Fiscal Consolidation Under Imperfect Credibility*

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Abstract

This paper examines the effects of expenditure-based fiscal consolidation when credibility for the cuts to be long-lasting is imperfect. We contrast the impact limited credibility has when the consolidating country has the means to tailor monetary policy to its own needs, versus the case when it is a small member of a currency union with negligible impact on currency union interest rates and nominal exchange rates. We find two key results. First, under independent monetary policy, the adverse impact of limited credibility is relatively small, and consolidation can be expected to reduce government debt at a relatively low output cost given that monetary policy provides more accommodation that it would under perfect credibility. Second, the lack of monetary accommodation under currency union membership implies that the output cost can be significantly larger, and that progress to reduce the government debt in the short- and medium-term may be limited under imperfect credibility.

JEL Classification: E32, F41

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1 Introduction

The global financial crisis and slow ensuing recovery have put severe strains on the fiscal positions of many industrial countries, and especially many peripheral economies in the euro area. Between 2007 and 2013, debt/GDP ratios climbed considerably in many euro area countries, including Greece (+66.6pp), Ireland (+98.0pp), Portugal (+60.5pp), Spain (+57.6pp)and Italy (+29.3pp). Mounting concern about high and rising debt levels, especially in the wake of the run-up in borrowing costs, spurred efforts to implement sizable fiscal consolidation plans. So far, many of the fiscal consolidation plans that have received legislative approval in the peripheral euro area economies appear to have broadly similar features – they are typically fairly front-loaded, and more focused on spending cuts than tax-hikes.

However, as can be seen in Figure 1, the debt ratios in these economies have apparently not improved much in 2012 and 2013 despite significant consolidation efforts, and output growth appears to have been low relative to European peers which did not pursue fiscal austerity to the same extent during these years. Only in Ireland, debt fell in 2014 as growth was sizeably above euro area average this year. In other countries debt was roughly unchanged and output growth still subpar to its peers. Hence, the evolution of debt and output during this period does not seem to support the popular policy recipe, prominently advocated by Alesina and Ardagna (2010), Alesina and Perotti (1995, 1997) and Giavazzi and Pagano (1990), that large spending-based fiscal consolidations are likely to have expansionary effects on the economy.

In this paper, we seek to analyze the impact that imperfect commitment to follow through on the announced consolidation efforts has on the output cost of fiscal austerity and their effectiveness to reduce debt-ratios in the short- and medium term. Given the sizable consolidation plans, we believe that economic actors – both households and investors – may have had considerable doubts about the ability of politicians to follow through on the implementation of them, and we seek to understand how these doubts may have affected their efficiency. Our paper makes a purely positive assessment of this issue by, first, making an assessment if imperfect credibility seems is empirically important, and second, by investigating how the economic impact of expenditure-based consolidation depends on the degree of credibility that the spending cut will be permanent and not transient.

To examine the first issue, we decompose data on government spending (as share of trend output) into permanent and temporary component for a selected set of peripheral euro area economies.[1] Our simple decomposition supports the notion that credibility is imperfect for some of these economies; in particular, we find that credibility for permanent spending cuts is impaired for Greece.

Given this finding, we attack the second issue, which is to quantify the economic impact of imperfect fiscal credibility in two variants of a dynamic stochastic general equilibrium (DSGE henceforth) model of an open economy. We start out our analysis using the analytically tractable benchmark model of Clarida, Galí, and Gertler (2001), and then check the robustness of our findings in a fully-fledged workhorse open economy model used by Erceg and Lindé (2010, 2013). This model features "rule of thumb" households who consume all of their after-tax income as in Erceg, Guerrieri, and Gust (2006) as ample micro and macro evidence suggests that such non-Ricardian consumption behavior is a key transmission channel for fiscal policy.[2] On other dimensions, this model is a relatively standard two country open economy model with endogenous capital formation which embeds the nominal and real frictions that have been identified as empirically important in the closed economy models of Christiano, Eichenbaum, and Evans (2005) and Smets and Wouters (2003), as well as analogous frictions relevant in an open economy framework (such as costs of adjusting trade flows). Given the importance of financial frictions as an amplification mechanism – as highlighted by the recent work of Christiano, Motto and Rostagno (2010) – the model also incorporates a financial sector following the basic approach of Bernanke, Gertler, and Gilchrist (1999).

To begin with, we assume that the consolidating economy has the means to pursue independent monetary policy (IMP henceforth), here defined as the ability for the central bank

[1] For a point of comparison of our procedure, we also perform the decomposition for Germany and the United States.

[2] Using micro data from the Consumer Expenditure Survey, Johnson et al (2006) and Parker et al. (2011) find evidence of a substantial response of U.S. household spending to the temporary tax rebates of 2001 and 2008. On the macro side, Galí, López-Salio and Vallés (2007) present evidence from structural VARs that government spending shocks tend to boost private consumption, and show how the inclusion of rule-of-thumb agents in their DSGE model helps it account for this behavior. Blanchard and Perotti (2002) and Monacelli and Perotti (2008) obtain similar empirical findings.

to tailor nominal interest rates (and hence the exchange rate) to stabilize inflation around target and output around its efficient level. After considering IMP as a useful reference point, we move on to the benchmark case in which the consolidating economy is a small member of a currency union (CU henceforth), without the means to exert any meaningful influence on currency union policy rates and its nominal exchange rate. The latter case, we believe, is the most interesting one given the prevailing situation for many European peripheral economies.

Our main findings are as follows. First, under IMP, the adverse impact of limited credibility is relatively small, and consolidation can still be expected to reduce government debt at a relatively low output cost given that monetary policy provides more accommodation that it would have to do under perfect credibility. Second, the lack of monetary accommodation under CU membership implies that the output cost can be significantly larger under imperfect credibility, implying that progress to reduce government debt in the short- and medium-term is limited when the consolidation is implemented quickly. For a small CU member, a gradual approach to consolidation plan has the dual benefit of mitigating the need for monetary accommodation and building credibility for the cuts to be permanent more quickly. While the benefit of acting gradually due to the less need of monetary accommodation have been pointed out previously by Corsetti, Meier and Müller (2012) and Erceg and Lindé (2013), we show that imperfect credibility is an additional argument why it may be advantageous to proceed in a gradual fashion.

