Inflation and Quantitative Tightening

- *A theoretical assessment of contractionary monetary policy and real economic activity*

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Abstract

Following the associated lockdown measures of the Covid-19 pandemic in 2020, the world economy started facing inflationary pressures from a surge in energy prices and supply chain disruptions at the end of 2021. Given the economic environment with low inflation and expansionary monetary policy following the Great Financial Crisis (GFC), central banks around the world have built up large balance sheets following the unconventional measure called Quantitative Easing (QE). Now when inflation is on the rise, a debate regarding whether to sell off these assets as a contractionary measure, dubbed Quantitative Tightening (QT), has emerged. In this thesis, I will use a Dynamic Stochastic General Equilibrium (DSGE) model estimated to U.S data and with financial frictions to evaluate the impact on real economic activity from an inflation shock and assess how different monetary policy strategies can dampen the adverse impact. The main findings are that a more conventional monetary policy strategy is to prefer over QT when it comes to dampening the fall in output. Furthermore, a more persistent inflation exacerbates the adverse impact on the real economy and the model simulations also show that gradual increases of the federal funds rate is favorable compared to more aggressive increases.

Keywords: Inflation, Unconventional Monetary Policy, Real Economic Activity, DSGE, The U.S Economy

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List of Abbreviations

DSGE = Dynamic Stochastic General Equilibrium

EH = Expectation Hypothesis

FOMC = Federal Open Market Committee

GFC = Great Financial Crisis

MBS = Mortgage-Backed Securities

OAPEC = Organization of Arab Petroleum Exporting Countries

QE = Quantitative Easing

QT = Quantitative Tightening

TFP = Total Factor Productivity

1. Introduction

After decades of low inflation, in which central banks in advanced economies failed to meet their inflation targets despite extensive expansionary monetary policies, the topic of high inflation has once again emerged on the economic horizon. In this thesis, I investigate appropriate monetary tools that can help to address the problem of rising inflation. In particular, I focus on the tools at the disposal of the Federal Reserve and the impact on the U.S. economy.

During the outbreak of the Covid-19 pandemic in 2020, countries all over the world implemented lockdowns as a means of curbing the spread of the virus. Following these strict lockdown measures came a severe economic downturn that depressed both economic growth and pushed the world economy towards deflation. With the help of both expansionary fiscal and monetary policy, the world economy recovered and these expansionary polices were slowly phased out. However, in late 2021 issues related to strict lockdown measures started to emerge in the form of increasing energy prices and supply chain bottlenecks. These factors created an almost textbook like supply-side shock to the price level of the world economy, and rising inflation became a fact. In March 2022, the rate of inflation in the U.S reached 8.6 % and as of April 2022, it measures 8.2 %, however it is too early to say that inflation has reached its peak. These high levels of inflation have not been seen since the period of high inflation which started in the 1970s, and which peaked at a level of 14.6 % in March 1980. Given that inflation has not been this high in the U.S for over forty years, there are striking similarities between today and the 1970s. While the inflation in the 1970s has often been seen as a consequence of the oil price shocks that occurred back then, the inflation today has mostly been attributed to rising energy prices. That is, a rise in prices of crucial energy sources used as inputs in production has been the main explanation for the uptick in prices during both of these time periods. Moreover, both of these periods were characterized by previous expansionary monetary policy, large fiscal deficits and supply-side bottlenecks, all of which contributed to raising the price level.

While the similarities are striking, the focus of this thesis will be on the main difference between these two time periods, namely the toolbox at the disposal of the Federal Reserve to conduct monetary policy. Before the GFC, the main tool to conduct monetary policy for central banks was through altering their policy rate. But following the associated economic downturn from the GFC, unconventional measures such as asset purchases were introduced and have now become a standard tool for most central banks worldwide. These asset purchases, dubbed QE, meant that central banks bought government bonds and other securities in order to lower long-term interest rates, with the intention to increase real economic activity and stimulate inflation. Today however, when central banks want to dampen inflation, the effectiveness of the opposite, namely QT, for achieving price stability is highly uncertain. QT would mean that the central bank instead sold off some of its holdings of bonds in order to dampen inflation. In this thesis, I will address this topic by using a DSGE model with financial frictions to explain some of the potential effects of QT and other contractionary monetary policies on the U.S economy. In a nutshell, an exogenous inflation shock will be applied to the DSGE model by Carlstrom, Fuerst and Paustian (2017) to shed light on how to conduct monetary policy to combat the adverse impact on real economic activity. The main findings after conducting a few different simulations are that unconventional monetary policy in the form of QT exacerbates the fall in output, a more persistent inflation further depresses real economic activity and that raising the federal funds rate quickly is unfavorable compared to gradual increases.

This thesis is structured as follows: section two gives a brief overview over the impact of energy prices on the economy, the period of high inflation in the U.S during the 1970s, the present inflation and monetary policy in the U.S and a summary of the main arguments with regards to QT. Section three describes and motivates the model by Carlstrom, Fuerst and Paustian (2017). Section four describes the results from the model simulations, section five discusses the results and section six concludes.

2. Energy Prices, Inflation and Monetary Policy

2.1. Energy prices and the economy

Before going into inflation and monetary policy, this subsection will outline the impact energy prices have on inflation and the real economy. While the oil price shock was not the only source of inflation during the 1970s, the impact oil has on the macroeconomy and its relative role during the 1970s inflation is a highly researched topic. Authors like Rasche and Tatom (1977), Rotemberg and Woodford (1996) and Hamilton (2005) have rejected the notion of correlation between oil prices and GDP being random and find a significant relationship between the two. Given that oil or any other source of energy in production is a crucial input good, an increase in energy prices creates inflationary pressures. To give a theoretical backdrop, an energy price shock can be viewed either as exogenous or endogenous. Throughout this subsection, an oil price shock is assumed to be analogous to a price shock to any other energy source used for production.

When an energy price shock is viewed as exogenous, there are two categories from which this transmission occurs, from the supply-side and from the demand-side. On the supply-side there are three main channels, which are summarized graphically in figure 1 below. The first channel within the supply-side is how energy prices affect production. When the price of energy increases, firms reduce the amount used of that energy source, which results in a lower level of production. This makes an energy price shock classified as an adverse shock on the supply-side (Bohi, 1989). When applying this theory to data however, empirical results contradict this mechanism. Among others, Rotemberg and Woodford (1996) finds that only a very small portion of the marginal costs of production represent oil and energy costs, thus making it unlikely to be the main driver of reduced output. The second channel within the supply-side is the impact energy prices can have on productivity. The argument is that a reduction in the energy source used, due to higher energy prices, leads to a lower level of productivity of capital. For example, Baily (1981) makes this concrete by arguing that given the increase in energy prices during the 1970s, installed capital with a high energy-usage became more costly, and thus less profitable for production. He argues that this can lead to less output with the same number of inputs, effectively undermining productivity. However, counterarguments have been made by for example Hulten, Robertson and Wykoff (1989), where they state that this theory would lead to lower prices of used equipment due to the deprecation of capital. Hulten, Robertson and Wykoff do however find that the price of energy-intensive capital actually increased in some cases during the 1970s. The third channel of transmission is the impact on employment. To exemplify this, as the price level in the economy increases after this energy price shock, labor unions will bargain for increased real wages by requiring even higher nominal wages (Layard, Nickell & Jackman, 1991). Due to the increased costs for wages, the demand for labor goes down if a decline in energy usage lowers labor productivity, and if wages are sticky, the level of employment will fall. Wage stickiness has been argued to be a crucial driver of unemployment following the oil price shocks in the 1970s (Bohi, 1989).

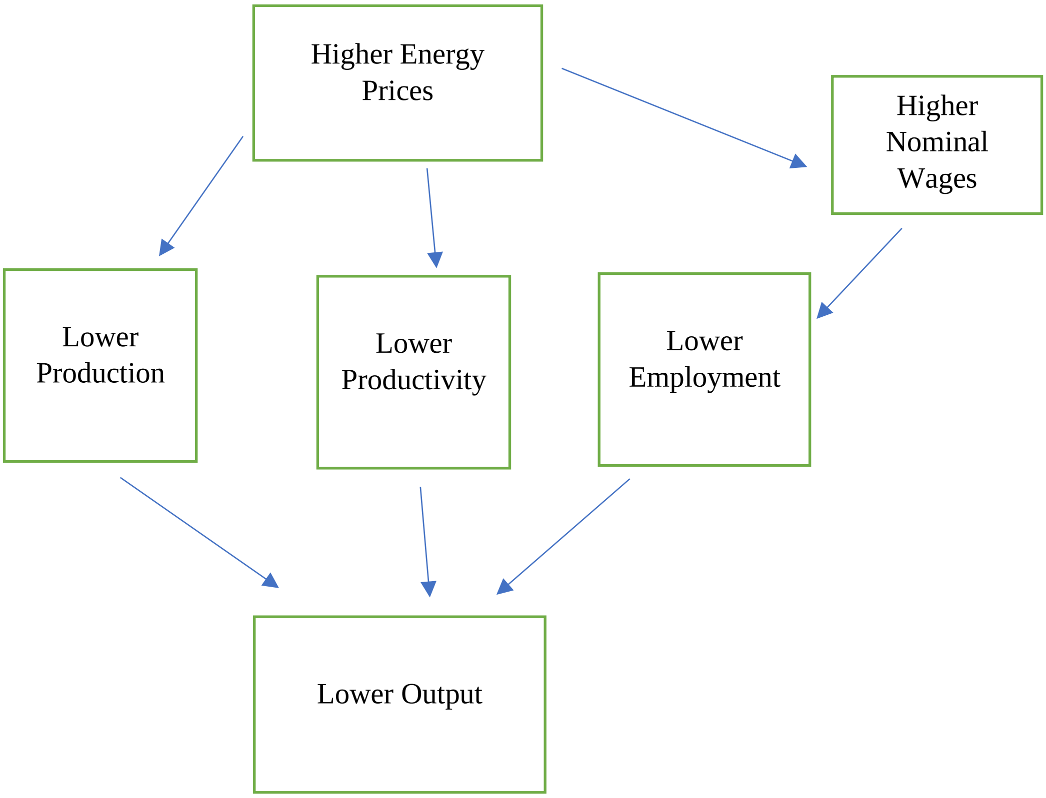


Figure 1, Source: own work based on authors description in Mohan (2015)

However, authors like Lee and Ni (2002) argue that the impact of energy costs on output is better explained from the demand side. From the demand side, an energy price shock can cause disruptions in the spending behavior of firms and households. A framework to analyze the impact of energy price shocks on the demand side is the "sectoral shocks hypothesis", according to Lilien (1982) and Hamilton (1988). This framework inhibits two effects, the uncertainty effect and the operating cost effect. The changing energy prices create uncertainty about the level of inflation in the economy, thus the uncertainty effect make households postpone consumption, effectively reducing demand today. The operating cost effect is similar but affects the demand of, for example, oil-intensive goods like automobiles (Kilian, 2008). Another framework for analyzing demand side mechanisms, but from the perspective of firms, is the model by Bernanke (1983). This model introduces uncertainty that affects the investment decision of firms. Here the firms will postpone new capital investment until it is clear whether the increased energy prices are temporary or permanent. However, authors like Barksy and Kilian (2004) are critical to this framework, arguing that the investment uncertainty effect is too small to explain the impact of oil prices on output. For an intuitive simplification of these frameworks, see figure 2 below.

