Fiscal Policy in an Unemployment Crisis

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Abstract. This paper argues that the effectiveness of fiscal policy may increase markedly during periods of low nominal interest rates and high, persistent, unemployment. An increase in government spending boosts economic activity and reduces the unemployment rate both in the present and in the future. As a less disconcerting future spurs a rise in private consumption, unemployment falls even further and triggers an additional rise in private demand, and so on. In a stylized model, I show that the marginal impact of government spending on output is equal to the reciprocal of the elasticity of intertemporal substitution. In a more realistic framework, the effect is somewhat attenuated and displays significant nonlinearities with respect to the depth of the crisis as well as the size of the stimulus package. But in a severe recession with an unemployment rate of eight percent or above, the fiscal multiplier is equal to 1.5.

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1. Introduction

The recent financial crisis plunged the world economy into a deep recession with stagnating growth and soaring, persistent, unemployment rates. Despite aggressive actions undertaken by monetary authorities, demand remained stubbornly weak. With unprecedented low levels of short term interest, policy makers were compelled to reach for alternative stabilization tools, including expansionary fiscal policy. The effectiveness of fiscal policy, however, remains highly controversial and its study is plagued by numerous theoretical challenges which are still vividly discussed amongst professional- and academic economists. This paper aims to address some of the most pressing concerns by providing a novel answer to a, by now, classic question: What is the size of the fiscal multiplier?[1]

I show that the potency of fiscal policy can be strikingly large during periods of low nominal interest rates and high, persistent, unemployment. The argument relies on two separate but reinforcing mechanisms. First, in a liquidity trap, output is largely determined by demand. If households wish to consume more, firms will also produce more. Second, the labor market is inertial. As a consequence, any change in current unemployment is likely to persist into the future. Together these two mechanisms imply that an increase in government spending raises output and lowers the unemployment rate both in the present *and* in the future. But as rational economic actors desire to smooth consumption over time, the increase in future output feeds back to a further rise in current demand, and so on. This interplay between present- and future economic activity has the capacity to propagate the effectiveness of demand-stimulating policies many time over, and the fiscal multiplier exceeds unity under a wide range of circumstances.[2]

But a tale of recovery is also a tale of a slump. Confronted with disappointing news concerning future income, households wish to save resources in order to insulate themselves from the dire times ahead. If news are sufficiently ominous, the nominal interest rate falls to zero and brings the economy into a liquidity trap. Savings materialize as cash hoardings which drain economy of liquidity. With downwardly rigid money-wages the associated shortfall in nominal demand may have real consequences, and provokes a marked decline in current economic activity. This is the old news.

With rising, *and persistent*, unemployment, however, the future now appears even bleaker. Additional measures to smooth consumption only amplifies the initial decline in economic

[1]Througout this paper, 'the fiscal multiplier' refers to the marginal change in output in response to a marginal change in *contemporaneous*, and *wasteful*, government purchases. I therefore abstract from possible cumulative effects on output, anticipation effects of future policy on current aggregates, and productive government investments.

[2]Of course, as Ricardian equivalence holds (Barro, 1974), 'the balanced budget multiplier' (Haavelmo, 1945) exceeds unity as well.

activity, raises unemployment, and further depresses the economic outlook. I show that this downward spiral of *self-reinforcing thrift* can have an abysmal effects on economic activity *even in the absence* of any real shocks to contemporaneous productivity.

But the government can turn a vicious circle around. By borrowing – or taxing – unutilized cash and spending it, unemployment falls and the future appears less disconcerting.The downward spiral of self-reinforcing thrift is deflected into a virtuous in which spending begets spending. In a stylized model, I show that the marginal impact of government purchases on output equals the reciprocal of the elasticity of intertemporal substitution, or simply the coefficient of relative risk aversion. In a more realistic framework, the effect is somewhat attenuated and displays significant nonlinearities with respect to the depth of the crisis as well as the size of the stimulus package. But in a severe recession with unemployment exceeding the natural rate with three percentage points or more, the fiscal multiplier is equal to 1.5.

Some may argue that the above scenario yields few further insights than those traditionally associated with Keynes (1936). That would be a mistake. The Keynesian narrative hinges on the presumption of myopic consumers which, once replaced by forward looking behavior, attenuates the multiplier not to exceed unity (see for instance Krugman (1998)).[3] Indeed, the fundamental propagation mechanism explored in this paper – the interplay between current- and future economic activity – is not an outcome *in despite of* rational expectations, but rather a result *by cause of* of rational expectations. For better *and* worse, forward looking consumers brings the future to the present, and vice versa.

With respect to the previous literature, there has been no shortage of papers exploring the effectiveness of fiscal policy. Since the seminal works by Hall (1980), Barro (1981), and Barro and King (1984) the mechanisms within the standard flexible-price neoclassical framework are well understood. An increase in government spending reduces private wealth, and thus stimulates labor supply. Real wages fall in response to clear the labor market, but the net effect on output is unambiguously positive. Contrary to the empirical evidence, however, the same wealth-effect which instills a rise in output depresses private demand and, in marked contrast to this paper, suggest a negative response in consumption.[4]

Confronted with these anomalies, researchers have instead turned attention towards new-Keynesian flavored models with sticky prices. When monopolistic firms are unable to reset

[3]Or at least, this used to be true. Bilbiie (2009) shows that in an otherwise straight-shooting neoclassical model the multiplier may exceed one if consumption is an inferior good. See Monacelli and Perotti (2008) for a further discussion of the impact of preferences on fiscal policy.

[4]Admittedly, the empirical literature is not conclusive on this point. Fatas and Mihov (2001), Blanchard and Perotti (2002), Galí et al. (2007), Perotti (2008), Fisher and Peters (2009) find empirical support of a positive response in consumption. But studies such as Ramey and Shapiro (1998) and Ramey (2011) do not.

prices at their own discretion, markups – or, in many cases, simply the reciprocal of real wages – turn countercyclical. Thus, as expansionary fiscal policy enhances labor supply, real wages increase instead of decrease, and cushion the aforementioned fall in private consumption. Regrettably, however, the associated response in monetary policy may well mitigate much of the first-order effects, and the fiscal multiplier remains below unity under a wide range of circumstances.[5]

Those circumstances do not extend, however, to a situation of a liquidity trap. In recent, and highly influential work, Christiano, Eichenbaum and Rebelo (2011) and Eggertsson (2010) analyze the effectiveness of fiscal policy at the 'zero lower bound'.[6] With nominal rates stuck at zero, staggered pricing causes a deflationary spiral which raises the real interest rate, stimulates savings, and thus exacerbates any initial decline in economic activity. In similarity to this paper, fiscal policy has the capacity to turn a vicious circle around. An increase in both current *and future* public outlays sets the economy on an inflationary path in which spending begets spending. The fiscal multiplier, they show, can be sizable and easily exceed one.

This story is quite different from mine. Christiano et al. (2011) and Eggertsson (2010) primarily analyze a situation with *multiple* liquidity spells and with *repeated* fiscal action. I consider a liquidity trap which lasts for one period with an associated one-shot increase in government purchases. The difference is subtle, but the consequences important. Absent repeated liquidity spells, the aforementioned deflationary spiral vanishes, and the potency of fiscal policy is reduced. Letting the duration of the liquidity crisis approach one attenuates the multiplier in Eggertsson (2010) to unity, and Christiano et al. (2011) to 1.3.[7] It is therefore neither the presence of a liquidity trap nor the increase in contemporaneous spending *per se* which renders a large fiscal multiplier. Rather, it is the *combination* between a deep and prolonged recession with a long lasting, committed, fiscal expansion that provides a fertile ground for effective public spending. Although a very appealing and relevant scenario, these ideas contrast markedly to this study in which purely temporary fiscal policy may be highly effective even in a brief, albeit deep, downturn.

Apart from these diverging views, there are also some pronounced differences in the mechanics underpinning the results. I consider a frictional labor market with rigid nominal

[5]See for instance, Galí et al. (2007), Monacelli and Perotti (2008), and Woodford (2011) for a detailed discussion.

[6]See Christiano (2004), Braun and Waki (2010), Erceg and Lindé (2010), Cogan, Cwik, Taylor and Wieland (2010), and Taisuke (2012) for further studies on this topic.

[7]In this situation the real interest rate is constant and a unit multiplier follows straightforwardly from the analysis of Woodford (2011). A multiplier of 1.3 in Christiano et al. (2011) follows from non-separable preferences in consumption and leisure as illustrated in Bilbiie (2009), and Monacelli and Perotti (2008).

wages. As a consequence, the main thrust in this paper is governed by labor *demand*, and not by supply. An increase in government spending puts upward pressure on current prices, *reduces* real wages, and encourages hiring. The reciprocal of real wages are therefore procyclical with respect to variations in demand, but turn countercyclical in face of shocks to labor productivity.[8]

But ideas are also shared. In similarity to this paper, Eggertsson (2010) and Christiano et al. (2011) acknowledge the importance of an intertemporal feedback mechanism which is capable of propagating the effectiveness of demand-stimulating policies many times over. In their studies, this feedback stems from the inflationary/deflationary spiral associated with the prolonged nature of the recession, and with the positive 'news' associated with sustained fiscal actions.[9] In this paper, the feedback mechanism rather relies on the inherent sluggishness observed in frictional labor markets, which tightly interlinks current economic activity to the future, and vice versa. Needless to say, this paper builds upon, and I believe complements, the works of Eggertsson and Christiano et al.

Empirical estimates of the fiscal multiplier are dispersed. In a recent survey, Ramey (2011) concludes that an increase in government purchases stimulates the economy with a multiplier between 0.8 and 1.5. Hall (2009), on the other hand, suggests a slightly smaller range of 0.7 to 1.0.[10] But the disparity in estimates also underlines a widely acknowledged fact: There exist no single fiscal multiplier. Rather, the effectiveness of fiscal policy varies crucially with the state of the economy, and estimates diverge depending on the choice of sample period and identification methods (see Parker (2011) for a discussion).