After having established these preliminary results in the stylized model, we move to a more serious quantitative analysis in the fully-fledged model of Erceg and Lindé (2013), in which we allow for interest rates spreads in the periphery to respond endogenously to the path of expected debt and deficits. In this model, we indeed find that a fiscal consolidation may even be expansionary if the government enjoys a sufficiently high degree of credibility. Even so, the favorable results under endogenous spreads are sensitive to the implementation of the consolidation. In particular, if the government pursues a too ambitious spending-based consolidation program that seeks to reduce the debt-ratio even in the short-run through aggressive spending cuts, they run the risk of chasing their own tail and withdraw too much demand in the economy which may have a counter-productive impact on the debt-ratio in the short- and medium-term. Thus, echoing the benefits of acting gradually in the stylized model, a more effective route for the government to reduce debt quickly at low output cost in the fully-fledged model is to implement permanent spending-cuts gradually and be patient until private demand is crowded in, tax revenues rise, and debt starts falling. An empirical paper of Born et al. (2014) provides estimates of a panel VAR on a dataset of 26 emerging and advanced economies regarding the interaction of fiscal consolidation and interest rate spreads. Consistent with the findings in our workhorse model, it shows that a cut in government consumption that is perceived to be temporary can induce a short-term rise in spreads, whereas spreads fall following a permanent spending cut.

Perhaps somewhat surprisingly, relatively few papers have analyzed the role imperfect credibility might play for shaping the effects of fiscal consolidations in a DSGE framework. First, Clinton et al. (2011) show with the GIMF model that credibility plays a crucial role in determining the size of output losses, by analyzing sensitivity of these losses to the length of an initial period without any credibility. Focusing on spillover issues, in't Veld (2013) uses as a benchmark scenario a multi-year consolidation with gradual learning, i.e. where austerity measures are considered as temporary in a learning period and are expected to be permanent only after this learning period. He shows that, in the short-run, output losses would be considerably smaller if consolidations gains credibility earlier. Simulations of consolidations with ECB's NAWM model also deliver larger multipliers in the case of "imperfect credibility" (modeled in the same way with a learning period where fiscal shocks are initially perceived as temporary, see Box 6 of ECB, 2012). A key difference between our approach and the one adopted by these papers is that the degree of credibility in our setup is *endogenous* as it depends on the path of government spending and is not assumed exogenously given for a fixed number of quarters.

The reminder of the paper is organized as follows. The next section assess the empirical relevance of imperfect credibility. Section 3 presents the simple benchmark model, discusses its calibration, and examines the role imperfect credibility plays in this stylized model under monetary independence and currency union membership. In Section 4, we then examine the robustness of the results for the stylized model in the large-scale model with hand-to-mouth households and financial frictions. Finally, Section 5 concludes.

2 An Empirical Assessment of Credibility

In this section, we attempt to decompose government spending into permanent and temporary components. This empirical study will be useful assessing the influence of imperfect credibility. Indeed, as we will show in quantitative simulations of the paper, the larger is the weight of the permanent component, relative to the temporary one, the easier it is to extract this permanent component and the faster a permanent consolidation of government spending will become fully credible.

Here, we focus on countries of the euro area periphery: Ireland, Italy, Portugal, Spain and Greece. We also add Germany and the United States as benchmarks. To do this analysis, we use OECD national accounts quarterly series for "Government final consumption expenditures" and GDP in constant prices over the period 1980Q1-2008Q4. Then, we measure government spending as a ratio of government consumption over (lagged) trend output, as in Gali et al (2007).[3] We believe 1980 is a good starting point, because the 1960s and 1970s was a period characterized by an expanding welfare state in many European countries, which obviously had nothing to do with consolidations. The estimation sample ends 2008Q4, in order to avoid to get results influenced by the specific evolution of government spending after the financial crisis. The data we use in the estimations are plotted in Figure 2 (blue solid line).

The starting point in our empirical analysis is that total government spending (as share of lagged trend output), g_t, is the sum of a permanent (g_t^{perm}) and a transient (g_t^{temp}) component, which are assumed to be given by the following processes:

$$g_t - \bar{g} = (g_t^{perm} - \bar{g}) + g_t^{temp} \quad (1)$$

$$\Delta\left(g_t^{perm} - \bar{g}\right) = \rho_1^{perm}\Delta\left(g_{t-1}^{perm} - \bar{g}\right) - \rho_2^{perm}(g_{t-1}^{perm} - \bar{g}) + \frac{1}{g_y}\varepsilon_t^{perm} \quad (2)$$

$$g_t^{temp} = \rho^{temp} g_{t-1}^{temp} + \frac{1}{g_y}\varepsilon_t^{temp} \quad (3)$$

where the standard errors of the shocks ε_t^{perm} and ε_t^{temp} are given by σ_{perm} and σ_{temp}, respectively. By assuming that the permanent component follows an AR(2)-process with positive persistence in growth rates ($\rho_1^{perm} > 0$) and slow mean reversion back to steady

[3] We compute trend output by using a HP filter with a parameter $\lambda = 6400$. The parameter 6400 is the upper value of λ proposed in Hodrick and Prescott (1997).

state $\bar{g}$ (ρ_2^{perm} is assumed to be very small), we ensure that the permanent component in equation (2) will be a smooth process. The temporary component, shown in equation (3), on the other hand, is assumed to be a simple AR(1) process and may hence be characterized by transient fluctuations when ρ^{temp} is relatively small and σ_{temp} is high.

We estimate the parameters in eqs. (2)-(3) by likelihood based methods, but since some of the parameters are weakly identified as we only match one time series (g_t), we impose strict priors for some of the parameters. To begin with, we assume that $\rho_1^{perm} = 0.9$, and $\rho_2^{perm} = 0.001$.[4] As discussed previously, this ensures that the permanent component is fairly smooth. We also assume that $\rho^{temp} = 0.8$. This value is reasonable since the persistence of government spending shocks in the businesss cycle literature (which will have both permanent and transient shocks according to eq. 1) is normally calibrated to be between $0.9 - 0.95$. While the exact details of the estimation results are somewhat sensitive to these choices, the overall message is not much affected, as discussed in further detail below.

