Bank of Finland Research Discussion Papers
6 • 2018

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Bank of Finland
Research

Bank of Finland Research Discussion Papers
Editor-in-Chief Esa Jokivuolle

Bank of Finland Research Discussion Paper 6/2018
26 February 2018

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ISBN 978-952-323-218-1, online
ISSN 1456-6184, online

Bank of Finland
Research Unit

PO Box 160
FIN-00101 Helsinki

Phone: +358 9 1831

Email: research@bof.fi
Website: www.bof.fi/en/research

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High Trend Inflation and Passive Monetary Detours

Guido Ascari[a]
University of Oxford
University of Pavia
Bank of Finland

Anna Florio[b]
Politecnico di Milano

Alessandro Gobbi[c]
University of Pavia

February 2018

Abstract

According to the long-run Taylor principle (Davig and Leeper, 2007), a central bank can deviate to a passive monetary policy and still obtain equilibrium uniqueness if a sufficiently aggressive monetary policy is expected for the future. Does this principle hold true when both monetary and fiscal policies can switch between active and passive and there is positive trend inflation? We find that passive monetary detours are no longer possible when trend inflation is high, whatever fiscal policy is in place. This has important policy implications in terms of flexibility and monetary-fiscal authorities coordination.

Keywords: trend inflation, monetary-fiscal policy interactions, Markov-switching, determinacy.
JEL classification: E52, E63.

1 Introduction

After years from the trough of the Great Recession, the Great Moderation seems just a distant memory. With the major economies stuck at the zero lower bound, there have been different proposals to leave this impasse. The challenge is to increase inflation expectations in order to reduce real rates. The most common proposals entail an active role for fiscal policy and the suggestion, by some influential economists, to increase the inflation target.[1] Were these proposals put at work, would it always

[a]Corresponding author: Department of Economics, University of Oxford, Manor Road, Oxford OX1 3UQ, United Kingdom. E-mail address: guido.ascari@economics.ox.ac.uk

[b]Department of Management, Economics and Industrial Engineering, Politecnico di Milano, via Lambruschini 4/B, 20156 Milan, Italy. E-mail address: anna.florio@polimi.it

[c]Department of Economics and Management, University of Pavia, Via San Felice 5, 27100 Pavia, Italy. E-mail address: alessandro.gobbi@unipv.it

[1]Blanchard et al. (2010), Ball (2014), Krugman (2014).

be possible to return to an era such as the Great Moderation? This would be characterised by a monetary led policy regime, where the central bank respects the Taylor principle while the government implements the fiscal adjustments necessary to stabilise debt.

To answer this question we extend the work by Ascari et al. (2016), which studies determinacy under monetary-fiscal interactions in a Markov-switching model, to include trend inflation. That paper modifies Davig and Leeper (2007) placing fiscal policy in the foreground;[2] here we want to check whether the long run Taylor principle holds once trend inflation, typically omitted in these analyses of changing policy regimes, is introduced. The enlarged determinacy region found by Davig and Leeper could be to some extent offset by a higher level of trend inflation if, as Ascari and Ropele (2009) find, an increase in trend inflation makes the determinacy area shrink.

Coibion and Gorodnichenko find, in a fixed coefficient model, that the reduction in trend inflation during Volcker's mandate was a key factor behind the Great Moderation. Our work can be considered as an extension of that paper to a monetary and fiscal regime switching setting to understand whether a strong commitment to achieve low and stable inflation would have been sufficient to go out from the Great Inflation.

This paper contributes to the recent growing literature on monetary-fiscal policy interactions (see Davig and Leeper, 2006, 2011; Bianchi, 2012; Bianchi and Melosi, 2013; Bianchi and Ilut, 2017) adding determinacy analysis and trend inflation. Foerster (2016), like us, considers inflation target switching in a model with predetermined variables but, assuming full price indexation, shows that it does not affect determinacy. Our model differs from his in that we do not have indexation and, especially, because we consider regime switches of fiscal policy too. Our model is the same as the one by Florio and Gobbi (2015) but in a regime switching context; theirs, on the contrary, is a fixed-coefficient model with learning to study the effects of trend inflation and transparency on expectations anchoring under different monetary-fiscal mixes.

The main finding of the paper is that passive monetary detours are no longer possible when trend inflation is moderately high. And this is true both under a constantly passive fiscal regime or when fiscal policy fluctuates between active and passive. The impossibility of switching from an active to an accommodating monetary policy regime has relevant policy implications in terms of flexibility and monetary-fiscal authorities coordination. Furthermore, we find that increasing the inflation target

[2] Davig and Leeper (2007) analyse regime changes in monetary policy with an always passive fiscal policy. We here apply the terminology in Leeper (1991). Active monetary (AM) policy arises when the response of the nominal interest rate to inflation is more than one-to-one. Otherwise, we have passive monetary (PM) policy. Analogously, passive fiscal (PF) policy occurs when taxes respond sufficiently to debt to prevent its explosion; otherwise we have active fiscal (AF) policy. In many fixed-coefficient models, a unique bounded equilibrium requires one active and one passive policy.

during the Great recession with interest rates are at zero could seriously impair the return to an expected AM/PF regime, once and if the passive monetary regime would be abandoned. The paper proceeds as follows. Section 2 describes the New Keynesian model with trend inflation and regime switching in both monetary and fiscal policy as well as the methodology employed. Section 3 illustrates the results about determinacy and Section 4 their policy implications. Section 5 concludes.