Barro and Redlick (2011), for instance, find a multiplier of 0.7. But when they allow for interactions with the unemployment rate, the multiplier rises to unity.[11] Gordon and Krenn (2011) confine attention to the defense build-up associated with World War II. They argue that past estimates are attenuated by capacity constraints during the later stages of the war, as well as outright prohibitions on the production of civilian goods. By cutting their sample at the second-, instead of the fourth quarter, of 1941, they avoid such concerns and the estimated multiplier increases from 0.9 to 2.5.Recent evidence from cross-state studies further corroborates these findings. Nakamura and Steinsson (2011) and Shoag (2010) show

[8]Although this is not a study of business cycle properties, recent research by Hall (2009) and Nekarda and Ramey (2010) lend empirical support to this view.

[9]Indeed, Woodford (2011) notes that "Eggertsson (2010) obtains a multiplier of 2.3, 1.0 of this is due to the increase in government purchases during the current quarter, while the other 1.3 is the effect of higher anticipated government purchases in the future". An analogous argument applies to Christiano et al.

[10]Ramey (2011) adds the savings clause that "[r]easonable people can argue, however, that the data do not reject 0.5 or 2" (p. 673), and Hall (2009) argues that "higher values are not ruled out" (p. 183).

[11]Assuming an unemployment rate of 12 percent.

that estimates of the multiplier may nearly double in periods in which the unemployment rate exceeds the sample mean. And using a structural VAR based approach, Auerbach and Gorodnichenko (2011; forthcoming) show that the multiplier is only moderate, or even negative, in expansions, while it exceeds two in periods of recessions.

The framework analyzed in this paper is consistent with these observations. During a deep downturn in which the unemployment rate exceeds the natural by two percentage points or more, the multiplier exceeds unity, and plateaus at 1.5. Private consumption rise in response to an increase in government spending, and fiscal policy unambiguously improves welfare. Interestingly, however, as the stimulus package expands and closes much of the output-gap – arguably a relevant scenario in the war-years of 1940-1945 – both the marginal and the *average* multiplier fall well below one. Indeed, the average multiplier associated with a deep recession, but in which fiscal spending has successfully closed most of the output-gap, equals 0.75, a number markedly in line with the estimates provided in Barro (1981). During less distressing times, however, the multiplier falls short of unity even at modest levels of spending, and public outlays unambiguously crowds-out private consumption. In 'normal' times the multiplier is zero.

2. Model

The economy is populated by a government, a large number of potential firms, and a unit measure of workers. The planning horizon is infinite, and time is discrete. There are two types of commodities in the economy. Cash, m_t, which is storable, but not edible. And output, y_t, which is edible, but not storable. Cash assumes the role of the numeraire, and output trades at relative price p_t. In order to abstract from any potential effects of monetary policy, I assume that cash is in fixed supply, such that $m_t = m$ for all time periods, t. The output good, however, is repeatedly produced in each period using labor, n_t, and labor productivity, z_t, as the sole factors of production. The precise nature of technology will be specified and discussed in the subsequent sections. There is no physical capital, nor any investments.

2.1. **Households.** Household initiate their lives in period zero. They supply labor inelastically and the time-endowment is normalized to one, $\ell_t = 1$. Employment is denoted n_t, and the unemployment rate is therefore given by the difference in labor supplied and labor demanded, $u_t = 1 - n_t$.

The wage-rate in the economy is denoted $\tilde{w}_t$. Total income (or simply *income*) constitutes both total labor income, $n_t\tilde{w}_t$, as well as firm profits (if any), π_t, and is denoted w_t. There are complete insurance markets across households, so each household earns income w_t irrespective of whether she is employed or not. Income is received by the very end of a

period – i.e. after any consumption decisions – and is therefore *de facto* first disposable in the ensuing period.

A representative household enters period t with assets b_t, paying net return i_t. Assets are thought of as one-period nominally riskless bonds. The household pays lump-sum taxes $T_t \geq 0$, and may spend the remaining resources on consumption, $p_t c_t$, or on purchases of new assets, b_{t+1}.[12] The sequence of budget constraints is given by

$$b_t(1+i_t) + w_{t-1} - T_t = p_t c_t + b_{t+1}, \quad t = 0, 1, \ldots \tag{1}$$

with the associated no-Ponzi condition

$$\lim_{t\to\infty} \frac{b_{t+1}/p_{t+1}}{\Pi_{n=0}^{t}(1+i_{n+1})p_n/p_{n+1}} \geq 0 \tag{2}$$

Given a process of taxes and prices, $\{T_t, p_t, i_t\}_{t=0}^{\infty}$, the household decides on feasible consumption and asset plans, $\{c_t, b_{t+1}\}_{t=0}^{\infty}$, to maximize her expected net present value utility

$$V(\{c_t\}_{t=0}^{\infty}) = E\sum_{t=0}^{\infty} \beta^t u(c_t) \tag{3}$$

For the time being, I will remain agnostic with respect to the stochastic processes underlying the economy, and simply let E denote the (mathematical) expectations operator conditional on period zero information. The momentary utility function $u(\cdot)$ is assumed to be once continuously differentiable with $\lim_{c\to 0} u'(c) = \infty$, $-\frac{cu''(c)}{u'(c)} = \sigma > 1 \ \forall c \in \mathbb{R}_+$, and $\beta \in (0,1)$.[13] The parameter σ is commonly known as the coefficient of relative risk aversion, and its reciprocal represents the elasticity of intertemporal substitution.

In addition to equations (1) and (2), any optimal and feasible plan must observe the Euler equation

$$u'(c_t) = \beta E_t[(1+i_{t+1})\frac{p_t}{p_{t+1}}u'(c_{t+1})] \tag{4}$$

as well as the transversality condition

$$\lim_{n\to\infty} E_t \beta^n u'(c_{t+n})\frac{b_{t+n+1}}{p_{t+n}} \leq 0 \tag{5}$$

where E_t denotes the expectations operator conditional on period t information.

[12] As labor supply is entirely inelastic, lump-sum taxes are isomorphic to income taxes, and the distinction is meaningless from a substantive point of view.

[13] Following the seminal work of Arrow (1971) and Pratt (1964), the *only* class of utility functions satisfying the above assumptions is given by; $u(c) = \frac{c^{1-\sigma}-1}{1-\sigma}$, with $\sigma > 1$.

2.2. **Government.** Apart from lump-sum taxes, T_t, the government has access to two additional policy tools; government spending, G_t, and public debt, d_t. For the ease of exposition, they are all denominated in terms of the numeraire. A process of taxes, spending, and debt, $\{T_t, G_t, d_t\}_{t=0}^{\infty}$, is *feasible* if it satisfies the sequence of budget constraints

$$T_t + d_{t+1} = G_t + (1 + i_t)d_t, \quad t = 0, 1, \ldots \tag{6}$$

as well as the no-Ponzi condition

$$\lim_{t\to\infty} \frac{d_{t+1}/p_{t+1}}{\Pi_{n=0}^{t}(1 + i_{n+1})p_n/p_{n+1}} \leq 0 \tag{7}$$

As a consequence, whenever constraint (7) holds with equality, the net present value of real government spending equals the net present value of taxes.

Lastly, the sum of the government's and the private sector's initial nominal disposable resources must sum to m. That is

$$(b_0 - d_0)(1 + i_0) + w_{-1} = m$$

2.3. **The equation of exchange.** Combining the households' and the government's budget constraints yields

$$(b_t - d_t)(1 + i_t) + w_{t-1} = p_t c_t + G_t + (b_{t+1} - d_{t+1})$$

Define S_t as *aggregate savings*; i.e. $S_t = b_t - d_t$. An equilibrium in the bond market infers that $S_t \geq 0$, $i_t \geq 0$, and $S_t \times i_t = 0$. That is, either aggregate savings are zero, and the interest rate may be positive, or aggregate savings are positive, and the interest-rate must be zero.[14] Thus, whenever aggregate savings exceeds zero, cash is *hoarded*.

The national income identity is given by $p_t y_t = p_t c_t + G_t$, and aggregate allocations therefore observe

$$S_t(1 + i_t) + w_{t-1} = p_t y_t + S_{t+1} \tag{8}$$

By definition, $S_0(1 + i_0) + w_{-1}$ equals initial aggregate nominal disposable resources, m. As a consequence, if the interest rate in period one is positive, S_1 must equal zero, and disposable income in period one, w_0, is equal to nominal spending in period zero, $p_0 y_0$. By construction $p_0 y_0$ is equal to m. On the other hand, if S_1 is strictly positive, the interest rate must be zero and $S_1(1+i_1)+w_0 = S_1+p_0 y_0 = m$. Thus, $S_t(1+i_t)+w_{t-1} = m$ implies that $S_{t+1}(1 + i_{t+1}) + w_t = m$, and by construction, $S_0(1 + i_0) + w_{-1} = m$.

An equilibrium in the bond market therefore infers

$$m = p_t y_t + S_{t+1}, \quad t = 0, 1, \ldots$$

[14]As agents are permitted to freely borrow and lend at the market interest rate, i_t, a negative rate of interest yields infinite arbitrage possibilities which are ruled out by the zero lower bound, $i_t \geq 0$.

or, by defining the *velocity of money* as $v_t = \frac{m - S_{t+1}}{m}$,

$$mv_t = p_t y_t, \quad t = 0, 1, \ldots \tag{9}$$

Equation (9) is commonly known as the *equation of exchange*, and it relates the supply money and its velocity to the nominal level of output (Fisher, 1911).

While much of the supply side of the economy is yet to be specified, the equation of exchange contains some important intuition with respect to later results. Suppose that aggregate savings suddenly would rise and exceed zero. The velocity of money then declines and the economy is drained of liquidity. If prices, p_t, are downwardly rigid, such a shortfall of velocity will lead to a fall in real economic activity, y_t, and potentially to rising unemployment. As argued in the introduction, a persistent rise in unemployment may feed back to a further increase in savings, as households wish to shield themselves from the dire times ahead. Thus, an initial increase in savings may provoke a decline in economic activity, a rise in the unemployment rate, which in turn sparks a further rise in savings, and so on.

