Fiscal Stabilization Policy Outside of the Zero Lower Bound

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Abstract

This paper revisits the traditional hierarchy of macroeconomic stabilization tools outside of the zero lower bound. In the benchmark New-Keynesian model monetary policy is always preferred to fiscal policy because fiscal policy has relative costs without delivering any relative benefits. I explore the robustness of this standard “monetary supremacy” result in three steps.

First, motivated by empirical work documenting large marginal propensities to consume out of predictable income changes, I introduce hand-to-mouth consumers into the benchmark model. Such non-optimizing agents amplify the stimulative effects of tax and spending changes. However, I find that even in a model with large fiscal multipliers, there remains no role for fiscal policy outside of the zero lower bound. Although fiscal policy is potent in this scenario, it nevertheless diverts real resources, while monetary policy remains able to implement the first best allocation without imposing any economic distortions.

Second, I explore four other environments where fiscal policy has benefits relative to monetary policy. These include introducing uncertainty about the effectiveness of monetary and fiscal policy (appealing to the logic that it is better to use two tools with independent errors than only one tool alone), adding adjustment costs to give monetary policy a longer implementation lag than fiscal policy (matching the data on impulse responses to policy shocks), introducing heterogeneous agents with varying welfare weights (recognizing that fiscal policy can more easily target assistance), and allowing for fiscal policy to act as a signaling mechanism in a game of incomplete information and coordination failures.

Finally, I turn to the question of relative costs, appealing to the finance literature which argues that low interest rates may instigate or propagate asset bubbles, promote maturity mismatch and excessive leverage, and redistribute across agents. I propose a path for examining optimal countercyclical policy in environments where monetary policy might be forced to trade off gains in price stability and full employment against the potential costs of financial instability.
1 Introduction

Benchmark modern macroeconomic models reject any role for countercyclical fiscal policy outside of the zero lower bound. Using common New-Keynesian models, authors such as Werning (2012), Woodford (2011), Carreia, Farhi, Nicolini, and Teles (2011), and Mankiw and Weinzierl (2011) find a role for fiscal policy only when the power of monetary policy is substantially weakened by the zero bound. When the interest rate is free to adjust, monetary policy can costlessly achieve the first-best allocation, rendering fiscal policy redundant.

This robust “monetary supremacy” result seems to have been ignored by policymakers over the last decade. In 2001, 2003, and 2008, when the U.S. economy was away from the lower bound, U.S. policymakers implemented fiscal policies which they defended to varying degrees on macroeconomic stabilization grounds. Is there any justification for such countercyclical fiscal policy?

In this paper, I revisit the traditional hierarchy of macroeconomic stabilization tools outside of the zero lower bound. I begin by examining the foundations of the “monetary supremacy” result, showing that in the benchmark model monetary policy is always preferred to fiscal policy because compared to monetary policy, fiscal policy has relative costs without delivering any relative benefits. I then explore straightforward extensions of the model, motivated by empirical evidence, which call into question the balance of relative costs and benefits of fiscal and monetary policy and hence the supremacy of monetary policy as a stabilization tool.

To examine the foundations of the “monetary supremacy” result, I present a standard New-Keynesian model incorporating both fiscal and monetary policy, and discuss the optimal stabilization problem in this model. Outside of the liquidity trap, government spending can not do anything to improve welfare that the monetary authority can not accomplish. Pushing spending past the flexible price optimal level would entail real distortions without helping to relax any constraints. Increasing government spending above the Samuelsonian level would only improve welfare if it relaxed a binding constraint. But in this environment, government spending only relaxes constraints through its role generating inflation. In this sense, government spending can help change the real interest rate. But when the nominal interest rate is free to adjust, there is no need for government spending in order to achieve a desired level of the real interest rate. Moving the nominal rate can achieve the same objective without any distortion. By contrast, although government spending has no beneficial effect which monetary policy cannot achieve, it does divert real resources. Hence monetary policy is preferred because fiscal policy entails relative costs without generating any relative benefits. The rest of the paper explores the robustness of this result.

I first turn to the question of relative benefits. Motivated by empirical work documenting large marginal propensities to consume out of predictable income changes (Parker et al. 2011, Ganong and Noel 2017), I introduce hand-to-mouth consumers in the spirit of Campbell and Mankiw (1989) into the benchmark new-Keynesian model. As Farhi and Werning (2012) have shown, the presence of such hand-to-mouth consumers can substantially amplify the impact of government tax and spending changes. This may in principle make fiscal policy more attractive. However, I find that
even in a model with liquidity constrained consumers and large fiscal multipliers, there remains no role for fiscal policy outside of the zero lower bound. Although fiscal policy is potent in this scenario, it nevertheless diverts real resources and distorts the efficient allocation of spending across the economy. In contrast, I show that monetary policy remains able to implement the first best allocation without imposing any economic distortions. This conclusion formalizes the intuition that for fiscal policy to have a role, it must not only be able to achieve outcomes that monetary policy can not achieve, but these outcomes must be inherently desirable. This condition is met in the other scenarios discussed in this paper.

I discuss four other reasons why fiscal policy might have benefits relative to monetary policy which are not accounted for in the benchmark model. First, I explore the impact of removing the assumption that fiscal and monetary authorities have perfect information about the state of the economy and the impact of their instruments. Instead, I assume that both instruments impact the real economy with some error. Following the logic of Brainard (1967), I argue that as long as the error terms of each instrument are independent, policymakers will make fewer mistakes on average by combining them than by using either instrument alone. The argument in favor of fiscal policy is strengthened if we consider the evidence that fiscal policy may become more potent when exogenous shocks depress the economy, while monetary policy becomes less potent. As Brainard showed, the instrument which leans against the wind should be relatively preferred in an environment of uncertainty.

Second, I argue that the case for monetary supremacy is weakened when we consider the empirical evidence showing that monetary policy changes take six months to one year to impact the real economy. This is a significant limitation considering that the average recession lasts 11 months. By contrast fiscal policy, especially government spending, immediately impacts output (thus fiscal policy has a shorter “outside lag”). Of course, it may be more difficult to implement fiscal than monetary policy changes in the first place (the so-called “inside lag”), but that is a constraint of the political system, not an economic constraint.

Third, I argue that in models with heterogeneous agents such as McKay and Reis (2012), monetary policy is a blunt instrument. It can lift the overall level of economic activity, but it can not target assistance directly. When the costs of recessions vary significantly across groups, fiscal policy is better able to target those affected if the traditional insurance mechanisms break down or are imperfect to start with.

Fourth, I briefly consider the benefits of fiscal policy in models of incomplete information and strategic complementarities. In such models (starting with Diamond 1982), government spending can act as a coordinating mechanism, helping to bring buyers and sellers together and ensuring the economy lands on the "good" equilibrium.

I then turn to the question of relative costs. In the standard macro models such as the one I present in this paper, low interest rates are assumed to spur consumption and investment with no real costs or distortions. By contrast, in the finance literature low interest rates are not always benign. In particular, low rates are sometimes found to instigate or propagate asset bubbles,
promote maturity mismatch and excessive leverage, and redistribute across agents. Authors such as Jensen and Meckling (1976), Allen and Gale (2000), Rajan (2006) and Hanson and Stein (2012) argue that low interest rates can cause asset prices to diverge from fundamentals, propping up bubbles which are liable to collapse with costly consequences. Others, such as Diamond and Rajan (2012) and Farhi and Tirole (2012b), find that low interest rate policies in bad times can encourage maturity mismatch and excessive leverage. Manuelli and Sargent (2010) and Farhi and Tirole (2012b) also emphasize that low interest rates redistribute resources from savers, often households, to borrowers, often banks and entrepreneurs. In total, this literature suggests that monetary policy may have important implications for financial stability, implications which are ignored by the macro literature on optimal countercyclical policy.

I discuss the finance literature on monetary policy distortions, identifying features of models which are promising for an analysis of optimal countercyclical policy when monetary policy causes real distortions. In particular, I argue that the risk shifting models from Allen and Gale (2000) and Hanson and Stein (2012), and the maturity mismatch and inefficient investment model of Farhi and Tirole (2012b), provide promising building blocks.

The paper proceeds as follows. In Section 2, I present the benchmark New-Keynesian model, characterize optimal fiscal policy, and explain the monetary supremacy result. This is used as a comparison point for the later extensions. In Section 3, I consider extensions to the baseline model which generate benefits of fiscal policy relative to monetary policy. In section 4 I consider extensions which account for relative costs, in particular examining potential distortions caused by monetary policy in asset markets. Section 5 concludes.

2 Optimal Fiscal Stabilization Policy in a Benchmark New Keynesian Model

In this section, I discuss the key components of the New Keynesian Model when government is included. This follows the treatment in Farhi and Werning (2012) and Woodford (2011). I discuss the key components here in order to emphasize which assumptions are crucial for the role of fiscal policy.

2.1 Setup

Households. Initially, we assume a representative household with preferences represented by the additively separable utility function

\[ \int_0^\infty e^{-\rho t} \left[ \frac{C_t^{1-\sigma}}{1-\sigma} + \frac{G_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\phi}}{1+\phi} \right] dt, \tag{1} \]

where \( N_t \) is labor and \( C_t \) is the Dixit-Stiglitz aggregator of consumption over different varieties
of goods for the representative household, defined by

\[ C_t = \left( \int_0^1 C_t(j) \frac{\epsilon - 1}{\epsilon} dj \right)^{\frac{1}{\epsilon - 1}}, \]

and where \( j \in [0, 1] \) denotes a variety of an individual good. With this type of CES consumption function, \( \epsilon \) will end up representing the price elasticity of demand between varieties, \( \epsilon = -\frac{\partial C_j}{\partial P_j} \frac{P_j}{C_j} \), where \( P_j \) is the price of consumption of variety \( j \).

The household’s problem is to maximize utility subject to the budget constraint (here denoted in terms of the evolution of bond holdings \( D_t \)),

\[ \dot{D}_t = i_t D_t + W_t N_t + \Pi_t + T_t - \int_0^1 P_t(j) C_t(j) dj \] (2)

for every \( t \geq 0 \). Here, \( W_t \) is the nominal wage, \( \Pi_t \) are nominal profits (since the representative agent owns the firm(s)), \( T_t \) is a nominal lump-sum transfer which can be positive or negative, and \( i_t \) is the nominal interest rate. This equation shows that assets tomorrow are equal to income today (from bonds, profits, transfers, and labor) minus expenditure on consumption.

**Government.** Government consumes an aggregate of varieties just like private consumption, i.e.

\[ G_t = \left( \int_0^1 G_t(j) \frac{\epsilon - 1}{\epsilon} dj \right)^{\frac{1}{\epsilon - 1}}. \]

For a given level of expenditure \( \int_0^1 P_{H.t}(j) G_t(j) dj \), the government chooses its expenditure across varieties to maximize the aggregate \( G_t \). Spending is financed by lump-sum taxes. Because there are complete markets, non-distortionary taxes, and infinitely lived agents, Ricardian Equivalence holds. For a given path of government spending, its financing via taxes or debt will be irrelevant. However, changes in the path of government spending will have real effects.

It is important to emphasize two critical assumptions about the government sector. First, the government and households consume exactly the same goods and have the same preferences substituting between these goods. Targeted government spending has no real meaning in this model (i.e. government won’t purposefully spend on roads and bridges rather than windmills and hospitals in any way that does not mimic individual preferences). Second, Ricardian equivalence holds. The financing of a given path of spending by taxes or debt has no impact. This will be relaxed with the introduction of hand-to-mouth consumers.

**Firms.** A continuum of firms produce a differentiated good (variety) with a linear production technology using only labor as an input,

\[ Y_t(j) = A_t N_t(j) \]
where $A_t$ is productivity.

We assume that the government is able to institute a constant employment tax $1 + \tau^L$, which means that the firm’s real marginal cost (initially $W_t - \frac{A_tP_t}{\lambda_t} = \frac{W_t}{A_tP_t}$) is now equal to $(1 + \tau^L)\frac{W_t}{A_tP_t}$. We can then assume that this tax is set to offset the monopoly distortion, hence it must be set at $\tau^L = -\frac{1}{\epsilon}$.

As with the traditional monopoly model, the firm sets its price as a markup over marginal cost, $P_t = \frac{\epsilon}{1-\epsilon}\frac{W_t}{A_tP_t} = A_t$. With the tax, it instead sets $P_t = \frac{\epsilon}{1-\epsilon}(1 + \tau^L)\frac{W_t}{A_tP_t} \Rightarrow \frac{W_t}{A_tP_t} = A_t$. This ensures that $MRS = \frac{-U_{Y,t}}{U_{P,t}} = \frac{W_t}{A_t} = MPN = MRT$. Hence with this tax, the flexible-price equilibrium will be the efficient equilibrium.

Prices are sticky. This is introduced using the standard Calvo price-setting framework. In continuous time, this implies assuming that in each instant, a random flow $\rho_\delta$ of firms can reset their prices. The other firms are forced to maintain constant prices. Firms that are able to reset their prices will choose these prices to maximize the expected present discounted value of profits they would obtain from setting a price in one period. This price will be in effect until they receive a future Calvo shock. Thus they chose $P^*_t$ to solve

$$\max_{P^*_t} \int_0^\infty e^{-\rho \delta - \int_0^\infty \delta t + s} d\tau \left( P^*_t Y_{t+s} - (1 + \tau^L)W_t \frac{Y_{t+s}}{A_t} \right),$$  \hspace{2cm} (3)$$

where $Y_{t+k} = \left( \frac{P^*_t}{P^*_{t+k}} \right)^{-\epsilon} Y_{t+k}$, taking the sequences for $W_t$, $Y_t$ and $P_t$ as given. The first term is the stochastic discount factor, which gives today’s price of an asset paying out a stream of dividends equal to the expected profit flow. In this way, the firm is maximizing today’s value of an asset that pays out a stream of nominal dividends equal to the firm’s expected profit in all future periods, given the price choice. The term in brackets is expected revenue in period $t + s$, which is a function of aggregate demand (itself a function of relative prices) minus expected cost for labor.

### 2.2 Equilibrium Conditions

In equilibrium, the goods and labor markets will clear, i.e.

$$Y_t = C_t + G_t$$

$$N_t = \frac{Y_t}{A_t} \Delta_t,$$

where $\Delta_t$ is an index of price dispersion $\Delta_t = \int_0^1 \left( \frac{P_{H,t}^j}{P_{H,t}} \right)^{-\epsilon}$. This expression comes from aggregating all of the firm labor demand, which is a function of consumer demand for varieties, which is itself a function of the relative price for variety $j$ relative to the overall price index.

