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Can a tax cut deepen the recession?[1]

– preliminary and incomplete –

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Abstract:

This paper shows that at zero short-term nominal interest rate tax cuts reduce output in a standard New Keynesian model. They do so because they increase deflationary pressures. Policies aimed at stimulating aggregate demand work better. These policies include (i) a temporary increase in government spending and (ii) a commitment to inflate. The multiplier of tax cuts goes from positive at positive interest rates to negative once the interest rate hits zero, while the multiplier of government spending not only stays positive but becomes many times larger at the zero bound. The model suggests policy today should not be based on empirical studies that use post WWII data because that period is characterized by positive interest rates.

Key words: tax and spending multipliers, zero interest rates, deflation.
JEL classification: E52,

[1] This paper was written following an interesting email exchange with Gregory Mankiw about my paper "Was the New Deal Contractionary?" Disclaimer: This paper presents preliminary findings and is being distributed to economists and other interested readers solely to stimulate discussion and elicit comments. The views expressed in the paper are those of the author and are not necessarily reflective of views at the Federal Reserve Bank of New York or the Federal Reserve System. Any errors or omissions are the responsibility of the author.

Table 1

	Tax Multiplier	**Spending Multiplier**
Positive interest rate	0.15	0.5
Zero interest rate	-1.9	2

1 Introduction

There has been much discussion in recent weeks about a stimulus plan to revive the US economy. Many economists argue that a recovery plan should include aggressive tax cuts (see e.g. Hall and Woodward (2008) and Bils and Klenow (2008)). In this paper I show that under the special circumstances which the US is experiencing today – interest rates that are close to zero and deflationary pressures – tax cuts are contractionary in a standard New Keynesian model. Why? Tax cuts cause deflationary pressures in the model and thereby increase the real interest rate. The Fed can't accommodate this by cutting the Fed Funds rates, since they are already close to zero. Higher real interest rates are contractionary.

The standard New Keynesian model is too stylized to draw any specific conclusions about taxation as I discuss further in the conclusion of the paper. The general conclusion I want to stress is that the principal goal of policy at zero interest rates should *not be to increase aggregate supply*. Instead, the goal should be to increase aggregate demand – the overall level of spending in the economy. This is because at zero interest rates output is demand determined, at least according to the model presented here. At zero interest rate aggregate supply is mostly relevant in the model because it pins down expectations about future inflation. Policies that aim at increasing aggregate supply can create deflationary expectations and thus be counterproductive. Turning to aggregate demand, I show that it can be increased by either temporarily increases in government spending, or a commitment to inflate the currency.

I compute multipliers of tax cuts and government spending analytically in the model. These multipliers answer the question: By how many dollars does output increase for every dollar in tax cuts or government spending increases. While the multiplier on tax cuts is positive under normal circumstances, it becomes negative at a zero interest rate. In a numerical example shown in Table 1 it goes from 0.15 at a positive interest rate to -1.89 once the interest rate hits zero. The multiplier of government spending, however, gets several times larger at a zero interest rate. In the numerical example shown in Table 1 it goes from 0.5 to 1.95. The analytical results and the numerical examples illustrate that empirical studies on taxes and spending that use post war data can be misleading in guiding policy today. The entire post-war period was characterized by positive short-term nominal interest rate while they have collapsed to zero today.

Taxes in the standard New Keynesian model studied here are labor taxes. Under certain assumptions about the pricing behavior of firms, they can also be interpreted as sales taxes. The result does therefore not establish that all tax cuts are contractionary at zero interest rates. My conjecture is that only those tax cuts that have a strong positive effect on aggregate spending will be successful in battling a recession at zero interest rates (e.g. tax credits aimed at increasing

investment spending), while those aimed at supply incentives may be counterproductive.[2] At a loose and "intuitive" level policy should not be aimed at increasing the supply of goods — when there problem is that there are not enough buyers for the goods already produced.

The results in this paper are closely related to Eggertsson (2008b) that studies the expansionary effect of the National Industrial Recovery Act during the Great Depression. That paper, in turn, builds on a string of papers studying the zero bound on the short-term nominal interest rates, such as Krugman (1998), Eggertsson and Woodford (2003,2004), Eggertsson (2006,2008a,b,c), Adam and Billi (2006) and Jung et al (2006).

2 The Model

The model is a standard New Keynesian model as, for example, derived from microfoundations by Benignio and Woodford (2003). Aggregate demand is given by the linearized CE equation (from "Consumption Euler Equation")

$$\hat{Y}_t = E_t\hat{Y}_{t+1} - \sigma(i_t - E_t\pi_{t+1} - r_t^e) + (\hat{G}_t - E_t\hat{G}_{t+1}) \tag{1}$$

where $\hat{Y}_t$ is output, i_t is the nominal interest rate, π_t is inflation, r_t^e is an exogenous shock and E_t is an expectation operator, $\hat{G}_t$ is government consumption, and the coefficient $\sigma > 0$[3]. Hats denote deviation from steady state.[4] The short term nominal interest rate cannot be negative so that

$$i_t \geq 0 \tag{2}$$

Aggregate supply is given by the FE equation (from "Firm Euler Equation")

$$\pi_t = \kappa\hat{Y}_t + \beta E_t\pi_{t+1} + \kappa\psi\hat{\tau}_t - \kappa\psi\sigma^{-1}\hat{G}_t \tag{3}$$

where the coefficients $\kappa, \psi > 0$ and $0 < \beta < 1$.[5] This equation is derived under the assumption that firm adjust their prices at stochastic intervals as in Calvo (1983). The tax rate $\hat{\tau}_t$ is a labor tax rate.[6] It can also be interpreted as a sales tax, under the assumption that the price that firms set at staggered intervals include the tax.[7]

Monetary policy follows a Taylor rule

$$i_t = \max(0, r_t^e + \phi_\pi\pi_t + \phi_y\hat{Y}_t) \tag{4}$$

[2] It is true that investment tax credit will also improve aggregate supply in the long run, however, my conjecture is that this effect will be trounced by the effect a higher investment spending would have on aggregate demand in the short run. This, however, remains a conjecture and would require further study.