2 Model and methodology

The model is the most basic New Keynesian model with fiscal policy. The non-linear model equations are:

$$1 = \beta \mathbb{E}_t \left(\frac{Y_t - G}{Y_{t+1} - G} \frac{R_t}{\Pi_{t+1}} \right), \tag{1}$$

$$\phi_t \left(1 - \alpha \Pi_t^{\theta-1}\right)^{\frac{1}{1-\theta}} = \frac{\mu\theta \left(1-\alpha\right)^{\frac{1}{1-\theta}}}{\theta - 1} Y_t + \alpha\beta \mathbb{E}_t \left[\phi_{t+1} \Pi_{t+1}^{\theta} \left(1 - \alpha \Pi_{t+1}^{\theta-1}\right)^{\frac{1}{1-\theta}} \right], \tag{2}$$

$$\phi_t = \frac{Y_t}{Y_t - G} + \alpha\beta \mathbb{E}_t \left[\Pi_{t+1}^{\theta-1} \phi_{t+1} \right], \tag{3}$$

$$\frac{b_t}{R_t} = \frac{b_{t-1}}{\Pi_t} + G - \tau_t, \tag{4}$$

$$\tau_t = \tau \left(\frac{b_{t-1}}{b} \right)^{\gamma_{\tau,t}} e^{u_{\tau,t}}, \tag{5}$$

$$R_t = R \left(\frac{\Pi_t}{\bar{\Pi}} \right)^{\gamma_{\pi,t}} e^{u_{m,t}}. \tag{6}$$

Equation (1) is a standard Euler equation for consumption, where Y_t is output, R_t the nominal interest rate, Π_t the gross inflation rate and G government spending, which is assumed to be exogenous and constant. Equations (2) and (3) describe the evolution of inflation in the non-linear model. ϕ_t is an auxiliary variable (equal to the present discounted value of expected future marginal revenues) that allows us to write the model recursively. Equation (4) is the government's flow budget constraint, where $b_t = B_t/P_t$ is real government debt. We follow Leeper (1991) in using lump-sum taxes, i.e., τ, which are set according to the fiscal rule (5): taxes react to the deviation of lagged real debt from its steady-state level (b) according to the parameter $\gamma_{\tau,t}$. Equation (6) describes monetary policy. It is a simple Taylor rule whereby the central bank reacts to the deviations of current inflation from the target level ($\bar{\Pi}$) according to the parameter $\gamma_{\pi,t}$. A variable without the time index (i.e., τ, b and R) indicates the value at the steady state. β is the intertemporal discount factor; θ is the Dixit-Stiglitz elasticity of substitution between goods; and α is the Calvo probability that a firm is unable to optimise its price.

The key parameters of our analysis are $\gamma_{\pi,t}$ and $\gamma_{\tau,t}$, which describe the time-varying stance of monetary and fiscal policy, respectively. We assume that these parameters follow an underlying two-state Markov process and are equal to $(\gamma_{\pi,i},\ \gamma_{\tau,i})$ when the economy is in regime i, for $i = 1, 2$. The transition probabilities of going from regime i to regime j are denoted by p_{ij}. Thus, p_{ii} is the probability of remaining in regime i, and $p_{ij} = 1 - p_{ii}$.

2.1 Solution method and determinacy criterion

As our model includes fiscal policy, we need to account for the dynamics of government debt, which is an endogenous state variable. To do so, we employ the perturbation method developed by Foerster et al. (2016) (henceforth FRWZ) that allows us to solve for the minimal state variable (MSV) solutions of a Markov-switching model in the presence of predetermined variables. In our previous paper (Ascari et al., 2016), we used the same approach to find the rational expectations solutions of a similar model in which zero trend inflation is assumed.[3] The FRWZ method retrieves all the MSV solutions corresponding to a given parametrization. We need therefore to apply a stability criterion in order to understand whether a given solution is stable or not. In the context of Markov switching models, the concept of *mean square stability* (MSS) - proposed by Costa et al. (2005) and Farmer et al. (2009) - is a straightforward choice as it reduces the stability analysis to checking a simple condition entailing the autoregressive roots of state variables and the transition probabilities.

Therefore, any given parameter configuration can either lead to: (i) determinacy, when a unique stable solution exists; (ii) indeterminacy, when multiple stable solutions exist; or (iii) explosiveness, when no stable solutions exist. In what follows we seek to explore the parameter space to identify the regions corresponding to these three cases.

3 Determinacy under positive trend inflation

We concentrate (mainly) on the case where one of the two regimes is AM/PF. This is the benchmark mix in the New Keynesian literature and the policy regime that, according to many, prevailed in the U.S. during the post-1984 Great Moderation era.[4] Figure 1 reports the monetary frontiers—i.e., the combinations of monetary policy coefficients in the two regimes ($\gamma_{\pi,1}$ and $\gamma_{\pi,2}$) that deliver determinate

[3] Refer to that paper for more details on our application of the FRWZ method. More on the solution method in the Appendix.

