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Policy Paradoxes in the New Keynesian Model

Michael T. Kiley*

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Abstract

The most common New-Keynesian model—with sticky-prices—has potentially implausible implications in a zero-lower bound environment. Fiscal and forward guidance multipliers can be implausibly large. Moreover, the sticky-price model implies that positive supply shocks, such as an increase in productivity, will lower production, and that increased price flexibility can exacerbate such a decline in output (as well as amplifying the effects of other shocks). These results are fragile and disappear under a plausible alternative to sticky prices – sticky information: Fiscal and monetary multipliers are smaller, positive supply shocks raise output, and greater price flexibility, in the sense of more frequent updating of information, moves the economy’s response toward the neoclassical benchmark. These results suggest caution in drawing policy lessons from a single, sticky-price framework. Finally, we highlight how strategies akin to nominal-income targeting can enhance the ability of policymakers to affect demand in sticky-price and sticky-information models.

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1 Introduction

The most commonly-used New-Keynesian model – which focuses on results using the sticky-price Phillips Curve – produces a number of “paradoxes” which call into question its central role in policy analysis. At the very least, recent analyses have emphasized that this model, while widely used, has a significant number of predictions (especially around the zero lower bound on nominal interest rates) that may be at odds with the data or which seem somewhat extreme and implausible.

Four predictions of New-Keynesian models using sticky prices seem either extreme and counter-intuitive, and therefore deserve investigation in a broader set of frameworks. Such a broader investigation is particularly important because two or three of these predictions have played an important role in policy discussions since 2008.

- Forward guidance regarding nominal interest rates can have a large effect on real activity and inflation, and hence can be a very effective monetary policy strategy at the zero lower bound.
- The government-expenditure, or (as a short-hand) the fiscal, multiplier can be large if monetary policy is passive, and the fiscal multiplier grows with the duration of fiscal/monetary stimulus; as a result, the fiscal multiplier may be unusually large at the zero lower bound.
- At the zero lower bound or under passive monetary policy, adjustments in the short-term nominal interest rate do not crowd-in demand in response to the inflation consequences of improvements in aggregate supply (e.g., increases in productivity or labor supply); as a result, positive supply shocks can lower demand/production in the short run, by potentially very large amounts. (The so-called paradox of toil.)
- Increased flexibility of prices – that is, a greater responsiveness of prices to shifts in nominal marginal cost – raise volatility in response to shocks, rather than

moving the economy’s response toward the (typically moderate) neoclassical benchmark response that would occur under price flexibility. (The so-called paradox of volatility.)

We revisit each of these issues within the New-Keynesian framework. In doing so, we highlight several key considerations. Perhaps most importantly, we emphasize assumptions regarding nominal price dynamics: The overwhelming majority of the literature, as well as the policy models at central banks around the world, use a version of the “sticky-price” framework (of Rotemberg [1982] and Calvo [1983]), which yields the New-Keynesian Philips curve linking current and expected future inflation. We consider both sticky-price and sticky-information (Mankiw and Reis [2002]) models of price dynamics. Nearly as important, we discuss the role of “passive” monetary policy for policy multipliers: In the fiscal context, passivity corresponds to an assumption that fiscal actions do not lead to any response of the short-term nominal interest rate either because the monetary authority accommodates the fiscal action or because the zero lower bound constrains a monetary policy response; in the monetary context, passivity corresponds to the notion that forward guidance is communicated in terms of the path for the nominal interest rate, not in terms of goals for inflation, the price level, or output. In mathematical terms, passivity will arise when the monetary policy reaction function (in the absence of endogenous state variables, as in the basic New-Keynesian framework) does not introduce additional state variables into the model’s solution, implying the economy returns to steady state once exogenous forces return to steady state; we will present an example of such a passive strategy in deriving the results (although the results hold for any strategies with this property).

By examining each of these issues under two views regarding price dynamics and alternative assumptions on the passivity of monetary policy, we show that changes in assumptions can overturn the key predictions emphasized in recent work. First, increasing flexibility (that is, the response of prices to marginal cost) moves the economy toward the flexible-price (or neoclassical) responses under sticky information

and lowers volatility, eliminating the paradox of volatility. Similarly, positive supply shocks (e.g., improvements in productivity) boost output, even at the zero lower bound, under sticky information, in contrast to the sticky-price prediction of a paradox of toil. Regarding policy actions, the fiscal multiplier is *strictly below one* and *decreasing in the duration* of fiscal stimulus under sticky information, whereas it is *strictly above one* and *increasing in the duration* of the fiscal stimulus under sticky prices. Moreover, forward guidance regarding the nominal interest rate is not increasingly powerful with the horizon of such guidance in the sticky information model, in contrast to the prediction of the sticky-price model.

In each case, the starkly different predictions of the New-Keynesian model under sticky-information price setting from those under sticky prices stems from the same force: Within the sticky price framework, a passive (e.g., non-responsive) monetary policy regime, which could reflect zero-lower bound considerations, implies potentially very large movements in the long-run price level following shifts in “demand” or “supply”; in contrast, a passive monetary policy implies that the long-run price level is unresponsive to “demand” and “supply” shocks in the sticky-information model. These differences in long-run price level responses imply very different movements in real interest rates, and hence very different implications for demand/production through movements along the “IS-curve” across the sticky-price and sticky-information frameworks – thereby accounting for the starkly different predictions for the multipliers associated with government expenditure and forward guidance, and for the absence of paradoxes of toil and volatility.

While our core results are illustrated within the simplest New-Keynesian model, we illustrate that our results on policy multipliers are robust to models that are more complex than the simple (and largely static) textbook model by showing how our results continue to hold in larger models like that of Smets and Wouters [2007]; we specifically present such an illustration for the case of the fiscal multiplier.

Finally, we show that policy multipliers can be increased, regardless of the struc-

tural assumptions on price dynamics, by active policies that seek to raise the nominal price level, such as nominal income targeting. The importance of such active steps reiterates a lesson from Krugman [1998] and Eggertson and Woodford [2003] that is absent in strategies focusing on nominal interest rates (such as that of Campbell et al [2012]).

Before turning to the analysis, it is important to remember that our results concern the magnitude of policy multipliers in the core model used in research and policy debates – but does not consider the importance of the many additional factors, outside the core model but still important, such as rule-of-thumb consumers, the financial system, the distortionary nature of the tax system, heterogeneity among households, and many others. These other factors are important for specific quantitative answers and for a full evaluation. For example, we find that the fiscal multiplier is strictly below one in the core model when price dynamics are governed by sticky information: This finding implies that fiscal expansion is welfare decreasing, even at the zero lower bound (in contrast to the outcome under sticky prices). This result does not imply that fiscal expansion is welfare decreasing “in the real world”, but rather implies that one cannot simply use the passivity of the monetary policy reaction and the resulting large fiscal multiplier under sticky prices to justify a welfare improvement from a fiscal expansion.

Our analysis first presents the basic framework before turning to the results on the magnitude of multipliers. Following this analysis, we consider larger macroeconomic models and the role of active monetary policies.

2 The Basic Framework

We adopt a standard model as in Woodford [2003]. In the long-run, the model is a simple neoclassical benchmark with imperfect competition in product markets. The short-run behavior is influenced by sluggish nominal price adjustment. At its

core, the short-run model consists of two equations – an IS curve governing spending decisions, and a Phillips curve governing price-level dynamics.

We first introduce the long run.

2.1 The Classical, or Long-run, or Flexible-Price, Benchmark

Assume that a representative household maximizes a time-separable utility function in consumption (C) and hours-worked (H), with per-period utility given by $U(C_t) - V(H_t)$. Households receive a real wage, which (due to imperfect competition) equals the marginal product of labor divided by a markup ($F_H(H_t)/\mu$). Equating the marginal rate of substitution between hours worked and consumption to the real wage ($V(H_t)/U(C_t) = F_H(H_t)/\mu$), taking natural logarithms, and totally differentiating under the assumption that the markup is constant yields

$$\frac{dC}{dH} = -\left(\frac{F_{NN}}{F_N} - \frac{V_{NN}}{V_N}\right)\frac{U_{CC}}{U_C}. \quad (1)$$

Under standard assumptions – constant or decreasing returns to scale ($F_N > 0, F_{NN} \leq 0$), increasing marginal disutility of work ($V_N > 0, V_{NN} \geq 0$), and decreasing marginal utility of consumption ($U_C > 0, U_{CC} \leq 0$), it is clear that consumption is decreasing in hours worked (in the long run), reflecting the “wealth effect” – higher levels of consumption/wealth lead households to wish to work less. Since aggregate expenditure in this simple model is simply the sum of consumption and government expenditure,

$$F(N_t) = C_t + G_t, \quad (2)$$

any increase in output from an increase in government expenditure must be partially crowded-out by the accompanying decrease in consumption through this wealth effect. This prediction carries over to the case with capital accumulation, etc., as emphasized

by Baxter and King [1993]; we use the simple model, as in Woodford [2011], for analytical clarity, and consider a model with capital accumulation later.

