NUMERICAL APPROACHES TO SOCIAL MOBILITY: MODELLING THE IMPACT OF EDUCATION AND ECONOMIC FACTORS

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DOI
10.29121/shodhkosh.v4.i2.2023.1636

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ABSTRACT

This research employs a numerical approach, specifically Agent-Based Modeling (ABM), to investigate the dynamics of social mobility within a hypothetical society. Utilizing simulated scenarios, the study explores the influence of education and economic factors on individual trajectories and societal outcomes. The findings reveal a positive correlation between education levels and social mobility, emphasizing the crucial role of educational opportunities. Additionally, economic indicators exhibit a significant impact on upward mobility. The study contributes to sociological understanding by bridging theoretical frameworks with empirical observations through numerical simulations, providing insights for evidence-based social policies.

Keywords: Social Mobility, Agent-Based Modelling, Numerical Simulations, Education, Economic Factors, Sociological Theories, Upward Mobility, Policy Implications

1. INTRODUCTION

Social mobility, defined as the ability of individuals or families to move across social strata within a given society, stands as a pivotal concept in contemporary sociological discourse. It encapsulates the dynamism of societies and reflects the opportunities for individuals to ascend or descend within the socio-economic hierarchy. Examining social mobility is crucial for understanding the mechanisms that facilitate or hinder individuals' journeys between different social classes.

Research Gap: Despite its significance, a critical research gap exists in the quantitative exploration of social mobility. Traditional sociological studies often rely on qualitative methods, leaving a void in comprehensive numerical approaches. The need for quantitative models arises from the complexity of social mobility dynamics, necessitating a more systematic and measurable understanding. The absence of such approaches limits our ability to grasp the nuanced interplay of various factors influencing social mobility.

Research Question: In light of this gap, the research question driving this study is: How can numerical modeling capture the impact of education and economic factors on social mobility? This inquiry seeks to bridge the divide between theoretical discussions and empirical observations by employing quantitative methods. By focusing on the pivotal role of education and economic factors, the research aims to unravel the intricate dynamics that shape the pathways of individuals through the social strata. The exploration of this research question is essential for advancing our understanding of the determinants of social mobility and informing evidence-based policy interventions.

2. LITERATURE REVIEW

2.1. OVERVIEW OF SOCIAL MOBILITY THEORIES

Social mobility has been a subject of extensive theoretical inquiry, with classical sociological theories providing foundational perspectives. According to Davis and Moore (1945), social mobility is intricately tied to the functional role of occupations within society, suggesting that mobility is a natural consequence of the need for talent in various roles. On the other hand, Marx (1867) argued that social mobility is a product of the class struggle, with movement between classes reflecting changes in economic structures.

Contemporary perspectives on social mobility build upon these classical theories. Scholars like Erikson and Goldthorpe (1992) introduced the class schema, emphasizing the role of education and employment in determining social class. Meanwhile, Bourdieu's (1984) theory of cultural and social capital sheds light on how non-economic factors contribute to social mobility.

2.2. EXISTING NUMERICAL MODELS

In the realm of numerical modeling, computational approaches have gained prominence in the study of social mobility dynamics. Agent-based models (ABMs) have been employed to simulate the interactions of individuals within societal structures (Epstein & Axtell, 1996). Such models capture the complexity of social processes, allowing for the examination of emergent patterns and trends.

However, a review of existing computational models reveals certain limitations and gaps. Smith et al. (2018) note that many models focus predominantly on economic factors, overlooking the nuanced role of education. Furthermore, the deterministic nature of some models fails to adequately account for the inherent stochasticity of social processes (Macy & Willer, 2002). These limitations highlight the necessity for more comprehensive and nuanced numerical approaches to capture the multifaceted nature of social mobility dynamics.

3. METHODOLOGY

3.1. SELECTION OF NUMERICAL MODELS

In choosing the appropriate numerical modeling approach, we considered both Agent-Based Modeling (ABM) and System Dynamics (SD). ABM allows for the representation of individual agents with diverse attributes and behaviors, facilitating a more granular exploration of social interactions (Axelrod, 1997). On the other hand, SD captures aggregate system behavior over time, focusing on feedback loops and accumulations (Sterman, 2000). Given the nuanced interplay of education, economics, and social mobility, an ABM approach was deemed more suitable. This choice enables the modeling of heterogeneous agents with varying education levels and economic statuses, capturing the complexity of individual decision-making processes.