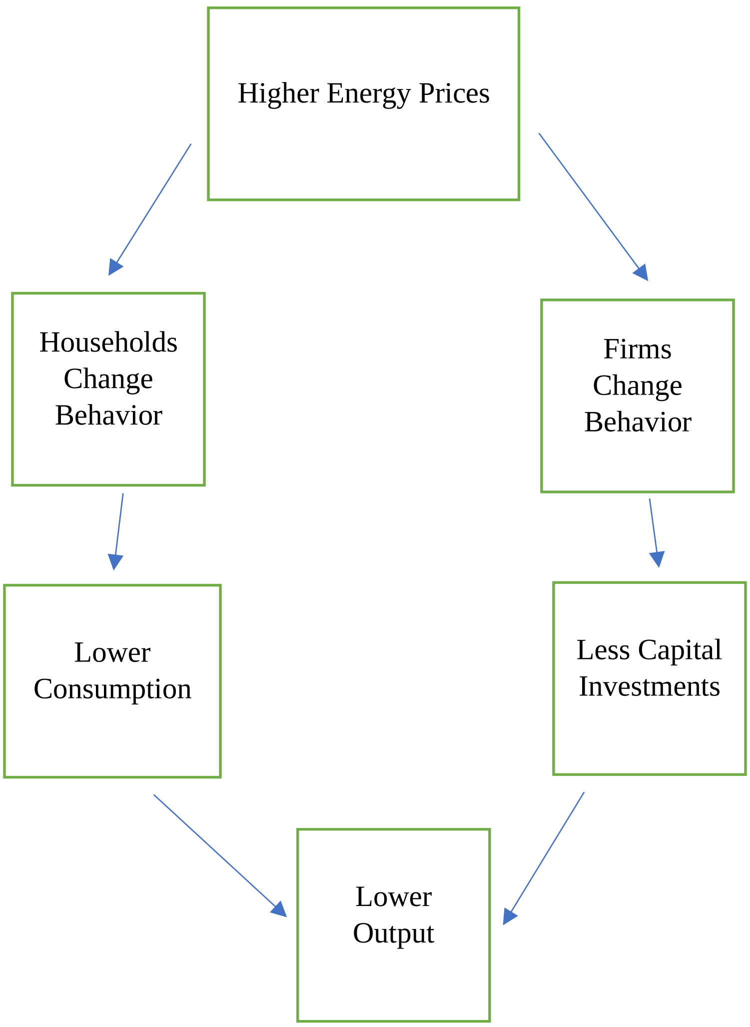


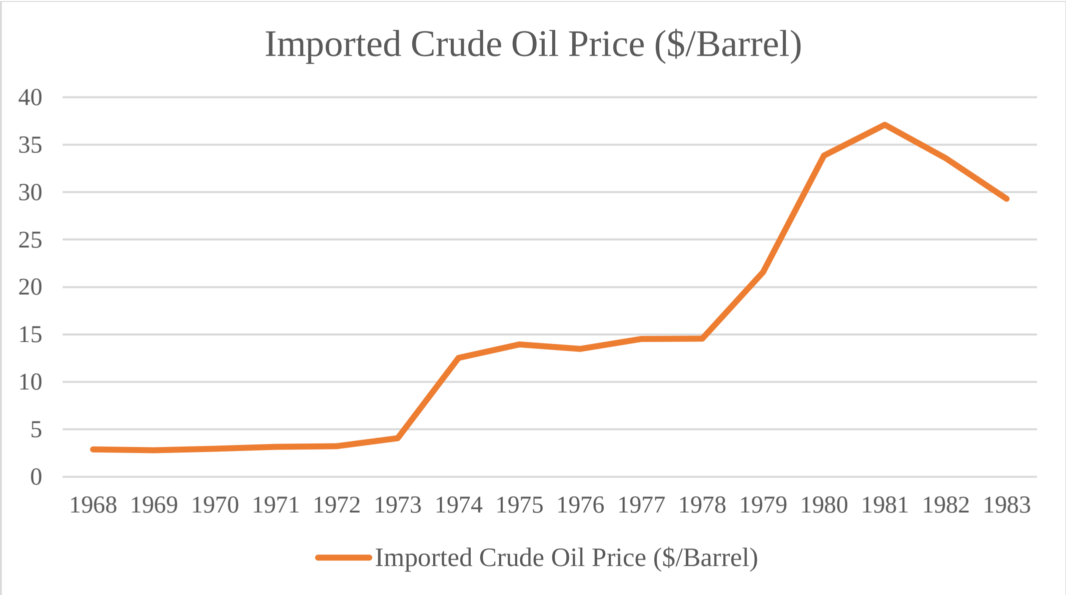
Figure 2, Source: own work based on authors description in Mohan (2015)

From the endogenous perspective, authors like Barksy and Kilian (2001) argue that the oil price increases were a result of the booming business cycle that emanated from previous expansionary monetary policy. Even though the oil embargo of the 1970s was a political decision, which could be viewed as exogenous, the authors argue that the embargo would have been far less likely if the booming economy had not induced excess demand in the oil market. Barksy and Kilian (2001) also find support for sluggish inflation expectations being at the center of the 1970s stagflation, rather than high oil prices. Given the sluggish inflation expectations, the higher inflation was an endogenous response to previous accommodative monetary policy they argue. Another case for the endogenous explanation comes from Bernanke, Gertler and Watson (1997). They find that the decision by the Federal Reserve to increase interest rates to combat the supposedly oil-induced inflation was the factor that pushed the U.S economy into a recession, not the reduced output due to higher oil prices. In fact, the authors argue that the Federal Reserve should have lowered the federal funds rate to combat the recession. However, authors like Blinder and Rudd (2008) find that small increases in interest rates could not have caused a recession of the magnitude seen in the 1970s. In addition, the paper by Hamilton and Herrera (2004) show that had the Federal Reserve eased monetary policy, as Bernanke, Gertler and Watson (1997) argue in their paper, interest rates would have needed to go below what was considered conventional levels at that time to dampen the economic downturn.

This endogenous argument found traction during the 2000s since higher oil prices in the 2000s had not created inflationary pressures, and Kilian (2014) even find support for oil price increases being deflationary due to the negative effect on consumer demand. The muted inflationary pressures from oil price increases in the 2000s is attributed to the improvements in how the Federal Reserve conducts monetary policy after the 1970s. These improvements are namely that the Federal Reserve started to respond to core rather than headline inflation (Nordhaus, 2007) and the increased credibility for inflation-combating policies due to the Federal Reserve's success in taming inflation in the 1970s (Blanchard & Galí, 2007).

2.2. Inflation during the 1970s

On October 19, 1973, President Nixon requested Congress to make $2.2 billion USD in emergency aid to Israel available for the conflict known as the Yom Kippur War against Syria and Egypt (Reich, 1995). In an immediate response to this the Organization of Arab Petroleum Exporting Countries (OAPEC) implemented an oil embargo on the U.S and other countries that were viewed as supporting Israel (Hamilton, 2011). This embargo led to a series of cuts in oil production which nearly quadrupled the price from $2.90 a barrel to $11.65 a barrel in January 1974, see graph 1 below. In March 1974 the embargo was lifted, however the increased oil prices remained intact (Merrill, 2007).



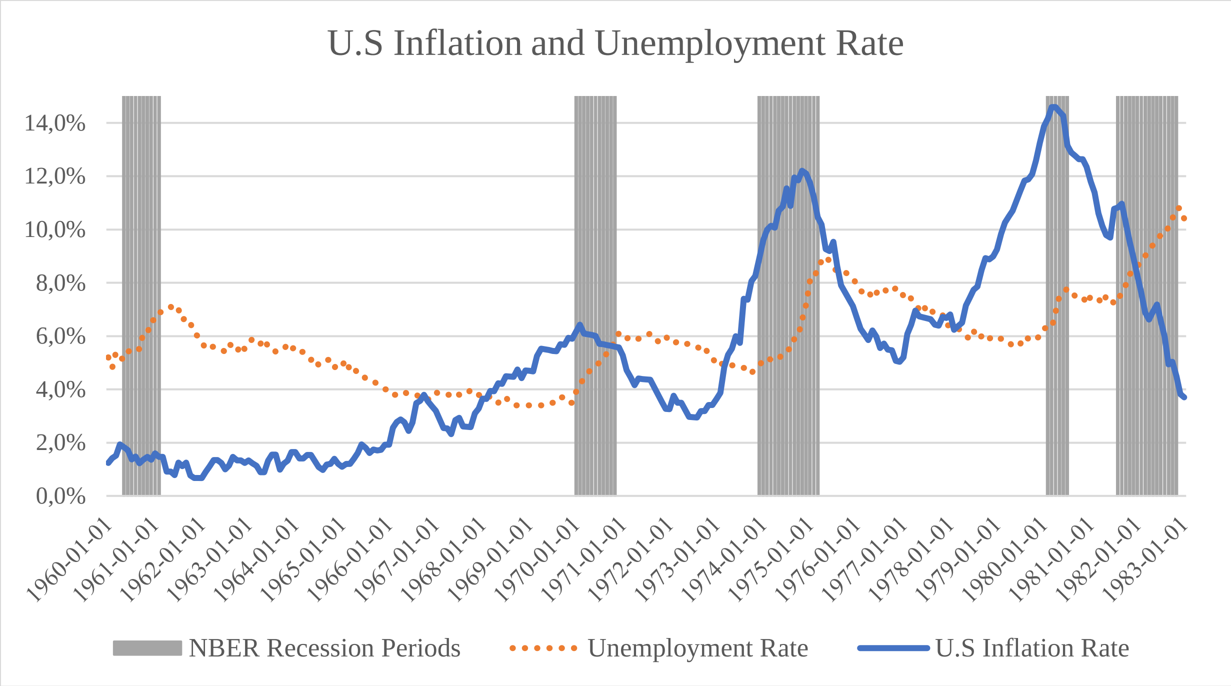
Graph 1, Source: EIA (n.d)

While the impact of oil prices on the macroeconomy is a debated subject, most agree on the unfortunate timing of this oil price shock to the U.S economy. Domestic oil production in the U.S had peaked in 1972, and to satisfy the demand the U.S started to rely on imported oil from the Middle East. Thus, as production cuts in the Middle East occurred, the U.S oil industry was not in a position so raise supply, which resulted in a steep increase in oil prices (Hamilton, 2011). Aside from these supply and demand forces on the oil market, the U.S economy was already moving towards an inflationary state. As the chairman of the Federal Reserve in 1974, Arthur Burns explained, since the wholesale prices of industrial goods were already increasing and the U.S industrial plants were already working at full capacity, this embargo came at a very unfortunate time (Burns, 1974). As both domestic and foreign inflationary pressures were at play, the U.S moved towards an inflationary environment. A second oil price shock occurred in 1979 which also had its roots in Middle Eastern conflicts, but which also inhibited global demand forces. Following the Iranian revolution, Iran’s oil production decreased by 4.8 million barrels a day, which amounted to around 7 % of the world’s oil production in 1979. Aside from reducing supply, some argue that the increase in oil prices also came from a booming global economy and an increase in precautionary demand manifesting itself as speculative hoarding of oil (Graefe, 2013). Both oil price shocks led to an increase in U.S inflation in subsequent years, but as explained the price of oil was not the only force at play. Fed chairman Burns mentioned factors as the loose financing of the Vietnam war, the dollar devaluations in previous years and large crop failures as crucial drivers of the high U.S inflation in the 1970s (Burns, 1979).

2.3. Monetary policy during the 1970s

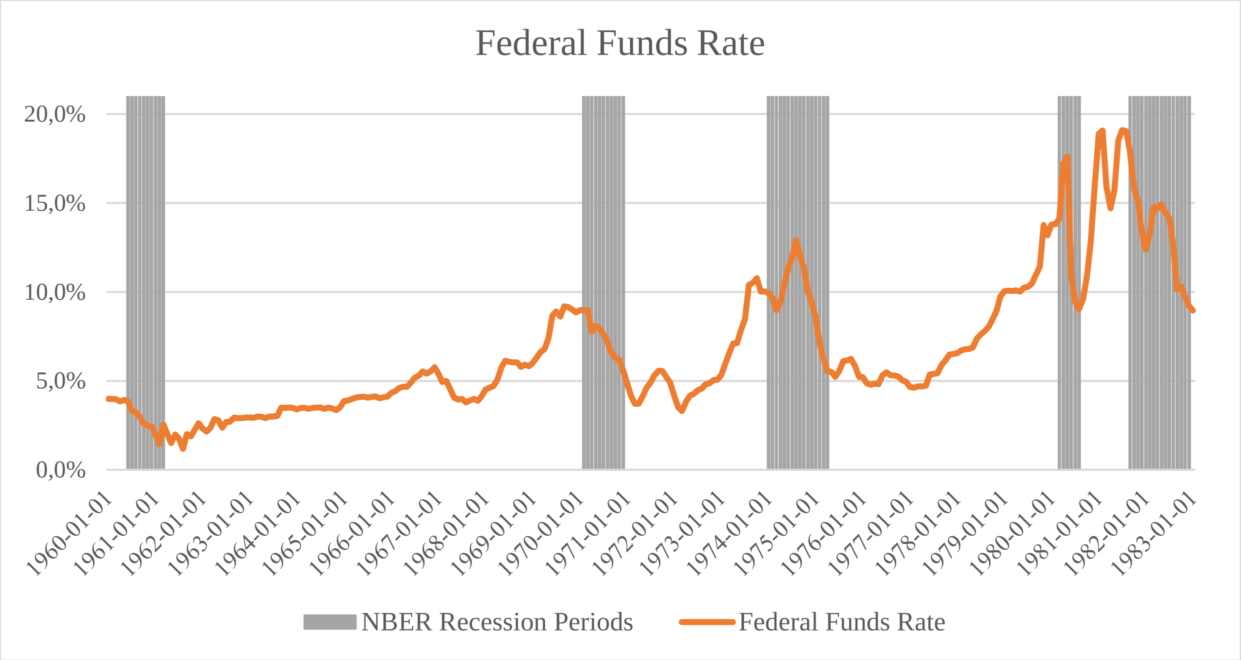
In the beginning of the 1970s, inflation arising from increases in energy prices, which led to increased prices for input goods, was viewed as outside the control of monetary authorities (Romer & Romer, 2012). However, economists have since realized that the monetary authority can affect inflation arising from these supply side shocks, but that they face a tradeoff in doing so (Corbett, 2013). The supply side shock of an oil price increase can have both inflationary features and dampen economic growth. Bernanke (2004) highlights the difficulties here by stating that increasing interest rates could dampen inflation but create a slowdown in economic growth, while lowering interest rates could stimulate growth while adding to the inflationary pressures. The decision when faced with this trade-off, he argues, depends on the relative emphasis that central bank policymakers put on employment and price stability respectively.

