Aggregating Individual Decisions to Represent a Macro Economy

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COMP SCI 372, June 2024

1 Introduction

1.1 Macroeconomics

Understanding how an economy functions is crucial for grasping the complexities of everyday life and the larger economic environment. The macro economy is derived from the aggregation of individual decisions made by households and firms. These entities make rational choices based on their income, expectations, and market conditions. This interconnected network can be effectively modeled as a circular economy, where households supply labor to firms and receive wages in return, while firms produce goods and services consumed by households. In this circular flow, money circulates, and resources are allocated through the interactions between households and firms, forming the foundation of the macro economy.

1.2 What Can We Learn

The motivation behind modeling a circular macro economy stems from the need to understand the intricate dynamics within it. By examining the interactions between households, firms, and macroeconomic variables like inflation and output, a model provides valuable insights into how different policy interventions and economic shocks can impact the overall economy. This understanding is crucial for researchers and policymakers who strive to predict and manage economic conditions effectively to promote stable prices and low

unemployment. Simulating these dynamics allows for a deeper comprehension of the complex relationships that drive economic outcomes, highlighting the importance of such a model in economic analysis.

Additionally, the model addresses the critical linkages between microeconomic foundations and macroeconomic frameworks. By incorporating individual decision-making behaviors into a broader economic context, the model bridges the gap between micro and macro-level analysis. This integration is essential for capturing both bottom-up effects, where individual actions aggregate to influence the economy, and top-down effects, where macroeconomic policies and conditions impact individual behavior. Such a holistic approach provides a more comprehensive view of economic phenomena, enhancing our ability to analyze and interpret economic data.

Furthermore, a bottom up model serves as a powerful tool for policy analysis and planning. It enables researchers to evaluate various policy scenarios and strategies, exploring the potential effects of fiscal and monetary policies, as well as structural reforms, on key economic indicators such as inflation, output, and interest rates. This capability is invaluable for informing decision-makers and guiding policy formulation and implementation. By understanding the likely outcomes of different policy measures, policymakers can make more informed choices, ultimately leading to more effective economic management.

1.3 Agent-Based Modeling

Agent-based modeling (ABM) offers a robust framework for capturing the complexities of the circular macro economy. Unlike traditional equation-based models, ABM allows for the simulation of individual entities—households and firms in this case—that interact based on predefined rules and exhibit adaptive behaviors. This bottom-up approach is particularly advantageous for several reasons.

ABM can effectively capture heterogeneity among agents. In the real world, households and firms are not homogeneous; they differ in their preferences, constraints, and decision-making processes. By allowing each agent to operate according to unique characteristics and rules, ABM provides a more nuanced representation of economic dynamics. This heterogeneity is critical for understanding how aggregate phenomena emerge from individual behaviors, such as how variations in household consumption or firm investment decisions contribute to overall economic trends.

ABM also facilitates the modeling of complex interactions and feedback loops within the economy. Economic agents interact in multifaceted ways, influencing and being influenced by the actions of others. For instance, a firm's investment decisions can affect the income and consumption choices of households, which in turn impact the firm's revenue and future investment. ABM captures these intricate interdependencies, enabling the exploration of emergent properties that might be overlooked in more simplistic models. This capability is essential for studying phenomena such as economic cycles, market crashes, or the propagation of shocks through the economy.

Moreover, ABM is highly flexible and adaptable, allowing researchers to incorporate a wide range of behaviors and policies. This flexibility is crucial for analyzing the impact of various macroeconomic policies under different scenarios. For instance, researchers can simulate the effects of changing interest rates, tax policies, or government spending on economic outcomes. By experimenting with different policy interventions within the model, ABM provides valuable insights into the potential effectiveness and unintended consequences of policy measures. This feature is particularly useful for policymakers seeking to design strategies that promote economic stability and growth.