However, the government may turn a vicious circle around. When $S_{t+1} = b_{t+1} - d_{t+1}$ strictly exceeds zero, equation (9) provides some *prima facie* reasons as to why an increase in government debt – accompanied by an increase in government expenditures – may *reduce* aggregate savings; *increase* the velocity of money; and ultimately put upward pressure on economic activity. Indeed, together with the amplifying mechanism underpinning the labor market, these ideas summarize the main argument put forward in this article which will be formally explored in the subsequent sections.

As a final remark, it should be noted that the equation of exchange – together with the households budget constraint (1)-(2), and the Euler equation (4) – reveals that Ricardian Equivalance holds (Barro, 1974). For instance, given a certain level of spending G_t, an increase in lump-sum taxes, T_t, followed by a decrease in government debt, d_{t+1}, can easily be parried by an identical decrease in private savings, b_{t+1}, leaving both aggregate savings, S_{t+1}, and the path of consumption *entirely* unaltered. As a consequence, inasmuch as a debt fueled increase in government spending may reverse a vicious circle, so may a contemporaneously tax financed expansion.

It is important to notice that most, if not all, of the above propagating effects are initiated by a sharp increase in aggregate savings, S_{t+1}. As excess savings must take the form of cash hoarding at a zero rate of interest, the economy is in a liquidity trap (Eggertsson, 2008).

Definition 1. *The economy is in a liquidity trap in period t, if and only if $S_{t+1} > 0$.*

3. Analytic Framework

This section provides a simple analytical illustration of the main mechanism developed in this paper. To this end, I consider firms which operate a constant returns to scale technology, absent any costs of recruitment. Inertia, or frictions, in the labor market exist but are imposed rather than derived, and the evolution of unemployment follows an exogenously specified law of motion. Despite these limitations, the resulting framework generates several important insights which are valid under a wide range of circumstances. Section 4 will consider an environment in which the persistence of unemployment is endogenously determined. The associated complications, however, calls for a numerical solution method which, of course, somewhat clouds the analysis. Nonetheless, the main results developed here remain qualitatively, and to a large extent also quantitatively, unaffected.

Firms produce the output good using labor, n_t, and labor productivity, z_t, according to the technology

$$y_t = z_t n_t$$

As a consequence, the hiring decision of a price-taking and profit-maximizing firm observes

$$p_t z_t = \tilde{w}_t \tag{10}$$

where, as previously, $\tilde{w}_t$ denotes the wage rate in period t. Constant returns to scale implies that both the number of firms, as well as the measure of hired workers, are undetermined. That is, as long as prices, p_t, productivity, z_t, and wages, $\tilde{w}_t$, satisfy the first order condition in equation (10), an arbitrary number of firms are willing to hire all, $n_t = 1$, none, $n_t = 0$, or some, $n_t \in (0, 1)$, of the workers in the economy.

The definition of a competitive steady-state equilibrium is standard and therefore omitted. The following proposition states that such an equilibrium exists and is unique.

Proposition 1. *Suppose that $z_t = z > 0$ and $G_t/p_t = \hat{g}$, with $\hat{g} < z$, for $t = 0, 1, \ldots$ Then there exist a unique competitive equilibrium with prices $p_t = m/z$, $\tilde{w}_t = m$ and $i_{t+1} = 1/\beta - 1$.*

Proof. In Appendix A. □

Proposition 1 reveals two important features of the economy. First, as money supply is constant there exist a unique steady-state equilibrium. This is a well-known result and hinges on the fixed supply of the numeraire, m, and the inability of both the private and the public sector to endogenously create money (Sargent and Wallace, 1975; Benhabib et al., 2001). Second, the equilibrium is uniquely determined under *any* process of taxes, T_t, and public debt, d_t, as long as these satisfy the government's budget constraint, (6), and the no-Ponzi condition, (7). This, of course, is yet another reflection of Ricardian equivalence.

3.1. **Experiment.** In order to understand to what extent fiscal policy may alleviate the adverse effects of a negative demand shock, I will consider the following simple experiment. In period $t = -1$ the economy is initially at the steady state equilibrium. In period zero, however, agents unexpectedly receive news that labor productivity in period one will decline and equal $\delta < z$. With regard to the future process of shocks I will continue to remain somewhat equivocal. The process of future shocks is merely assumed to be such that the economy is *not in a liquidity trap in period one.*

Assumption 1. *The future process of shocks is such that $S_{t+1} = 0$, for $t = 1$.*

There is a wide range of processes which naturally satisfy the above assumption. If, for instance, labor productivity, z_t, reverts back to its steady-state value in period two onwards, aggregate savings are zero in each period on the continuation path, including period one.[15] In a two-period setting, $S_2 = 0$ corresponds to a finite horizon end-condition, and is therefore trivially satisfied. However, there are also reasons to believe that period-one savings may equal zero for a much larger class of processes, and Assumption 1 may therefore be seen as a more prudent restriction than a particular choice of the evolution of events. Liquidity traps are, after all, quite rare affairs.

While it appears obvious that a decline in future labor productivity may engender a fall in the intertemporal marginal rate of substitution, it is less obvious that such a decrease may have a real effect on current economic allocations. For instance, a *ceteris paribus* fall in the nominal interest rate may well offset a decline in intertemporal substitutability, leaving all optimality conditions intact at unaltered (real and nominal) allocations. If the fall in productivity is large enough for the interest rate to drop to zero, however, *intratemporal prices* – and possibly also quantities – are left as the only relevant margins of adjustment. Yet, the equation of exchange in (9) accompanied by Assumption 1 reveals that $p_1 = m/y_1$, which closely ties together prices in period one with demanded quantities. In addition, Assumption 2 ensures that nominal wages are downwardly rigid, putting further structure on the possible movements of prices.

Assumption 2. *Nominal wages in period zero are downwardly rigid; $\tilde{w}_0 \geq m$.*

That is, nominal wages in the presence of a news shock cannot fall short of those in its absence.[16] It is straightforward to see that a profit-maximizing firm's first order condition

[15]See the proof of Proposition 1, Appendix A.

[16]Recall that the steady-state wage rate is given by m. Barattieri et al. (2010) and Bewley (1999) provide empirical support in favor of downward nominal wage rigidities.

– equation (10) – infers that $p_0 \geq m/z$, and that rigid nominal wages therefore infer rigid nominal prices.[17]

With respect to the labor market, unemployment is assumed to be persistent. More specifically, employment evolves according to an exogenously imposed law of motion, intended to parsimoniously capture the idea of a frictional labor market.

Assumption 3. *Employment evolves according to* $n_{t+1} = h(n_t)$*, with* $h'(n_t)n_t/h(n_t) = \alpha$ *for* $0 \leq \alpha \leq 1$*, and* $h(1) = 1$*.*

The elasticity α governs the degree of frictions in the labor market.[18]If α equals zero, the labor market collapses to a Walrasian spot-market, and there is no persistence in unemployment. If α, however, is equal to one, there are 'infinite' frictions, and unemployment displays hysteresis. For any value of α in between these extremes, employment follows a mean-reverting process and eventually returns to its steady-state value absent any further disturbances.

Lastly, apart from period zero, real government spending is treated as a given, exogenous, process denoted $g_t = G_t/p_t$, $t = 1, 2, \ldots$ Expenditures in period zero, however, are instead comprised by two distinct parts; a non-discretionary component, denoted g_0, and a discretionary component, simply denoted g. The objective is to understand to which extent changes in real discretionary spending, g, translates to changes in real contemporaneous output, y_0.

For simplicity, all equilibrium outcomes will be *evaluated* at a spending level which is equal to a constant fraction of output; i.e. $g_t = \gamma \times y_t$, where $\gamma \geq 0$ denotes the spending-to-output ratio. Non-discretionary spending therefore takes on a fixed hypothetical value, g_t, which merely happens to coincide with the fraction, γ, of output. Obviously, in the absence of such a view, discretionary spending may causally affect non-discretionary spending, and therefore yield misleading results.

3.2. **Results.** Under the hypothesis that discretionary spending equals zero, the assumptions stipulated above imply the following equilibrium conditions

$$u'(y_0) = \beta(1 + i_1)p_0 \frac{y_1}{m} u'(y_1) \tag{11}$$

$$\frac{y_1}{z} \leq (1 + i_1)p_0 \frac{y_1}{m} \tag{12}$$

$$n_1 = \delta h(n_0) \tag{13}$$

[17]It should however be noted that this is not longer true in the richer framework developed in Section 4.

[18]This law of motion is not taken out of thin air. See Section 4.5 on page 21 for a discussion of how this functional form relates to a log-linear approximation of a more familiar evolution of employment.

where the first line merely restates the Euler equation under the premise that $p_1 = m/y_1$.[19] The second equation follows from Assumption 2 together with the zero lower bound, and the third from the imposed law of motion for employment. In addition, an equilibrium in goods and bond markets observes

$$m = p_0 y_0 + S_1 \tag{14}$$

$$i_1 \geq 0, \text{ and } S_1 \geq 0 \tag{15}$$

$$i_1 \times S_1 = 0 \tag{16}$$

Define δ^* as the lowest possible productivity level in period one which does *not* put the economy in a liquidity trap.[20] That is

$$u'(z) = \frac{\beta}{z}\delta^* u'(\delta^*) \tag{17}$$

With constant relative risk-aversion, δ^* is given by $z\beta^{\frac{1}{\sigma-1}}$, which is strictly less than z.

Proposition 2. *If $\delta \geq \delta^*$ there exist a unique equilibrium with $y_0 = z$, $y_1 = \delta$, and $p_0 = m/z$, and the fiscal multiplier is zero.*

Proof. In Appendix A. □

Together with Proposition 2 above, the equation of exchange reveals that whenever $\delta \geq \delta^*$, $S_1 = 0$ and the economy is not in a liquidity trap. Output in both period zero and one are equal to their potential values, z and δ, respectively, and the fiscal multiplier is zero.

