



Helicopter Money in a Standard New Keynesian Model

— Modelling and Simulation —

Ivo Inácio Gomes

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Supervisor:

Professor Vivaldo Mendes

Department of Economics, ISCTE-IUL

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Resumo

O dinheiro de helicóptero é um tema extremamente controverso que tem merecido muita atenção no decorrer dos últimos 5 anos. Nesta dissertação irei desenvolver um modelo DSGE que procura explicar como é que esta forma particular de criação de moeda poderá afectar a inflação e o hiato do produto. O modelo apresentado caracteriza o dinheiro de helicóptero como oferta de moeda permanente e explora as consequências do banco central restringir a sua capacidade de seguir uma política monetária mais restritiva no futuro, aumentando a quantidade de dinheiro de helicóptero presente na economia. Os factores mais relevantes que explicam o comportamento do hiato do produto e da inflação são o efeito desta restrição na formação de expectativas de inflação e de consumo futuros.

Os resultados indicam que, para que o dinheiro de helicóptero seja considerado uma medida viável, o impacto da restrição da taxa de juro nas expectativas de consumo futuro precisa de ser grande o suficiente para contrabalançar o efeito de aumento da expectativa de inflação futura.

Palavras-chave

Política monetária, Modelos DSGE, "Dinheiro de helicóptero", Macroeconomia.

Classificação JEL

E30, E31, E32, E37.

Abstract

Helicopter money is an extremely controversial topic that has been gaining a lot of attention over the last five years or so. In this dissertation I will develop a DSGE model that attempts to explain how this particular form of money creation may affect inflation and the output gap. The model presented here characterizes helicopter money as permanent money supply and exploits the consequences of the central bank constraining its capacity to tighten monetary policy in the future by choosing a contemporaneous increase in helicopter money. The main factors behind the behavior of the output gap and inflation are explained by the impact of this constraint upon the formation of future inflation and consumption expectations. The results lead us to the conclusion that for helicopter money to be considered as a viable policy option, the impact of the interest rate constraint on expected future consumption needs to be high enough so that it counter-balances its effect on expected future inflation.

Key-words

Monetary policy, DSGE models, Helicopter Money, Macroeconomics.

JEL Classification

E30, E31, E32, E37

To *my family* and *friends*

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Chapter 1

Introduction

Helicopter money is a controversial topic that has been gaining a lot of attention in the latest years. In the last few years, central banks have found their conventional tools used to conduct monetary policy to be ineffective, since interest rates effectively reached the zero lower boundary (ZLB). Since then they have turned to more unconventional tools like quantitative easing programs, increasing central banks' balance sheets, although mostly with the public assurance that the purchases would eventually be reversed. Even though central banks used their biggest guns, they are still struggling in making monetary policy stimulate the economy. On the other side, fiscal authorities are facing high levels of debt that are not compatible with a strong fiscal stimulus, due to debt sustainability concerns. In the last years, helicopter money has surged as an idea that can potentially solve the problems of both fiscal and monetary authorities, through cooperation between the two.

In this paper will build and analyze a model which looks at helicopter money and the impact it has in main economic variables, such as output gap and inflation. Even though helicopter money involves a level of cooperation between fiscal and monetary

authorities, I chose to abstract from the fiscal authority's role in delivering a fiscal stimulus to the economy. Instead I will focus my analysis on the main characteristic that distinguishes helicopter money from quantitative easing. While quantitative easing is designed to be temporary, helicopter money is a permanent stimulus. For this reason, the model treats helicopter money as permanent money supply.

This thesis is structured in 4 sections. Section 2 presents a literature review of the topic. Section 3 presents the model and section 4 presents an analysis of the model. In the end, section 5 concludes.

Chapter 2

Literature Review

Since the financial crisis of 2008, central banks like the FED and the ECB have been struggling with a situation that have only been experienced in Japan in the last two decades. Central banks dropped interest rates to zero and below, recurring to quantitative easing programs (QE) to stimulate their economies when conventional monetary policy became depleted, and central banks' balance sheets grew to unprecedented values while inflation remained below target and the economy below potential. With this apparent lack of ability of monetary policy to stimulate the economy there has been increasing support for even more unconventional policies, like helicopter money. In this chapter I will look at the debate in the literature surrounding the implications of central banks' usage of helicopter drops as a part of their toolkit and what are the main arguments of its proponents and contestants.

2.1 Brief history of the idea

Helicopter money is an idea popularized by Milton Friedman in his paper "The Optimum Quantity of Money" published in 1969. In that paper, Friedman proposed

a thought experiment which consisted of dropping \$1000 to an economy from a helicopter, to illustrate the costs of holding money as well as to demonstrate an effortless way for the central bank to generate inflation if it wishes to (Friedman, 1969).

In the early 2000's, this concept was brought back by the former federal reserve chairman Ben Bernanke regarding Japan's liquidity trap, as one of several tools BoJ could use to bring back inflation to its desired level (Bernanke, 2000, 2003).

2.2 Definitions

According to Ben Bernanke "a 'helicopter drop' of money is an expansionary fiscal policy – an increase in public spending or tax cut – financed by money creation" (Bernanke, 2016). In its essence is fiscal policy financed by money creation. Another definition is given by Adair Turner, who says that "[m]onetary finance is defined as running a fiscal deficit (or a higher deficit than would otherwise be the case) which is not financed by the issue of interest-bearing debt, but by an increase in the monetary base – i.e. of the irredeemable fiat non-interest-bearing monetary liabilities of the government/central bank."(Turner, 2015)

2.3 Different implementations

There are some ways helicopter money could be implemented. The central bank could transfer directly money to the government account, it could buy government bonds and transform them in perpetuities (with no principal nor interest payment). Central bank could also buy government debt and commit to its rolling over per-

petually and return the interest earned to the treasury as a profit, which simply means a perpetual QE (Nathan, 2017). It could also take the form of a permanent transfer from the central bank to households (people's QE).

