Exploring Wealth Accumulation with a Ability-Luck Perspective: Using ABM Method

1. Research Question

In a society where opportunity and misfortune events occur randomly, to what extent do an individual's ability and luck play a role in the success of wealth accumulation? Which one is more pivotal in the process of wealth accumulation?

2. ODD Description

2.1 Purpose and Patterns

2.1.1 purpose

This model is designed to investigate the influence of individual ability and luck on wealth accumulation.

2.1.2 Patterns

1. Wealth distribution inequality: A minority of individuals holds a disproportionate share of wealth, which is consistent with a Pareto distribution (Pareto 1964)

2. Wealth dynamics: Personal wealth is subject to the effects of both positive and negative random events, leading to varied growth or decline patterns.

3. Ability, luck and wealth correlation: Higher-ability individuals are more likely to capture opportunities and increase wealth, and resist the damage from misfortune events. Despite this, the randomness of events means high ability does not ensure becoming the wealthiest.

4. Macroeconomic effects: It examines how economic growth or recession influence individual wealth changes and the broader social wealth distribution.

2.2 Entities, state variables, and scales

2.2.1 Entities and state variables

People (individual): The model's autonomous agents with heterogeneity, move and interact within the environment to change their wealth through event engagement.

State variables for people include:

1. wealth: Current wealth, starting as a constant and updated by event interactions.

2. ability: Normally distributed, influences vision range, speed, and event handling success.

3. vision-range: Proportional to ability, defines the search area for opportunities.

4. people-speed: Proportional to ability, determines chase efficiency of opportunities.

5. focus-time: Time spent chasing a targeted opportunity.

6. focus-event: The specific opportunity currently being pursued.

Opportunity-events: Positive incidents that individuals can detect and pursue.

Misfortune-events: Negative incidents that are permanent in the environment, detectable by individuals but not actively avoidable.

Both opportunity and misfortune events have no intrinsic state variables, only have spatial coordinates.

2.2.2 Scales

Spatial: 100*100 patches in grid. Temporal: 160 time steps. See table 1 below.

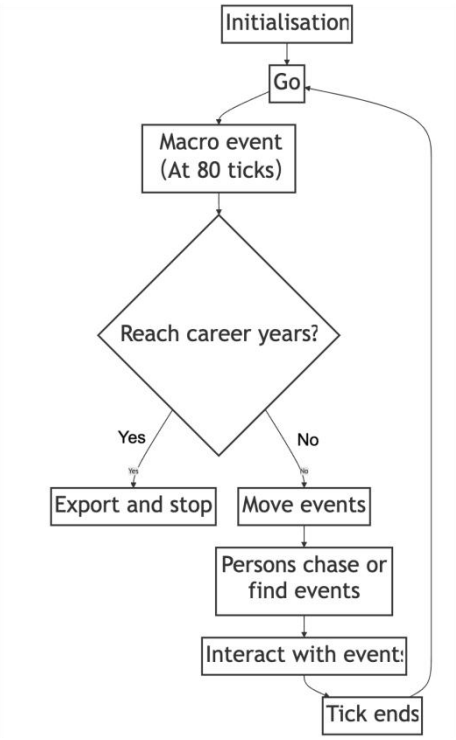
Table 1: The sptial and temporal scale of model

Scale Type	Representation in Model	Real-World Correspondence
Time Step	1 tick	3 months
Simulation Duration	160 ticks	40 years
Spatial Extent	100 x 100 grid	Abstract space, no real-world correspondence
Spatial Resolution	1 cell	Abstract space, no real-world correspondence

2.3 Process Overview and Scheduling

The model executes the following sub-processes at each time step (Figure 1):

Figure 1: Flow diagram for the model



1. Event Movement: Opportunity and misfortune events move randomly within the environment.

2. Chasing opportunity: Based on focus-time, individuals either permanent in chasing a focus-event or seek new ones.

3. People-Event Interaction: Success in capturing opportunity-events or resisting misfortune event consequences (affecting wealth positively or negatively) depends on their ability, demonstrating the interplay of ability and luck in wealth dynamics.

4. Macro Event: At 80-tick, economic booms or recessions occur based on settings, simulating external shocks to wealth.

5. Update Indicators and Visualization: Updates and visualise real-time aggregate and individual wealth data, ability distribution data.

6. Termination: Ends simulation upon reaching preset career-years

2.4 Design Concepts

2.4.1 Emergence

In the model, macro emergence is evident in societal wealth distribution. Individuals' abilities lead to wealth accumulation and inequality at the micro-level, creating a Matthew effect. The aggregate wealth distribution emerges from these individual interactions, highlighting how diversity and randomness shape societal disparities and inequalities.