Proposition 3. *If $\delta < \delta^*$ there exist a unique equilibrium such that*

$$y_0 = z\left(\frac{\delta}{\delta^*}\right)^{\frac{\sigma-1}{\sigma-\alpha(\sigma-1)}} < z, \quad y_1 = \delta h(y_0/z) < \delta, \text{ and } p_0 = m/z \tag{18}$$

Proof. In Appendix A. □

Again, the equation of exchange infers that $S_1 > 0$, and for any $\delta < \delta^*$ the economy is therefore driven into a liquidity trap. Proposition 3 suggests that under these circumstances, output in both period zero as well as period one fall well below their potential values, z and δ, respectively. The reason is that a sufficiently severe fall in future labor productivity triggers a spur in savings which drives the nominal interest rate to zero. At zero interest, excess savings takes the form of cash hoardings which drains the economy of liquidity. As wages, and ultimately prices, are downwardly rigid, a fall in nominal demand yields lower output and rising unemployment. When the unemployment rate is persistent, the future

[19] As real government spending is equal to γy_t, consumption equals $y_t(1-\gamma)$, with the latter the factor canceling out in the Euler equation.

[20] Propositions 2 and 3 verifies this interpretation of δ^*.

appears even bleaker, provoking a further rise in savings, weaker demand, and a larger rise in the unemployment rate, and so on.

Proposition 3 suggests that this intertemporal propagation mechanism can be profoundly compromising with respect to period-zero output. When the labor market displays hysteresis and the intertemporal elasticity of substitution approaches zero, the economy shuts down and the unemployment rate soars to 100 percent. Admittedly, of course, this rather draconian scenario hinges on quite unrealistic parameter values, and should not be taken literally.

Other features of Proposition 3 may come less as a surprise. Output tend to be lower the larger the decline in labor productivity, δ, as more disappointing news translate into larger savings; a steeper fall in both liquidity and economic activity; and ultimately a larger rise in the unemployment rate. In addition, a more persistent rise in unemployment – i.e. an α closer to unity – is associated with a larger decline in output, and a more pronounced rise in the unemployment rate. Clearly, a more persistent rise in unemployment yields an even more distressing outlook for the future, which in turn exasperates the private sector's willingness to save further.

3.2.1. *Fiscal Policy.* So to what extent may fiscal policy backtrack the downward spiral illustrated above? By borrowing – or taxing – unutilized cash and spending it, the government may turn a vicious circle around. The associated increase in aggregate demand raises output, lowers unemployment, and instigates a brighter future. As a consequence, private savings fall, consumption rises, and the unemployment rate decreases further. Of course, in as much as an arbitrarily small elasticity of intertemporal substitution may have an abysmal effect on period-zero output in the wake of a liquidity trap, government spending may have an equally powerful impact in the opposite direction.

As previously, let g_t denote *real* government purchases, $g_t = G_t/p_t$. Under the hypotheses laid out in Proposition 3, the equilibrium conditions in (11)-(16) can be summarized by the Euler equation

$$u'(y_0 - g_0 - g) = \frac{\beta}{z} y_1 u'(y_1 - g_1) \tag{19}$$

with $y_1 = \delta n_1$, $n_1 = h(n_0)$, and where $g \geq 0$ denotes the discretionary part of government purchases. I pay no attention to whether an increase in spending is debt- or tax financed, as this is inconsequential.

Proposition 4 summarizes the main result of this section.

Proposition 4. *Under the hypotheses laid out in Proposition 3, the fiscal multiplier is given by*

$$\frac{\partial y_0}{\partial g} = \frac{1}{1-\alpha\left(1-\frac{1}{\hat{\sigma}}\right)}, \qquad \text{with} \quad \hat{\sigma} = \frac{\sigma}{1-\gamma}$$

Proof. In Appendix A. □

To get an intuitive grasp of Proposition 4 and how government spending trickles through the economy, it is illustrative to decompose the total effect on output into several successive rounds. For the moment let me ignore the case in which the output-to-spending ratio, γ is positive, such that $g_0 = g_1 = 0$.

First of all, as the aggregate supply relation – the firms' first order condition in (10) – is horizontal, a marginal increase in government spending translates to an immediate one-to-one response in output. That one is easy.

Second, however, an increase in contemporaneous output lowers unemployment both in the present and in the future, which in turn raises current output further, and so on. Thus, to understand the impact of any successive rounds beyond the immediate, it is imperative to understand how changes in current output translates to changes in future output, and vice versa.

Employment evolves according to $n_1 = h(n_0)$. If period-zero output equals y_0, employment is straightforwardly given by y_0/z. And as period-one output is given by δn_1, it follows that $y_1 = \delta h(y_0/z)$. Thus, the elasticity of future output with respect to current output is given by α.

To find the reverse effect – i.e. the elasticity of current output with respect to future output – implicit differentiation of the Euler equation in (19) reveals that

$$\frac{\partial \ln y_0}{\partial \ln y_1} = 1 - 1/\sigma \tag{20}$$

The reason is straightforward. Following the Euler equation, a unit percentage increase in future consumption yields a *ceteris paribus* one-to-one percentage increase in current consumption. Regrettably, this is not a ceteris paribus world. An increase in future output is deflationary, and the associated substitution effect offsets the initial response by the elasticity of intertemporal substitution, $1/\sigma$.[21] The total net effect is therefore $1 - 1/\sigma$.

Combining the these two elasticities reveals a striking relation

$$\frac{\partial y_1}{\partial y_0} \times \frac{\partial y_0}{\partial y_1} = \alpha\left(1 - \frac{1}{\sigma}\right) \tag{21}$$

[21]Following the equation of exchange, inflation is simply "too much money chasing too few goods", and an increase in output reduces prices.

That is, a marginal increase in current output propagates by way of a persistent labor market *and* a brighter future to a further marginal increase of $\alpha(1-1/\sigma)$. As a consequence, an increase in government spending carries a first round impact on output of *one*, a second round impact of $\alpha(1-1/\sigma)$, a third round of $(\alpha(1-1/\sigma))^2$, and so on. The fiscal multiplier is given by the sum of the successive rounds. That is

$$\frac{\partial y_0}{\partial g} = 1 + \alpha\left(1-\frac{1}{\sigma}\right) + \left(\alpha\left(1-\frac{1}{\sigma}\right)\right)^2 + \ldots = \frac{1}{1-\alpha\left(1-\frac{1}{\sigma}\right)}$$

which replicates the result in Proposition 4 with γ set to zero.

Consider the case in which there are no labor market frictions, i.e. $\alpha = 0$. Proposition 4 then reveals that under this hypothesis the fiscal multiplier is equal to unity. This result corroborates the findings of Krugman (1998), Eggertsson (2010), and Christiano et al. (2011), and suggests that it is not the presence of a liquidity trap *per se* which is the main driving force behind a potentially large multiplier.[22]

In the polar-, but arguably more realistic, scenario in which unemployment displays hysteresis, α is equal to one, and the fiscal multiplier is instead given by the parameter σ; the inverse of the elasticity of intertemporal substitution.[23] While estimates of either σ or its reciprocal are both unreliable and controversial, I believe few economists would outrightly reject an elasticity of around one-half or smaller. From this perspective, labor market frictions appear incredibly important for the effectiveness of fiscal policy.

Lastly, for any intermediate case, i.e. $\alpha \in (0,1)$, the multiplier varies but *always* exceeds unity. As the elasticity of intertemporal substitution approaches zero, the multiplier peaks at $1/(1-\alpha)$.

The above discussion intentionally abstract from the possibly amplifying effects of *non*-discretionary spending, g_t. Proposition 4, however, reveals that the mere size of the public sector, γ, may indeed be of importance. The reason is straightforward. One of the key components of the fiscal multiplier is given by the elasticity of current output with respect to future output. In the absence of non-discretionary spending, this elasticity is, quite

[22]Christiano et al. (2011) and Eggertsson (2010) study the effects of *multiple* liquidity spells with associated *multiple* spending shocks. To make results comparable, I set μ and σ in equation (32) in Christiano et al. (2011), to zero and one respectively, and the parameter ρ in Eggertsson (2010) to zero. Under these circumstances – i.e. a one-time liquidity- and spending shock in the absence of complementarities between consumption and leisure – the fiscal multiplier equals one.

[23]How relevant is this scenario? Using monthly data on unemployment in the United States (BLS series UNRATE) from 1980-2011, I regress $\ln(n_t/\bar{n})$ on a constant and on its own lagged value, where $\bar{n}$ refers to the sample mean. This yields estimates -0.0001 and 0.9967, respectively, with $R^2 = 0.99$. An augmented Dickey-Fuller test cannot reject the unit-root $\ln(n_{t+1}) = \ln(n_t) + u_t$, against a multitude of stationary specifications. Thus the function $h(n_t) = n_t^{\alpha}$ with α close or equal to one appears to provide a reasonable approximation to what can be observed in the data.

intuitively, given by $1-1/\sigma$. However, as the fiscal multiplier is related to how *output*, and not *consumption*, responds to government spending, the relevant measure of intertemporal substitution is given by

$$-\frac{\partial \ln(y_{t+1}/y_t)}{\partial \ln(u'(c_{t+1})/u'(c_t))} = \frac{1-\gamma}{\sigma} = \frac{1}{\hat{\sigma}}$$

As a consequence, in the presence of non-discretionary spending, the elasticity of current output with respect to future output equals $1-1/\hat{\sigma}$, which thus further intensifies the potency of discretionary fiscal policy.

But why does non-discretionary spending abate intertemporal substitution? As private consumption is given by $c = y - g$, a percentage increase in output yields a $1/(1-\gamma)$ percentage increase in consumption, and the aforementioned intertemporal propagation mechanism is magnified to the same extent.

Lastly, there are two additional implications that deserves to be mentioned. First, the response in private consumption with respect to a marginal increase in discretionary public spending is quite trivially given by the fiscal multiplier less one. Since σ is assumed to be greater than unity, the 'consumption multiplier' is strictly positive, and fiscal stimulus is, at least on the margin, unambiguously welfare improving for all $\alpha > 0$. Second, the tax multiplier is zero. This follows from Ricardian equivalence.

