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Hysteresis and Fiscal Policy

Philipp Engler and Juha Tervala*

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Abstract

Empirical studies support the hysteresis hypothesis that recessions have a permanent effect on the level of output. We analyze the implications of hysteresis for fiscal policy in a DSGE model. We assume a simple learning-by-doing mechanism where demand-driven changes in employment can affect the level of productivity permanently, leading to hysteresis in output. We show that the fiscal output multiplier is much larger in the presence of hysteresis and that the welfare multiplier of fiscal policy–the consumption equivalent change in welfare for one dollar change in public spending–is positive (negative) in the presence (absence) of hysteresis. The main benefit of accommodative fiscal policy in the presence of hysteresis is to diminish the damage of a recession to the long-term level of productivity and, thus, output.

Keywords: Fiscal policy, hysteresis, learning by doing, welfare

JEL classification: E62, F41, F44

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1 Introduction

The hysteresis hypothesis that recessions have a permanent effect on the level of output is supported by several empirical studies. Ball (2014) estimates the long-term effects of the global recession of 2008-2009 on potential output in 23 countries. He finds that most countries suffered from a hysteresis effect, as deviations of actual output from pre-recession trends lowered potential output substantially. Blanchard et al. (2015) analyze the effects of recessions over the past 50 years in 23 countries and find that roughly two-thirds of the countries suffered from hysteresis. After recessions, actual output remains low relative to pre-recession trends, even after the economy has recovered. Fatas and Summers (2016a) find empirical support for the presence of strong hysteresis effects of fiscal policy. Fiscal consolidations after the Great Recession have not only caused a temporary loss in output but also permanent damage to potential output.

Summers (2015) criticizes dynamic stochastic general equilibrium (DSGE) models and New Keynesian macroeconomics because they ignore hysteresis. He points out that in New Keynesian models, stabilization policy cannot affect the average level of output over time; it can affect only the amplitude of economic fluctuations. He argues that stabilization policy is not as essential if it cannot affect the average level of output over time. According to him, the study of stabilization policy without hysteresis "essentially abstracts away from most of what is important in macroeconomics." The Chair of the Federal Reserve System Janet Yellen (2016) notes that "hysteresis effects–and the possibility they might be reversed–could have important implications for the conduct of monetary and fiscal policy."

Motivated by the empirical results, the criticisms of Summers (2015), and the observations of Yellen (2016), we analyze the consequences of hysteresis for fiscal policy in a DSGE model.[1] Traditionally, modeling hysteresis relies on the labor market. Blanchard and Summers (1986) argue that a rise in cyclical unemployment increases long-term unemployment or unemployed workers may experience a fall in their skills, leading to a persistent or even a permanent fall in employment and output. Fatas and Summers (2016b) argue that one should think about a broader concept of hysteresis that allows a temporary downturn to affect productivity and capital accumulation dynamics, thereby creating a much stronger connection between recessions and long-term output.

Reifschneider et al. (2015) find that the Great Recession caused notable

[1] Gali (2015), Kienzler and Schmid (2014), and Reifschneider at al. (2015), for instance, study the implications of hysteresis for monetary policy.

damage to the U.S. economy's supply side, with weak demand causing a significant portion of it. Their estimates suggest that the largest contribution to the recent (2008-2013) slowdown in potential output growth was from growth in labor productivity, reflecting a decline in capital accumulation and slower growth in total factor productivity (TFP). Trend growth in labor input has also slowed, reflecting less rapid population growth and a modest increase in the natural rate of unemployment. However, the latter accounts for only 13% of the cumulative post-Great Recession shortfall in potential output, while the rest is explained by the damage of the Great Recession to productivity.

Anzoategui et al. (2016) study the view that the productivity slowdown after the Great Recession was an endogenous response to a reduction in demand. They develop a New Keynesian DSGE model with endogenous TFP that allows for the costly development and adoption of new technologies. They find that, in the recent productivity slowdown, TFP declined by roughly 5 percentage points relative to the trend. The endogenous component explains 4.75 percentage points of the slowdown and most of the 7 percentage points decline in labor productivity.

The findings of Anzoategui et al. (2016) suggest that endogenous changes in TFP caused by a fall in demand is the most important factor of hysteresis. To model endogenous changes in TFP, we add a very simple learning-by-doing mechanism into the production function, following the formulation of Tervala (2013), based on the idea of Chang et al. (2002).[2] They assume skill accumulation through past work experience, such that the current labor supply affects future productivity. We assume, unlike Chang et al. (2002) and Tervala (2013), that fluctuations in employment can affect TFP permanently. We use a two-country model in order to have an external and entirely demand-driven source for a recession and assume that a foreign time preference shock drives the domestic economy into a recession.

A common argument against accommodative fiscal policy is that (short-term) fiscal output multipliers are low. Our first main finding is that the introduction of hysteresis raises the net present value fiscal multiplier (NVPM), the sum of output over a certain time horizon discounted at the steady state interest rate divided by public spending calculated in the same way, from 0.5 to 3 under the benchmark parameterization. The main benefit of fiscal policy in the presence of hysteresis is to limit, by reducing the depth of a recession, the damage of a recession to the long-term level of productivity and,

[2] Chang et al. (2002) shows the learning-by-doing mechanism improves the DSGE model's ability to fit the dynamics of aggregate output and hours. Tervala (2013) examines the consequences of persistent changes in productivity on the international transmission of monetary policy.

thus, output. Consequently the NVPM is very large, even if the short-term (cumulative) output multiplier is somewhat below one.

The most directly related paper is Rendahl (2016), who analyzes the efficacy of fiscal policy in a liquidity trap in a model with persistent – hysteresis-like – movements in the unemployment rate. In his model, fiscal expansion lowers the unemployment rate both in the present and in the future. Consequently, the influence of demand on aggregate supply increases the fiscal multiplier, which he finds to be in the range of 0.8 to 1.8. Our results are in line with Rendahl (2016); however, the influence of demand on aggregate supply through productivity seems to increase the efficacy of fiscal policy much more. Moreover, our results do not rely on the liquidity trap environment.

Another argument against accommodative fiscal policy is to say that it does not necessarily increase welfare, even when fiscal output multipliers are large (see e.g. Bilbiie et al. 2014 and Mankiw and Weinzierl 2011). Motivated by this, we investigate the welfare multiplier of fiscal policy, defined as the consumption equivalent change in welfare for one dollar change in public spending. Our second main finding is that in the absence of hysteresis, the welfare multiplier of fiscal policy is negative; hysteresis, however, makes it positive. The welfare multiplier with hysteresis is 1.1, even when public spending does not provide direct utility to households. So one dollar spent by the government raises domestic welfare by the equivalent of 1.1 dollars of private consumption. The reason for the positive welfare multiplier is that countercyclical fiscal policy diminishes the damage of a recession to the long-term level of private consumption. When the weight of public consumption relative to private consumption is 0.4, the welfare multiplier is 1.5.

Rendahl (2016) finds that the welfare multiplier is at most 0.7, when public spending is pure waste. He also finds that if the duration of a rise in public spending is short, relative to the duration of the liquidity trap, welfare multipliers turn negative. In our case, where the influence of demand on aggregate supply is modelled through productivity, welfare multipliers are positive. In addition, welfare multipliers are the highest for short-lived fiscal expansions, because they limit–by reducing the depth of a recession at the right time–the damage to productivity the most effectively.

The rest of the paper is organized as follows. Section 2 introduces the model. Section 3 discusses the parameterization of the model. Section 4 studies the output and welfare multipliers of fiscal policy. Section 5 concludes and discusses the policy implications of hysteresis.

2 Model

We use a New Keynesian open-economy model with two countries: home and foreign. The size of the world population is normalized to 1 and a continuum of firms and households are indexed by $z \in [0,1]$. A fraction n $(1-n)$ of them are domestic (foreign).