For now, it is clear that the long-run benchmark is a government expenditure multiplier less than one. We will use the parameter Γ to denote the long-run, or, in our largely static framework, the flexible-price, fiscal multiplier – that is, the effect of a change in government expenditure of one percent of output on output under price flexibility is given by Γ . For simplicity’s sake, we will further assume that, due to some system of subsidies to offset any effects of markups above marginal cost, the long-run, or steady-state, of our model is efficient. As a result, the change in output associated with a change in government expenditure, under flexible prices, is efficient, or corresponds to the change in the *natural-rate of output* which will be relevant for marginal cost/price-setting considerations, as in Woodford [2003] or Woodford [2011].

In addition to shifts in government expenditure, we will consider a supply shock, namely a shift in labor productivity (Z_t). For simplicity, we will employ a normalization in which the efficient, flexible-price, natural-rate response of output to productivity is one-for-one. Denoting the natural rate of output as Y_t^{NR} , movements in the natural rate are given by

$$\frac{Y_t^{NR} - \bar{Y}}{\bar{Y}} = \frac{Z_t - \bar{Z}}{\bar{Z}} + \Gamma \frac{G_t - \bar{G}}{\bar{Y}} \quad (3)$$

where \bar{Y} , \bar{Z} and \bar{G} are the long-run steady-state values of output, labor productivity (technology), and government expenditure.¹ Using lower-case letters to denote the appropriate deviations, our expression for the natural rate of output is

$$y_t^{NR} = z_t + \Gamma g_t. \quad (4)$$

¹Note we have omitted the many details that are important in our description, including that government expenditure is financed via lump-sum taxes and the nature of subsidies to eliminate any distortions from, for example, imperfect competition, etc.

2.2 Aggregate Demand in the Short Run

Our model of the determination of demand in the short run follows the basic approach in the New-Keynesian literature, thereby allowing for a very clean comparison with the later related literature discussed above.

Private expenditure in the simple framework refers only to consumption outlays C_t , and hence the determination of private expenditure is given by the standard intertemporal optimality condition relating consumption today to future consumption, the household discount factor, and the gross *real* interest rate

$$\frac{dU}{dC_t} = E_t \beta \frac{R_t P_t}{P_{t+1}} \frac{dU}{dC_{t+1}}. \quad (5)$$

Log-linearization and iterating the resulting expression forward in time yields the familiar *Intertemporal IS curve* (where, for the remainder of the analysis, we assume that β is arbitrarily close to one, thereby eliminating an inessential parameter from the the remaining expressions)

$$c_t = -\sigma E_t \left[\sum_{j=0}^{\infty} r_{t+j} - (p_{t+1+j} - p_{t+j}) \right] \quad (6)$$

where c_t equals $(C_t - \bar{C})/\bar{Y}$ – that is, we are expressing private expenditure as deviations from its steady-state share of output for convenience (and in parallel with the treatment of government expenditure above). The IS curve implies that private expenditure increases with a decline in the long-run real interest rate, where the sensitivity of expenditure to interest rate movements is given by the intertemporal elasticity of substitution σ .

The resource constraint 2 implies that the deviation of output from its steady-state level equals the share-weighted deviations of private expenditure and government expenditure ($(Y_t - \bar{Y})/\bar{Y}$ equals $(C_t - \bar{C})/\bar{Y} + (G_t - \bar{G})/\bar{Y}$, or y_t equals $c_t + g_t$, which

yields the following expression for the *Intertemporal IS curve*

$$y_t = g_t - \sigma E_t \sum_{j=0}^{\infty} [r_{t+j} - (p_{t+1+j} - p_{t+j})]. \quad (7)$$

While this model of aggregate demand determination is very simple, it is also very useful and hence has been used to illustrate key insights regarding monetary and fiscal policy multipliers in a large literature (e.g., Woodford [2003], Levin et al [2010], Woodford [2011], Christiano, Eichenbaum, and Rebelo [2011], Carlstrom, Fuerst, and Paustian [2012b], and Carlstrom, Fuerst, and Paustian [2012a]).

2.3 Short-Run Aggregate Supply: Two Cases

Our analysis builds on the (by now) well-known New-Keynesian framework (Woodford [2003]). In the basic framework, desired prices are a markup over real marginal cost, and, in the simplest cases, real marginal cost is proportional to the deviation of output from its natural, or flexible-price, level. In our simple case, the (deviation from steady state of the) natural rate of output, as presented in 4, is simply $z_t + \Gamma g_t$, and hence the deviation of output from its natural rate is $y_t - z_t - \Gamma g_t$ (much as in Woodford [2011]). In both specifications of short-run aggregate supply considered below, this “gap” will be the driver behind fluctuations in inflation: Specifically, we will assume that marginal cost equals $\alpha(y_t - z_t - \Gamma g_t)$ – that is, that the elasticity of marginal cost with respect to the output gap is α .

2.3.1 A Sticky-Price Framework

Our analysis first presents the framework that dominates the literature and has been most influential in policy-related discussions – the sticky-price framework (e.g., Woodford [2003], Woodford [2011], Cogan et al [2010], Christiano, Eichenbaum, and Rebelo [2011], Erceg and Linde [2010], Carlstrom, Fuerst, and Paustian [2012a], Carlstrom, Fuerst, and Paustian [2012b], and Coenen et al [2012]).

The basic sticky-price framework, whether motivated by the staggered-price-setting model of Calvo [1983] or the quadratic-costs-of-price-adjustment framework of Rotemberg [1982], consists of the forward-looking Phillips curve

$$p_t - p_{t-1} = \eta\alpha(y_t - z_t - \Gamma g_t) + E_t[p_{t+1} - p_t]. \quad (8)$$

In 8, the sensitivity of inflation to deviations of output from its natural rate ($\eta\alpha$) is a function of the underlying parameters determining marginal cost α (e.g., preference and production parameters) and those determining price rigidity (summarized by η); as will be clear below, the specific values for these parameters will have no effect on the comparison across sticky-price and sticky-information models, and hence are not emphasized herein.²

It will be convenient below to refer to the form of the sticky-price Phillips curve that iterates 8 forward to yield

$$p_t - p_{t-1} = E_t \sum_{j=0}^{\infty} \eta\alpha(y_{t+j} - z_{t+j} - \Gamma g_{t+j}). \quad (9)$$

This form highlights very clearly the dependence of inflation on future conditions in the sticky-price framework—current inflation rises with the expected future output gap, and hence a more-persistent anticipated increase in economic activity leads to a larger rise in inflation in the current period.

2.3.2 A Sticky-Information Framework

An alternative model of nominal rigidities, albeit one less typically employed, is the sticky-information model of Mankiw and Reis [2002]. As highlighted earlier, some researchers have argued that the predictions of this framework are more plausible; for a recent summary of this work, see Mankiw and Reis [2010]. One reason—albeit a very

²The interested reader can find these expressions in, for example, Woodford [2003] or Woodford [2011].

poor reason—that the sticky-price approach is much more commonly used than the sticky-information approach is that the recursive formulation of the sticky-price model is much simpler to express in commonly-used simulation software such as Adjemian et al [2011] (as discussed in Verona and Wolters [2012]).

The sticky-information framework emphasizes the notion that the sluggish response of nominal prices to shocks may reflect slow updating of information. Under the assumption that a random-fraction λ of price setters update their information set each period, Mankiw and Reis [2002] show that the price level under the sticky-information specification is given by

$$p_t = \lambda \sum_{j=0}^{\infty} (1 - \lambda)^j E_{t-j} [p_t + \alpha(y_t - z_t - \Gamma g_t)]. \quad (10)$$

This price-level expression yields the sticky-information Phillips curve

$$p_t - p_{t-1} = \frac{\lambda \alpha}{1 - \lambda} (y_t - z_t \Gamma g_t) + \lambda \sum_{j=0}^{\infty} (1 - \lambda)^j E_{t-1-j} (p_t - p_{t-1} + \alpha [y_t - y_{t-1} - (z_t - z_{t-1}) - \Gamma (g_t - g_{t-1})]). \quad (11)$$

In 10 or 11, the sensitivity of the price level/inflation to deviations of output from its natural rate is a function of the degree of information rigidity (λ) and the sensitivity of marginal cost to movements of output away from its natural rate (α); the specific values for these parameters will have no effect on the comparison across sticky-price and sticky-information models, and hence are not emphasized herein.