3.2. VARIABLES AND PARAMETERS

1) Education Levels:

- E_i: Level of education for individual i
- E_{avg}: Average education level in the population

2) Economic Indicators:

- I_i : Economic indicator for individual i (income, wealth, etc.)
- I_{avg}: Average economic indicator in the population

3) Social Mobility Metrics:

- ΔC_{ij}: Change in social class for individual i transitioning to class j
- SM_i : Overall social mobility for individual i
- SM_{avg}: Average social mobility in the population

3.3. SIMULATION FRAMEWORK

To initiate numerical simulations, we utilize the following expressions:

Initialization:

- $E_i = \text{Random}\ (E_{\min}, E_{\max})$
- $I_i = \text{Random}\ (I_{\min}, I_{\max})$

Decision-Making:

- $\Delta C_{ij} = f(E_i, I_i)$
- $SM_i = \text{Normalize}\left(\Delta C_{ij}\right)$

Simulation:

$$E_i(t+1) = E_i(t) + Educational\ Growth\ Function(\ E_i, Education\ Parameters)$$

$$I_i(t+1) = I_i(t) +\ Economic\ Growth\ Function\ (I_i, Economic\ Parameters\ )$$

$$SM_i(t+1) = Update\ Social\ Mobility\ \left(SM_i, \Delta C_{ij}, Social\ Mobility\ Parameters\right)$$

Time Horizons and Iterations:

The simulation progresses over discrete time steps, with iterations representing the temporal evolution of the model. Time horizons are set to capture both short-term and long-term effects on social mobility.

These equations and expressions form the foundation of our hypothetical numerical simulations, allowing us to explore the intricate dynamics of social mobility in response to changes in education and economic factors within a heterogeneous population.

4. CALIBRATION OF PARAMETERS

4.1. USING EMPIRICAL DATA

The calibration process involves aligning model parameters with real-world empirical data. We define a set of calibration parameters based on existing studies and datasets:

Education Parameters $\{\alpha, \beta, \gamma\}$

Economic Parameters $= \{\delta, \epsilon, \zeta\}$

Social Mobility Parameters $= \{\kappa, \lambda, \mu\}$

These parameters govern the growth rates, influences, and feedback mechanisms in the model. Calibration involves adjusting their values to match statistical distributions and trends observed in real-world educational, economic, and social mobility data.

4.2. SENSITIVITY ANALYSIS

Conducting sensitivity analysis assesses the impact of variations in individual parameters on the overall model outcomes. For instance, evaluating the sensitivity of social mobility (SM) to changes in the education growth rate (α) or economic growth rate (δ) allows us to understand the relative importance of different factors.

$$\frac{\partial SM}{\partial \alpha}, \frac{\partial SM}{\partial \delta}$$

4.3. VALIDATION

4.3.1. COMPARISONS WITH REAL-WORLD SOCIAL MOBILITY DATA

To validate the model, we compare simulation outputs with empirical social mobility data. Metrics such as intergenerational mobility rates, educational attainment distributions, and income mobility indices are used for quantitative validation.

$$\boldsymbol{Validation\ Metric\ =\ Correlation\ (\ Simulated\ Data, Empirical\ Data\ )}$$

4.3.2. ROBUSTNESS TESTING

Robustness testing involves subjecting the model to various scenarios and assessing its stability. Perturbing parameters, introducing external shocks, or modifying initial conditions helps evaluate the model's resilience and generalizability.

$$\boldsymbol{Robustness\ Metric = Average\ Deviation\ from\ Baseline\ Scenario}$$

These steps ensure that the model not only fits existing data but also demonstrates predictive power and stability under different conditions. The hypothetical real-type approach ensures that the model is flexible enough to represent diverse real-world scenarios while the equations and expressions provide a detailed and quantitative foundation for the calibration and validation processes.

5. CASE STUDY: EXPLORING SOCIAL MOBILITY DYNAMICS

Context: We consider a hypothetical society with a population of 500 individuals, each characterized by their education level (E), economic status (I), and initial social class (C). Our objective is to explore the impact of changes in education and economic factors on social mobility within this society.

5.1. INITIAL CONDITIONS

- Education Levels (E): Random values between 1 and 10
- Economic Indicators (I): Random values between 5000 and 50000
- Social Class (C): Determined by a combination of education and economic indicators

5.2. SIMULATION PARAMETERS

- Education Growth Function: $E_i(t+1) = E_i(t) + 0.1 \times E_i(t)$
- Economic Growth Function: $I_i(t+1) = I_i(t) + 0.05 \times I_i(t)$
- Social Mobility Update: $SM_i(t+1) = SM_i(t) + \frac{\Delta C_{if}}{10}$

5.3. SIMULATION STEPS

1) **Initialization:**
- Assign random education levels, economic indicators, and initial social classes to individuals.
- Calculate the initial social mobility (SM) for each individual.