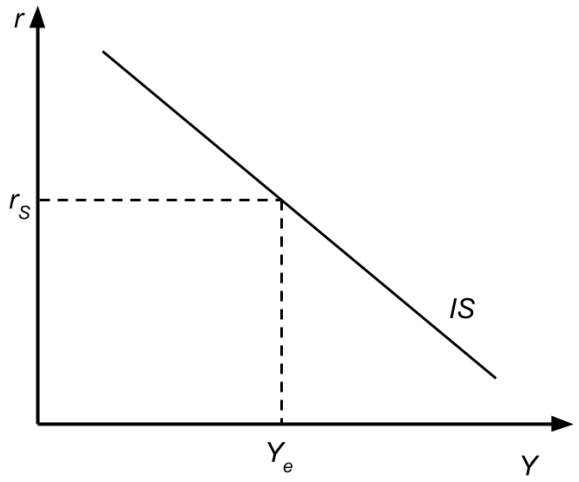
2 Background

2.1 The 3-Equation Model

To capture the intricate relationships within a macro economy, economists use the three-equation model. This model integrates three key relationships: the IS curve, the Phillips curve, and the monetary policy rule, providing a comprehensive view of how aggregate demand and supply dynamics shape macroeconomic outcomes. The IS curve represents the relationship between interest rates and output, showing how changes in interest rates influence investment and consumption decisions. The Phillips curve illustrates the trade-off between inflation and unemployment, indicating how inflationary pressures arise from deviations in output from its potential level. Finally, the monetary policy rule describes how central banks adjust interest rates in response to changes in inflation and output, aiming to stabilize the economy.

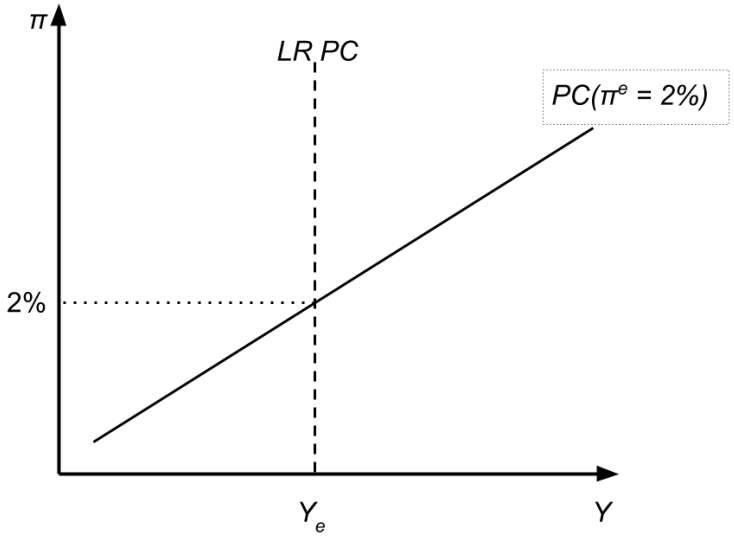
By understanding these interactions, policymakers can better predict and manage economic fluctuations, striving to maintain stable growth and low

inflation. The three-equation model thus serves as a vital tool for analyzing the macroeconomic environment, highlighting the importance of coordinated policy responses to various economic shocks and trends.



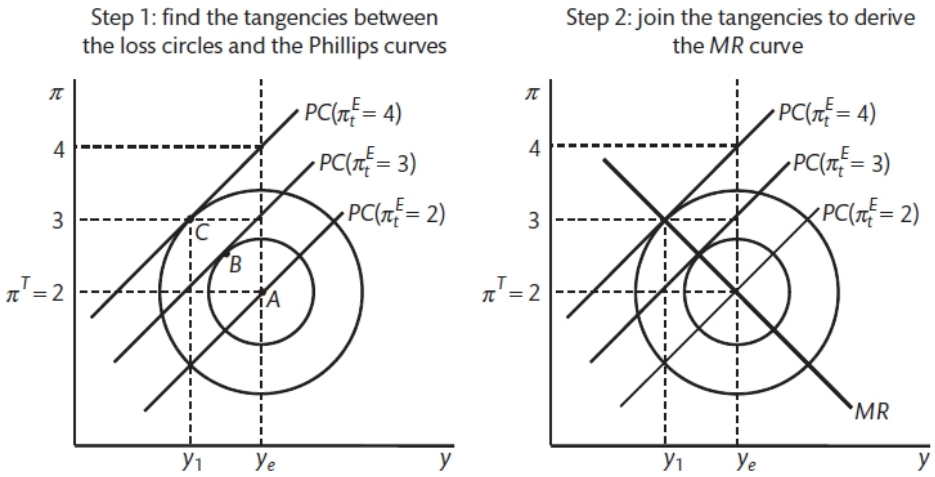
The IS curve represents the relationship between output and the interest rate, reflecting the demand side of the economy. It posits that aggregate demand is influenced by the real interest rate, which affects consumption and investment decisions. Lower interest rates tend to stimulate investment and consumption, leading to higher output. Conversely, higher interest rates suppress these activities, reducing output. Aggregate demand (AD) in this context is the total spending on goods and services in the economy, driven by consumption and investment. This spending by households and firms determines the level of economic activity and output.