[3] This coefficient is the intertemporal elasticity of substitution, see Eggertsson and Woodford (2004).

[4] Here $\hat{G}_t$ is the percentage deviation of government spending from steady state over steady state aggregate output.

[5] For a definition of the coefficient in terms of the deep parameters of the model, see Eggertsson and Woodford (2004).

[6] This variable is defined as $\hat{\tau}_t \equiv \tau_t - \bar{\tau}$ where τ_t is the tax rate at time t and $\bar{\tau}$ is its steady state value. See Eggertsson and Woodford (2004).

[7] Hence an increase in the tax under this interpretation, does not affect the price the firm charges until the firm readjusts its price the next time. See discussion in Eggertsson and Woodford (2004).

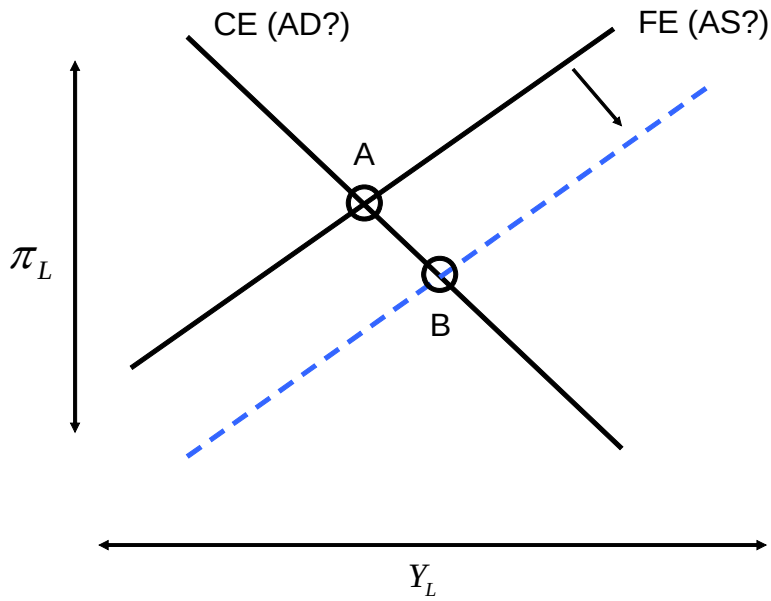

Figure 1: The effect of cutting taxes at a positive interest rate.

Under normal circumstances a tax cut is expansionary in this model. Consider a one time tax cut in period 0 that is reversed the next period. Let $\hat{G}_t = 0$. Substituting 4 into the CE equation we can write the CE and FE equation as

$$\hat{Y}_0 = \frac{-\sigma\phi_\pi}{1+\sigma\phi_y}\pi_0 \tag{5}$$

$$\pi_0 = \kappa\hat{Y}_t + \kappa\psi\tau_0. \tag{6}$$

Figure 1 shows the FE and CE curves (5) and (6). The figure looks like any undergraduate textbook AS-AD diagram, where AS corresponds to the FE curve and AD to the CE curve. A tax cut shifts down the FE curve because now people want to work more since they get more money in their pocket for each hour worked. A new equilibrium is found at point B. We can compute the multiplier of tax cuts by using method of undetermined coefficients. In computing the multiplier I assume that taxes follow the stochastic process $\hat{\tau}_t = \rho_\tau\hat{\tau}_t + \epsilon_t$ where ϵ_t is normally distributed iid. The tax cut multiplier is

$$\frac{\Delta\hat{Y}_t}{-\Delta\hat{\tau}_t} = \frac{\sigma\phi_\pi\kappa\psi}{(1-\rho_t+\sigma\phi_y)(1-\rho_t\beta)+\sigma\phi_\pi\kappa} > 0 \tag{7}$$

Here Δ denotes change relative to the benchmark of no variations in taxes. To illustrate the multiplier numerically I use the values reported in Table 2, taken from Eggertsson and Woodford

(2004)[8], and assume $\rho_t = 0.9$. Then the multiplier is 0.15. If the government cuts taxes by 1 dollar in a given period, this increases output by 15 cents. We now turn to the case when the zero bound is binding.

Table 2, parameters from Eggertsson and Woodford (2004)

parameters	σ	β	κ	ψ	μ	r_L^e	ϕ_π	ϕ_y
values	0.5	0.99	0.02	0.4	0.9	-0.02	1.5	0.25

3 The Zero Bound

Observe that when $r_t^e < 0$ then the zero bound is binding so that $i_t = 0$. This shock generates a recession in the model.

A1 – Structural shocks: $r_t^e = r_L^e < 0$ *unexpectedly at date* $t = 0$. *It returns back to steady state* $r_H^e = \bar{r}$ *with probability* $1-\mu$ *in each period. The stochastic date the shock returns back to steady state is denoted* T^e. *To ensure a bounded solution, the probability* μ *is such that* $L(\mu) = (1-\mu)(1-\beta\mu) - \mu\sigma\kappa > 0$.

Where does this shock come from? In the most simple version of the model, a negative r_t^e is equivalent to a preference shock, see Eggertsson (2008a). Everyone suddenly want to save more so that the real interest rate has to decline for output to stay constant. More sophisticated interpretations are possible, however. Eggertsson (2008c), building on Curdia and Woodford (2008), shows that a model with financial frictions can also be reduced to equations (1)-(3). In this more sophisticated model the shock r_t^e corresponds to an exogenous increase in the probability of default by borrowers and banks. What is nice about this interpretation is that r_t^e can now be mapped into the wedge between a risk free interest rate rate and a interest rate paid on risky loans. Both rates are observed in the data. The wedge implied by these interest rates has exploded recently in the US economy, giving empirical evidence for a large negative shock to r_t^e. A banking crisis – characterized by an increase in probability of default by banks and borrowers– is my story for the model's recession.