2.1 Households

2.1.1 Preferences

All households have identical preferences. The intertemporal utility function of the representative domestic household is (if equations are symmetric across countries we present only domestic equations)

$$U_t(z) = E_t \sum_{s=t}^{\infty} \beta^{s-t} \epsilon_s^{TP} \left[\log C_s - \frac{(\ell_s(z))^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}} + \nu \log G_s \right], \tag{1}$$

where E is the expectation operator, β is the discount factor, ϵ_t^{TP} is a time preference shock that affects the intertemporal substitution of households, C_t is a private consumption index, $\ell_t(z)$ is the labor supply, φ is the Frisch elasticity of labor supply, G_t is a public consumption index, and ν is the weight of public consumption relative to private consumption. The private consumption index is given by

$$C_t = \left[(\alpha n)^{\frac{1}{\rho}} (C_t^h)^{\frac{\rho-1}{\rho}} + (1-\alpha n)^{\frac{1}{\rho}} (C_t^f)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}, \tag{2}$$

where C_t^h and C_t^f, respectively, are indexes of domestic and foreign goods, αn $(0 < \alpha n < 1)$ is the share of domestic goods in the consumption basket ($\alpha > 1$ captures the degree of home bias in consumption) and $\rho > 0$ measures the elasticity of substitution between domestic and foreign goods (the cross-country substitutability, for short).[3] The public consumption indexes are identical to the private consumption ones.

The consumption indexes of the different types of domestic C_t^h and foreign goods C_t^f are given by

$$C_t^h = \left[n^{-\frac{1}{\theta}} \int_0^n (c_t^h(z))^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}}, \quad C_t^f = \left[(1-n)^{-\frac{1}{\theta}} \int_n^1 (c_t^f(z))^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}},$$

[3] The foreign consumption index is $C_t^* = \left[(\alpha n^*)^{\frac{1}{\rho}} (C_t^{*h})^{\frac{\rho-1}{\rho}} + (1-\alpha n)^{\frac{1}{\rho}} (C_t^{*f})^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}$, asterisks show consumption by the foreign household. Home bias in consumption requires $\alpha^* < 1$.

where $c_t^h(z)$ ($c_t^f(z)$) is the consumption of differentiated domestic (foreign) good z by the domestic household and $\theta > 1$ is the elasticity of substitution between goods produced in the same country (the within-country substitutability, for short).

The private demand functions for the differentiated domestic and foreign goods by domestic and foreign households are (the demand functions by governments are defined in an analogous way)

$$c_t^h(z) = \left[\frac{p_t^h(z)}{P_t^h}\right]^{-\theta} \left[\frac{P_t^h}{P_t}\right]^{-\rho} \alpha C_t,$$

$$c_t^f(z) = \left[\frac{p_t^f(z)}{P_t^f}\right]^{-\theta} \left[\frac{P_t^f}{P_t}\right]^{-\rho} \left[\frac{1-\alpha n}{1-n}\right] C_t,$$

$$c_t^{*h}(z) = \left[\frac{p_t^{*h}(z)}{P_t^{*h}}\right]^{-\theta} \left[\frac{P_t^{*h}}{P_t^*}\right]^{-\rho} \alpha^* C_t^*,$$

$$c_t^{*f}(z) = \left[\frac{p_t^{*f}(z)}{P_t^{*f}}\right]^{-\theta} \left[\frac{P_t^{*f}}{P_t^*}\right]^{-\rho} \left[\frac{1-\alpha^* n}{1-n}\right] C_t^*.$$

$p_t^h(z)$ and $p_t^f(z)$ show, respectively, the domestic currency price of domestic and foreign goods. P_t^h and P_t^f are the price indexes that correspond to domestic and foreign aggregate consumption baskets C_t^h and C_t^f. All price indexes are expressed in local currency terms, and foreign currency price indexes are denoted with an asterisk. For instance, the foreign currency price of a domestic good is p_t^{*h}.

The domestic price indexes are as follows:

$$P_t^h = \left[n^{-1}\int_0^n p_t^h(z)^{1-\theta}\,dz\right]^{\frac{1}{1-\theta}}, \quad P_t^f = \left[(1-n)^{-1}\int_n^1 p_t^f(z)^{1-\theta}\,dz\right]^{\frac{1}{1-\theta}}$$

$$P_t = \left[\alpha n (P_t^h)^{1-\rho} + (1-\alpha n)(P_t^f)^{1-\rho}\right]^{\frac{1}{1-\rho}}. \tag{3}$$

2.1.2 Budget Constraint

The budget constraint of the domestic household, in nominal terms, is given by

$$D_t = (1+i_t)D_{t-1} + w_t\ell_t - P_tC_t + \pi_t - P_tT_t. \tag{4}$$

D_t is nominal bonds, which pays one domestic currency in period $t+1$, held at the beginning of period t, i_t is the nominal interest rate on bonds between

$t-1$ and t, w_t is the nominal wage, π_t is the nominal profits/dividends of domestic firms, and T_t is lump-sum taxes.

The domestic bond is the only internationally traded asset. The global asset market-clearing condition for domestic bonds is $nD_t + (1-n)D_t^* = 0$. The foreign bond (F^*) that denominated in the foreign currency can be held only by the foreign household. Because the foreign country has only the representative household, the net supply of them is zero.

The budget constraint of the foreign household is

$$\frac{D_t^*}{S_t} + F_t^* = (1+i_{t-1})\frac{D_{t-1}^*}{S_t} + (1+i_t^*)F_{t-1}^* + w_t^*\ell_t^* - P_t^*C_t^* + \pi_t^* - P_t^*T_t^*. \quad (5)$$

As in Schmitt-Grohe and Uribe (2003) and Bergin (2006), we assume a risk premium for the uncovered interest rate parity (UIP) that depends on the country's net external debt level. The risk premium forces the debt to converge back to zero in the long term. The interest parity condition with a risk premium is given by

$$(1+i_t) = (1+i_t^*)\frac{S_{t+1}}{S_t} + \psi(\exp(D_t) - 1), \quad (6)$$

where $\psi(\exp(D_t) - 1)$ is the risk premium.

The household's optimality conditions are:

$$\beta(1+i_t)E_t\left(\frac{\epsilon_{t+1}^{TP}P_tC_t}{\epsilon_t^{TP}P_{t+1}C_{t+1}}\right) = 1, \quad (7)$$

$$\ell_t(z) = \left(\frac{w_t}{C_tP_t}\right)^{\nu}. \quad (8)$$

Equation (7) is the Euler equation for optimal consumption. Equation (8) governs the labor supply.

2.2 Firms

2.2.1 Productivity and Profits

Martin et al. (2015) show that severe recessions have sizable effects on the level of output relative to pre-recession trend and that even normal recessions have permanent, but smaller, effects. They also shows that after normal recessions, the employment rate and total hours worked return to their pre-recession trends, whereas labor productivity (they do not analyze TFP) shows a highly persistent or even permanent fall. It does not show any signs, 6 years after the start of the recession, that it would start to converge back to its pre-recession trend. In addition, Anzoategui et al. (2016, 29) find, as mentioned in the introduction, that endogenous changes in TFP explain most of the drop in labor productivity during and after the Great Recession. Motivated by these findings, we focus exclusively on hysteresis caused by endogenous changes in TFP and–in order to keep the model as simple as possible–ignore capital deepening and hysteresis in employment. Our way of modelling the influence of demand on aggregate supply only through TFP yields a realistic extent of hysteresis, as shown later in this paper.

All firms produce a differentiated good. The production function is given by

$$y_t(z) = a_t(z)\ell_t(z), \tag{9}$$

where $y_t(z)$ is the total output of firm z, $a_t(z)$ is the level of TFP and $\ell_t(z)$ is the labor input used by the firm. The production function without capital and constant returns to labor imply that labor productivity is simply the level of TFP $(y_t(z)/\ell_t(z) = a_t(z)\ell_t(z)/\ell_t = a_t(z))$.