Since the end of the 1960s, the U.S faced an increasing trend in inflation. By 1973 the Federal Reserve increased the federal funds rate to contain this inflation trend, which was exacerbated by the oil price shock of 1973. However, due to its dual mandate of promoting employment and price stability, the Federal Reserve eased its policy stance before inflation was fully contained and the inflation rate reached its bottom at 5 % in December 1976 before it started to increase once again (Medley, 2013). This accommodative policy, which seemed unable to stimulate an increase in employment was held intact until 1978. Alongside this accommodative monetary policy, energy price increases transmitted into higher inflation, which reached almost 7 % by March 1979 (Graefe, 2013), see graph 2 below.



Graph 2, Source: Federal Reserve (n.da) and (n.db)

Despite the unease of both higher inflation and a decreasing value of the dollar, at first policy makers at the Federal Reserve were reluctant to increase the federal funds rate in fear of dampening economic growth. Eventually the federal funds rate was increased from 6.9 % in April 1978 to 10 % by the end of 1978 (Graefe, 2013). In the following year the Carter administration chose to appoint Paul Volcker as chairman of the Federal Reserve. This was seen as a direction towards more aggressive contractionary monetary policy to further tackle the U.S inflation problem (Medley, 2013). Volcker made taming inflation the Federal Reserve's main priority, even if it meant short term decreases in the level of employment. During Volcker's first months as chairman of the Federal Reserve, the federal funds rate was pushed higher while at the same time unemployment reached 6 %, to the discontent of the Carter administration.

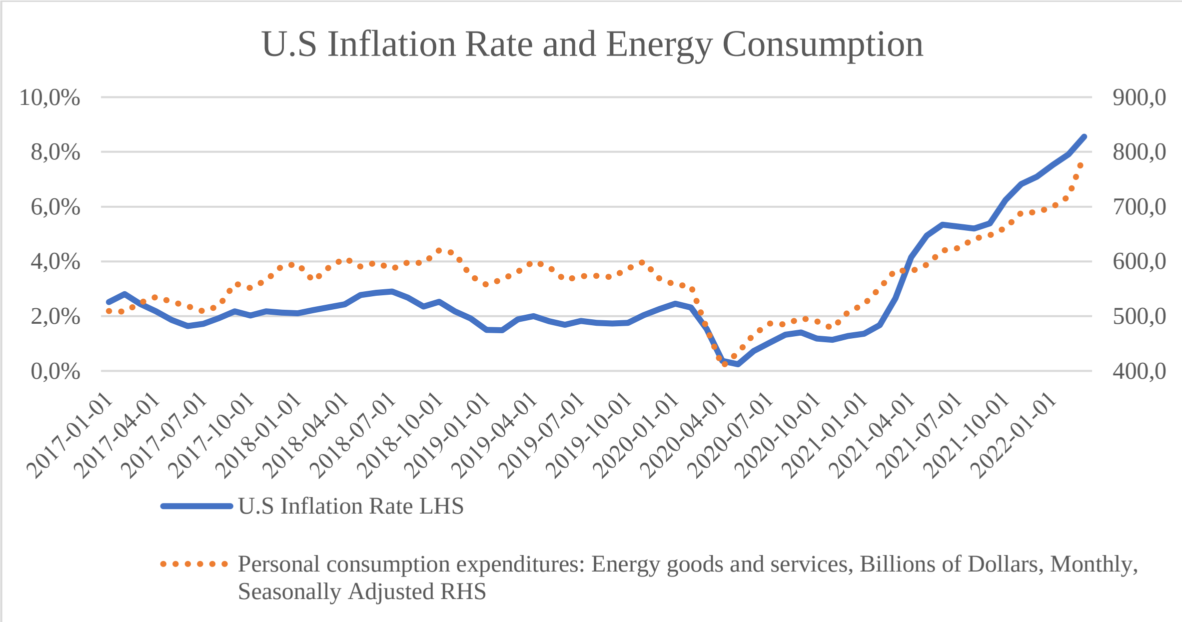


Graph 3, Source: Federal Reserve (n.dc)

However due to the unstoppable increase in inflation, the Federal Reserve felt the need to change method to combat the ever-rising prices. At a press conference on October 6, 1979, Volcker stated that the Federal Reserve will shift its focus to controlling the volume of bank reserves in the lending system rather than steering the short-term fluctuations of the federal funds rate (Lindsey, Orphanides, & Rasche, 2005). This approach was assumed to dampen inflation, while on the other hand create more volatile movements of the federal funds rate. Before this change of focus, the Federal Reserve had targeted the money supply growth rate and kept the federal funds rate within a narrow band to meet its monetary growth objectives. The Board of Governors however felt that this procedure was less effective in this inflationary environment, and thus the pivot to focusing on bank reserves was favored (Federal Reserve Bank of St. Louis, 1979). While this was a clear move to combat surging prices, inflation expectations were already ingrained, and the consumer price index increased to 9 % by the end of 1979 (Graefe, 2013). As the new approach to fight inflation came to use, inflation eventually peaked at 14.6 % in March 1980 and the federal funds rate reached its top at 20 % in late 1980, which can be seen in graph 3 above. Here the typical trade-off between inflation and economic growth was present and as the Federal Reserve tamed inflation, the economy was pushed into a recession. The increasing unemployment and financing difficulties for firms led to negative public sentiment towards the Federal Reserve as an institution (Medley, 2013). Farmers protested at the Federal Reserve headquarter, car dealers sent coffins filled with car keys to unsold vehicles, and Congressman Henry Gonzalez of Texas even went so far as threating to introduce a new bill in favor of impeaching Volcker and other Federal Reserve governors (Todd, 2012). After the peak in inflation, prices began to decrease and by early 1982 the inflation rate measured 6.1 %. By July 1982 the recession had reached its trough and Volcker announced a looser monetary policy stance, a true consolation for the Reagan administration. At the end of 1982 the inflation rate had been reduced to a mere 3.7 % and unemployment peaked at 10.8 % before it started to descend. As the rampant inflation was tamed, the negative sentiment towards the Federal Reserve was forgotten and it was viewed as a credible institution for combating inflation. This credibility was the foundation for the following economic period of sustainable growth rates and moderate inflation, also called the Great Moderation (Medley, 2013).

2.4. Inflation in the 2020s

When comparing the proposed drivers of inflation in present time to the those of the 1970s, several similarities exist. Both inflationary periods came after a longer period of expansionary monetary policy. While the accommodative policies of the Federal Reserve in the 1960s was quite expansionary (Barsky & Kilian, 2001), it was perhaps not as unconventional as the QE programs launched in the aftermath of the GFC in 2008. While the price of oil was the dominating price shock in terms of energy prices in the 1970s, both periods have seen a large increase in energy prices in general (Federal Reserve, 2022a). In present time, the sharp drop followed by a distinct rebound in demand for energy consumption after the Covid-19 lockdowns, see graph 4 below, together with a lower than expected supply and a long and cold winter has put tremendous upward pressure on energy prices (Alvarez & Molnar, 2021).

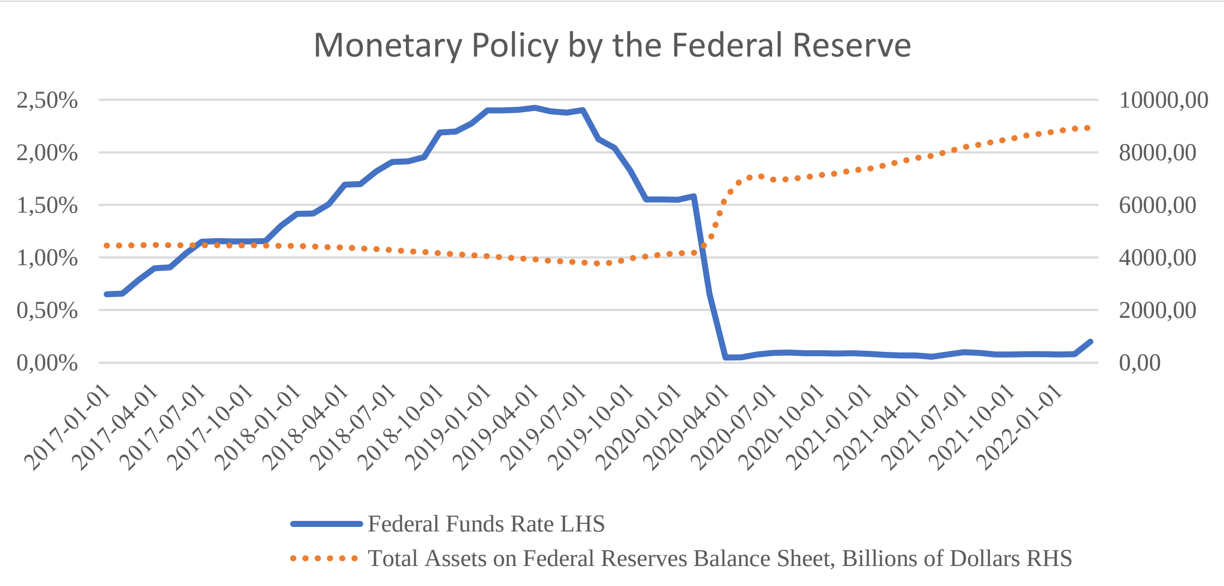


Graph 4, data up until April 1st, 2022, Source: Federal Reserve (n.db) and (n.dd)

In turn, while the period in the 1970s saw large scale crop failures causing supply chain disruptions, today the global economy is faced with the large supply chain disruption caused by the Covid-19 pandemic and its associated lockdown measures. The present supply chain disruptions, in the form of transport delays and shortage of crucial input goods, are suspected to have exacerbated the current uptick in inflation (Leibovici & Dunn, 2021). As documented by Labonte and Levit (2008), financing of American wars can lead to a war-time economic boom due to fiscal stimulus, which can have inflationary pressures. While the U.S has not had any massive fiscal stimulus to finance a war lately, they have however financed an unprecedented stimulus package to combat the economic downturn that the Covid-19 pandemic caused. Thus, as in the in the 1970s, the U.S enters an inflationary period with deteriorated public finances following a large fiscal stimulus package (OECD, 2021). While conflicts in the Middle East was an element of uncertainty in the 1970s, following the Russian invasion of Ukraine, this conflict is expected to have both an inflationary and recessionary impact on the global economy (Federal Reserve, 2022c). While there do exist strong similarities between these two periods, the toolkit of the Federal Reserve is quite different today compared to the 1970s. This thesis will examine whether the new tool in the form of QT could be of use as the U.S will try to dampen the inflationary pressure and spur economic activity.

2.5. Monetary policy in the 2020s

The Federal Open Market Committee (FOMC) seeks to achieve maximum employment and inflation at the rate of 2 percent over the longer run (Federal Reserve, 2022a). In achieving these goals, the FOMC has through forward guidance communicated that the range for the federal funds rate would be between 0 % and 0.25 % during most of 2021. Before the outbreak of the Covid-19 pandemic, the Federal Reserve's balance sheet measured $4.2 trillion, but has now grown to roughly $8.9 trillion through increased asset purchases. Between June 2020 and November 2021, the Federal Reserve increased the holdings of Treasury securities by $80 billion per month and increased the holdings of agency mortgage-backed securities (MBS) by $40 billion per month. These large increases in bond holdings are visualized in graph 5 below. Given the improvements of the economy towards price stability and maximum employment in November 2021, the FOMC reduced the net purchases of Treasuries and MBS to $60 billion and $30 billion per month respectively (Federal Reserve, 2021a).