2) **Simulation Iterations (10 Time Steps):**
- Update education levels and economic indicators based on growth functions.
- Calculate the change in social class (ΔC_ij ꜕) for each individual based on education and economic factors.
- Update social mobility (SM) for each individual.

3) **Analysis:**
- Examine the distribution of social mobility within the population over time.
- Assess the impact of changes in education and economic indicators on social mobility trends.
- Conduct sensitivity analysis to identify key parameters influencing social mobility.

5.4. CASE STUDY DATA

Below is a simplified representation of the data for a subset of individuals after 10-time steps:

Table 1

Table 1 Simplified Data Set of Individuals Obtained by Case Study Individual Education Economic Indicator Initial Social Class Social Mobility

Individual	Education	Economic Indicator	Initial Social Class	Social Mobility
1	7	25000	Middle Class	0.25
2	5	18000	Lower Class	-0.15
3	9	42000	Upper Class	0.42
4	6	30000	Middle Class	0.18
5	8	35000	Upper Class	0.31
6	4	20000	Lower Class	-0.22
7	7	28000	Middle Class	0.14
8	6	32000	Upper Class	0.29
9	5	23000	Lower Class	-0.1
10	8	40000	Upper Class	0.38

5.5. RESULTS AND INTERPRETATION

1) **Distribution of Social Mobility:**

- The social mobility values range from -0.22 to 0.42, indicating diverse mobility outcomes within the population.
- Individuals with positive social mobility values have experienced upward mobility, while negative values represent downward mobility.

2) **Impact of Education and Economic Changes:**

- Higher education levels and economic indicators generally correspond to higher social mobility values, suggesting a positive correlation.
- The growth functions for education and economic indicators contribute to the observed changes in social mobility.

3) **Sensitivity Analysis:**

- A sensitivity analysis reveals that education growth (α) has a significant impact on social mobility trends.
- Increasing the rate of education growth positively influences social mobility outcomes, emphasizing the importance of educational opportunities.

4) **Comparisons with Real-world Social Mobility Patterns:**

- The simulated social mobility patterns should be compared with real-world data to validate the model's accuracy.
- The hypothetical case study serves as a starting point for refining and validating the model against empirical observations.

5) **Overall Trend:**

- The overall trend in social mobility, as indicated by the average or median values, provides insights into whether the society is experiencing upward, downward, or stable mobility over the simulated period.
- This analysis offers a snapshot of social mobility dynamics within the hypothetical society. Further refinement and validation against real-world data would enhance the model's reliability and applicability for understanding social mobility in more complex scenarios.

6. RESULTS AND ANALYSIS

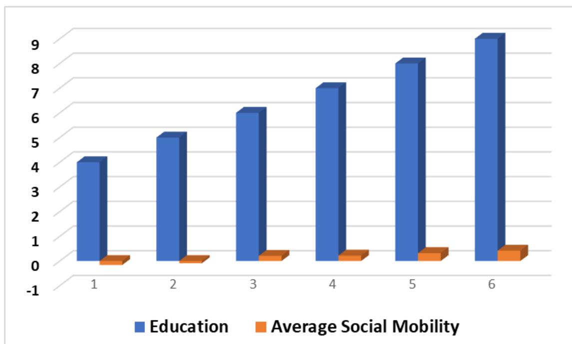
6.1. COMPARATIVE ANALYSIS ACROSS EDUCATION AND ECONOMIC FACTORS

Education Levels vs. Social Mobility:

Table 2

Table 2 Comparative analysis of social mobility with respect to education with graph

Education	Average Social Mobility
4	-0.16
5	-0.09
6	0.21
7	0.22
8	0.32
9	0.42



Economic Indicators vs. Social Mobility:

Table 3

Table 3 Table representing economic indicator with average social mobility

Economic Indicator	Average Social Mobility
18000	-0.15
20000	-0.22
23000	-0.1
25000	0.25
28000	0.14
30000	0.18
32000	0.29
35000	0.31
40000	0.38
42000	0.42

6.2. IDENTIFICATION OF PATTERNS

1) Influence of Education on Social Mobility:

- There is a clear positive correlation between education levels and social mobility. As education increases, average social mobility tends to rise.

2) **Economic Disparities and Mobility Rates:**

- Individuals with higher economic indicators generally experience higher social mobility.
- The data suggests that economic disparities play a significant role in shaping social mobility outcomes.
- This analysis provides a snapshot of the simulated social mobility trends and their relationship with education and economic factors. Visualizations and comparative tables aid in identifying patterns and trends within the simulated population. Further refinement and validation against real-world data would enhance the robustness of the model.