We use a very simple way of modeling hysteresis that can be easily incorporated into DSGE models. Chang et al. (2002) assume a simple skill accumulation mechanism through learning by doing, in which the skill level accumulates over time depending on past employment and that the skill level raises the effective unit of labor supplied by the household. Following this idea, Tervala (2013) assumes that the level of productivity accumulates over time according to past employment. As in Tervala (2013), the level of productivity evolves according to the following log-linear equation:

$$\hat{a}_t(z) = \phi\hat{a}_{t-1}(z) + \mu\hat{\ell}_{t-1}(z), \tag{10}$$

where $0 \leq \phi \leq 1$ and μ are parameters. Percentage changes from the initial steady state are denoted by hats (for instance, $\hat{a}_t = da_t/a_0$, where the subscript zero denotes the initial steady state). Equation (10) highlights that a change in the current labor supply changes the level of productivity in the next period, with an elasticity of μ. The change in the level of productivity may not be permanent, because the level of productivity depreciates over time at the rate of $1 - \phi$. If $\phi = 1$, then the level of productivity shifts permanently when employment changes. In this case, temporary shocks have a permanent effect on the equilibrium level of output, meeting the requirement for hysteresis. If $\phi < 1$, then temporary shocks have a persistent, but not permanent, effect on the level of productivity and output.

Reifschneider et al. (2015) use a quite similar way of modelling hysteresis, as they assume that TFP today depends on its value in the previous period and the difference between the natural rate of unemployment and the actual rate of unemployment in the previous period.

Figure 1 on page 31, which shows U.S. TFP and GDP in 2000-2015, indicates some support for our view. TFP fell during the Great Recession. In addition, the U.S. GDP and TFP do not show signs that they would have started to converge back to their pre-recession trends.

The domestic firm maximizes profits

$$\pi_t(z) = p_t^h(z)\, y_t^d(z) - w_t \ell_t(z), \tag{11}$$

taking account the production function (9) and the demand curve for its products

$$y_t^d(z) = \left[\frac{p_t^h(z)}{P_t^h}\right]^{-\theta} \left[\frac{P_t^h}{P_t}\right]^{-\rho} \alpha n (C_t + G_{t)}) + \left[\frac{p_t^h(z)}{S_t P_t^{*h}}\right]^{-\theta} \left[\frac{S_t P_t^{*h}}{S_t P_t^*}\right]^{-\rho} (1-n)\alpha^*(C_t^* + G_t^*).$$

2.2.2 Price Setting

Under flexible prices, the domestic firm maximizes profits, equation (11), with respect to $p_t^h(z)$. The solution is

$$p_t^h(z) = \frac{\theta}{\theta - 1} \frac{w_t}{a_t(z)}. \tag{12}$$

Following Calvo (1983), each firm may reset its price only with a probability of $1 - \gamma$ in any given period, independent of the time passed since the last price adjustment. The domestic firm seeks to maximize the discounted present value of expected real profits

$$\max_{p_t^h(z)} V_t(z) = E_t \sum_{s=t}^{\infty} \gamma^{s-t} Q_{t,s} \frac{\pi_s(z)}{P_s},$$

where $\zeta_{t,s}$ is a stochastic discount factor between periods t and s. The solution is

$$p_t^h(z) = \frac{\theta}{\theta - 1} \frac{E_t \sum_{s=t}^{\infty} \gamma^{s-t} \zeta_{t,s} Q_s \frac{w_s}{a_s(z)}}{E_t \sum_{s=t}^{\infty} \gamma^{s-t} \zeta_{t,s} Q_s}, \tag{13}$$

where

$$Q_s = \left(\frac{1}{P_s^h}\right)^{-\theta} \left(\frac{P_s^h}{P_s}\right)^{-\rho} \alpha n \left(\frac{C_s + G_s}{P_s}\right) + \left(\frac{1}{S_s P_s^{*h}}\right)^{-\theta} \left(\frac{P_s^h}{S_s P_s^*}\right)^{-\rho} (1-n)\alpha^* \left(\frac{C_s^* + G_s^*}{P_s}\right).$$

The log-linear version of equation (13) is a handy way to interpret it

$$\hat{p}_t^h(z) = \beta\gamma E_t \hat{p}_{t+1}^h(z) + (1 - \beta\gamma)(\hat{w}_t - \hat{a}_t(z)).$$

The change in the optimal price is the weighted average of the changes in current and future nominal marginal costs. A fall in the level of productivity raises the optimal price.

2.3 Fiscal and Monetary Policy

We assume the simplest possible way to model public spending: taxes are non-distortionary, as in Rendahl (2016), and the government budget is balanced. The government budget constraint, in per-capita and real terms, is expressed as

$$T_t = G_t. \tag{14}$$

We assume that public spending follows an exogenous AR (1) process

$$\hat{G}_t = \rho^G \hat{G}_{t-1} + \varepsilon_t^G,$$

where $\rho^G \in [0, 1]$ and ε_t^G is a white-noise process with zero mean that represents an unanticipated change in public spending.

Furman (2016) highlights that a decade ago the common view among economists was that discretionary fiscal policy is dominated by monetary policy as a stabilization tool. He adds that the new view of fiscal policy is that fiscal policy is a beneficial complement to monetary policy in case where low interest rates limit conventional monetary policy. DeLong and Summers (2012) find that even a small amount of hysteresis makes expansionary fiscal policy very beneficial and even likely to be self-financing at the zero lower bound. Our intention is to analyze whether hysteresis, which seems to also be relevant in normal recessions, renders accommodative fiscal policy beneficial also outside the zero lower bound. Therefore, the central bank does not face the zero lower bound.

The use of the standard Taylor rule implies that the model must be stationary. Hysteresis conforms to non-stationarity. Therefore, we assume a pure inflation targeting rule. The central bank adjusts the interest rate in response to the deviations of inflation from the zero inflation target, according to a log-linear interest rate rule with interest rate smoothing:

$$\hat{\imath}_t = (1 - \mu_1)\mu_2 \Delta \hat{P}_t + \mu_1 \hat{\imath}_{t-1},$$

where coefficients μ_1 and μ_2 are non-negative, and Δ is the first difference operator.

2.4 Symmetric Equilibrium

The consolidated budget constraint of the home economy is derived with equations (4), (11) and (14)[4]

$$D_t - (1 + i_t)D_{t-1} = p_t^h(z)\, y_t(z) - P_t C_t.$$

[4] The foreign equation is $\frac{n}{1-n}\frac{D_t}{S_t} - (1 + i_t)\frac{n}{1-n}\frac{D_{t-1}}{S_t} = p_t^{*f}(z)\, y_t^*(z) - P_t^* C_t^*$.

We log-linearize the model around a symmetric steady state where initial net foreign assets are zero. For simplicity, public spending is zero in the initial steady state and the initial level of productivity is normalized to one. Equations (8), (9) and (12) imply that the initial level of employment is given by

$$\ell_0(z) = y_0 = C_0 = \left(\frac{\theta - 1}{\theta}\right)^{\frac{1}{1+\frac{1}{\nu}}}.$$

Equilibrium is a sequence of variables that clear the goods and labor markets in both countries every period, while satisfying pricing rules and intertemporal budget constraints.

3 Parameter Values

Table 1 shows the baseline values for the parameters. Periods represent quarters and the discount factor (β) is set to 0.99. The relative size of the home country (n) is set to 0.5. The home bias parameter in domestic consumption (α) is set to 1.5. This implies that the import-to-GDP ratio ($1 - \alpha n$) is equal to 0.25. This matches with the average import-to-GDP ratio in the OECD countries (World Bank 2016). We assume that the ratio is identical in both countries, consequently $\alpha^*$is set to 0.5.

