Should Do Ch 12 IS-MP Simulations Report

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1 Introduction to the IS-MP Model

In this report, we utilize the IS-MP model as a framework for analyzing short-run economic fluctuations. This model builds on concepts from previous macroeconomic models and allows us to explore how real interest rates and aggregate demand interact in the short run. Specifically, it helps us understand how short-run output ($\tilde{Y}$), determined by the IS curve, responds to changes in the real interest rate (R), which is set by the MP curve.

Components of the IS-MP Model

The IS curve in the IS-MP model is represented mathematically by:

$$\tilde{Y}_t = a - b(R_t - \bar{r})$$

Where:

- $\tilde{Y}_t$ is short-run output.
- a represents an aggregate demand shock.
- b captures the sensitivity of output to interest rate changes.
- R_t is the real interest rate set by the central bank.
- $\bar{r}$ is the natural (or neutral) real interest rate that maintains output at potential.

This equation shows how interest rate changes affect investment and consumption, and therefore short-run output. In contrast, the MP curve reflects how the central bank sets the real interest rate, and is given by:

$$R_t = \bar{r}$$

Where:

- R_t is the real interest rate at time t.
- $\bar{r}$ is the natural real interest rate that stabilizes the economy at potential output.

Together, these two curves form the IS-MP diagram shown below:

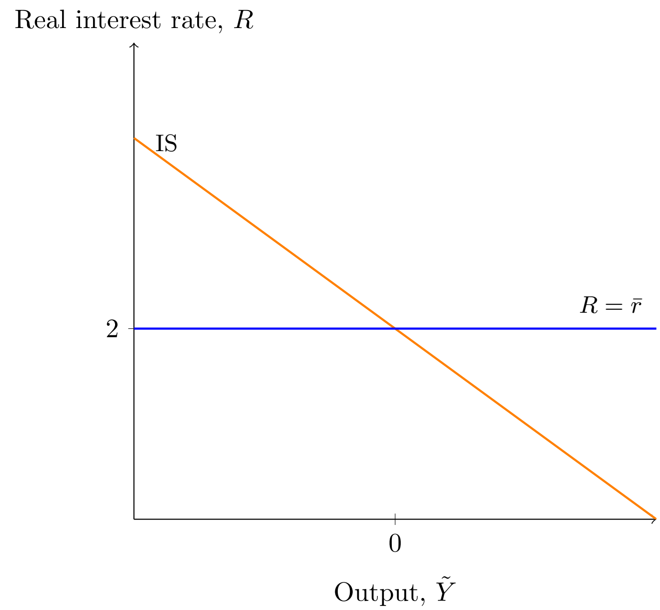


Figure 1: IS-MP Diagram at Equilibrium

This diagram illustrates how the central bank sets interest rates to reach an equilibrium that balances output and inflation. In the sections below, we will conduct quantitative experiments using this model to simulate economic shocks and examine how monetary policy can respond over time.

2 Consumption Shock Experiment

For our first quantitative experiment using the IS-MP model, we analyze how a consumption shock affects short-run output and inflation, and how the Fed's response can alter the trajectory of the economy. Suppose the economy experiences a considerable negative shock to consumption such that:

$$a = -5 \quad \text{for periods 5 through 10}$$

In response, the Federal Reserve reduces the real interest rate to:

$$R = 1\% \quad \text{for periods 6 through 11}$$

The effects of both the consumption shock and the Fed's monetary policy response on short-run output are shown in the figure below:

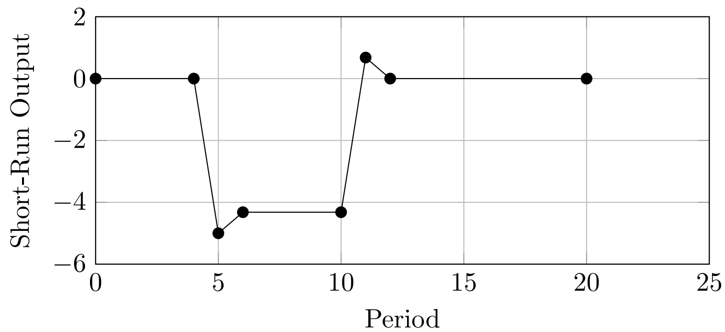


Figure 2: Change in Short-Run Output

At period 5, the immediate effect of the shock is a sharp drop in short-run output. The decrease in a to -5 causes a corresponding decline in $\tilde{Y}$, indicating a contraction in aggregate demand. As consumption falls, households reduce spending, leading to a decrease in real GDP below its potential level (Y^*).