Table 1: Estimated standard deviations of shocks for government spending process.

	Country						
Parameter	Ireland	Italy	Portugal	Spain	Greece	Germany	United States
σ_{perm}	0.108	0.032	0.026	0.032	0.028	0.028	0.030
σ_{temp}	0.188	0.127	0.114	0.142	0.257	0.157	0.130
SNR	0.574	0.252	0.229	0.225	0.109	0.175	0.230

Note: The estimates reported are conditional on $\rho_1^{perm} = 0.9, \rho_2^{perm} = 0.001$ and $\rho^{temp} = 0.8$. For Portugal we use $\rho_1^{perm} = 0.7$. The SNR is defined in equation (4).

In Table 1, we report the estimation results in terms of standard deviations for the permanent and transient shocks, and the implied signal to noise ratio of innovations, SNR henceforth, defined as

$$SNR = \frac{\sigma_{perm}}{\sigma_{temp}}. \tag{4}$$

As can be seen from the table, Greece has the lowest signal to noise ratio of .11. The SNR for the other countries ranges from .18 (Germany) to .57 (Ireland). United States obtains a reasonably high SNR (0.23). The finding that Greece has the lowest SNR is perhaps not too surprising. More surprising is perhaps the fact that Germany has the second-lowest SNR and that Ireland is most credible according to this metric. To get a better grasp of the

[4] For Portugal, however, we set $\rho_1^{perm} = 0.7$ to obtain convergence in the estimations.

mechanisms at work, Figure 2 shows the two-sided smoothed permanent component along with the actual g_t series.

From Figure 2, we see that Ireland is characterized by very persistent movements in g_t during the sample period. Thus, according to our simple, yet straightforward, assumptions about the permanent and transient components, Ireland is estimated to have a relatively high variance of the permanent component, and thus a relatively high SNR. Germany, on the other hand, which does not have a low-frequency drift its series, will have relatively more mass in the transient component and thus a lower SNR. Because we do not think a country (like Germany) who manages to keep its spending ratio roughly constant for a considerable period should necessarily be plagued by imperfect credibility if they indeed attempted to reduce their spending ratio, we believe this finding underscores possible limitations with our method, which is statistical in nature and does not take intangibles like the political decision process into consideration.[5]

Despite these shortcomings of our simple method, we believe it is sufficiently robust to point out that Greece is special: As can be seen from Figure 2, the Greek spending series has more high-frequency movements than the German series and little signs of an upward or downward trend. Hence, it seems totally reasonable that our method classifies the country to have a low SNR. Moreover, that Greece has the lowest SNR is a robust finding in our estimations and is not sensitive to the strict priors we adopt for ρ_1^{perm}, ρ_2^{perm} and ρ^{temp}. When we vary these parameters within reasonable bounds, Greece comes out with the lowest SNR in 92 percent of the draws. If anything, the smoothed permanent component in Figure 2 may be too fast-moving for all countries, and one could easily make a case that the SNRs should estimated to be lower than reported in Table 1.

In the following, we use the results for Spain – which are in the mid-range of the SNR-ratios – in our model simulations. This should give us reasonable assessment of how important credibility issues may be. Nevertheless, we acknowledge that our empirical results should be taken with a grain of salt and more work on refining and examining the robustness of our findings with an alternative empirical strategy would be of interest.[6]

[5] For instance, it cannot deal with the impact of the German reunification, which is likely to have exerted an upward pull on government expenditures in Germany.

[6] Following the approach in Erceg and Levin (2003), one such strategy would be to estimate the signal-

3 Imperfect Credibility in a Stylized Small Open Economy Model

We start our model in a simple stylized DSGE model. In Section 4 we examine the robustness of our results in a workhorse large scale model.

3.1 Model

Our stylized model is very similar to the small open economy model of Clarida, Galí, and Gertler (2001). Households consume a domestic and foreign good that are imperfect substitutes. To rationalize Calvo-style price rigidities, the domestic good is assumed to be a comprised of a continuum of differentiated intermediate goods, each of which is produced by a monopolistically competitive firm. The government consumes some of the domestic good and finances itself through lump-sum taxes. The home economy is small in the sense that it does not influence any foreign variables, and financial markets are complete. To save space, we present only the log linearized model in which all variables are expressed as percent or percentage point deviations from their steady state levels, and we omit all foreign variables.

Under an independent monetary policy, the key equations are given by:

$$x_t = \mathrm{E}_t x_{t+1} - \hat{\sigma}^{open}(i_t - \mathrm{E}_t \pi_{t+1} - r_t^{pot}), \tag{5}$$

$$\pi_t = \beta \mathrm{E}_t \pi_{t+1} + \kappa_x x_t, \tag{6}$$

$$i_t = \gamma_\pi \pi_t + \gamma_x x_t, \tag{7}$$

$$y_t = \hat{\sigma}^{open} \tau_t + g_y g_t + (1 - g_y)(1 - \omega)\nu_c \nu_t \tag{8}$$

noise ratio by minimizing the sum of squared deviations between observed data and one year-ahead expected government spending and the corresponding inflation expectations implied by our state-space model using forecasts from OECD economic outlooks. A clear disadvantage of such an approach is that it relies heavily on the unbiasedness of the forecasts, which is a strong assumption. We instead plan to improve our current procedure by estimating the persistence parameters jointly with the standard deviations using Bayesian techniques.

$$y_t^{pot} = \frac{1}{\phi_{mc}\hat{\sigma}^{open}}[g_y g_t + (1-g_y)(1-\omega)\nu_c \nu_t] \tag{9}$$

$$\tau_t^{pot} = -\frac{1}{\hat{\sigma}^{open}}(1 - \frac{1}{\phi_{mc}\hat{\sigma}^{open}})\,[g_y g_t + (1-g_y)(1-\omega)\nu_c \nu_t] \tag{10}$$

$$r_t^{pot} = \mathrm{E}_t \tau_{t+1}^{pot} - \tau_t^{pot}, \tag{11}$$

where $\hat{\sigma}^{open} = (1-g_y)[(1-\nu_c)(1-\omega)^2\sigma + \omega(2-\omega)\varepsilon_P]$ and the superscript 'pot' denotes the level that would prevail under completely flexible prices.