Panel (a) in Figure 2 illustrates assumption A1 graphically. Under this assumption, the shock r_t^e remains negative in the recession state denoted L, until some stochastic date T^e, when it returns to steady state. For starters let us assume that $\hat{\tau}_t = \hat{G}_t = 0$. It is easy to show that monetary policy now takes the form

$$i_t = r_H^e \text{ for } t \geq T^e \tag{8}$$

$$i_t = 0 \text{ for } 0 < t < T^e \tag{9}$$

We can now derive the solution in closed form for the other endogenous variables assuming (8)-(9). In the periods $t \geq T^e$ the solution is $\pi_t = \hat{Y}_t = 0$. In periods $t < T^e$ assumption A1

[8] This corresponds to the zero debt case in Table 1 of their paper.

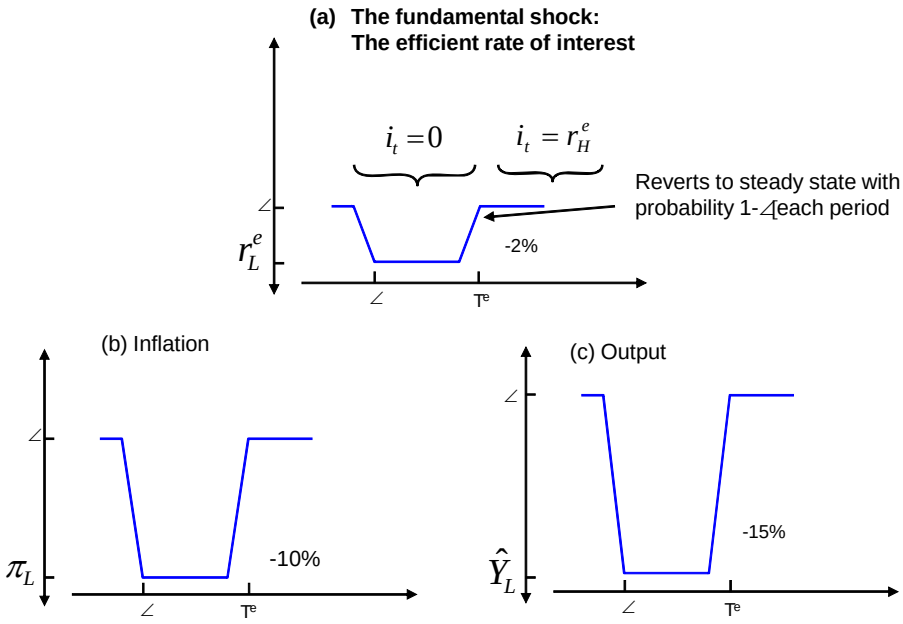

Figure 2: The effect of negative r_t^e on output and inflation.

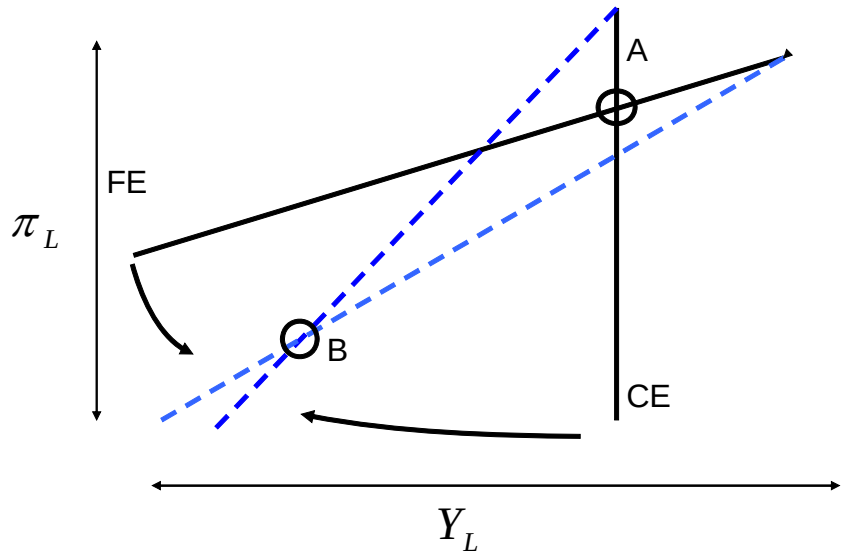

Figure 3: The effect of multiperiod recession.

implies that inflation in the next period is either zero (with probability $1-\mu$) or the same as at time t, i.e., $\pi_t = \pi_L$ (with probability μ). Hence the solution in $t < T^e$ satisfies the CE and the FE equations

$$CE \qquad \hat{Y}_L = \mu\hat{Y}_L + \sigma\mu\pi_L + \sigma r_L^e \tag{10}$$

$$FE \qquad \pi_L = \kappa\hat{Y}_L + \beta\mu\pi_L \tag{11}$$

It is helpful to graph the two equations in $(\hat{Y}_L, \pi_L)$ space. Consider first the special case in which $\mu = 0$, i.e. the shock r_L^e reverts back to steady state in period 1 with probability 1. This case is shown in Figure 3. It only applies to equilibrium determination in period 0. The equilibrium is shown where the two solid lines intersect at point A. At point A, output is completely demand determined by the vertical CE curve and pinned down by the shock r_t^e.[9] For a given level of

[9] A higher efficient rate of interest, r_L^e, corresponds to an autonomous increase in the willingness of the household to spend at a given nominal interest rate and expected inflation and thus shifts the CE curve. Note that the key feature of assumption A1 is that we are considering a shock that results in a negative efficient interest rate, that in turn causes the nominal interest rate to decline to zero. Another way of stating this is that it corresponds to an "autonomous" decline in spending for given prices and a nominal interest rate. This shock thus corresponds to what the old Keynesian literature referred to as "demand" shocks, and one can interpret it as a stand-in for any exogenous reason for a decline in spending. Observe that in the model all output is consumed. If we introduce other sources of spending, such as investment, a more natural interpretation. lf a decline in the efficient interest rate is an autonomous shock to the cost of investment in addition to the preference shock (see further discussion in Eggertsson (2008)).