Beginning in period 6, the Fed lowers the real interest rate to 1%. This monetary stimulus reduces the cost of borrowing and encourages consumption and investment, slightly increasing short-run output. However, since the underlying shock persists, output remains below potential until the shock ends in period 10. The Fed's intervention helps to cushion the downturn, but is not sufficient to fully offset the impact of the shock. The effects on inflation follow a different path, as illustrated below:

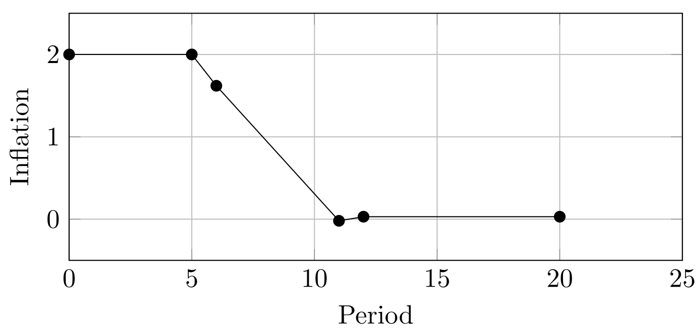


Figure 3: Change in Inflation

Prior to the shock, inflation holds steady around 2%. Following the drop in a, inflation begins to fall as reduced aggregate demand places downward pressure on prices. Firms respond by slowing their rate of price increases. Because inflation is sticky, the response is gradual—becoming more pronounced as the output gap persists. The Fed's interest rate cut in period 6 slightly slows this decline, but inflation continues to fall, turning negative around period 11 before stabilizing.

In summary, the consumption shock led to a significant contraction in output and a delayed disinflationary response. The Fed's monetary policy partially stabilized the economy, but was not significant enough to fully restore output or inflation until the shock subsided. This experiment demonstrates the IS-MP model's ability to capture the dynamics of policy response and economic adjustment in the face of demand-side shocks.

3 Responses to Economic Shocks

The IS-MP model provides a useful framework for evaluating how the central bank should respond to shocks. In each case, we state the shock, assess its impact on short-run output and inflation, and recommend a new real interest rate (R) to stabilize the economy.

Interest Rate Recommendation Due to Consumption Shock

Suppose consumer confidence declines, leading to a decrease in consumption. We model this as a negative shock to a:

$$\Delta a_C = -0.5\%$$

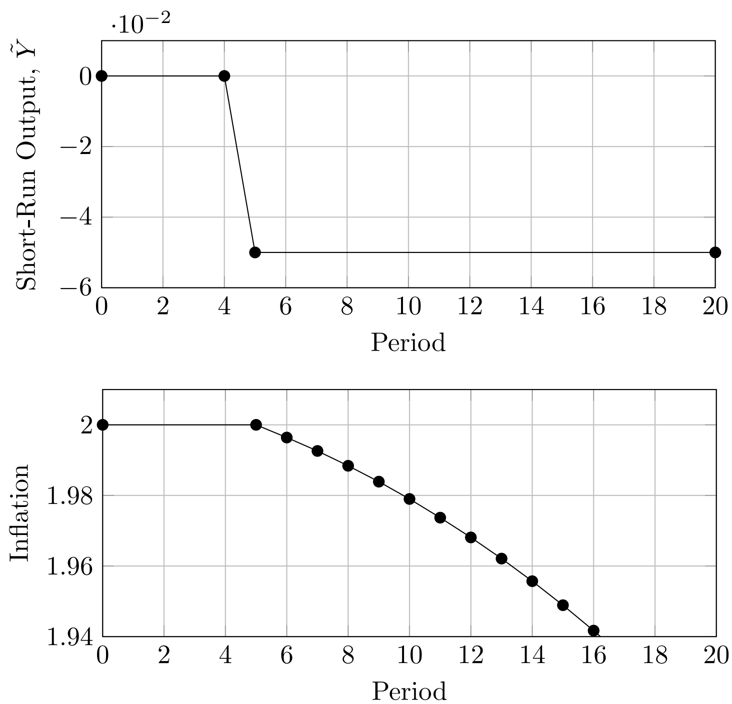


Figure 4: Short-Run Output and Inflation Response to a Persistent Consumption Shock