As in Clarida et al, the first three equations represent the New Keynesian open economy IS curve, Phillips Curve, and monetary rule, respectively, that jointly determine the output gap ($x_t = y_t - y_t^{pot}$), price inflation (π_t), and the nominal policy rate (i_t). Thus, the output gap x_t depends inversely on the deviation of the real interest rate ($i_t - \mathrm{E}_t\pi_{t+1}$) from the potential real interest rate r_t^{pot}, with the sensitivity parameter $\hat{\sigma}^{open}$ varying positively with the household's intertemporal elasticity of substitution in consumption σ and substitution elasticity ε_P between foreign and domestic goods (the relative weight on the latter rises with trade openness ω). The Phillips curve slope κ_x in equation (6) is the product of parameters determining the sensitivity of inflation to marginal cost κ_{mc} and of marginal cost to the output gap ϕ_{mc}, i.e. $\kappa_x = \kappa_{mc}\phi_{mc}$. From equation (9), a contraction in government spending g_t (g_y is the government spending share of steady state output) or negative taste shock ν_t (ν_c is a scaling parameter) reduces potential output y_t^{pot}. Even so, both of these exogenous shocks, if negative, cause the the potential terms of trade τ_t^{pot} to depreciate (a rise in τ_t^{pot} in equation 10) because they depress the marginal utility of consumption (noting $\phi_{mc}\hat{\sigma}^{open} > 1$). If both shocks follow stationary AR(1) processes, and hence have front-loaded effects, a reduction in government spending or negative taste shock reduces r_t^{pot}. Finally, the nominal exchange rate e_t equals $p_t + \tau_t$ where $p_t = p_{t-1} + \pi_t$.

Given that the form of the equations determining output, inflation, and interest rates is identical to that in a closed economy – as emphasized by Clarida et al – results from extensive closed economy analysis, e.g., Erceg and Lindé (2010a) are directly applicable for assessing the impact of government spending shocks within this open economy framework.

We next consider how the model is modified for the CU case (largely following the analysis of Corsetti et al 2011). A CU member takes the nominal exchange rate as fixed, so that the terms of trade τ_t is simply the gap between home and foreign price levels, i.e., $\tau_t = -(p_t - p_t^*) = -p_t$.[7] Moreover, the home economy is assumed to be small enough that the policy rate is effectively exogenous. Given that equation (8) implies that the output gap is proportional to the terms of trade gap, i.e.

$$x_t = \hat{\sigma}^{open}(\tau_t - \tau_t^{pot}), \tag{12}$$

the price setting equation (6) may be expressed as a second order difference equation in the terms of trade, yielding a solution of the form:

$$\tau_t = \lambda\tau_{t-1} + \kappa_x\hat{\sigma}^{open}\frac{\lambda}{1-\beta\rho\lambda}\tau_t^{pot}, \tag{13}$$

The persistence parameter $\lambda = 0.5(a - \sqrt{a^2 - 4/\beta}\ )$, where $a = (\frac{1}{\beta})(1 + \beta + \kappa_x\hat{\sigma}^{open})$, lies between 0 and unity, and ρ is the persistence of the shocks (assumed to be described by AR(1) processes for the moment being). Equation (13) has two important implications. First, because $\lambda > 0$, a contraction in government spending – which raises τ_t^{pot} by equation (10) – moves τ_t in the same direction, implying a depreciation. Together with equation (8), this implies that the government spending multiplier m_t is strictly less than unity, i.e., $m_t = \frac{1}{g_y}\frac{dy_t}{dg_t} = 1 + \frac{\hat{\sigma}^{open}}{g_y}\frac{d\tau_t}{d\tau_t^{pot}}\frac{d\tau_t^{pot}}{dg_t} < 1$ (recalling that $\frac{d\tau_t^{pot}}{dg_t} < 0$). Second, as $\kappa_x\hat{\sigma}^{open}$ becomes very small, λ rises toward unity and the coefficient on τ_t^{pot} shrinks, implying very gradual adjustment of the terms of trade to τ_t^{pot} (and hence to a change in government spending); conversely, the terms of trade adjustment is more rapid if $\kappa_x\hat{\sigma}^{open}$ is larger. In economic terms, the terms of trade adjusts more quickly if the Phillips Curve slope is higher (high κ_x), or if aggregate demand is relatively sensitive to the terms of trade (high $\hat{\sigma}^{open}$).

3.2 The Signal Extraction Problem

To allow for imperfect credibility, we make the standard assumption that agents in the economy have to solve a signal extraction problem to filter out permanent (g_t^{perm}) and transient

[7] As the real exchange rate is proportional to τ_t, we use the terms interchangeably.

(g_t^{temp}) spending components from observed overall government spending, g_t. The processes for these variables were specified in $(1)-(3)$, and can be rewritten in the following state-space form:

$$\begin{array}{c} g_t - \bar{g} = HZ_t \\ Z_t = FZ_{t-1} + \frac{1}{g_y}V_t \end{array} \tag{14}$$

where

$$\begin{aligned} Z_t &= \left[\begin{array}{ccc} g_t^{perm} - \bar{g} & g_{t-1}^{perm} - \bar{g} & g_t^{temp} \end{array} \right]', V_t = \left[\begin{array}{ccc} \varepsilon_t^{perm} & 0 & \varepsilon_t^{temp} \end{array} \right]' \sim N(0, Q), \\ F &= \left[\begin{array}{ccc} 1 + \rho_1^{perm} - \rho_2^{perm} & -\rho_1^{perm} & 0 \\ 1 & 0 & 0 \\ 0 & 0 & \rho^{temp} \end{array} \right], H = \left[\begin{array}{ccc} 1 & 0 & 1 \end{array} \right], Q = \left[\begin{array}{ccc} \sigma_{perm}^2 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & \sigma_{temp}^2 \end{array} \right]. \end{aligned} \tag{15}$$

In the "Full credibility" case, private agents know the present and future path of the permanent shock. In the "No credibility" case, they always believe that all shocks are temporary, regardless of the spending path. In the "Imperfect credibility" case, they do not observe the shocks directly, but they learn them through Kalman filtering. This is a standard device used in the learning literature for modeling a learning process (Evans and Honkapohja, 2001), because this algorithm is optimal for extracting a signal from a given sample in real-time (Harvey, 1989).