2.4.2 Interaction

The model's core interactions are between individuals and events. People use their abilities to detect and chase opportunities, increasing wealth with success or suffering losses from misfortunes, with probabilities tied to their abilities. While individuals don't interact directly, they implicitly compete for limited opportunities. These interactions, follows probabilistic principles, illustrate how ability and luck influence wealth.

2.4.3 Stochasticity

Randomness is represented in two primary ways: the stochastic emergence of opportunity/misfortune events and the random assignment of individual abilities. Event distribution is unpredictable, mirroring the real-world's variable opportunities and misfortunes. Individual abilities are normally distributed at random, reflecting real-life diversity in talents. This twofold randomness underpins the complexity of personal outcomes and societal uncertainty, serving as a foundational simulation for examining wealth dynamics influenced by the interplay of ability and luck.

2.5 Initialisation

A set of key parameters must be chosed carefully, so that the final wealth distribution fit the Pareto distribution (Pareto, 1964) as a relable reflection of real world. See table 1 for details.

All agents are distributed randomly in the world at the begginning.

Table 2: The intialised settings of key variables and states

	Variables	Initialised Value	Description
Global Variables	num-people	Set by default to 1000.	The number of simulated individuals.
	num-events	Set by default to 500.	The total number of initial events.
	career-years	Set by default to 40.	The total duration of the simulation in years.
	economic-boom	Set by default to trun-on.	Triggers the generation of 1000 lucky events every 80 ticks.
	economic-recession	Set by default to trun-off.	Triggers the generation of 300 unlucky events every 80 ticks.
	events-die	Set by default to trun-off (consumed).	Determines whether opportunity events are consumed.
People-own variables	ability	Randomly sampled from a normal distribution with a mean of 0.6 and a standard deviation of 0.12.	Ensuring all values are non-negative.
	vision-range	Calculated adn set by default to (15 * ability^2).	The range people can see envents, influenced by ability.
	people-speed	Calculated adn set by default to (8 * ability^2).	The speed people chase envents, influenced by ability.
	focus-time	Set by default to 0.	Indicating that the individual has not yet engaged with any opportunity event.
	focus-event	Set by default to 'nobody' at the start.	Indicating that the individual has not yet focused on any specific opportunity event.
	wealth	Set by default to 50.	Representing the initial wealth of individual.
Events variables	Initial Quantity of Events	The number of opportunity events is 2000; The number of misfortune events is 300.	Opportunity events die after doubling wealth but misfortune events persistently exist, so the former is of more number.
	Initial Placement of Events	All randomly distributed in the wolrd.	They will move randomly with a speed of 20.

2.6 Input data

The model operates without the use of external input data. All parameters within the model are internally set at the time of initialization.

However, there is an output data for every run, which include the ability and final wealth of all “people”. It can be used in data anlysis part.

2.7 Submodels

2.7.1 Event Movement Submodel

Events move randomly each timestep, directed by the events-move procedure. Their movement is independent of other events or individuals.

2.7.2 People Action Submodel

Individuals decide their actions each timestep based on focus-time: continue chasing a current event or seek a new one. When seeking, they re-lock the nearest opportunity event in their vision. Movement speed is based on ability.

2.7.3 People-Event Interaction Submodel

Interactions occur when individuals and events at same patch. For opportunity events, individuals may successfully capture them, based on ability, doubling their wealth and ending the event. For misfortune events, individuals may be affected, based on ability, halving their wealth.

3. Brief methodology

Utilizing this model, we can explore the relative influence of ability and luck on wealth accumulation through the following steps:

1. Develop an experimental design and define societal economic conditions (boomor recession). Adjust initial parameters to fit the Pareto distribution (Pareto, 1964), with roughly 20% of the population controlling 80% of wealth, mirroring real-world wealth distribution.

2. Conduct multiple simulations (e.g. 1000+ runs) with BehaviorSpace, tracking key measurements such as the wealth and ability of the richest individuals, ability distribution within the wealthiest 20%, and wealth history of the highest ability individuals.

3. Data analysis using statistical methods. Create histograms of the highest-wealth individuals' abilities from all runs to assess the impact of ability on wealth—whether individuals with high abilities consistently attain high wealth. Also, generate histograms for the ability distribution of the top 20% wealthiest from all runs, indirectly showing the effect of ability on wealth—whether the wealthy consistently possess higher ability.

4. Conduct a qualitative analysis of data analysis results, considering empirical evidence from specific social contexts, to infer the effects of ability and luck on wealth. Discuss the relevance of the model's findings to the understanding of wealth distribution in the real world and potential policy implications.

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Reference

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