[4] This is the reason why we do not deal with the case of an always active fiscal policy. The analysis can be easily extended to that case.

equilibria—for different levels of trend inflation (0, 2%, 4%, 6%) when fiscal policy stays passive in both regimes (with $\gamma_{\tau,1} = \gamma_{\tau,2} = 0.2$) and the transition probabilities are $p_{11} = p_{22} = 0.95$. This case, with fiscal policy in the background, is the most common case analysed in the monetary policy literature. The remaining structural parameters are calibrated as described in Table 1.[5]

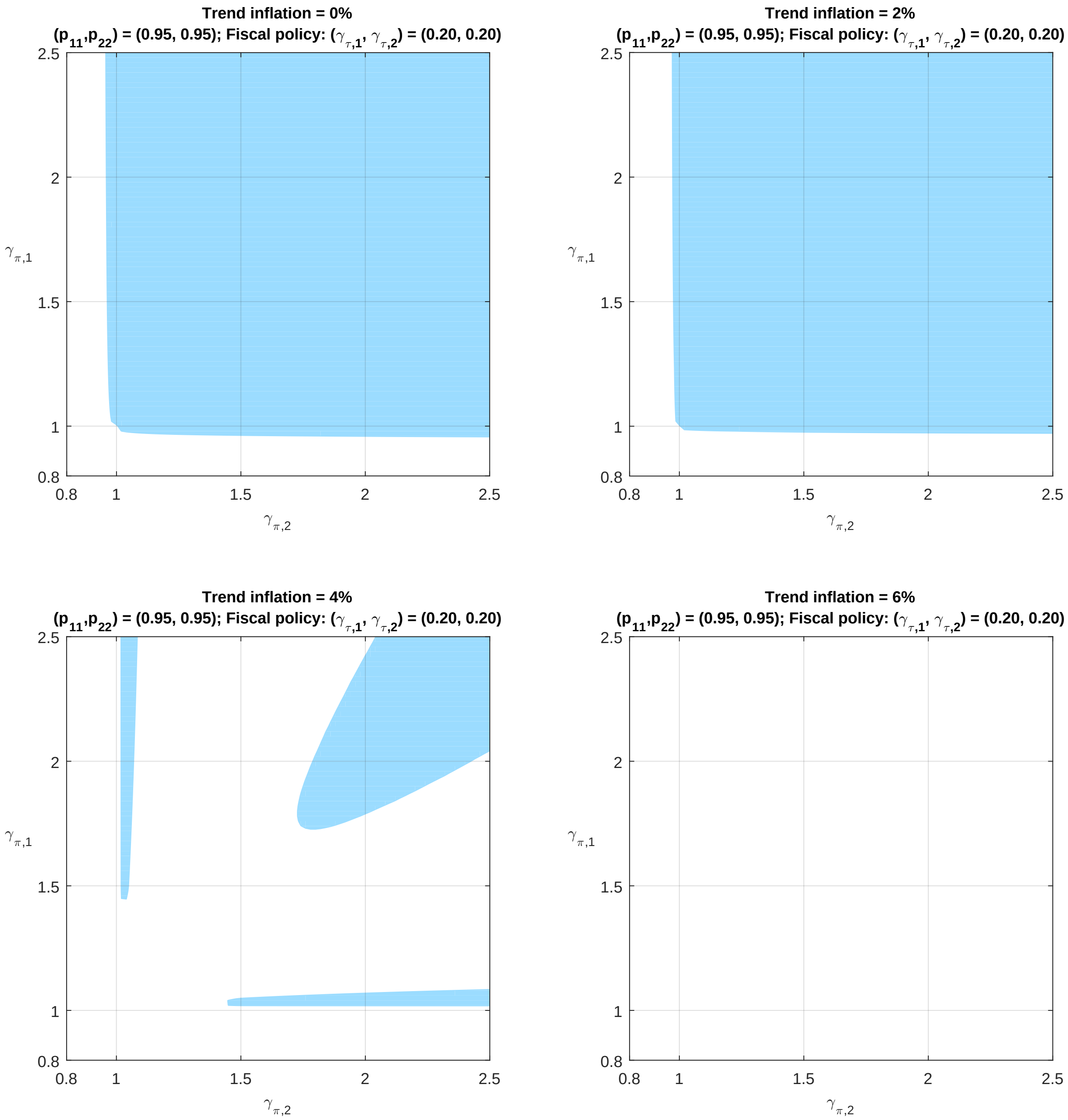

Figure 1: The monetary policy frontier for different levels of trend inflation.
Notes: Light blue: unique solution; white: indeterminacy.

When trend inflation is zero (top-left panel of Figure 1), the well-known Davig and Leeper's (2007)

[5]The labor disutility parameter (μ) is calibrated so that households work for one third of their amount of time at steady state.