For example, during a credit crisis, the cost of borrowing rises, reducing interest-sensitive spending and shifting the IS curve to the left. This necessitates a reduction in the central bank's interest rate to guide the economy back to equilibrium output at target inflation levels (Witte).



The Phillips curve captures the supply side by illustrating the relationship between inflation and the output gap. The output gap is the difference between actual output and potential output, the latter being the level of output an economy can sustain without generating inflationary pressures. When actual output exceeds potential output, it creates upward pressure on prices, leading to higher inflation. Conversely, when output is below potential, inflation tends to decrease. This relationship highlights how economic overheating can lead to inflation, while economic slack can result in disinflation or deflation.

For instance, a positive supply-side shock, such as an increase in productivity, shifts the Phillips curve to the right, indicating lower inflation for a given level of output (Witte).



Monetary policy, often represented by the central bank's interest rate setting, aims to stabilize the economy by targeting inflation and output. The policy rule encapsulates how the central bank adjusts the nominal interest rate in response to deviations in inflation from its target and output from its potential level. By influencing the interest rate, the central bank can indirectly control inflation and stabilize economic fluctuations.

During periods of economic distress, such as a housing market collapse, the central bank may lower interest rates to stimulate spending and investment, aiming to return the economy to its potential output (Witte).

By incorporating these three components—interest rates, inflation, and output—into the three-equation model, economists can better understand and predict the effects of various economic policies and shocks. This model underscores the delicate balancing act central banks perform in stabilizing the economy, highlighting the interconnectedness of macroeconomic variables and the importance of coordinated policy responses.

3 Design

3.1 Circular Economy Dynamics Model

The "Circular Economy Dynamics Model" simulates inflation within a circular economy using two types of agents: households and firms, based on

the 3-equation model framework. In this model, households make consumption decisions based on their income and inflation expectations and purchase goods and services from firms. Firms, in turn, determine their investment levels based on the prevailing interest rates and use these investments to pay households for labor. The model dynamically updates inflation based on households' adaptive expectations and the output gap, while the interest rate is adjusted according to a policy rule designed to stabilize the economy. This interaction between households and firms creates a detailed representation of macroeconomic dynamics, facilitating the analysis of various economic scenarios and policy interventions.

3.2 Model Parameters

3.2.1 Simulation Setup

- `n-households`: Number of household agents
- `n-firms`: Number of firm agents

3.2.2 Household Properties

- `MPC`: Marginal propensity to consume. This is an average with a standard deviation of 0.1
- `inflation-adaptability`: How adaptable households' inflation expectations are (1 is adaptive, 0 is grounded). This is an average with a standard deviation of 0.1

3.2.3 Firm Properties

- `interest-sensitivity`: How sensitive investment is to interest changes. This is an average with a standard deviation of 0.1

3.2.4 Monetary Policy

- `loss-balance`: How inflation and unemployment are balanced by the policy rule (1 is perfectly balanced)

3.2.5 Model Conditions

- `inflation-sensitivity`: How sensitive inflation is to the output gap
- `stabilising-interest-rate`: The interest rate that keeps the economy in equilibrium

3.3 Rules

3.3.1 Initialize

- Create `n-households` and `n-firms`
- Set initial macroeconomic variables to be in equilibrium

3.3.2 At each clock tick:

Each household:

- Decides consumption based on the `MPC` (marginal propensity to consume)
- Finds and buys from a random firm using their consumption budget
- Updates inflation expectations based on `inflation-adaptability`

Each firm:

- Decides investment based on `interest-sensitivity` and the current interest rate
- Finds and pays a random household using their investment budget

The model:

- Updates macroeconomic variables based on the 3-equation model, including aggregate consumption, aggregate investment, output, and inflation
- Sets the interest rate based on the policy rule to stabilize the economy

3.4 Justification

The rules governing the "Circular Economy Dynamics Model" are designed to encapsulate the core dynamics of a macroeconomic system in a way that reflects realistic economic behaviors and interactions. Each rule is grounded in economic theory and empirical observations, ensuring the model's relevance and accuracy in simulating real-world economic phenomena.

The decision-making processes for households and firms are rooted in well-established economic principles. Households decide their consumption based on their marginal propensity to consume (MPC), reflecting the tendency of individuals to allocate a portion of their income to consumption. This approach captures the variability in consumption patterns among different households, allowing the model to reflect a more realistic distribution of economic behavior. Additionally, households update their inflation expectations adaptively, which aligns with the observed behavior that individuals adjust their expectations based on past experiences and current economic conditions. This adaptive mechanism ensures that the model can simulate how changes in economic policy or external shocks influence household behavior over time.

For firms, the investment decision is modeled based on interest sensitivity, which reflects how firms adjust their investment levels in response to changes in interest rates. This rule captures the influence of monetary policy on business investment decisions, a critical aspect of macroeconomic dynamics. By linking investment to interest rates, the model can simulate the effects of monetary policy interventions on economic activity. Furthermore, the interaction between firms and households through wage payments ensures that the circular flow of income is maintained, highlighting the interdependence between production and consumption in the economy.

The model's rules for updating macroeconomic variables and setting interest rates are based on the 3-equation model, a fundamental framework in macroeconomic theory. By updating variables such as aggregate consumption, investment, output, and inflation, the model captures the dynamic interplay between different sectors of the economy. The interest rate setting rule, designed to stabilize the economy, ensures that the model can simulate the impact of monetary policy on economic stability. These rules provide a comprehensive framework for analyzing the effects of various economic policies and external shocks, making the model a valuable tool for investigation.

3.5 Assumptions

The "Circular Economy Dynamics Model" operates under several key assumptions that simplify the complexities of real-world economics while capturing essential dynamics for analytical purposes. One fundamental assumption is that the market is perfectly competitive, where the prices of firms equal their marginal cost. This assumption abstracts away from market power and strategic interactions among firms, allowing the model to focus on the aggregate behavior of the economy without the complications of monopoly or oligopoly dynamics.

Building off this simplification, the model employs highly simplified consumption and investment decisions for individual agents. Unlike traditional microeconomic models where households optimize their utility and firms engage in strategic competition (as described by game theory models like Cournot and Bertrand), the model assumes more straightforward behavior. Households base their consumption purely on their current income and MPC, while firms determine their investment based on interest sensitivity and prevailing interest rates. This simplification facilitates the analysis of macroeconomic dynamics by focusing on aggregate trends rather than individual optimization problems.

Another significant assumption is related to the marginal propensity to consume (MPC). The model posits that MPC is not strongly influenced by interest rates, implying that consumption remains relatively stable in response to income changes. While higher interest rates might theoretically induce more savings due to the substitution effect, the model assumes that this effect is counterbalanced by the fact that higher interest rates reduce the amount of savings needed for future consumption. Thus, the overall impact on consumption remains neutral, simplifying the consumption decision-making process for households.

Furthermore, the model incorporates the assumption of the neutrality of money, which suggests that in the long run, changes in the money supply only affect nominal variables such as prices and wages, without impacting real variables like output, consumption, and investment. This principle implies that while inflation can influence the price level, it does not alter the real economy's underlying structure. This assumption allows the model to focus on the short-to-medium-term dynamics of inflation and output without delving into the complexities of long-term monetary impacts.