2.4 Helicopter money vs QE

To fully understand what helicopter money is and what alternative it provides, we need to understand the main differences between this policy and other policies central banks have at their disposal. One policy that has been used largely all over the world recently is quantitative easing. It can be argued that QE can finance an expansionary fiscal policy. If the central bank decides to buy government bonds, it increases the monetary base and lowers the financing cost of public debt, allowing for the government to issue more debt to increase spending or cut taxes. The main issue with QE is that it is reversible, which means that the central bank will eventually drop the assets purchased back into the economy, reducing the monetary base and reverting the previous stimulus. If the principle of Ricardian Equivalence holds, economic agents' reaction may offset the stimulus. This reversibility does not happen with helicopter money, because it is a permanent measure. The fact that QE is temporary has two important consequences. Let's consider a situation where the central bank buys government bonds in a QE operation. First, in a situation where fiscal policy is constrained by sovereign debt default risk, a temporary purchase of government bonds does not reduce the debt sustainability problem. Although it reduces the government debt held by the private sector in the short run, in the long run the situation does not change, thus the government's ability to pursue an

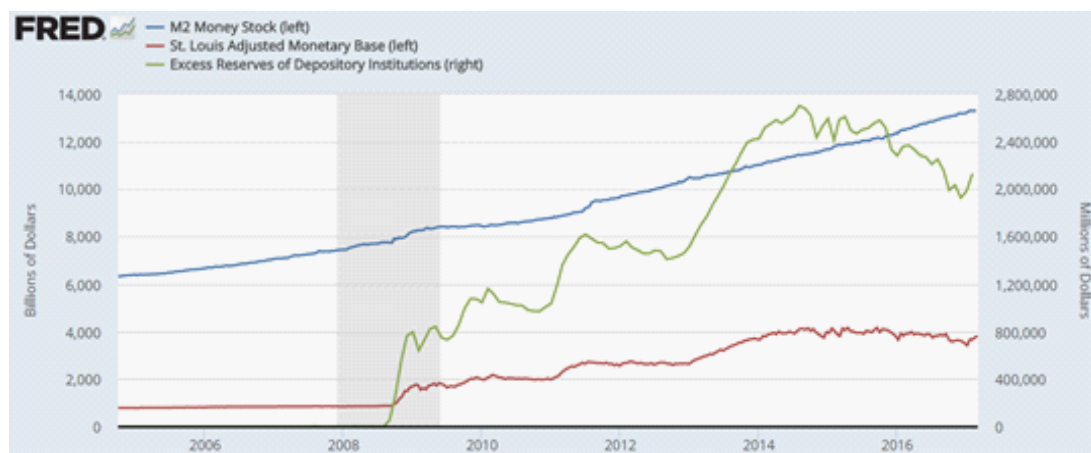


Figure 2.1: Money supply, monetary base and excess reserves in the US

expansionary fiscal policy does not increase if it was limited by debt sustainability concerns. Second, if the increase of the monetary base is perceived by the economic agents as a temporary one, the impact on the money supply may be limited, as figure 2.1 shows. Since the end of 2008, when the QE1 was used by the FED, monetary base increased four times, while money remained growing at roughly the same rate as before. However, the excess reserves of depository institutions held by the FED increased dramatically, which points to the fact that the stimulus did not have the effect that was intended.

A permanent purchase of government bonds by the central bank funded by money creation, would permanently decrease the level of public debt held by the private sector as well as increase permanently monetary base.

2.5 Arguments in favor of helicopter money

Why do we need helicopter money? One argument in favor is linked with the idea of a balance sheet recession.

If the economy is in a situation where the private sector is deleveraging (balance sheet recession), monetary policy may not have the power to stimulate the economy.

Richard Koo (2011) argues that when an economy is in a balance sheet recession (after a prolonged period of debt accumulation, the private sector is forced to clean its balance sheets), conventional monetary policy becomes ineffective, since “people with negative equity are not interested in increasing borrowing at any interest rate” (Koo, 2011: 20). The usual credit channel central banks use to fight recessions doesn’t work, and debt minimization becomes more important to private agents with balance sheet problems than profit maximization. There is then a need for fiscal policy to step in and do monetary policy’s work, while the private sector is deleveraging, to avoid a prolonged recession (Koo, 2011).

Adair Turner argues that the main issue of helicopter money is not technical, but political. His main concern is whether we can create mechanisms to ensure that monetary finance is only used when appropriate. Turner also argues that debt finance effectiveness depends on whether Ricardian Equivalence holds or not in the real economy. Helicopter money on the other hand, does not need Ricardian agents to influence consumers’ decision to spend, since there is no reason to be expected higher taxes in the future to offset the present stimulus (Turner, 2015).

Paul McCulley and Zoltan Pozsar relate this concept with the idea of helicopter

money. They claim that there is a need to combine monetary with fiscal stimulus (helicopter money), to help the government maintaining the stimulus while the deleveraging process occurs. Fiscal policy in this situation is very effective, but is politically constrained due to fear of sovereign debt problems, so the stimulus provided by the fiscal authority alone may be limited. A possible solution to each one of these two authorities' problems could be fiscal-monetary cooperation. On one hand, monetary policy solves the problem of lack of borrowing by substituting private with public borrowing. On the other hand, the fiscal policy's problem of excessive debt can be solved by monetizing some of it (McCulley & Pozsar, 2013).

This fiscal-monetary cooperation allows for a simultaneous private sector deleveraging and an increase in nominal demand. Though one can be uncertain about how monetary finance affects separately real variables and the price level, Willem Buiter argues that it will always boost aggregate demand, either by increasing real output or inflation (or some combination of the two), given three conditions are met. The price of money must be positive, fiat base money needs to have value other than its return and to be irredeemable (which means that is not considered as a liability by the central bank). This last condition is key to Buiter's result, and in his partial equilibrium model it is represented by applying a solvency constraint on terminal non-monetary liabilities of the State (Government and Central Bank), instead of using financial liabilities as usual (Buiter, 2014).

“UK currency notes [...] carry the proud inscription “promise to pay the bearer the sum of £X” but this merely means that the Bank of England will pay out the face value of any genuine Bank of England note no matter how old. [...] Because

it promises only money in exchange for money, this ‘promise to pay’ is [...] a statement of the irredeemable nature of Bank of England notes.” (Buiter, 2014)

Ben Bernanke, who has earned the nickname of ‘Helicopter Ben’, has defended some form of helicopter money for Japan in some speeches (Bernanke, 2000) and (Bernanke, 2003), as a policy to increase nominal demand and get Japan out of the liquidity trap it suffers since the 1990’s. In a 2016 blog post (Bernanke, 2016), Bernanke argues that, though it is not likely that helicopter money will be used in the US in the short run, “under certain extreme circumstances—sharply deficient aggregate demand, exhausted monetary policy, and unwillingness of the legislature to use debt-financed fiscal policies—such programs may be the best available alternative. It would be premature to rule them out.” (Bernanke, 2016)

Kemal Dervis, former minister of Economic Affairs of Turkey, points out the positive effects of having the central bank printing money and bypassing the financial and corporate sectors and to deliver it straight into the middle and lower income consumers (Dervis, 2016). He argues that this would help to improve inclusiveness in economies with strong inequalities. Also, he claims that “Zero or negative real interest rates, when they become quasi-permanent, undermine the efficient allocation of capital and set the stage for bubbles, bursts and crisis” (Dervis, 2016).

Because of the irredeemable feature of base money, we know that helicopter money will increase nominal demand. This is an important result, as it puts aside the hypothesis that deflation or secular stagnation are scenarios that an economy could get stuck in, regardless of the policies (monetary and fiscal) pursued. Instead, they are policy choices (Buiter, 2014). The term of ‘helicopter money’ was coined by

Milton Friedman in (Friedman, 1969), as a parable to demonstrate that there is no need for deflation since, if needed, the central bank could always drop money from a helicopter to the economy, and prices would eventually rise. However, it is important to know how this increase in nominal demand is revealed in the economy. Either prices rise, output rises, or a combination of both will happen.