*Graph **5**, data up until April 1st, 2022, Source: Federal Reserve (n.dc) and (n.de)*

This trend continued in December 2021, which led the FOMC to reduce the net purchases of Treasuries and MBS to $40 billion and $20 billion per month respectively (Federal Reserve, 2021b). In January 2022 with inflation significantly over 2 % and with a strong U.S labor market, the FOMC communicated that the target range for the federal funds rate could be increased soon (Federal Reserve, 2022a). At their January 2022 meeting they also decided to further reduce net asset purchases, leading the monthly pace of net purchases of Treasuries and MBS to $20 billion and $10 billion respectively. The FOMC stated that they expect inflation to decline during 2022 as the supply and demand imbalances caused by the Covid-19 pandemic are expected to disappear (Federal Reserve, 2022b). In order to steer expectations in the right direction the FOMC communicated that the federal funds rate is the primary tool to alter the monetary policy stance, meaning that reducing the size of the Federal Reserves balance sheet would occur only after a hike in the federal funds rate is conducted (Federal Reserve, 2022a). Going into March 2022, inflation is further increased by the supply and demand imbalances and increased energy prices. Furthermore, the impact of the Russian invasion of Ukraine on the U.S economy is highly uncertain but is likely to have an inflationary pressure and negative impact on economic activity. Due to further inflationary pressures, the FOMC decided to increase the range for the federal funds rate to 0.25 % to 0.5 % and anticipates further increases over the year. While the balance sheet was held intact, the FOMC decided to start reducing the size of the balance sheet at a coming meeting (Federal Reserve, 2022c). The inflationary pressures continued throughout the spring of 2022 and at their May 2022 meeting, the FOMC decided to increase the range of the federal funds rate to 0.75 % to 1 % and start reducing the size of its balance sheet. This 0.5 percentage point change to the range, compared to a more standard 0.25 percentage point change, and the start of the balance sheet reduction was felt needed to reach the objective of the Federal Reserve to uphold price stability (Federal Reserve, 2022d).

2.6. Quantitative Tightening

While research on the impact of QE is quite vast, the literature on how QT would impact the economy is limited. James Bullard builds an argument for QT having small scale effects on the real economy. The starting point of his argument builds on the neutrality proposition of Cúrdia and Woodford (2010). This neutrality theory suggests that when the policy rate is above the zero lower bound, temporarily increasing the size of a central banks balance sheet will not give rise to macroeconomic effects. However, when the Federal Reserve did conduct their QE programs, the federal funds rate was close to zero, thus QE gave rise to macroeconomic effects. QE had a macroeconomic effect through signaling that interest rates would be kept low for the foreseeable future. Today, when the federal funds rate is clearly above zero, these signaling effects are somewhat muted, making the underling neutrality proposition applicable. What this means for Bullard’s argument is that conducting QT, in a slow and predictable way, now when the federal funds rate is clearly above zero would not cause any adverse effects on the economy.

Thus, there will not be a symmetric relationship between the actual impact of previous QE and a possible future QT program. To summarize, a slow unwinding of the Federal Reserve's balance sheet only when the federal funds rate is clearly above zero percent is what Bullard (2019) argues for.

Ben Bernanke, a former chair of the Federal Reserve, has also contributed to the debate regarding QT. Drawing from his experience as chair, in 2013 when he communicated that the FOMC was considering reducing the pace of QE if the economy kept improving, financial markets became volatile and long interest rates rose sharply. Actors on the markets assumed this to mean a fast increase in short interest rates in the near future, which caused this turbulence. With this experience in mind Bernanke argues that in order to minimize market risks, the unwinding of the balance sheet should occur in a slow and predictable manner. Given that the consequences of QT on financial conditions are uncertain, Bernanke also argues that the federal funds rate should be increased before any QT takes place. If the federal funds rate is well above zero, it is a tool for combating the potential adverse effects of QT he argues (Bernanke, 2017). The FOMCs reasoning is in line with Bernanke's argument, as they have communicated that they would act passively and in a predictable manner during an eventual reduction of its balance sheet. The FOMC also clearly stated in 2014 that a reduction of its balance sheet would not occur through sales of assets, but through phasing out its practice of reinvestment in bonds held on its balance sheet (Federal Reserve, 2014).

Kristin Forbes, a former member of the monetary policy committee of the Bank of England, argues that there are several reasons for central banks to reduce their balance sheet during this inflationary period. Since inflation is above target and the output gap largely closed, she reasons that the Federal Reserve will need to tighten monetary conditions quite a bit, meaning there is room for more than just rate hikes. She goes on by saying that if the level of inflation keeps beating expectations, QT would enable short term interest rates to be raised more gradually. This is important since households and firms might not be prepared for the higher interest rate costs that comes with fast rate hikes. Thus, QT would tighten conditions meanwhile interest rates can be increased slowly, giving economic agents more time to prepare. She also argues that if unwinding the balance sheet is at the center of the monetary policy strategy, it could signal a clear independence of the Federal Reserve. Using the balance sheet would show that QE was not a tool for financing fiscal deficits indefinitely and that the Federal Reserve will not support market liquidity forever. Forbes does however address some risks with conducting QT. Given that the effects of QE are highly researched, the effects of QT are quite uncertain, meaning that we do not have a comparable metric for the impacts of QT compared to QE. Thus, she states that reducing the balance sheet should be addressed well in advance and be conducted in a gradual manner to avoid any financial market disruptions that have an adverse impact on the macroeconomy (Forbes, 2022).

3. Model

3.1. Motivation for the model

In order to evaluate the adverse impact on the U.S economy from this rise in inflation and what monetary policy strategies to conduct to combat it, I apply a DSGE model with financial frictions. The choice of which DGSE model to use for this inflation simulation was not completely obvious. The main reason for choosing the model by Carlstrom, Fuerst and Paustian (2017) is the extensive modeling of unconventional monetary policies in the form of asset purchases. Given that most central banks have a toolbox that not only includes the policy rate, a model which inhibits asset purchases, and its real economic impact, is an obvious choice. Furthermore, this model is quite detailed when it comes to the financial sector, however it is quite a standardized New Keynesian framework when it comes to the rest of the model. This is an advantage when it comes to interpreting the effects of an inflation shock and the associated monetary policies, however some disadvantages are also present. But since the focus of my simulation is to evaluate and compare the impacts between different monetary policy strategies, this model is a suitable choice. To summarize, in the result section below I will apply an exogenous inflation shock to this model by Carlstrom, Fuerst and Paustian (2017) to evaluate what kind of monetary policy will dampen the fall in output the most.

The two main disadvantages with this model are the lack of energy prices and unemployment. However, I argue that the lack of energy prices is not that big of a drawback. To explain why the absence of energy prices does is not a problem, we first look at how inflation is defined in this model. Inflation is modelled as a Philips curve that has both a backward- and a forward-looking component and that takes marginal costs into consideration:

$$\pi_t = \frac{\kappa_\pi}{1+\beta\iota_p} mc_t + \frac{\beta}{1+\beta\iota_p} E_t\pi_{t+1} + \frac{\iota}{1+\beta\iota_p}\pi_{t-1} + \varepsilon_t^p \tag{1}$$

Where π_t is current inflation, π_{t-1} is the previous periods inflation, $E_t\pi_{t+1}$ is the expected next period inflation and mc_t stands for current marginal costs. ε_t^p is the exogenous "price markup shock" and is defined as the following AR(1) process:

$$\varepsilon_t^p = \rho_\pi \varepsilon_{t-1}^p + \vartheta_t^p \tag{2}$$

Where ρ_π is the persistence of the shock and is estimated to a value of 0.66 and the error term ϑ^p is i.i.d. N (0, 0.2442^2). This exogenous price markup shock is the shock that is applied to inflation to simulate this current real world economic state of rising inflation. Given the discussion in section 2, energy prices and its impact on the economy can be viewed as either exogenous or endogenous. My line of argument for applying a completely exogenous price markup shock to emulate the current state of the economy goes like this: Given that increases in energy prices and supply chain disruptions seems to be the main drivers of the current rise in inflation, these two issues have been described as a consequence of the lockdown measures following the outbreak of the Covid-19 pandemic. While the lockdown measures were implemented by governments trying to dampen the spread of the virus, the creation and worldwide spread of this pandemic was, I would argue, completely exogenous. With that I mean that the outbreak of the Covid-19 pandemic was not an endogenous response to any previous political or economic decision. Thus, even though energy prices are absent in this model, the assumption of increased inflation being quite exogenous justifies my choice of model simulation. Thus, my simulation would go along with for example Bohi´s (1989) reasoning, where energy price increases are seen as an exogenous shock to the economy.

The lack of an unemployment variable is also an issue but however perhaps not a problem. Given the highly credited negative empirical relationship between the unemployment rate and GDP growth, known as Okun´s law (Okun, 1962), the associated change in unemployment from this shock could easily be identified. There are several versions of Okun´s law, where the gap-version state that if the unemployment rate increase, then GDP must be below potential GDP and vice versa. While I will not derive a rate of unemployment from this simulation, the assumption of increased unemployment when GDP falls is not farfetched.

3.2. The model by Carlstrom, Fuerst, and Paustian (2017)

Aside from the extensive modelling of financial intermediaries in this model, the authors follow a standard New Keynesian framework. Here I give a qualitative explanation of the model, the interested reader is referred to the paper for further microeconomic intuition and model proofs (Carlstrom, Fuerst & Paustian, 2017). This model is estimated using U.S data which, given the focus on the U.S economy in this thesis, makes it an appropriate choice for the model simulations in section 4 below.

3.2.1. Financial Intermediaries

The authors extend a standardized framework by introducing segmented financial markets in which the net worth of banks limits the degree of arbitrage across the term structure. In more intuitive terms, this means that there exists a market for short bonds that can only be used for savings, and there exist a market for long bonds which can only be used for borrowing. Banks on the one hand borrow in the short bond market and lend in the long bond market, thus they conduct maturity transformation. All capital investments are financed by so-called investment bonds with a long maturity, and these bonds are perfect substitutes to long government bonds in this model. Furthermore, short-term bonds are the same as bank deposits in this model, and the two terms are used interchangeably throughout this thesis.

To model the distortion arising from segmented financial markets, the authors introduce what is often called an "investment wedge". This investment wedge is similar to the wedges introduced in Chari, Kehoe and McGrattan (2007), i.e., a wedge that distorts equilibrium outcomes. The rationale for these wedges is that they better explain the fluctuations of business cycles over the course of history. In this model the investment wedge goes into the capital Euler equation and can be interpreted as some sort of mark-up or tax on the price of new capital. Furthermore, the term premium in this model is defined as:

$$tp_t = r_t^{10} - r_t^{EH,10} \tag{3}$$

Where tp_t is the term premium at time t, r_t^{10} is the ten-year interest rate and $r_t^{EH,10}$ is the ten-year interest rate implied by applying the expectation hypothesis (EH) of the term structure to the series of short interest rates. What this means is that since markets are segmented and arbitrage limited, the ten-year yield is not the expected average of short rates, i.e., there exists a term premium. It can be shown that the term premium in this model essentially is the investment wedge. This result lies at the heart of the paper since the rationale for targeting or including the term premium in policy rules, due to its impact on real economic activity, is found here.

Also, banks face adjustment costs when it wants to vary the size of net worth in the wake of a shock. Given this adjustment cost, as the bank cannot vary net worth frictionlessly, the size and composition of its balance sheet will change in the wake of a shock. The segmentation of financial markets and the adjustment cost implies that central bank purchases of long bonds will have a significant effect on long bond yields. Since this model assumes that investment bonds and government bonds are perfect substitutes, they are sold in the same market, making asset purchases affect the yield on investment bonds as well, thus impacting real activity in the economy (Carlstrom, Fuerst & Paustian, 2017).

3.2.2. Households

Households consume and provide labor to firms in the economy. They save via short-term deposits at the bank and borrow through the so-called long-term investment bonds. As they cannot borrow short-term or save long-term this is the segmented financial market feature in the model. Households own the physical capital stock, that is financed through investment bonds, and lease the physical capital to firms.

3.2.3. Firms

There are three different kinds of firms in this model. The new capital producers are owned by households and take investment goods and transforms them into new capital goods. The intermediate good producer is a monopolist who produces the intermediate good by combining capital goods and labor. And lastly there are final goods producers that produce the final consumption good. These producers work on a perfectly competitive market and use intermediate goods as inputs to their final goods production.