More fundamentally, the sticky-information model links nominal prices and the contemporaneous (expected) values of the output gap – not the entire sequence of expected future values. As such, the role of future expected future conditions in inflation determination within the sticky-price model is absent from the sticky-information model.

2.4 Key Structural Differences Across the Models

In looking over the models, it is clear, and amply discussed in the previous literature, that the central difference in the models stems from the forward-looking nature of price-setting induced by the overlapping nature of nominal price rigidities in the sticky-price specification, versus the absence of such forward-looking behavior in the sticky-information model. In the sticky-price specification, price-setters look to future inflation in setting today's price because the nominal prices they set today will compete with future nominal prices (under the overlapping contracts motivation of Calvo [1983]) or because they find price adjustment costly and hence smooth their choice for nominal prices over time (in the adjustment cost specification of Rotemberg [1982]). In contrast, the sticky-information model has price-setters adjust prices in response to their expectations, perhaps stale, of what contemporaneous conditions imply.

As emphasized in previous work (e.g., building on Fischer [1977] and Taylor [1980]), these differences imply that the sticky-information model has more “classical” properties than the sticky-price model. This can be seen most clearly in the finite-horizon versions of these models, in which all cohorts have either updated their information sets or adjusted prices within some finite period T . Under those conditions, for example, a monetary expansion announced today for the period after all adjustment has taken place is neutral (with respect to economic activity) under the sticky-information model (e.g., its “classical” tendency), whereas such an expansion is non-neutral under the sticky-price model. This difference in classical tendencies will be important in the results below.

Finally, consider a case in which some set of shocks occurs which causes agents to expect that output will be above its natural rate between the current time period t and period $t+k$, after which output is expected to equal its natural rate for all future periods. It should be clear from equation 9 that the change in the price level to period $t+k+1$, relative to that in period t , will equal the sum of output gaps over the

period t to $t+k$ – and hence the price level will be permanently higher. In contrast, the sticky-information model is consistent with the possibility that the price level in period $t+k+1$ equals that in period t – as the course of the output gap between period t and $t+k$ does not enter equation 10. Under a passive monetary policy, it will indeed be the case that the long-run price level does not rise with a transitory increase in output above its natural rate, and this difference from the sticky-price model will imply stark contrasts between the sticky-price and sticky-information models under passive monetary policies, such as those possible at the zero-lower bound.

3 Monetary Policy Multipliers

We now consider the magnitude of the “monetary-policy” multiplier associated with forward guidance. Specifically, we ask how much output increases with a cut in the nominal short-term interest rate T periods in the future. We assume that this reduction in the interest rate is perfectly credible and that the nominal interest rate equals a baseline value (which we will normalize to 0) in all other periods prior to period T . That is, we are examining the *impulse response* to a one-time shift in the nominal interest rate at horizon T , with a commitment not to adjust the nominal interest rate over the intervening period. While not confined to periods at which the zero lower bound on nominal interest rates holds, these policy exercises have the same content as one in which it is assumed that the zero lower bound binds prior to period $t+T$, does not bind in period $t+T$, and policymakers promise to lower the nominal interest to its lower bound in period $t+T$ while abstaining from responding to any output or inflation developments over the period through T .

Following period $t+T$, monetary policy follows the reaction function

$$r_t = \phi_{\Delta p}(p_{t+1} - p_t) + \phi_y y_t. \tag{12}$$

This reaction function will prove *passive* in both the sticky-price and sticky-information

models, where passivity refers to the property that policy experiments over a horizon T will be consistent with a return to steady state in period $t+T+1$. This property of passivity implies that the behavior of monetary policy does not introduce any additional state variables to the solution of the model. We will return to active policy rules later in the analysis.³ These experiments are analogous to those in, for example, Carlstrom, Fuerst, and Paustian [2012b], Del Negro, Giannoni, and Patterson [2012] or Lasen and Svensson [2011].

We first consider the sticky-price case examined in previous research.

Proposition 1: *In the sticky-price model, the increase in output in the current period t associated with lowering the nominal interest rate T periods in the future (while promising not to change the nominal interest rate from its baseline path in any other period prior to time T) is bounded below by the intertemporal elasticity of substitution σ and increases with the horizon T .*

Proof: We know that the response of output and inflation at period $t+T$ is the same regardless of how far in the future T lies, as the nominal interest rate, inflation, and output will all equal baseline (for example, 0) in period $t+T+1$. Because the sum of future nominal interest rates is the same in period $t+T-1$ as in period $t+T$, but inflation is above baseline in period $t+T$ (in contrast to period $T+1$), output and inflation exceed their period $t+T$ values in period $t+T-1$. Iterating backward, output and inflation are higher in period $t+T-2$ than in period $t+T-1$, etc., implying that the

³Such a passive rule, in which monetary policy does not introduce additional states into the determination of the equilibrium, is standard in related analyses of the power of forward guidance, fiscal multipliers, and the paradox of toil (cited previously). In these analyses using the sticky-price model, passivity occurs when the rule is specified as in 12 or when inflation enters contemporaneously. As an alternative, one could simply ignore the monetary policy rule and specify the path of the nominal interest rate as following some baseline path irrespective of inflation and output developments. Some readers may question whether the assumption that the nominal interest rate follows a baseline path is reasonable – that is, whether an endogenous response of the nominal interest rate is needed to ensure reasonable dynamics. While an endogenous response of the nominal interest rate is needed to ensure equilibrium determinacy, it is not needed to examine the impulse response as defined herein. For those readers troubled by this possibility, one could assume that policymakers respond to any deviations of inflation or output that lie off the impulse response function to ensure “uniqueness”; but this assumption is not necessary. (For similar logic, see Cochrane [2011a] or Atkeson, Chari, and Kehoe [2010]). Under this interpretation, we are examining the minimum state variable solution.

Table 1: Output and Inflation Following Forward Guidance Under Sticky Prices

Period (j)	y_j	$p_j - p_{j-1}$
t+T+1	0	0
t+T	$-\sigma r_{t+T}$	$-\eta\alpha\sigma r_{t+T}$
t+T-1	$-\sigma(1 + \eta\alpha\sigma)r_{t+T}$	$-\eta\alpha\sigma(1 + (1 + \eta\alpha\sigma))r_{t+T}$

1. Assumes that the nominal interest rate equals r_{t+T} in period t+T and zero (baseline) in all other periods.

monetary policy multiplier at time t increases with the horizon of forward guidance T. Finally, a response of inflation ensures that the output response is strictly greater than σ . *Q.E.D.*

To see these mechanics more clearly, table 1 reports the backward induction process underlying proposition 1. In period t+T+1, all variables equal 0. In period t+T, expected inflation is zero and the nominal interest rate falls to $r_{t+T} < 0$, implying output equals $-\sigma r_{t+T}$ and inflation equals $-\eta\alpha\sigma r_{t+T}$. Iterating backward to period t+T-1, the expected inflation in period T contributes to an increase in output larger than that in period t, by lowering real interest rates (for the assumed decline in nominal interest rates, $r_{t+T} < 0$, and hence positive expected inflation). It is also clear that the initial response of output is bounded below by σ for $T \geq 1$, as illustrated in the T-1 row. These result are well known, albeit less explicitly discussed, from previous work: Carlstrom, Fuerst, and Paustian [2012b] present analytic formulas illustrating proposition 1, and numerical simulations in a wide number of previous analyses make the same point (e.g., Del Negro, Giannoni, and Patterson [2012] and Lasen and Svensson [2011]).

Note that proposition 1 implies that the zero lower bound, if expected to last for a finite period of time, may not be an important constraint on the ability of monetary policy to cushion adverse shocks to demand because forward guidance is very powerful, especially if the forward guidance is about the far future. Indeed, this conclusion partially underlies the results of Eggertson and Woodford [2003] and

Levin et al [2010], who show that the zero-lower bound has little effect on the ability of policymakers to stabilize output and inflation if policymakers can commit to a path for future interest rates.

We now turn to the sticky-information case.