Jordi Galí tries to model the effects on real variables as well as on the price level, of a fiscal stimulus (increased government spending) financed with helicopter money, as opposed to the usual debt financed stimulus. (Galí, 2014) He compares a fiscal stimulus in a Classical Monetary Model and in a New Keynesian Model, to find out that nominal rigidities are very important to explain the effects of monetary finance on output and inflation.

A fiscal stimulus can be done in two separate ways, either by an increase in government spending, or by a tax cut. It is likely the effects of monetary finance of both kinds of policies will be different. The paper (Galí, 2014) was revised in December 2016, to include the effects of both a tax cut and a government spending increase. It also analyzes a situation where the zero lower bound constraint (ZLB) on the nominal rate is binding. The results point out that helicopter money can help increasing output if there are sufficient nominal rigidities, only at the cost of relatively mild inflation. In the case of a binding ZLB, the way of financing appears to be less important (Galí, 2016).

2.6 Critics

However, such an unconventional idea has received also lots of criticism. Kocherlakota defends that financing a government stimulus with debt or new money will end up having the same impact on the economy (Kocherlakota, 2016). Because central banks pay interest on reserves, any new money created would eventually have the same cost as if the fiscal authority borrowed it. So, he argues, there is no need for helicopter money.

In my opinion Kocherlakota's argument hinges on the assumption that the government can sell bonds at an equal rate as the central bank deposit rate. This means that private agents don't believe in a sovereign debt default, and see it as a safe asset. In this situation, the problem that fiscal policy faces that requires the cooperation of monetary policy (McCulley & Pozsar, 2013) would no longer exist. The government could use fiscal policy to stimulate the economy and generate inflation (with a passive response by the central bank), without the need for help from monetary policy. However, Kocherlakota's argument is well in noting that money has a cost too, not just debt. In a situation where the government is considered credible and no risk premium is charged on public debt, increasing base money would end up increasing reserves at the central bank, and the interest the government would save in bonds would be offset by less dividends from the central bank. However, this argument does not hold in a world where fiscal authorities face credibility problems when public debt gets too high, thus losing power to stimulate the economy by themselves. In the case of public debt crisis, governments may face

positive risk premiums, which makes it effectively cheaper for the central bank to create money instead of the fiscal authority issuing bonds (helicopter money is not cost-free though, just a cheaper option in this case).

Claudio Borio et al. claim that embarking on helicopter money means to give up entirely on monetary policy. The basis of the argument rests on the lack of consideration for realistic interest rates by the central banks (Borio, Disyatat, & Zabai, 2016).

If a central bank decides to engage in monetary finance, what are the consequences for its balance sheet? It ultimately depends on which way the central bank decides to it. If the central bank decides to buy government bonds and commits to roll them over perpetually, there would be an expansion of the central bank balance sheet (increase in government bonds and base money). If the central bank decides to write down public debt, replace it with non interest bearing perpetuities (which have a value of 0) or just transfer new money to individuals, it would have a negative impact on central bank equity.

Chapter 3

Modelling and simulation

In this chapter I will describe the features and assumptions of the model economy. It is a new Keynesian DSGE model with Calvo pricing featuring helicopter money. In this framework, helicopter money is defined as the amount of money in the economy that is permanent. Let's assume that the model economy has a single nominal interest rate which is controlled by the central bank by changing the amount of monetary base supplied to the economy. To simplify matters, assume that there is no intermediate banking, so that the monetary base is equal to money supply. To increase the quantity of money in circulation and reduce the nominal interest rate the central bank purchases riskless bonds from the household sector. By selling bonds back to the households the central bank reduces money supply and therefore raises interest rates. However, in this last case, the central bank may find itself without bonds left in its balance sheet to sell, becoming unable to decrease the quantity of money and increase the interest rate any further. Let's assume a money demand function,

$$m_t = y_t - \eta r_t \quad (3.1)$$

where m_t is the natural log of real money demand, y_t represents the natural log of real output, r_t is the nominal interest rate and $\eta \geq 0$ represents the semi-elasticity of money demand. Let's define H_t as helicopter money. Instead of being considered an expansionary fiscal policy financed by money creation, as Bernanke (2016) defines it, helicopter money will take other meaning in this model. In this framework, helicopter money is defined as the minimum amount of money in circulation the central bank can achieve by selling bonds in its balance sheet. An increase in helicopter money can be interpreted as a giveaway of money to the economy, without resorting to the trade of bonds. However, a simple increase in helicopter money will not lead to an increase in money supply, which would continue to be dependent on equation (3.1).

Let's define \bar{r}_t as the maximum interest rate the central bank can achieve. From equation (3.1) we get the maximum interest rate

$$\bar{r}_t = \frac{1}{\eta}(y_t - h_t) \quad (3.2)$$

where $h_t \equiv \ln H_t$. From the equation above we can see that helicopter money has the effect of limiting monetary policy by restricting the interest rate the central bank can set. Even though the central bank sets both the interest rate (following a Taylor rule) and helicopter money, these are two different instruments of monetary policy. While the former aims at keeping output gap and inflation close to a target level the latter can be thought of as a self-induced constraint on future (restrictive)

monetary policy. As a measure of the importance of this self-induced constraint, we have τ_t . Let's define τ_t as

$$\tau_t \equiv \bar{r}_t - r_t, \tau \geq 0 \quad (3.3)$$

where τ_t describes how close the central bank is to become unable to raise interest rates any further (a lower τ_t means a more constrained central bank).

Using equations (3.1) and (3.2) we can describe the constraint using money supply and helicopter money.

$$\tau_t = \frac{1}{\eta}(m_t - h_t) \quad (3.4)$$

3.1 Household's problem

The representative infinitely-lived household maximizes the following intertemporal utility function:

$$\max U_t = E_t \sum_{i=0}^{\infty} \beta^{t+k} u(C_{t+k}, N_{t+k}) \quad (3.5)$$

where C_t is the quantity of the single good consumed, N_t is the number of hours worked and β is the gross rate of intertemporal discount of utility.

The representative household then allocates her consumption between a set of consumption goods given by:

$$C_t \equiv \left(\int_0^1 C_t(i)^{1-\frac{1}{\epsilon}} di \right)^{\frac{\epsilon-1}{\epsilon}} \quad (3.6)$$

The representative household faces a period budget constraint of:

$$\int_0^1 P_t(i)C_t(i)di + Q_tB_t = B_{t-1} + W_tN_t \quad (3.7)$$

where P_t is the price of the consumption good, B_t represents one-period riskless bonds, bought in period t and maturing in $t + 1$. Q_t is the price of a bond, which gives 1 unit of money at maturity and W_t represents the nominal wage.