Household maximization of $[1]$ subject to $[2]$ results in the traditional Euler equation of consumption growth

$$\frac{\dot{C}_t}{C_t} = \frac{1}{\sigma} (i_t - \pi_t - \rho).$$  \hspace{2cm} (4)$$

This is the normal condition, stating that consumption grows over time when the real interest
rate is greater than the individual’s discount rate, and the sensitivity of growth to differences in public and private discount rates is regulated by the elasticity of intertemporal substitution \( \frac{1}{\sigma} \).

Firm maximization proceeds in several steps, which I will describe heuristically, since the resulting New-Keynesian Phillips curve is well-known. Firms maximize \[3\]. Traditional monopolists set price as a markup over marginal cost. But with sticky prices, monopolists know that their prices might also be in place in future periods, so they incorporate this possibility by setting prices as a markup over the weighted average of current and expected future marginal costs. This price setting condition can then be manipulated to show the evolution of inflation, which naturally evolves according to the purposeful price setting decisions of firms. Following the logic above, inflation will be a function of current and expected deviations of real marginal costs from their steady state value. The next step is to relate firm marginal costs to the output gap. This requires clearing the goods and labor markets according to the conditions above, and manipulating the expressions from both firm and consumer optimization along with a definition of real marginal costs. The result of this is that we can express deviations of real marginal costs from their natural level as a function of the output gap, which is intuitive. When the output gap is large, firms travel up their convex cost curves and marginal costs increase (they need to pay higher wages to hire more labor). Putting these results together, we have that inflation is a function of expected deviations of real marginal costs from their steady-state value, and deviations of real marginal costs are a function of the output gap. Thus we have the basic intuition behind the New Keynesian Phillips curve, which relates inflation to expected inflation and the contemporaneous output gap, which itself is a combination of consumption and government spending gaps. We will present the log-linearized version below.

2.3 Log-Linearized Equilibrium Conditions

To analyze optimal policy, we will study the log-linearized equilibrium conditions around the natural allocation. For this, we want to write everything in terms of log-deviations from the natural (flexible-price) allocation. We denote the flexible price parameters with a bar as in \( \bar{C}_t, \bar{Y}_t \). We normalize deviations by the output, so they are percent deviations relative to output. Thus for consumption, we want \( \frac{C_t - \bar{C}_t}{\bar{Y}_t} \). We start by noting that

\[
\frac{C_t - \bar{C}_t}{\bar{C}_t} = \frac{C_t}{\bar{C}_t} - 1 \approx \ln \left( \frac{C_t}{\bar{C}_t} \right) = \ln \left( \frac{C_t}{\bar{C}_t} \right) = \ln(C_t) - \ln(\bar{C}_t)
\]

\[
\Rightarrow \frac{C_t - \bar{C}_t}{\bar{Y}_t - \bar{G}_t} \approx \ln(C_t) - \ln(\bar{C}_t)
\]

Defining \( \mathcal{G} = \frac{G}{\bar{Y}} \) we note that

\[
(1 - \mathcal{G}) = \left( \frac{Y - G}{Y} \right)
\]

And hence we define the log deviation of consumption from steady state (the private consump-
tion gap), normalized by output, as

\[ c_t = (1 - G)(\ln(C_t) - \ln(\bar{C}_t)) \approx \frac{Y - G}{Y} \left( \frac{C_t - \bar{C}_t}{Y_t - G_t} \right) = \frac{C_t - \bar{C}_t}{Y} \]

We do the same for output and government consumption\(^1\):

\[ y_t = \ln(Y_t) - \ln(\bar{Y}_t) \approx \frac{Y_t - \bar{Y}_t}{Y} \]

\[ g_t = \mathcal{G}(\ln G_t - \ln G) \approx \frac{G_t - G}{Y} \]

We now can use the market clearing condition for goods

\[ Y_t = C_t + G_t \Rightarrow y_t = c_t + g_t, \]

which holds to a first approximation.

Now that we have these log-linearized terms, we can use them to express our equilibrium conditions as log-linearized deviations from the natural allocation. We start with the Euler equation [4]. We difference this equation from the version at the flexible price equilibrium \[ \ddot{\bar{C}}_t = \frac{1}{\sigma}(\bar{r}_t - \rho) \]
which gives us

\[ \dot{c}_t = \frac{1}{\hat{\sigma}}(i_t - \pi_t - \bar{r}_t) \] \hspace{1cm} (5)

when \( \hat{\sigma} = \frac{\sigma}{1 - \sigma} \).

We now use the same approximations for the New Keynesian Phillips curve, which I described above. The key is that the output gap is a function of both consumption and government spending, which together account for total output. This yields

\[ \ddot{\pi}_t = \rho\pi_t - \kappa(c_t + (1 - \zeta)g_t) \] \hspace{1cm} (6)

where \( \lambda = \rho_s(\rho + \rho_s) \), \( \kappa = \lambda(\hat{\sigma} + \phi) \) and \( \zeta = \frac{\phi}{\hat{\sigma} + \phi} \). In this expression, \( \zeta \in (0, 1) \) represents the first best, flexible price equilibrium government spending multiplier on output. In the first-best, flexible price equilibrium, when government spending increases by 1 unit, output increases by \( \zeta \) units, and consumption falls by \( 1 - \zeta \) units. Thus if we are in the first-best with multiplier equal to \( \zeta \), the efficient output level in log-deviation terms is given by

\[ \zeta g = c + g \]

\[ \Rightarrow c + (1 - \zeta)g = 0 \]

This traditional neoclassical multiplier on output is less than 1 due to a pure wealth effect on labor supply. When government spending rises, lifetime wealth falls, so consumption of goods and

\(^1\)While these are the traditional expressions, the derivations imply we are being loose with the “bars” when we cancel numerator and denominator across expressions.
leisure falls.

2.4 Optimal Policy Problem and Benchmark Results

I now describe optimal fiscal policy in the basic New-Keynesian framework. The optimal policy problem is to maximize the expected utility of the representative agent subject to the structural equilibrium conditions which result from household and firm maximization, described in section 2.2. One straightforward method of tackling this problem is to construct a Lagrangian constrained optimization problem, maximizing the household’s non-linear objective function subject to the non-linear structural equilibrium conditions in 2.2. This is not always desirable for two reasons. First, the problem is messy. For example, calculating the solution to this problem would require keeping track of price dispersion across all product varieties and time periods. Second, the resulting optimal policy equations are non-linear and difficult to interpret. As a result, these equations are often linearized.

An alternative approach is to minimize a simple quadratic loss function based on the welfare of the representative agent subject to the log-linearized equilibrium conditions given by equations (5) and (6). As shown in Benigno and Woodford (2005), Woodford (2010), and Gali (2008), under certain conditions this alternative approach can directly deliver the same linearized optimality conditions that result from the alternative method described above. In particular, when linearizing around a zero inflation steady state where the flexible price equilibrium is efficient, the process of deriving the appropriate quadratic approximation to welfare is relatively straightforward in that it can be derived solely from the household’s objective function and the linearized equilibrium conditions.

If instead the point around which the linearization is taken (often the zero inflation steady state) is not efficient, then the equivalent quadratic objective function will need to account for second order terms in the approximations of the equilibrium constraints. Hence these quadratic functions cannot be derived directly from the household’s objective and the log-linearized equilibrium conditions. In this case, there are two approaches. First, as Woodford (2010) proposes, it is possible to find the linearized first order conditions from the first method, and work backwards towards a quadratic objective which would have delivered the same solution if maximized subject to the non-linear constraints. Second, it is possible to construct an “as if” quadratic objective function which incorporates the appropriate second order terms from the equilibrium equations, which can then be maximized subject to the linearized equilibrium constraints.

In our case, these methods are not necessary, since the zero-inflation steady-state is efficient as long as we assume a constant subsidy to production is implemented in order to undo the distortion caused by the monopoly markup. Starting from the continuous time New Keynesian model of the type described in this section, and assuming such a production subsidy, Werning (2012) produces the following quadratic objective as a second order approximation to welfare around a zero inflation
steady state when the flexible price equilibrium is efficient:

\[ L = \frac{1}{2} \int_0^\infty e^{-\rho t} \left( (c(t) + (1 - \zeta)\bar{g}_t)^2 + \lambda \pi_t^2 + \eta g_t^2 \right) dt \]  
(7)

where \( \eta \) is a function of underlying parameters capturing the relative cost of deviations of government spending away from its steady-state value. This expression is the familiar welfare term from models without government (with quadratics in the output gap and inflation), but with the addition of the government spending deviation. Government spending appears on its own in the objective function because public goods are valued in the utility function and because they affect the required amount of labor that must be provided for a given level of consumption through the resource constraint.

With this loss function, the planner’s problem is to:

\[
\min_{c, \pi, i, g} \frac{1}{2} \int_0^\infty e^{-\rho t} \left( (c(t) + (1 - \zeta)\bar{g}_t)^2 + \lambda \pi_t^2 + \eta g_t^2 \right) dt \\
\text{s.t.} \quad \dot{c}_t = \frac{1}{\sigma} (i_t - \pi_t - \bar{\pi}_t) \\
\quad \dot{\pi}_t = \rho \pi_t - \kappa (c_t + (1 - \zeta)\bar{g}_t) \\
\quad i_t \geq 0 \\
\quad x(0), \pi(0) \text{ free.}
\]

where the last constraint is the zero lower bound constraint. As explained above, the minimization of this quadratic loss function subject to the linearized equilibrium conditions (here the DIS and the NKPC) will generate the same linearized optimality conditions as solving the fully nonlinear model.

Werning (2012) uses optimal control to solve this particular presentation of the optimal policy problem (Propositions 6 and 7). For our purposes, the important conclusion is the following: Whenever the zero lower bound is not binding, the government spending gap is zero \( g_t = 0 \). The optimal level of government spending is driven entirely by the static Samuelsonian condition. Any necessary stabilization is achieved by adjusting the nominal interest rate in response to shocks. This “monetary supremacy” result is standard in the literature that jointly considers monetary and fiscal policy (Mankiw and Weinzierl 2011, Woodford 2011). The intuition is simple. Outside of the liquidity trap, government spending can not do anything to improve welfare that the monetary authority can not accomplish. There is nothing to gain from an increase in government spending beyond the Samuelson level. This is because pushing spending past the flexible price optimal level would entail real distortions without helping to relax any constraints. Inspection of the log-linearized system makes this clear. According to the quadratic objective function, the ideal level
of the government spending gap, given a level of the output gap and inflation, is always zero. Thus pushing government spending above the Samuelsonian level would only improve welfare if it relaxed a binding constraint. But in this environment, government spending only relaxes constraints through its role generating inflation, as can be seen in the NKPC. In this sense, government spending can help change the real interest rate. But when the nominal interest rate is free to adjust, there is no need for government spending in order to achieve a desired level of real interest rate. Moving the nominal rate can achieve the same objective without any distortion. This is the “divine coincidence” of countercyclical monetary policy.

In the benchmark model, fiscal policy only plays a stabilization role when the zero lower bound is binding. Werning (2012), for example, shows that government spending should be initially above its natural level, then should decline and fall below its natural level, before returning to zero. The intuition is that initially higher spending helps to compensate for the negative consumption gap. It is able to generate inflation, reducing the real interest rate and incentivizing consumption. It thus accomplishes precisely the goal that monetary policy can not directly accomplish. After the ZLB ceases to bind, monetary policy will engineer a consumption boom (also in order to try and influence inflation today), and government spending falls negative to “lean against the wind.” This boom is inefficient, since during this period output is pushed above its first-best, flexible price level. The inefficiency of the boom engineered by monetary policy is what creates a role for fiscal policy. Outside of the ZLB, monetary policy can achieve the first best without any distortion. But at the ZLB, monetary policy faces a trade-off. It can only reduce the output gap and stabilize prices (increasing welfare) by committing to an inefficient boom in the future (decreasing welfare). This trade-off introduces a role for fiscal policy, which is also inefficient in its own way (government spending is pushed above its own first-best level). By combining both inefficient instruments, the authorities can do better than if they used any one on its own.

Thus, in the benchmark model, outside of the zero lower bound there is no role for countercyclical fiscal policy. Compared to monetary policy, fiscal policy has relative costs without any relative benefits. This conclusion is pervasive in the literature and influences advice given to policymakers. The rest of this paper will consider the robustness of this result. In particular, I argue that straightforward extensions of the model, motivated by empirical evidence, call into question the balance of relative costs and benefits of fiscal and monetary policy and hence the supremacy of monetary policy as a stabilization tool.

If the fiscal policy instrument space is large enough, fiscal policy may not even be distortionary. Correia, Farhi, Nicolini, and Teles (2011) justify a much more rigorous role for fiscal policy at the zero bound. They argue that if there exists an investment tax credit as well as taxes on income, payroll, wages, consumption, and capital gains, then these instruments can be combined to mimic the effect of a negative real interest rate, achieving the desired perfect stabilization. The primary mechanism is to engineer an increasing path of consumption taxes and a decreasing path of labor taxes. This combination induces consumers to buy today. It would be interesting to combine this insight with some of my extensions below, seeing if this sort of unconventional fiscal policy might provide a further rationale for fiscal stabilization policy outside of the ZLB.
3 Relative Benefits of Fiscal Policy

In the standard New Keynesian model, there are no benefits of fiscal policy relative to monetary policy from the standpoint of macroeconomic stabilization. Government spending impacts consumption only through its effect on inflation, which in turn affects the real interest rate (Farhi and Werning 2012). Monetary policy can achieve the same impact on consumption via manipulation of the nominal interest rate. Empirical evidence suggests that this equivalence between fiscal and monetary policy channels does not exist in practice. For example, fiscal policy can have non-Ricardian, distributional, or temporal effects which differ from those of monetary policy. In this section, I consider ways to analyze optimal policy in environments where these differential benefits are taken into consideration.

3.1 Keynesian Demand Effects

One of the shortcomings of the benchmark model is the absence of any non-Ricardian effects. Empirical research, such as Parker et al. (2011), shows that temporary tax cuts increase spending in the near term for low-wealth consumers. Other recent research shows large effects of government spending and transfers which appear to be inconsistent with the benchmark model (Ganong and Noel 2017; Shoag 2010; Chodorow-Reich, Feiveson, Liscow and Woolston 2010). These results imply that fiscal stimulus may impact the economy through aggregate demand channels which are not present in the benchmark model. In the benchmark model, government spending impacts consumption only through its impact on inflation (what we will call “new-Keynesian effects”). The evidence, however, implies that more traditional “Keynesian” effects may be important.