Table 1. Calibration

Parameter	Value	Description
β	0.99	Intertemporal discount factor
θ	11	Dixit-Stiglitz elasticity of substitution
α	0.75	Calvo probability not to optimise prices
$\bar{b}$	0.4	Debt-to-GDP ratio
$\bar{c}$	0.8	Consumption-to-GDP ratio

long run Taylor principle holds: a passive monetary policy, which is indeterminate in a static context, could return determinacy if, in the other regime, monetary policy is sufficiently aggressive. Given an AM/PF regime, determinacy is preserved if monetary policy deviates timidly from an AM behavior becoming to a certain extent passive. With trend inflation at 2% we get the same figure. However, as trend inflation increases going to 4% or higher, we get two important points. The first, not new in the literature,[6] is that the Taylor principle breaks down as trend inflation rises. As you can see from the bottom panels, with trend inflation equal to 4%, in order to have determinacy, it does not suffice to have $\gamma_\pi > 1$, as the Taylor principle prescribes, but the central bank must be much more hawkish to inflation and, the more so, the more trend inflation increases. The second, as far as we know entirely new, is that as trend inflation increases, not only the Taylor principle but even the long-run Taylor principle breaks down. In other words, with moderate trend inflation (higher than 2%) and an always passive fiscal policy in the two regimes, monetary policy can never be passive rather, to return determinacy, it must be very active. One can not go from a double passive regime to an AM/PF one and still have determinacy. We think this result has important policy implications. We will defer their discussion to the next section.

The same comments apply when fiscal policy, rather than being constantly passive, deviates from being passive in one of the two regimes. This case returns monetary policy frontiers for different levels of trend inflation qualitatively similar to those in Figure 1 (see Figure A.1 in the Online Appendix).[7] However, note that now these results arise in a switching fiscal policy context. So, with trend inflation at 4% or higher, one can never switch from PM/AF to AM/PF, two determinate regimes under fixed-coefficients, and maintain determinacy.

Result *With $\alpha = 0.75$,[8] once the inflation target is moderate ($> 2\%$), if the economy is in a passive monetary regime, there is no chance to reach a determinate equilibrium even if agents expect an*

[6] See Hornstein and Wolman (2005), Kiley (2007), and Ascari and Ropele (2009).

[7] We use parameter values consistent with the estimates in Chung et al. (2007); Davig and Leeper (2007); Bianchi (2012); Bianchi and Melosi (2013).

[8] The following results hold for $\alpha \geq 0.75$.

active monetary stance under the other regime. The long run Taylor principle never holds.

4 Policy Implications

Lack of flexibility Central bank's flexibility to accommodate short-run disturbances is a desirable aspect in the conduct of monetary policy. Davig and Leeper (2007, p. 618) note that, however, central banks "also desire the *flexibility* to respond to developments that may entail a departure from the Taylor principle". This departure could be either short or long-lasting, depending on the length of the period when active inflation stabilization is de-emphasized to the benefit of other short-run objectives.[9] Woodford (2001, p. 671), for example, stresses how this kind of *flexibility* could be of use in periods of fiscal dominance: "regimes (...) in which other goals of central bank policy are subordinated to the goal of assisting in the financing of the government budget." Our model shows that this flexibility is seriously impaired by high trend inflation. *A rise in the inflation target would make the central bank less flexible since it could never depart from an active monetary policy. Furthermore, as the inflation target rises, the central bank must be more and more hawkish toward inflation to get determinacy and this is true irrespective of the fiscal regime in place.*

Monetary-fiscal coordination problems Davig and Leeper (2006) find policy coordination problems to be irrelevant because, despite periods of double active or double passive monetary and fiscal policies that under fixed-coefficients lead, respectively, to explosive and indeterminate solutions, the expectations of stable policy mixes would suffice to get a determinate equilibrium. We find this is not the case with high trend inflation. *With a trend inflation higher than 2%, the economy can never visit a double passive regime and get determinacy even if a stable policy mix is expected in the future. The only possibility is going from a double active regime to an AM/PF one* (see Figure A.1 in the Online Appendix). Therefore coordination problems of monetary and fiscal policies become a fact in the presence of high trend inflation.

Switching from the Great Inflation to the Great Moderation The literature that blames bad policy for high inflation in the seventies ascribes this to a central bank that did not respect the Taylor principle. Many believe that in the late 1979 there was a regime change with monetary policy switching from passive to active. In the presence of an unchanging (passive) fiscal policy, this implies the shift from a double passive, hence indeterminate in fixed coefficient policy mix, to a determinate

[9] See on this point even Bianchi and Melosi (2013).