In addition to these specific assumptions, the model aligns with the gen-

eral assumptions of the 3-equation model, which forms its theoretical foundation. The 3-equation model typically includes assumptions such as rational expectations, where agents form their expectations about future economic variables in a forward-looking manner, and the presence of sticky prices, which prevent immediate adjustment of prices to their equilibrium levels. These assumptions underpin the model's ability to simulate the effects of various macroeconomic policies and shocks, providing a structured framework for understanding economic fluctuations and policy impacts.

By incorporating these assumptions, the model achieves a balance between simplicity and realism, allowing it to serve as a valuable tool for analyzing macroeconomic dynamics and policy interventions while acknowledging the limitations inherent in any model-based representation of the economy.

4 Results

4.1 Inflation Adaptability

To investigate the dynamics of inflation expectations and economic adjustment, we use the Circular Economy Dynamics Model to run an experiment that examines how different levels of household inflation-adaptability influence the economy's response to a positive demand shock. Using BehaviorSpace, we test five different levels of inflation-adaptability $[0, 0.25, 0.5, 0.75, 1]$, under a set of base conditions to understand the differential impacts on key macroeconomic variables. The base conditions include: a stabilizing interest rate of 0.05, inflation sensitivity of 0.35, marginal propensity to consume (MPC) of 0.4, interest sensitivity of 0.6, 40 firms, 100 households, and a loss balance parameter of 1.

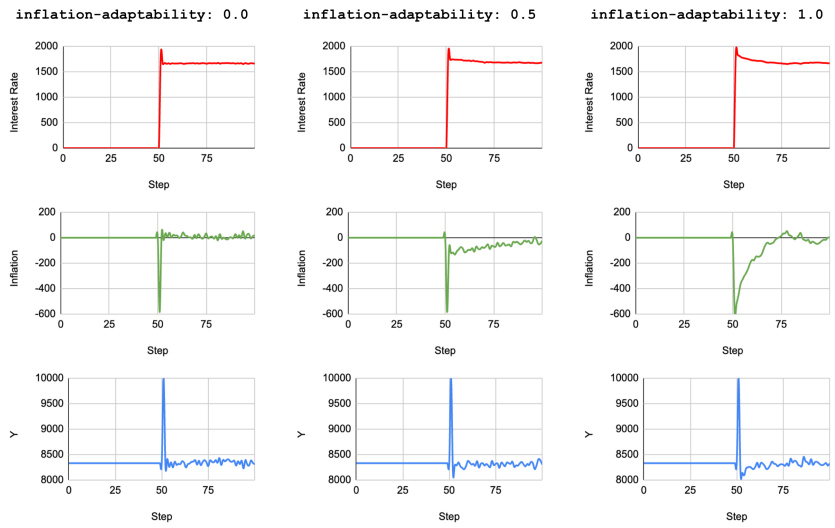
The experiment is structured to simulate a demand shock by increasing exogenous investment by 1000 units. Each trial begins with the economy running for 50 ticks to reach a stable state. After this stabilization period, the positive demand shock is introduced by increasing exogenous investment, and the stabilizing interest rate is adjusted accordingly based on the shifted IS curve. The economy is then allowed to evolve for another 50 ticks before the experiment concludes. Each combination of inflation-adaptability levels is tested five times, resulting in a total of 25 trials to ensure robustness in the findings.

The motivation behind this experiment is to explore the role of inflation

expectations in the economic adjustment process. Inflation-adaptability reflects how quickly households adjust their expectations in response to new information. By varying this parameter, we can observe how different adaptive behaviors impact the economy's resilience to demand shocks. This analysis provides valuable insights into the effectiveness of monetary policy and the importance of managing inflation expectations in maintaining economic stability. Understanding these dynamics is crucial for policymakers to design strategies that effectively mitigate the adverse effects of economic fluctuations.

4.2 Results from Experiments

The experiment results for varying levels of inflation-adaptability (0.0, 0.5, and 1.0) illustrate the behavior of key macroeconomic indicators—interest rate, inflation, and output (Y)—over time in response to a positive demand shock.