The graphs above show the effects of a persistent negative shock to consumption on short-run output and inflation. As expected, short-run output ($\tilde{Y}$) falls and settles at a lower steady state. Inflation also begins to decline, reflecting weaker aggregate demand, and continues to drift downward throughout the simulation. In response to this scenario, the central bank would be concerned about both recessionary pressures and the risk of deflation. To counter the drop in output and inflation, it can use monetary policy by adjusting the real interest rate. Using the IS curve:

$$\tilde{Y}_t = a - b(R_t - \bar{r})$$

we set $\tilde{Y}_t = 0$ and solve for R_t, assuming $\bar{r} = 2\%$ and $b = 0.68$:

$$0 = -0.5 - 0.68(R_t - 2) \Rightarrow R_t = 2 + \frac{0.5}{0.68} \approx 1.265\%$$

This implies that the Fed should reduce the real interest rate to approximately 1.265% to fully offset the 0.5% drop in aggregate demand. In theory, this would return output to potential and prevent further disinflation. To observe the actual impact, we implement this rate adjustment at $t = 7$ and simulate the resulting dynamics:

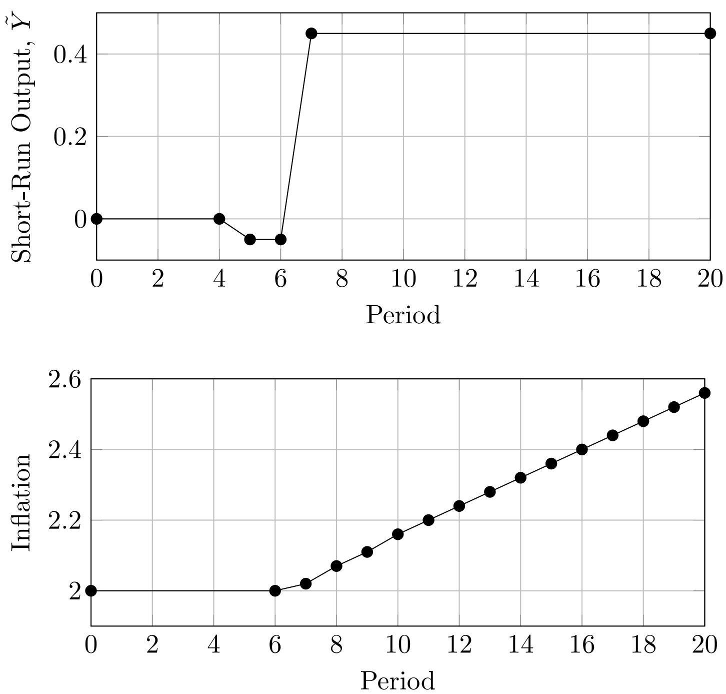


Figure 5: Short-Run Output and Inflation Response to Interest Rate Adjustment at $t = 7$

As shown, the interest rate cut leads to an overshoot in short-run output and a gradual increase in inflation above the 2% target. While 1.265% is the theoretically correct value based on the IS curve with $\bar{r} = 2\%$, the simulation reveals that the economy responds differently, overshooting output and pushing inflation higher than expected. This result underscores a real-world challenge: even accurate theoretical policy targets may lead to unintended side effects due to the lagged and cumulative nature of monetary policy.