AM/PF one, that contributes decisively to the advent of a Great Moderation era. This result, both if derived in a fixed coefficient context (Lubik and Schorfheide, 2004; Clarida et al., 2000) or in a Markov-switching one (Davig and Leeper, 2007; Bianchi, 2012; Baele et al., 2015), is based on the assumptions of always passive fiscal policy and zero trend inflation. Coibion and Gorodnichenko (2011) re-examine these results considering, more realistically, a positive trend inflation in the United States for that period. Building on the finding that the Taylor principle does not guarantee determinacy as trend inflation rises, Coibion and Gorodnichenko (2011) claim that the switch to determinacy at the end of the 1970s was due, in large part, to the substantial reduction in the level of trend inflation during the Volcker tenure.[10]

However, it is becoming more and more common the idea that even fiscal policy could have changed going from the Great Inflation to the Great Moderation. In these last years many examine this possibility employing models with regime switching changes in both monetary and fiscal policies. Markov-switching regressions suggest the shift, for those years, from an active fiscal policy to a passive one. In other words, the pre-Volcker era is found to be consistent with a PM/AF regime (Favero and Monacelli, 2005; Davig and Leeper, 2006, 2011; Sims, 2011; Bianchi, 2012; Bianchi and Melosi, 2013; Bianchi and Ilut, 2017). As a result, the rise of inflation in that period could be ascribed to a lack of fiscal discipline given by a non-Ricardian policy. However, according to Bianchi and Ilut (2017), "If in the 70s agents had been confident about moving to the AM/PF regime, the Great Inflation would not have occurred".[11]

When agents expect an AM/PF regime in the future and trend inflation is low, our model finds determinacy under both the policy mixes that, according to the literature, could have prevailed during the seventies. In particular, looking at the first two panels of Figure 1, one can realise that, provided monetary policy is not too passive, one can go from a double passive mix to an AM/PF and still have determinacy. The same is true when the regime shifts from PM/AF to AM/PF (Figure A1).

However, as the previous Section shows, the presence of high trend inflation changes dramatically determinacy areas. With high trend inflation, as in the 70s, if agents had been confident about the advent in the early 80s of the AM/PF regime, both if they were under a PM/PF regime or under a PM/AF one, equilibrium determinacy could not have been reached. *The possibility to avoid indeterminacy, once in a passive regime, expecting an active monetary policy in the future, depends*

[10] Trend inflation, then, could make indeterminate even equilibria where policymakers satisfy the Taylor principle. According to Orphanides (2002), this was precisely the case before the advent of Volcker in the United States.

[11] See on this point even Bianchi (2012, 2013) and Bianchi and Melosi (2013) who claim that if agents are aware of the possibility of a return to the AM/PF mix, a fiscal imbalance would not be inflationary.

on trend inflation at the time of the conjecture (very high during the great inflation, indeed). *With moderate (greater than 2%) trend inflation this is not feasible.* The only way to have determinacy would have been reducing trend inflation. As Coibion and Gorodnichenko (2011) maintain, our model confirms a lower level of trend inflation to be a key factor behind the Great Moderation.

Escaping the Great Recession The recent financial crisis has spurred some well-known economists (Rogoff, 2008; Blanchard et al., 2010; Ball, 2013) to suggest an increase in the inflation target to a value in the 4-6% range. The main motivation behind this proposal is to help the economies, stuck at their zero lower bound, to decrease real rates in order to go out from the recession.

According to Davig and Leeper (2011), the regime that probably best describes policy behavior during the early years of the Great Recession is the PM/AF one. This is the same policy mix invoked by Bianchi and Melosi (2017) as a way to escape the Great Recession by inflating debt away. Were this the regime in place, our model suggests that increasing the inflation target, as suggested, from 2% to 4%, could not be a good idea. Once in a PM/AF regime, with trend inflation equal to 4%, it would not be possible to go back to an AM/PF regime and, at the same time, reach a determinate equilibrium. With high trend inflation, flexibility would be lost.

5 Conclusions

Once monetary-fiscal interactions are taken into account, the role of a low trend inflation as a key factor to switch towards a Great Moderation era is confirmed. We find that an increase in trend inflation invalidates the long run Taylor principle: even if agents expect an active monetary stance for the future, there is no chance to reach a determinate equilibrium if the economy is in a passive monetary regime. Furthermore, as the inflation target rises, the central bank must be more and more hawkish toward inflation to get determinacy and this is true irrespective of the fiscal regime in place. This has important policy implications in terms of flexibility and monetary-fiscal authorities coordination. A rise in the inflation target would make the central bank less flexible since it could never depart from an active monetary policy.

As a consequence, we argue that a strong commitment of monetary policy to react heavily to inflation in the future would not have been sufficient, in any case, to go out from the Great Inflation. When monetary policy is passive but expected to be active in the future, the possibility to avoid indeterminacy depends on the level of trend inflation at the time of the conjecture. Reducing it is the only way to achieve determinacy, and this is true whatever fiscal policy is in place.

As for the proposal to increase the inflation target as a way to overcome the zero lower bound during the Great Recession, we find that it could seriously impair the return to an expected AM/PF regime, once and if the passive monetary regime would be abandoned. This, again, is true whatever fiscal policy is in place.