For an inflation-adaptability of 0.0, representing fully grounded inflation expectations, the interest rate remains constant until step 50, where it experiences a sharp spike upwards, followed by stabilization at a higher level. Inflation undergoes a sudden and significant drop at step 50, then oscillates before stabilizing at a lower level. The output (Y) shows a sudden spike at

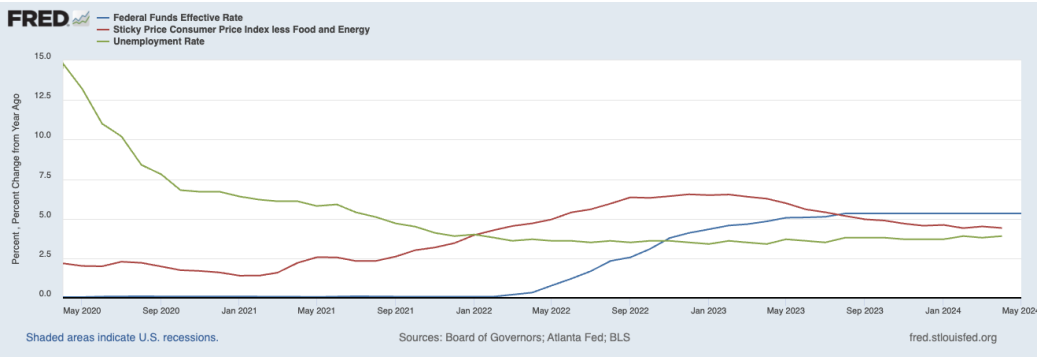
around step 50, quickly returning to its previous levels with minor oscillations.

With an inflation-adaptability of 0.5, the interest rate sharply increases at step 50, then gradually decreases and stabilizes at a higher level than before the shock. Inflation initially drops sharply at step 50 but gradually increases back to near its original level. The output experiences a sharp increase at around step 50, similar to the 0.0 scenario, but returns to near previous levels with less pronounced oscillations.

For an inflation-adaptability of 1.0, the interest rate spikes significantly at step 50 and gradually decreases, stabilizing at a higher level. Inflation drops sharply at step 50, followed by a gradual increase and eventual stabilization above the pre-shock level. The output displays a significant increase at step 50, followed by a return to levels similar to those before the shock, with more notable fluctuations.

4.3 Empirical Validation

The empirical data from the St. Louis Federal Reserve (FRED) offers a valuable context for validating the results of the experiment conducted with the Circular Economy Dynamics Model, particularly regarding the impact of the COVID relief acts and the subsequent economic recovery.



The graph from FRED displays the Federal Funds Effective Rate, the Sticky Price Consumer Price Index (CPI) less Food and Energy, and the Unemployment Rate from May 2020 to May 2024. This period aligns with the implementation and effects of the CARES Act (March 2020) and the American Rescue Plan Act (March 2021).

The Federal Funds Rate remained near zero from May 2020 until early 2022, reflecting the Federal Reserve's response to the economic downturn caused by the pandemic. The aim was to keep borrowing costs low and stimulate economic activity. A gradual increase in the Federal Funds Rate starting in early 2022 indicates the Fed's efforts to normalize monetary policy as the economy showed signs of recovery and inflation pressures emerged. This gradual rate increase supports the model's adjustment mechanisms in response to rising inflation and economic stabilization efforts.

Initially, inflation remained relatively low and stable throughout 2020 and early 2021, reflecting subdued demand during the peak of the pandemic. However, from mid-2021 onwards, inflation began to rise steadily, peaking in early 2023. This increase corresponds with economic recovery and associated demand pressures, validating the experiment's finding that inflation can rise following a positive demand shock. The observed increase in the Sticky Price CPI aligns with the model's projection of rising inflation, particularly noticeable in the fully adaptive inflation scenario.

The unemployment rate saw a steep decline from its peak in mid-2020, indicating a rapid recovery in employment as the economy started to reopen and benefit from the fiscal stimulus provided by the CARES Act and the American Rescue Plan Act. The steady decline in unemployment rates through 2021 and into 2022 aligns with the model's projection that increased output (economic recovery) follows a positive demand shock, validating the effectiveness of the COVID relief measures. This decline in unemployment rates corroborates the model's projection of increased output and employment following the demand shock induced by the fiscal stimulus.