output, then, inflation is determined by where the CE curve intersects the FE curve. Its worth emphasizing again: *Output is completely demand determined, i.e. completely determined by the CE equation.*

Consider now the effect of increasing $\mu > 0$. In this case, the contraction is expected to last for longer than one period. Because of the simple structure of the model, and the two-state Markov process for the shock, the equilibrium displayed in the figure corresponds to all periods $0 \leq t < T^e$. The expectation of a possible future contraction results in movements in both the CE and the FE curves, and the equilibrium is determined at the intersection of the two dashed curves, at point B. Observe that the CE equation is no longer vertical but upward sloping in inflation, i.e., higher inflation *expectations* $\mu\pi_L$ increase output. The reason is that for a given nominal interest rate ($i_L = 0$ in this equilibrium), any increase in expected inflation reduces the real interest rate, making current spending relatively cheaper, and thus increasing demand. Conversely, expected deflation, a negative $\mu\pi_L$, causes current consumption to be relatively more expensive than future consumption, thus suppressing spending. Observe, furthermore, the presence of the expectation of future contraction, $\mu\hat{Y}_L$, on the right-hand side of the CE equation. The expectation of future contraction makes the effect of both the shock and the expected deflation even stronger. Let us not turn to the FE equation (11). Its slope is now steeper than before because the expectation of future deflation will lead the firms to cut prices by more for a given demand slack, as shown by the dashed line. The net effect of the shift in both curves is a more severe contraction and deflation shown by the intersection of the two dashed curves at point B in Figure 3.

The more severe depression at point B is triggered by several contractionary forces. First, because the contraction is now expected to last more than one period, output is falling in the price level, because there is expected deflation, captured by $\mu\pi_L$ on the right-hand side of the CE equation. This increases the real interest rate and suppresses demand. Second, the expectation of future output contraction, captured by the $\mu\hat{Y}_L$ term on the right-hand side of the CE equation, creates an even further decline in output. Third, the strong contraction, and the expectation of it persisting in the future, implies an even stronger deflation for given output slack, according to the FE equation.[10]

Note the role of the aggregate supply, or the FE equation. It is still really just important to determine the expected inflation in the CE equation. This is the sense in which the output is demand determined in the model even when the shock lasts for many periods. That is what makes tax policy so tricky as we soon will see.

[10] Observe the vicious interaction between the contractionary forces in the CE and FE equations. Consider the pair $\hat{Y}_L^A, \pi_L^A$ at point A as a candidate for the new equilibrium. For a given $\hat{Y}_L^A$, the strong deflationary force in the FE equation reduces expected inflation so that we have to have $\pi_L < \pi_L^A$. Due to the expected deflation term in the CE equation this again causes further contraction in output, so that $\hat{Y}_L < \hat{Y}_L^A$. The lower $\hat{Y}_L$ then feeds again into the FE equation, triggering even further deflation, and thus triggering a further drop in output according to the CE equation, and so on and on, leading to a vicious deflation-output contractionary spiral that converges to point B in panel (a), where the dashed curves intersect.

To summarize, solving the CE and FE equations with respect to π_t and $\hat{Y}_t$, we obtain (the footnote comments on why the denominator has to be positive)[11]

$$\pi_t = \frac{1}{(1-\mu)(1-\beta\mu)-\mu\sigma\kappa}\kappa\sigma r_L^e < 0 \text{ if } t < T^e \text{ and } \pi_t = 0 \text{ if } t \geq T^e \tag{12}$$

$$\hat{Y}_t = \frac{1-\beta\mu}{(1-\mu)(1-\beta\mu)-\mu\sigma\kappa}\sigma r_L^e < 0 \text{ if } t < T^e \text{ and } \hat{Y}_t = 0 \text{ if } t \geq T^e \tag{13}$$

The two-state Markov process for the shock allows us to collapse the model into two equations with two unknown variables, as shown in Figure 3. It is important to keep in mind, however, the stochastic nature of the solution. The output contraction and the deflation last only as long as the stochastic duration of the shock, i.e., until the stochastic date T^e, and the equilibrium depicted in Figure 3 applies only in the "recession" state. This is illustrated in Figure 2, which shows the solution for a arbitrary contingency in which the shock lasts for T^e periods. I have added for illustration numerical values in this figure, using the parameters from Table 2.

4 Why Tax Cuts are Contractionary

Let us now consider the effect of tax cuts when the zero bound is binding. In particular, consider a temporary tax cut aimed at ending the recession. Assume the tax cut takes the form

$$\hat{\tau}_L = \phi_\tau r_L^e < 0 \text{ when } 0 < t < T^e \tag{14}$$

with $\phi_\tau > 0$ and

$$\hat{\tau}_t = 0 \text{ when } t \geq T^e. \tag{15}$$

Consider now the solution in the periods when the zero bound is binding but the government follows this policy. Output and inflation again solve the CE and FE equations. While the CE equation is unchanged, the FE equation is now

$$FE \qquad \pi_L = \kappa\hat{Y}_L + \beta\mu\pi_L + \kappa\varphi\hat{\tau}_L \tag{16}$$

where the tax appears on the right-hand side. An increase in $\hat{\tau}_L$ shifts the FE curve outwards denoted by a dashed line in Figure 4. Why does the FE curve shift? This is just a traditional shift in "aggregate supply" outwards. Consider a reduction in taxes. The firms are now in a position to

[11] The vicious dynamics described in last footnote amplify the contraction without a bound as μ increases. As μ increases, the CE curve becomes flatter and the FE curve steeper, and the cutoff point moves further down in the $(\hat{Y}_L, \pi_L)$ plane in panel (a) of Figure **??**. At a critical value $1 > \bar{\mu} > 0$ when $L(\bar{\mu}) = 0$ in A1, the two curves are parallel, and no solution exists. The point $\bar{\mu}$ is called a *deflationary black hole.* In the remainder of the paper we assume that μ is small enough so that the deflationary black hole is avoided and the solution is well defined and bounded (this is guaranteed by the inequality in assumption A1). A deflationary solution always exists as long as the shock μ is close enough to 0 because $L(0) > 0$ (at $\mu = 0$ the shock reverts back to steady state with probability 1 in the next period). Observe, furthermore, that $L(1) < 0$ and that in the region $0 < \mu < 1$ the function $L(\mu)$ is strictly decreasing, so there is some critical value $\bar{\mu} = \mu(\kappa, \sigma, \beta) < 1$ in which $L(\mu)$ is zero and the model has no solution.