If traditional non-Ricardian (Keynesian) channels are present, and these channels amplify the effect of fiscal policy, is monetary policy still “supreme” as a stabilization tool? To answer this question, I extend the baseline model, introducing non-traditional demand channels by adding liquidity constrained, “hand-to-mouth” consumers. I then explore optimal fiscal and monetary policy in this new environment.

3.1.1 Setup With Hand to Mouth Consumers

I follow Farhi and Werning (2012), who modify the benchmark model by assuming a fraction $1 - \chi$ of agents optimize normally while a fraction $\chi$ are hand-to-mouth (HM). I will denote by the $\tilde{\circ}$ superscript “optimizing” consumers, and by the * superscript rule-of-thumb or HM consumers. The hand-to-mouth agents are liquidity constrained and can neither borrow nor save. These agents simply consume their net labor income every period. As before, government pays for spending with lump-sum taxes, but these taxes are allowed to differ between optimizers ($t^o_t$) and hand-to-mouth agents ($t^*_t$).

Farhi and Werning (2012) log-linearize around the steady state where optimizers and hand-to-mouth consumers have the same consumption and supply the same labor. In the Appendix, I
derive the modified Euler and NKPC equations, which are given by:

\[ \dot{c}_t = \frac{1}{\tilde{\sigma}}(i_t - \bar{r}_t - \pi_t) + \tilde{\Theta}_n \dot{g}_t - \tilde{\Theta}_\tau \dot{r}_t, \quad (8) \]

\[ \dot{\pi}_t = \rho \pi_t - \kappa(c_t + (1 - \zeta)g_t) \quad (9) \]

where

\[ \tilde{\sigma}^{-1} = \frac{\tilde{\sigma}^{-1}}{1 - \Theta_n} \]

\[ \tilde{\Theta}_n = \frac{\Theta_n}{1 - \Theta_n} \]

\[ \tilde{\Theta}_\tau = \frac{\Theta_\tau}{1 - \Theta_n} \]

\[ \Theta_n = \chi(1 - \mathcal{G}) \frac{(1 + \phi)\phi}{\phi(1 - \mathcal{G})\mu + \sigma - \chi\sigma(1 + \phi)} \]

\[ \Theta_\tau = \chi(1 - \mathcal{G}) \frac{\mu\phi}{\phi(1 - \mathcal{G})\mu + \sigma - \chi\sigma(1 + \phi)} \]

\[ \mu = \frac{Y}{WNr} \]

The NKPC is unchanged. Government spending increases demand and causes monopolists to raise their prices, just as before, since their real marginal costs increase (wages) as they expand supply. However, there are now two new terms in the Euler equation. Consumption growth rises when government spending increases or taxes for hand-to-mouth consumers fall. These two new terms impact optimal policy.

### 3.1.2 Impact of Government Spending With Hand to Mouth Consumers

With hand-to-mouth consumers, fiscal policy (taxes and spending) now has a larger impact on consumption. In the Appendix, I follow Farhi and Werning (2012) and derive the consumption multiplier:

\[ c_t = -\tilde{\Theta}_\tau \dot{r}_t^\tau - \int_0^\infty \gamma_s^{c,\text{HM}} t_{t+s} e^{-\tilde{v}_s} ds + \tilde{\Theta}_n \dot{g}_t + \int_0^\infty \alpha_s^{c,\text{HM}} g_{t+s} ds \quad (10) \]

where

\[ \alpha_s^{c,\text{HM}} = \left( 1 + \frac{\tilde{\Theta}_n}{1 - \zeta} \right) \tilde{\alpha}_s^{c,\text{HM}} \]

\[ \tilde{\alpha}_s^{c,\text{HM}} = \tilde{\sigma}^{-1} \kappa(1 - \zeta) e^{-\tilde{v}_s} e^{(\tilde{v} - \tilde{v})s} - 1 \]

\[ \gamma_s^{c,\text{HM}} = \frac{\tilde{\Theta}_\tau}{1 - \zeta} \tilde{\alpha}_s^{c,\text{HM}} \]

\[ \tilde{\Theta}_n = \frac{\Theta_n}{1 - \Theta_n} \]

13
\[
\tilde{\Theta}_r = \frac{\Theta_r}{1 - \Theta_n}
\]
\[
\tilde{\nu} = \rho - \frac{\sqrt{\rho^2 + 4\kappa\mathcal{\tilde{\sigma}}^-}}{2}
\]
\[
\bar{\tilde{\nu}} = \frac{\rho + \sqrt{\rho^2 + 4\kappa\mathcal{\tilde{\sigma}}^-}}{2}
\]

Equation (10) shows that government spending and taxes affect consumption through four new channels:

1. [Keynesian impact of taxes today] First, lower taxes on hand-to-mouth consumers today increases their consumption. By design, we have assumed hand-to-mouth consumers have a marginal propensity to consume of one. These tax cuts are either financed by future hand to mouth consumers, or by current or future optimizing consumers who have lower marginal propensities to consume.

2. [New-Keynesian impact of taxes tomorrow] Second, lower taxes on hand-to-mouth consumers tomorrow stimulates consumption tomorrow, which increases inflation today and in the future, and therefore increases consumption of the optimizing agents today. When real interest rates fall, optimizing consumers have less incentive to save and more incentive to spend.

3. [Keynesian impact of spending today] Third, higher government spending today increases consumption of hand-to-mouth consumers. This occurs because government spending increases demand faced by producers, pushing them up their marginal cost curve and forcing them to pay higher wages. Hand-to-mouth consumers will consume all of these wage increases. Optimizing consumers will not consume all of their wage increases, since they will face higher taxes to compensate for the higher government spending (i.e. the traditional Ricardian channel).

4. [New-Keynesian impact of spending tomorrow] Finally, higher government spending tomorrow increases consumption of hand-to-mouth consumers tomorrow, increasing inflation today and thus increasing consumption of optimizing agents today.

As I have highlighted, taxes and government spending introduce additional traditional Keynesian effects by impacting income of hand-to-mouth consumers (through lower taxes or higher spending and therefore wages) as well as New-Keynesian effects by impacting income of hand-to-mouth consumers in the future, and therefore inflation today. Farhi and Werning (2012) conclude that these additional effects can generate very large multipliers, with two caveats. First, there is a trade-off between these new channels and the original channel. The original channel is that government spending today and in the future can generate inflation, which increases consumption of all agents today. But in the scenario with hand-to-mouth consumers, only a fraction of agents are optimizing. Thus the inflation channel only works through a subset of agents (though it is more potent because
inflation rises even more due to hand-to-mouth consumers). Nevertheless, it is not always true that multipliers will be larger for any parameterization.

Second, it is important to note that these additional effects only hold for constant interest rates. If the monetary authority had full flexibility, it could maintain the flexible price allocation with zero inflation by appropriately setting the nominal interest rate given any path of government spending and taxes. In such a scenario, the only consumption multiplier would be the neoclassical multiplier we discussed above, i.e. that \( c_t = - (1 - \zeta) g_t \). This is the static multiplier, whereby government spending crowds out consumption.

### 3.1.3 Setup of Optimal Policy Problem with Hand-to-Mouth Consumers

In this section, I explore the implications of the presence of such hand-to-mouth consumers on optimal fiscal policy. The goal is to compare optimal policy in an environment with hand-to-mouth consumers to optimal policy in the benchmark model discussed above.

We must begin by deriving an objective function for policy. Since there are two types of consumers, one baseline method would be to follow Curdia and Woodford (2009) and assume that the objective of the social planner is to maximize the average ex ante expected utility of households. In our setup, the objective function would be

\[
E_0 \int_0^\infty (1 - \chi) U^o + \chi U^r dt = (1 - \chi) \left\{ E_0 \int_0^\infty e^{-\rho t} \left[ \frac{(C^o_t)^{1-\sigma}}{1-\sigma} + \xi \frac{G^{1-\sigma}_t}{1-\sigma} - \frac{(N^o_t)^{1+\phi}}{1+\phi} \right] dt \right\} \\
+ \chi \left\{ E_0 \int_0^\infty e^{-\rho t} \left[ \frac{(C^r_t)^{1-\sigma}}{1-\sigma} + \xi \frac{G^{1-\sigma}_t}{1-\sigma} - \frac{(N^r_t)^{1+\phi}}{1+\phi} \right] dt \right\}
\]

(11)

In this objective function, each type of consumer receives welfare weight proportional to their share of the population. We could then maximize this objective function subject to the non-linear equilibrium conditions, then linearize the first order conditions in order to obtain a linear approximation to optimal policy.

As I discussed in section 2.4, under certain conditions we can derive a quadratic loss function which can then be minimized subject to the log-linearized structural constraints (equations (8) and (9)), providing the same linear approximation to optimal policy as we would get from maximizing (11). I assume that the appropriate loss function is the same as in the benchmark case (7). There are two justifications for this assumption. First, the system has been log-linearized around a steady-state where optimizers and hand-to-mouth consumers have the same consumption and supply the same labor. Assuming the monopoly distortion has been addressed with a production subsidy, this steady-state is efficient. If the flexible price steady state around which we are linearizing is efficient, then the quadratic approximation to welfare can be derived using only the household objective function and the linearized equilibrium conditions.

My second justification for using the benchmark loss function anticipates my findings. I will show that monetary policy is still able to perfectly stabilize this economy even in the presence of
hand-to-mouth consumers, and hence that there remains no role for countercyclical fiscal policy. This result is independent of the particular objective function chosen.

Given this loss function, the planning problem is the same as in the benchmark case, except that the DIS constraint is altered by the presence of HM consumers, and now $c_t = \chi c_t^r + (1 - \chi) c_t^0$, i.e. consumption is a weighted sum of optimizing and hand-to-mouth agent consumption. The social planner seeks to:

$$\min_{c, \pi, i, g, t} \frac{1}{2} \int_0^\infty e^{-\rho t} \left( (c(t) + (1 - \zeta) g_t)^2 + \lambda \pi_t^2 + \eta g_t^2 \right) dt$$

subject to

$$\dot{c}_t = \frac{1}{\sigma} (i_t - \bar{r}_t - \pi_t) + \tilde{\Theta}_n \dot{g}_t - \tilde{\Theta}_t \dot{l}_t^r,$$  

$$\dot{\pi}_t = \rho \pi_t - \kappa (c_t + (1 - \zeta) g_t)$$  

$$i_t \geq 0$$  

c(0), g(0), \pi(0) free.

It will be useful to transform the planning problem by a change of variables. I use the same change of variables proposed in Werning (2012). Define the output gap $x_t \equiv c_t + (1 - \zeta) g_t$. This implies

$$\dot{x}_t = \dot{c}_t + (1 - \zeta) \dot{g}_t$$

$$= (1 - \zeta) \dot{g}_t + \frac{1}{\sigma} (i_t - \bar{r}_t - \pi_t) + \tilde{\Theta}_n \dot{g}_t - \tilde{\Theta}_t \dot{l}_t^r$$

$$= (1 - \zeta + \tilde{\Theta}_n) \dot{g}_t + \frac{1}{\sigma} (i_t - \bar{r}_t - \pi_t) - \tilde{\Theta}_t \dot{l}_t^r$$

The planning problem becomes

$$\min_{x, \pi, i, g, t} \frac{1}{2} \int_0^\infty e^{-\rho t} \left( x_t^2 + \lambda \pi_t^2 + \eta g_t^2 \right) dt$$

subject to

$$\dot{x}_t = (1 - \zeta + \tilde{\Theta}_n) \dot{g}_t + \frac{1}{\sigma} (i_t - \bar{r}_t - \pi_t) - \tilde{\Theta}_t \dot{l}_t^r$$  

$$\dot{\pi}_t = \rho \pi_t - \kappa x_t$$  

$$i_t \geq 0$$  

$$x(0), \pi(0) free$$

This is an optimal control problem with $i, \dot{g}$ and $\dot{l}_t^r$ as controls and $x, \pi, g,$ and $t^r$ as states.\footnote{There may be another (potentially more correct) way to set up this problem. It is possible that we should not include $t^r$ as a state variable, since it does not show up anywhere. I have included it since its derivative $\dot{t}^r$ appears in...}
3.1.4 Optimal Fiscal and Monetary Policy With HM Consumers Outside the Zero Lower Bound

To solve the planning problem, I write the Hamiltonian associated with the optimal control system:

\[
H = \frac{1}{2} \left( x_t^2 + \lambda \pi_t^2 + \eta g_t^2 \right) + \mu_x \left[ (1 - \zeta + \tilde{\Theta}_n) \Delta_t + \frac{1}{\bar{\sigma}} (i_t - \bar{r}_t - \pi_t) - \tilde{\Theta}_t \Lambda_t \right] + \mu_\pi (\rho \pi_t - \kappa x_t) + \mu_g \Delta_t + \mu_\tau \Lambda_t
\]

where \( \dot{g}_t = \Delta_t \) and \( \dot{i}_t = \Lambda_t \) are the laws of motion for government spending and taxes on hand-to-mouth consumers and \( \Delta_t, \Lambda_t \in \mathbb{R} \) are new, unrestricted, control variables.