4. Endogenous Persistence

The objective of this section is to dispense with Assumption 3, and evaluate the effects of fiscal policy in a context in which the persistence of unemployment is endogenously determined. The behavior of the government and the households are unchanged, but the firms' problem is modified accordingly. The setting is intentionally kept as sleek as possible in order to closely tie it together with the analysis in the preceding section. Thus, although a numerical solution methods is used I do not embark on a large-scale quantitative assessment of the model properties. Instead, and following the main gist developed throughout this paper, the purpose is to give an illustration of the main mechanisms at work, and show that none of the past conclusions are artifacts of the, admittedly synthetic, imposed law of motion for employment.

A few additional challenges arise. First, in order to provide a reasonable story of the evolution of unemployment, the augmented model must encompass a frictional labor market with potentially long-lasting employment relations. To this end, I consider firms which operate within a Mortensen-Pissarides flavored framework (Mortensen and Pissarides, 1994).

Second, and as a consequence of the dynamic nature of firm-recruitment, some questions arise with respect to the future processes of labor productivity, nominal wages, and prices.

To remain somewhat agnostic, I will assume that firms' quasi-rents revert back to their steady-state value in all periods beyond the second. This idea contrasts to studies such as Hall (2005), which assumes a constant ratio between the process for nominal wages and prices – i.e. *real wages* – but allow for random variations in the process for labor productivity. However, as a constant real wage induces quite substantial pro-cyclical movements in quasi-rents, and ultimately in recruitment, I view the aforementioned assumption as relatively prudent and likely to attenuate the effects of both 'news' and fiscal policy on current economic activity.

Lastly, and as previously noted, a final difficulty arises as the framework does not admit a closed-form solution. As a consequence, I will numerically evaluate the model predictions. The computational details can be found in Appendix B.

As will become apparent, the main conclusions from the preceding analysis remain largely unaffected, with slight but interesting modifications. Most notably, the fiscal multiplier displays quite dramatic nonlinearities with respect to both the magnitude of the shock and the size of the stimulus package. With an elasticity of intertemporal substitution of one-third, the model predicts a fiscal multiplier which ranges from 0.3 to 1.5, depending on the severity of the recession and the extent of government purchases.

4.1. **Firms.** A potential firm opens up a vacancy at cost $k > 0$. The cost k is thought to represent an entrepreneur's disamenity associated with the efforts of setting up a firm, and not as a real, or monetary, cost per se. Conditional on posting a vacancy, a firm will instantaneously meet a worker with probability q_t. With the complementary probability, however, the vacancy is instead void and the vacancy-cost, k, is sunk. A successfully matched firm-worker pair becomes immediately productive and produces z_t units of the output good in each period. The employment relation may last for perpetuity, but separations occur in each period with probability λ. Entrepreneurs are assumed to be risk-neutral, hand-to-mouth agents, and evaluate a successful employment relation in period t according to

$$J_t = E_t \sum_{s=0}^{\infty} (\beta(1-\lambda))^s \left(z_{t+s} - \frac{\tilde{w}_{t+s}}{p_{t+s}} \right) \tag{22}$$

A utility maxmimizing entrepreneur will therefore post a vacancy in period t if and only if the expected benefits, $q_t J_t$, (weakly) exceed the associated costs, k; $q_t J_t \geq k$.

It ought to be noted that the preferences of entrepreneurs are divorced from those of the households. In particular, while firms ultimately redistribute operation profits, or quasi-rents, to the households, entrepreneurs do not internalize the associated welfare effects when making the decision to enter the market. I relax this assumption in Appendix B.1 and show that it is entirely innocuous from both a qualitative as well as quantitative perspective.

4.2. **Equilibrium.** An employment-relation is formed in a frictional matching market. With a slight abuse of notation, let v_t denotes the measure of firms posting a vacancy in period t. The measure of successful matches is then given by

$$M_t = M(v_t, u_t)$$

where u_t represents the unemployment-rate in period t. The matching-function $M(\cdot)$ exhibits constant returns to scale, and a firm posting a vacancy will therefore find a worker with probability

$$q_t = \frac{M_t}{v_t} = q(\theta_t), \quad \text{with} \quad \theta_t = \frac{v_t}{u_t} \tag{23}$$

As usual, θ_t denotes the *labor market tightness* in period t. Analogously, the job finding probability of an unemployed worker in period t is given by

$$f_t = \frac{M_t}{u_t} = f(\theta_t), \quad \text{with} \quad f(\theta_t) = \theta_t q(\theta_t) \tag{24}$$

As a consequence, employment evolves according to

$$n_t = (n_{t-1}\lambda + (1 - n_{t-1}))f_t + (1 - \lambda)n_{t-1} \tag{25}$$

The first term in brackets on the right-hand side represents the measure of joblessness in the beginning of period t. Of these, a fraction, f_t, will successfully find a job. The last term represents the measure of non-separated workers from the preceding period. Obviously, the measure of workers in period t must equal the measure of successful searchers, and the measure of non-separated workers.

Definition 2. *Given a process of wages, $\{\tilde{w}_t\}_{t=0}^{\infty}$, and a feasible process of policies, $\{G_t, T_t, d_{t+1}\}_{t=0}^{\infty}$, a competitive equilibrium is a process of prices $\{p_t, i_{t+1}\}_{t=0}^{\infty}$ and quantities $\{c_t, S_{t+1}, y_t, \theta_t, n_t\}_{t=0}^{\infty}$ such that for $t = 0, 1, \ldots$*

(i) Given prices and taxes, $\{c_t, b_{t+1}\}_{t=0}^{\infty}$ solves the household's problem (3)*, subject to constraints* (1) *and* (2)*.*

(ii) Free entry ensures that $k = q_t J_t$, with J_t and q_t defined in equations (22) *and* (23)*, respectively.*

(iii) The law of motion for employment satisfies equation (25)*, with n_{-1} given.*

(iv) Markets clear. That is

$$m = p_t y_t + S_{t+1}$$

$$y_t = n_t z_t$$

with $S_{t+1} \geq 0$, $i_{t+1} \geq 0$ and $S_{t+1} \times i_{t+1} = 0$.

Notice that the process of wages is taken as *given*. The reason is that once we leave the realm of indeterminacy as discussed in Section 3, page 9, employment is always determined for a sufficiently well-behaved problem under *any* wage-process. Yet, the equilibrium allocations will undoubtedly depend on the precise nature of this choice. While there is no single compelling theory for wage determination in this framework (see Hall (2005) for a discussion), the subsequent section will provide sufficient additional structure to determine a unique equilibrium allocation.

4.3. **Experiment.** The experiment is virtually identical to that in Section 3.1, with minor differences in terms of assumptions. In particular, the economy is initially at the steady state equilibrium. In period zero agents unexpectedly receive news that labor productivity in period one will equal δ. The main objective is then to analyze to which extent current discretionary fiscal policy may alleviate the adverse effects brought on by the news of future productivity.

As in the previous sections, I remain agnostic with respect to the evolution of events beyond the first period. To accomplish this, it is again assumed that the economy is not in a liquidity trap in period one, i.e. $S_2 = 0$ (Assumption 1). However, and in contrast to the preceding analysis, a firm's decision to enter the market now depends on the entire perceived path of future quasi-rents, $z_{t+s} - \tilde{w}_{t+s}/p_{t+s}$, for $s, t = 0, 1, \ldots$ Thus, I will henceforth assume that a firm's continuation profits from period two onwards is equal to its steady-state value.

Assumption 4. *Let $\tilde{w}$ and p denote the steady-state value of nominal wages and prices. A firm's expected net present value profits, J_t, is given by*

$$J = \frac{z - \tilde{w}/p}{1 - \beta(1 - \lambda)}, \quad \text{for} \quad t = 2, 3, \ldots$$

Combining Assumptions 1 and 4 infers that the future processes of productivity, news, and nominal wages can, again, be left unspecified.

As I do not develop a theory of (re-)negotiations, nominal wages are assumed to be both downwardly as well as upwardly rigid in periods zero and one.

Assumption 5. *Let $\tilde{w}$ denote the steady-state value of nominal wages. Then,*

$$\tilde{w}_t = \tilde{w}, \quad \text{for} \quad t = 0, 1$$

It should be noted that much of the implications of Assumptions 4 and 5 are likely to attenuate both the effects of news on economic activity, as well as the potency of fiscal policy. To appreciate this, notice that as nominal wages are both upwardly and downwardly rigid, a fall in output in period one translates to a fall in the contemporaneous real wage

at an elasticity of unity.[24] Thus, while negative news concerning future productivity may, *ceteris paribus*, reduce firm profits, the associated fall in the real wage may well offset a large share of the initial decline, and consequently abate the effect on real economic allocations. Additionally, if shocks to labor productivity exhibit some degree of persistence, expected net present value profits in periods two onwards are likely to fall well short of the steady-state value J. As a consequence, Assumptions 4 and 5 may plausibly mitigate some of the effects of news on firm profits, on entry, employment and, ultimately, on real economic activity.

Lastly, real government spending in any period other than zero is constant and equal to $G_t/p_t = \bar{g} \geq 0$. In period zero, however, government purchases are, again, comprised by two distinct parts; a non-discretionary component, $G_0/p_0 = \bar{g}$, and a discretionary component, g. The objective is, of course, to understand to which extent changes in real discretionary spending, g, translates to changes in contemporaneous output, y_0.

4.4. **Calibration.** The model is calibrated to target the US economy at a monthly frequency. The matching function is given by

$$M(v_t, u_t) = v_t(1 - e^{-\frac{\eta}{\theta_t}}) \tag{26}$$

which exhibits constant returns to scale, with $q(\theta)$ and $f(\theta) \in (0, 1)$ for all $\theta \in \mathbb{R}_+$ (Petrongolo and Pissarides, 2001). The steady-state level of labor productivity, z, is normalized to unity, and cash, m, is set equal to the steady-state employment rate, n. As a consequence, the steady-state price level, p, equals one. Following Hall (2005), the nominal wage, $\tilde{w}$, is set to 0.965.[25] As I consider a monthly frequency, the discount factor, β, is set to $0.95^{1/12}$, and the separation rate, λ, to 0.034 (Hall, 2005; Shimer, 2005).