To avoid a situation where the household enters in a Ponzi-scheme, a solvency constraint is needed:

$$\lim_{T \rightarrow \infty} E_t\{B_T\} \geq 0 \quad (3.8)$$

Each good (i) faces a demand given by the following demand function

$$C_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\epsilon} C_t \quad (3.9)$$

where the price level is given by following equation.

$$P_t \equiv \left(\int_0^1 P_t(i)^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}} \quad (3.10)$$

The aggregate nominal consumption is given by the equation below.

$$\int_0^1 P_t(i)C_t(i)di = P_tC_t \quad (3.11)$$

From equations (3.7) and (3.11) we get the budget constraint for the representative household below.

$$P_t C_t + Q_t B_t = B_{t-1} + W_t N_t \quad (3.12)$$

Assuming a period utility function

$$u(C_t, N_t) \equiv \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi}$$

we get the following optimality conditions

$$w_t - p_t = \sigma c_t + \varphi n_t \quad (3.13)$$

$$c_t = E_t c_{t+1} - \frac{1}{\sigma} (r_t - E_t \pi_{t+1} - \rho) \quad (3.14)$$

where lower case letters represent the natural log of the of corresponding upper case letter (i.e. $w_t \equiv \log W_t$), and the nominal interest rate and household's discount rate are defined respectively as: $r_t \equiv -\log Q$ and $\rho \equiv -\log \beta$.

Now let's assume that the interest rate constraint, given by $-\tau_t$, has two different effects on economic agents' expectations. One affects expectation of future consumption, and the other the expectations of future inflation. A higher constraint (lower τ_t), increases the probability of future interest rates being lower than expected in the case of a central bank not constrained. This effect has a positive impact on expected future consumption and is captured in the model by $-\kappa\tau_t$, where κ is the parameter that represents the future consumption effect. The effect on the expectations of future inflation, arises from the fear of monetary policy falling out of control of the central bank, since the central bank loses the ability to control an positive inflation shock if the interest rate reaches \bar{r}_t . This effect is captured in

the model by $-\frac{1}{\sigma}\omega\tau_t$, where ω is the parameter that represents the future inflation effect. Note that $-\kappa\tau_t$ and $-\frac{1}{\sigma}\omega\tau_t$ both have a positive impact on consumption, when the constraint (and helicopter money) increases. These effects lead to the Euler equation shown below.

$$c_t = E_t c_{t+1} - \frac{1}{\sigma}(r_t - E_t \pi_{t+1} - \rho) - \frac{1}{\sigma}\omega\tau_t - \kappa\tau_t \quad (3.15)$$

3.2 Firm's problem

The firms in the model economy set prices in a Calvo price setting. Each firm has a probability θ of not resetting its price each period. The optimal frictionless price (p_t^*) for firms is achieved by each firm wanting to charge a fixed markup (μ) over the marginal cost mc_t (in logs), as stated in equation (3.18). The representative firm chooses its price to minimize the loss function (3.16).

$$L(z_t) = \sum_{k=0}^{\infty} (\theta\beta)^k E_t (z_t - p_{t+k}^*)^2 \quad (3.16)$$

where z_t is the price set by the proportion $(1 - \theta)$ of firms that reset their prices in period t .

$$z_t = (1 - \theta\beta) \sum_{k=0}^{\infty} (\theta\beta)^k E_t p_{t+k}^* \quad (3.17)$$

$$p_t^* = \mu + mc_t \quad (3.18)$$

The price level in period t is given by the weighted average of the price level in period $t - 1$ and the new price set by firms in period t .

$$p_t = \theta p_{t-1} + (1 - \theta)z_t \quad (3.19)$$

It is also assumed that the real marginal cost $\hat{m}c_t^r$ is a function of real output y_t , with γ being the real output elasticity of real marginal costs.

$$\hat{m}c_t^r = \gamma y_t \quad (3.20)$$

Inflation ($\pi_t = p_t - p_{t-1}$) can then be written as equation (3.21), where x_t is the output gap and y^* represents the potential output level, which is set to zero for simplicity,

$$\pi_t = \beta E_t \pi_{t+1} + \lambda x_t \quad (3.21)$$

where λ and x_t are defined as

$$\lambda \equiv \gamma \frac{(1 - \theta)(1 - \theta\beta)}{\theta} \quad (3.22)$$

$$x_t \equiv y_t - y^* \quad (3.23)$$

The effect on the expectations of future inflation is also felt in equation (3.21), and it is captured in the AS equation below as $-\beta\omega\tau_t$.

$$\pi_t = \beta E_t \pi_{t+1} + \lambda x_t - \beta\omega\tau_t \quad (3.24)$$

3.3 The equilibrium

The goods market clearing condition is given the following condition.

$$y_t = c_t \quad (3.25)$$

IS equation:

Putting together the Euler equation (3.15) and the goods market clearing condition (equation 3.25) and adding a demand shock u_t , we get the IS equation .

$$x_t = E_t x_{t+1} - \frac{1}{\sigma}(r_t - E_t \pi_{t+1} - \rho) - \left(\frac{\omega}{\sigma} + \kappa\right)\tau_t + u_t \quad (3.26)$$

where $u_t = \rho_u u_{t-1} + \varepsilon_t^u, \varepsilon_t^u \sim (0, 1)$

AS equation:

To find the AS equation we only need to add a supply shock v_t to (3.24)

$$\pi_t = \beta E_t \pi_{t+1} + \lambda x_t - \beta \omega \tau_t + v_t \quad (3.27)$$

where $v_t = \rho_v v_{t-1} + \varepsilon_t^v, \varepsilon_t^v \sim (0, 1)$

Interest rate rule:

The central bank follows a Taylor rule in order to determine the nominal interest rate at any period t ,

$$r_t = r^n + \gamma_\pi (\pi_t - \pi^*) + \gamma_x (x_t - x^*), (\gamma_\pi, \gamma_x) > 0 \quad (3.28)$$

where γ_π and γ_x are respectively the weight of inflation and output in the Taylor rule, π^* and x^* are the central bank's inflation and output targets and r^n is the natural interest rate.

Money demand

By adding a shock to the money demand (equation (3.1)), we get,

$$m_t = y_t - \eta r_t + s_t \quad (3.29)$$

where $s_t = \rho_s s_{t-1} + \varepsilon_t^s, \varepsilon_t^s \sim (0, 1)$

Helicopter money

The final assumption is that helicopter money follows an autoregressive process given by

$$h_t = \rho_h h_{t-1} + \varepsilon_t^h \quad (3.30)$$

where ρ_h is the persistence of the helicopter money shock and ε_t^h a shock, .