In the "Imperfect credibility" case, we assume that agents compute recursively filtered estimates $Z_{t|t}$ of unobserved components at date t (given information up to date t) and their variance $P_{t|t}$ through the following Kalman filter:

$$\begin{aligned} Z_{t|t} &= FZ_{t-1|t-1} + L_t v_t, \\ P_{t|t} &= FPF' + Q - \left(FP_{t-1|t-1}F' + Q\right) H' h_{t|t-1}^{-1} H \left(FP_{t-1|t-1}F' + Q\right), \end{aligned} \tag{16}$$

where the forecast error v_t, its variance $h_{t|t-1}$ and the gain L_t of the filter is computed with the formulas:

$$\begin{aligned} v_t &= g_t - \bar{g} - HFZ_{t-1|t-1}, \\ h_{t|t-1} &= H\left(FP_{t-1|t-1}F' + Q\right) H', \\ L_t &= \left(FP_{t-1|t-1}F' + Q\right) H' h_{t|t-1}^{-1}. \end{aligned} \tag{17}$$

Within the stylized model of previous section (or the large-scale model of section 4), we incorporate this signal extraction process by replacing the 3-dimensional true vector of exogenous shocks V_t by the vector of shocks $\tilde{V}_t = g_y \left(Z_{t|t} - FZ_{t-1|t-1} \right) = g_y L_t(g_t - \bar{g} - HFZ_{t-1|t-1})$ that underlies the filtered estimates $Z_{t|t}$.[8]

3.3 Calibration

For the calibration of the Phillips Curve parameter *relating inflation to marginal cost*, we set $\kappa_{mc} = 0.012$, towards the low end of empirical estimates (see e.g. Altig et al., 2011, Galí and Gertler, 1999, and Lindé, 2005). If factors were completely mobile, this calibration would imply mean price contract durations of about 10 quarters, but – as emphasized by an extensive literature (e.g., Altig et al., 2011 and Smets and Wouters, 2007) – the reduced form slope could be regarded as consistent with much shorter contract durations under reasonable assumptions about strategic complementarities.

For other parameters, we adopt a standard quarterly calibration by setting the discount factor $\beta = 0.995$, and steady state net inflation $\pi = .005$ so that $i = .01$. We set $\sigma = 1$ (log utility), the capital share $\alpha = 0.3$, the Frisch elasticity of labor supply $\frac{1}{\chi} = 0.4$, the government spending share $g_y = 0.2$, and the taste shock parameter $\nu_c = 0.01$ (implying $\phi_{mc} = \frac{\chi}{1-\alpha} + \frac{1}{\tilde{\sigma}^{open}} + \frac{\alpha}{1-\alpha} = 5.1$). In the absence of CU membership, monetary policy completely stabilizes output and inflation (achieved by making γ_π (or γ_x) in eq. 7 arbitrarily large). We will refer to this as IMP – independent monetary policy. Finally, the open economy parameters $\omega = 0.3$, and $\varepsilon_p = 1.5$.

For government spending, we will consider both front-loaded and gradual consolidations. We start out by studying front-loaded consolidations that comes on line with full force immediately. In this case, we assume actual spending follows an AR(1)-process with a very high persistence (0.999) and is reduced by 1 per cent as share of trend output. The parameters in this case is taken from the estimations for Spain in Section 2 but sets $\rho_1^{perm} = 0$.[9] Second, we study the consequences of the fiscal authority proceeding gradually, in which case we simply use the estimated AR(2)-process for Spain but adjust the size of the initial spending shock so that spending eventually declines reduced by 1 percent as share of trend

[8] Notice that even if the true variance of the second state innovation is equal to 0, the second component of $\tilde{V}_t$ will differ from 0 when the permanent component follows an AR(2) process.

[9] As discussed briefly in Section 2, we decided to use results for Spain to have an intermediate case between full and no credibility. Given the low estimated SNR for Greece, it will behave very closely to the "No credibility" case in the short- and medium term.

GDP. For the benchmark value $\rho_1^{perm} = 0.9$, it takes about 5 years before the consolidation comes into full effect in this case.

3.4 Results

We now proceed to discuss the quantitative results in the stylized model. We first discuss the reference case with independent monetary policy (Figure 3), and then turn to the case where the consolidating economy is a small member of a currency union (Figures 4 and 5).

3.4.1 Independent Monetary Policy

Figures 3 provide the results under IMP for three alternative assumptions about credibility, assuming that the actual and permanent spending path follows an AR(1) near unit root process. The blue solid line shows results under perfect credibility: in this case the government cuts spending aggressively with 1 percent of trend GDP today and everyone believes this cut to be near permanent, as indicated by the solid black line in the bottom panels. The dotted green line shows the "No credibility" case, in which agents in the economy in each period think that spending will revert quickly back to baseline (0) with the root $\rho^{temp} = 0.8$ as indicated by the thin red lines in the bottom left panel. This simulation follows in't Veld (2013) by assuming that agents never update their expectations regarding the persistence of the cut although the government keeps actual spending at the same level as under perfect credibility. Finally, the red dash-dotted red line shows the "Imperfect credibility" case, in which agents solve the signal extraction problem outlined in Section 3.2 to filter out the transient and permanent components of the spending cut in each period. Under learning about the transient and permanent component, a well-known result in the AR(1)-case is that the filtered share of the permanent component in the first period will be

$$g_{0|0}^{perm} = \frac{\sigma_{perm}^2}{\sigma_{perm}^2 + \sigma_{temp}^2} \tag{18}$$

and the transient component will simply be $1 - g_{t|t}^{perm}$. Given our estimates of σ_{perm} and σ_{temp} for the various countries reported in Table 1, it is clear that the filtered permanent component is quite low in the first period. With the estimates for Spain, $g_{0|0}^{perm}$ will be a little below 5 per cent of the total cut.