Under these parameter values, J is equal to 0.92. Given a labor market tightness of 0.45, the parameter η in the matching function is set such that the steady-state unemployment rate, u, equals five precent.[26] Thus, the cost of posting a vacancy k is set to $q(0.45)J$. The elasticity of intertemporal substitution is set to 1/3, and real non-discretionary government spending equals 35 percent of steady-state output.[27]

The calibrated parameter values are summarized in Table 1, and the details of the computational procedure is outlined in Appendix B.

[24]By Assumption 1 the real wage in period one is given by $\tilde{w}/p = \tilde{w}y_1/m$, and the result follows.

[25]Under the current parameterization, a real wage of 0.965 corresponds to a 50/50 Nash-bargaining solution at a flow-value of unemployment of 0.6. Using Hall's (2005) flow-value of 0.4 infers a real wage of 0.95. The numerical results presented below are robust to such changes.

[26]A labor market tightness of 0.45 corresponds to the US average in the years 2001-2009 according to JOLTS data.

[27]According to the IMF's World Economic Outlook database, a spending-to-output ratio of 0.35 corresponds to the US average in 2000-2007.

TABLE 1. Calibrated parameters and steady-state values

σ	β	η	λ	m	$\tilde{w}$	k	$\bar{g}/y$	z	p	u	y	θ
3	0.996	0.925	0.034	0.95	0.965	0.8	0.35	1	1	0.05	0.95	0.45

4.5. **Results.** Figure 1 illustrates the relationship between anticipated changes in labor productivity ('news') and the fiscal multiplier. Changes in labor productivity ranges from an approximate *decline* of six percent, to a three percent *increase*.[28] The associated unemployment rate is provided in parenthesis.

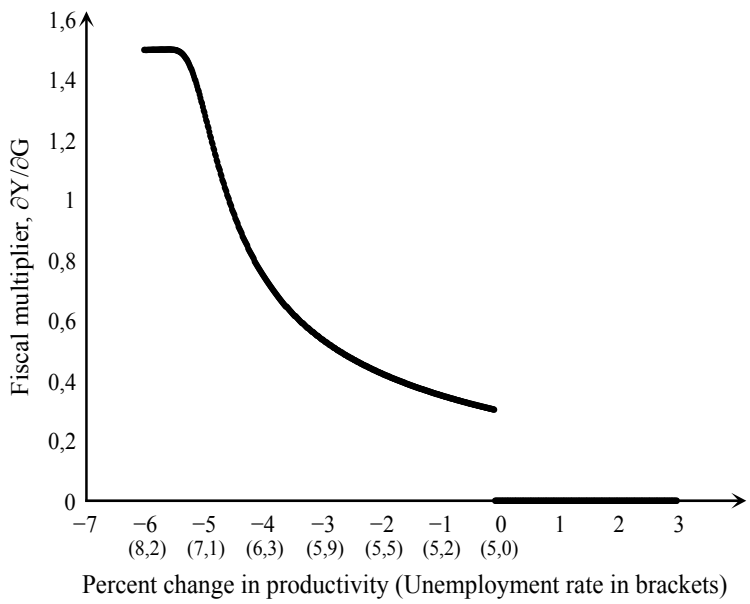

FIGURE 1. The fiscal multiplier with respect to news of future productivity.

Three quite stark characteristics emerges. First, the fiscal multiplier is *zero* whenever the economy is not in a liquidity trap.[29] This corroborates the conclusions drawn in the preceding sections, and follows as government spending crowds-out private consumption one-to-one. Second, the relationship between anticipated changes in productivity and the

[28]At a six percent decline in labor productivity the job finding rate is driven zero. Any further decline in productivity infers that firms make negative operation profits even in ongoing employment relations. Under such a scenario, either renegotiations are imminent, or there are endogenous layoffs. Both situations are considered beyond the scope of this paper.

[29]The zero-lower bound on the interest rate is binding at a decline of future labor productivity of around 0.1 percent

fiscal multiplier displays quite substantial nonlinearities. For instance, in a relatively modest recession in which, say, the unemployment rate increases by two percentage points or less, the fiscal multiplier is well below unity and government spending partly crowds-out private consumption. Lastly, during more distressing times, the fiscal multiplier peaks – and plateaus – at around 1.5. The consumption multiplier is, in contrast, equal to 0.5 and there is therefore no crowding-out. Thus, under this hypothesis even entirely wasteful public spending unambiguously improve welfare.

What aspects of the economy are responsible for these predictions? Log-linearizing the equation describing law of motion for employment in (25), yields

$$\ln(n_{t+1}/n) = \alpha \ln(n_t/n)$$

with $\alpha = 1 - f(\theta)/n$, and where n and θ refer to the steady-state values of employment and labor market tightness, respectively. Inserting the parameter values provided in Section 4.4, reveals that α is approximately equal to 0.58.[30] Thus, following the formula derived in Proposition 4, we would expect to observe a multiplier of around 1.8. The peak value of 1.5 in Figure 1 is, I believe, remarkably consistent with this result. A trough of 0.3, however, is not.

The reason behind this discrepancy is illustrated in Figure 2. The relationship marked AS depicts the free entry condition $k = q(\theta_t)J_t$, with θ_t expressed in terms of employment, n_t (which, in turn, is equal to output, y_t). The two relationships marked AD illustrates on the other hand the equation of exchange, $m = py + S$, with S satisfying the Euler equation at different anticipated declines in labor productivity; a fall equal to one (AD) and five percent (AD'), respectively. Clearly, in anticipation of a large fall in future labor productivity the economy plunges into an equilibrium at a much flatter part of the aggregate supply curve. As a consequence, government spending does little to raise prices, and does not crowd-out private consumption by a noticeable amount. In contrast, at a relatively modest decline in labor productivity, the equilibrium is left at a much steeper part of the aggregate supply relation, and crowding-out is instead an imminent threat.[31]

4.5.1. *Marginal vs. Average Multipliers.* 'The fiscal multiplier' is commonly thought of as the marginal change in contemporaneous output in response to a marginal increase in contemporaneous spending. While Figure 1 reveals that this relation may well depend on the

[30]As the estimated value of α in US data cannot be rejected to differ from unity, the model performs – at least to a first approximation – quite poorly with respect to the persistence in unemployment.

[31]The kink which can be observed in the AD curve emerges quite naturally. At an off-equilibrium unemployment rate of 7% or so, mean reversion is forceful, and the future does not appear very bleak in comparison to the current situation. The economy is therefore *not* in a liquidity trap at this off-equilibrium unemployment rate.

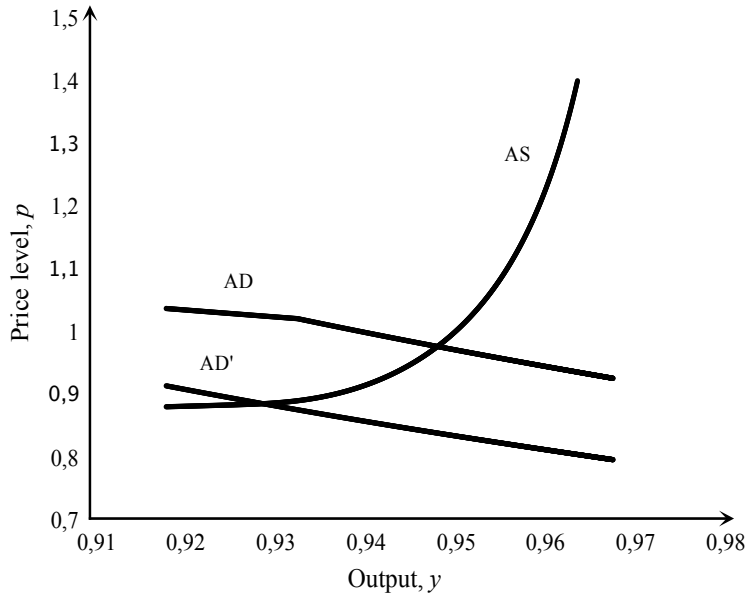

FIGURE 2. Aggregate Demand and Supply.

severity of the recession, there are also reasons to believe that the size of the stimulus package itself may influence the effectiveness of government policy. Is the *marginal* multiplier increasing or decreasing in the amplitude of discretionary spending? And, given a certain amount of purchases, what is the size of the *average* multiplier?

Figure 3 illustrates the relationship between the extent of government spending and the average as well as the marginal multiplier.[32] The 'extent' of spending is quantified as real government purchases in percent of output at the trough, evaluated at a recession associated with an 8.2 percent unemployment rate. Perhaps unsurprisingly, the marginal impact of fiscal policy is declining in the size of the stimulus package. And inasmuch as the average is merely defined as the integral of the marginal, the average multiplier is declining in the amplitude of spending as well, but always exceeds the marginal. Under the hypothetical scenario depicted in Figure 3 it is apparent that a stimulus package of around three percent of output is unambiguously welfare improving, leaving private consumption entirely unaffected. The associated recovery closes approximately 80 percent of the output-gap.

[32]Given a certain amount of government spending, $\bar{g}$, the average multiplier is given by

$$\int_0^{\bar{g}} \left.\frac{\partial y}{\partial g}\right|_{g=\hat{g}} d\hat{g}$$

where $\partial y/\partial g|_{g=\hat{g}}$ denotes the marginal multiplier evaluated at spending-level $\hat{g} \leq \bar{g}$.

