Imperial College London

Macroeconomic Agent Based Modelling

Author: Feyzi Can Eser

Supervisor: Salvador Navarro Martinez

Introduction

Economic modelling is critical for policymakers to predict the effects of policy changes on key economic outcomes, such as inflation and growth. This project aims to build a model utilising Macroeconomic Agent-Based Modelling (MABM). This computational method simulates the interactions of individual heterogeneous agents in an economy to analyse emergent macroeconomic phenomena.

The final model is intended to act as a digital laboratory for policymakers to test various economic policies to decide the best one to implement.

Background

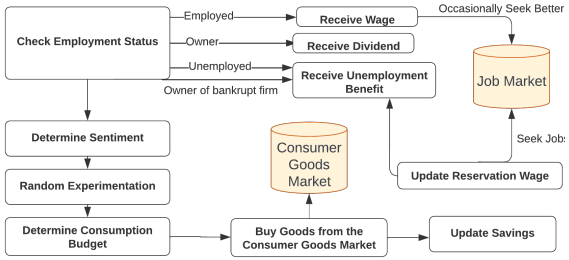
An agent is an autonomous entity characterised by a set of attributes and decision-making rules. An agent's state evolves as a function of its previous state, environment, and behavioural rules. MAMBs work by modelling the interaction of many agents, like households and firms.

Agents are governed by bounded rationality and simple behavioural rules. The overall system gives rise to complexity thanks to the randomness, non-linearity, and interaction links between agents. These interactions mimic those in real economies and models and thus replicate real-life macroeconomic phenomena, allowing for policy analysis by tweaking selected parameters. Crucially, MABMs can exhibit naturally occurring disequilibrium states, such as economic crises with unexpected drops in spending and rises in unemployment.

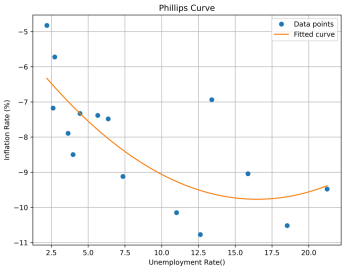
Model Description

The model was developed in C++. The model's agents comprised of worker and firm owner households, consumer and capital firms, and a single central bank. Consumer and capital goods markets, a labour market, and a public information board were used to facilitate inter-agent communication and interaction.

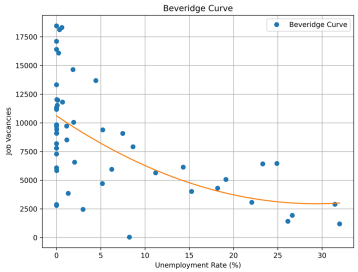
The final model incorporated unique features, including consumer sectors with carbon emission metrics and emission-conscious consumers. It accommodates various user-defined scenarios, expanding the model's potential as a digital economics laboratory.



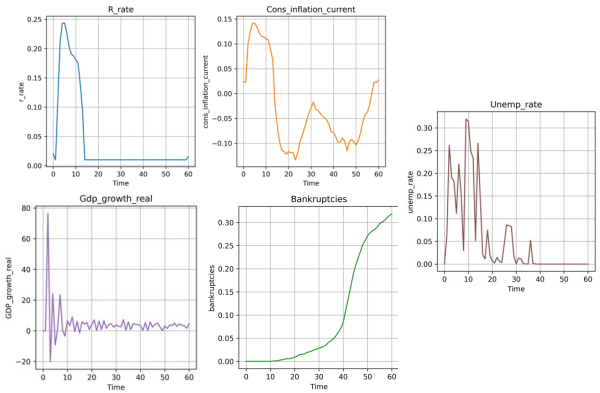
Sequence of Key Actions of a Household Agent at a given timestep



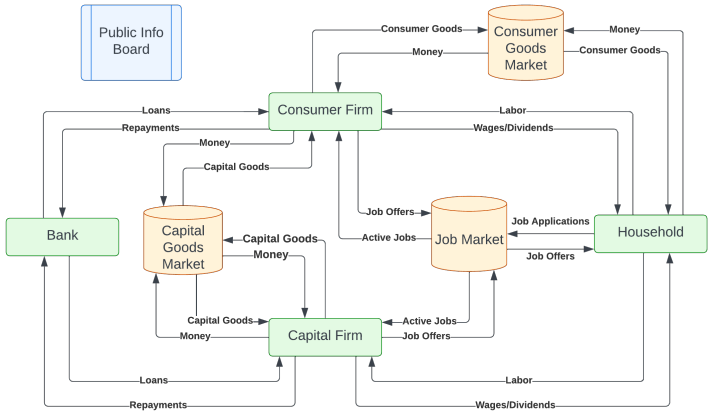
Phillips Curve from Randomised Simulation



Beveridge Curve from Randomised Simulation



Key Results from Monetary Policy Simulations



Overall Model Schematic

Results and Discussion

The model was validated by tests that showed it could reproduce real-world macroeconomic phenomena, such as naturally occurring business cycles, income inequality, and fluctuating economic growth. Key stylized economic facts, such as the inverse relationship between inflation and unemployment as described by the Phillips curve and that between unemployment and vacancies as described by the Beveridge curve, were observed throughout the simulations.

In all simulations, the economy grew over time despite being interrupted by bouts of slowing growth and downturns. These showed that the model exhibited the desired endogenous business cycles without externally applied shocks.

The chaotic nature of the model meant it was highly sensitive to slight changes in simulation parameters. However, the model demonstrated the desired economic phenomena to varying extents, regardless of the simulation scale or agents' initial homogeneity or heterogeneity.

In most tests, unemployment settled to zero after a certain time, contrary to expectations of low but stable unemployment. A persistent demand and supply mismatch in the labour market due to imperfect parameter calibrations was to blame.

Economic Policy Tests

Economic policy tests showed that changing key policy parameters led, for the most part, to the predicted outcome. For instance, tighter monetary policy and lending criteria resulted in lower inflation, higher bankruptcies, and reduced vacancies.

Strict emission regimes, characterised by more emission-sensitive consumers, prodded firms to invest proportionately in buying emission offsets. However, varying the strictness of the emission regime did not lead to predicted changes in spending and price growth in the affected sectors.

Conclusions

The tests proved that the model did what it set out to do: it is an artificial economy that exhibits many of the key stylised economic facts observed in real economies. Its outputs make intuitive sense and can be justified with economic theories. The system is inherently chaotic and unpredictable yet obeys conventional economic laws and theories. However, more rigorous calibration and additional systematic testing are needed to make the model more reliable.

Additional model features, such as restricting the interaction links between firms and households based on past relationships, allowing workers to develop differentiated skills, and modelling technological development, would also make the model more representative of real life.