Peterman (2016) highlights that the Frisch elasticity of labor supply (φ) is a key parameter in macro models used to analyze fiscal policy. It is often set close to 1 in macro models. Chetty et al. (2013), however, claim that in macro models the Frisch elasticity on the intensive margin should be set to 0.5. We follow the advice and set the Frisch elasticity to 0.5. Our choice is influenced by the fact that with this parameter value the size of the cumulative fiscal multipliers are consistent with the empirical evidence.

The baseline value of the weight of public consumption to relative private consumption (ν) is set to 0.4, following Song et al. (2012). They argue that the parameter measures the efficiency in the provision of public goods. Since the welfare multipliers of fiscal policy are sensitive to changes in this parameter value, we vary it in the 0 to 1 range.

The within-country substitutability (θ) is set to 9, as in Gali (2015b). The cross-country substitutability (σ) is set to 1.5. This value is a widely used in international macroeconomics and is consistent with Dong (2012).

The risk premium parameter in UIP (ψ) is set to 0.004, based on Bergin (2006). We set the price rigidity parameter (γ) to 0.75, which is in line with the estimates of Rabanal and Tuesta (2010). Coefficients for the monetary policy rule are standard: the degree of interest smoothing (μ_1) is set to 0.79, based on Clarida et al. (2000) and the inflation coefficient is set to 1.5, based on Taylor (1993).

We assume that a time preference shock follows an AR (1) process

$$\hat{\epsilon}_t^{TP} = \rho^{TP}\hat{\epsilon}_{t-1} + \hat{\varepsilon}_t^{TP}.$$

The persistence of a time preference shock (ρ^{TP}) is set to 0.75, as in Bodenstein et al. (2009). We set the size of a foreign preference shock ($\hat{\varepsilon}^{*TP}$), which drives economies into recessions, to -5. This causes roughly a one percent fall in domestic output relative to the initial steady state.

Table 1: Baseline parameterization

Parameter	Description	Value	Reference
β	Discount factor	0.99	
n	Relative size of Home	0.5	
α	Home bias parameter	1.5	World Bank (2016)
α^*	Home bias parameter	0.5	World Bank (2016)
φ	Frisch elasticity	0.5	Chetty et al. (2013)
ν	Weight of public consumption	0.4	Song et al. (2012)
θ	Within-country substitutability	9	Gali (2015)
σ	Cross-country substitutability	1.5	Dong et al. (2012)
ψ	Risk premium parameter	0.004	Bergin (2006)
γ	Price rigidity	0.75	Rabanal/Tuesta (2010)
μ_1	Interest rate smoothing	0.79	Clarida et al. (2000)
μ_2	Inflation coefficient	1.5	Taylor (1993)
ρ^{TP}	Persistency of preference shock	0.75	Bodenstein et al. (2009)
$\hat{\varepsilon}^{*TP}$	Foreign time preference shock	-5	
ρ^G	Persistency of fiscal shock	0.75	Iwata (2013)
ϕ	Persistency of productivity	0.99	
μ	Elasticity of productivity	0.11	Chang et al. (2002)

The persistence of fiscal shocks (ρ^G) is set to 0.75, based on the findings of Iwata (2013). We assume that the size of a domestic fiscal shock ($\hat{\varepsilon}_t^G$) is 0.5% of initial GDP.

Our aim is to analyze the macroeconomic effects of fiscal policy during recessions and, consequently, we set the persistence of the changes in the level of productivity (ϕ) such that recessions have hysteresis or hysteresis-like effects on productivity and, thus, output. As discussed in Section 2.2.1, hysteresis requires that ϕ is one. We, however, set ϕ to 0.99. This generates a hysteresis-like response of productivity, but it, and the economy, eventually converge back to the initial steady state. Reifschneider et al. (2015) use the same approach and argue that although deep recessions can have a persistent effect on labor supply, they do not change fundamental determinants of longer-term conditions in the labor market. The same can be argued about productivity.

A key parameter is the elasticity of productivity with respect to employment (μ), as it affects the extent of hysteresis. Chang et al. (2002) find the value of 0.11, which we use. DeLong and Summers (2012) examine the limited evidence on the extent of hysteresis and argue that the plausible range of their hysteresis parameter–a proportional reduction in potential output from a temporary downturn–is between zero and 0.2. In our model, the proportional reduction in output in the 20th period, when a foreign time preference shock has, in practice, died away and prices have adjusted, to first-period output is 0.08[5] in the home country. Rawdanowicz et al. (2014) analyze empirically the hysteresis parameter–the effect of one percentage point of the negative output gap on reducing potential output–and find a value of 0.1 for the U.S. and 0.3 for the euro area. In our model, the ratio of the reduction in output in the 20th period to the first period output gap, defined as the deviation of output from the level that prevails in the case of flexible prices, is 0.14[6] in the home country. So the parameterization generates a realistic extent of hysteresis.[7]

4 Fiscal Policy in a Recession

4.1 Output and Welfare Multipliers

The main contribution of our paper is to analyze the consequences of hysteresis for the output and welfare multipliers of fiscal policy. Empirical studies often measure the effectiveness of fiscal policy as the cumulative output multiplier (CM), which is defined as the cumulative change of output over the cumulative change of fiscal policy (see eg. Gechert and Rannenberg (2014)): $CM = \sum_h dY_{t+h} / \sum_h dG_{t+h}$. In our model, a foreign time preference shock drives the home economy into a recession and we analyze the adjustment of two economies with and without expansionary domestic fiscal policy. The cumulative output multiplier is calculated as the difference of the cumula-

[5] The average in cases with and without fiscal expansion.

[6] The average in cases with and without fiscal expansion.

[7] We run the model using the algorithm of Klein (2000) and McCallum (2001).

tive change in output in case with fiscal expansion (denoted by superscript FE) and without fiscal expansion (denoted by superscript WFE), over the cumulative change of fiscal policy:

$$CM = \frac{\sum_h \hat{Y}_{t+h}^{FE} - \sum_h \hat{Y}_{t+h}^{WFE}}{\sum_h \hat{G}_{t+h}^{FE}}.$$

Several theoretical studies, following the work of Uhlig (2010), calculate the net present value fiscal multiplier (NPVM), which is the sum of output over a certain time horizon discounted at the steady state interest rate divided by public spending calculated in the same way. In our case NPVM is

$$NPVM = \frac{\sum_{s=t}^{h} \beta^{s-t} \hat{Y}_s^{FE} - \sum_{s=t}^{h} \beta^{s-t} \hat{Y}_s^{WFE}}{\sum_{s=t}^{h} \beta^{s-t} \hat{G}_s^{FE}}.$$

Sims and Wolff (2014) and Rendahl (2016) define the welfare multiplier of fiscal policy as the change in aggregate welfare–in consumption equivalent terms–for a one unit change in public spending. Following the idea of Schmitt-Grohe and Uribe (2007), we first calculate the welfare effect of fiscal policy as a percentage of consumption that households are willing to pay for policy A–now the fiscal expansion case–to remain as well off in the policy A case as in case of alternative policy B–now the case without fiscal expansion. Second, then we divide this by the change in public spending.