The empirical data from the St. Louis Fed corroborates the model experiment results, demonstrating the significant impact of fiscal stimulus on economic recovery, inflation dynamics, and employment levels during the post-pandemic period. The positive demand shocks from the COVID relief acts led to increased economic activity, higher inflation, and lower unemployment, consistent with both the model's projections and real-world observations.

5 Analysis and Discussion

5.1 Interpretation of Experiment Results

The results of the experiment highlight the correlation between inflation-adaptability and the behavior of key macroeconomic indicators in response to a positive demand shock. Higher inflation-adaptability, where households quickly adjust their expectations based on recent economic changes, results in a more dynamic and responsive adjustment of inflation and interest rates.

In the case of fully grounded inflation expectations (0.0 adaptability), the central bank's aggressive response to stabilize inflation leads to a sharp spike in interest rates. Inflation does not adjust quickly, resulting in significant drops and oscillations before stabilizing at a lower level. This scenario indicates that grounded expectations lead to slower adjustments in inflation, requiring more forceful monetary policy interventions.

As inflation-adaptability increases to 0.5, households moderately adjust their expectations. This results in a more gradual stabilization of inflation, with interest rates adjusting less aggressively compared to the fully grounded scenario. The output stabilizes more smoothly, indicating that moderate adaptability helps the economy adjust more efficiently to the demand shock.

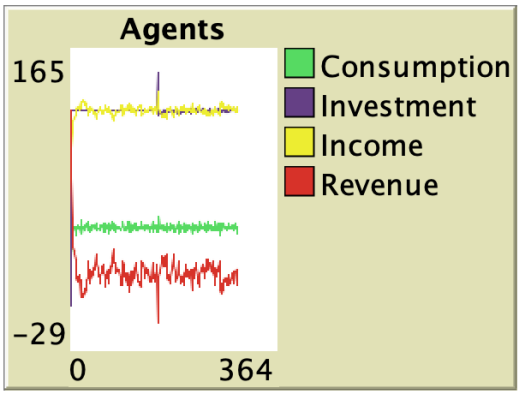
With fully adaptive inflation expectations (1.0), households quickly incorporate new economic information into their expectations, leading to a quicker stabilization of inflation. However, this also results in greater fluctuations in output. The interest rate adjusts significantly, reflecting the central bank's efforts to manage the rapid changes in inflation.

Overall, the experiment demonstrates that higher inflation-adaptability results in more responsive inflation adjustments and smoother economic stabilization, but it also introduces greater volatility in output. This highlights the importance of managing inflation expectations in economic policy, as different levels of adaptability can significantly influence the economy's resilience and response to demand shocks.

5.2 Emergent Phenomena

The experiment results, depicted in the provided screenshot, illustrate several emergent phenomena involving consumption, investment, income, and revenue within the agent-based model. Throughout the simulation, household consumption remains relatively stable, indicating consistent spending

behavior even in the presence of a positive demand shock, which in this context is characterized by an increase in firm investment due to higher exogenous investment. This stability in consumption reflects the model's marginal propensity to consume (MPC) parameter, ensuring that household consumption patterns are maintained over time.



Investment by firms shows a significant spike at the moment the demand shock is introduced, highlighting the firms' responsiveness to the increased exogenous investment. This temporary increase in investment activity is followed by a return to more stable levels, suggesting that firms quickly adjust their strategies to align with the new economic conditions. Similarly, household income remains fairly stable with minor fluctuations, demonstrating the model's assumption of steady income distribution among households. These slight variations can be attributed to the dynamic interactions between firms and households, where wages are influenced by the firms' revenue and investment decisions.

In contrast, firms' revenue exhibits more pronounced variability. An initial significant drop in revenue is observed, followed by a period of oscillation, reflecting the dynamic nature of revenue generation processes in response to household consumption and increased investment activities. This initial drop likely corresponds to the adjustment period following the demand shock, indicating the firms' adaptation to the changing economic landscape.