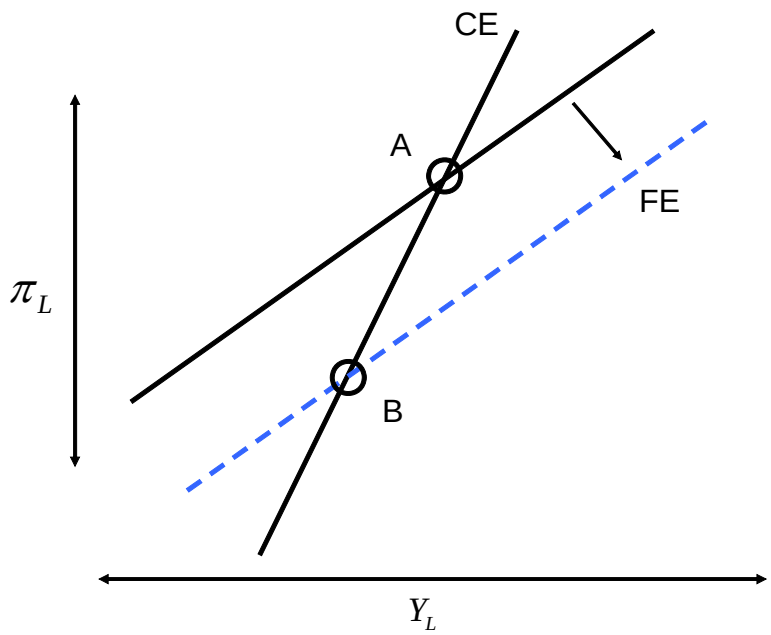

Figure 4: The effect of cutting taxes at a zero interest rate.

charge lower price on their products than before. This suggests that they will reduce their prices relative to the prior period for any given level of production in the recession state, hence shifting the FE curve. A new equilibrium is formed at the intersection of the dashed FE curve and the CE curve at lower output and prices, i.e., at point B in Figure 4. The general equilibrium effect of the tax cut is therefore an output contraction.

The intuition for this result is that the expectation of lower taxes in the recession creates deflationary expectations *in all states of the world in which the shock* r_t^e *is negative*. This makes the real interest rate higher – which reduces spending according to the CE equation.

$$\begin{aligned} \hat{Y}_L^{tax} &= \frac{1}{(1-\mu)(1-\beta\mu)-\mu\sigma\kappa}[(1-\beta\mu)\sigma r_L^e + \mu\kappa\sigma\varphi\hat{\tau}_L] < \hat{Y}_t^{notax} \text{ if } t < T^e \\ \text{and } \hat{Y}_L^{tax} &= 0 \text{ if } t \geq T^e \end{aligned}$$

$$\pi_t^{tax} = \frac{\kappa}{1-\beta\mu}(\hat{Y}_t^D + \varphi\hat{\tau}_L) < \pi_t^{notax} \text{ if } t < T^e \text{ and } \hat{Y}_t^D = 0 \text{ if } t \geq T^e$$

We can now compute the multiplier of tax cuts at zero interest rates. Its is negative and given by

$$\frac{\Delta\hat{Y}_L}{-\Delta\hat{\tau}_L} = -\frac{\mu\kappa\sigma\varphi}{(1-\mu)(1-\beta\mu)-\mu\sigma\kappa} < 0 \tag{17}$$

Using the numerical values in Table 2 this corresponds to a multiplier of -1.89. This is a large number. It means that if the government reduces taxes by 1 dollar at zero interest rates,

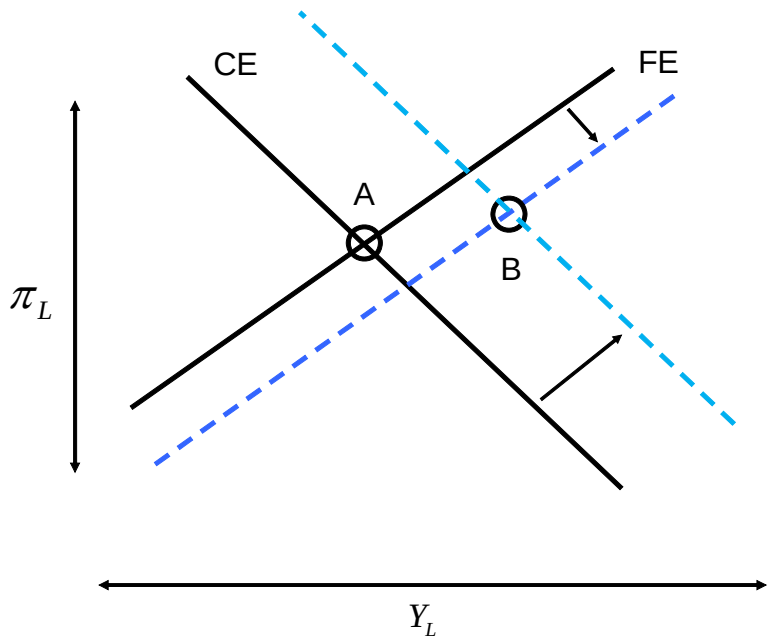

Figure 5: Increasing government spending at positive interest rates

then aggregate output declines by 1.89 dollars. To keep the multipliers (7) and (17) comparable I assume that the expected persistence of the tax cuts is the same across the two experiments i.e. $\mu = \rho_\tau$.