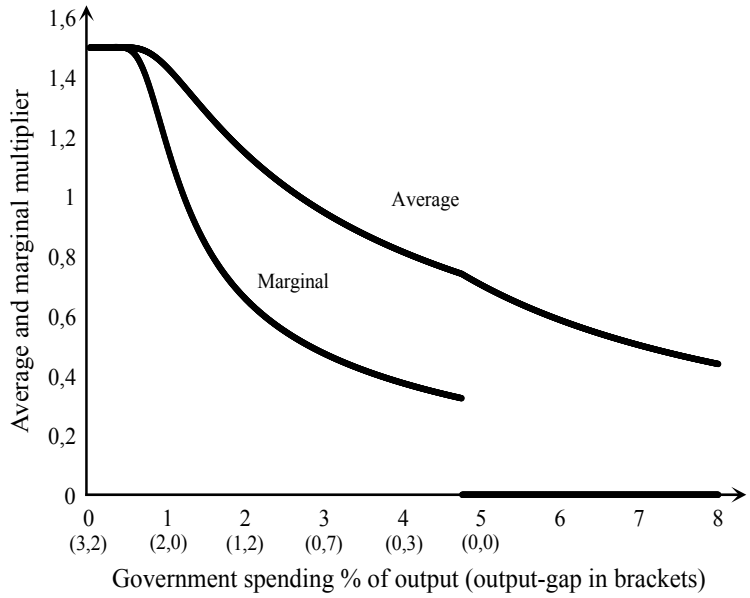

FIGURE 3. The fiscal multiplier with respect to news of future productivity.

However, while it might be reassuring to restrain government spending such that the associated benefits, at the very least, are equal to the costs, such policy may be far from optimal. In particular the *marginal* benefits of government purchases *unambiguously* exceeds the *marginal* costs at a level of spending which closes around 45 percent of the output gap, or equivalently, around 1.2 percent of output.

5. Concluding Remarks

This paper has studied a model in which the effectiveness of fiscal policy increases markedly in periods of low nominal interest rates and high, persistent, unemployment. At the core of the analysis lies a novel intertemporal propagation mechanism in which the labor market plays a pivotal role. With persistent unemployment, any increase in current demand translates to an associated rise in future supply. But as rational economic actors desire to smooth consumption over time, the increase in future supply feeds back to a further rise in current demand.

These reinforcing mechanisms amplify the effectiveness of fiscal policy many times over. An increase in government spending stimulates economic activity and lowers the unemployment rate both in the present and in the future. But as a brighter future instills a rise in private demand, unemployment falls even further and triggers an additional rise in private demand, and so on. In a stylized framework in which the labor market exhibits hysteresis, the fiscal multiplier is equal to the reciprocal of the elasticity of intertemporal

substitution, or simply the coefficient of relative risk aversion. In a more realistic setting, the effect is somewhat dampened and displays significant nonlinearities with respect to the output-gap. But in a severe recession with an unemployment rate exceeding the natural by three percentage points or more, the marginal impact of government spending on output equals 1.5.

However, the same mechanisms which may engender a large multiplier also infer some restrictions on the conduct of efficient expansionary fiscal policy. Foremost, government spending must create jobs. Real jobs. Letting idle workers dig a hole only to fill it up again is not a viable option as it is unlikely to allow for a *persistent* decline in the unemployment rate. Indeed, within the framework analyzed in this paper, a hole-digging policy is isomorphic to a tax-financed tax-cut, which, from a representative agent's perspective, is a wash. Spending must therefore take the form of *purchases* of goods or services which would *normally* be provided in the economy even in the absence of fiscal intervention.

Second, while the analysis in this paper is centered around a one-sector framework, it is, to a certain extent, straightforward to extrapolate results to a more realistic setting: Spending must target sectors which exhibits spare capacity. Outbidding potential buyers at a Sotheby's auction is likely to yield a multiplier of zero or less. But investing in infrastructure during a housing crisis may plausibly carry a much larger kickback. Perhaps paradoxically then, while government purchases ought to be directed towards sectors where private demand is temporarily slack, public goods must not substitute for private consumption. If the private enjoyment of publicly purchased goods substitute for that of privately purchased goods, the stimulative properties of government spending vanish.

But acknowledging the challenges to effective fiscal policies is not the same as dismissing them as mere fairy tales. The main point of this paper still remains. At low levels of nominal interest and high, persistent unemployment, accurately targeted fiscal policy may be a potent tool in combatting a deep, demand-driven, recession.

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Appendix A. Proofs

A.1. **Proof of Proposition 1.** In the steady state, $y_t = z$ and $c_t = y_t(1-\gamma)$. As a consequence an equilibrium allocation of prices and quantities must satisfy the following sequence of equations for all time-periods t

$$\beta(1+i_{t+1})\frac{p_t}{p_{t+1}} = 1 \tag{A1}$$

$$m - p_t z \geq 0 \tag{A2}$$

$$i_{t+1} \geq 0 \tag{A3}$$

$$(m - p_t z)i_{t+1} = 0 \tag{A4}$$

Accompanied with equation (A1), the no-Ponzi conditions – equations (2) and (7) – imply

$$\lim_{n\to\infty} \beta^n \frac{S_{t+n+1}}{p_{t+n}} \geq 0$$

Combining with the transversality condition yields

$$\lim_{n\to\infty} \beta^n \frac{S_{t+n+1}}{p_{t+n}} = 0 \tag{A5}$$

Let us first verify that $p_t = m/z$ and $i_{t+1} = 1/\beta - 1$ is indeed a solution. Obviously $p_t = m/z$ and $(1+i_{t+1})\beta = 1$ satisfy equation (A1), as well as equation (A2) with equality. As a consequence, $i_{t+1} = 1/\beta - 1$ satisfies the inequality in equation (A3). Since, $p_t = m/z$, equation (A4) follows. Since $S_{t+1} = m - p_t z_t$, the transversality condition in (A5) is satisfied with equality. Thus $p_t = m/z$ and $i_{t+1} = 1/\beta - 1$ is indeed a sequence of equilibrium prices.

Now suppose there exist some other equilibrium allocation with $0 \leq p_t < m/z$ for some t.[33] Then by equation (A4), $i_{t+1} = 0$. By equation (A1), $p_{t+1} = \beta p_t$, and thus $i_{t+2} = 0$, and so on. As a consequence, $p_{t+n} = \beta^n p_t$. Inserting into the transversality condition reveals that

$$\lim_{n\to\infty} \beta^n \frac{S_{t+n+1}}{p_{t+n}} = \lim_{n\to\infty} \frac{\beta^t}{p_t}(m - z\beta^n p_t) > 0$$

As a consequence, $p_t < m/z$ for some t cannot be an equilibrium. Thus there exist a unique steady-state equilibrium with prices $p_t = m/z$ and $i_{t+1} = 1/\beta - 1$.

With respect to the discussion in Section 3.1, on page 10, suppose that $z_0 = \delta < z$. It is trivial to show that $p_0 = m/\delta$, and $i_1 > 0$ such that

$$\frac{u'(\delta)}{u'(z)} \times \frac{\delta}{z} = \beta(1+i_1) > 1$$

with p_t and i_{t+1} as previously for $t \geq 1$, satisfies the above (appropriately modified) equilibrium conditions, with $S_1 = 0$. Again, if $p_0 < m/\delta$, we have that

$$p_{t+1} = \beta\frac{u'(z)}{u'(\delta)}p_t < \beta\frac{u'(z)}{u'(\delta)}\frac{m}{\delta} < \frac{m}{z}$$

where the last inequality follows from

$$\frac{u'(z)}{u'(\delta)} \times \frac{z}{\delta} < 1$$

[33]Notice that $p_t > m/z$ would imply that $S_{t+1} < 0$ which is an impossibility.

A.2. **Proof of Proposition 2.** First, notice that $y_0 > z$ is not a possible equilibrium as it would violate the time-endowment of unity. As a consequence, $y_0 \leq z$. Suppose that the inequality is strict. The aggregate budget constraint, $m = p_0 y_0 + S_1$, then infers that either $p_0 > m/z$, or $S_1 > 0$ (or both). Under this hypothesis there is involuntary unemployment and wages must fall until $p_0 = m/z$. The Euler equation is therefore given by

$$u'(y_0) = \frac{\beta}{z}\delta h(y_0/z)u'(\delta h(y_0/z))$$

Using the parametric forms $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$ and $h(n) = n^{\alpha}$ reveals that there are two solutions associated with the above equation

$$y_0 = z\left(\frac{\delta}{\delta^*}\right)^{\frac{1-\sigma}{\sigma-\alpha(\sigma-1)}} \quad \text{or} \quad y_0 = 0$$

In the first case, y_0 must (weakly) exceed z as, $\delta \geq \delta^*$, and $\frac{1-\sigma}{\sigma-\alpha(\sigma-1)} > 0$. This is a contradiction. In the second case, $y_0 = 0$ indeed solves the Euler equation, but the not the households' optimization problem: If $y_0 = 0$, a representative household allocates all her nominal resources towards period one, in which prices are infinite, and resources useless. Given such prices, the household would be better off by spending some initial nominal resources in period zero, ruling out $y_0 = 0$ as a possible equilibrium.

It remains to be verified that $y_0 = z$ is indeed an equilibrium. Due to downward nominal wage rigidity $p_0 \geq m/z$. Thus, according to the aggregate budget constraint together with the condition $S_{t+1} \geq 0$, it follows that $p_0 = m/z$ and $S_1 = 0$. As a consequence, there exist a unique $i_1 \geq 0$ such that

$$u'(z) = \beta(1+i_1)\frac{\delta}{z}u'(\delta)$$

Lastly, consider the effect of fiscal policy. For any $g > 0$, there exist a $i_1 > 0$ such that

$$u'(z(1-\gamma)-g) = \beta(1+i_1)\frac{\delta}{z}u'(\delta(1-\gamma))$$

As a consequence, there is full crowding-out and the multiplier is zero.

A.3. **Proof of Proposition 3.** First, suppose that $y_0 = z$. Then using the arguments in the proof of Proposition 2 it is immediate that $p_0 = m/z$ and that $S_1 = 0$. However, as $\delta < \delta^*$, the interest-rate which satisfies

$$u'(z) = \beta(1+i_1)\frac{\delta}{z}u'(\delta)$$

must be negative, which violates the zero lower bound. As a consequence, $y_0 < z$, $p_0 = m/z$, $S_1 > 0$ and $i_0 = 0$. The Euler equation is thus given by

$$u'(y) = \frac{\beta}{z}\delta h(y/z)u'(\delta h(y/z))$$

Using the aforementioned parametric forms we have

$$y_0 = z\left(\frac{\delta}{\delta^*}\right)^{\frac{1-\sigma}{\sigma-\alpha(\sigma-1)}} \quad \text{or} \quad y_0 = 0$$

Again, $y_0 = 0$ can be ruled out by repeating the previous arguments.