Proposition 2: *In the sticky-information model, the increase in output in the current period t associated with lowering the nominal interest rate T periods in the future (while promising not to change the nominal interest rate from its baseline path in any other period prior to time T) is bounded above by the intertemporal elasticity of substitution σ and is constant for all T .*

Proof: Note that in these policy actions, government expenditure and productivity equal baseline (0). The right hand side of equation 10 can be broken into two components,

$$p_t = \lambda \sum_{j=0}^{t+k} (1-\lambda)^j E_{t-j}[p_t + \alpha(y_t - z_t - \Gamma g_t)] + \lambda \sum_{j=t+k+1}^{\infty} (1-\lambda)^j E_{t-j}[p_t + \alpha(y_t - z_t - \Gamma g_t)]. \quad (13)$$

In period $t+k$, the second term equals 0, and all expectations within the first component are identical (as they are based on the same information); as a result,

$$p_{t+k} = \frac{(1 - (1 - \lambda)^{k+1})}{(1 - \lambda)^{k+1}} \alpha y_{t+k} \quad (14)$$

for $0 \leq k \leq \infty$. In addition, it is straightforward to express the IS-curve 7 as

$$y_t - g_t = -\sigma E_t \left[\sum_{j=0}^{\infty} r_{t+j} - (p_{t+\infty} - p_t) \right]. \quad (15)$$

Using 13, 15, and the passive monetary rule 12, the price level returns to baseline in period $t+T+1$ and thereafter. This is apparent by combining the fact that prices set by those in the second component of equation 13 in period $k = T + 1$ are 0 with the remaining equations, which yields prices chosen in the first component of 13 equal

to zero (and output and nominal interest rates also at baseline for all periods after T).⁴ Combining equation 15, 14, $p_{t+\infty} = 0$ and the assumption that r is zero for all periods prior to period $t+T$ yields

$$y_{t+j} = -\sigma \frac{(1-\lambda)^{j+1}}{((1-\lambda)^{j+1} + (1-(1-\lambda)^{j+1})\alpha\sigma)} r_{t+T}. \quad (16)$$

The response to the change in r_{t+T} is bounded above by σ and independent of T . (Moreover, the maximum response occurs in period t , $j = 0$). *Q.E.D.*

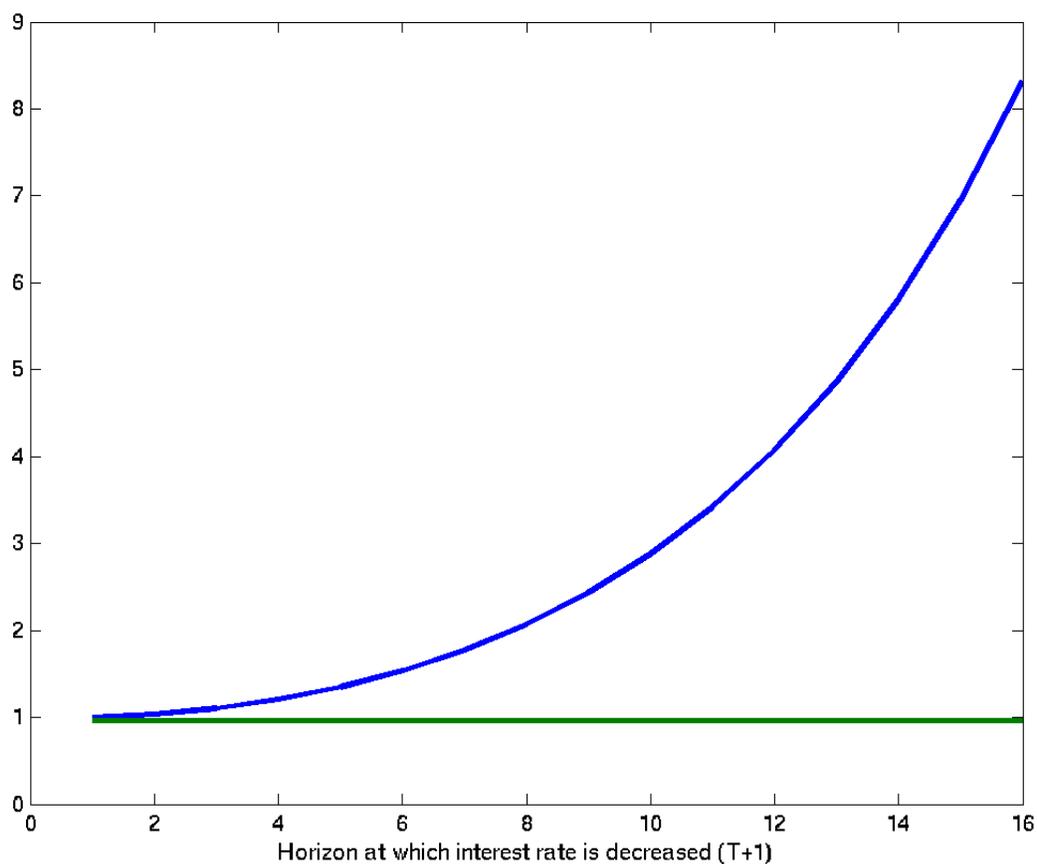
Proposition 2 implies that monetary policy remains effective at the zero lower bound – because forward guidance can stimulate production. However, *forward guidance is not more powerful* than current accommodation as is true of the sticky-price specification. This difference arises because of the different dynamics associated with the sticky-information model – specifically, the fact that future inflation does not feed directly into current inflation, in contrast to the link in the sticky-price model.

As a result, the sticky-information framework may be a “solution” to the puzzle regarding the effectiveness of forward-guidance emphasized by Levin et al [2010], Lasen and Svensson [2011], and Del Negro, Giannoni, and Patterson [2012]. Note also that the *upper bound* for the power of forward guidance under sticky-information is the *lower bound* under sticky prices. To place these results in perspective, let’s compare the analysis of forward guidance in the sticky-price case, as exemplified by, for example, Carlstrom, Fuerst, and Paustian [2012b], Levin et al [2010], Del Negro, Giannoni, and Patterson [2012], and Lasen and Svensson [2011], with the implica-

⁴The absence of endogenous state variables, through lags of output, prices, or interest rates, leads to this result, and more general cases will be considered later. Note that this result is quite different from that associated with a permanent monetary expansion. Assuming a money-demand function that implies a constant level of real balances in the steady-state, a permanent expansion in the money supply would raise the long-run price level by the same amount. This remains consistent with equation 14, as this process occurs only asymptotically (as j approaches ∞), with output approaching zero and the coefficient in front of output approaching ∞ (in a manner that offsets). The link between a permanent expansion in the supply of money, a passive monetary policy, and an active monetary policy will be discussed later. At this point, it is simply noted that a passive monetary policy as in 12 (in the experiments we conduct) is not consistent with a permanent expansion in the money supply.

tions of the sticky-information assumption. As most of these previous analyses were based on simple simulations, we pursue the same strategy. We set the intertemporal elasticity of substitution σ at 1 and choose identical inflation effects of a reduction in the nominal interest rate at period t (that is, for the T equal to 0 case).⁵ Figure 1 presents the effect on output in period t for reductions in the nominal-interest rate in period $t+T$ (where T increases along the x axis). As illustrated, the lower bound for the impact under sticky prices is σ (e.g., 1), and the impact rises rapidly with the degree of forward guidance. The sticky-information model has a “flat” money

Figure 1: Effect on Output (at t) of Forward Guidance (of Horizon T)



⁵The specific values for the parameters of the Phillips curves are not especially important.

multiplier at a value bounded from above by the intertemporal elasticity of substitution. The value is bounded from above because the long-run price level is not affected by a one-time monetary surprise – in this simple model – and hence inflation after period t , on average, is modestly below baseline, counteracting a small part of the stimulus from a cut in the nominal interest rate. We will revisit this prediction, and its implications for policy design, in the penultimate section.

4 The Government Expenditure Multiplier

We now consider the magnitude of the “fiscal” multiplier – that is, the size of the change in overall production associated with an increase in government expenditure equal to 1 percent of output. We focus on the case in which monetary policy is completely passive – that is, we assume no response of the nominal interest rate over the horizon of the fiscal expansion, and reversion to the policy rule 12 after the fiscal expansion ends. This focus is of interest for two reasons. First, a large recent literature has emphasized how the fiscal multiplier can be large in a model with sticky prices if the monetary authority is passive either because of a concerted desire to coordinate stimulus with the fiscal authority or because the nominal interest rate is stuck at the zero-lower bound (e.g., Christiano, Eichenbaum, and Rebelo [2011], Cogan et al [2010], Coenen et al [2012], Woodford [2011], Erceg and Linde [2010], and Carlstrom, Fuerst, and Paustian [2012a]). Second, we will also consider how specific forms of active monetary policy may affect the fiscal multiplier in the penultimate section, and hence find it of interest to focus on the case in which monetary policy is passive as the initial benchmark case. As in the monetary multiplier analysis above, we are examining the *impulse response* to a shift in government expenditure, in this case an increase in government spending from period t to period $t+T$, $T \geq 0$. These experiments are analogous to those in, for example, Christiano, Eichenbaum, and Rebelo [2011], Woodford [2011], and Carlstrom, Fuerst, and Paustian [2012a].