5 Why government spending are expansionary

Let us now consider government spending. We abstract from the effect the spending may have on current or future taxes. Consider first the effect of increasing government spending in period t for one period in the absence of the deflationary shock so that the short-term nominal interest rate is positive. Substituting the Taylor rule into the CE equation we can write the FE and CE curves as

$$\hat{Y}_0 = \frac{-\sigma\phi_\pi}{1+\sigma\phi_y}\pi_0 + \frac{1}{1+\sigma\phi_y}G_0 \tag{18}$$

$$\pi_0 = \kappa\hat{Y}_t - \kappa\delta G_0 \tag{19}$$

The experiment is shown in Figure 5. It looks almost identical to a standard undergraduate text book AD-AS diagram. An increase in G_0 shifts out demand for all the usual reasons. i.e. it is an "autonomous" increase in spending. In the standard New Keynesian model there is an additional kick, however, akin to the effect of reducing labor taxes. Government spending also shifts out aggregate supply. Because government spending takes away resources from private

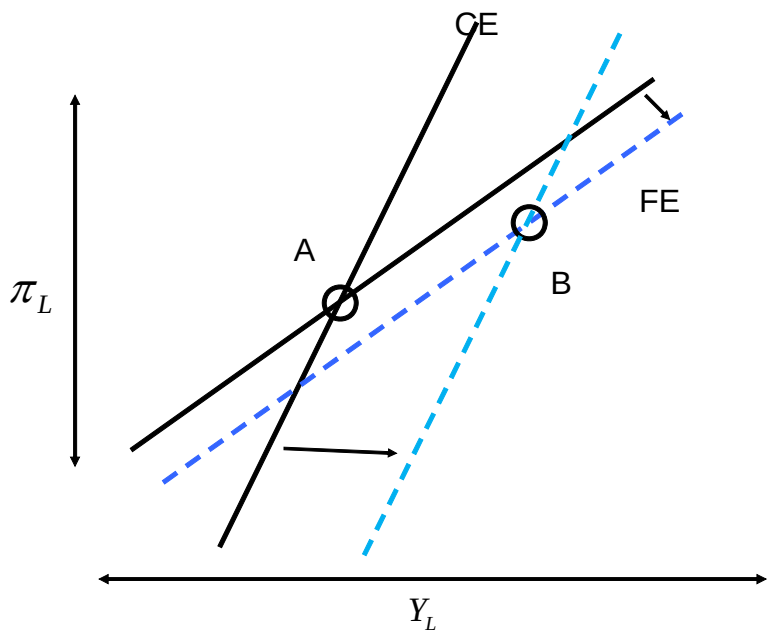

Figure 6: The effect of increasing government spending at zero interest rates.

consumption, people want to work more to make up for lost consumption, shifting out labor supply and reducing real wages. This effect is shown by the outward shift in the FE curve in the figure. The new equilibrium is in point B. Let us assume that government spending follows an autoregressive process $\hat{G}_t = \rho_g \hat{G}_{t-1} + \epsilon_t$. Using method of undetermined coefficients, we can compute the multiplier of government spending at positive interest rates as

$$\frac{\Delta \hat{Y}_0}{\Delta G_0} = \frac{1 - \rho_G + \frac{\phi_\pi - \rho_G}{1-\rho_G \beta} \kappa \psi}{1 - \rho_G + \sigma \phi_y + \frac{\phi_\pi - \rho_G}{1-\rho_G \beta} \sigma \kappa} > 0$$

Using the parameter values in table on we find that the one dollar in government spending increases output by 0.51 which is almost four times bigger than the multiplier of tax cuts at positive interest rates.

Consider now the effect of government spending at zero interest rates. In contrast to tax cuts, increasing government spending is very effective at zero interest rates. Consider the following fiscal policy:

$$\hat{G}_t = \hat{G}_L > 0 \quad \text{for} \quad 0 < t < T^e \tag{20}$$

$$\hat{G}_t = 0 \quad \text{for} \quad t \geq T^e \tag{21}$$

Under this specification, the government increases spending in response to the deflationary shock

and then reverts back to steady state once the shock is over.[12] The CE and FE equations can be are written as:

$$CE \qquad \hat{Y}_L = \mu\hat{Y}_L + \sigma\mu\pi_L + \sigma r_L^e + (1-\mu)\hat{G}_L \tag{22}$$

$$FE \qquad \pi_L = \kappa\hat{Y}_L + \beta\mu\pi_L - \kappa\delta\hat{G}_L. \tag{23}$$

Figure 6 shows the effect of increasing government spending. Increasing $\hat{G}_L$ shifts out the CE equation, stimulating both output and prices. At the same time, however, it shifts out the FE equation as we discussed before, so there is some deflationary effect of the policy, which arises because there is an increase in the labor supply of workers. This effect, however, is too small to overcome the stimulative effect of government expenditures. In fact, solving these two equation together, its easy to show that the effect of government spending is always positive and always greater than one. Solving (22) and (23) together yields the following multiplier[13]

$$\frac{\Delta\hat{Y}_L}{\Delta\hat{G}_L} = \frac{(1-\mu)(1-\beta\mu) - \sigma\mu\kappa\delta}{(1-\mu)(1-\beta\mu) - \sigma\mu\kappa} > 1$$

i.e. one dollar of government spending, according to the model, has to increase output by more than one. In our numerical example the multiplier is 1.95, i.e., each dollar of government spending increases aggregate output by 1.95 dollars. Why is the multiplier so large? The main cause of the decline in output and prices was the expectation of a future *slump* and *deflation*. If the private sector expects an increase in future government spending in all states of the world in which the zero bound is binding, contractionary expectations are changed in all periods in which the zero bound is binding; thus having a large effect on spending in a given period. Thus, expectation about future policy play a key role in explaining the power of government spending, and key element of making it work *is to commit to sustain the spending spree until the recession is over.*

6 A Commitment to Inflate

Finally I consider another policy to increase demand, a commitment to inflate the currency. Expansionary monetary policy is modeled as a commitment to a higher growth rate of the money supply in the future, i.e., at $t \geq T^e$. As shown by several authors, such as Eggertsson and Woodford (2003) and Auerbach and Obstfeld (2005), it is only the expectation about future money supply (once the zero bound is no longer binding) that matters at $t < T^e$ when the interest rate is zero. Consider the following monetary policy rule:

$$i_t = \max\{0, r_t^e + \pi^* + \phi_\pi(\pi_t - \pi^*) + \phi_y(\hat{Y}_t - \hat{Y}^*)\} \tag{24}$$

where π^* denotes the implicit inflation target of the government and $\hat{Y}^* = (1-\beta)\kappa^{-1}\pi^*$ is the implied long-run output target. Under this policy rule a higher π^* corresponds to a credible

[12] This equilibrium form of policy is derived from microfoundations in Eggertsson (2008) assuming a Markov perfect equilibrium.