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Appendix

A Solution method

We employ the perturbation method developed by Foerster et al. (2016) (henceworth FRWZ). Using their notation, our model can be written as:

$$\mathbb{E}_t \boldsymbol{f}\left(\boldsymbol{y}_{t+1}, \boldsymbol{y}_t, \boldsymbol{x}_t, \boldsymbol{x}_{t-1}, \boldsymbol{\varepsilon}_{t+1}, \boldsymbol{\varepsilon}_t, \boldsymbol{\theta}(s_{t+1}), \boldsymbol{\theta}(s_t)\right) = \mathbf{0}$$

where $\boldsymbol{x}_t = b_t$ and $\boldsymbol{y}_t' = [Y_t, \Pi_t, \phi_t, R_t]'$ are the predetermined and non-predetermined variables, respectively, and $\boldsymbol{\theta}'(s_t) = [\gamma_\pi(s_t), \gamma_\tau(s_t)]'$ is the vector of parameters that switch according to the Markov-switching process s_t. We look for recursive solutions in the form

$$\boldsymbol{x}_t = \boldsymbol{h}_{s_t}(\boldsymbol{x}_{t-1}, \boldsymbol{\varepsilon}_t, \chi) \tag{7}$$

$$\boldsymbol{y}_t = \boldsymbol{g}_{s_t}(\boldsymbol{x}_{t-1}, \boldsymbol{\varepsilon}_t, \chi) \tag{8}$$

perturbed around the non-stochastic steady state $[\boldsymbol{x}, \boldsymbol{y}']'$. Note that in our model the solutions are regime-dependent while the steady state is not. The perturbation method in FRWZ allows to check the existence and uniqueness of the solution to the first order approximation of the dynamic system. Under regime i, the first order Taylor expansions of the solutions are

$$b_t \approx b + h_{i,b}(b_{t-1} - b) + \boldsymbol{h}_{i,\varepsilon}\boldsymbol{\varepsilon}_t + h_{i,\chi}\chi, \qquad \boldsymbol{y}_t \approx \boldsymbol{y} + \boldsymbol{g}_{i,b}(b_{t-1} - b) + \boldsymbol{g}_{i,\varepsilon}\boldsymbol{\varepsilon}_t + \boldsymbol{g}_{i,\chi}\chi,$$

with the partial derivatives evaluated at the steady state. The derivatives of $\mathbb{E}_t\boldsymbol{f}$ are equal to zero and depend on the unknown coefficients $h_{i,b}$, $\boldsymbol{h}_{i,\varepsilon}$, $h_{i,\chi}$, $\boldsymbol{g}_{i,b}$, $\boldsymbol{g}_{i,\varepsilon}$, $\boldsymbol{g}_{i,\chi}$. $h_{i,b}$ and $\boldsymbol{g}_{i,b}$ are necessary to perform the determinacy analysis. FRWZ show that the $h_{i,b}$ and $\boldsymbol{g}_{i,b}$ are the roots of a separated system of quadratic equations, that they propose to solve by using Groebner basis to find all the possible solutions. Note that $h_{i,b}$ and $\boldsymbol{g}_{i,b}$ characterise the response of the endogenous variables, predetermined and non-predetermined variables respectively, to the state variable in the policy functions. Once all the admissible solutions are find, a stability criterion needs to be imposed to select the stable ones. The criterion is the concept of *mean square stability (MSS)* proposed by Costa et al. (2005) and Farmer et al. (2009). MSS requires the existence of:[12]

$$lim_{t\to\infty}\mathbb{E}_0\left(\begin{bmatrix}\boldsymbol{x}_t\\ \boldsymbol{y}_t\end{bmatrix}\right), \quad \text{and} \quad lim_{t\to\infty}\mathbb{E}_0\left(\begin{bmatrix}\boldsymbol{x}_t\\ \boldsymbol{y}_t\end{bmatrix}\begin{bmatrix}\boldsymbol{x}_t\\ \boldsymbol{y}_t\end{bmatrix}'\right). \tag{9}$$

In our context with 2 regimes and 1 state variable, the condition for MSS constrains the values of the autoregressive roots in the state variable policy function in the two regimes. In particular, the solution $(h_{1,b}, h_{2,b})$ is MSS if the following matrix has all its eigenvalues inside the unit circle:

$$\begin{bmatrix} p_{11}h_{1,b}^2 & (1-p_{22})h_{2,b}^2 \\ (1-p_{11})h_{1,b}^2 & p_{22}h_{2,b}^2 \end{bmatrix} \tag{10}$$

To have mean square stability (MSS), thus, $h_{1,b}, h_{2,b}$ should satisfy these conditions:

$$\left|h_{1,b}^2 h_{2,b}^2\left(p_{11}+p_{22}-1\right)\right| < 1 \tag{11}$$

$$p_{11}h_{1,b}^2\left(1-h_{2,b}^2\right)+p_{22}h_{2,b}^2\left(1-h_{1,b}^2\right) < 1-h_{1,b}^2 h_{2,b}^2 \tag{12}$$

Hence, any given parameter configuration could lead to: (i) determinacy, that admits a unique stable solution; (ii) indeterminacy, that admits multiple stable solutions; (iii) explosiveness, that admits no stable solutions. In what follows we want to identify the determinacy region in the parameter space that is, all those parametrization for which a unique MSS solution exists.