We first consider the sticky-price case emphasized in previous work.

Proposition 3: *In the sticky-price model, the government expenditure multiplier – that is, the average increase in output over the period of higher government expenditure – is strictly greater than one and increasing in the duration (T) of coordinated fiscal expansion/monetary accommodation.*

Proof: Consider an increase in government expenditure of 1 percent of output. We know, in this simple model, that output, inflation, and the nominal interest rate will equal baseline values in period $t+T+1$ and thereafter (from inspection of 7 and 8). If inflation were always at baseline, the multiplier would be 1, from 7. For the same reason (subsequent inflation at baseline), the increase in output is 1 in period $t+T$. Because this increase in output of 1 in period $t+T$ exceeds the increase in the natural rate of output, inflation is above baseline in period $t+T$. Therefore, output and inflation exceed baseline by more than 1 in period $t+T-1$, through the IS curve 7 and Phillips curve 8. Iterating backward, output and inflation are higher in period $T-2$ than in period $T-1$, etc., implying that the fiscal multiplier over the entire horizon of higher spending increases with the horizon of increased expenditure. Moreover, the initial response is bounded below by 1. *Q.E.D.*

As before, this backward-induction argument is most easily illustrated in a table, and hence table 2 provides an illustration. In period $t+T$, output rises with government expenditure, reflecting the absence of any change in the real interest rate (given the assumed monetary policy and sticky-price dynamics). As this increase exceeds the increase in the natural rate (which equals $\Gamma < 1$), inflation is positive in period $t+T$, which boosts output in period $t+t-1$ (through lower real interest rates).

This reasoning is well documented in the previous literature (with analytic contributions from Christiano, Eichenbaum, and Rebelo [2011], Woodford [2011], or Carlstrom, Fuerst, and Paustian [2012a] and numerical simulations in a wide number of previous analyses (e.g., Erceg and Linde [2010] and Cogan et al [2010])).

We now consider the sticky-information case.

Table 2: Output and Inflation Following Fiscal Expansion Under Sticky Prices

Period (j)	y_j	$p_j - p_{j-1}$
t+T+1	0	0
t+T	g	$\eta\alpha(1 - \Gamma)g$
t+T-1	$(1 + \sigma\eta\alpha(1 - \Gamma))g$	$\eta\alpha(1 - \Gamma + (1 + \sigma\eta\alpha(1 - \Gamma)))g$

1. Assumes that government expenditures equal g from period t to $t+T$ and zero (baseline) thereafter. Monetary policy is held at baseline through period T and follows 12 thereafter.

Proposition 4: *In the sticky-information model, the government expenditure multiplier is strictly less than one and decreasing in the duration (T) of coordinated fiscal expansion/monetary accommodation.*

Proof: The proof is similar to that of proposition 2. For the same reasons as in proposition 2, the price level is unaffected in all periods after $t+T$ under the sticky-information price-setting process 10. Similarly, output and the nominal interest rate return to 0 for all periods greater than $t+T$ as in proposition 2. Using 13 to determine the relationship between the price level, output, and government expenditure, we see that the second term on the right-hand side equals 0, and all expectations within the first component are identical (as they are based on the same information); as a result,

$$p_{t+k} = \frac{(1 - (1 - \lambda)^{k+1})}{(1 - \lambda)^{k+1}} \alpha(y_{t+k} - \Gamma g) \quad (17)$$

for $0 \leq k \leq T$. Using 17, 15, $p_{t+\infty} = 0$ and $r_{t+j} = 0$ for all periods prior to period $t+T$ yields

$$y_{t+j} = \frac{(1 - \lambda)^{j+1} + (1 - (1 - \lambda)^{j+1})\alpha\sigma\Gamma}{(1 - \lambda)^{j+1} + (1 - (1 - \lambda)^{j+1})\alpha\sigma} g. \quad (18)$$

The response to government expenditure g in period $t+j$ is bounded above by 1 and independent of T . Moreover, the response is decreasing in j (and approaches $\Gamma < 1$ as j approaches ∞). Because the response in period $t+j+1$ is less than that in period

$t+j$, the average response over the entire period of stimulus is decreasing in T . *Q.E.D.*

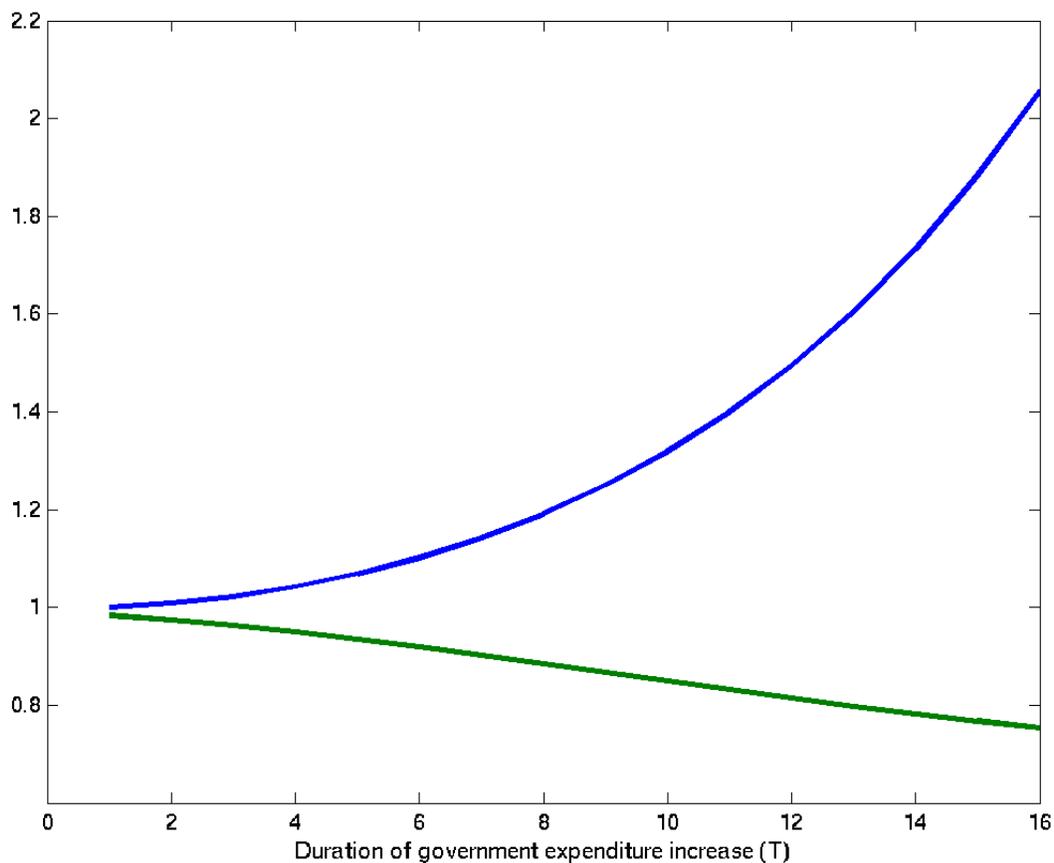
The intuition is simple: Suppose that the multiplier is one. Under these conditions, inflation in period t is the same sign as the change in government expenditure (as the change in output exceeds the change in the natural rate). If the price level after period $t+T$ is unaffected, then inflation from period $t+1$ onward must, on average, be of the opposite sign of the change in government expenditure in period t . However, this, through the IS curve ⁷, implies that the change in output must be less than the change in government expenditure – that is, the multiplier must be less than one. As in our analysis of forward guidance, the fact that a passive monetary policy implies the price level returns to baseline following a fiscal expansion is important, and active monetary strategies will be considered later.⁶

To place these results in perspective, let’s compare the analysis of the fiscal multiplier in the sticky-price case, as exemplified by, for example, Carlstrom, Fuerst, and Paustian [2012a], Woodford [2011], and Christiano, Eichenbaum, and Rebelo [2011], with the implications of the sticky-information assumption. As most of these previous analyses were based on simple simulations, we pursue the same strategy, using the parameters from the previous section.⁷ Figure 2 presents the average multiplier over periods t to $t+T$ from increases in government expenditure (where T increases along the x axis). As illustrated, the lower bound for the multiplier under sticky prices is 1, and the multiplier rises rapidly with the duration of fiscal stimulus (given a pas-

⁶The importance of long-run price-level dynamics also illustrates the link between the analysis herein and that of Farhi and Werning [2012]. Specifically, Farhi and Werning [2012] examine the fiscal multiplier in a “sticky-price” model, but *within a currency union*, and demonstrate that the currency union lowers the fiscal multiplier substantially, to below one. In the case of a small economy, which has no effect on rest-of-world outcomes, this occurs because a temporary fiscal stimulus has no effect on the long-run real exchange rate (or terms of trade) in their model – which implies no effect on the long-run domestic price level when the nominal exchange rate is fixed. This contrasts with the large jump in the long-run domestic price level that occurs in the absence of a currency union (or in a closed economy like that analyzed herein). This difference in price dynamics following fiscal stimulus accounts for the smaller multiplier found in Farhi and Werning [2012]. (Farhi and Werning [2012] offer related but somewhat different reasoning: To see that the reasoning herein is consistent with theirs, see the description of their example 5.) Our consideration of the sticky-information model will also imply, under a passive monetary policy, that the long-run price level is unchanged and hence that the fiscal multiplier is less than one.