Let U_t^{WFE} denote welfare in case without fiscal expansion, and let $\{C_s^{WFE}, G_s^{WFE}, \ell_s^{WFE}(z)\}_{s=t}^{\infty}$ denote the associated private and public consumption and labor supply paths:[8]

$$U_t^{WFE}(z) = E_t \sum_{s=t}^{\infty} \beta^{s-t} \left[\log C_s^{WFE} - \frac{\left(\ell_s^{WFE}(z)\right)^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}} + \nu \log G_s^{WFE} \right].$$

The welfare benefit of fiscal expansion relative to the case without fiscal expansion, denoted by λ_t, is measured as the fraction of initial consumption that the domestic household would be willing to pay–assuming that labor supply is held constant–to be as well off in the fiscal expansion case as in the case without fiscal expansion. Let U_t^{FE} be the welfare obtained in case

[8] The calculation of the welfare multiplier is partly based on Ganelli and Tervala (2016). There are no time preference shocks in the home country. Therefore, we can normalize ϵ to one in the welfare calculus.

without fiscal expansion. It can be written using the definition of λ_t as follows:

$$\begin{aligned} U_t^{FE} &= E_t \sum_{s=t}^{\infty} \beta^{s-t} \left[\log((1+\lambda_t) C_s^{WFE}) - \frac{\left(\ell_s^{WFE}(z)\right)^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}} + \nu \log G_s^{WFE} \right] \\ &= \frac{1}{1-\beta} \log(1+\lambda_t) + U_t^{WFE}. \end{aligned}$$

Solving for λ_t and multiplying the equation with 100 to express the welfare benefit as the percentage of consumption we obtain

$$\lambda_t = 100 \times [\exp(1-\beta)(U_t^{FE} - U_t^{WFE}) - 1]. \tag{15}$$

Substituting the first-order approximations of the utility function to (15) yields

$$\begin{aligned} \lambda_t = \; & 100 \times [\exp((1-\beta)(\sum_{s=t}^{\infty} \beta^{s-t} (\hat{C}_s^{FE} - (\ell_0(z))^{1+1/\nu} \hat{\ell}_s^{FE} + \nu \hat{G}_s^{FE}) \\ & -(\sum_{s=t}^{\infty} \beta^{s-t} (\hat{C}_s^{WFE} - (\ell_0(z))^{1+1/\nu} \hat{\ell}_s^{WFE} + \nu \hat{G}_s^{WFE}))) - 1]. \end{aligned} \tag{16}$$

Equation (16) shows that the welfare benefit of fiscal expansion is the sum of welfare benefits relative to the case without fiscal expansion discounted at the steady state interest rate. The welfare multiplier (WM) is the welfare benefit divided by public spending discounted in the same way:

$$WM_t = \frac{\lambda_t}{\sum_{s=t}^{h} \beta^{s-t} \hat{G}_s}. \tag{17}$$

Equation (17) measures the consumption equivalent change in welfare for one dollar change public spending.

4.2 Transmission of Shocks without Hysteresis

Figure 2 on page 31 plots the dynamic effects of a foreign time preference shock on key variables in cases without hysteresis ($\mu = \phi = 0$). The horizontal axes show time and the vertical axes typically show percentage deviations from the initial steady state. The response of inflation is is expressed as percentage point deviations in annual terms. In addition, the difference between the response of domestic consumption in cases without fiscal expansion and with fiscal expansion would be hard to see. Therefore, Figure 1(b) shows the difference between the response of domestic consumption in cases without fiscal expansion and with fiscal expansion ($\hat{C}_t^{WFE} - \hat{C}_t^{FE}$). The consumer price index based real exchange rate, shown in Figure 2(g), is $S_t P_t^* / P_t$. The domestic terms of trade, plotted in Figure 2(h), is defined as the ratio of domestic export prices to domestic import prices. Changes in bond holdings of domestic households and public spending, whose initial values are zero, are expressed as percent deviations from initial steady state (SS) output. The solid lines depict the case without fiscal expansion, while the dashed lines depict the case in which domestic public spending is increased by 0.5% of initial output.

A strong foreign time preference shock causes a reduction in foreign consumption and labor supply, and thus affecting aggregate demand negatively. These induce a severe recession in the foreign country. Foreign demand for domestic goods falls and the home country experiences an export-driven recession. A recession in both countries induces deflation. However, the recession is deeper in the foreign country and, consequently, deflation is stronger in the foreign country. Therefore, the real exchange rate of the home country appreciates, as shown in Figure 2(g).

An increase in the relative supply of domestic goods causes an improvement in the domestic terms of trade. This increases domestic consumption. A decrease in the foreign bond holdings of domestic households causes a negative wealth effect on labor supply and an increase in long-term output.

Table 2 shows the output and welfare multipliers of fiscal policy. The cumulative output multiplier is calculated using 16 quarters. NPVM and the welfare multiplier are calculated using 2,000 periods. As mentioned, our baseline value for the weight of public consumption to relative private consumption is 0.4. However, Table 2 shows the welfare multipliers in alternative cases in which $\nu = 0$ and $\nu = 1$.

Table 2: Output and Welfare Multipliers

Cumul. multiplier	Net present value multipl.	Welfare multiplier $\nu = 0$	$\nu = 0.4$	$\nu = 1$
		Without hysteresis		
0.4	0.5	-1	-0.6	-0.01
		With hysteresis		
0.9	2.9	1.1	1.5	2.0

Figure 2(a) illustrates that a domestic public spending shock causes an increase in domestic output relative to the case without fiscal expansion. Table 2 shows that the cumulative output multiplier is 0.4 and the net present value fiscal multiplier is somewhat larger (0.5). Gechert and Rannenberg (2014) carry out a meta-analysis on fiscal multipliers based on 98 empirical studies and find that the cumulative multipliers of public spending are in the range of 0.4 to 0.7. Ramey and Zubairy (2016) find that the cumulative multipliers at the four-year horizon "are below unity," but most estimates are in the range of 0.3 to 0.8. Our result is line with these empirical findings.

The welfare multiplier in the baseline case is -0.6: A one dollar increase in domestic public spending yields the welfare loss that corresponds to a 0.6 dollars fall in domestic private consumption, i.e. domestic households are willing to pay 0.6 dollars to avoid a one dollar rise in public spending. An increase in public consumption increases welfare. This is, however, more than offset by negative effects. Figure 2(b) shows that private consumption falls because of higher taxes, relative to the case without fiscal expansion. In addition, a rise in public spending increases labor supply, relative to the case without fiscal expansion. Table 2 shows that the welfare multiplier becomes practically zero when public consumption yields as much utility as private consumption ($\nu = 1$).

In the absence of hysteresis, our model is very similar to Ganelli and Tervala (2016), who find that a rise in public consumption spending reduces welfare, unless the weight of public consumption is larger than the weight of private consumption in the utility function. Our welfare results are fully consistent with their findings.

4.3 Transmission of Shocks with Hysteresis

Figure 3 on page 32 displays the responses of the main variables to a foreign time preference shock in the presence of hysteresis ($\mu = 0.11$ and $\phi = 0.99$). It does not show inflation, but they behave similar to the previous case. Instead Panels (e) and (f) of Figure 3 show the changes in TFP.

A foreign time preference shock causes a recession in both countries. A fall in employment induces a deterioration in the level of productivity, shown in Figures 2(e) and 2(f). The ratio of the peak deviation in productivity from the initial steady state to the peak deviation in output is 0.24 (a one percent fall in output causes a 0.24% fall in productivity).[9] According to Conference Board (2016) data and our calculations on projections for GDP and productivity, shown in Figure 1, the ratio of the deviation of actual

[9] In comparison, in Reifschneider et al. (2015) the ratio is roughly 0.1.

productivity from pre-recession trend to the deviation of actual output from pre-recession trend in the U.S. in 2009 was 0.26.[10] This suggests that the basic parameterization generates a realistic relationship between recessions and productivity.

A decline in productivity implies that the fall in domestic and foreign output in the presence of hysteresis is much more persistent than in the absence of hysteresis. The solid line of Figure 3(a) shows that without fiscal expansion, domestic output in the 20th period remains much below the initial level, even if the foreign shock has died away and the negative wealth effect tends to increase labor supply. A temporary demand-driven recession, which causes a fall in employment, deteriorates the equilibrium level of output by causing a fall in productivity. For the sake of comparison, in the absence of hysteresis and fiscal expansion, domestic output is above the initial level in the 20th period due to the negative wealth effect on the labor supply.

Figure 3(a) shows that in the case with fiscal expansion, the fall in domestic output is smaller. In the short term, fiscal expansion stimulates demand, but the benefits of fiscal expansion last much longer than the demand effect. In the case with fiscal expansion, a fall in employment is smaller and, consequently, the level of productivity deteriorates less, as shown in Figure 3(e). Thus the effect of fiscal expansion on productivity is positive. A weaker negative effect of a recession on the long-term level of output implies higher long-term output multipliers.