3.2.4. Policy Authorities

The central bank set the short-term policy rate according to the following Taylor-rule:

$$r_t = \rho r_{t-1} + (1-\rho)\left(\tau_\pi \pi_t + \tau_y y_t^{gap}\right) + \varepsilon_t^r \quad (4)$$

Where r_t is the short-term interest rate, r_{t-1} is the short-term interest rate in the previous period, π_t is the rate of inflation and y_t^{gap} is the deviation of output to its flexible price counterpart i.e., the output gap. ε_t^r is an error term that follows an AR(1) process and is called a monetary policy shock. Aside from setting the interest rate, the central bank also conducts what is called long-term debt policies or balance sheet policies. These long-term debt policy regimes define the movement of the supply of long government bonds in circulation in the economy.

Conventional policy [1]: In this case the supply of long government bonds in circulation in the economy is held fixed. This means that the amount of government bonds on the banks' balance sheet will also be held fixed since the central bank will neither buy nor sell any of these long government bonds. The only way the supply of long government bonds in circulation could change is through an exogenous shock i.e., that the decision of the central bank to conduct QE or QT is determined outside the model. This means that as the supply is held fixed, the interest rate on these bonds and thus the term premium will fluctuate endogenously in this model economy.

Unconventional policy [2]: In this case the central bank pegs the term premium instead. This is the opposite scenario since to keep the term premium fixed, the supply of long government bonds in circulation will have to vary. To keep the term premium fixed, the central bank must buy or sell long government bonds to the banks to affect the interest rate on these bonds. So, under this regime the change in the supply of long government bonds happen endogenously i.e., the decision of the central bank to conduct QE or QT is made from within the model (Carlstrom, Fuerst & Paustian, 2017).

The fiscal authority is completely passive in this model, which means that government expenditures are set to zero and lump sum taxes just move along endogenously.

3.3. Results from the paper by Carlstrom, Fuerst, and Paustian (2017)

In the paper by Carlstrom, Fuerst, and Paustian (2017) they apply several different shocks and evaluate different policy regimes. First the authors apply a QE shock to evaluate the impact of QE on this model economy. What matters in the model is how much government bonds the bank must hold. Having to hold fewer government bonds allow the banks to buy more private investment bonds, which allows them to finance more investment projects. So, the QE experiment in their paper is reducing government bonds held by banks (since the central bank buys them from the banks), thereby effectively freeing up balance sheet space for banks. Thus, the QE shock promotes investments, and thus output.

Secondly, they find that when a total factor productivity (TFP) shock is applied, the unconventional monetary policy strategy promotes investment more and thus leads to higher

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[1] *In the paper the conventional policy is called the "exogenous debt policy".*
[2] *In the paper the unconventional policy is called the "endogenous debt policy".*

output. What also should be highlighted is that when the unconventional strategy i.e., a term premium peg is conducted, the effects from a credit shock are completely sterilized. This, at least in a theoretical setting, argues for an unconventional monetary policy strategy when a shock originating from the financial sector occurs.

Lastly, the authors also include a term premium component to the Taylor rule, thus contributing to the literature of whether including financial variables to Taylor rules is welfare increasing. They measure welfare as the discounted lifetime utility of the household and the authors find that the new Taylor rule is welfare increasing [3].

To summarize, the main results from the paper are that firstly, the financial market segmentation distortion implies a sizeable effect of central bank asset purchases on interest rates and real economic activity. Secondly, there are welfare gains to having the central bank respond to the term premium, like including the term premium in the Taylor Rule. And third, a policy that directly targets the term premium i.e., the unconventional monetary policy strategy, sterilizes the effect on the real economy from shocks originating in the financial sector (Carlstrom, Fuerst & Paustian, 2017).

3.4. The Term Premium and The Yield Curve

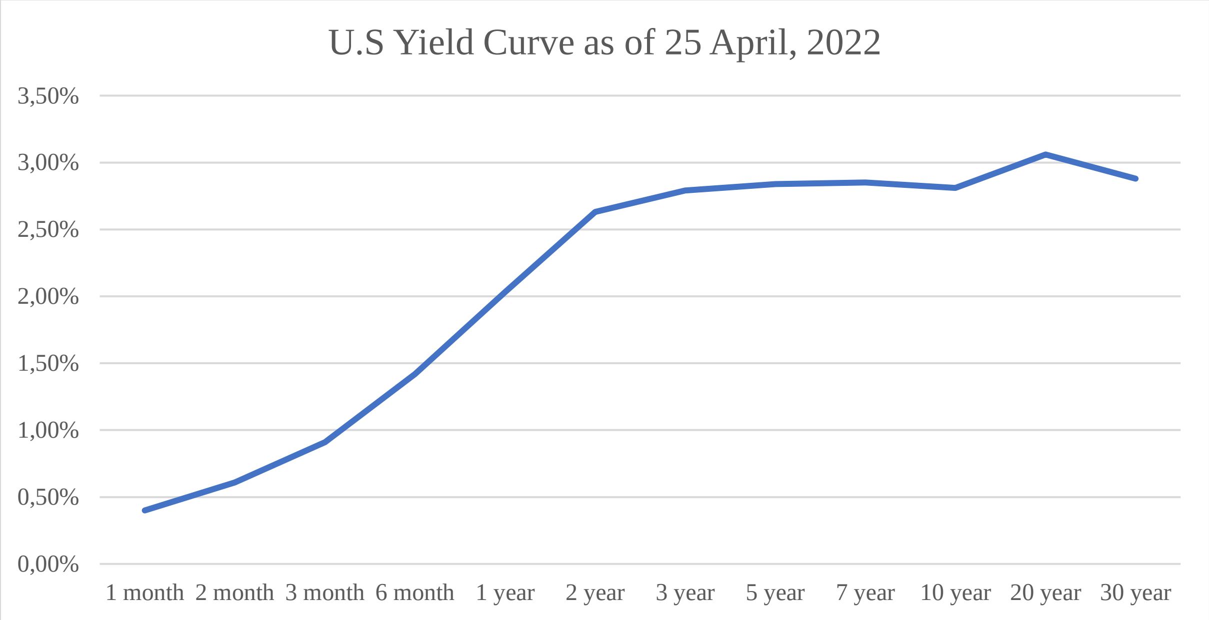
Before moving into the results from the model simulations, a clearer explanation of the term premium and the yield curve is in order to understand the results below. According to economic theory, the yield on Treasury securities includes two components, the term premium and the expectations of the future path of short-term Treasury yields. The term premium thus reflects how much investors expect to be compensated for holding bonds for longer time periods. The term premium in the model is defined above in equation (3) but more generally it is defined as:

$$tp_t = r_t^n - r_t^{EH,n} \tag{5}$$

Where tp_t is the term premium at time t, r_t^n is the n-year interest rate on a long-term bond and $r_t^{EH,n}$ is the n-year interest rate implied by applying the EH of the term structure to the series of short interest rates (Kim & Orphanides, 2007). Given the definition of the term premium, it is not directly observed, and must be estimated by using macroeconomic or financial variables

[3] *I also conducted an experiment where I augmented the Taylor rule with a term premium component when an inflation shock was applied. However, since the dynamics of the variables in question did not show a significant difference, I abstained from presenting this experiment in the thesis.*

(Federal Reserve Bank of New York, n.d.). On the other hand, the yield curve, shown in graph 6 below, is an illustration of yields of different maturities and thus shows the difference between short-term and long-term yields.



Graph 6, Source: Statista (2022)

While the term premium is not the same as the difference in yields implied by the yield curve, authors like Crump, Eusepi and Moench (2016) have shown that the term premium account for most of the reaction of the yield curve to macroeconomic shocks.

An inversion of the yield curve i.e., when long-term yields are lower than short-term yields, has often been succeeded by a recession in the United States. The economic intuition for this is quite straightforward. In standard asset-pricing theory, the real interest rate equals the rate at which consumption is expected to grow over a certain time period (Lucas, 1978). If the one-year real interest rate is 2 %, that is the rate at which consumption is expected to grow during the following one-year period. The same holds for all other time periods, which means that a real yield curve that is upward sloping indicate that consumption in ten years will be higher than in one year, which means that the consumption growth is expected to accelerate over time. Given this, the opposite also holds, and an inverted real yield curve indicates that consumption growth is expected to decelerate. To connect these theoretical asset pricing features to reality, an inverted yield curve thus indicates that the economy is moving towards a state of lower growth. As growth is lower in this state, the probability of an adverse shock moving the economy into a negative growth state is higher when the yield curve is inverted. Thus, the notion of an inverted yield curve forecasting a recession is not completely correct. An inverted yield curve forecasts the economic conditions that makes the probability of a recession higher (Andolfatto & Spewak, 2018).

4. Results

4.1. Description of the simulations

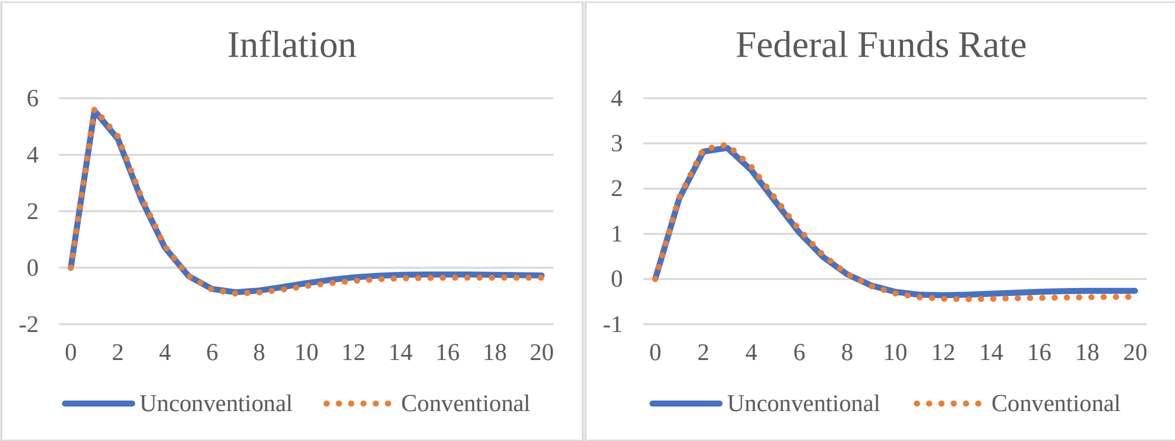
The intent of the simulations I conduct in this thesis is to emulate the current economic state of rising inflation. To conduct these simulations, I will apply the shock to inflation, mentioned above as the "price markup shock". Through utilizing different monetary policy strategies and inflation developments, the aim of these simulations is to find the monetary policy strategy that will dampen the fall in output the most from this inflation shock. All the variables in the figures below are in percentage points.

The results from the first simulation are presented in subsection 4.2 where two different strategies by the Federal Reserve to combat the inflation are shown. The conventional strategy follows the thinking of Bernanke (2017) where the federal funds rate is the primary tool to stabilize the economy. According to this strategy, the large balance sheet that was accumulated through previous QE should not be used to further tighten monetary conditions. Instead of either conducting QE or QT, the Federal Reserve only reinvest maturing bonds to keep the size of its balance sheet stable. Thus, this strategy could be seen as the same as the one the Federal Reserve communicated on March 16, 2022, i.e., that the federal funds rate will be increased, and the balance sheet kept intact (Federal Reserve, 2022c). The second strategy is called the unconventional strategy and follows more the thinking of Forbes (2022) i.e., that the balance sheet should be used to further tighten monetary conditions. This strategy includes both the federal funds rate and QT as primary tools to combat inflation. Under this strategy the Federal Reserve can conduct QT to keep the term premium fixed, which can be viewed as a yield curve control policy. Bernanke (2020) explains yield curve control as a balance sheet policy that targets the price of bonds and thus leads the amount of bonds bought or sold to be determined endogenously to uphold the price target. Given that the Federal Reserve have started to increase the federal funds rate and stopped net purchases of bonds, the two strategies in this simulation are similar to two potential paths that the Federal Reserve can choose from at upcoming FOMC meetings. The second simulation, in subsection 4.3, compares the conventional and unconventional strategies under a scenario where inflation becomes more persistent, and thus leads to a period of higher and longer-lasting inflation.

The third simulation, in subsection 4.4, compares the baseline conventional strategy with a version of the conventional strategy that has a Hawkish monetary policy stance. There exist two different stances of monetary policy, namely Dovish and Hawkish, and their definitions are quite straight forward. A Dovish monetary policy stance is one that advocates for low interest rates and that in general puts higher emphasis on combating high unemployment rather than high inflation. The intuition is that as interest rates are kept low, households and firms can borrow to consume and invest more easily, which leads to economic growth and reduced unemployment. On the other hand, a Hawkish monetary policy stance is one that prioritize combating high inflation, and thus is more willing to increase interest rates to curb strong price increases (Zanzalari, 2022). To clearly distinguish, a monetary policy strategy describes the toolbox at the disposal of the central bank, like raising the interest rate or conducting asset purchases. On the other hand, a monetary policy stance describes the emphasis that central bank policy makers put on inflation and unemployment respectively, and thus how willing they are to change the interest rate drastically. To reiterate, this third simulation is one where the baseline conventional strategy is compared to a conventional strategy with more of a Hawkish monetary policy stance.