[13] Note that the denominator is always positive according to A1. See discussion in footnote 6.

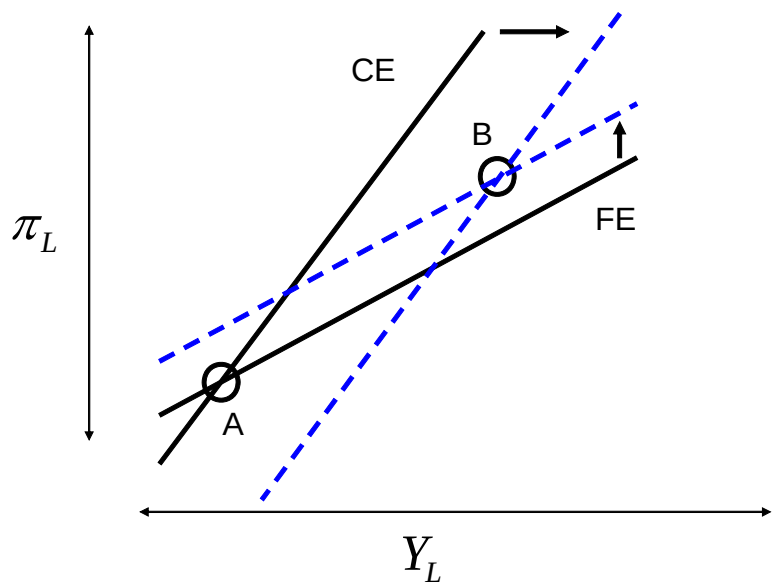

Figure 7: Commitment to inflate at zero nominal interest rates

inflation commitment. Consider a simple money constraint as in Eggertsson (2008a), $M_t/P_t \geq \chi \hat{Y}_t$ where M_t is the money supply and $\chi > 0$. Then a higher π^* corresponds to a commitment to a higher growth rate of the money supply in $t \geq T^e$ at the rate of π^*. The assumption about policy in (4) is a special case of this policy rule with $\pi^* = 0$.

What is the effect of an increase in the inflation target? It is helpful write out the FE and CE equations in periods $0 < t < \tau$ when the zero bound is binding:

$$CE \qquad \hat{Y}_L = \mu \hat{Y}_L + (1-\mu)\hat{Y}^* + \sigma\mu\pi_L + \sigma(1-\mu)\pi^* + \sigma r_L^e \tag{25}$$

$$FE \qquad \pi_L = \kappa \hat{Y}_L + \beta\mu\pi_L + \beta(1-\mu)\pi^* \tag{26}$$

Consider the effect of increasing $\pi^* = 0$ to a positive number $\pi^* > 0$. As shown in Figure 7 this shifts the CE curve to the right and the FE curve to the left, increasing both inflation and output. The logic is straight forward: A higher inflation target in period $t \geq T^e$ reduces the real rate of interest in period $t < T^e$, thus stimulating spending in the depression state. This effect can be quite large owing to a similar effect as described in the case of fiscal policy. The effect of π^* does not only increase inflation expectation at dates $t \geq T^e$, it also increases inflation in all states of the world in which the zero bound is binding. In general equilibrium the effect of inflating the currency is very large for this reason.

Consider the following, "inflation target multiplier". This statistic answers the question, by how much does output increase, for each percentage increase in the implicit inflation target of the

government? This number is given by

$$\frac{\Delta Y_L}{\Delta \pi^*} = \frac{(1-\mu)\{(1-\beta\mu)(1-\beta)k^{-1}+\sigma\}}{(1-\beta\mu)(1-\mu)-\sigma\mu\kappa}$$

to 7.2 percent using the parameter values from Table 1. Hence, a fully credible increase in the inflation target increases output by 7.2 percent once the zero bound is binding.

We can compute this the same "multiplier" at positive interest rate, i.e. when there is no deflationary shock. In this case we have

$$\frac{\Delta Y^*}{\Delta \pi^*} = (1-\beta)\kappa^{-1}$$

so that a percentage increase in inflation increases output by only 0.125 percent. Hence, inflation is inflation is nearly neutral at positive interest rate.

7 Credibility

Expansionary monetary policy can be difficult if the central bank cannot commit to future policy. The problem is that an inflation promise is not credible for a discretionary policymaker. The welfare function in the model economy is given by the utility of the representative household, which to a second order can be approximated as[14]

$$E_t \sum_{t=0}^{\infty} \beta^t (\pi_t^2 + \lambda \hat{Y}_t^2)$$

The central bank has an incentive to promise future inflation at date $t < T^e$ but then to renege on this promise at data $t \geq T^e$ since at that time the bank can achieve both zero inflation and set output at trend, which is the ideal state of affairs according to this welfare function. Eggertsson (2006) shows this formally and calls it the "deflation bias" of discretionary monetary policy at zero interest rate. Government spending does not have this problem. In fact, the policy under full discretion will take exactly the same form as the spending analyzed in section **??**. The intuition is that fiscal policy does not only require promises about what the government will do in the future, it also involves direct actions today. And those actions are fully consistent with those the government promises in the future (namely increase government spending throughout the recession period).