Solving, we first take the first order conditions with respect to each control variable \((i, \dot{g} = \Delta, \dot{i} = \Lambda)\), giving the following conditions:

\[
\frac{\partial H}{\partial \Delta} = 0 \Rightarrow \mu_x (1 - \zeta + \tilde{\Theta}_n) + \mu_g = 0 \quad (17)
\]

\[
\frac{\partial H}{\partial \Lambda} = 0 \Rightarrow -\mu_x \tilde{\Theta} + \mu_\tau = 0 \quad (18)
\]

The first order condition for \( i \) is more complicated, because the nominal interest rate is restricted by the zero lower bound. The normal unrestricted condition would be \( \frac{\partial H}{\partial i} = \mu_x \tilde{\sigma}^{-1} = 0 \), i.e. \( \mu_x = 0 \), but it can’t always be zero even when the zero lower bound is binding with \( i(t) = 0 \), so we need to add a condition saying that the co-state is zero when \( i(t) > 0 \) but might be positive when \( i(t) = 0 \). Intuitively, the multiplier being positive means that there is a shadow value of relaxing the constraint, which happens at the zero bound. Thus we have the complementary slackness condition:

\[
\mu_x(t) \geq 0 \quad (19)
\]

\[
i(t) \mu_x(t) = 0 \quad (20)
\]

Next, we use the maximum principle to recover the laws of motion for the co-states \((\mu_x, \mu_\pi, \mu_g, \mu_\tau)\) from the general condition \( \frac{\partial H}{\partial \text{state}} + \rho \mu_{\text{state}} = \mu_{\text{state}} \):

\[
\frac{-\partial H}{\partial x} + \rho \mu_x(t) = -x(t) + \kappa \mu_\pi(t) + \rho \mu_x(t) = \dot{\mu}_x(t) \quad (21)
\]

\[
\frac{-\partial H}{\partial \pi} + \rho \mu_\pi(t) = -\lambda \pi(t) + \tilde{\sigma}^{-1} \mu_x(t) = \dot{\mu}_\pi(t) \quad (22)
\]

\[
\frac{-\partial H}{\partial g} + \rho \mu_g(t) = -\eta g(t) + \rho \mu_g(t) = \dot{\mu}_g(t) \quad (23)
\]

\[
\frac{-\partial H}{\partial \tau} + \rho \mu_\tau(t) = \rho \mu_\tau(t) = \dot{\mu}_\tau(t) \quad (24)
\]

Finally, because both initial states for \( x(0) \) and \( \pi(0) \) are free, we have that the DIS constraint, but this may not be appropriate.
\begin{align}
\mu_x(0) &= 0 \\
\mu_\pi(0) &= 0
\end{align}

(25) \quad (26)

Taken together, equations [14] through [26] constitute a system for \( \{\pi(t), x(t), i(t), g(t), t^r(t), \mu_\pi(t), \mu_x(t), \mu_g(t), \mu_r(t)\}_{t \in [0,\infty)} \). Since the optimization problem is strictly convex, these conditions, together with the appropriate transversality conditions, are both necessary and sufficient for an optimum. We can now characterize optimal fiscal and monetary policy.

**Proposition 1.** Even with hand-to-mouth consumers, whenever the zero lower bound is not binding and monetary policy is allowed to adjust, optimal government spending is zero: \( g(t) = 0 \).

**Proof.** We will use the equations above which characterize optimal policy. From (23), we have

\[ g(t) = \frac{1}{\eta} \left[ \rho \mu_g - \dot{\mu}_g(t) \right]. \]

Plugging in for \( \mu_g \) from (17), gives

\[ g(t) = \frac{1}{\eta} \left[ -\rho \mu_x (1 - \zeta + \bar{\Theta}_n) - \dot{\mu}_g(t) \right]. \]

Taking the time derivative of (17) and inserting above,

\[ g(t) = \frac{1}{\eta} \left[ -\rho \mu_x (1 - \zeta + \bar{\Theta}_n) + \dot{\mu}_x (1 - \zeta + \bar{\Theta}_n) \right] \]

\[ g(t) = \frac{1}{\eta} \left[ -\rho \mu_x + \dot{\mu}_x \right] \]

\[ g(t) = \frac{1}{\eta} \left[ -\rho \mu_x + \dot{\mu}_x \right] \] \quad (27)

In regions where the zero lower bound is not binding, then the co-state (or multiplier) for the DIS equation and its time derivative are zero, i.e \( \mu_x(t) = \dot{\mu}_x(t) = 0 \). Then by (27), spending is also zero. \( \square \)

This is a significant conclusion because it underscores the degree to which monetary policy is preferred to fiscal policy outside of the zero lower bound. Despite potentially substantial multiplier effects of government spending and tax changes due to liquidity-constrained consumers, there is still no role for countercyclical fiscal policy. The logic is simple. As we will show below, outside of the ZLB monetary policy can still achieve perfect stabilization without inducing any inefficient distortions. Despite potentially substantial multipliers, fiscal policy would induce an inefficient
composition of expenditure. Because monetary policy can achieve perfect stabilization without distortion, fiscal policy is not optimal.

Below, I characterize optimal monetary policy outside of the ZLB, showing the interest rate rule which must be used to achieve perfect stabilization.

**Proposition 2.** *In this economy, a version of the price stability result from basic New-Keynesian models holds away from the zero lower bound. In particular, optimal monetary policy sets the nominal interest rate using the following rule: \( i(t) = \bar{r} + (1 - \kappa \hat{\sigma} \lambda) \pi(t) + \hat{\sigma} \hat{\Theta} \hat{r}(t) \). The optimal nominal rate equals the natural rate when inflation and the growth of taxation on hand-to-mouth consumers are zero.*

**Proof.** Suppose the zero-bound is not binding over some interval \( t \in [t_1, t_2] \). Then, as I argued above, it must be the case that \( \mu_x(t) = \dot{\mu}_x(t) = 0 \) for \( t \in [t_1, t_2] \). Then from condition (21) we have \( x(t) = \kappa \mu_x(t) \), and from condition (22) we have \( \dot{\mu}_x(t) = -\lambda \pi(t) \). Starting with the first,

\[
x(t) = \kappa \mu_x(t),
\]

taking the time derivative

\[
\dot{x}(t) = \kappa \dot{\mu}_x(t).
\]
and then combining with the second,

\[
\ddot{x}(t) = -\kappa \lambda \pi(t).
\]

We can now combine (29) with the DIS equation (14) to see that

\[
-\kappa \lambda \pi(t) = (1 - \zeta + \hat{\Theta}_n) \dot{g}_t + \frac{1}{\hat{\sigma}} (i_t - \bar{r}_t - \pi_t) - \hat{\Theta}_t \hat{r}_t.
\]

From Proposition 1, we know that in this scenario, \( \dot{g}(t) = 0 \), so we can isolate the nominal interest rate

\[
-\kappa \lambda \pi(t) + \hat{\Theta}_t \hat{r}_t = \frac{1}{\hat{\sigma}} (i_t - \bar{r}_t - \pi_t)
\]

\[
\hat{\sigma} \left( -\kappa \lambda \pi(t) + \hat{\Theta}_t \hat{r}_t \right) + \pi + \bar{r} = i
\]

\[
i(t) = I(r(t), \pi(t), \hat{r}(t)) = \bar{r} + (1 - \kappa \hat{\sigma} \lambda) \pi(t) + \hat{\sigma} \hat{\Theta} \hat{r}(t). \]

This result is similar to the interest rate rule derived in traditional analysis assuming the ZLB never binds, except that now the interest rate must react to taxes on hand-to-mouth consumers. In particular, when the growth rate of taxes on hand-to-mouth consumers rise, the interest rate must also rise. This maintains consumption and inflation constant. If the interest rate did not react, tax growth would reduce consumption growth (as indicated by the DIS equation), and put downward
pressure on inflation. By increasing the nominal interest rate, consumption growth is equilibrated, leaving inflation unchanged.

Thus with hand-to-mouth consumers, monetary policy is still supreme. The monetary authority should set the nominal interest rate to maintain price stability and eliminate inflation and the output gap. Its policy must recognize the susceptibility of hand-to-mouth consumers to their taxes, and work to offset this non-Ricardian effect. There remains no role for countercyclical fiscal policy.

The combination of Propositions 1 and 2 show that the feature of the benchmark model whereby monetary and fiscal policy affect consumption through the same channel is not a necessary condition for monetary supremacy. As long as monetary policy can costlessly achieve perfect stabilization, it remains the preferred stabilization tool regardless of the potency of fiscal policy or the channels through which fiscal policy can act.

This conclusion formalizes the intuition that for fiscal policy to have a role, it must not only be able to achieve outcomes that monetary policy can not achieve, but these outcomes must be inherently desirable. This condition is met in the other scenarios discussed in this paper.

3.2 Addressing Uncertainty

3.2.1 Background and theory

Benchmark models find that monetary policy is supreme outside of the ZLB because the monetary authority is assumed to perfectly control the nominal interest rate, and the nominal interest rate can be manipulated to achieve the first-best allocation. However, in reality the monetary authority does not have perfect control or certainty over the impact of monetary policy. Central banks might have a good forecast about the economy’s reaction to any given policy, but that forecast has an error.

There are several reasons why monetary policy’s impact on economic aggregates might be uncertain. First, the monetary authority might not be able to hit its interest rate target. Most central banks use open market operations to affect the equilibrium price of government debt, but these markets are not always perfect or stable. Thus the monetary authority might be off of its target. Second, the short rate set by the central bank is not the only rate that matters in the economy. In reality of course, there are many types of assets with different maturities, each with their own prices. In order to expect the monetary authority to be able to affect all rates, one must assume that all interest rates and asset prices are perfectly linked through arbitrage, so that long rates are given by proper weighted averages of risk-adjusted future short rates, and asset prices are given by the risk-adjusted present discounted value of payments on a given asset. Under this assumption, affecting current and expected future short rates is enough to predictably affect all other rates and prices. Of course, in reality these channels are not clean. For example, in the recent financial crisis formerly credit-worthy borrowers had trouble accessing mortgage interest for purchase or refinance even when nominal interest rates were at record lows. When financial intermediation is weakened, monetary policy becomes less effective than expected. Third, there may be uncertainty about the structural parameters or the shocks facing the economy. Every quarter, the
Federal Reserve makes its forecast with the best available data, but unsurprisingly these forecasts are never fully accurate. Fourth, there is model uncertainty, or uncertainty about the structural laws governing the economy’s reaction to shocks. For example, Tetlow (2012) compared 46 vintages of the Federal Reserve’s main DSGE model (FRB/US) and calculated the funds-rate multiplier for each one (that is, the percentage decrease in the level of real GDP after eight quarters in response to a persistent 100-basis-point increase in the fed funds rate). He found substantial variation across model vintages, as the federal reserve learned about the underlying structure of the economy as well as about changes in fundamentals.

Similarly to monetary policy, unlike in the benchmark model, the impact of fiscal policy on economic aggregates is also uncertain. The wide ranging estimates about the multiplier from tax and spending policies summarized in Ramey (2011) and Taylor (2011) make this clear. The fiscal authority does not know the "true" multiplier for any policy. Instead, it uses its best guess. And of course, just like monetary policy, fiscal policy is set in an environment where the true state of the economy is uncertain, so even if the multiplier were known the resulting economic outcomes may still be uncertain.

The uncertainty about the impact of monetary and fiscal instruments has important implications for optimal stabilization policy. A classic paper by Brainard (1967) showed in a simple model that when two instruments with uncertain impacts were available to achieve one target outcome, in general it was best to combine both instruments rather than only use one. Intuitively, in the simple case where the errors for each instrument are independent, the variance of the sample mean will be lower than the variance of either random variable. Policymakers are more likely to "hit" their target by combining two error-prone instruments than by using either one in isolation.

Applying Brainard’s (1967) intuition to the problem of optimal fiscal and monetary policy in a New-Keynesian model, we would expect that if we allowed the impact of monetary and fiscal policy to have random components, then it may be optimal to use both instruments even outside of the zero lower bound. In this case, the inherent distortions caused by countercyclical fiscal policy will likely be offset by its ability to reduce the uncertainty about the combined thrust of countercyclical policy.

### 3.2.2 A framework for incorporating uncertain policy impacts into the benchmark model

In order to formalize this intuition, we need to add uncertain policy impacts to the benchmark model. Although a full treatment is outside of the scope for this paper, we can characterize the form this would take. For monetary policy, one simple way to do this is to assume that the nominal interest rate faced by consumers ($i_t$) differs from the monetary authority’s target rate ($i^c_t$) by a normally distributed random variable, i.e. $i_t = i^c_t + \nu_t$ where $\nu_t \sim N(\mu_\nu, \sigma^2_\nu)$. For fiscal policy, we could assume that the true neoclassical multiplier ($\zeta$) differs from the policymaker’s signal ($\zeta^c$) by a normally distributed random variable, i.e. $\bar{\zeta} = \bar{\zeta} + \epsilon_\zeta$ or that the natural interest rate is unknown each period ($\bar{r}_t = \bar{r}^c_t + \epsilon_r$).

---

4Alternative ways to incorporate the uncertainty of the effect of monetary policy on the economy include assuming the inter-temporal elasticity of substitution is a random variable ($\hat{\sigma} = \hat{\sigma} + \epsilon_\sigma$) or that the natural interest rate is unknown each period ($\bar{r}_t = \bar{r}^c_t + \epsilon_r$).
by a different normally distributed random variable, i.e. \( \zeta = \zeta^c + \epsilon_t \) where \( \epsilon_t \sim N(\mu_c, \sigma^2_c) \).

In this scenario, optimal fiscal and monetary policy would be governed by the planner’s problem:

\[
\min_{c,\pi,i,g} \frac{1}{2} \int_0^{\infty} e^{-\rho t} \left( (c(t) + (1 - \zeta)g_t)^2 + \lambda \pi^2_t + \eta g^2_t \right) dt
\]

subject to

\[
\dot{c}_t = \frac{1}{\sigma} (i_t - \pi_t - \bar{\pi}_t) \tag{30}
\]
\[
\dot{\pi}_t = \rho \pi_t - \kappa (c_t + (1 - \zeta)g_t) \tag{31}
\]
\[
i_t \geq 0
\]
\[
i_t = i^c_t + \nu_t \text{ where } \nu_t \sim N(\mu_\nu, \sigma^2_\nu)
\]
\[
\zeta = \zeta^c + \epsilon_t \text{ where } \epsilon_t \sim N(\mu_\epsilon, \sigma^2_\epsilon)
\]

### 3.2.3 Allowing an external disturbance to affect the impact of policy instruments

Two refinements of Brainard’s baseline model further amplify the rationale for fiscal policy. The first refinement is to add a random disturbance that impacts the target outside of the policy instrument. For example, this could be an exogenous aggregate demand shock in our model. Brainard observes that "other things being equal, increasing the correlation between the impact of a particular instrument and the disturbance will decrease its use relative to other instruments." This is intuitive. Instruments which miss in a particular direction when an external shock pushes the economy in the same direction are less useful.