4.2. Simulation with Conventional and Unconventional Monetary Policy Strategies

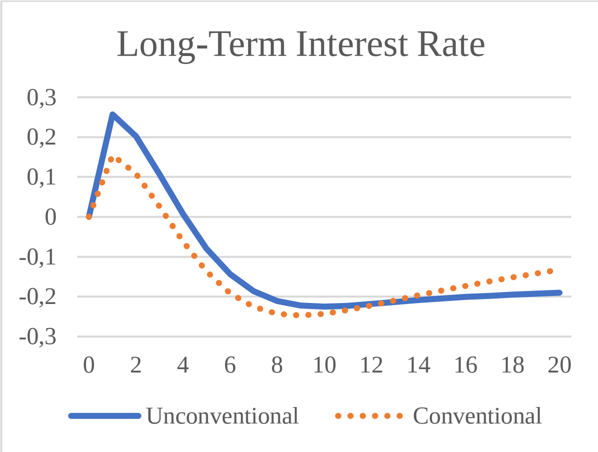
To emulate this current economic state of rising inflation due to increased energy prices and supply chain disruptions, the inflation shock from equation (2) is applied. Given the Taylor rule that the Federal Reserve follows in this model, the federal funds rate is increased to combat this surge in prices. Due to higher inflation, the real wage is reduced and thus less labor is supplied. This leads to a lower level of consumption due to this shock. Since consumption is affected very similarly under the two different monetary policy strategies the focus here will be more on how the choice of strategy eventually affects capital investments.



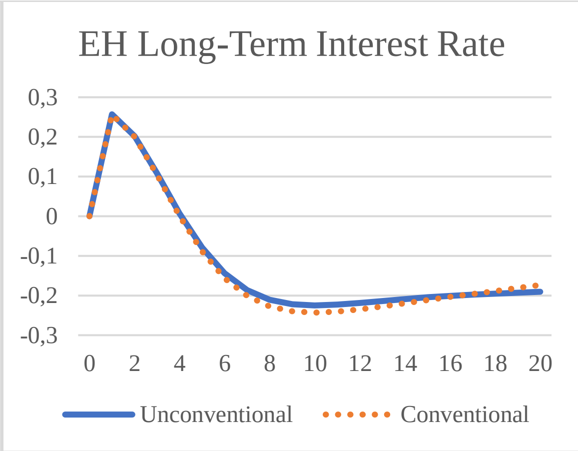
a) *b)*

Figure 3 a)-b), impulse response functions to an inflation shock

In figure 3 we see that as inflation increases, the federal funds rate increases, and the inverse relationship between bond prices and interest rates kicks in and long-term bond prices fall (Keen, n.d.). The term premium, which is defined in equation (3) above and visualized in figure 4c), thus decreases. As Crump, Eusepi and Moench (2016) show, the term premium accounts for most of the variation in the yield curve, and as it decreases the economy faces a flattening or even an inverted yield curve due to this shock. Given the ability of the yield curve to predict periods with a high probability of a recession, this reduction in the term premium creates expectations of a recession in the near future. However, under the unconventional strategy the Federal Reserve aims at selling off its balance sheet with the aim of keeping the term premium fixed, and thus stopping any flattening or inversion of the yield curve. For the Federal Reserve to do this they start selling of their bond holdings to the banking sector, which is why the fall in bond prices is exacerbated here. By conducting QT, the Federal Reserve manage to increase the long-term interest rate to the same level as the EH long-term interest rate, and thus pegging the term premium. The movements of these variables are seen in figure 4 below.



a)



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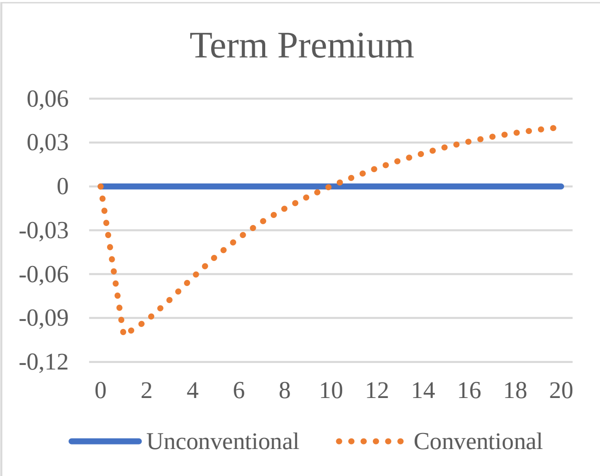

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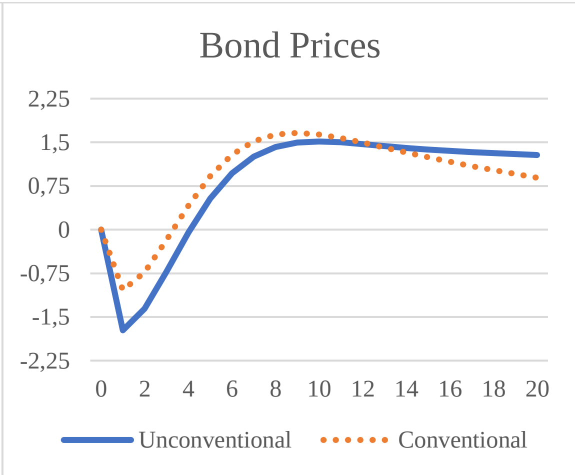

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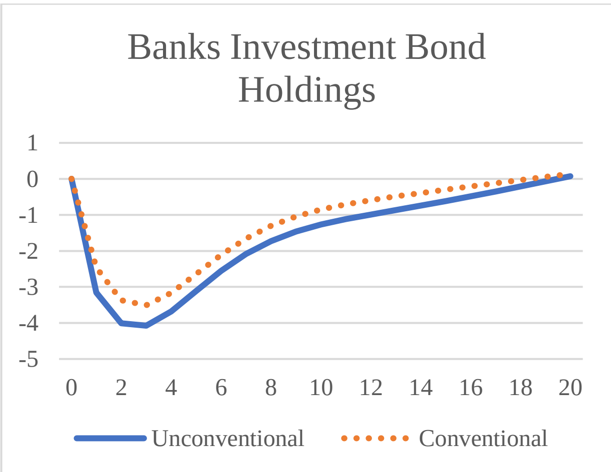

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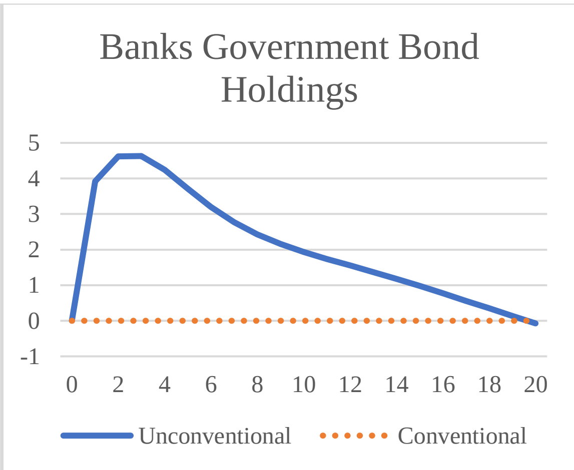
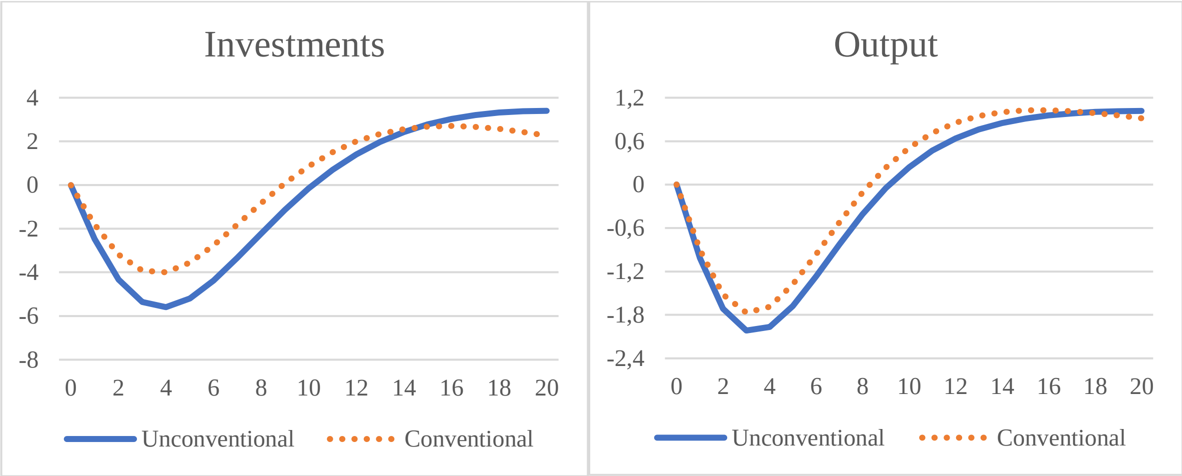


f)

Figure 4 a)-f), impulse response functions to an inflation shock

Since a higher rate of inflation erodes the value of bonds and that higher interest rates cause lower bond prices, banks want to reduce their holdings of these so-called investment bonds that finance capital investments. Since bond prices fall more under the unconventional strategy, banks want to further reduce their holdings of investment bonds following the inflation shock. Given that the unconventional strategy by the Federal Reserve makes the supply of government bonds on the market greater, banks can replace their unwanted investment bonds with government bonds, and thus as they keep the size of their balance sheet more intact, they can avoid adjustment costs of altering the size of their balance sheet.



a) *b)*

Figure 5 a)-b), impulse response functions to an inflation shock

By reducing the amount of investment bonds on its balance sheet, the bank effectively reduces the supply of loans to finance capital investments. This leads to less capital investments and thus also less output in the economy, as seen in figure 5 above. Since the bank under the unconventional strategy reduces its holdings of investment bonds more, investment and output fall more under the unconventional strategy as compared to the conventional strategy. This can seem a bit counterintuitive since a reduced term premium increases the expectations of a recession, but when the term premium is pegged through QT, we still see a more adverse impact on real economic activity. However, given that bond prices fall more under the unconventional strategy, and that banks have the possibility to exchange investment bonds for government bonds, a greater negative impact on investment, and thus on output, occurs. A disappointing fact from this simulation is that the choice of monetary policy strategy does not seem to have a major impact on the evolution of inflation. While the unconventional monetary policy strategy dampens the rise in inflation a little bit compared to the conventional strategy, both strategies lead to a sharp rise in inflation of almost equal magnitude.

4.3. Simulation with Persistent Inflation

The purpose of this second simulation is to evaluate the impact of inflation being more persistent i.e., that inflation will be higher and more long-lived. Given that there exist different beliefs regarding the duration of this inflationary period, a comparison of the outcome under different levels of inflation persistence is of interest. Advocates of the belief that this inflation period will be more persistent argue that, as of December 2021, we have not yet started to see inflation spread to many other goods and services than energy related ones, but that this spread is imminent (Blinder, 2021). Looking at graph 4, U.S inflation had reached 7.1 % as of December 2021, and as of April 2022 it has reached 8.2 %, thus as inflation keeps increasing it provides a motivation for conducting this simulation. Thus, this simulation will showcase the adverse impact on real economic activity if inflation becomes more persistent.