⁷The specific values for the parameters are not qualitatively important.

Figure 2: Government Expenditure Multiplier (Spending of Duration T)



sive monetary policy). This result has been widely discussed and even influential in policy deliberations – that is, the potential power of fiscal expansion given a passive monetary policy has become a benchmark in some circles.

The sticky-information model has a fiscal multiplier that *decreases with horizon* and is bounded above by 1. This has a strong implication: In the sticky information case, fiscal expansion is necessarily welfare-reducing, as the increase in government expenditure crowds out private consumption and results in more hours worked; since welfare is increasing in consumption and decreasing in hours worked, fiscal expansion

must reduce welfare. In contrast, fiscal expansion can increase welfare in the sticky-price case, as higher consumption can offset any drag on welfare from hours worked (Christiano, Eichenbaum, and Rebelo [2011] and Woodford [2011]). We will revisit this prediction, and its implications for policy design, in the penultimate section.

5 Two Other Paradoxes

By now it is clear that the sticky-price case emphasized in much New-Keynesian research has implications not shared by other models of price adjustment. This dissimilarity extends to recent work on the “paradox of toil” and the “paradox of volatility”. Specifically, previous research has shown the following implications of the sticky-price framework.⁸

- At the zero lower bound or under passive monetary policy, adjustments in the short-term nominal interest rate do not crowd-in demand in response to the disinflationary consequences of positive aggregate supply shocks; as a result, positive supply shocks (e.g., an increase in productivity) can lower demand/production in the short run, by potentially very large amounts.
- Under a passive monetary policy, increased flexibility of prices – that is, a greater responsiveness of price adjustment to shifts in nominal marginal cost – may raise volatility in response to shocks, rather than moving the response to shocks toward the (typically moderate) neoclassical benchmark response that would occur under price flexibility.

We now compare the sticky-price and sticky-information models along these dimensions. It is straightforward to derive the following proposition:

Proposition 5: *Under a passive monetary policy, the sticky-price model implies that an improvement in productivity/technology for period t to period $t+T$ leads to a*

⁸The paradox of toil is emphasized in Eggertson [2010], Eggertson [2011], Eggertson [2012], and Wieland [2013]; the paradox of volatility is emphasized in Werning [2012], Eggertson and Krugman [2011], Christiano and Eichenbaum [2012] and Bhattarai, Eggertson, and Schoenle [2012].

*decline in output over period t to $t+T-1$; the magnitude of this decline is larger for greater degrees of price flexibility. In the sticky-information model, an improvement in productivity/technology for period t to period $t+T$ leads to an increase in output over the entire period t to $t+T$; the magnitude of this increase is larger for greater degrees of price/information flexibility.*⁹

Proof: Consider first the case of perfect flexibility in nominal prices (no sticky prices or information). In that case, output increases by the improvement in productivity (z) in each period from t to $t+T$, through the definition of the natural rate. At the other extreme, consider perfectly rigid nominal prices: In this case, output remains unchanged at baseline in all periods, as the passive monetary policy and rigidity of nominal prices imply no movement along the IS curve, equation 7. Now turn to the sticky-price case. The argument will follow the same backward induction logic as before and is laid out in table 3. In periods after $t+T$, output, inflation, and nominal interest rates equal 0. As a result, output equals zero in period $t+T$ from 7 (i.e., there is no crowding in of demand from movements in real interest rates). Because the natural rate of output equals the level of productivity but output does not respond in period $t+T$, inflation falls to $-\eta\alpha z$. Iterating backward, the disinflation in period $t+T$ pushes output below zero (to $-\sigma\eta\alpha z$) in period $t+T-1$, with further disinflationary consequences. These effects increase further in period $t+T-2$. Moreover, increased price flexibility (a larger η) exacerbates the decline in output. Now turn to the sticky-information model. For the same reasons as before, output, nominal interest rates, and the price level return to zero after period $t+T$. With government expenditure at baseline (zero), equation 13 simplifies to

$$p_{t+k} = \frac{(1 - (1 - \lambda)^{k+1})}{(1 - \lambda)^{k+1}} \alpha(y_{t+k} - z) \quad (19)$$

⁹While proposition 5 is written for a finite horizon T , it is trivial to show that the results are the same for an AR(1) process for technology in which the improvement in technology only asymptotes to 0.

Table 3: Output and Inflation Following Productivity Expansion Under Sticky Prices

Period (j)	y_j	$p_j - p_{j-1}$
t+T+1	0	0
t+T	0	$-\eta\alpha z$
t+T-1	$-\sigma\eta\alpha z$	$-\eta\alpha(1 + \sigma\eta\alpha)z$

1. Assumes that productivity increases to z from period t to $t+T$ and returns to zero (baseline) thereafter. Monetary policy is held at baseline through period T and follows 12 thereafter.

for $0 \leq k \leq T$. Using 19, 15, $p_{t+\infty} = 0$ and $r_{t+j} = 0$ for all periods prior to period $t+T$ yields

$$y_{t+j} = \frac{(1 - (1 - \lambda)^{j+1})\alpha\sigma}{(1 - \lambda)^{j+1} + (1 - (1 - \lambda)^{j+1})\alpha\sigma} z. \quad (20)$$

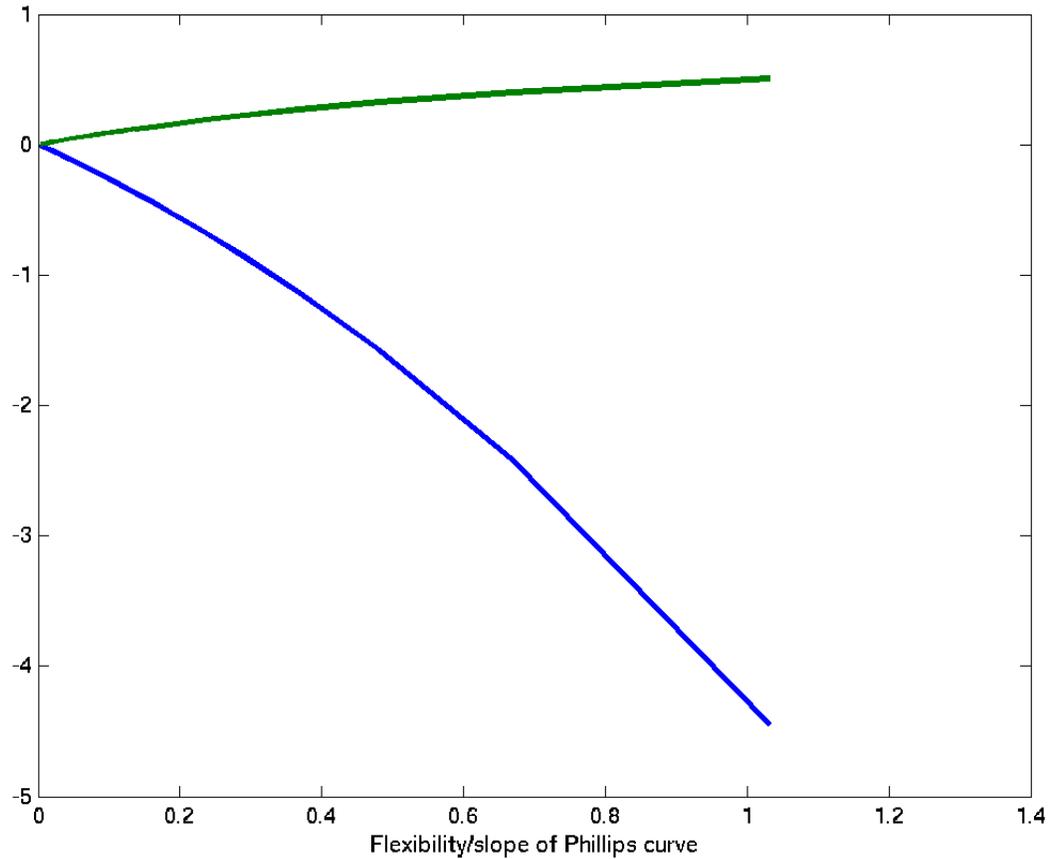
The response of output to the increase in productivity is strictly positive. Moreover, it approaches one as information becomes more flexible (as λ approaches one). *Q.E.D.*