Although the spending cut is very persistent, it will take over 5 years before the permanent component exceeds the transient component as shown in the bottom right panel. Given our calibration of the parameters in learning process, it will take as long as 10 years before the permanent component equals 3/4 of the actual spending cut. Had we used the standard errors for Greece in Table 1, the permanent component would only constituted about a third of total cut after 10 years, so a Greek calibration of the "Imperfect credibility" case would have very similar properties as the "No credibility" case in the short- and medium term.

With this in mind, we now discuss the economic consequences of the alternative assumptions on credibility. Within the context of the simple model, the nominal exchange rate and thus the terms of trade, τ_t, depreciates considerably on impact as shown in the next-to-top right panel in the figure. This result can be shown analytically by combining eqs. (9) and (8), and recognizing that an unconstrained aggressive monetary policy rule which fully stabilizes inflation will keep actual output at its potential level (as shown by the top left and right panels in the figure). So under IMP, an aggressive policy rule which engineers a sharp depreciation of the nominal exchange rate can keep the paths for τ_t and y_t unaffected by the degree of credibility. Even so, the effects on the potential real rate differ, implying that different paths of the nominal policy rate are called for. In the "Perfect credibility" case, r_t^{pot} remains roughly unchanged as it is determined by the expected change in τ_t (see eq. 11). Accordingly, no major cuts in the nominal policy rate are needed; inflation and the output gap can be kept at target levels nevertheless.

In the "No credibility" case, however, r_t^{pot} will fall substantially because τ_t in each point in time is expected to start to revert (i.e. appreciate) back towards its baseline value. This happens because agents in the model do not expect that the spending cut will be long-lasting. Accordingly, the central bank needs to cut the policy rate in tandem with the fall in the potential real rate to keep output at potential and inflation at its targeted rate. The "Imperfect credibility" case is somewhere in between these two polar cases (depending on the signal-to-noise ratio) and thus requires some additional monetary policy accommodation by the central bank. To wrap up, within the context of the simple model outlined above, impaired credibility implies that some additional monetary policy accommodation is needed to ameliorate adverse effects on the output gap and inflation during front-loaded fiscal consolidations. Notice however, that even when the consolidation is perfectly credible, the central bank ensures that output is kept at potential and inflation at target by engineering a sharp depreciation of the nominal exchange rate and the terms-of-trade.

3.4.2 Currency Union Membership

We now redo the same experiment as in Figure 3, but assume that the consolidating economy is a small member of a currency union. In all other respects the nature of the experiment remains identical to the IMP case just discussed.

The CU results are reported in Figure 4. The direct difference w.r.t. the IMP results is that neither the nominal exchange rate nor the nominal interest rate changes, as seen in the upper panels. Because the foreign price level, p_t^*, is unchanged (follows from our SOE assumption), any changes in the terms-of-trade thus has to happen through movements in domestic inflation when the nominal exchange rate is fixed. Hence, inflation (next-to-upper-left panel in Figure 4) has to fall in order for the actual τ_t to depreciate and close the gap to the potential terms-of-trade τ_t^{pot} (shown by the dashed black line in the next-to-upper-right panel in Figure 4). Even so, because prices are sticky inflation will not fall enough in the short-term and τ_t will therefore only depreciate gradually, resulting in a significant negative terms-of-trade gap ($\tau_t - \tau_t^{pot} < 0$). This negative terms of trade gap triggers a negative output gap according to equation (12), and output therefore falls below its potential level, as seen in the next-to-last panel in the left column.

Currency union membership thus generates a negative output gap and a fall in the inflation regardless of whether credibility is impaired or not. Even so, the lower the ability of policy makers to establish credibility for the cuts to be long-lasting, the more adverse the effects on the economy are under CU membership. In the full credibility case, actual output falls roughly four times more than potential output, but the output gap is closed after roughly 4 years. In the no credibility case, the sustained decline in output is about three times larger than that of potential output. The imperfect credibility case is somewhere in between; sizeable but the losses are notably smaller than the no credibility case after 3 years. An easy way to understand why the output costs are more substantial and persistent in the no-credibility case is to look at real interest rate gap. As we noted in Figure 3, the r_t^{pot}

fell much more in the no-credibility case compared to full credibility. Therefore, although the actual real interest rate rises less in the NC case compared to the FC case, as seen in the next-to-bottom-right panel in Figure 4, the NC case is associated with a significantly larger adverse impact on the real interest rate gap, $r_t - r_t^{pot}$, compared to the FC case. This explains why the output gap falls much less in the FC case, although the actual real interest rate rises by less in the NC case. Again, the adverse impact on the real interest rate gap for the imperfect credibility case in somewhere in between these polar cases.

Our analysis shows that CU constraints might impose significant headwinds for front-loaded aggressive consolidatios to reduce debt at low output costs, especially when credibility is impaired. Some papers in the literature has therefore suggested that consolidations should be implemented more gradually, as more gradual consolidations does not require the same dose of monetary accommodation as front-loaded consolidations do. We now proceed to show that impaired credibility, in addition to the monetary constraints posed by CU membership, is an additional reason to proceed in a gradual fashion.

As discussed in Section 3.3, we implement a more gradual consolidation profile by letting actual and permanent spending follow an AR(2)-process with the parameters used to produce the estimation results in Table 1. It is imperative to understand that both the front-loaded consolidation approach studied in Figures 3-4 and the gradual approach studied in Figure 5 features exactly the same signal-to-noise ratio for the innovations; so a higher signal-to-noise ratio is not the reason why the filtered permanent component catches up much quicker with the actual spending cut in the gradual case (see lower right panel in Figure 5). Instead, the reason why the filtered permanent component swamps the transient component already after 3 years is the profile of the spending cut. Under the assumption that the temporary component follows an AR(1)-process with uncorrelated residuals, agents simply find it more unlikely that several negative temporary shocks cause the gradual decline in actual spending they observe in Figure 5. As such, a gradual path is more credible compared to the front-loaded path studied earlier. This is counter to the conventional wisdom, in which a front-loaded spending cut is meant to build credibility for a persistent spending cut. This intution might be right, but our analysis makes clear it rests on “political capital” arguments, and not economic arguments.