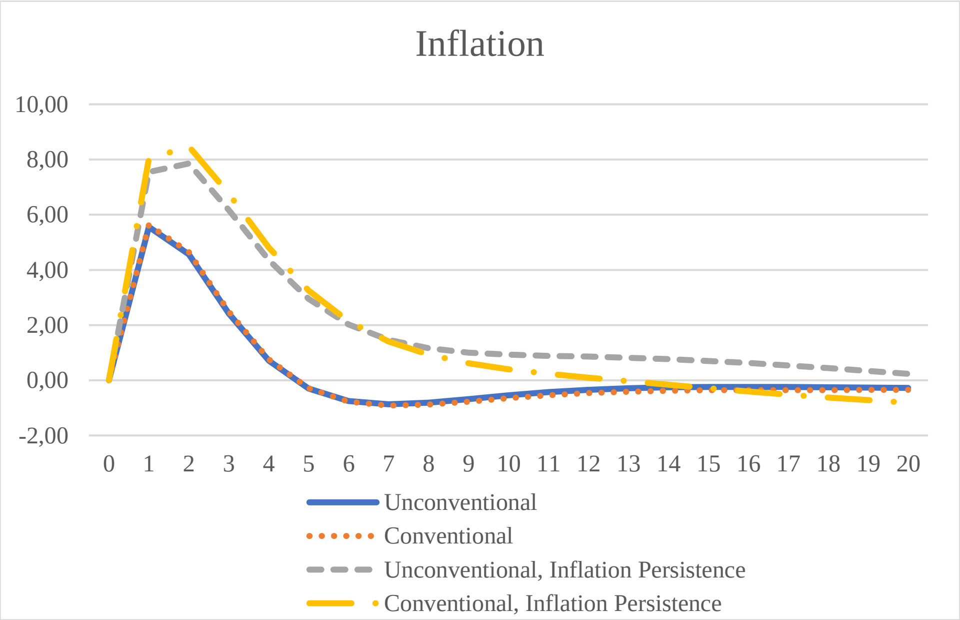
More practically, the simulation is conducted by increasing the autoregressive parameter in the AR(1) price markup shock process from the baseline estimation of 0.66 to 0.9. The choice of 0.9 for the persistence of the shock process is motivated by the fact that the seminal paper by Smets and Wouters (2007) estimated the parameter to 0.9. The model by Smets and Wouters (2007) is, like the model I use, estimated to U.S data. Thus, setting the autoregressive parameter to 0.9 provides a good comparison since it is significantly different from the baseline estimation of 0.66 and it is taken from an influential paper like Smets and Wouters (2007). In this simulation the price markup shock process from equation (2) is now defined as:

$$\varepsilon_t^p = 0.66\varepsilon_{t-1}^p + \sigma_t^p \tag{6}$$

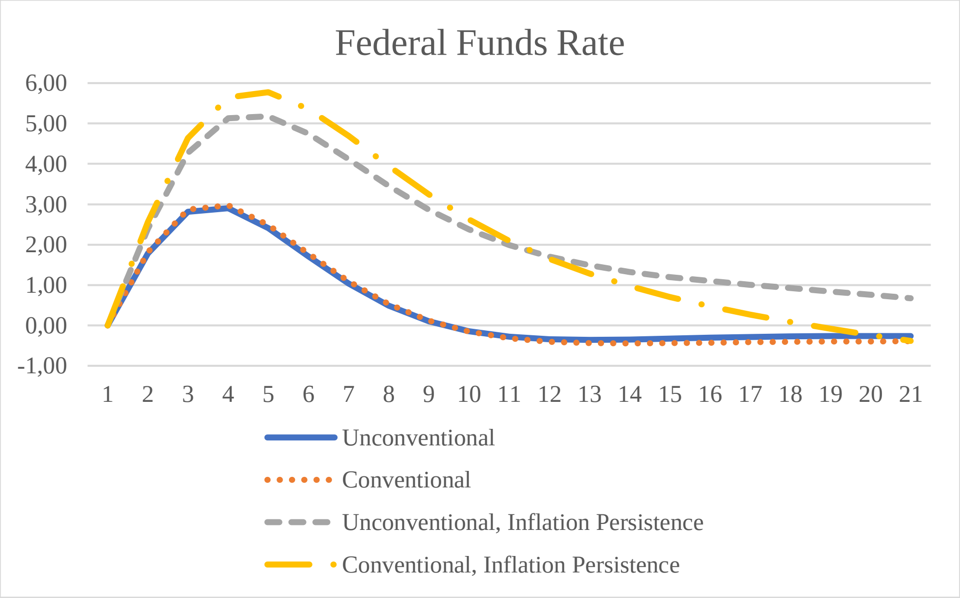
And in the case with more persistent inflation, the shock process from equation (2) is defined as:

$$\varepsilon_t^p = 0.9\varepsilon_{t-1}^p + \sigma_t^p \tag{7}$$

While this change to the shock process is quite large, most of the model dynamics is the same as in the first simulation, albeit most responses increase in magnitude. To summarize, as inflation increases the Federal Reserve increases the federal funds rate in order to dampen the surge in prices. Due to this increase in interest rates, bond prices fall, and banks want to reduce their holdings of investment bonds and replace them with government bonds. Since inflation, and thus the federal funds rate, increases more in the case with higher inflation persistence, banks sell off more of their investment bond holdings. This reduces investments, and thus also output, more when inflation is more persistent. Figure 6 below depict and compare what happens to key macroeconomic variables when inflation is more persistent.



a)



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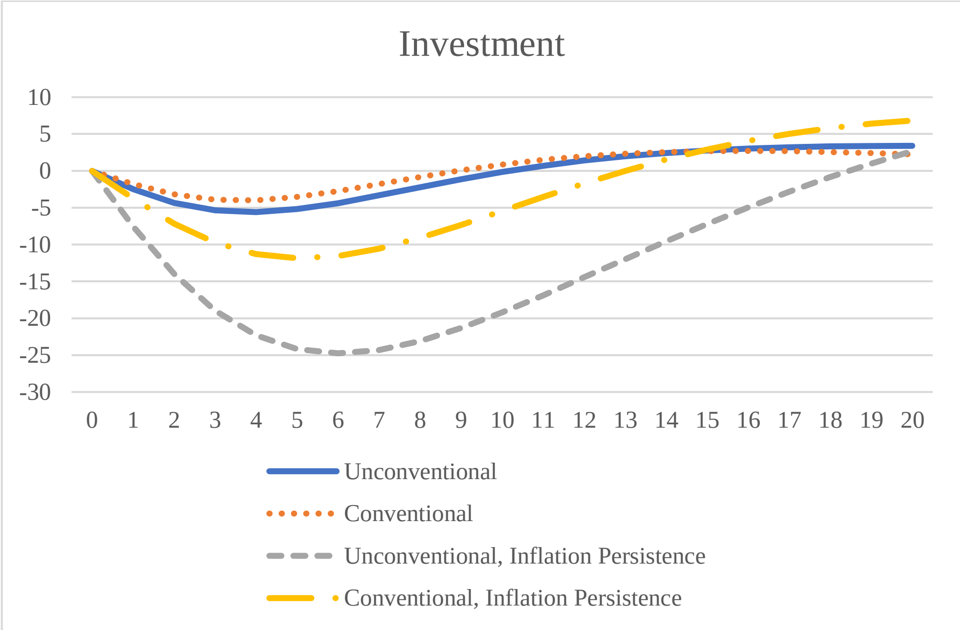

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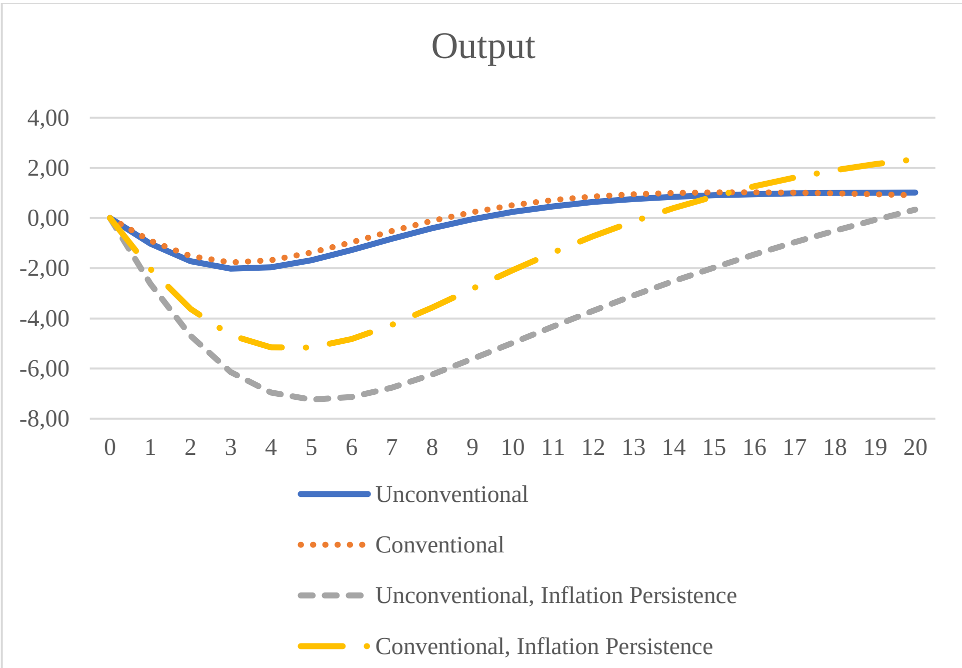


d)

Figure 6 a)-d), impulse response functions to an inflation shock

The result of this simulation with inflation being more persistent leads to the same conclusion as in the first simulation, where conducting QT further exacerbates the downward pressure on investment and output from the inflation shock. Thus, regardless of how persistent the inflation is, conventional monetary policy is preferred in order to dampen the loss to output. However, the unconventional strategy does dampen the rise in inflation a bit compared to the conventional strategy, but again the difference is quite small between the two strategies. While the choice of conventional versus unconventional strategy does matter, this simulation showcases the large adverse impact on real economic activity if inflation becomes more persistent.

4.4. Simulation with a Hawkish Monetary Policy Stance

Often central bank decisions or communication can be labelled as having a Dovish or Hawkish stance. With this third simulation, the intention is to compare how a more Hawkish monetary policy stance affect real economic activity when the inflation shock hits. The baseline stance of the model is the Taylor rule from the model by Carlstrom, Fuerst and Paustian (2017), defined in equation (4) above and is estimated as follows:

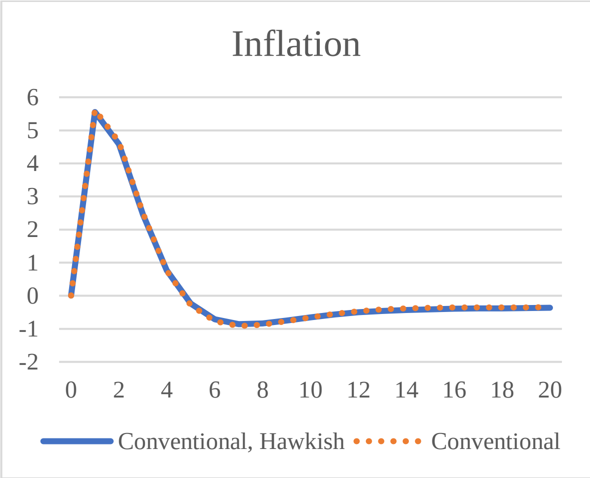
$$r_t = 0.77r_{t-1} + (1 - 0.77)(1.42\pi_t + 0.49y_t^{gap}) + \varepsilon_t^r \tag{8}$$

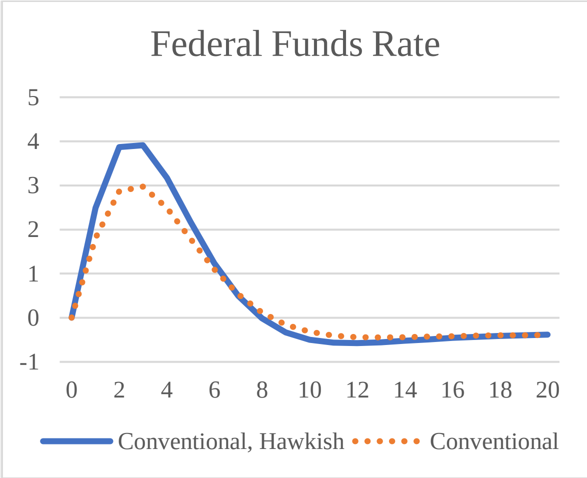
Thus, this stance follows the same monetary policy rule as the conventional strategy in the first simulation. The Hawkish monetary policy stance however is modelled following the same monetary policy rule but with the weight on inflation taken from Smets and Wouters (2007). The Hawkish stance is estimated as follows:

$$r_t = 0.77r_{t-1} + (1 - 0.77)(2.04\pi_t + 0.49y_t^{gap}) + \varepsilon_t^r \tag{9}$$

Given that the model by Smets and Wouters (2007) is a workhorse model within monetary economics, using their weight on inflation is a reasonable choice for comparison. Under the Hawkish stance the weight on inflation in the monetary policy rule is higher. This means that the Federal Reserve will increase the interest rate more when this inflation shock hits, with the intention to dampen this increase in prices.

Since in my two previous simulations, the conventional strategy was favorable over the unconventional strategy, I only compare the outcomes of these two stances under a conventional monetary policy strategy i.e., with only the federal funds rate as a monetary policy tool.