Fatas and Summers (2016a) find that fiscal consolidations after the Great Recession caused both a temporary loss in output and permanent damage to potential output. Standard New Keynesian DSGE models are unable to explain permanent output losses, whereas our model can explain the persistent or even permanent effects of fiscal policy on potential output.

The idea that fiscal policy can affect TFP is not new, but the dominant view focuses exclusively on the consequences of the composition of public spending and taxation on TFP growth in the long term (see Everaert et al. 2015 and IMF 2015). In a rare paper, Linnemann et al. (2016) analyze the effects of fiscal policy on productivity from a business-cycle perspective. They find that a positive public spending shock causes an increase in labor productivity. They argue that their finding poses a real challenge to the fiscal transmission mechanism embedded in most DSGE models: a rise in public spending raises output and employment. If the production function includes capital, which is predetermined in the short term, decreasing returns to labor implies a fall in labor productivity. If the production function excludes capital

[10] According to Conference Board (2016) data and our calculations, shown in Figure 4, the same ratio in the euro area in 2014 was 0.24.

and is linear in labor, labor productivity remains constant.

When Linnemann et al. (2016) use a sign restriction to invoke a negative correlation between output (or total hours worked) and labor productivity, they find a negative output response to a public spending shock. They argue that either fiscal policy may indeed have negative effects on output and employment or "the standard view of the fiscal transmission mechanism needs to be augmented" (p. 13). We believe that the latter approach is right because virtually all studies find a positive output response to fiscal shocks. As mention in Section 2.2.1, TFP is equal to labor productivity in our model. So, in our model, a rise in public spending also increases labor productivity. Consequently, our production function with hysteresis seems to be a step into a right direction. It can explain the positive response of labor productivity to a rise in public spending.

Table 2 shows that the cumulative output multiplier is 0.9 in the presence of hysteresis. As mentioned, Ramey and Zubairy (2016) find that most estimates are in the range of 0.3 to 0.8. On the other hand, IMF (2012) finds that the cumulative output multiplier of a positive spending shock in the case of a negative output gap is 1.2. So our result is in the range of empirical estimates that are relevant for the question at hand. Table 2 also shows that the NPVM (2.9) is considerably greater than the cumulative multiplier (0.9). Figure 3(j) illustrates that after 20 periods, public spending has, in practice, returned to zero. However, the difference in domestic outputs, shown in Figure 3(a), depending on whether public spending is increased or not, is notable.

A typical argument against accommodative fiscal policy during and after the Great Recession was that fiscal multipliers are low. Ramey and Zubairy (2016) argue that if fiscal multipliers are below unity, they imply that fiscal expansion does not stimulate private activity and that fiscal consolidation is cannot do much harm to the private sector. The results of our paper suggest that the main benefit of fiscal expansion in a recession is to mitigate the adverse consequences of a recession for the long-term level of output. Consequently, the focus on short-term output multipliers as the main indicator of the effectiveness of fiscal policy in a recession may be misleading. In addition, Figure 3(b) shows that a rise in public spending – in the presence of hysteresis – increases private consumption in the medium and long term, relative to the case without fiscal expansion. The crowding-out of private consumption is a short-lived phenomenon.

Rendahl (2016) studies the effectiveness of fiscal policy in a liquidity trap using a model with persistent – hysteresis-like – movements in the unemployment rate. He finds that a rise in public spending lowers the unemployment rate in the present and in the future. Therefore, the influence of demand on aggregate supply through unemployment increases the fiscal output multiplier, which he finds to be in the range of 0.8 to 1.8. Our results are in line with Rendahl (2016), but they hint that the influence of demand on aggregate supply through productivity seems to increase output multipliers much more. The results of Reifschneider et al. (2015) and Anzoategui et al. (2016) lead us to believe that endogenous changes in productivity are the most important factor of hysteresis. Therefore, the results of Rendahl (2016) may underestimate the effectiveness of fiscal policy in the presence of hysteresis.

In the presence of hysteresis, Table 2 shows that the welfare multiplier is above 1, even if public spending is pure waste ($\nu = 0$). In the baseline case ($\nu = 0.4$), the welfare multiplier is 1.5, implying that one dollar spent by the public raises domestic welfare by the equivalent of 1.5 dollars of private consumption. An increase in domestic public spending reduces domestic private consumption in the short term because of higher taxes. After a while, the higher tax burden ends. As mentioned, a key benefit of fiscal expansion is that it limits the damage of a recession to long-term output. Therefore, a rise in public spending increases domestic private consumption relative to the case without fiscal expansion, as shown in Figure 3(b). The positive effect of fiscal expansion on private consumption in the medium and long term explains the positive welfare multiplier.

Rendahl (2016) finds that the welfare multiplier is in the range of -0.4 and 0.7 in cases where public spending does not provide direct utility to households. He shows that if the duration of a rise in public spending is short, relative to the duration of liquidity trap, the welfare multipliers are negative. In Section 4.4, we analyze the sensitivity of our welfare results with respect to the persistence of a fiscal shock and find different results.

Woodford (2011) shows the output multiplier in New Keynesian models depends crucially on monetary policy. He shows that the output multiplier can be well in excess of one at the zero lower bound. In this case, a rise in public consumption, which provides direct utility to households, which partially fills the output gap that arises from the inability to lower interest rates, increases welfare, because it does not crowd out private consumption. Bilbiie et al. (2014) find that, when public spending does not provide direct utility, expansionary fiscal policy is by and large welfare decreasing. Our paper highlights that in the presence of hysteresis, fiscal expansion increases welfare considerably, even if the central bank does not face the zero lower bound.

4.4 Robustness Checks

We now check the sensitivity of our main results to changes in key parameter values. Table 3 presents the output and welfare multipliers in the presence of hysteresis with row 1 replicating the baseline result. The second column shows the parameters used in the sensitivity analysis and the respective values of the baseline parameterization are shown in brackets.

Table 3: Varying Key Parameters in the Presence of Hysteresis

Row	Parameter	Cumul. multipl.	NPVM	Welfare Multiplier ($\nu = 0$)	($\nu = 0.4$)
1	Baseline	*0.9*	*2.9*	*1.1*	*1.5*
2	$\mu = 0.06$ (0.11)	0.7	1.9	0.2	0.6
3	$\mu = 0.15$ (0.11)	1.1	3.8	1.8	2.2
4	$\phi = 0.96$ (0.99)	0.9	1.5	-0.1	0.3
5	$\phi = 0.8$ (0.99)	0.6	0.7	-0.9	-0.4
6	$\varphi = 1.0$ (0.5)	1.2	3.8	1.7	2
7	$\gamma = 0.5$ (0.75)	0.7	2.4	0.8	1.1
8	$\sigma = 3.0$ (1.5)	0.9	3.2	1.4	1.8
9	$\rho^G = 0.6$ (0.75)	1.1	3.2	1.3	1.6

Rows 2-5 show modifications of the properties of the production function. In row 2, the elasticity of productivity with respect to employment, μ, is reduced from the baseline value of 0.11 to 0.06. A lower value of μ implies a weaker effect of employment changes on productivity. This reduces the cumulative output multiplier from 0.9 to 0.7 and the NPVM from 2.9 to 1.9. The welfare multipliers fall strongly but remain positive. Thus, sizable welfare effects depend crucially on the strong linkage between employment and productivity. However, Chang et al. (2002), using a Bayesian approach, find posterior estimates for μ of 0.11 and 0.15. This suggests that for realistic values of μ, positive welfare multipliers and high output multipliers are reasonable.

