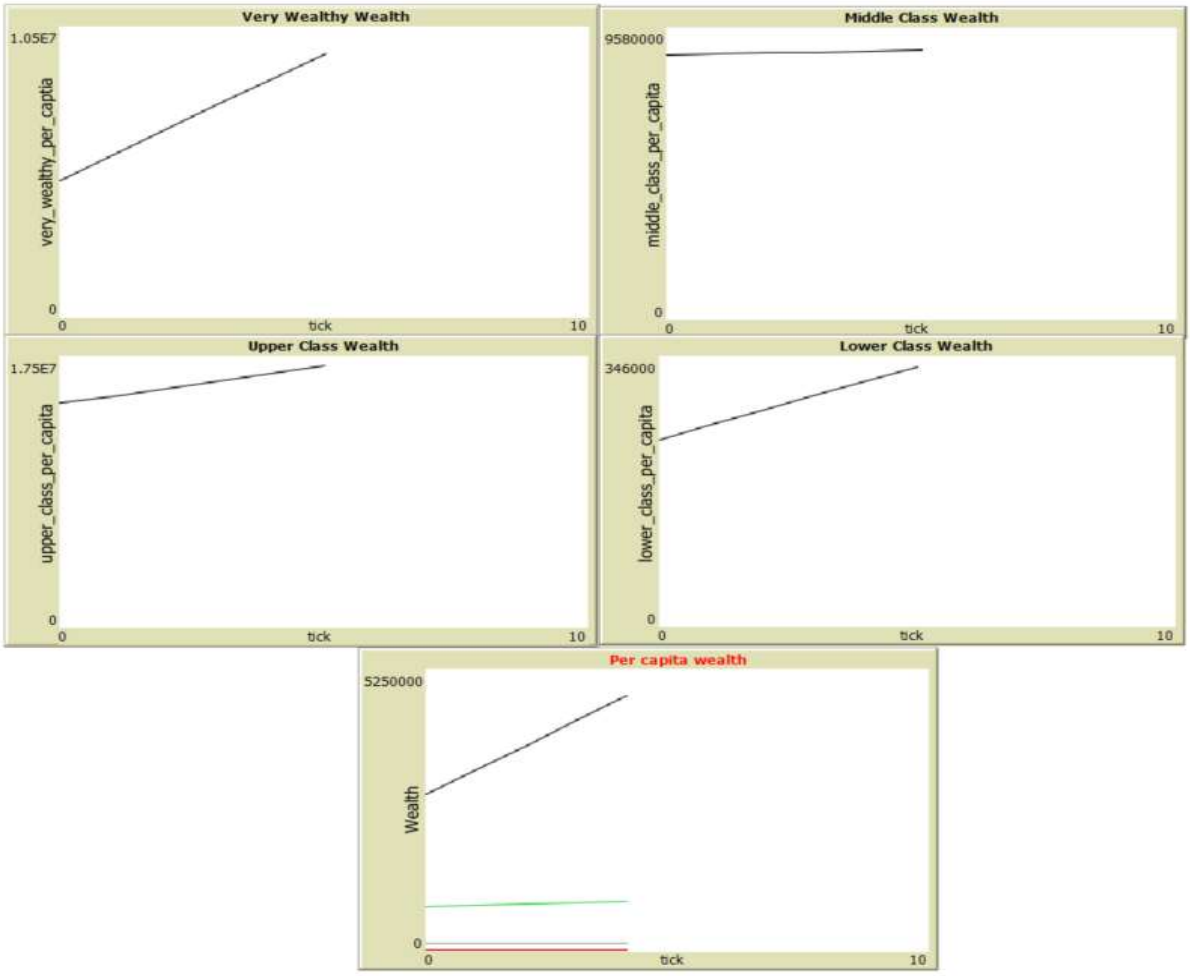

Figure 3. Scenario Two

For the third scenario, the authors introduced an intriguing policy intervention: an annual stimulus of $5,000 exclusively directed to the lower and middle classes, with the stipulation that it could only be used for investment purposes. Under this scenario, the lower and middle classes exhibited a gradual but noticeable improvement in their wealth accumulation, as shown in Fig. 4. However, it's essential to highlight that despite this positive development, the pace at which they were building wealth remained significantly slower when compared to the wealth growth experienced by the upper class.