Full model

By plugging equations (3.1) and (3.28) into equation (3.4) we get the expression below.

$$\tau_t = \frac{1}{\eta} ((1 - \eta\gamma_x)x_t - h_t + s_t) - \gamma_\pi \pi_t \quad (3.31)$$

For simplicity let's define a as:

$$a \equiv \frac{\omega}{\sigma} + \kappa$$

The next step is simply to insert the equations (3.28) and (3.31) into the IS and AS equations and add the four shocks and we get the full model.

$$E_t x_{t+1} + \frac{1}{\sigma} E_t \pi_{t+1} = \left(1 + \frac{\gamma_x}{\sigma} + a \left(\frac{1}{\eta} - \gamma_x\right)\right) x_t + \left(\frac{1}{\sigma} - a\right) \gamma_\pi \pi_t - \frac{a}{\eta} h_t - u_t + \frac{a}{\eta} s_t \quad (3.32)$$

$$\beta E_t \pi_{t+1} = -\left[\lambda + \beta \omega \left(\gamma_x - \frac{1}{\eta}\right)\right] x_t + (1 - \beta \omega \gamma_\pi) \pi_t - \frac{\beta \omega}{\eta} h_t + \frac{\beta \omega}{\eta} s_t - v_t \quad (3.33)$$

$$h_{t+1} = \rho_h h_t + \varepsilon_{t+1}^h \quad (3.34)$$

$$u_{t+1} = \rho_u u_t + \varepsilon_{t+1}^u \quad (3.35)$$

$$v_{t+1} = \rho_v v_t + \varepsilon_{t+1}^v \quad (3.36)$$

$$s_{t+1} = \rho_s s_t + \varepsilon_{t+1}^s \quad (3.37)$$

3.4 Numerical Simulation

In this section I will simulate the behavior of the main variables of the model using impulse response functions (IRF's) of each shock present for different parameters. The baseline calibration of the parameters can be seen in the Matlab routine used to generate the IRF's that is available in Annex 1.

We can write the model in matrix form:

$$\begin{aligned}
 & \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & \frac{1}{\sigma} \\ 0 & 0 & 0 & 0 & 0 & \beta \end{bmatrix} \times \begin{bmatrix} E_t h_{t+1} \\ E_t u_{t+1} \\ E_t v_{t+1} \\ E_t s_{t+1} \\ E_t x_{t+1} \\ E_t \pi_{t+1} \end{bmatrix} = \\
 & \begin{bmatrix} \rho_h & 0 & 0 & 0 & 0 & 0 \\ 0 & \rho_u & 0 & 0 & 0 & 0 \\ 0 & 0 & \rho_v & 0 & 0 & 0 \\ 0 & 0 & 0 & \rho_s & 0 & 0 \\ -\frac{a}{\eta} & -1 & 0 & \frac{a}{\eta} & 1 + a\left(\frac{1}{\eta} - \gamma_x\right) + \frac{\gamma_x}{\sigma} & \left(\frac{1}{\sigma} - a\right)\gamma_\pi \\ -\frac{\beta\omega}{\eta} & 0 & -1 & \frac{\beta\omega}{\eta} & -\left[\lambda + \beta\omega\left(\gamma_x - \frac{1}{\eta}\right)\right] & 1 - \beta\omega\gamma_\pi \end{bmatrix} \times \begin{bmatrix} h_t \\ u_t \\ v_t \\ s_t \\ x_t \\ \pi_t \end{bmatrix} \\
 & + \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \times \begin{bmatrix} \varepsilon_{t+1}^h \\ \varepsilon_{t+1}^u \\ \varepsilon_{t+1}^v \\ \varepsilon_{t+1}^s \end{bmatrix}
 \end{aligned}$$

3.4.1 Shocks in helicopter money

Figure 3.1 displays the IRF's of a unit shock on h_t , the helicopter money variable, with a shock persistence ρ_h of 0.6 and $\kappa = 0.02$. Output and inflation both increase with the shock. The figure also shows how ω affects the response of output gap and inflation. A higher ω , would lead to a sharper response of inflation to helicopter

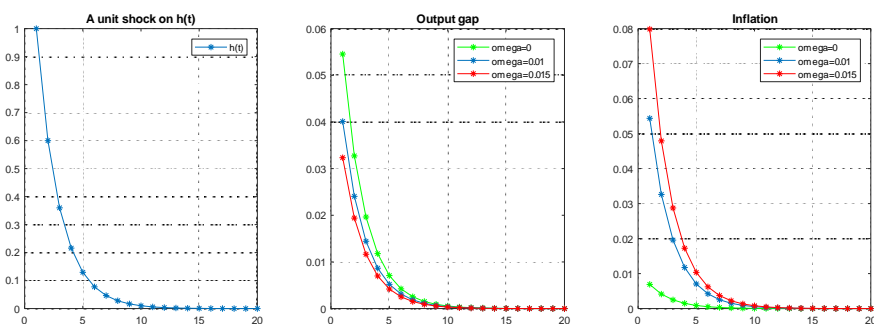
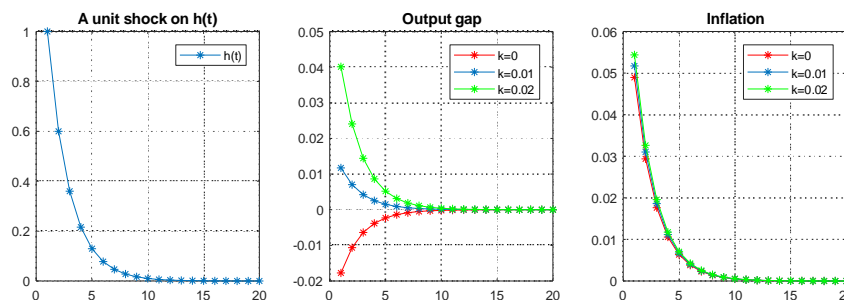


Figure 3.1: IRF's of a helicopter money shock ($\kappa = 0.02$)

money and a smaller increase of output gap. This happens because the central bank is still setting interest rates and following a Taylor rule. Even though a higher expectation of inflation in the future as an effect of increasing both output and inflation in the first place, the rise of the interest rate to control inflation offsets the positive effect on output gap.

Figure 3.2 shows the impulse response functions of output gap and inflation, but this time for different values for κ . As expected, output increases more if κ is higher. If κ is sufficiently close to zero, a helicopter money shock decreases output gap. This happens because of the impact of helicopter money on inflation, and the increase in the interest rate to offset it causes a downward pressure on output gap. This result points to the conclusion that for helicopter money to be considered a viable policy option, κ needs to be high enough so that it counters the inflation effect given by ω .