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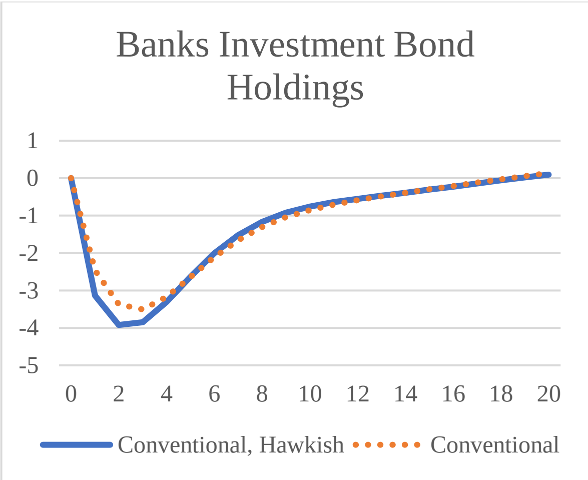
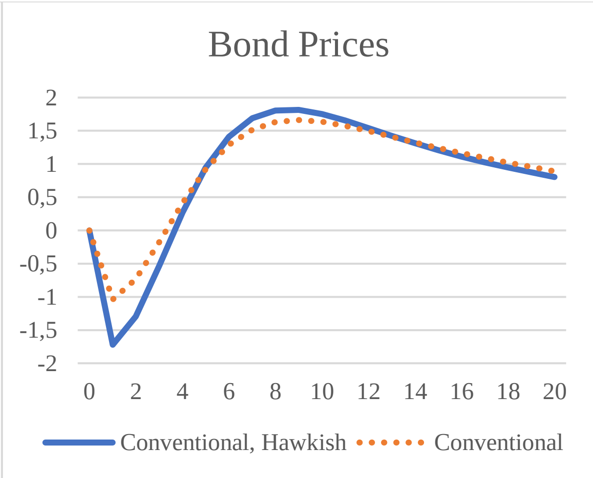
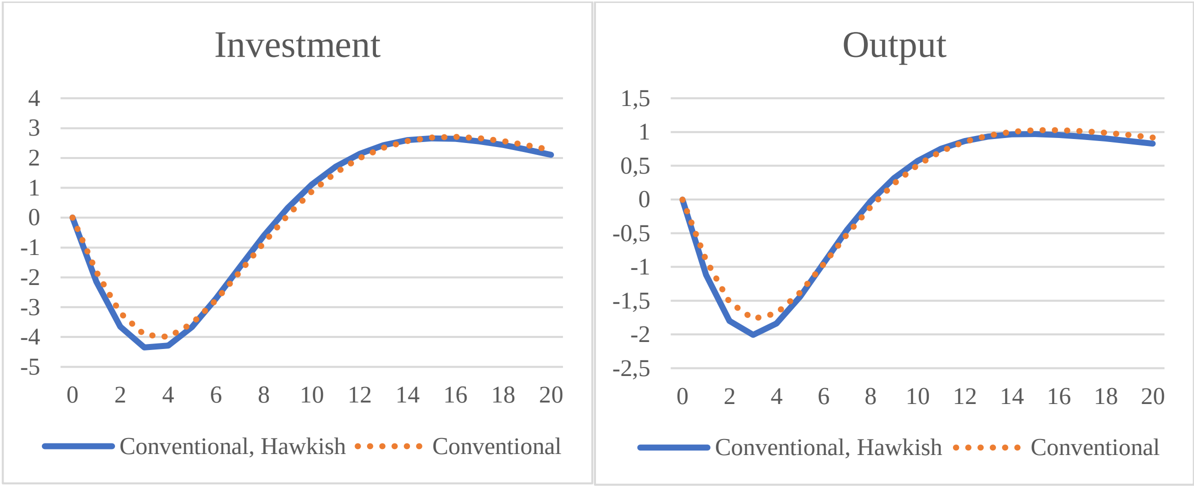




c) *d)*

Figure 7 a)-d), impulse response functions to an inflation shock

In figure 7 we see that as the inflation shock hits, the Federal Reserve responds by increasing the federal funds rate. Given that the Hawkish stance puts higher emphasis on combating inflation, the federal funds rate is increased more under the Hawkish stance. Due to the increased federal funds rate, long-term interest rates increase, which means long-term bond prices decrease. The increase in inflation and the decrease in bond prices induces banks to reduce their holdings of investment bonds. The fall in investment bond holdings is exacerbated under the Hawkish stance due to the larger decrease in bond prices.



a) *b)*

Figure 8 a)-b), impulse response functions to an inflation shock

Given that banks reduce their holdings of investment bonds due to this adverse shock, the possibility for firms to finance investments thus decreases. This leads to a fall in capital investments and thus also a fall in output, as can be seen in figure 8. Once again, the larger increase in the federal funds rate under the Hawkish stance is what drives the results. Thus, a more Hawkish stance leads to a larger fall in output but does not combat the surge in inflation in any meaningful way.

5. Discussion of Results

The model simulations presented in section 4 lays out a clear message, unconventional monetary policy of contractionary nature creates an adverse impact on real economic activity after an exogenous inflationary shock hits the economy. The simulations also showcase the damaging effects a more persistent inflation can have on the economy. Also, a Hawkish stance exacerbates the adverse impact from the inflation shock. Thus, when the model tries to emulate the decision by the Federal Reserve at the May 4, 2022, meeting to raise the federal funds rate more aggressively, it shows that more gradual increases of the federal funds rate are more favorable.

When assessing the impact of the Federal Reserve´s interest rate increases during the inflationary period of the 1970s, Bernanke, Gertler and Watson (1997) argue that it in fact was the sharp increases in the federal funds rate that lead to a recession. Given that the third simulation in section 4 above indicates that a Hawkish stance exacerbates the fall in output, it grants some support to the argument by Bernanke, Gertler and Watson. However, validation of the authors argument from the model simulation is somewhat thin since in the model simulation above the Federal Reserve conducts a contractionary monetary policy, while Bernanke, Gertler and Watson argue for an expansionary monetary policy to reduce the fall in output. Given the similar discontent for a Hawkish stance, but the different opinion with regards to conduct expansionary or contractionary monetary policy, one must remember the crucial difference in assumptions between these two arguments. With the model I used, energy price increases and thus the inflation shock is modelled as an exogenous shock while Bernanke, Gertler and Watson argue that the inflation during the 1970s was an endogenous phenomenon following the expansionary monetary policy of the 1960s. Since there exists a fundamental difference in how inflation is defined between these two arguments, it is not surprising that the opinion of how to conduct monetary policy differs. While analyzing how the assumption of an endogenous rise in inflation leads to an argument for expansionary monetary policy is outside the scope of this thesis, the third simulation does highlight the importance of the definition of the inflation shock for constructing monetary policy.

When evaluating the question of whether further monetary tightening through QT is a potential path to take, the simulations clearly support the argument by Bernanke (2017). Bernanke state that due to the turmoil on financial markets when the Federal Reserve communicated a potential reduction in their balance sheet, QT might not be the right way forward. The model simulations produce a similar scenario since long-term interest rates rise sharply and disrupt the credit facilitation, which leads to a reduction in real economic activity. Given the support of Bernanke´s argument, these simulations also produce a few counterarguments towards Forbes (2022). From the first simulation, the conventional strategy was better suited to dampen the fall in output. The further monetary tightening through QT that Forbes advocates is not a better tool to combat inflation, it just exacerbates the fall in output. While none of the effects from a potential QT program are obvious in advance, an untested method for quite heavy monetary tightening having a large adverse impact on real economic activity is not that surprising. Forbes also states that since inflation today keeps beating expectations, further monetary tightening is important to signal a hard stance against surging prices. However, with this model simulation, unconventional monetary policy only further exacerbates the negative impact on real economic activity from higher realized inflation. And, as mentioned in the results section, unconventional policies do little to decrease the surge in inflation. Since Forbes argues that conducting QT would dampen inflationary pressures and thus reduce the need to increase policy rates drastically, her stance can be viewed as a bit Dovish when it comes to changing the short-term interest rate. But, since she advocates for a quite hefty contractionary monetary policy to rein in inflation, she could also be viewed as more of a Hawk. Thus, the unfavorable model outcome of the Hawkish stance grants support to her argument for not sharply increasing the federal funds rate. However, given Forbes opinion that monetary conditions should be tightened, I would argue that the overall outcome from these model simulations goes against her line of reasoning.

While these model simulations provide support for different monetary policy strategies, the drawback of this rather simplified framework needs to be accounted for. Sims (2020) brings up the limitation to external validity of the model results, which is the assumption of perfect substitutability between investment and government bonds. Since these two bonds are not perfect substitutes in real life, the passthrough of the effects from QE towards these private investment bonds would not be one-for-one as in the model. Given this simplifying assumption, Sims (2020) states that since the impact on investment bonds is too strong, the impact on investment and output is thus also too strong, meaning that the model probably produces the upper bound of positive effects on real economic activity from QE. Taking this as given, if QT is conducted, this would mean that model simulations of the impact on real economic activity from QT might create the upper bound of negative effects. Meaning that since the model overestimate the positive impact from QE, the model might overestimate the negative impact from QT as well. This, however, is not confirmed by any model comparisons. If the model by Carlstrom, Fuerst and Paustian does overestimate the impact of QT, it opens up for another drawback of this model, namely that the model creates a symmetric response to balance sheet policies. The asymmetry of the reaction between QE and QT is the assumption that lays the foundation for both opponents and proponents of QT and seems to be consensus in both theoretical work like Cúrdia and Woodford (2010) and more policy-oriented arguments like Bullard (2019). Thus, having a symmetric reaction between QE and QT is a drawback of using this model.

While both the impact of conducting QT and the stance of the conventional monetary policy does matter, it seems like the most important factor when evaluating the adverse impact on real economic activity is the persistence of inflation. The more persistent the inflation is, the more it exacerbates the fall in output from this exogenous shock. While the second model simulation does not provide any insight into how to combat this more persistent inflation, it does showcase the rationale for why some central bankers argue for a more Hawkish monetary policy stance. The longer it takes to rein in inflation towards the inflation target, the more severe the economic downturn becomes, and hence some policymakers argue for a more Hawkish stance. However, as clearly stated from the third simulation, this model does not produce a favorable outcome when a Hawkish stance is conducted.

Given that the FOMC decided on May 4, 2022, to increase the federal funds rate by 0.5 percentage points, instead of the more standard 0.25 percentage point change, it could be viewed as more of a Hawkish stance. They also decided to not conduct any QT, but decided to stop reinvesting the maturing bonds on their balance sheet in the near future (Federal Reserve, 2022d). The choice of not conducting QT is in line with the model simulations above, while the more Hawkish stance after the May 4, 2022, meeting goes against the model simulations. Thus, the simulations conducted in this thesis could work as some sort of theoretical support or counterargument for the actions taken by the Federal Reserve. To summarize, both this model and the Federal Reserve themselves seem to prefer a conventional monetary policy strategy to combat inflation, while the Federal Reserve, with their more Hawkish stance, want to "grab the bull by its horns" to a larger extent than the model.

6. Conclusions

The aim of this thesis is to shed light on how different monetary policies, following a sharp increase in inflation, affects real economic activity. Even though there do exist strong similarities between the inflationary period of the 1970s and today, the focus of this thesis is on how the Federal Reserve should utilize its toolbox filled with different monetary policy strategies. As presented in this thesis, unconventional monetary policy in the form of QT further exacerbates the fall in output through its disruption of the credit facilitation. The consensus among policy makers seems to be that conducting QT through outright asset sales is not the best way forward. The model simulations presented here goes along the lines with the argument by Bernanke (2017), which is that the federal funds rate should be raised before any experimenting with unconventional monetary tightening occurs. Thus, this thesis contributes with model theoretical support for conducting conventional monetary policy to combat this present inflationary period. The model findings do state that a Hawkish stance is unfavorable for dampening the fall in output following this inflation shock, which goes against the decision by the FOMC on May 4, 2022, to increase the federal funds rate with 0.5 percentage points. However, the results I receive are model specific and the reader should keep in mind that these results might not hold in other models. Thus, the intention with my results is not to give critique towards the Federal Reserve's decisions, it should rather be viewed as contributing to the literature of potential effects of different monetary policy strategies.

A potential path for future research would be to use a model with more detailed modeling of unconventional monetary policies and how those interact with more conventional tools. That is, how the combination between for example QT, forward guidance, or funding-for-lending schemes together with the policy rate can combat inflationary pressures and stabilize the fall in output. Also, given the argument that the 1970s inflation was an endogenous phenomenon, perhaps evaluating if there could exist an endogenous explanation for the period after the GFC, which was characterized by very low inflation, could be an endeavor for future research.

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