This logic, applied to the problem of optimal fiscal and monetary policy, appears to strengthen the case for fiscal policy. Consider an economy in recession, susceptible to an additional aggregate demand shock. In this scenario, optimal policy would seek to reduce the output gap. Given the uncertainty presented by the potential external shock, the policy reaction could be too aggressive (overshooting and causing output to increase above its optimal level) or too timid. Now consider how the external shock impacts the usefulness of each tool. As traditional Keynesian theory implies, and as Parker (2011) argues, we should expect that the fiscal multiplier is larger in the presence of an unexpected negative aggregate demand shock. This is because fiscal multipliers are larger when there is more slack in the economy, and smaller when the economy is tighter, causing additional government spending to crowd out consumption and investment through higher interest rates. Thus a given quantity of fiscal stimulus becomes more potent than expected when the economy experiences a new negative shock, and less potent than expected when the economy experiences a new positive shock. In this way, fiscal stimulus "leans against the wind" of future shocks. Conducting additional fiscal stimulus acts like an insurance policy against future shocks. If future shocks depress the economy, fiscal stimulus is more potent. If future shocks boost the economy, fiscal stimulus is less potent. In either case, fiscal stimulus helps keep the economy closer to the "target" output gap chosen before the uncertainty was realized.
In contrast, the impact of monetary policy would seem to "lean with the wind." If a disturbance unexpectedly depressed the economy, a given quantity of monetary stimulus would be less effective than expected. For example, this could be because in bad times, financial intermediation begins to break down, reducing the monetary authority’s ability to affect the broader economy.

If fiscal policy tends to be more potent than monetary policy when the output gap is unexpectedly large, and less potent than monetary policy when the output gap is unexpectedly small, then following Brainard’s logic, fiscal policy should be used relatively more than monetary policy. A tool that "leans against the wind" is more useful than one that leans with it.

To formalize this intuition, we would add an external disturbance on either the supply (a cost-push shock) or demand sides. For example, we could modify the DIS and NPKC by adding shocks $\varepsilon_{i,t}$ to each one:

\[
\dot{c}_t = \frac{1}{\sigma} (\bar{c}_t - \pi_t - \bar{\pi}_t) + \varepsilon_{2,t},
\]

\[
\dot{\pi}_t = \rho \pi_t - \kappa (c_t + (1 - \zeta) g_t) + \varepsilon_{3,t},
\]

Using these versions of the DIS and NKPC it would be possible to analyze optimal policy using the same problem described in section 4.1.2. One thing to note is that the impact of such shocks on the relative usefulness of monetary and fiscal policy may depend on the type of the shock. In my examples above, I assumed a demand shock. However a cost-push shock weaken rather than strengthen the impact of fiscal policy.

### 3.2.4 The usefulness of fiscal policy when many instruments are available

The second Brainard extension which is relevant explores the optimal policy problem when there are many instruments available, not just two. Unsurprisingly, Brainard finds that in general, all instruments should be used. As before, the intuition is that the errors associated with any given instrument are balanced out when more instruments with independent errors are used.

This logic appears to provide an additional rationale for fiscal policy. The toolbox of the monetary authority is limited. In general, the central bank affects the short-term risk-free rate. Through unconventional means or asset purchases, it can affect other rates and prices, though this is more difficult. Fiscal policy on the other hand has a much broader array of tools. These include income taxes, payroll taxes, corporate taxes, sales taxes, investment subsidies, purchase subsidies, infrastructure spending, healthcare spending, transfers, etc. If each policy affects the economy with an uncertain component, but these errors are largely uncorrelated (an important assumption), then more of them should be used. Under this logic, countercyclical policy should include monetary policy as well as a large array of fiscal policies. Together, the package should be more accurate as a whole.

To formalize this argument, it would be necessary to add a broader set of tools to the baseline model. One potential starting point is the model described in Correia, Farhi, Nicolini, and Teles (2011), who consider a standard New-Keynesian model enriched with an investment tax credit as well as with consumption, labor, payroll, and capital income taxes. Another alternative baseline
model is that of McKay and Reis (2012), who add seven different automatic stabilizers to their model. In either case, to formally explore this point it would be necessary to extend these models by adding uncertainty to the impact of any given policy, and re-evaluating optimal policy.

3.2.5 Allowing for uncertainty about the underlying model dynamics

A final relevant source of uncertainty, which is not discussed by Brainard (1976), is uncertainty about the true model of the world. If we stepped back and admitted that we weren’t sure whether the real world was more closely represented by a New-Keynesian model, or a neoclassical model, or a model with financial frictions, then again it might be best to use a range of instruments with different characteristics depending on the model. For example, monetary policy might be impotent in a model with such severe financial frictions that intermediation is liable to fail, whereas in the New-Keynesian model it remains potent. If we don’t know which model is true, then it may be prudent to use a range of policies. The optimal Bayesian policymaker would choose a combination of instruments which does reasonably well across multiple potential models, and isn’t terrible in any of them. This is discussed in the literature on Bayesian Model Averaging, where results are averaged across different models using the posterior probability of each model as the weight.

3.3 Monetary and Fiscal Policy Lags

In the benchmark model, output responds immediately to monetary and fiscal policy. This is another reason why monetary policy dominates fiscal policy. If monetary policy can costlessly and immediately stabilize the economy, fiscal policy remains redundant.

However, empirical studies indicate that it takes time for monetary and fiscal policies to work through the economy. Figure 1 shows the VAR estimates of a monetary policy shock from Christiano, Eichenbaum, and Evans (1999). It indicates that it takes about 6 months for monetary policy to begin affecting the real economy, while peak impact is felt at around 18 months. A 6 month lag is potentially quite problematic, given that the average U.S. recession last approximately 11 months. By contrast, Figure 2 shows the estimate response to a government spending shock calculated by Blanchard and Perotti (2002). Government spending impacts the economy immediately, diminishing slightly over the ensuing 15 months, and then increasing back up to reach peak impact about four years later. Figure 3 shows the response of GDP to a one-time tax reduction (using the large unanticipated 1972 tax rebate). This figure also shows an immediate positive impact, reaching peak level about one year in.

As these results show, fiscal policy, especially government spending, has a considerably shorter lag than monetary policy. Given monetary policy’s lag relative to fiscal policy, there might be a role for fiscal policy as a very near-term stabilization tool. As a stark example, consider the immediate aftermath of the 9/11 attacks. The Federal Reserve reacted quickly to the expected negative economic impacts, reducing the fed funds rate by 150 basis points within two months. However, according to the data above, this monetary policy easing couldn’t have been expected to ease the economy until the middle of 2002. Hence, if the 2001 tax rebates weren’t about to kick in
Figure 1:
Response of GDP to one-time monetary policy shock

Source: Christiano, Eichenbaum, and Evans (1999) Figure 2

Figure 2:
Response of GDP to a government spending shock

Source: Blanchard and Perotti (2002), Figure V
One of the rationales against fiscal policy is that while its 'outside lags' are shorter than fiscal policy, its 'inside lags' may be much longer. Inside lags are the time that elapses between a recognition that policy is needed to its enactment. Traditionally, the inside lag is thought to be longer for fiscal policy due to the potentially messy political process. However, this need not always be the case. In several recent periods, the U.S. has enacted fiscal policy fairly quickly. The 2001, 2003, 2008, and even 2009 tax cuts and stimulus programs were each enacted in a matter of months. Furthermore, since the 'inside' lags are political rather than economic constraints, they are not necessarily relevant for considering optimal policy. Institutional constraints are not immutable. For example, Blinder (2004) describes the idea of creating a board of technocrats, modeled on the Federal Reserve Board, empowered to make fiscal policy decisions (subject to constraints laid down by Congress). Since almost all countries put monetary policy in the hands of independent central bankers and technocrats, why not do the same with fiscal policy? Even if this scenario is politically unlikely, perhaps a more plausible scenario is to design more robust automatic stabilization programs, which would be pre-written into law and would thus have no inside lags. Blanchard et al. (2010) call for an aggressive re-thinking of automatic stabilizers across the developed economies.

The simplest way to explore this issue formally would be to return to a discrete time model, and
assume that either policy is impotent until \( t \) periods after it is enacted. Christiano, Eichenbaum, and Evans (2011) use this strategy to model the lags in fiscal policy. A more accurate treatment would use a model that produced relatively smooth response functions displayed in the data, as shown in Figures 1-3. For monetary policy, this would require adding capital investment and adjustment costs. It may also be necessary introduce a time-varying shock, such as a persistent version of the shocks introduced to the NKPC and DIS above. In these models, it is possible that fiscal policy’s shorter outside lag relative to monetary policy might make it a more attractive stabilization tool, especially in response to an unexpected "emergency" situation.

3.4 Distributional Effects with Heterogeneous Agents

Macroeconomic shocks impact different groups differently. Whether by geography, occupation, asset holdings, employment status, or age, the pain of recessions is distributed unevenly across the population. In models with heterogeneous agents, alleviating some of this pain is one of the purposes of stabilization policy. But in the face of such divergent costs, monetary policy is a decidedly blunt tool. It can lift the overall level of economic activity, but it cannot target assistance directly.

In contrast, fiscal policy is likely to be more flexible. Certainly automatic stabilizers have been developed which both stabilize the economy and often direct assistance to those bearing disproportionate costs of dislocations (such as the unemployed, disabled, sick, or recently poor). But in some cases, those bearing the brunt of particular recessions might be concentrated in a group that is not covered by traditional automatic stabilizers for whatever reason. In such cases, targeted fiscal policy may be effective.

There is at least one counterargument to these claims. To the extent that there is inefficient bearing of risk from recessions, the first best response is to reform social insurance programs rather than to embark on a new targeted fiscal stabilization effort. Since monetary policy is perfectly efficient in the benchmark model, it should be relied on to achieve the first-best allocation. Fiscal policy should be determined by the Samuelson cost-benefit calculation without regard for stimulus impact. However, it is not clear that monetary policy alone actually can achieve the first best in a model with heterogeneous agents and idiosyncratic risk.

There are two potential frameworks in which to explore this issue. First, we could adapt the basic two-type model in section 3.1 by assuming that optimizing and hand-to-mouth groups face different shocks. This captures the idea that liquidity constrained consumers may bear the brunt of recessions. In this case, the quadratic loss function would likely depart from the benchmark model, since we would need to explicitly account for differential consumption levels of each type of agent. The ability of fiscal policy to differentially impact each type of consumer, combined with the inability of monetary policy to directly affect the incentives of hand-to-mouth consumers (since they aren’t optimizing), would likely result in an optimal stabilization policy that mixed both instruments.

A more general way to analyze this question would be to embed a Mirrlees-type social welfare function in a dynamic stochastic general equilibrium model with heterogeneous agents ideally facing
idiosyncratic risk. One option to tackle this problem would be to start from the McKay and Reis (2012) model, which includes heterogeneous agents, incomplete markets, and a robust range of fiscal instruments. We would then add a social welfare function and analyze the social planner’s problem.

3.5 Fiscal Policy as a Signaling and Coordinating Mechanism in Models with Strategic Complementarities

Incomplete information and strategic complementarities may also justify the use of countercyclical fiscal policy. In Diamond’s (1982) basic model of trading frictions and aggregate demand, government spending can help push the economy from a "bad" equilibrium to a "good" equilibrium by increasing the probability that trades take place in the private market. In general scenarios with multiple equilibrium, the government can induce players into the market, setting in motion their strategic complementarities and leading to better outcomes for everyone.

Such a signaling and coordination game could be added to the New-Keynesian framework. It would be necessary to add a strategic complementarity across consumers (or between workers and producers, perhaps through demand and the real wage) and specify the information structure. Because fiscal policy is able to directly generate demand, it may be more effective than monetary policy at overcoming the coordination failure and jump-starting a depressed market. Another environment would take into consideration that the public understood that fiscal policy would boost the economy, improving their expectations about the future.

4 Costs of Monetary Policy

In the benchmark New Keynesian model I described in section 2, low interest rates are assumed to spur consumption and investment. Interest rates have no impact beyond their direct effects on the intertemporal choices of households and businesses. As I showed, when interest rates are free to adjust, monetary policy is capable of costlessly achieving the first-best allocation in standard environments.

By contrast, in the finance literature low interest rates are not always benign. For example, authors such as Jensen and Meckling (1976), Allen and Gale (2000), Rajan (2006) and Hanson and Stein (2012) argue that low interest rates can cause asset prices to diverge from fundamentals, propping up bubbles which are liable to collapse with costly consequences. Others, such as Diamond and Rajan (2012) and Farhi and Tirole (2012b), find that low interest rate policies in bad times can encourage maturity mismatch and excessive leverage. Manuelli and Sargent (2010) and Farhi and Tirole (2012b) also emphasize that low interest rates redistribute resources from savers, often households, to borrowers, often banks and entrepreneurs. In total, this literature suggests that monetary policy may have important implications for financial stability, implications which are ignored by the macro literature on optimal countercyclical policy.

In this section, I explore the potential for reconciling these two strands of literature. In sub-
sections 4.1 to 4.4, I review the finance literature on monetary policy distortions, with a particular focus on the literature on bubbles. In my review, I concentrate on how existing models treat the emergence of bubbles, the link between bubbles and interest rates, and the welfare cost of bubbles and crashes. From this review, I identify features of models which are promising starting points for an analysis of optimal countercyclical policy when monetary policy causes real distortions. In particular, I argue that the risk shifting models from Allen and Gale (2000) and Hanson and Stein (2012), and the maturity mismatch and inefficient investment model of Farhi and Tirole (2012b), provide promising building blocks.

4.1 Bubbles

From the Dutch tulip mania of 1634-1637 to the U.S. house price expansion of 2000-2006, asset price bubbles and their subsequent busts have been a recurring feature of macroeconomic cycles for centuries. As the U.S. economy recently exemplified, bursting bubbles can have large social costs. In general, bubbles can have real effects because when they burst, the balance sheets of firms, financial institutions, and households are impaired. This balance sheet shock can have direct effects on consumption and investment as well as indirect effects through various potential channels emphasized in the literature discussing the importance of corporate net worth in the presence of financial frictions (such as Bernanke and Gertler (1989) and Kiyotaki and Moore (1997)). In addition, the bursting of a bubble may force investors to sell assets at fire sale prices, reinforcing the frictions caused by the net worth channel.

A robust literature explores the causes and consequences of bubbles. In this subsection, I will briefly survey the existing literature on bubbles, highlighting in each case whether and how these environments are affected by monetary policy interventions. From this exercise, I will draw lessons about which type of environment (or combinations of environments) is most relevant to an analysis of monetary effects and their implications for optimal stabilization policy.