Turning to the results in Figure 5, we see that the difference between the FC and IC cases are starts to shrink considerably already after 10 quarters, reflecting that agents learn rather quickly that the spending cut is very persistent. For the NC case, there are no differences as the transient component by construction will be the same regardless if the consolidation is front-loaded or gradual. But in the realistic case where there is indeed some learning, Figure 5 show that private agents will learn faster that the fiscal consolidation is permanent if the consolidation is implemented gradually. Hence, the responses with imperfect credibility is much close to those obtained under perfect credibility.

Since the different spending profiles in Figures 4 and 5 makes it hard to compare the relative impact on output, we compute the cumulated spending multipliers as a final exercise. Table 2 shows the present value government spending multiplier as in Uhlig (2010), which at horizon K is defined as

$$m_K = \frac{1}{g_y} \frac{\sum_0^K \beta^K \Delta y_{t+K}}{\sum_0^K \beta^K \Delta g_{t+K}}. \tag{19}$$

Thus, the impact multiplier m_0 is simply given by $\frac{1}{g_y}\frac{\Delta y_t}{\Delta g_t}$. Table 2 report results for the impact, 4, 12, 20 and 40 quarter cumulated multipliers.

Table 2: Cumulated Spending Multipliers.

	Front-loaded Consolidation					Gradual Consolidation				
	CU multiplier					CU Multiplier				
Cred. Assumption	m_0	m_4	m_{12}	m_{20}	m_{40}	m_0	m_4	m_{12}	m_{20}	m_{40}
No Credibility	0.91	0.81	0.68	0.64	0.59	0.91	0.84	0.72	0.66	0.61
Perfect Credibility	0.84	0.67	0.45	0.37	0.29	0.44	0.40	0.33	0.29	0.25
Imperf. Credibility	0.90	0.80	0.66	0.58	0.49	0.90	0.83	0.66	0.54	0.38
	IMP multiplier - Full Stab.					IMP multiplier - Full Stab.				
All cred. ass.	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21

Note: CU multiplier is the multiplier computed according to equation (19) using the data in Figures 3-5. m_0 is the impact multiplier, and m_K where $K = 4, 12, 20, 40$ the cumulated 1-, 3-, 5- and 10-year multiplier. The "Front-Loaded Consolidation" refers to the AR(1) case, and the "Gradual Consolidation" to the AR(2) case. IMP multiplier is the corresponding multiplier when monetary policy provides full stabilization for both consolidation profiles. The multiplier schedules are in this case invariant to alternative credibility assumptions, and are simply reported as "All cred. ass".

As can be seen from Table 2, the results show that the cumulated multiplier schedule is flat under IMP which is able to keep output at its potential level. Given equation (9), this is to expected and the multiplier simply equals $\frac{1}{\phi_{mc}\hat{\sigma}^{open}}$. It is important to notice though, that significantly less monetary accommodation is needed for the gradual consolidation to keep output at it potential level, implying the multiplier would be more elevated in the front-loaded case if monetary policy were able to provide less stimulus (for instance by being constrained by the effective lower bound on interest rates).

Turning to the CU results in the first three rows with multipliers, we see that the multipliers are highest in the NC case, regardless of the consolidation is gradual or front-loaded. In fact, for the NC case the short- and long-run cumulated multipliers are independent of the consolidation profile. This is expected because of the way we add unanticipated shocks to the temporary spending process to keep actual spending at the target path in the NC case. When credibility if perfect, we see that the multiplier schedule is signifantly lower in the gradual case, especially in the shorter-term. A similar finding hold when agents solve the signal-extraction problem (imperfect credibility), with the interesting twist that the short-term multipliers (m_0 and m_4) are relatively high even under under a gradual profile while the long-run multiplier is substantially lower ($m_{40} = 0.38$ instead of 0.49). However, because relatively small spending cuts are undertaken in the short run under a gradual strategy, the still somewhat elevated multiplier in the short run is less damaging to the level of output compared to a front-loaded strategy. Thus, the table clearly identifies imperfect credibility as an additional reason to pursue consolidations more gradually and confirms the visual results in Figures 4 and 5.

4 Robustness in a Large-Scale Open Economy Model

In this section, we examine the robustness of our results in Section 3 in a fully-fledged open economy model. Before we turn to the results in Sections 4.3 and 4.4, we provide a model overview with a focus on the modeling of fiscal policy and discuss the calibration of some key parameters. A complete description of the model is available in Appendix A.

4.1 Model

The model is adopted from Erceg and Lindé (2010, 2013) aside from some features of the fiscal policy specification (as discussed in further detail below), and consists of two countries (or country blocks) that differ in size, but are otherwise isomorphic. The first country is the home economy, or "Periphery", while the second country is referred to as the "Core." The countries share a common currency, and monetary policy is conducted by a single central bank, which adjusts policy rates in response to the aggregate inflation rate and output gap in the currency union. By contrast, fiscal policy may differ across the two blocks. Given the isomorphic structure, our exposition below largely focuses on the structure of the Periphery.

Abstracting from trade linkages, the specification of each country block builds heavily on the estimated models of Christiano, Eichenbaum and Evans (2005), CEE henceforth, and Smets and Wouters (2003, 2007), SW henceforth. Thus, the model includes both sticky nominal wages and prices, allowing for some intrinsic persistence in both component; habit persistence in consumption; and embeds a $Q-$theory investment specification modified so that changing the level of investment (rather than the capital stock) is costly. However, our model departs from CEE and SW in two substantive ways. First, we assume that a fraction of the households are "Keynesian", and simply consume their current after-tax income; this evidently contrasts with the analysis in our stylized model which assumed that all households made consumption decisions based on their permanent income. Galí, López-Salido and Vallés (2007) show that the inclusion of non-Ricardian households helps account for structural VAR evidence indicating that private consumption rises in response to higher government spending. Second, we incorporate a financial accelerator following the basic approach of Bernanke, Gertler and Gilchrist (1999).

On the open economy dimension, the model assumes producer currency pricing as in the benchmark model, but allow for incomplete international financial markets (the stylized model in Section 3 presumed complete financial markets domestically and internationally).