Interest Rate Recommendation Due to Increase in MPK

For our next experiment, let's say that the there are significant improvements in information technology in the economy. This leads to an increase in productivity and in turn marginal productive of capital so that:

$$\Delta r = 1\%$$

This figure shows us the effects of such a change at the new level of $\bar{r}$:

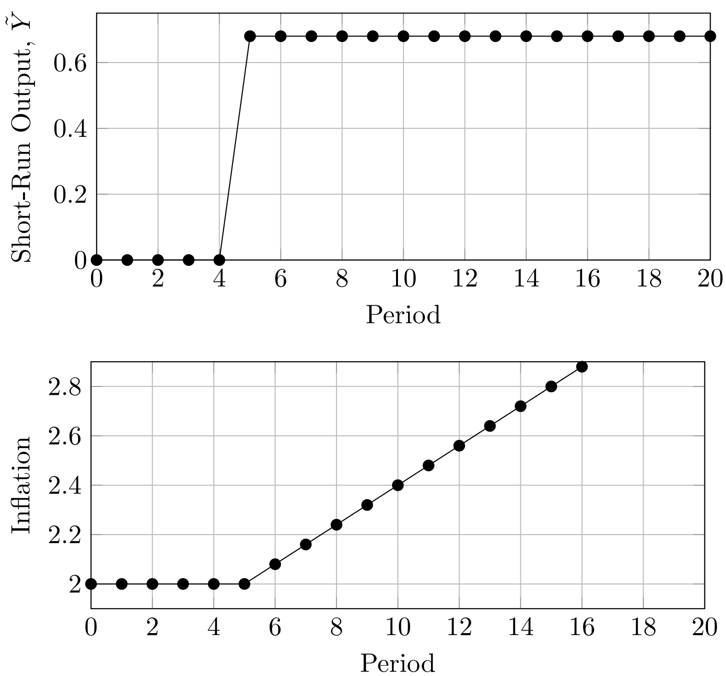


Figure 6: Short-Run Output and Inflation Response to an Increase in $\bar{r}$ (Pre-Policy Adjustment)

At first glance, an increase in the marginal product of capital may seem like a positive development. However, within the IS-MP framework, this shock actually creates recessionary pressures in the short run. Without a monetary policy response, output falls below potential and inflation begins to decline.Fortunately, the central bank can respond. The necessary adjustment is relatively straightforward in this case. We return to the IS curve for guidance:

$$\tilde{Y}_t = a - b(R_t - \bar{r})$$

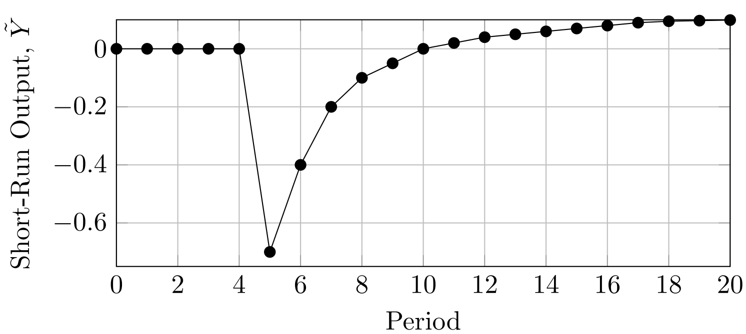
Assuming that only change is $\bar{r}$ and setting $\tilde{Y}_t = 0$ to keep output at potential, we solve for the appropriate real interest rate R_t:

$$0 = a - b(R_t - \bar{r}) \Rightarrow R_t = \bar{r}$$

In this scenario, $\bar{r}$ increases by 1 percentage point, from 2% to 3%:

$$\bar{r}_{\text{new}} = 3\% \Rightarrow R_t = 3\%$$

Therefore, to stabilize output, the central bank should raise the real interest rate to match the new natural rate at 3%. The results of this policy implementation are shown in the graphs below:



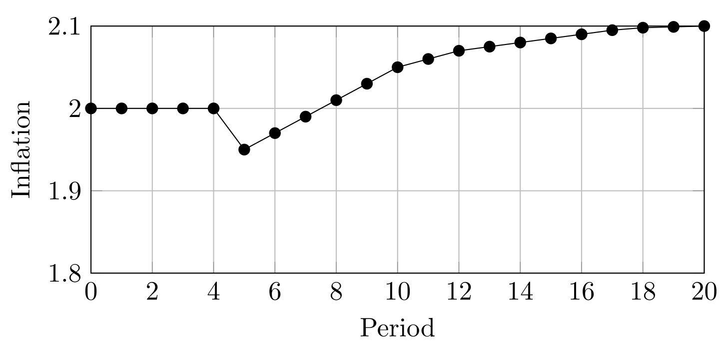


Figure 7: Short-Run Output and Inflation Response to Interest Rate Adjustment after an Increase in $\bar{r}$

As shown, the policy is effective in quickly bringing short-run output back toward potential and returning inflation to the target of 2%. However, both output and inflation slightly overshoot their targets after the adjustment, highlighting the inherent challenges and imperfections of monetary policy. While effective in the short run, these tools are not always precise or sufficient for fine-tuning the economy in the long run.

Interest Rate Recommendation Due to Housing Bubble Pop

For this experiment, let's say that there is a housing bubble that pops in the economy. This leads to a 20% drop in the housing prices and new home sales drop sharply such that:

$$\bar{a} = -0.75$$

This occurs several aspects of the economy and consumers are affected negatively. However, because this shock is so significant however, there is a resulting shock to inflation affecting our Phillips curve part of the model such that:

$$\bar{o} = -0.2$$

The figure below represents the affects of the shock on the economy in the absence of any policy response:

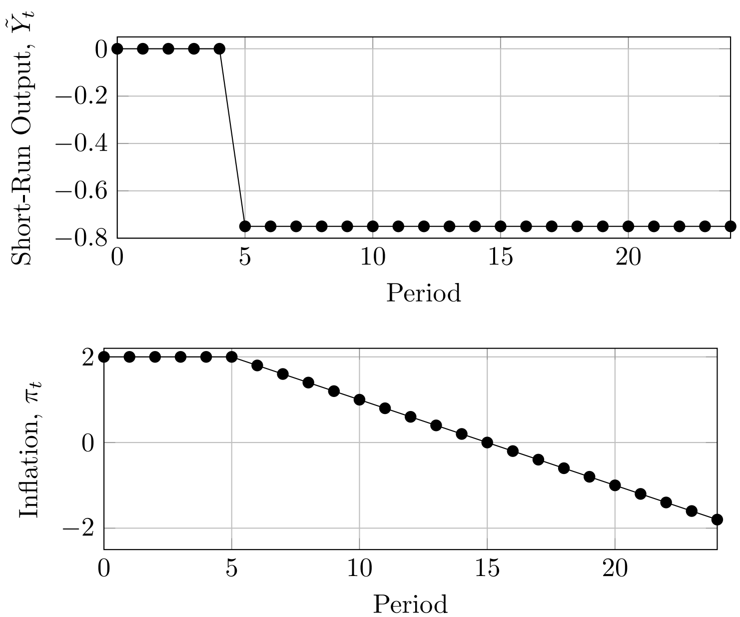


Figure 8: Short-Run Output and Inflation After a Housing Bubble Collapse.

What we can see from this graph is that the impacts are significant: inflation consistently declines, and short-run output drops and stays at a significantly lower steady state. To correct for this problem, we turn to the IS-MP framework and solve for the appropriate real interest rate that would return output to potential.

To respond to the collapse of the bubble, the central bank is given a trade-off depending on whether it wants to prioritize output or inflation. If the objective is to return output to its potential level, we use the IS curve and set $\tilde{Y}_t = 0$. Solving for the real interest rate with $\bar{a} = -0.75$, $\bar{b} = 2$, and $\bar{r} = 2\%$ yields:

$$R_t = \bar{r} + \frac{\bar{a}}{\bar{b}} = 2 - 0.375 = \boxed{1.625\%}$$

This rate would restore output but allow inflation to continue falling due to the persistent deflationary shock $\bar{o} = -0.2$ in the Phillips curve. Alternatively, if the central bank's goal is to stabilize inflation—i.e., to keep $\pi_t = \pi_{t-1}$—we solve the Phillips curve by setting $\tilde{Y}_t = -\bar{o}/\bar{v} = 0.4$, assuming $\bar{v} = 0.5$. Plugging this into the IS curve gives:

$$R_t = \bar{r} + \frac{\bar{a} - \tilde{Y}_t}{\bar{b}} = 2 + \frac{-0.75 - 0.4}{2} = \boxed{1.425\%}$$