A.4. **Proof of Proposition 4.** The Euler equation is then given by

$$u'(y_0 - g_0 - g) = \frac{\beta}{z}\delta h(y_0/z)u'(\delta h(y_0/z) - g_1)$$

Applying the implicit function theorem evaluated at $g_t = \gamma y_t$, $t = 0, 1$, and $g = 0$ yields

$$\frac{\partial y_0}{\partial g} = -\frac{u''(y_0(1-\gamma))}{\frac{\beta}{z}\delta h'(y_0/z)\frac{1}{z}u'(\delta h(y_0/z)(1-\gamma)) + \frac{\beta}{z}\delta h(y_0/z)u''(\delta h(y_0/z)(1-\gamma))\delta h'(y_0/z)\frac{1}{z} - u''(y_0(1-\gamma))}$$

Using the Euler equation together with the following relations

$$\frac{yu''(y(1-\gamma))}{u'(y(1-\gamma))} = \frac{\sigma}{1-\gamma} = \hat{\sigma} \quad \text{and} \quad h'(y/z)\frac{y}{zh(y/z)} = \alpha$$

leaves us with

$$\begin{aligned}\frac{\partial y_0}{\partial g} &= -\frac{u''(y_0(1-\gamma))}{\frac{\alpha}{y_0}u'(y_0(1-\gamma)) - \hat{\sigma}\frac{\alpha}{y_0}u'(y_0(1-\gamma)) + \hat{\sigma}\frac{\alpha}{y_0}u'(y_0(1-\gamma))} \\ &= \frac{1}{1-\alpha\left(1-\frac{1}{\hat{\sigma}}\right)}\end{aligned}$$

Appendix B. Computational Details

In period $t = 1$ the equilibrium is described by the following equations

$$\begin{aligned} k &= q(\theta_1)\left(\delta - \frac{\tilde{w}}{p_1} + \beta(1-\lambda)J\right) \\ n_1 &= (n_0\lambda + (1-n_0))h(\theta_1) + n_0(1-\lambda) \\ y_1 &= \delta n_1 \\ p_1 &= \frac{m}{y_1} \end{aligned}$$

where the three first equations can be combined to yield the aggregate supply relation, and the last equation describes aggregate demand.

I solve the above equations for the unknowns θ_1, n_1, y_1, and p_1 using a nonlinear equation solver for each value of n_0 on a grid containing 1000 equidistant nodes between 0.9 and 0.95. Using linear interpolation, this yields policy functions $p_1(n_0, \delta)$, $y_1(n_0, \delta)$, $J_1(n_0, \delta)$ and $c_1(n_0, \delta)$.

In period zero, the equilibrium is given by the following system of equations

$$k = q(\theta_0)\left(\delta - \frac{\tilde{w}}{p_0} + \beta(1-\lambda)J_1(n_0, \delta)\right) \tag{A6}$$

$$n_0 = (n_{-1}\lambda + (1-n_{-1}))h(\theta_0) + n_{-1}(1-\lambda) \tag{A7}$$

$$y_0 = n_0 \tag{A8}$$

$$m = p_0 y_0 + S_1 \tag{A9}$$

$$u'(\frac{m - \hat{S}_1}{p_0} - \bar{g} - g) = \beta\frac{p_0}{p_1(n_0, \delta)}u'(c_1(n_0, \delta)) \tag{A10}$$

with $S_1 = \max\{\hat{S}_1, 0\}$. Given, $n_{-1} = n$, this yields policy functions $p_0(\delta, g)$, and $y_0(\delta, g)$. For a certain value of δ, the fiscal multiplier is calculated as

$$\frac{\partial y_0}{\partial g} = \frac{y_0(\delta, \varepsilon) - y_0(\delta, 0)}{\varepsilon}$$

with $\varepsilon = 1e(-8)$.

To generate Figure 1, I calculate the fiscal multiplier for each value of δ on a grid containing 1000 equidistant nodes between 0.9 and 1.03.

In contrast, to generate Figure 3, I set δ at a fixed value of 0.941 and solve system (A6)-(A10) for each value of g on a grid containing 1000 equidistant nodes between 0 and 0.05. Let j denote an arbitrary node in the grid. The average multiplier is then calculated as

$$\frac{\sum_{s=1}^{j}(y_0(\delta, g_s) - y_0(\delta, g_{s-1}))}{g_j}$$

The output gap is given by

$$(\ln 0.95 - \ln y_0(\delta, g_j)) \times 100$$

Lastly, to generate Figure 2, I construct a grid of labor market tightness, θ_0, containing 1000 equidistant nodes between zero and one. Implicitly, this defines a grid of output ranging from approximately 0.9177 to 0.9674. Given $\delta = 0.99$, I then solve equations (A6)-(A8) for "supply prices", and plot these together with the grid for output to generate the AS curve. In a similar way, I solve equations (A9)-(A10) for "demand prices" to generate the AD curve. Then I set $\delta = 0.95$ and recompute equations (A9)-(A10) to generated the AD' curve.[34]

B.1. **Alternative discounting.** Following equation (22) firms evaluate a successful match according to

$$J_t = E_t \sum_{s=0}^{\infty} (\beta(1-\lambda))^s \left(z_{t+s} - \frac{\tilde{w}_{t+s}}{p_{t+s}} \right)$$

Thus, as firms discount future profits by β, entrepreneurs do not internalize their entry-decision on household welfare.

Consider the alternative. The marginal effect of an additional vacancy yields nominal profits in period t equal to $p_t \times (z_t - \tilde{w}_t/p_t)$. As these profits are first disposable to the household in period $t+1$, the marginal gain is therefore

$$(z_t - \frac{\tilde{w}_t}{p_t})\beta u'(c_{t+1})\frac{p_t}{p_{t+1}}$$

As a consequence, a firm which internalizes the decision to entry on the representative household's welfare evaluates a successful match according to

$$J_t = E_t \sum_{s=0}^{\infty} (\beta(1-\lambda))^s \beta u'(c_{t+s+1}) \frac{p_{t+s}}{p_{t+s+1}} \left(z_{t+s} - \frac{\tilde{w}_{t+s}}{p_{t+s}} \right)$$

Let us rewrite the vacancy-posting cost k as $k = \tilde{k}\beta u'(c)$, where c denotes the steady-state level of consumption. The free-entry condition is then given by

$$\tilde{k} = q_t E_t \sum_{s=0}^{\infty} (\beta(1-\lambda))^s \frac{u'(c_{t+s+1})}{u'(c)} \frac{p_{t+s}}{p_{t+s+1}} \left(z_{t+s} - \frac{\tilde{w}_{t+s}}{p_{t+s}} \right)$$

Thus by Assumption 4 and 5, the free-entry condition in period one is given by

$$\tilde{k} = q_1 \left[E_1 \frac{u'(c_2)}{u'(c)} \frac{p_1}{p_2} \left(\delta - \frac{\tilde{w}}{p_1} \right) + \beta(1-\lambda)J \right]$$

The model does not have enough structure to pin down the value of neither c_2 nor p_2. For simplicity, I will assume that they equal their steady-state values. Under these conditions *period-one* free-entry infers

$$\tilde{k} = q_1 \left[p_1 \left(\delta - \frac{\tilde{w}}{p_1} \right) + \beta(1-\lambda)J \right] = q_1 J_1$$

[34]The AS relation changes unnoticeably between setting δ equal to 0.99 or 0.95. As a consequence, I only plot the former.

And the equivalent condition in *period zero* is given by

$$\tilde{k} = q_0 \left[\frac{u'(c_1)}{u'(c)} \frac{p_0}{p_1} \left(z - \frac{\tilde{w}}{p_1} \right) + \beta(1-\lambda) J_1 \right] = q_0 J_0$$

with $\tilde{k}$ calibrated to the *same* value as k.[35]

Figure 4 reproduces Figure 1 using the free-entry conditions above (grey curve), and the free-entry condition associated with equation (22) (black curve). Clearly, the numerical results are robust to alternative

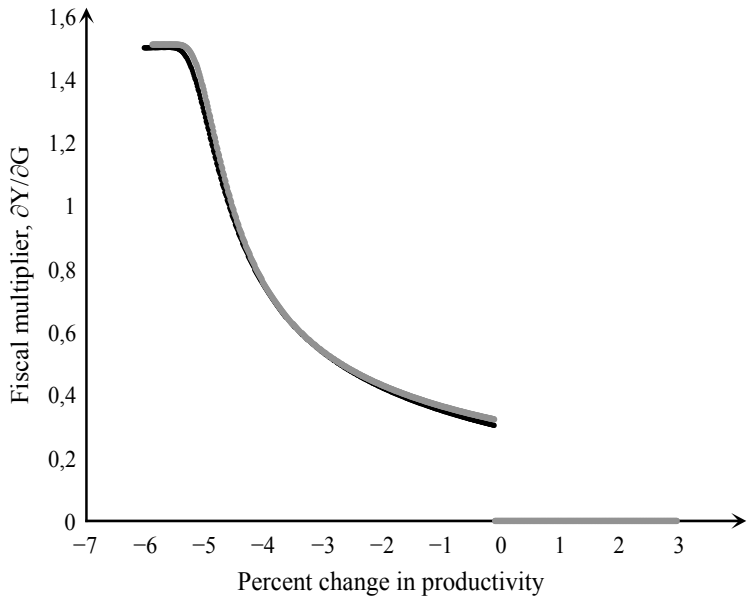

FIGURE 4. The fiscal multiplier with respect to news of future productivity.

discounting procedures.

[35]Notice that if $\tilde{k}$ takes on the same value as k, the steady-state targets discussed in Section 4.4 are satisfied.