The persistence of the shock is also a crucial factor in determining the effects of a helicopter money shock. A higher persistence means that the central bank will keep itself constrained for longer after taking the policy decision of increasing

Figure 3.2: IRF's of a helicopter money shock ($\omega = 1$)

helicopter money. A low persistence on the other hand will mean that the constraint that helicopter money creates is phased out quicker. Figure 3.3 shows the impulse response functions of unit shocks on helicopter money with different persistences. One can observe that a higher value for ρ_h leads to an increase in the response of inflation, from a 0.05% increase in the first period with $\rho_h = 0.6$ to an increase of 0.2% in the first period with $\rho_h = 0.9$, with the effect on inflation persisting even after 20 periods away from the shock. This effect on inflation puts downward pressure on output gap when the persistence of the shock is high. The result can be seen in the response of output to the shocks. For small values of ρ_h , an increase in the persistence will lead to a higher increase in output gap in response to the shock. However, after a certain threshold of ρ_h , the inflation pressure on interest rates of a higher persistence gets high enough to fully offset the positive effect. With $\rho_h = 0.9$ output gap even decreases 0.01% when subject to a unit shock of helicopter money. A helicopter money shock with $\rho_h = 0.6$, appears to be more effective at increasing output gap without the cost of too much inflation created.

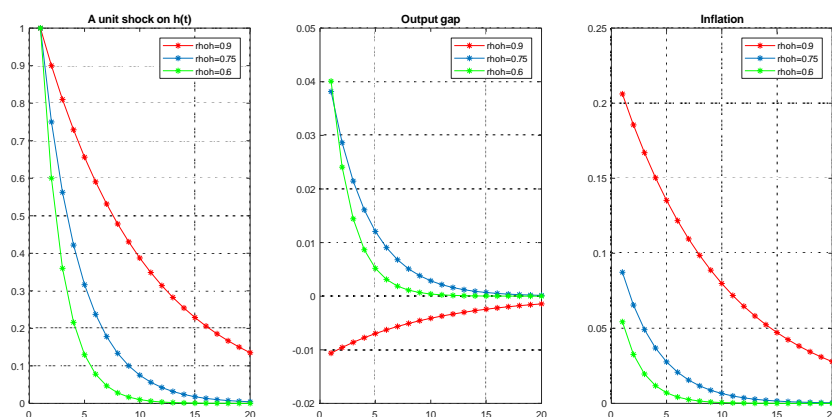


Figure 3.3: IRF's of a helicopter money shock ($\omega = 0.01$, $\kappa = 0.02$)

3.4.2 Money supply shock

We can see by looking at the figure 3.4, that a positive shock in the money supply has the exact opposite effect as a helicopter money shock, if the persistence of the shocks is equal. This could be explained by the fact that the channel through which money supply affects the economy is the same as the one used by helicopter money. An increase in money supply effectively reduces the interest rate constraint the central bank faces. This feature means that effect of helicopter money in the model economy will depend on money supply shocks as well. Figure 3.4 show the IRF's of a unit shock in the money supply, with a persistence (ρ_s) of 0.6, $\omega = 0.01$ and $\kappa = 0.02$.

This result points to the conclusion that for helicopter money to be considered a viable policy option, κ needs to be high enough so that it counters the inflation effect given by ω .

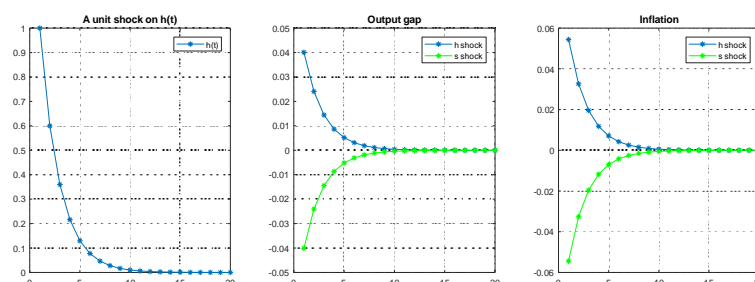
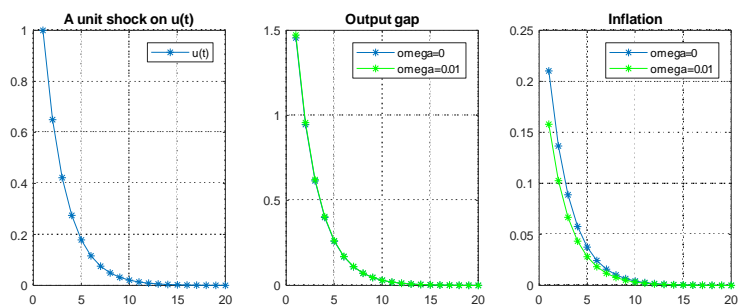
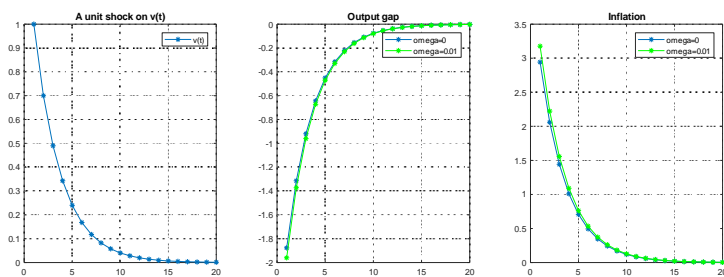


Figure 3.4: Helicopter money and money supply shocks

3.4.3 Shocks in demand and supply

I will now analyze how changes in ω affect shocks of demand (u) and supply (v). With the baseline parameters ($\omega = 0.01, \kappa = 0.02$) and a unit demand shock with a persistence (ρ_u) of 0.65 increases output gap by 1.5% and inflation by 0.15% in period 1, as figure 3.5 shows. However, reducing ω has the effect of a sharper increase in inflation in response to a demand shock, even with a similar response of output gap (see figure 3.5). This might be an effect of agents putting more weight (higher ω) on central bank's control over monetary policy when forming future inflation expectations. A higher value for ω would mean that although helicopter money shocks have worse effects on inflation, business cycles caused by demand shocks would lead to more stable inflation.

A positive unit shock on the supply side (v_t increases) with $\kappa = 0.02$ and $\omega = 0.01$ and $\omega = 0$ generates the IRF's depicted in figure 3.6. Output gap decreases by near 2% in period 1 while inflation increases in period 1 by 3%.

Figure 3.5: Demand shock ($\kappa = 0.02$)Figure 3.6: Supply shock ($\kappa = 0.02$)

3.5 Concluding Remarks

Helicopter money has becoming over the last five years one major monetary strategy (possibly) available to central banks and governments to combat long periods of economic stagnation. The fact that this strategy is not possible to be implemented from a legal point of view in most (if not all) advanced industrialized countries, does not mean that one should not enquire about its potentiality as an important new tool in monetary policy. I hope that this paper may shed some light in the huge discussions that have been taking place recently, by providing a simple framework in which helicopter money can be analyzed: the standard New Keynesian Model.