This more aggressive interest rate cut would generate a positive output gap large enough to offset the recessionary pressures and bring inflation back to a more stable level. However, it comes with the cost of potentially overheating the economy, as output could continue to rise above potential. This example illustrates the challenges of responding to complex economic shocks and highlights the difficulty of making effective monetary policy decisions—where a trade-off is almost always required.

4 The COVID-19 Economic Crisis

One of the most significant economic shocks in recent history is the COVID-19 economic crisis. The IS-MP model provides a powerful framework for analyzing the short-run impacts of this event, particularly how output and inflation evolved and how the Federal Reserve responded. In this section, we use data from FRED and apply the IS-MP model to estimate the magnitude of the shock, simulate the policy response, and reflect on the challenges of forecasting economic conditions during a period of extreme uncertainty.

4.1 Estimating Parameter Changes During the COVID-19 Shock

In 2020, the coronavirus outbreak caused a severe and sudden economic contraction in the United States and globally. Widespread lockdowns, consumer panic, and supply chain disruptions led to sharp declines in GDP, employment, and inflation. Using data from FRED, we can estimate how key parameters in the IS-MP model, specifically $\bar{a}$ and $\bar{o}$, and how they were affected during this period and form the basis for monetary policy recommendations. The first graph data set we will see is Real GDP represented by the graph below:

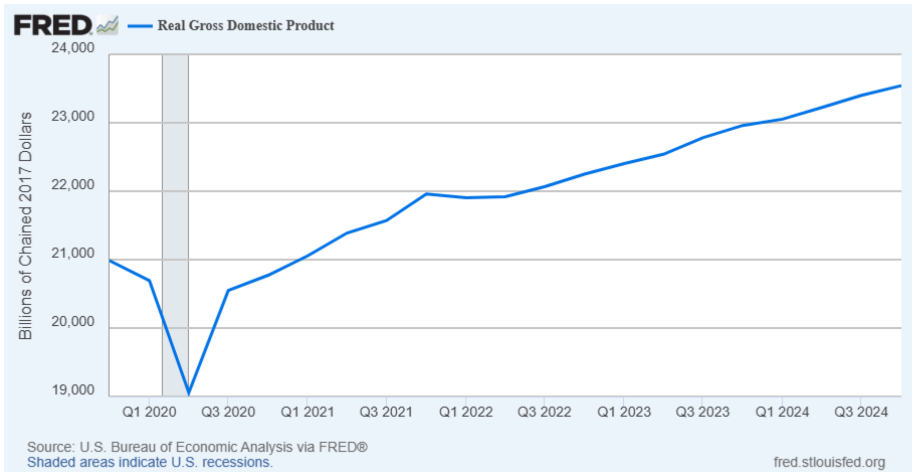


Figure 9: Real GDP Source: FRED.

Real GDP dropped by approximately 9.1% (annualized) in the second quarter of 2020. In the IS-MP framework, we treat this as a negative demand shock, modeled as a decline in $\bar{a}$. To represent this within our model in a manageable way while maintaining interpretability in the graphs, we estimate $\bar{a} = -5$ as a conservative but reasonable approximation of the output shortfall relative to potential. Below we will do a similar analysis using the data for CPI:

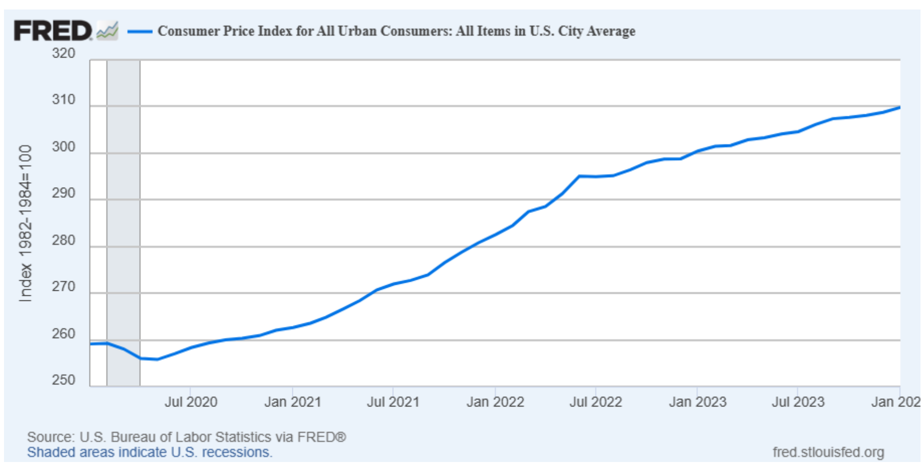


Figure 10: CPI Source: FRED.

The Consumer Price Index (CPI), a measure of inflation, also experienced a temporary slowdown in early 2020. This suggests that inflation expectations briefly fell, even as output contracted. We interpret this as a short-run inflation shock, which the IS-MP model represents through the $\bar{o}$ term in the Phillips curve. Based on the observed dip and quick recovery, we estimate $\bar{o} = -0.3$ for the purposes of our simulation.

While FRED data provides a solid empirical foundation for estimating these parameters, this approach does rely on several simplifying assumptions. For example, the IS curve treats demand shocks as purely autonomous and independent of policy reactions or structural economic changes. Likewise, the inflation shock $\bar{o}$ is assumed to be exogenous, though in reality it may have been influenced by fiscal stimulus and global supply chain distortions. Despite these limitations, the estimates serve as a strong foundation for applying the IS-MP model to analyze and simulate the Fed's policy response to COVID-19.

4.2 Monetary Policy Simulation and Recommendation

Utilizing the IS-MP model we can simulate what would happen using the parameters we estimated from the previous section. We assume $\bar{a} = -5$ and $\bar{o} = -0.3$ from periods 5 to 7, and both return to 0 starting in period 8. First we will graphically see what the affects on the economy will be and then calculate for the suitable interest rate required:

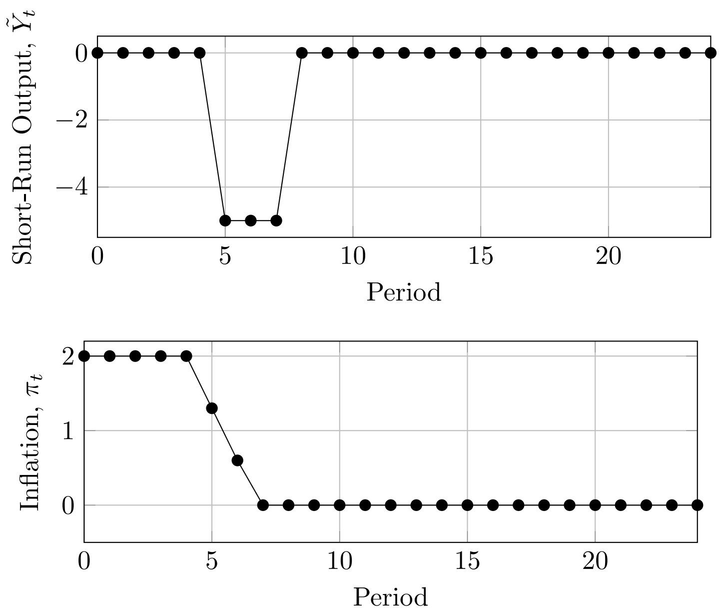


Figure 11: Short-Run Output and Inflation in Response to COVID-19 Shocks Without Policy Intervention

The changes are to be expected here. Short-run output and inflation both drop sharply and bottom out at a significantly lower steady state. However the Fed's dual mandate is to seek maximum employment and price stability.