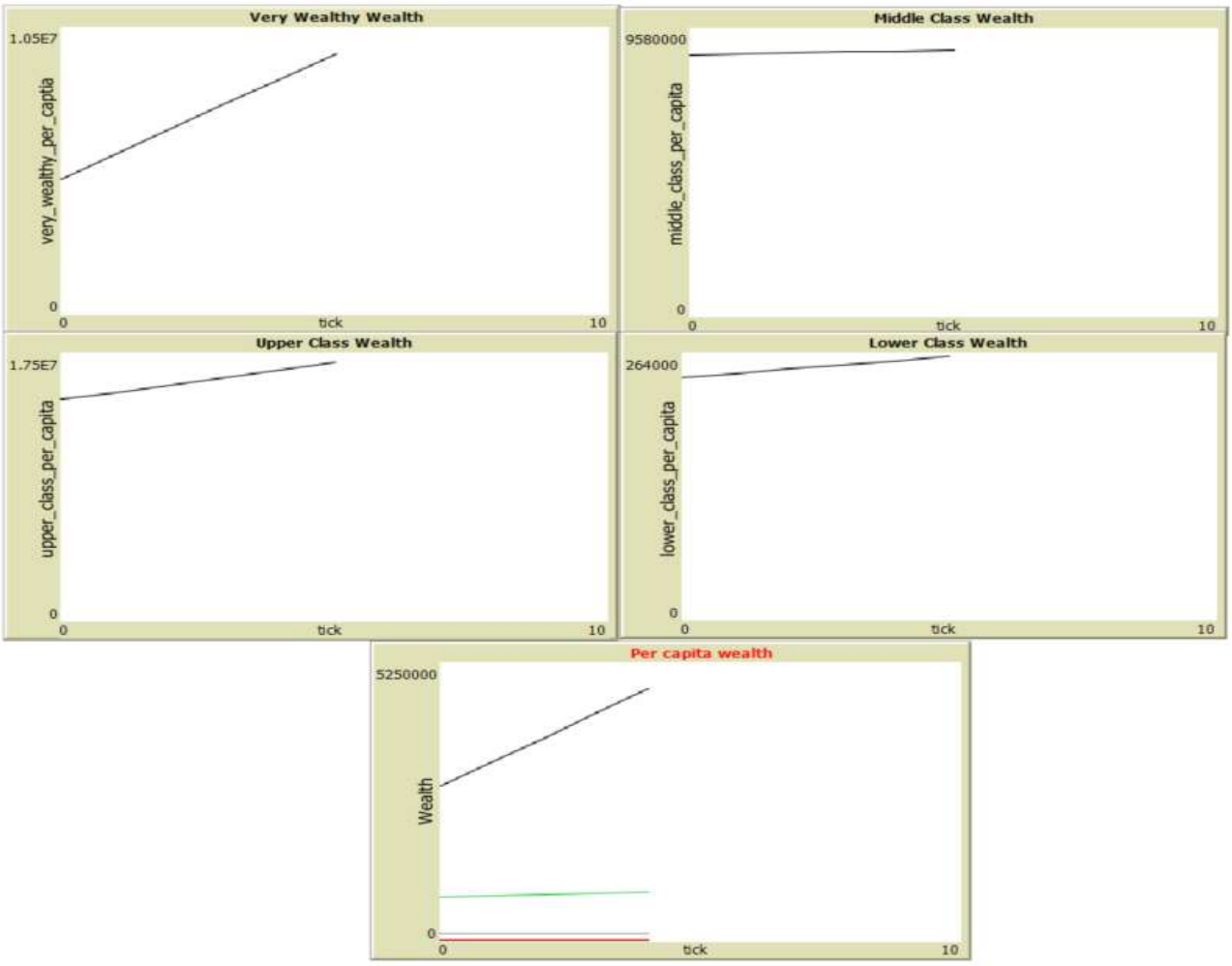

Figure 4. Scenario Three

RESULTS ANALYSIS

The outcomes of the three scenarios from our Societal Wealth Distribution Model provide crucial insights into the intricate relationship between socioeconomic policies and the distribution of wealth. These simulations underscore the significance of considering multiple factors, such as people's spending habits, investment pattern, government support and the varying impacts on different income groups, when formulating policies aimed at addressing wealth disparities within a society.

In the simulations, the authors observed that with current economic policies, the wealthier classes continue to experience growth in their wealth, while the lower economic class faces a decline. One significant contributing factor to this trend is the lack of available capital for the lower class to save and invest, hindering their ability to improve their financial standing. However, when the authors introduced a policy adjustment in the form of a minimum wage increase, doubling the income of the lower class, the authors witnessed an immediate improvement in their wealth accumulation. Although this simulation did not account for the effects of inflation and made certain simplifications, such as assuming universal benefits and stable expenses, it demonstrated the potential positive impact of raising the minimum wage on narrowing the wealth gap. Furthermore, the authors conducted a simulation where the government provided an annual stimulus of $5,000 exclusively for investment purposes to the lower and middle classes. Under this scenario, the authors observed a gradual improvement in wealth accumulation for these segments of society. Nevertheless, it's essential to recognize that despite this progress, the rate at which the lower and middle classes built wealth remained considerably slower compared to the wealth growth experienced by the upper class.