Row 3 shows multipliers in case where μ is increased to 0.15. In this case, the ratio of the peak decline in productivity to the peak decline in output increases from 0.24 to 0.31. This is higher than the observed ratio during the Great Recession in the U.S. (0.26). In addition, the ratio of the reduction in output in the 20th period to the first period output gap increases from 0.14 to 0.21 in the home country. As mentioned in Section 3, Rawdanowicz et al. (2014) find that this type of hysteresis parameter is 0.1 for the U.S. and 0.3

for the euro area. They, however, calculate the hysteresis parameters for 32 countries and 25 of them show signs of hysteresis and the average, non-GDP-weighted, hysteresis parameter in these 25 countries is as high as 0.5. So our baseline parameterization may underestimate the size of the hysteresis effects after deep recessions.

The results in row 3 indicate that in case of $\mu = 0.15$, accommodative fiscal policy has much larger benefits than in the baseline case. Moreover, the potential benefits of fiscal policy are much larger than in the previous literature that ignores the possibility of hysteresis. In our model, the NPVM can be almost eightfold in the presence of hysteresis (3.8), compared with the absence of it (0.5). Uhlig (2010) argues that fiscal policy has potentially drastic long-term consequences. In his model a deficit-financed rise in public spending stimulates output in the short term. The tax increases necessary to repay the increased public debt then hamper the economy considerably. We acknowledge that our model's limitation is that taxes are non-distortionary. Our model, however, shows that the potential long-term benefits of accommodative fiscal policy during recessions can be substantial due to hysteresis that is ignored in DSGE macroeconomics.

In the specifications of rows 4 and 5, the persistence of the level of productivity (ϕ) is reduced to 0.96 and 0.8, respectively, from 0.99. The former parameter value is used in Reifschneider et al. (2015). The latter value is consistent with the estimate of Chang et al. (2002), who use micro-level data from 1953-1997. It is, however, questionable whether the estimate of Chang et al. (2002) is relevant for recessions. The assumption that $\phi = 0.8$ does not generate a hysteresis-like response of output, because productivity converges rapidly back to the initial steady state ($0.8^{20} \approx 0.01$). This is inconsistent with the empirical evidence showing that recessions have permanent or highly persistent effects on output.

A reduction in the persistence of productivity has a large effect on welfare multipliers. In fact, only in the case where $\phi = 0.96$ and $\nu = 0.4$ the welfare multiplier remains positive; in other cases welfare multipliers turn negative. A reduction in the persistence of productivity has a sizable effect on NPVM, and in the case of $\phi = 0.8$, it falls below one. The positive welfare multipliers require that fiscal expansion limits the damage of a recession to the long-term level of output to the extent that it crowds in private activity in the medium and long term for a sufficiently long time. Therefore, we conclude that a high persistence of productivity is needed for the positive welfare effects that we find in our baseline case. A policy implication is that accommodative fiscal policy only makes sense in an environment where the economy is subject to hysteresis or hysteresis-like effects.

Row 6 shows the multipliers when the Frisch elasticity of labor supply (φ) is increased from 0.5 to the commonly used value of 1. Unsurprisingly, the output and welfare multipliers both rise. The reason is the stronger response of the labor supply to the increase in aggregate demand.

In row 7, the price rigidity parameter (γ) is reduced from 0.75 to 0.5, meaning that prices are changed on average once every two quarters rather than once a year. The cumulative output multiplier and the net present value multiplier fall slightly to 0.7 and 2.4, respectively, and the welfare multipliers fall to the range of 0.8 to 1.1. The multipliers are reduced because the greater price flexibility brings about a faster adjustment to the steady state.

In international macroeconomics, transmission mechanisms are often quite sensitive to the cross-country substitutability (σ). Feensta et al. (2014) find that it may be near unity in the U.S., but it could also be between 3 and 4. In an alternative setup, presented in row 8, we increase σ to 3. All multipliers rise slightly because the terms of trade improvement causes a greater consumption response after the shock.

In row 9, we present the effects of a reduction in the persistence parameter of the fiscal shock from 0.75 to 0.6. In our model, where the influence of demand on aggregate supply is modelled through productivity, we observe a small increase in the output and welfare multipliers. This is opposite to the result of Rendahl's (2016) model that has hysteresis-like movements in the unemployment rate. He finds that the welfare multipliers turn negative in the case where the duration of a rise in public spending is short, relative to the duration of the zero lower bound. In our model, a key benefit of fiscal expansion is that it limits the permanent damage of a recession to productivity in the short term. A short-lived fiscal expansion seems to cause a bigger bang for the buck, because it mitigates the permanent fall in productivity and output the most effectively. This gives some support for the view that fiscal stimulus should be–as often argued–timely and temporary. On the other hand, the output multipliers are very high, even if the duration of a fiscal shock is high.

5 Conclusions for Economic Policy

Several empirical studies (including Ball 2014, Blanchard et al. 2015, Martin 2015) find evidence for the hysteresis hypothesis, according to which recessions have permanent effects on the level of output. The relationship between recessions and the equilibrium level of output is inadequately modeled in DSGE macroeconomics. We presented a DSGE model that incorporates a link between economic activity and potential output. Furthermore, Fatas and Summers (2016a) show that post-Great Recession fiscal consolidations have induced permanent damage to potential output. Fatas and Summers (2016b) and Yellen (2016) argue that hysteresis can change the way economists think about the conduct of fiscal policy. Therefore, we analyze the implications of hysteresis for fiscal policy.

Our results suggest that the detrimental effects of fiscal consolidation in weak economic conditions, where hysteresis is relevant, are considerable. Gechert et al. (2015) estimate that cumulative discretionary fiscal consolidation measures in the euro area between 2011 and 2013 were 3.9% of output (2% in 2011; 1.3% in 2012 and 0.6% in 2013). This estimate of the size of fiscal consolidation and our results regarding cumulative output multipliers and the effects on TFP imply that the euro area's fiscal consolidation reduced output and TFP by 2.8% and 0.6%, respectively, relative to the no-consolidation baseline by 2013.

Fiscal consolidation was likely a key factor to the euro area's recession during the 2010s. Figure 4 on page 32 shows that TFP fell in the recession of the 2010s and it was 1.1% below trend in 2013.[11] Accordingly, fiscal consolidation may explain roughly half of the fall in TFP in 2011-2013. Hysteresis, however, implies that the damage of the euro area's fiscal consolidation is not limited to the short term because of its substantial medium- and long-term effects. Our cumulative output multipliers imply that the euro area's fiscal consolidation of 2011-2013 will cause output losses of 6.8% relative to the no-consolidation baseline by 2020. In addition, it will still, according to our results, reduce the potential level of output in 2020 by 0.6% due to its detrimental effects on productivity. Moreover, our benchmark parameterization may underestimate the costs of the euro area's fiscal consolidation, because it implies a much smaller extent of hysteresis (0.14) than Rawdanowicz et al. (2014) find for the euro area (0.3).

Furman (2016) summarizes that the new view of fiscal policy is that discretionary fiscal policy can be a useful complement to monetary policy in a world with low interest rates that limit conventional monetary policy. Reifschneider et al. (2015) study the implications of hysteresis for the conduct of monetary policy and find that optimal monetary policy becomes more accommodative when the economy is subject to hysteresis effects that policy can mitigate. Our findings suggest that accommodative fiscal policy becomes desirable–even in recessions where the central bank does not face the zero lower bound–when the economy is subject to hysteresis effects; accommoda-

[11] Data are from the Conference Board's (2016) total economy database. The euro area GDP and TFP were aggregated for the original 11 euro area countries (i.e. excluding Greece). The (slightly) time varying country weights were calculated as GDP weights based on constant price GDP in 1990 US-Dollars (converted at Geary Khamis PPPs).

tive fiscal policy is not desirable in the absence of hysteresis due to negative welfare multipliers. Our findings and those of Reifschneider et al. (2015) indicate that hysteresis has more profound implications for the conduct of fiscal policy than to monetary policy. Overall our results support the view of Yellen (2016), according to which, "hysteresis would seem to make it even more important for policymakers to act quickly and aggressively in response to a recession, because doing so would help to reduce the depth and persistence of the downturn, thereby limiting the supply-side damage that might otherwise ensue."