That means that we want to return to the long-run output level, so short-run output equals zero, and meet the inflation target of 2% per year. To calculate the correct interest rate to meet those objectives it is required we look back to our IS-MP model:

$$\tilde{Y}_t = \bar{a}_t - \bar{b}(R_t - \bar{r})$$

Setting $\tilde{Y}_t = 0$, we solve for R_t:

$$0 = \bar{a}_t - \bar{b}(R_t - \bar{r}) \quad \Rightarrow \quad R_t = \bar{r} + \frac{\bar{a}_t}{\bar{b}}$$

Substituting in the values:

$$\bar{a}_t = -5, \quad \bar{b} = 2, \quad \bar{r} = 2\%$$

$$R_t = 2 + \frac{-5}{2} = 2 - 2.5 = \boxed{1.5\%}$$

This is the best policy response given the economic shocks in the model. It is the level of real interest rate that will help with both output and inflation and give us the best level that we can. The effects of the policy change on the economic shock are represented by the graphs below:

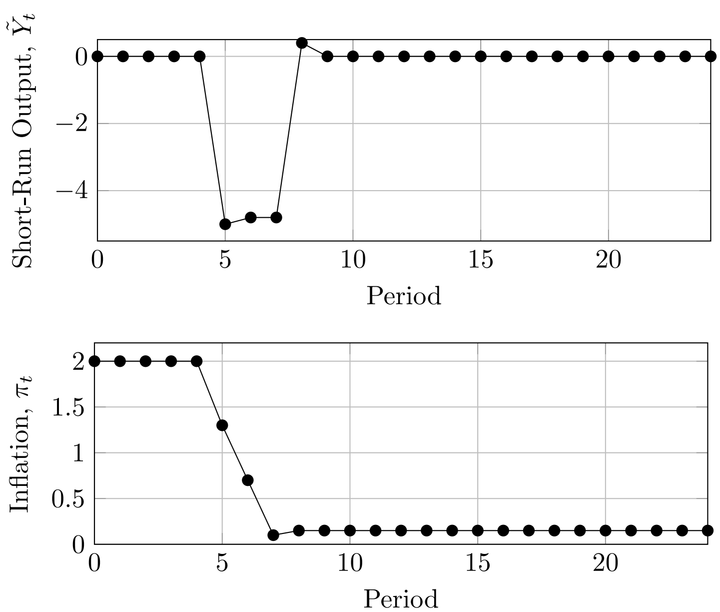


Figure 12: Short-Run Output and Inflation Response to COVID-19 with Policy Intervention ($R_t = 1.5\%$)

The graphs show that the policy response helped ease the impact of the COVID shock. Output doesn't immediately return to zero, but it recovers quickly once the interest rate adjustment takes effect. Inflation still falls but stays above zero and stabilizes, which is a better outcome than what we'd see without any action. This highlights the strengths and limits of monetary policy. While the Fed can soften a major shock with tools like interest rate cuts, it can't fully undo the damage or guarantee a perfect recovery. In a complex economy, even well-designed policies can only go so far.

4.3 Reflection on Difficulties in Forecasting and Policy Design

During the COVID-19 pandemic, a flurry of economic shocks hit all at once, leading to a recession that almost no one predicted. While the statistical models we use today are extremely helpful for giving a general idea of where the economy might be heading, there was no way to know exactly how things would unfold in real time. A recession like the one caused by COVID-19 came out of nowhere, and traditional forecasting tools—like projected GDP and unemployment models—didn't anticipate such a sharp decline because of the unpredictable behavior the crisis introduced.

The reality of monetary policy is that it's always reactive. Decisions on where to set the interest rate and how to implement policy are based on past data, not present conditions. On top of that, monetary policy doesn't work instantly. In the face of a sudden economic shock, it takes time for policymakers to recognize the problem, adjust rates, and then wait for those changes to work their way through the economy.

Even though there were contingency plans for some kinds of recessions, nothing could fully prepare the Fed for a global pandemic on that scale—we were blindsided. Still, models like the IS-MP framework help us get a rough picture of how the economy might respond. The IS-MP model offers a simplified way to think through complex issues, but it also has its limitations. It doesn't account for things like consumer expectations or supply chain disruptions, which clearly played a role in both inflation and output during the pandemic. That said, even with those limitations, models help us organize our thinking and make better-informed decisions in uncertain times.