To verify the accuracy of our model, the authors conducted a comparison of growth or loss over a specific period with real-world economic data. Upon referencing the data from Pew Research [9], it was found that the net worth of the lower class in real world declined from $20,600 to $11,300 over a 15-year period, ending in 2016. In contrast, our model successfully predicted a loss, projecting a decline from $12,000 to $11,000 over the same duration. Although our model predicts a less substantial loss, it should be noted that real-world events and complexities may not have been fully captured in the model during that time frame.

In terms of the upper-class model, the external data from Pew Research [9] indicated that their net worth grew from

$636,000 to $848,000 over the same 15-year period. Our model's projection for the upper class showed growth from $805,000 to $1.2 million in that time frame. While the starting points were different, the percentage change in net worth was similar, with Pew's data indicating a 25% increase, and our model producing a 33% increase.
This verification process highlights both the strengths and limitations of our model. While it demonstrated reasonably accurate predictions for the upper class, the lower class prediction showed some deviation from real-world data. These discrepancies may be attributed to the intricate and dynamic nature of economic changes and external factors that can influence wealth distribution.

CONCLUSIONS

In conclusion, the designed Societal Wealth Distribution Model proves to be a valuable tool for gaining an understanding of general trends and patterns in wealth distribution. Through the outcomes of the three simulation scenarios, the authors have gained crucial insights into the complex relationship between socioeconomic policies and the equitable distribution of wealth within a society.
The simulations have highlighted the importance of considering various factors, including people's spending and investment habits, government support, and their differing impacts on various income groups, when designing policies aimed at addressing wealth disparities. By acknowledging these multifaceted aspects, policymakers can craft more targeted and effective interventions to promote economic fairness and social stability. From the simulations, it became evident that under current economic policies, wealthier classes tend to experience continuous growth, while the lower economic class faces a decline. This situation is compounded by the lack of available capital for the lower class to save and invest, thereby hindering their ability to improve their financial well-being. However, the simulations also revealed the positive potential of policy adjustments. When the authors implemented a minimum wage increase, the lower class experienced immediate improvement in wealth accumulation. Although the simulation may not have accounted for all real-world complexities, such as inflation and individual variations, it demonstrated the potential benefits of targeted policy measures to narrow the wealth gap. Furthermore, when the government provided an annual investment stimulus of $5,000 to the lower and middle classes, both segments exhibited gradual improvements in wealth accumulation. While progress was evident, the growth rate remained notably slower compared to the wealth accumulation observed among the upper class.
In summary, the Societal Wealth Distribution Model serves as a valuable asset for advancing our understanding of wealth distribution and socioeconomic policies. By leveraging the power of data and simulations, the authors hope to contribute to the development of more equitable and sustainable economic systems, ultimately fostering a society where prosperity is accessible to all.

References

[1] Salas-Rojo, P., & Rodríguez, J. G. (2022). Inheritances and wealth inequality: a machine learning approach. Journal of Economic Inequality, 20(1), 27-51. https://doi.org/10.1007/s10888-022-09528-8
[2] NetLogo. Netlogo Home Page. (n.d.). http://ccl.northwestern.edu/netlogo/index.shtml
[3] Daly, L. (2023, July 6). What's the average net worth for the lower, middle, and upper class? The Motley Fool. https://www.fool.com/the-ascent/personal-finance/articles/whats-the-average-net-worth-for-the-lower-middle-and-upper-class/
[4] Neale Godfrey, F. L. E. (2022, August 12). Are you rich? U.S. wealth percentiles might provide answers. Kiplinger.com. https://www.kiplinger.com/personal-finance/605075/are-you-rich
[5] 2022-2023 tax brackets and federal income tax rates. NerdWallet. (n.d.)https://www.nerdwallet.com/article/taxes/federal-income-tax-brackets
[6] National News - U.S. News & World Report. (n.d.). https://www.usnews.com/news/national-news
[7] Desjardins, J. (2019, March 19). How Americans make and spend their money. Visual Capitalist. https://www.visualcapitalist.com/how-americans-make-spend-money/
[8] Bucovetchi, O., Badea, D., Oancea, R., Stanciu, RD (2018) Considerations on modelling resilience governance for decision support systems, University Politehnica of Bucharest Scientific Bulletin series B, Vol. 80, Iss. 2, pp. 181-192, ISSN: 1454-2331
[9] Mitchell, T. (2020, January 9). 1. trends in income and wealth inequality. Pew Research Center's Social & Demographic Trends Project. https://www.pewresearch.org/social-trends/2020/01/09/trends-in-income-and-wealth-inequality/ *Accessed:* 2023-06-24

Corresponding author:

At the end of the paper give:
Corresponding Author: Adrian V. Gheorghe
Name and surname, Title: Adrian V. Gheorghe, Professor
Full address: Department of Engineering Management and Systems Engineering, Old Dominion University, Norfolk, VA 23529, USA
Email: agheorgh@odu.edu
OrcID https://orcid.org/0000-0003-2830-675X