B Determinacy under zero trend inflation

B.1 Fixed-coefficient case

The log-linearized model is a trivariate dynamic system in the two jump variables $\hat{y}_t$ and $\hat{\pi}_t$ and the predetermined variable $\hat{b}_t$:

$$\frac{1}{\bar{c}}\hat{Y}_t = \frac{1}{\bar{c}}\mathbb{E}_t\hat{Y}_{t+1} - \left(\hat{R}_t - \mathbb{E}_t\hat{\Pi}_{t+1}\right), \tag{13}$$

$$\hat{\Pi}_t = \frac{\lambda}{\bar{c}}\hat{Y}_t + \beta\mathbb{E}_t\hat{\Pi}_{t+1}, \tag{14}$$

$$\hat{b}_t = \frac{1}{\beta}\left(1-\frac{\tau}{b}\gamma_\tau\right)\hat{b}_{t-1} - \frac{1}{\beta}\hat{\Pi}_t + \bar{b}\hat{R}_t + \frac{1}{\beta}\sigma_\tau u_{\tau,t}, \tag{15}$$

[12] Davig and Leeper (2007) employs a more restrictive concept of stability: bounded stability, which requires bounded paths and thus rules out temporarily explosive paths in one of the two regimes. See Farmer et al. (2009) for a discussion in the context of MS-DSGEs.

where $\hat{R}_t$ is given by the monetary policy rule: $\hat{R}_t = \gamma_\pi \hat{\Pi}_t + \sigma_m u_{m,t}$, and $\bar{b}$ and $\bar{c}$ are the steady state debt-to-GDP and consumption-to-GDP ratios, respectively. It is useful here to recall the necessary and sufficient conditions for determinacy of the REE in a fixed coefficient model. Using the renowned Leeper (1991) taxonomy, fiscal policy is said to be *passive* if the fiscal rule guarantees debt stabilisation in (15), that is if:

$$\left| \frac{1}{\beta}\left(1 - \frac{\tau}{b}\gamma_\tau\right) \right| < 1. \tag{16}$$

In case of passive fiscal policy, it is easy to show that the following conditions have to hold to yield determinacy:

$$\gamma_\pi > 1 \tag{17}$$

and

$$\gamma_\pi > \frac{\beta - 1}{\lambda}. \tag{18}$$

The first condition is the Taylor principle and it implies the second, which then becomes redundant. Still following Leeper, monetary policy is labelled *active* if it satisfies the Taylor principle, otherwise is labelled as *passive*. Hence, the famous result by Leeper (1991) follows: in the presence of *passive fiscal policy*, *monetary policy* needs to be *active* , i.e., $\gamma_\pi > 1$, to yield determinacy.

Conversely, in case of *active fiscal policy*, i.e., (16) does not hold, then monetary policy should be *passive* to guarantee determinacy: $\gamma_\pi < 1$. In this case, the REE is non-Ricardian, such that a change in lump-sum taxation has real effects, and the so-called "fiscal theory of the price level" holds. Summing up, in a fixed coefficient model as in Leeper (1991), the determinacy regions are defined by the following conditions:

- active monetary/passive fiscal (AM/PF) mix: $\gamma_\pi > 1$ and $(1-\beta)\frac{b}{\tau} < \gamma_\tau < (1+\beta)\frac{b}{\tau}$
- passive monetary/active fiscal (PM/AF) mix: $\gamma_\pi < 1$ and $\gamma_\tau < (1-\beta)\frac{b}{\tau}$ or $\gamma_\tau > (1+\beta)\frac{b}{\tau}$.

The REE equilibrium is instead indeterminate under PM/PF combinations and explosive under AM/AF ones.

B.2 Regime switching case

Applying the FRWZ method, we derive the following system for the general case with $p_{11}, p_{22} < 1$:

$$\begin{aligned} g_{1,\pi,b}\left\{1 + \lambda\gamma_{1,\pi} - h_{1,b}p_{11}\left(\beta + 1 + \lambda\right) + \beta h_{1,b}^2 p_{11}^2\right\} + (1-p_{11})\beta h_{1,b}h_{2,b}(1-p_{22})g_{1,\pi,b} \\ + g_{2,\pi,b}(1-p_{11})h_{1,b}\left[\beta h_{1,b}p_{11} - (\beta + 1 - \beta h_{2,b} + \lambda)\right] = 0 \end{aligned} \tag{19}$$

$$g_{2,\pi,b}\left\{1+\lambda\gamma_{2,\pi}-h_{2,b}p_{22}\left(\beta+1+\lambda\right)+\beta h_{2,b}^2p_{22}^2\right\}+(1-p_{22})\beta h_{1,b}h_{2,b}(1-p_{11})g_{2,\pi,b} \quad (20)$$
$$+\,g_{1,\pi,b}(1-p_{22})h_{2,b}\left[\beta h_{2,b}p_{22}-(\beta+1-\beta h_{1,b}+\lambda)\right]=0$$

with

$$g_{1,\pi,b}=\frac{\frac{1}{\beta}\left(1-\frac{\tau}{b}\gamma_{1,\tau}\right)-h_{1,b}}{b\left(\frac{1}{\beta}-\gamma_{1,\pi}\right)}, \quad (21)$$
$$g_{2,\pi,b}=\frac{\frac{1}{\beta}\left(1-\frac{\tau}{b}\gamma_{2,\tau}\right)-h_{2,b}}{b\left(\frac{1}{\beta}-\gamma_{2,\pi}\right)}, \quad (22)$$

and where the 4 unknowns are the coefficients $h_{1,b}$, $h_{2,b}$, $g_{1,\pi,b}$ and $g_{2,\pi,b}$. Recall that debt b_t is the state variable of the system, $h_{i,b}$ is the response of debt to its lag in regime i, and $g_{i,\pi,b}$ is the response of inflation to the lagged debt in regime i. Determinacy obtains when a *unique* pair $(h_{1,b},\, h_{2,b})$ satisfies the MSS conditions 11 and 12.