A few remarks are in order. First, recent research has emphasized that the response under sticky-prices to an improvement in technology can be perverse when nominal interest rates do not adjust to crowd-in demand (e.g., Eggertson [2010], Eggertson [2011], Eggertson [2012], and Wieland [2013]). However, this result reflects forces that have been understood for some time. In particular, Galí [1999] noted how the behavior of monetary policy was important in generating the positive response of output to an improvement in technology, and highlighted how the data suggest that monetary policy had not crowded-in output following technology shocks to a sufficient degree (so that, for example, labor input decline following an improvement in technology). Boivin, Kiley, and Mishkin [2010] emphasized how monetary policymakers in the United States appeared to crowd-in demand following a technology shock more strongly after the early 1980s. Of course, the result in Boivin, Kiley, and Mishkin [2010] relies on an *active* monetary policy regime in which nominal interest

rates respond to inflation and output.

Of particular interest for our analysis is how the different implications of the sticky-price and sticky-information models for the long-run price level are important in generating the paradoxes of toil and volatility highlighted in recent research – much as in the role of these factors in generating the “implausible” policy multipliers recently emphasized and explored in the previous sections. We will return to long-run price-level behavior in the penultimate section.

Figure 3: Response of Output to Improvement in Productivity (Period t)



Finally, we present an illustration of proposition 5 in figure 3. The figure presents the the response of output in period t to an improvement in productivity in period t of 1 percent which declines linearly to baseline (0) over three quarters (T equals 3). The degree of price/information flexibility is increasing along the x-axis, which is reported in units of the slope of the Phillips curve for each model for comparability. As can be seen, the sticky-information response moves to the flexible-price benchmark of 1 as flexibility increases; in contrast, increased flexibility in the sticky-price model leads to a collapse in output.

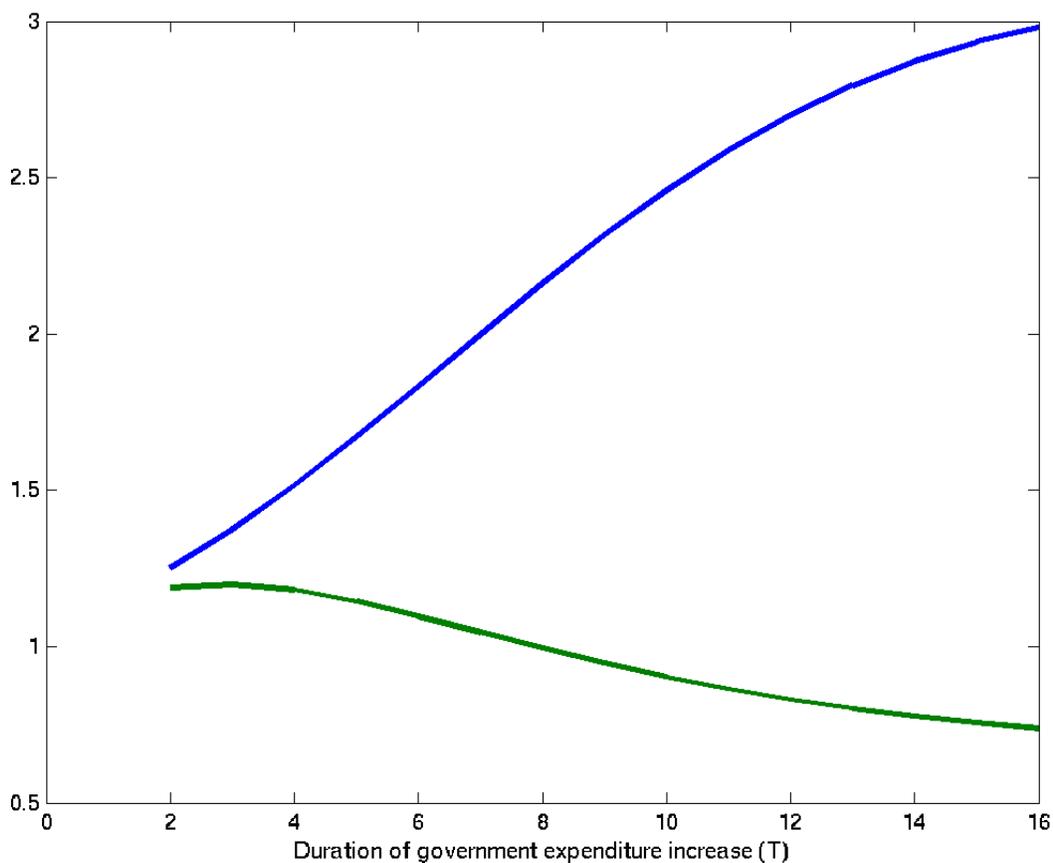
6 How Useful Is the Simple Framework?

The results in the simple model are stark: The sticky-price model implies large policy multipliers for actions of long duration/horizon (fiscal and forward-guidance), whereas the sticky-information framework implies multipliers of a much smaller size for long horizon or long duration actions – where the contrast is particularly notable in the case of fiscal multipliers, as the multiplier under sticky information approaches the neoclassical benchmark (below one) as the duration of the expansion in expenditure increases.

The relevance of these results could be called into question given the simple model. However, all of these key predictions of the model are at least somewhat robust to enlargement to “big” models. Indeed, this result is essentially immediate in larger models where the additional detail largely consists of providing the “micro-foundations” for the IS-curve and Phillips curve used herein: For example, the models of Mankiw and Reis [2007] and Reis [2009] are largely of this type, and the results regarding the sticky-information model carry over to their specifications.

Larger models require somewhat more examination, although the core message carries to such frameworks as well. For example, Lasen and Svensson [2011] and Del Negro, Giannoni, and Patterson [2012] have already confirmed that the sticky-price

Figure 4: Government Expenditure Multiplier In Larger DSGE Model (Spending of Duration T)



model, embedded in a large dynamic-stochastic-general-equilibrium (DSGE) model, implies a large and increasing multiplier from monetary forward guidance – and indeed view this prediction of the core framework as implausible. On the fiscal front, Christiano, Eichenbaum, and Rebelo [2011] and Erceg and Linde [2010] have similarly demonstrated that the large (and exponentially increasing in duration) fiscal multiplier also arises in larger DSGE models under the sticky-price assumption. Previous work has not explored the possibility that sticky-information could overturn these results, and our analysis makes clear the importance of considering this alternative.

A thorough consideration of the sticky-information framework in a much larger DSGE model, including estimation, is beyond the scope of this analysis. However, it is straightforward to change the wage and price setting processes in the model of Smets and Wouters [2007] to the sticky-information specification. Figure 4 presents the government expenditure multiplier for the model of Smets and Wouters [2007] under their specification and with the sticky-information assumption for prices and wages.¹⁰ In this larger model, the multiplier under sticky-information is not bounded above by one, and indeed lies slightly above 1 for a one-period increase in government expenditure (and close to the value under sticky prices). Moreover, there is some intrinsic inertia in the model of Smets and Wouters [2007], stemming from capital accumulation, investment adjustment costs, and habit persistence. As a result, the fiscal multiplier, even under sticky information, is somewhat larger for expansions in government expenditure of modest duration (e.g., 4 quarters) than it is for one-period expansions, in contrast to the simple model above. However, the role of intrinsic inertia is quickly overshadowed by the “classical” tendencies of the sticky-information model, and the fiscal multiplier declines quickly with the duration of the fiscal expansion once duration exceeds a few quarters, much as in the simple model. In contrast, the power of fiscal expansion increases rapidly with the duration of the fiscal expansion (and passive monetary accommodation) in the sticky-price model.¹¹

Overall, the simple model delivers the essential message: The core assumption of many policy models – sticky prices – creates very large fiscal and forward-guidance multipliers. Previous literature has, in some cases, embraced such large multipliers as possible justifications for policy actions and, in other cases, suggested these result are implausible. Our consideration of the sticky-information alternative shows that these large multipliers are not a core prediction of New-Keynesian models, but rather a peculiarity of the sticky-price model.