There is some relevant issues that we can clearly see from the model presented here. This model characterizes helicopter money as permanent money supply and exploits the consequences of the central bank constraining its capacity to tighten monetary policy in the future by choosing a contemporaneous increase in helicopter money. The main factors behind the behavior of the output gap and inflation are explained by the impact of this constraint upon the formation of future inflation and consumption expectations. The results lead us to the conclusion that for helicopter money to be considered as a viable policy option, the impact of the interest rate constraint on expected future consumption needs to be high enough so that it counter-balances its effect on expected future inflation.

Our model also seems to suggest that if private economic agents give a higher weight (or are more reactive) to helicopter money when forming their inflation expectations, helicopter money will have more adverse effects on the economy. How-

ever, the reaction of inflation to demand shocks becomes less sharp. This feature may give some support to the idea of keeping helicopter money away from the central bank's policy arsenal even if it could be a useful strategy in some extreme situations. The effect of stabilization of demand shocks, if economic agents become irrationally (or rationally) suspicious of helicopter money drops, can eventually overcome the drawback of not having the option available. However, a helicopter drop well planned by the central bank, announced to be phased out at the right rate may increase output at a mild cost of inflation.

One possible future development of the model would be to have the central bank operating at the zero lower bound, where it seems to be a better scenario to consider helicopter drops.

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Appendix A

Matlab code

```
beta=0.99;
sigma=2;
rn=0.02;
gama=0.6;
theta=0.75;
lambda=gama*(((1-theta)*(1-theta*beta))/theta);
gamapi=1.5;
gamax=0.5;
pistar=0;
xstar=0;
eta=0.5;
omega=0.01;
k=0.02;
a=(omega/sigma)+k;
rhoh=0.6;
```

```
rhov=0.65;
rhov=0.7;
rhos=0.75;
A=zeros(6,6);
A(1,1)=1;
A(2,2)=1;
A(3,3)=1;
A(4,4)=1;
A(5,5)=1;
A(5,6)=1/sigma;
A(6,6)=beta;
B=zeros(6,6);
B(1,1)=rhoh;
B(2,2)=rhov;
B(3,3)=rhov;
B(4,4)=rhos;
B(5,1)=-a/eta;
B(5,2)=-1;
B(5,4)=a/eta;
B(5,5)=1+a*((1/eta)-gamax)+(gamax/sigma);
B(5,6)=gamapi*((1/sigma)-a);
B(6,1)=-beta*omega/eta;
B(6,3)=-1;
```

```

B(6,4)=beta*omega/eta;
B(6,5)=-(lambda+beta*omega*(gamax-1/eta));
B(6,6)=1-beta*omega*gamapi
C=zeros(6,4);
C(1,1)=1;
C(2,2)=1;
C(3,3)=1;
C(4,4)=1
E=inv(A)*B
F=inv(A)*C
[vectors,eigenvalues]=eig(E)
val=diag(eigenvalues)
t=sortrows([val vectors'],1)
eigenvalues=diag(t(:,1))
vectors=t(:,2:7)
pstar=inv(vectors)
LAMBDA1=eigenvalues(1:4,1:4)
LAMBDA2=eigenvalues(5:6,5:6)
P11=pstar(1:4,1:4)
P12=pstar(1:4,5:6)
P21=pstar(5:6,1:4)
P22=pstar(5:6,5:6)
R=pstar*F

```

```

D=P11-P12*inv(P22)*P21;
f=-inv(P22)*P21
R1=R(1:4,:)
g=inv(D)*R1
z=inv(D)*LAMBDA1*D
n=20;
irf_h=zeros(6,n);
irf_u=zeros(6,n);
irf_v=zeros(6,n);
irf_s=zeros(6,n);
irf_h(1:4,1)=g*[1;0;0;0];
irf_u(1:4,1)=g*[0;1;0;0];
irf_v(1:4,1)=g*[0;0;1;0];
irf_s(1:4,1)=g*[0;0;0;1];
i=1;
for i=1:(n-1);
irf_h(1:4,i+1)=z*irf_h(1:4,i);
irf_u(1:4,i+1)=z*irf_u(1:4,i);
irf_v(1:4,i+1)=z*irf_v(1:4,i);
irf_s(1:4,i+1)=z*irf_s(1:4,i);
end;
irf_h(5:6,:)=f*irf_h(1:4,:);
irf_u(5:6,:)=f*irf_u(1:4,:);

```

```
irf_v(5:6,:)=f*irf_v(1:4,:);
irf_s(5:6,:)=f*irf_s(1:4,:);
irf_h=real(irf_h);
irf_u=real(irf_u);
irf_v=real(irf_v);
irf_s=real(irf_s);
h_h=irf_h(1,:);
u_h=irf_h(2,:);
v_h=irf_h(3,:);
s_h=irf_h(4,:);
x_h=irf_h(5,:);
pi_h=irf_h(6,:);
figure
subplot(231);plot(h_h,'-*');
legend('h(t)'); grid on;
subplot(232);plot(u_h,'-*');
legend('u(t)'); grid on;
subplot(233);plot(v_h,'-*');
legend('v(t)'); grid on;
title('A unit shock on h(t)')
subplot(234);plot(s_h,'-*');
legend('s(t)'); grid on;
subplot(235);plot(x_h,'-*');
```

```
legend('x(t)'); grid on;
subplot(236);plot(pi_h,'-*');
legend('pi(t)'); grid on;
h_u=irf_u(1,:);
u_u=irf_u(2,:);
v_u=irf_u(3,:);
s_u=irf_u(4,:);
x_u=irf_u(5,:);
pi_u=irf_u(6,:);
figure
subplot(231);plot(h_u,'-*');
legend('h(t)'); grid on;
subplot(232);plot(u_u,'-*');
legend('u(t)'); grid on;
subplot(233);plot(v_u,'-*');
legend('v(t)'); grid on;
title('A unit shock on u(t)')
subplot(234);plot(s_u,'-*');
legend('s(t)'); grid on;
subplot(235);plot(x_u,'-*');
legend('x(t)'); grid on;
subplot(236);plot(pi_u,'-*');
legend('pi(t)'); grid on;
```

```
h_v=irf_v(1,:);
u_v=irf_v(2,:);
v_v=irf_v(3,:);
s_v=irf_v(4,:);
x_v=irf_v(5,:);
pi_v=irf_v(6,:);
figure
subplot(231);plot(h_v,'-*');
legend('h(t)'); grid on;
subplot(232);plot(u_v,'-*');
legend('u(t)'); grid on;
subplot(233);plot(v_v,'-*');
legend('v(t)'); grid on;
title('A unit shock on v(t)')
subplot(234);plot(s_v,'-*');
legend('s(t)'); grid on;
subplot(235);plot(x_v,'-*');
legend('x(t)'); grid on;
subplot(236);plot(pi_v,'-*');
legend('pi(t)'); grid on;
h_s=irf_s(1,:);
u_s=irf_s(2,:);
v_s=irf_s(3,:);
```



```
s_s=irf_s(4,:);
x_s=irf_s(5,:);
pi_s=irf_s(6,:);
figure
subplot(231);plot(h_s,'-*');
legend('h(t)'); grid on;
subplot(232);plot(u_s,'-*');
legend('u(t)'); grid on;
subplot(233);plot(v_s,'-*');
legend('v(t)'); grid on;
title('A unit shock on s(t)')
subplot(234);plot(s_s,'-*');
legend('s(t)'); grid on;
subplot(235);plot(x_s,'-*');
legend('x(t)'); grid on;
subplot(236);plot(pi_s,'-*');
legend('pi(t)'); grid on;
```