C The monetary frontiers when fiscal policy switches

Figure 2 depicts the monetary frontiers for different levels of trend inflation when fiscal policy shifts from active in regime 1 ($\gamma_{\tau,1}=0$) to passive in regime 2 ($\gamma_{\tau,2}=0.2$), with $p_{11}=p_{22}=0.95$.[13]

[13] This is the case of a timid deviation from the passive fiscal regime in Ascari et al. (2016). From their calibration we have this case when $-0.02<\gamma_\tau<0.02$.

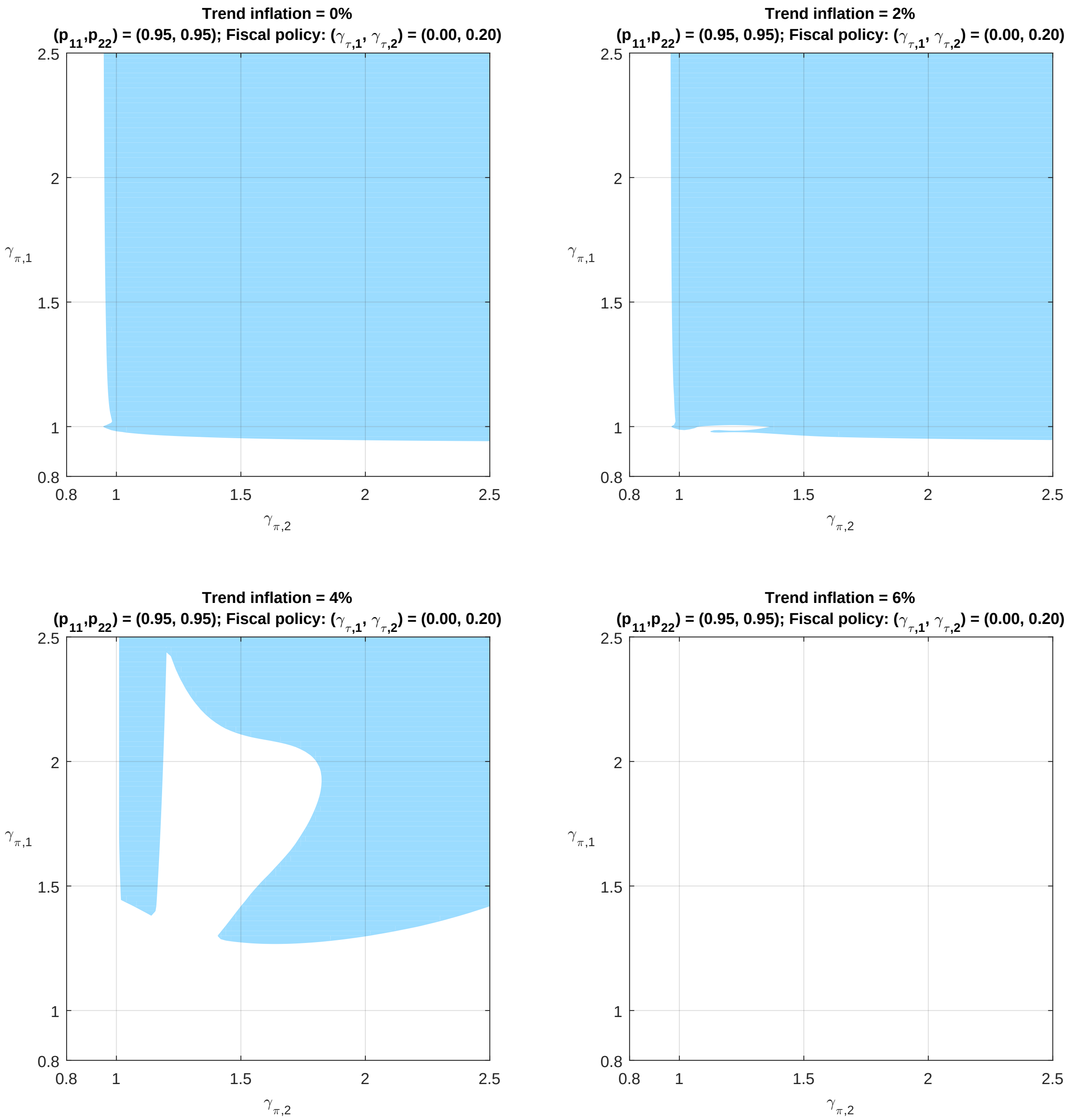

Figure 2: The monetary policy frontier when fiscal policy switches.

Notes: Light blue: unique solution; white: indeterminacy.

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