Its seem quite likely that in practice, especially for a central bank with a high degree of credibility, that a central bank can make credible announcements about its future policy and thereby have considerable effect on expectations. Moreover, many authors have analyzed explicit steps, such as expansion in the central banks balance sheet through purchases of various assets such as foreign exchange, mortgage backed securities or equities, that can help make an inflationary

[14] see e.g. Eggertsson and Woodford (2004). Our assumption about the shocks is such that $\hat{Y}_t^* = 0$ in their notation, see discussion in Section 1.2 of that paper and also Eggertsson (2008a) who discusses this assumption it in some detail.

pledge more credible (see e.g. Eggertsson (2006) and Jeanne and Svensson (2006)). Finally, if the government accumulates large amounts of nominal debt, this too, can be helpful in making an inflation pledge credible.

8 Tax Cuts Together with Demand Stimulus

Observe that neither the effect of the monetary expansion nor government spending changes *qualitatively* the effect of a tax cut as long as $\pi^* + [\phi_\pi \pi^G + \phi_y Y^G]\hat{G}_L \leq -r_L$. While the new equilibrium is associated with higher output and inflation than before, the effect of reducing $\hat{\tau}_L$ remains the same because the slopes of the FE and the CE curves remain unchanged. The key condition for this result is that the change in the implicit inflation target from 0 to π^*, and the increase in G_L, are still small enough to satisfy the condition stated above so that the interest rate remains at zero.

9 Conclusion

The main problem facing the model economy I have studied in this paper is insufficient demand. In this light, the emphasis should be on policies that stimulate spending. Payroll tax cuts may not be the best way to get there. The model shows that they can even be contractionary. What should be done according to the model? Traditional government spending is one approach. Another is a commitment to inflate. Ideally the two should be put together. Government spending has the advantage over inflation policy that is has no credibility problem associated with it. Inflation policy, however, has the advantage that it does not require any public spending, which may be at its "first best level" in the steady state of the model studied here. Any fiddling around with the tax code should take into account that deflation might be a problem. In that case shifting out aggregate supply can make things worse.

It is worth stressing that the way taxes are modelled here, although standard, is special in several respect. In particular tax cuts do not have any "direct" effect on spending. The variations in taxes only has an effect through the incentive it creates for employment and thus "shifts aggregate supply", thus lowering real wages and stimulating firms to hire more workers. One can envision various environment in which tax cuts stimulate spending, such as old fashion Keynesian models, or models where people have limited access to financial markets. In those models there will be positive spending effect of tax cuts, even payroll tax cuts like the ones in the standard New Keynesian model. For this reason I am bit hesitant to draw the lesson from this paper that it would be ideal to *raise payroll taxes* to stimulate the US economy today, although this clearly is a direct implication of the analysis .

It is also worth raising another channel through tax cuts can stimulate the economy. Tax cuts would tend to increase budget deficits and thus increase government debt. That gives the government a higher incentive to inflate the economy. As we have just seen in section 6, higher inflation expectations have a strong positive impact on demand at zero interest rates. Eggertsson

(2006) model this channel explicitly. In his model taxes have no effect on labor supply, but instead generate tax collection costs as in Barro (1978). In that environment tax cuts are expansionary because they increase debt and through that inflation expectations.

What should we take out of all of this? There are two general lesson I want to draw from this paper. The first is that insufficient demand is the main problem once the zero bound is binding, and policy should first and foremost focus on ways in which the government can increase spending. Policies that expand supply, such as some (but probably not all) tax cuts and also a variety of other policies, can have subtle counterproductive effects at zero interest rates by increasing deflationary pressures. This should – and can – be avoided by suitably designed policy. The second lesson is that policymakers today should view with great deal of scepticisms any empirical evidence on the effect of tax cuts or government spending based on post war US data. The number of these studies is high, and they are frequently cited in the current debate. The model presented here, which has by now become a workhorse model in macroeconomics, predicts that the effect of tax cuts and government spending is fundamentally different at zero nominal interest rates than under normal circumstances.

10 References

Adam, Klaus and Roberto Billi (2006), "Optimal Monetary Policy under Commitment with a Zero Bound on Nominal Interest Rates," Journal of Money, Credit and Banking, Vol. 38(7), 1877-1905.

Auerbach, Allan, and Maurice Obstfeld (2005) "The Case for Open Market Operations," American Economic Review, Volume 95, No. 1.

Benigno, Pierpaolo and Michael Woodford (2003), "Optimal Monetary and Fiscal Policy: A Linear Quadratic Approach," NBER Macroeconomics Annual 2003.

Bils, Mark and Pete Klenow (2008), "Further Discussion of Temporary Payroll Tax Cut During Recession(s)," mimieo, available at http://klenow.com/Discussion_of_Payroll_Tax_Cut.pdf.

Calvo, Guillermo. (1983) "Staggered Prices in a Utility-Maximizing Framework," Journal of Monetary Economics, 12: 383-98.

Curdia, Vasco and Michael Woodford (2008), "Credit Frictions and Optimal Monetary Policy," Columbia University, mimeo.

Eggertsson, Gauti (2008a), "Great Expectations and the End of the Depression," American Economic Review, forthcoming.

Eggertsson, Gauti, (2008b), "Was the New Deal Contractionary?", NYFed, mimeo.

Eggertsson, Gauti, (2008c), "What Caused the Great Depression?" NYFed, mimeo.

Eggertsson, Gauti. (2006), "The Deflation Bias and Committing to Being Irresponsible," Journal of Money, Credit, and Banking.

Eggertsson, Gauti and Woodford, Michael (2003), "The Zero Bound on Interest Rates and Optimal Monetary Policy," Brookings Papers on Economic Activity 1, 212-219.

Eggertsson, Gauti and Michael Woodford. (2004), "Optimal Monetary and Fiscal Policy in a Liquidity Trap," ISOM conference volume 2004.

Hall, Robert and Susan Woodford, "Options for Stimulating the Economy," mimeo, available at http://woodwardhall.wordpress.com/2008/12/08/options-for-stimulating-the-economy/

Jung, Terenishi, Watanabe (2005),"Zero bound on nominal interest rates and optimal monetary policy", Journal of Money, Credit and Banking, Vol 37, pp 813-836

Krugman, Paul (1998), "It's Baaack! Japan's Slump and the return of the Liquidity Trap," Brookings Papers on Economic Activity 2:1998.