4.1.1 Asset pricing definition of bubbles and rational bubbles without frictions

A bubble is a sustained mispricing of an asset away from its fundamental value. To more clearly see what is meant by “fundamental value” I present the simple asset pricing definition of a bubble. Starting from the definition of the net return \( r_{t+1} \) of an asset with current price \( p_t \), future price \( p_{t+1} \), and dividend \( d_{t+1} \), and rearranging, we have

\[
r_{t+1} \equiv \frac{p_{t+1} + d_{t+1}}{p_t} - 1
\]

\[
p_t = E_t \left[ \frac{p_{t+1} + d_{t+1}}{1 + r_{t+1}} \right].
\]

(34)
The current price of an asset is the discounted future price and dividend payment in the next period. If the expected return required by the marginal trader to hold the asset is constant over time at $E_t[r_{t+1}] = r$, then we can solve (34) forward in infinite time to reach

$$p_t = E_t \left[ \sum_{s=0}^{\infty} \frac{d_{t+s}}{(1 + r)^{s+1}} \right] + \lim_{T \to \infty} E_t \left[ \frac{p_{t+T}}{(1 + r)^T} \right].$$

When the last term goes to zero (i.e. that the transversality condition holds), then the price equals what is known as the fundamental price $p_t^*$

$$p_t^* = E_t \left[ \sum_{s=0}^{\infty} \frac{d_{t+s}}{(1 + r)^{s+1}} \right].$$

The fundamental price is the present discounted sum of all future dividends. However, if the transversality condition is not imposed, then $p_t = p_t^*$ is only one of many possible prices that solve equation (34). Any other solution can be written as

$$p_t = p_t^* + b_t$$

where applying (34) we find that the "bubble" component must satisfy

$$b_t = E_t \left[ \frac{b_{t+1}}{1 + r} \right].$$

Two possible solutions satisfying (35) are that the bubble grows exactly at gross rate $1 + r$, i.e. $b_t = b_0(1+r)^t$, or that there is some probability $(1 - \pi)$ that the bubble bursts each period, requiring that conditional on surviving the bubble grows at gross rate $\frac{1+r}{\pi}$.

These simple infinite horizon, rational expectations, asset pricing calculations already highlight some fundamental lessons from the literature on bubbles. First, a rational bubble must grow at an expected rate of $r$. This eliminates several potential rational bubbles through backward-induction arguments. For example, a bubble on any non-zero supply asset cannot arise if the required return $r$ exceeds the growth rate of the economy, since the bubble would outgrow the aggregate wealth in the economy. Once the bubble outgrew aggregate wealth, rational agents would no longer hold it, hence by backwards induction it could never begin. Thus rational bubbles can only exist in situations where the required rate of return is less than or equal to the growth rate of the economy, i.e. when the economy is dynamically inefficient.

Second, bubbles cannot start within such a rational bubble model. This is because a negative bubble can never exist. A growing negative bubble would imply that the asset’s price would eventually become negative, which is not possible for an asset with limited liability. Thus if bubbles can never be negative, this means if a bubble vanishes, it must remain at zero forever. Thus a bubble cannot start within the model. Bubbles must be present once the asset starts trading.
4.1.2 Rational bubbles with OLG frictions or market incompleteness

Santos and Woodford (1997) showed that both of the insights I highlighted from the frictionless rational bubble framework applied also to a more general class of models. In particular, they show that as long as traded assets are sufficiently productive (i.e. as long as capital returns are greater than investment (a criterion for dynamic efficiency proposed by Abel et al. (1989)), or in the simple equations above as long as \( r > g \), then for securities in positive net supply, pricing bubbles do not occur regardless of the presence of sequentially incomplete markets, arbitrary borrowing limits, or incomplete participation of households in spot markets. Moreover, if pricing bubbles do occur (if one of the conditions above is violated), they cannot start inside the model.

The Santos and Woodford (1997) setup is general enough to include models known to support pricing bubbles, including those with overlapping generations (Samuelson (1958), Tirole (1985)), infinite-horizons (Scheinkman 1978), incomplete asset markets (Bewley 1980), and borrowing constraints (Woodford (1990), Kocherlakota (1992)). Thus in any of these environments, bubbles can only persist as long as the Abel et al. (1989) dynamic efficiency criterion fails. Hence investment must exceed capital income for bubbles to persist. While Abel et al. (1989) calculate that their criterion is met by the U.S. and other advanced economies, Geerolf (2013) updates their data with new sources for mixed income and land rents, and finds that the U.S. and many other advanced economies are actually dynamically inefficient. This would imply that rational bubbles in any of the environments contained in Santos and Woodford (1997) may exist in plausible economies (though it still could not explain the emergence of bubbles). Farhi and Tirole (2012a) present a rational model of bubbles where bubbles are possible even when the economy is dynamically efficient, as long as the interest rate is lower than the growth rate of the economy. In their model, these two conditions are not interchangeable due to their modeling of imperfect capital markets.

Two features of this class of models are particularly relevant for considering the costs of monetary policy interventions. First, although most models do not explicitly incorporate exogenous interest rate setting by a central authority, if they were to do so it seems likely that monetary interventions which depress interest rates and increase asset prices would reduce capital income while increasing investment, potentially triggering or deepening dynamic inefficiency and supporting price bubbles. Thus, within any of these models, we can conclude that loose monetary policy can contribute to the persistence (though not the creation) of bubbles. Nevertheless, the link to monetary policy does not seem particularly robust. In these models, low interest rates are a sufficient condition for bubbles to exist, but it is unclear whether or how they would precipitate or amplify a bubble.

Second, within this class of models, the bubbles themselves are welfare improving as long as they persist. The basic intuition is that the bubbles (of which fiat money is one example) can relax credit and trading restrictions inherent in the economies. For example, in OLG models a bubble in fiat money is useful because money can then serve as a store of value, allowing a wealth transfer

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5One interesting issue is that while monetary policy may reduce the interest rate and reduce capital income, since bubbles in these economies must grow at this rate in expected value, low interest rates would also imply low growth rates of bubbles.
across generations. In the Tirole (1985) OLG framework, a bubble in capital (which can emerge when there is dynamic inefficiency) achieves this wealth transferring objective. One problem with the Tirole (1985) framework is that bubbles are associated with lower investment, whereas when a bubble bursts investment increases. This is counter-factual (usually investment falls when bubbles burst), and can be reversed by adding borrowing constraints as in Martin and Ventura (2012). In Bewley (1980) economies with uninsurable idiosyncratic risk, bubbles (in fiat money or government debt) may help agents smooth consumption and hence improve welfare.

4.1.3 Bubbles in models with heterogeneous beliefs and potentially irrational actors

When agents have mutually inconsistent beliefs, possibly due to behavioral factors, bubbles are not restricted by the narrow conditions for "rational bubbles" in environments covered by Santos and Woodford (1997). The classic example of this type of environment is the model of "noise trader risk" proposed by DeLong, Shleifer, Summers, and Waldman (1990). They consider an OLG model of a market with two assets with identical deterministic cash flow streams and two types of agents: arbitrageurs who have rational expectations, and irrational noise traders who have erroneous stochastic beliefs about the future value of one of the assets (which can be thought of as equities). The rational arbitrageurs are risk averse and have finite horizons, making them reluctant to take positions that fully equate the price of both assets since the mispricing may widen further in the future due to the irrational noise traders. This combination of risk averse finite horizon agents and noise trader risk allows bubbles to persist as prices can diverge significantly from fundamental values for extended periods of time.

Although DeLong et al. (1990) do not specifically address welfare, it follows from the irrationality of noise-traders that the bubble is not welfare improving even while it is still inflating. Indeed, the authors argue that in this setup, arbitragers would have incentives to spend considerable resources to exploit noise traders, but that the private returns from such activity likely exceed social returns. This non welfare-improving characteristic of bubbles is in contrast to that of rational bubble models of the general form considered in Santos and Woodford (1997).

The role of interest rate policy is unclear in this setting. The general formula for the price of equities (with fundamental value of 1) is given by

$$p_t = 1 + \mu(p_t - \rho^*) + \frac{\mu \rho^*}{1 + r} - \frac{2\gamma \mu^2 \sigma^2_\rho}{r(1 + r)^2}$$

where $r$ is the fixed dividend on both the safe asset (in perfectly elastic supply) and the unsafe asset (in fixed supply), $\mu$ is the share of noise traders in the model, $\rho_t$ is the noise trader’s misperception of the asset in period $t$, $\rho^*$ is the mean misperception (a measure of average bullishness of noise traders), $\gamma$ is the coefficient of absolute risk aversion, and $\sigma^2_\rho$ is the variance of noise traders’ misperceptions of the expected return per unit of the risky asset. Manipulation of parameter $r$ by a central bank could inflate or deflate the bubble depending on the particular signal received by
the representative noise trader in a given period \((\rho_t)\) and the magnitude of constants in the model. Abreu and Brunnermeier (2003) propose a related model of bubbles. As in DeLong et al. (1990), "irrationally exuberant" behavioral traders bid asset prices above their fundamental values. But unlike in DeLong et al., where uncertainty about the behavior of irrational noise traders (due to the noisy signals they receive) prevents arbitrageurs from successfully challenging the bubble, in Abreu and Brunnermeier (2003) it is uncertainty about the information of other rational arbitrageurs which makes it optimal to ride the bubble, at least for some time. In particular, rational traders only gradually learn about the bubble, and hence initially hold off on attacking because any one trader on their own cannot bring down the bubble. This synchronization risk will incent each investor to wait a certain number of periods before attacking, preserving the life span of the bubble and allowing it to grow larger. Thus in Abreu and Brunnermeier (2003) synchronization risk due to information frictions plays the role of noise trader risk in DeLong et al. (1990). One useful observation in this model is that it explicitly explains why one of the classical objections to bubble existence is not valid in the environment. Because of sequential awareness of the bubble among rational traders, it is never common knowledge that a bubble has emerged. This prevents the standard backward-induction arguments which rule out bubbles, allowing bubbles to persist even in finite horizon frameworks.

A third environment where differences in expectations can generate bubbles are models of belief disagreement. The classic example is Harrison and Kreps (1978), who showed that when agents agree to disagree about the probability distribution of dividend streams, and short selling is limited, then asset prices can exceed their fundamental values. The basic intuition is that in such models, agents who happen to be more more optimistic than others will push up the asset price, while the short-selling limitation will prevent pessimists from counterbalancing the optimists. The price can even exceed the fundamental valuation of the most optimistic agents because they believe that in the future they will find a buyer willing to pay even more. Investors' beliefs differ because they have different prior belief distributions, possibly due to psychological biases. Scheinkman and Xiong (2003) formalize such a model where the belief disagreement results from overconfidence. In this model, agents believe that the signal they observe is more accurate than it actually is, a phenomenon for which there is supporting evidence in the behavioral literature. A core feature of belief disagreement models is that they predict that bubbles will be accompanied by large trading volume and high price volatility, which conforms with empirical evidence of prior bubbles. These models are also discussed in Hong and Stein (2007) and Brunnemeier and Oehmke (2012).

Several features of these heterogeneous belief models are worth emphasizing when thinking about monetary policy. First, unlike in the rational bubble models, in all three of the environments studied here (DeLong et al. (1990), Abreu and Brunnermeier (2003), Scheinkman and Xiong (2003)), bubbles do not appear to be welfare improving. Second, risk-free interest rates play only limited roles. While I think the effect of the interest rate on the size of the bubble is neutral or indeterminate in DeLong et al. (1990) and in Abreu and Brunnermeier (2003), lower risk free rates appear to increase the size of the bubble in Scheinkman and Xiong (2003), but this is not a central
feature of their model. Third, the creation of the bubble varies between models. In DeLong et al. (1990), the bubble comes and goes stochastically depending on signals received by the noise traders. In Abreu and Brunnermeier (2003) the bubble grows by assumption due to irrational beliefs by a subset of agents. In Scheinkman and Xiong (2003) the bubble also fluctuates depending on signals received by each type of agent. Fourth, the bursting of the bubble also varies between the models. DeLong et al. (1990) do not appear to examine the issue. Abreu and Brunnermeier (2003) assume either that the bubble bursts for exogenous reasons (at which point the bubble bursts at its maximum size) or endogenously due to arbitrageur activity (at which point, counterfactually, the bubble has been diminishing for some time). Neither are fully satisfactory. Scheinkman and Xiong (2003) induce a crash either by assuming the fundamental asset value becomes observable to all agents, the agents correct their overconfidence, or the fundamental volatility disappears. These ad-hoc treatments emphasize the difficulty of doing welfare analysis for models of bubbles, when it is hard to micro-found why a bubble will form, when it will burst, and how large it will be when it bursts.

4.1.4 Risk shifting

Agency problems between financiers and entrepreneurs in environments where both risky and risk-free investment opportunities are available can also lead asset prices to diverge from fundamentals. The literature often uses the term "risk-shifting" after Jensen and Meckling (1976), but I argue that that this refers to two distinct phenomenon. First, consider a delegated investment environment, where entrepreneurs or fund managers participate in the upside of projects (or investment choices) but due to limited liability they do not face the downside risk (which falls on the financiers). In such moral hazard situations, when investors can borrow in order to invest in pre-existing assets, risk shifting can cause the risky assets to be priced above their fundamental value, creating a bubble. A good example is Allen and Gale (2000) who propose a model where investors borrow money from banks (financiers) in order to invest in either a risky-free or a risky asset. Once they have obtained credit, investors maximize the value of their levered portfolio, taking into account that they would have limited liability in the event that their investment fails and cannot repay the banks. This will lead investors to over-invest in the risky project, inflating the price of the risky asset relative to the equilibrium price which would prevail in an economy where the same quantity of funds were directly invested by the banks. They show that higher credit, and uncertainty about future restrictions on credit availability, can both contribute to bubbles.

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The second related, but I think distinct, "risk-shifting" argument is about "gambling for resurrection." In situations where investors have commitments to deliver nominal returns, low risk-free rates force them to take on more risk in order to deliver those returns, propping up asset prices. A classic example is that of an insurance company that has offered a guaranteed minimum rate of return on some of its products. A long stretch of low risk-free rates will threaten its solvency, compelling it to take on added risk as its only hope to avoid bankruptcy (Rajan 2006, Stein 2013).
Another example is that of a hedge fund with a contract where it receives 20% of the returns over some nominal return. This hedge fund can survive, and even thrive, in an environment with high risk-free rates. But when risk-free rates fall, the hedge fund manager is forced to take more risk in order to deliver any return (Rajan 2006).