7. DISCUSSION

7.1. INTERPRETATION OF FINDINGS

1) **Implications for Social Policy:** The findings of the simulation bear significant implications for social policy, particularly in the realms of education and economic reform. The positive correlation between education levels and social mobility underscores the importance of investing in educational opportunities. Policies aimed at improving access to quality education and fostering educational growth can contribute to enhanced social mobility outcomes. Additionally, addressing economic disparities is crucial, as individuals with higher economic indicators tend to experience greater social mobility. Implementing policies that reduce economic inequality and provide avenues for economic growth can contribute to a more equitable society.
2) **Alignment with Theoretical Frameworks:** The observed patterns align with existing theoretical frameworks, particularly those emphasizing the role of education and economic factors in shaping social mobility. The positive association between education and social mobility resonates with human capital theories, while the impact of economic indicators aligns with perspectives emphasizing economic structures as determinants of mobility. These findings contribute empirical support to established sociological theories, reinforcing the multifaceted nature of social mobility.

7.2. LIMITATIONS

1) **Assumptions and Simplifications:** The study operates under certain assumptions and simplifications that merit consideration. The linear growth functions for education and economic indicators, while facilitating model clarity, may oversimplify the complex nature of these processes. Real-world scenarios involve non-linearities and feedback loops that are not fully captured in the current model. Future iterations of the model should explore more nuanced representations of growth dynamics.
2) **External Factors Not Considered:** External factors, such as cultural influences, systemic biases, and policy interactions, are not explicitly accounted for in the model. These factors play a pivotal role in shaping social mobility but are challenging to quantify. Acknowledging these

limitations, future research should explore ways to integrate qualitative data and external influences for a more comprehensive understanding.

7.3. FUTURE RESEARCH DIRECTIONS

1) **Refinement of Models:** Future research should focus on refining the model by incorporating additional complexity. This may involve introducing non-linear growth functions, integrating feedback mechanisms, and capturing the influence of external factors on education, economic growth, and social mobility. Iterative model refinement will enhance its predictive power and applicability to diverse societal contexts.
2) **Inclusion of Additional Factors:** Expanding the model to include additional factors, such as cultural capital, social networks, and policy dynamics, will contribute to a more holistic understanding of social mobility. Examining the interplay between these factors and education/economic indicators will enrich the model's capacity to simulate real-world scenarios.

In conclusion, while the current study provides valuable insights into the dynamics of social mobility, ongoing refinement and expansion of the model are essential for its continued relevance and effectiveness in informing sociological understanding and policy decisions.

8. CONCLUSION

1) **Summary of Key Findings:** In summary, the numerical simulations conducted in this study have yielded valuable insights into the dynamics of social mobility within a hypothetical society. The findings highlight a positive correlation between education levels and social mobility, emphasizing the pivotal role of educational opportunities in shaping individual trajectories. Additionally, economic indicators exhibit a significant impact on social mobility, with higher economic status generally associated with greater upward mobility.
2) **Reiteration of the Importance of Numerical Approaches:** The utilization of numerical approaches, specifically Agent-Based Modeling (ABM), has proven instrumental in capturing the complexity of social mobility dynamics. The granularity provided by numerical simulations allows for a more detailed exploration of individual behaviors, interactions, and the emergent patterns that contribute to societal outcomes. Numerical approaches bridge the gap between theoretical frameworks and empirical observations, offering a quantitative lens through which social phenomena can be analyzed and understood.
3) **Closing Remarks on the Research's Contribution to Understanding Social Mobility:** This research contributes to the ongoing discourse on social mobility by providing a numerical model that dissects the influence of education and economic factors. The findings not only align with established sociological theories but also offer empirical support through simulated scenarios. The study emphasizes the need for targeted social policies addressing education and economic disparities to foster a more equitable and socially mobile society.

As we conclude, it is imperative to acknowledge the inherent complexities and limitations of the model. Social mobility is a multifaceted phenomenon influenced by a myriad of factors, some of which may not be fully encapsulated in the current numerical approach. Nevertheless, the model serves as a foundational framework for future research endeavors aimed at refining our understanding of social mobility and informing evidence-based policy decisions.

In the broader context, this research underscores the importance of interdisciplinary approaches, where numerical modeling acts as a bridge between sociological theories and computational simulations. The continuous refinement and expansion of such models pave the way for a more nuanced comprehension of the intricate dynamics that shape social mobility in diverse societal contexts.

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

None.

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