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Figure 1: Total factor productivity and GDP in the U.S. (indexes 2007=100), and their projections based on 1990-2007 trend, source: Conference Board (2016)

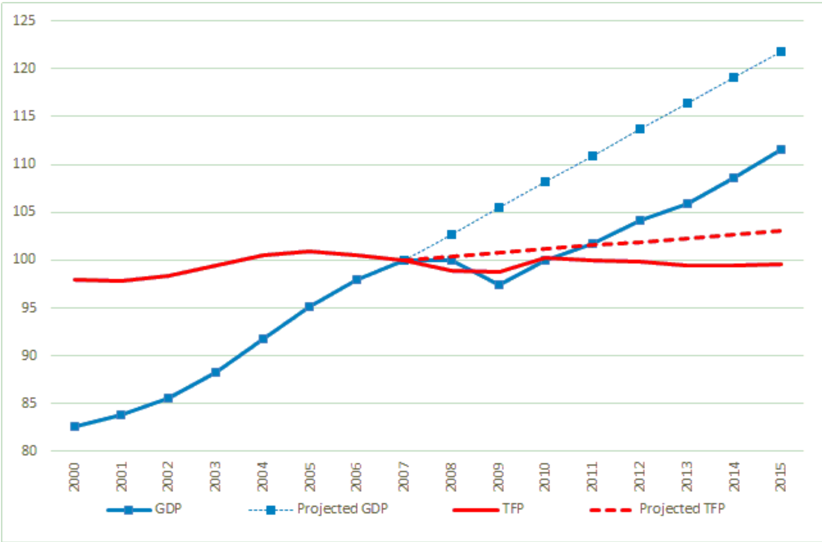

Figure 2: Dynamic responses to a foreign time preference shock without hysteresis

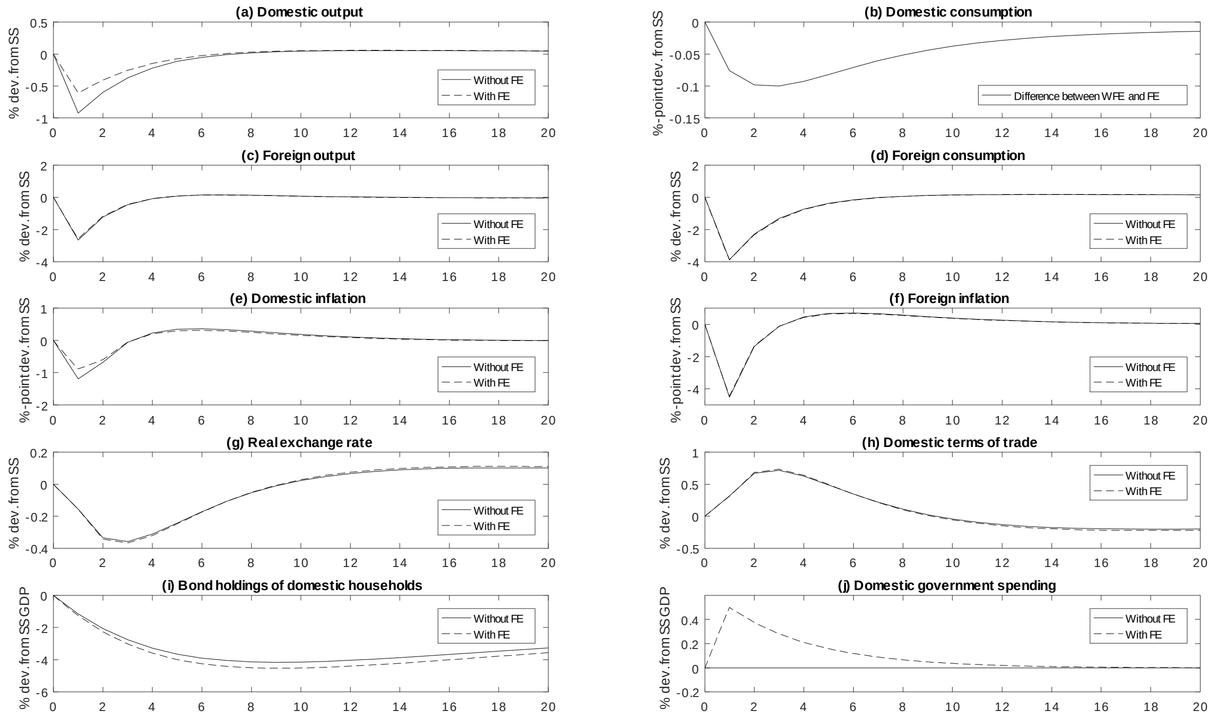

Figure 3: Dynamic responses to a foreign time preference shock in the presence of hysteresis

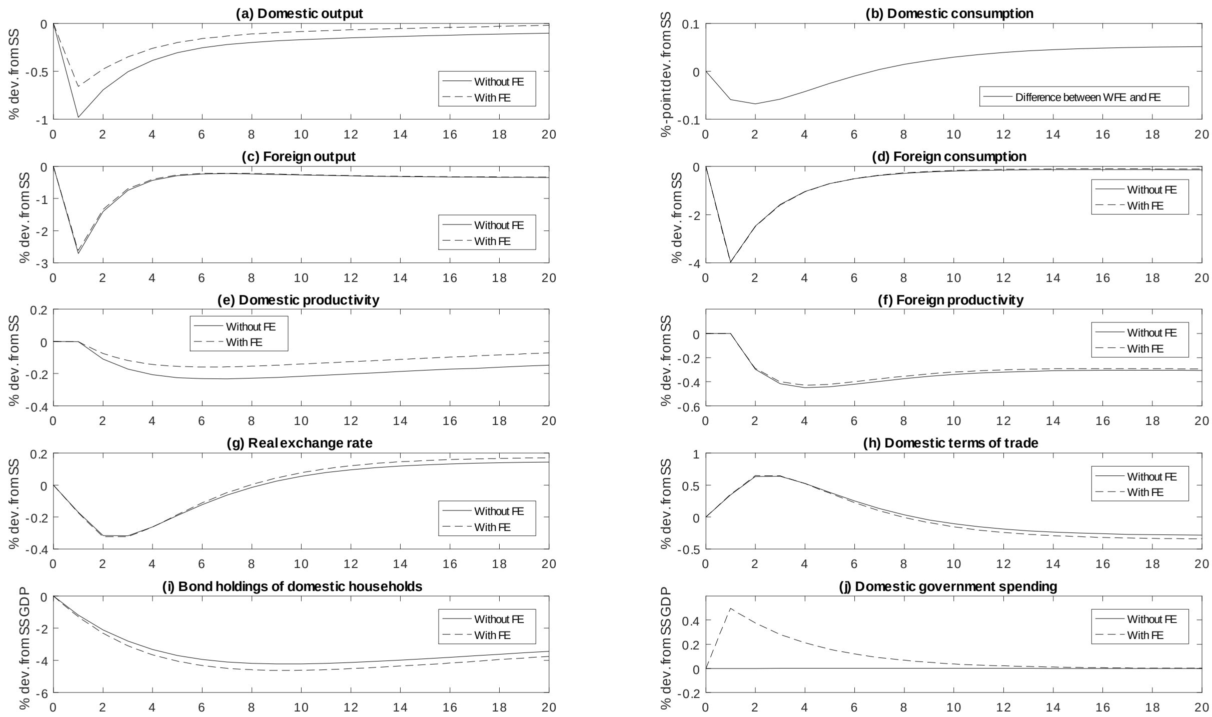

Figure 4: Total factor productivity and GDP in the euro area (indexes 2008=100), and their projections based on 1990-2008 trend, source: Conference Board (2016)