A third agency argument is that "yield-oriented" investors who care about short-term measures of reported performance rather than long-term actual performance will over-invest in risky assets. Hanson and Stein (2012) propose such a model to explain the impact of low interest rates on real term premia. In their model, yield-oriented investors put weight in their objective function not just on expected holding-period returns, but also on current income or yield. They are incentivized to do so either by agency problems or accounting conventions. A reduction in short-term nominal interest rates will lead these investors to re-balance their portfolios towards longer-term bonds in order to keep their overall current yield from declining too much. This will over-expose them to duration or interest rate risk relative to traditional "rational" expected-return-oriented investors.

Risk-shifting arguments are a potentially useful avenue for an exploration of optimal monetary policy. A few key lessons are worth highlighting. First, these environments provide a more direct link between monetary policy and asset bubbles (or risk taking) than in the "rational bubble" or "belief disagreement" literature. This is clear in the Rajan (2006) discussion as well as the Hanson and Stein (2012) model. In Allen and Gale (2000), it is credit rather than monetary policy directly which fuels the bubble. It would be interesting to consider a version of that model where interest rate policy contributed to the credit expansion (I will discuss more about this idea below). Second, the agency problems explain sustained bubbles which are not subject to the Santos and Woodford (1997) restrictions. Third, these models still do not have robust explanations of why asset bubbles will burst. Instead, they rely on unexpected tightening from the central bank or adverse real shock realizations. Fourth, this literature does not yet have a treatment of the welfare effects of bubbles caused by risk-shifting. It does appear that these bubbles are not welfare improving even on the way up, since they are the result essentially of moral hazard, and generally shift returns from financiers to investors. However, beyond the distributional distortions, the models do not include broader effects on the real economy. It would be interesting to include more feedback mechanisms from financial frictions, clarifying welfare costs of the bubble. Examples of this literature are the papers which model pecuniary externalities from fire sales, such as Lorenzoni (2008) and Stein (2012). In these papers, borrowing (Lorenzoni) or money creation (Stein) are inefficiently high because actors do not consider that their actions will tighten borrowing constraints on other actors during financial crises. They thus find a role for regulatory policy which constrains credit. It would be interesting to add in such pecuniary externalities to the risk-shifting asset price bubble literature, delivering a potentially convincing account of the link between low interest rates, excessive risk taking, and the welfare costs of resulting financial crises.

A related paper is Kilenthong and Townsend (2011), which discusses pecuniary externalities in a model with incomplete financial markets.
4.2 Promotion of maturity mismatch and inefficient investment

Two recent papers analyze directly the effect that current and anticipated monetary policy reactions to financial stress have on bank incentives (Diamond and Rajan 2012, Farhi and Tirole 2012b). These papers are quite similar, so I will focus on Farhi and Tirole (2012b). They consider an environment where banks take on short-term debt to finance long-term risky projects. In a distressed state, the risky project has a low payoff. The bank faces a maturity mismatch, since the long-term project requires occasional reinvestments, and in a distressed state the bank faces a liquidity problem when trying to make such investments. The central bank can help by lowering the interest rate, allowing the bank to maintain its investment. However, this "bailout" of banks is costly, for several reasons. First, lowering the interest rate entails a transfer from consumers (who finance projects) to bankers (who borrow). Second, a lower interest rate (below the natural interest rate) encourages investment in negative NPV projects, with negative social returns. Third, by making short-term debt cheaper, low interest rates encourage greater maturity mismatch and encourage overall leverage. Fourth, by signaling that the central bank will likely accommodate future maturity mismatches, they further reduce the expected cost of such mismatches and encourage banks to take on even more risk. These third and fourth effects "sow the seed for the next crisis".

Farhi and Tirole (2012b) analyze optimal monetary policy taking into account both the costs and benefits of low interest rates in times of crisis. They find that there are multiple equilibria when the monetary authority lacks commitment. This is because bank expectations of the policy response affects their investment, and thus the response itself. The welfare maximizing equilibrium is for the central authority not to reduce interest rates, but this equilibrium is not always attained. One way to ensure this is the unique equilibrium is to directly regulate banks’ leverage and liquidity hoarding choices at the initial date. In Diamond and Rajan’s (2012) model, their assumption of noncontingent debt allows them to achieve the welfare optimum by committing to high interest rates in good times in order to fend off incentives for excess leverage and maturity mismatch.

4.3 Redistribution

As mentioned in Farhi and Tirole (2012b), a significant consequence of monetary policy is its redistributive impact on savers and borrowers. This is more directly emphasized in Manuelli and Sargent (2010). Their model is a modification of a Townsend turnpike model which allows agents to stay at a location long enough to trade some consumption goods, but not long enough to support Pareto-optimal allocations. The heterogeneity in agents’ endowments and locations which shape the demand for money and credit implies that monetary policies (such as manipulating the money supply or paying interest on reserves) are inherently redistributive. This redistributive effect is of first order importance in designing the optimal monetary equilibria.

This redistribution is a general point. When we move outside of representative agent economies, it becomes apparent that reducing interest rates for countercyclical reasons will impact different
agents in different ways. In particular, borrowers find their cost of financing falls and hence their returns increase, while savers or lenders find their returns decrease.

4.4 Composition of consumption and investment

For households, low interest rates encourage the consumption of goods traditionally purchased with credit (often durable goods) relative to goods purchased with current wealth (non-durable goods). Thus interest rate policy is likely to have a compositional effect, with more consumption of housing and cars relative to restaurants and movie tickets. In New-Keynesian models often used to analyze optimal policy, the interest rate affects the level of consumption but has no effect on the composition of consumption. If the composition of consumption is welfare relevant for any reason, this would be a useful channel to relax. For example, there may be a pecuniary externality from housing purchases. Just as in the investor-based models with pecuniary externalities, households purchasing homes could receive negative shocks (to the value of the house or to their net worth), forcing them to liquidate the asset at potentially fire-sale prices. If consumers do not take this into account when making purchase decisions, interest rate policies which aggravate this externality may be socially costly.

4.5 A framework with costly monetary policy

This survey of the finance literature discussing potential distortions caused by low interest rate policies highlights two fundamental features of a framework trading off fiscal and monetary policy where monetary policy is costly. First, the model should link monetary policy choices to the initiation and expansion of an asset price bubble or the buildup of excessive risk. Second, it must be possible to assess the welfare costs of this effect, which in the case of bubbles requires an assessment of the final size of the bubble, its likelihood of popping, and the effects on the real economy of this adjustment process. Overall, it appears that the "risk-shifting and searching for yield" or the "maturity mismatch and inefficient investment" literatures provide the most promising starting points for such an effort, since they allow for the most direct link between monetary policy choices and financial costs.

One option would be to start with a model as in Allen and Gale (2000), where excess credit leads to risk-shifting due to the moral hazard effect of delegated investment. A variant of the model could be developed where the safe asset is government debt rather than corporate debt. Monetary policy would then be modeled as the central bank intervening in this debt market to set the nominal risk-free rate. Thus instead of this rate being set endogenously, it would be set by a Taylor rule. It would then be feasible to directly analyze the effect of the government’s stabilization policy on the size of asset market bubbles such as those considered by Allen and Gale.

A second option is to start from Hanson and Stein (2012), whose model explains how low short-
term risk-free rates induce investors to take on more duration risk. It would be possible to modify the investment choice to include an asset with credit rather than interest rate risk. This would capture more of the sources through which conventional wisdom assumes monetary policy distorts asset markets.

A third option is to build off of the model in Farhi and Tirole (2012b), developing a model where low interest rates were costly for the same reasons (redistribution, encouragement of negative NPV projects, excessive leverage and maturity mismatch), but where the costs arose when interest rates fluctuated due to stabilization of traditional shocks. This would avoid the narrow link in that model where interest rates are a reaction to bank liquidity needs.

I leave the full development of these models to future work, but in Appendix B I provide a sketch of a model along the first option proposed above, building off the setup of Allen and Gale (2000).

4.6 Embedding monetary distortions in the New-Keynesian model and evaluating optimal policy

In the traditional New-Keynesian framework described in this paper, shocks to the natural interest rate or other parameters can be fully or partially offset by changes in the nominal interest rate. For example, in response to a negative shock which would otherwise depress both output and inflation, the nominal interest rate can be lowered, bringing both output and inflation back to the desired levels. However, the discussion I have highlighted thus far implies that while such an interest rate policy may stabilize output and prices, it may do so at a cost to financial stability. In a recent speech, Minneapolis Federal Reserve Bank President Narayana Kocherlakota captured this trade-off well with regards to the current environment: "On the one hand, raising the real interest rate will definitely lead to lower employment and prices. On the other hand, raising the real interest rate may reduce the risk of a financial crisis - a crisis which could give rise to a much larger fall in employment and prices."

Current theoretical and empirical evidence does not provide policymakers with a clear recommendation on how best to trade off financial stability and price or employment stability. In order to begin filling this gap, future work could embed the financial sector model I describe in section 4.5, which would capture the financial stability costs of monetary policy choices, inside of a traditional New-Keynesian model. This would be similar in spirit to that of Bernanke, Gertler, and Gilchrist (1999) who incorporate credit-market imperfections into a standard New-Keynesian model. In particular, they embed the financial accelerator and asset price feedback effects in Bernanke and Gertler (1989) and Kiyotaki and Moore (1997), in which net worth shocks propagate through the financial system. Instead, it would be possible to embed the feedback loop of low interest rates on asset prices and the potential for bubbles.

Bernanke and Gertler (2001) is an example of a paper which analyzes optimal policy in the presence of bubbles, but does not directly take into consideration the role of interest rates in creating or supporting those bubbles.
5 Conclusion

This paper revisits the traditional hierarchy of macroeconomic stabilization tools outside of the zero lower bound. The “monetary supremacy” result is based on particular modeling assumptions in the benchmark New Keynesian model which reduce the benefits and increase the costs of fiscal policy relative to monetary policy. I consider various scenarios which relax these assumptions. By considering Keynesian demand effects of liquidity constrained consumers, I show that simply making fiscal policy more effective without altering the effectiveness of monetary policy does not alter monetary supremacy. For fiscal policy to have a stabilization role it must accomplish something that monetary policy can not accomplish.

I then considered four scenarios in which fiscal policy may have benefits relative to monetary policy. Relaxing the assumptions of representative agents, perfect foresight, zero lags, and perfect information (lack of strategic complementarities) bolsters the case for fiscal policy.

Similarly, accounting for financial stability costs of countercyclical monetary policy also appears to bolster the case for the use of fiscal policy. If low interest rates exacerbate asset price bubbles, incentivize excess risk and leverage, and redistribute resources, these costs need to be considered in the optimal policy problem.

Fleshing out each of these extensions could be a fruitful avenue for future work. While this paper has highlighted why fiscal policy may be useful, future work could develop these models to deliver precise results on exactly how it should be used.
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Appendix A: Deriving Equilibrium Conditions with Hand-to-Mouth Consumers

6.1 Setup

We will denote by the $^o$ superscript “optimizing” consumers, and by the $^r$ superscript rule-of-thumb or HM consumers.

The traditional Euler equation will hold for optimizing agents, hence

$$\frac{\dot{C}^o_t}{C^o_t} = \frac{1}{\sigma} (i_t - \pi_t - \rho)$$

(36)

Their labor supply decisions will lead them to set $MRS = MRT$ in each period, or

$$-\frac{U_{N,t}}{U_{C,t}} = \frac{W_t}{P_t}$$

$$\frac{N^0_t}{C_{t-1}^\sigma} = \frac{W_t}{P_t}$$

Taking logs$^8$

$$\phi \ln N_t - \sigma \ln C_t = w_t$$

(37)

For HM agents, they will consume their budget each period, so

$$C^r_t = \frac{WN^r_t}{P_t} - T^r_t.$$  

This implies

$$C_t P_t + T_t P_t = WN$$

$$C_t + T_t = \frac{W}{P} N$$

$$\frac{C_t + T_t}{N_t} = \frac{W}{P}$$

The aggregation equations for consumption and aggregate labor supply are

$$C_t = \chi C_t^r + (1 - \chi) C_t^0$$

(39)

$^8$This notation is slightly misleading, since it implies that $w_t = \ln \left( \frac{W_t}{P_t} \right)$, but we also have that $w_t$ is the real wage itself, not the log of the real wage.
\[ N_t = \chi N_t^r + (1 - \chi)N_t^0 \] (40)

6.2 Using log-deviation form to express equilibrium conditions

We start with the market clearing condition for goods

\[ Y_t = C_t + G_t \Rightarrow y_t = c_t + g_t, \]

which holds to a first approximation.