Appendix B

Figures: IRF

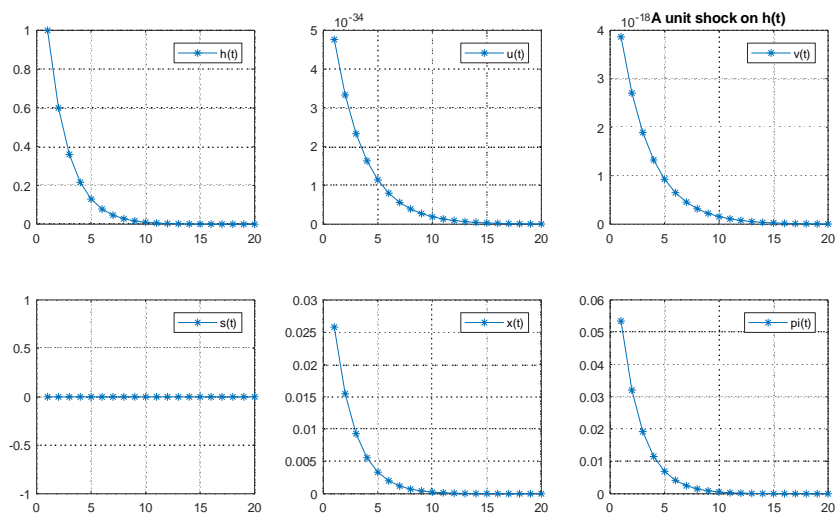


Figure B.1: IRF's of a helicopter money shock ($\omega = 0.01, \kappa = 0.02$)

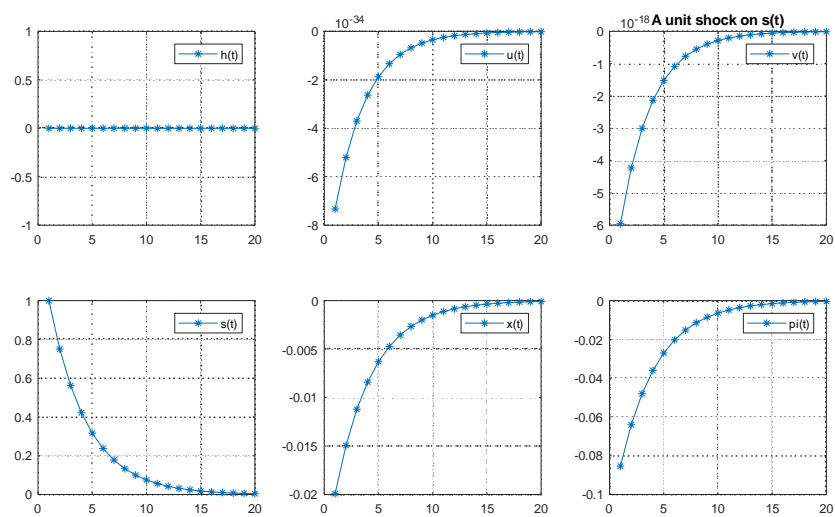


Figure B.2: IRF's of a money supply shock ($\omega = 0.01, \kappa = 0.02$)

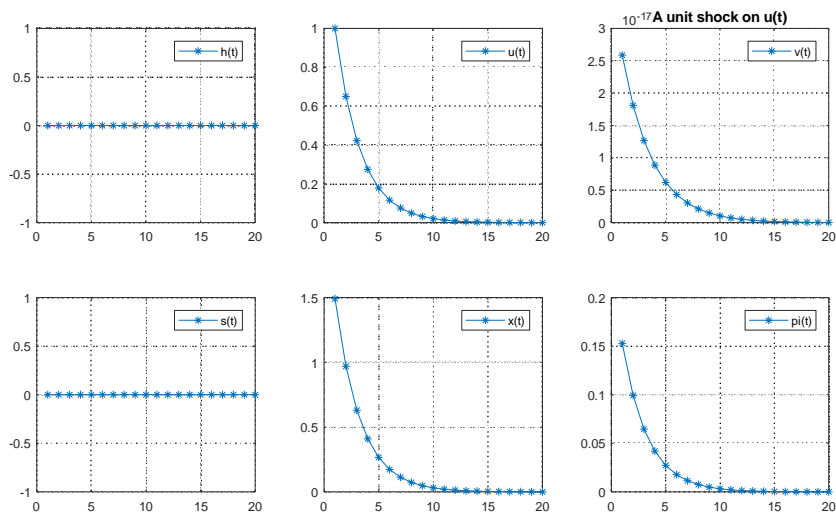


Figure B.3: IRF's of a demand shock ($\omega = 0.01, \kappa = 0.02$)

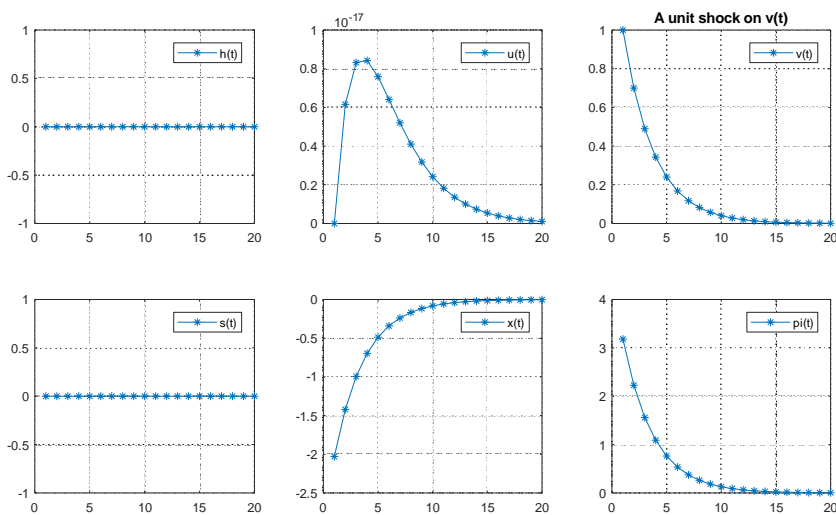


Figure B.4: IRF's of a supply shock ($\omega = 0.01, \kappa = 0.02$)