¹⁰The fraction of price and wages setters updating their information sets in each quarter is set to 0.25. Otherwise, parameters equal those in Smets and Wouters [2007].

¹¹The same basic tendencies arise in response to forward guidance in the model of Smets and Wouters [2007], as emphasized in Del Negro, Giannoni, and Patterson [2012].

7 Strategies to Enhance the Size of the Policy Multiplier in Sticky-Information Models

Our analysis has shown that, under a passive monetary policy (that is, a fixed path for the nominal interest rate over some horizon T , followed by reversion to a policy rule after T periods which does not introduce additional state variables into the model solution, such as equation 12 in both the sticky-price and sticky-information frameworks), multipliers are much smaller – for monetary or fiscal actions – under sticky information than under sticky prices. Indeed, fiscal actions tend toward their “classical” predictions under sticky information.

This result reflects the fact that the long-run price level ($p_{t+\infty}$) does not adjust to monetary or fiscal actions under the sticky-information model if monetary policy is passive. As a result, the impact of any shift in government expenditure or adjustment in the nominal interest rate through forward guidance is limited, as is immediately apparent from recasting the IS curve as in 15, repeated here

$$y_t - g_t = -\sigma E_t \left[\sum_{j=0}^{\infty} [r_{t+j}] - (p_{t+\infty} - p_t) \right]. \quad (21)$$

The lack of a long-run shift in the price level limits movements in the real (long-term) interest rate. In contrast, the sticky-price model implies that $p_{t+\infty}$ rises, and to an increasing degree, with the horizon/duration of forward guidance/fiscal expansion – thereby providing stimulus through the IS curve..

Obviously, the predictions of these alternative New-Keynesian specifications are not similar along this dimension. Given the lack of dispositive evidence regarding which specification is correct (e.g., Kiley [2007] and Mankiw and Reis [2010]), this dissimilarity thus raises the question of how to design an effective monetary/ fiscal action in either framework. Fortunately, the design of an effective monetary/ fiscal action in both sticky-price and sticky-information models is simple: Monetary policy

can commit to following an active stance in which $p_{t+\infty}$ rises by a set amount. Under this condition, the monetary multiplier will lie close to the sum of this set amount and the change in the nominal interest rate, multiplied by the intertemporal elasticity of substitution, and fiscal multiplier will lie above one by an amount close to the degree to which the monetary authority announces an intention to let the price level rise (again multiplied by the intertemporal elasticity of substitution).¹²

At this point, many readers may recognize that this method for raising the policy multiplier is simply that of Krugman [1998] or Eggertson and Woodford [2003] – monetary policy at the zero lower bound should aim to boost the long-run price level, perhaps through a strategy akin to nominal income targeting. Indeed, a permanent monetary expansion (as suggested in Krugman [1998]) is *not passive* in either model, and would imply a permanent rise in the price level (assuming a stable money-demand function with normal properties).

In our case, we have added two critical insights. First, much of the recent discussion by monetary policymakers has been regarding forward guidance for the nominal interest rate, not the price level. Under the sticky-price specification, forward guidance regarding the nominal interest rate, and passivity with respect to the price level, is not harmful, as the long-run price level changes with nominal-interest rate guidance in this model; this result has clearly influenced policymakers, who have presented analyses of forward guidance using DSGE models (e.g., Campbell et al [2012]) in which the Phillips curve takes the sticky-price form. However, passivity regarding the price level substantially mitigates the power of forward guidance in the sticky information model, and hence robustness with respect to the model of price dynamics requires that forward guidance include explicit price-level (or money supply) guidance, a practice that policymakers have not yet adopted.

Second, the New-Keynesian literature on fiscal multipliers has similarly empha-

¹²The word “close” is important in each sentence because some of the rise in the price level will occur in period t , mitigating the stimulus (see 21); indeed, in the classical limit, the price level simply jumps to the higher level, and there is no amplification of the fiscal multiplier (and the monetary multiplier is zero).

sized the role of a passive nominal interest rate, and has found large multipliers using sticky-price specifications because such models imply large movements in the long-run price level in response to fiscal shifts (from Christiano, Eichenbaum, and Rebelo [2011] to Erceg and Linde [2010]). Again, the lesson from this work – that interest-rate passivity can generate large multipliers – is not robust to alternative models of price dynamics such as sticky information. In order to robustly deliver a large fiscal multiplier, active fiscal-monetary coordination, involving a concerted effort to seek a higher price level, is required.

8 Conclusion

We reconsidered a host of recent issues regarding the properties of the New-Keynesian model at the zero lower bound (or, more appropriately, under passive monetary policy).

We have demonstrated that key predictions regarding the power of forward guidance and the size of the fiscal multiplier depend on the model of price dynamics that is assumed. While a sticky-price specification yields large effects on economic activity from forward guidance at far horizons or fiscal expansions of long duration, the sticky-information specification implies more muted multipliers under these conditions. For example, the government expenditure multiplier is bounded above, rather than below, by one under sticky-information price dynamics. In broad terms, these results solve “puzzles” highlighted by previous researchers such as Levin et al [2010], Lasen and Svensson [2011], Carlstrom, Fuerst, and Paustian [2012b], Carlstrom, Fuerst, and Paustian [2012b], Carlstrom, Fuerst, and Paustian [2012a], and Del Negro, Giannoni, and Patterson [2012].

Similar discrepancies arise when considering the paradoxes of toil and volatility discussed in Eggertson [2010], Eggertson [2011], Eggertson [2012], Wieland [2013], Werning [2012], Eggertson and Krugman [2011], and Bhattarai, Eggertson, and

Schoenle [2012]. In particular, the sticky-information model implies that improvements in productivity raise output even when monetary policy is passive, and that greater price flexibility moves the response of the economy toward the flexible-price benchmark. In contrast, the sticky-price model implies that output falls – potentially dramatically – in response to an improvement in productivity when monetary policy is passive, and that these peculiarities are exacerbated, rather than ameliorated, as price flexibility is increased.

One clear implication of our analysis is that the related literature should consider a broader set of models of price dynamics when considering policy questions. The overwhelming majority of macroeconomic models used at central banks around the world rely on a form of the New-Keynesian Phillips curve (e.g., the models in Coenen et al [2012]). The link between current and expected future inflation in this framework is central to the predictions in the literature on the power of forward guidance regarding short term interest rates and the size of the fiscal multiplier. However, plausible alternatives to the sticky-price framework, such as the sticky-information model, do not share the link between current inflation and expected future inflation – indeed, the absence of this link is viewed as a feature of such alternatives, as it contributes to the fact that such models make predictions deemed plausible to some, such as the idea that an anticipated disinflation leads to an economic contraction rather than a boom (e.g., Mankiw and Reis [2002]).¹³ Indeed, the different dynamics of expectations leading to the costs of anticipated disinflations are closely related to the distinctions found herein regarding forward guidance, fiscal multipliers, and the paradoxes of toil and volatility across the sticky-price and sticky-information frameworks.

Our results suggest that the role of “active” monetary policy strategies – that is, strategies focusing on the economic conditions that will govern the course of short-term interest rates – may deserve more consideration, as the recent reliance on “passive” strategies involving guidance for the path of short-term interest rates can yield

¹³With regard to the role of expected inflation, the differences across sticky prices and sticky information are reminiscent of those across Taylor [1980] and Fischer [1977].

important differences in equilibrium outcomes depending upon the underlying nature of price dynamics. Along this dimension, our results simply build on insights from Krugman [1998] and Eggertson and Woodford [2003] – making clear that the importance of affecting price-level expectations is not dependent on the form on “nominal rigidity” (a result that should also be clear from a reading of those earlier contributions) and indeed may be even more important under sticky information than under sticky prices.

And finally, a note on policy relevance: As we already highlighted, policy models overwhelmingly use a sticky-price specification for price dynamics; this approach has influenced discussions of fiscal policy¹⁴ and of the role of forward guidance.¹⁵ Our illustration that key results can be dramatically different under seeming small differences in assumptions (e.g., the upper bound of the fiscal multiplier under sticky information is the lower bound under sticky prices) suggests that strongly held views may be difficult to justify given our uncertain understanding of key mechanisms.

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¹⁴For example, Romer and Bernstein [2009]. Also, Blanchard and Leigh [2013] emphasize work by Christiano, Eichenbaum, and Rebelo [2011], Coenen et al [2012], and Woodford [2011]

¹⁵For example, see Lasen and Svensson [2011].

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