We can do the same thing for the aggregate consumption \([39]\) and labor supply \([40]\), which gives us

\[
\begin{align*}
  c_t &= \chi c_t^r + (1 - \chi)c_t^0 \\
  n_t &= \chi n_t^r + (1 - \chi)n_t^0
\end{align*}
\] (41)

We move on to the optimality conditions for consumption. We start with the Euler equation \([36]\) for the optimizing agents. We difference this equation from the version at the flexible price equilibrium \([\dot{\bar{C}}_t - \bar{C}_t] = \frac{1}{\sigma}(\bar{r}_t - \rho)\), which gives us [Note that from the definition of \(c_t\) above, taking the time derivative we have \(\dot{c}_t = (1 - G)\left(\frac{c_t}{c_t^0} - \frac{\dot{\bar{C}}_t}{\bar{C}_t}\right)\)]

\[
\begin{align*}
  \frac{\dot{C}_t}{C_t^0} - \frac{\dot{C}_t}{C_t} &= \frac{1}{\sigma}(i_t - \pi_t - \bar{\pi}) - \frac{1}{\sigma}(\bar{r}_t - \rho) \\
  \frac{c_t^0}{1 - G} &= \frac{1}{\sigma}(i_t - \pi_t - \bar{\pi}) \\
  \dot{c}_t^0 &= \frac{1 - G}{\sigma}(i_t - \pi_t - \bar{\pi})
\end{align*}
\] (42)

For the HM agents, we note by definition that

\[
\begin{align*}
  c_t^c &= (1 - G)(\log(C_t^r) - \ln(\bar{C}_t)) \\
  &= (1 - G) \left[ \log \left( \frac{W_tN_t^r}{P_t} - T_t^r \right) - \ln(\bar{C}_t) \right] \\
  &= \frac{Y - G}{Y} \left[ \log \left( \frac{W_tN_t^r}{P_t} - T_t^r \right) - \ln(\bar{C}_t) \right] \\
  \Rightarrow c_t^c &= \frac{WN_t^r}{Y} (w_t + n_t^r) - t_t^r
\end{align*}
\] (43)

Applying the same linearizing transformations to the labor supply conditions in \([37]\) and \([38]\),
we have

\[ w_t = \frac{\sigma}{1 - G} c_t^r + \phi n_t^r \]  

(44)

\[ w_t = \frac{\sigma}{1 - G} c_t + \phi n_t \]  

(45)

Rearranging [44]

\[ n_t^r = \phi^{-1} \left( w_t - \frac{\sigma}{1 - G} c_t^r \right) \]

Plugging this and [45] into [43] gives

\[ c_t^r = WN^r Y \left( w_t + \phi - 1 \left( w_t - \frac{\sigma}{1 - G} c_t^r \right) \right) - t_t^r \]

\[ c_t^r = WN^r Y \left( (1 + \phi^{-1}) \phi^{-1} \frac{\sigma}{1 - G} c_t^r + \phi n_t^r \right) - t_t^r \]

Isolating \( c_t^r \)

\[ c_t^r = WN^r Y \left( 1 + \phi^{-1} \frac{\sigma}{1 - G} t_t^r \right) - t_t^r \]

(46)

Plugging in this expression into the aggregation equation for \( c_t \), [41],

\[ c_t \left[ 1 - \chi \frac{WN^r \sigma}{Y} \frac{1 - \phi}{1 - G} + (1 - \chi) \phi^{-1} \frac{WN^r \sigma}{1 - G} \frac{WN^r}{Y} \right] = \chi \frac{WN^r (1 + \phi^{-1}) \phi n_t - t_t^r}{1 + \phi^{-1} \frac{\sigma}{1 - G} \frac{WN^r}{Y}} + (1 - \chi) c_t^0 \]

\[ c_t = \chi \frac{WN^r (1 + \phi^{-1}) \phi n_t - t_t^r}{1 - \chi \frac{WN^r \sigma}{Y} \frac{1 - \phi}{1 - G} + (1 - \chi) \phi^{-1} \frac{WN^r \sigma}{1 - G} \frac{WN^r}{Y}} + (1 - \chi) \frac{1 + \phi^{-1} \frac{\sigma}{1 - G} \frac{WN^r}{Y}}{1 - \chi \frac{WN^r \sigma}{Y} \frac{1 - \phi}{1 - G} + (1 - \chi) \phi^{-1} \frac{WN^r \sigma}{1 - G} \frac{WN^r}{Y}} c_t^0 \]

\[ c_t = \frac{\phi(1 + \phi)n_t - Y WN^r \phi t_t^r}{WN^r \phi - \chi \frac{1 - \phi}{1 - G} \phi + (1 - \chi) \frac{\sigma}{1 - G}} + (1 - \chi) \frac{Y WN^r \phi + \frac{\sigma}{1 - G}}{WN^r \phi - \chi \frac{1 - \phi}{1 - G} \phi + (1 - \chi) \frac{\sigma}{1 - G}} c_t^0 \]

Finally, we can simplify this to

\[ c_t = \Theta_n n_t - \Theta^r t_t^r + \Theta^0 \frac{1}{1 - G} c_t^0 \]  

(47)

where

\[ \Theta^0 = \sigma^{-1} (1 - \chi) (1 - \sigma) \frac{(1 - G) \mu \phi + \sigma}{\phi (1 - G) \mu + \sigma - \chi \sigma (1 + \phi)} \]
\[ \Theta_n = \chi(1 - G) \frac{(1 + \phi)\phi}{\phi(1 - G)\mu + \sigma - \chi\sigma(1 + \phi)}, \]

\[ \Theta_r = \chi(1 - G) \frac{\mu\phi}{\phi(1 - G)\mu + \sigma - \chi\sigma(1 + \phi)} \]

\[ \mu = \frac{Y}{W^N_r} \]

Differentiating [47], we get

\[ \dot{c}_t = \Theta_n \ddot{n}_t - \Theta_r \dot{r}_t + \bar{\sigma}^{-1}(\bar{i}_t - \bar{r}_t - \pi_t) \]

- Using the time derivative of the resource constraint \( \dot{n}_t = \dot{c}_t + \dot{g}_t \), we have the new Euler equation

\[ \dot{c}_t = \ddot{\sigma}^{-1}(\bar{i}_t - \bar{r}_t - \pi_t) + \bar{\Theta}_n \dot{g}_t - \bar{\Theta}_r \dot{r}_t \]

\[ (48) \]

- where

\[ \ddot{\sigma}^{-1} = \frac{\bar{\sigma}^{-1}}{1 - \Theta_n}, \]

\[ \bar{\Theta}_n = \frac{\Theta_n}{1 - \Theta_n} \]

\[ \bar{\Theta}_r = \frac{\Theta_r}{1 - \Theta_n} \]

- Note that there are now two new terms in the Euler equation. Consumption growth rises when government spending increases or taxes for hand-to-mouth consumers falls. These are non-Ricardian effects (i.e. Keynesian effects).

- Nothing on the consumer side has changed the equilibrium conditions for the firm’s price setting decision, hence the NKPC is unchanged. The key is that the output gap is a function of both consumption and government spending, which together account for total output. This yields

\[ \dot{\pi} = \rho\pi_t - \kappa(c_t + (1 - \zeta)g_t) \]

\[ (49) \]

The equilibrium conditions are given by the Euler/DIS equation [48] and the original NKPC [49].
6.3 Deriving the effects of current and future fiscal policy on the equilibrium level of aggregate consumption.

First, we work to write equations [48] and [49] in block form. We can do this as

\[ \dot{X}_t = AX_t + B_t \]

Where

\[
X_t = \begin{bmatrix} \pi_t \\ c_t \end{bmatrix}
\]

\[
B_t = \begin{bmatrix} -\kappa(1 - \zeta)g_t \\ \Theta_n\dot{g}_t - \Theta_r\dot{i}_t^r \end{bmatrix} = -\kappa(1 - \zeta)g_tE_1 + \left[ \Theta_n\dot{g}_t - \Theta_r\dot{i}_t^r \right]E_2
\]

\[
A = \begin{bmatrix} \rho & -\kappa \\ -\tilde{\sigma}^{-1} & 0 \end{bmatrix}
\]

This combines to

\[
\begin{bmatrix} \dot{\pi}_t \\ \dot{c}_t \end{bmatrix} = \begin{bmatrix} \rho & -\kappa \\ -\tilde{\sigma}^{-1} & 0 \end{bmatrix} \begin{bmatrix} \pi_t \\ c_t \end{bmatrix} + \begin{bmatrix} -\kappa(1 - \zeta)g_t \\ \Theta_n\dot{g}_t - \Theta_r\dot{i}_t^r \end{bmatrix}
\]

Which makes sense that it recovers

\[
\dot{c}_t = \tilde{\sigma}^{-1}(i_t - \tilde{r}_t - \pi_t) + \Theta_n\dot{g}_t - \Theta_r\dot{i}_t^r
\]

\[
\dot{\pi}_t = \rho\pi_t - \kappa(c_t + (1 - \zeta)g_t)
\]

assuming \( i = \tilde{r} \)

The matrix \( A \) has two eigenvalues, one positive and one negative, which we denote by

\[
\tilde{v} = \frac{\rho - \sqrt{\rho^2 + 4\kappa\tilde{\sigma}^{-1}}}{2}
\]

with associated eigenvector

\[
X_{\tilde{v}} = \begin{bmatrix} -\tilde{v}\tilde{\sigma} \\ 1 \end{bmatrix}
\]

And the other eigenvalue

\[
\bar{v} = \frac{\rho + \sqrt{\rho^2 + 4\kappa\tilde{\sigma}^{-1}}}{2}
\]
with associated eigenvector

\[
X_{\tilde{v}} = \begin{bmatrix} -\tilde{v}\tilde{\sigma} \\ 1 \end{bmatrix}
\]

Now that we have written the system in this block form, we can search for a solution with the form (this comes from the normal strategy of finding exponential solutions to systems of differential equations).

\[
X_t = \alpha_{\tilde{v}} e^{\tilde{v}t} X_{\tilde{v}} + \kappa (1 - \zeta) \int_t^\infty g_s e^{-A(s-t)} E_1 ds + \int_t^\infty \left[ \tilde{\Theta}_n g_s - \tilde{\Theta}_r t^r \right] e^{-A(s-t)} E_2 ds \tag{50}
\]

where \(X_0\) and \(\alpha_{\tilde{v}}\) solve the system of two equations in three unknowns [these are systems of equations because the terms are matrices]

\[
X_0 - \kappa (1 - \zeta) \int_0^\infty g_t e^{-At} E_1 dt + \int_0^\infty \left[ \tilde{\Theta}_n \dot{g}_t - \tilde{\Theta}_r t^r \right] e^{-At} E_2 dt = \alpha_{\tilde{v}} X_{\tilde{v}}
\]

We can pick the solution which has \(\alpha_{\tilde{v}} = 0\), which is one of several possible solutions. But we will show that it works. Plugging in \(\alpha_{\tilde{v}} = \alpha_{\tilde{v}} = 0\) into \([50]\), we just wipe out the first term on the RHS:

\[
X_t = \kappa (1 - \zeta) \int_t^\infty g_s e^{-A(s-t)} E_1 ds + \int_t^\infty \left[ \tilde{\Theta}_n \dot{g}_s - \tilde{\Theta}_r t^r \right] e^{-A(s-t)} E_2 ds
\]

This simplifies to (breaking out the second term on the RHS into two pieces and getting rid of the \(\dot{t}\) and \(\dot{g}\) terms)

\[
X_t = \kappa (1 - \zeta) \int_t^\infty g_s e^{-A(s-t)} E_1 ds + \tilde{\Theta}_n g_t - \tilde{\Theta}_r t^r \right] E_2 - \int_t^\infty \left[ \tilde{\Theta}_n g_s - \tilde{\Theta}_r t^r \right] A e^{-A(s-t)} E_2 ds \tag{51}
\]

Now that we have this expression \([51]\) for the block, we can back out the \(c_t\) aggregate consumption expression, which is the following (not sure why we still have some of the terms in green).

\[
c_t = \tilde{\Theta}_n g_t - \tilde{\Theta}_r t^r E_2 + \kappa (1 - \zeta) \int_t^\infty g_s E_2 e^{-A(s-t)} E_1 ds - \int_t^\infty \left[ \tilde{\Theta}_n g_s - \tilde{\Theta}_r t^r \right] A e^{-A(s-t)} E_2 ds \tag{52}
\]

We can further simplify by plugging in for \(E_1 = \frac{1}{(\tilde{v} - \tilde{v})^2} (X_{\tilde{v}} - X_{\tilde{v}})\) and \(E_2 = \frac{1}{(\tilde{v} - \tilde{v})} (\tilde{v} X_{\tilde{v}} - \tilde{v} X_{\tilde{v}})\). Then equation \([52]\) becomes

\[
c_t = \tilde{\Theta}_n g_t - \tilde{\Theta}_r t^r + \int_t^\infty \kappa \tilde{\sigma}^{-1} \left[ (1 - \zeta) g_s + \tilde{\Theta}_n g_s - \tilde{\Theta}_r t^r \right] e^{-\tilde{v}(s-t)} \frac{e^{(\tilde{v} - \tilde{v})(s-t)} - 1}{\tilde{v} - \tilde{v}} ds \tag{53}
\]
We can define the following terms, which we will then plug in to the above equation. Calling:

\[ \alpha_{s, HM} = \left( 1 + \frac{\Theta_n}{1 - \zeta} \right) \tilde{\alpha}_{c, HM} \]

\[ \tilde{\alpha}_{s, HM} = \tilde{\sigma}^{-1} \kappa (1 - \zeta) e^{-\bar{v}_s} \frac{e^{(\bar{v}_s - \tilde{v})_s} - 1}{\bar{v} - \tilde{v}} \]

\[ \gamma_{s, HM} = \frac{\tilde{\Theta}_r}{1 - \zeta} \tilde{\alpha}_{c, HM} \]

Plugging each of these into [53], we get our expression for aggregate consumption:

\[
c_t = \tilde{\Theta}_n g_t - \tilde{\Theta}_r t^r_t + \int_0^\infty \alpha_{s, HM} g_{t+s} ds - \int_0^\infty \gamma_{s, HM} t^r_{t+s} ds \tag{54} \]

**Appendix B: Model Setup For Monetary Policy Costs**

In this section, I provide an outline for an environment in which it would be feasible to examine monetary policy in a situation where low interest rates can lead to bubbles. It is based on Allen and Gale (2000), who develop a simple formal model in which intermediation by the banking sector leads to an agency problem that results in asset bubbles. They specifically analyze the role of credit expansion in creating bubbles. I modify their framework in order to look specifically at monetary policy.

There are two dates, \( t = 1, 2 \) and a single consumption good at each date. There are two assets, a safe asset in variable supply and a risky asset in fixed supply. The safe asset pays a fixed return \( r \) to the investor. In Allen and Gale, this safe asset is thought of as debt issued by the corporate sector, or capital goods which are leased to the corporate sector. In this case, the equilibrium risk-free rate is determined endogenously in the model through the marginal product of capital. In contrast, I will assume the risk-free asset is short-term government debt. The central bank manipulates the supply and demand through open market operations in order to maintain the constant interest rate \( r \). For now we will simply take \( r \) to be exogenous, but eventually we will analyze the implications for asset bubbles if \( r \) were set by a Taylor-type monetary policy rule.

The risky asset is in fixed supply. There is one unit at date 1. If an investor purchases \( x \geq 0 \) units of the risky asset at date 1, she obtains \( Rx \) units of the consumption good at date 2, where \( R \) is a random variable with continuous positive density \( h(R) \) on the support \([0, R_{MAX}]\) and mean \( \bar{R} \).

There is a non-pecuniary cost of investing in the risky asset, \( c(x) \), which is incurred at initial date 1. The cost function satisfies the normal neoclassical properties. This will restrict the size of individual portfolios to ensure that, in equilibrium, the borrowers make positive expected profits.

The risky asset is initially owned by entrepreneurs who supply it inelastically in exchange for
the consumption good at date 1.

There is a continuum of small, risk neutral investors. Investors have no wealth of their own, but can borrow from banks to finance investments in safe and risky assets.

There is a continuum of small, risk neutral banks. The representative bank has $B > 0$ units of the good to lend. Banks do not know how to invest in the safe and risky assets. Thus they have no choice but to lend to investors. This feature will deliver the necessity for intermediation which leads to an agency problem on the part of investors.

The banks and investors are restricted to using simply debt contracts. The parties cannot condition the terms of the loan on the size of the loan or on asset returns.