5.3 Implications

The interpretation of the experiment results and the observed emergent behavior has several significant implications for understanding macroeconomic

dynamics and policy formulation. The stability of consumption and income, even in the presence of a positive demand shock, suggests that household spending patterns are robust to economic changes. This robustness is crucial for maintaining economic stability, as consistent consumption can help cushion the economy against shocks. Policymakers can leverage this understanding to design interventions that support household income and consumption, ensuring sustained economic activity during periods of uncertainty.

The significant spike in firm investment in response to higher exogenous investment highlights the sensitivity of firms to economic stimuli. This behavior underscores the importance of targeted fiscal policies that encourage investment, especially during economic downturns. By increasing exogenous investment, governments can stimulate firm activities, leading to increased production and economic growth. However, the rapid adjustment also suggests that firms are quick to realign their strategies, indicating that such stimuli should be carefully timed and scaled to avoid potential overheating of the economy. Additionally, the pronounced variability in firms' revenue points to the dynamic and often unpredictable nature of revenue generation processes. This variability reflects the complex interplay between consumer behavior, investment decisions, and broader economic conditions.

The correlation between higher inflation-adaptability and more dynamic adjustments in inflation and interest rates suggests that managing inflation expectations is critical for economic stability. Households that quickly adjust their expectations based on recent economic changes can help stabilize inflation more rapidly, but this also introduces greater volatility in output. Policymakers must therefore balance the need for adaptive inflation expectations with measures that mitigate output fluctuations. The aggressive responses in interest rates observed in scenarios with different levels of inflation-adaptability indicate the central bank's pivotal role in stabilizing the economy. These findings reinforce the importance of timely and well-calibrated monetary interventions to manage inflation and support economic recovery.

The experiment's results emphasize the effectiveness of fiscal stimuli, such as increased exogenous investment, in driving economic recovery. Policymakers should consider incorporating flexible and responsive fiscal measures that can be quickly implemented to counteract economic downturns. The observed emergent phenomena underscore the value of agent-based models in capturing the intricate dynamics of macroeconomic systems. These models provide a detailed understanding of how individual behaviors aggregate

to influence broader economic trends, offering valuable insights for both researchers and policymakers. Continued development and refinement of such models can enhance our ability to predict and manage economic phenomena, leading to more effective and informed policy decisions.

6 Conclusion

6.1 Future Work

Future work on the model could involve further breaking down the macroeconomic model into more detailed microeconomic behavior models for individual households and firms. This approach would enhance the granularity and accuracy of the model by incorporating more realistic decision-making processes at the micro level. For instance, future iterations of the model could include utility optimization behaviors for households, where consumption, saving, and labor supply decisions are derived from utility maximization principles. This would allow the model to capture a wider range of household behaviors, including responses to varying economic incentives and constraints.

Similarly, firms could be modeled using more sophisticated investment and production functions, incorporating elements from game theory to reflect competitive behaviors in markets. By simulating firms' strategic interactions, such as price-setting in oligopolistic markets or output decisions in monopolistic competition, the model would provide a deeper understanding of how firm-level dynamics aggregate to influence macroeconomic outcomes. Additionally, incorporating behavioral aspects, such as bounded rationality and heterogeneous expectations among agents, could further enhance the model's ability to simulate real-world economic complexities.

6.2 Further Validation

Further validation of the model would benefit from a multi-faceted approach combining empirical data comparisons, sensitivity analyses, and real-world policy simulations. One critical step is to rigorously compare the model's output with historical economic data across different time periods and economic conditions. By calibrating the model against known economic events, such as past recessions, booms, and specific policy interventions, researchers

can assess its predictive accuracy and reliability. This empirical validation should involve not only aggregate indicators like GDP, inflation, and unemployment rates but also more granular data, such as sector-specific outputs and household-level consumption patterns.

Incorporating real-world policy simulations can also enhance the model's validation. For instance, simulating the effects of recent economic policies, such as the COVID-19 relief acts, and comparing the model's predictions with observed outcomes can provide practical insights into its accuracy and applicability. Collaborating with policymakers to test hypothetical scenarios and future policy proposals could also offer valuable feedback and help refine the model's structure and assumptions. By continuously iterating between model development and empirical validation, the Circular Economy Dynamics Model can evolve into a more robust and reliable tool for analyzing and forecasting economic dynamics.

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