To analyze the behavior of the model, we log-linearize the model's equations around the non-stochastic steady state. Nominal variables are rendered stationary by suitable transformations. To solve the unconstrained version of the model, we compute the reduced-form solution of the model for a given set of parameters using the numerical algorithm of Anderson and Moore (1985), which provides an efficient implementation of the solution method proposed by Blanchard and Kahn (1980). Since the Periphery is assumed to be very small relative to the Core country block, there is no need to take the ZLB into account as the actions of the Periphery will only have an negligible impact on the currency union as a whole.

The approach to analyzing the impact of imperfect credibility for fiscal consolidation is the same as in the stylized model, but because we are also interested in assessing the implications for the evolution of government debt, some further details on the modeling of debt stabilization are in order.

As noted in the description of the model in Appendix A, we presume that governments in Periphery and the Core has the capability to issue debt. In our benchmark specification, we further assume that policymakers adjust labor income taxes gradually to keep both the debt/GDP ratio, b_{Gt}, and the gross deficit, Δb_{Gt+1}, close to their targets (denoted b^*_{Gt} and Δb^*_{Gt+1}, respectively). Thus, the labor tax rate evolves according to:

$$\tau_{Nt} - \tau_N = \nu_{\tau_0}\left(\tau_{Nt-1} - \tau_N\right) + \left(1 - \nu_{\tau_0}\right)\left[\nu_{\tau_1}(b_{Gt} - b^*_{Gt}) + \nu_{\tau_2}(\Delta b_{Gt+1} - \Delta b^*_{Gt+1})\right]. \quad (20)$$

So when the government cuts the discretionary component of spending, g_t, in order to reduce government debt, we assume that the labor income tax τ_{Nt} will deviate from its steady state value τ_N gradually if a gap emerges between actual and desired debt and deficit levels.[10]

Our main simulations assume that the government in the Periphery desires to reduce its debt target b^*_{Gt}. It is realistic to assume that policymakers would reduce the debt target gradually to help avoid potentially large adverse consequences on output. To capture this gradualism, we assume that the (end of period t) debt target b^*_{Gt+1} follows an AR(2) process:

$$b^*_{Gt+1} - b^*_{Gt} = \rho_{d_1}(b^*_{Gt} - b^*_{Gt-1}) - \rho_{d_2} b^*_{Gt} + \varepsilon_{d^*,t}, \quad (21)$$

where the coefficient ρ_{d_1} is set to 0.99 and ρ_{d_2} is set to close to 0 (10^{-8}) so that the reduction in debt is gradual ($\rho_{d_1} > 0$) and essentially permanent ($\rho_{d_2} \approx 0$). The target path for Periphery government debt is plotted in Figure 6 (black dashed line) and is set so that it closely mimics the actual debt path under full credibility (the blue solid line). Thus, in the full credibility case, there is little movement of the labor income tax rate as the gap between actual and desired debt and deficit levels is negligable.

[10] Lower case letters are used to express a variable as a percent or percentage point deviation from its steady state level. Note that real government debt $b_{G,t}$ is defined as a share of steady state GDP and expressed as percentage point deviations from their steady state or "trend" values. That is, $b_{G,t} = \left(\frac{B_{G,t}}{P_t Y}\right) - b_G$, where $B_{G,t}$ is nominal government debt, P_t is the price level, and Y is real steady state output.

The Core is assumed to simply follow an endogenous tax rule as in (20), but does not change its debt target.

4.2 Calibration

Here we discuss the calibration of the key parameters pertaining to fiscal policy and trade; the remaining parameters – which are adopted from Erceg and Lindé (2013) – are reported and discussed in Appendix A.

The model is calibrated at a quarterly frequency. Structural parameters are set at identical values for each of the two country blocks, except for the parameter ζ determining population size (as discussed below), the fiscal rule parameters, and the parameters determining trade shares.

The parameters pertaining to fiscal policy are intended to roughly capture the revenue and spending sides of euro area government budgets. The share of government spending on goods and services is set equal to 23 percent of steady state output. The government debt to GDP ratio, b_G, is set to 0.75, roughly equal to the average level of debt in euro area countries at end-2008. The ratio of transfers to GDP is set to 20 percent. The steady state sales (i.e., VAT) tax rate τ_C is set to 0.2, while the capital tax τ_K is set to 0.30. Given the annualized steady state real interest rate (2 percent), the government's intertemporal budget constraint then implies that the labor income tax rate τ_N equals 0.42 in steady state. The coefficients of the tax adjustment rule (20) are set so that labor income taxes respond very gradually, which is achieved by setting $\nu_{\tau_0} = 0.985$ and $\nu_{\tau_1} = \nu_{\tau_2} = .1$. This implies that τ_{Nt} in the long-run is decreased (increased) by 0.1 percentage points in response to target deviations from debt $(b_{Gt} - b^*_{Gt})$ and deficit $(\Delta b_{Gt+1} - \Delta b^*_{Gt+1})$ with 1 percentage points. However, because ν_{τ_0} is set close to unity, the short-run response is substantially smaller. For the Core, we assume the same unaggressive tax rule.

The size of the Periphery is calibrated to be a very small share of euro area GDP, so that $\zeta = 0.02$. This corresponds to the size of Greece, Ireland or Portugal in euro area GDP. Identifying the mentioned countries as the Periphery to calibrate trade shares, the average share of imports of the Periphery from the remaining countries of the euro area was about 14 percent of GDP in 2008 (based on Eurostat). This pins down the trade share parameters

ω_C and ω_I for the Periphery under the additional assumption that the import intensity of consumption is equal to 3/4 that of investment. Given that trade is balanced in steady state, this calibration implies a very small export and import share for the Core countries as share of GDP.

4.3 Benchmark Results

The results in the benchmark calibration of the workhorse model are reported in Figure 6 for the CU case. By comparing the paths for government spending in the bottom panels to those in Figures 3 and 4, we see that they are the same as those in the stylized model when the permanent spending component follows an AR(1)-process. This ensures us that the modeling of government spending is identical as that in the simple model.

Turning to the other variables, we see that the main features of the results are very similar to those reported for the stylized model. The potential real rate falls the most in the "No credibility" case and the least under "Perfect credibility", but because the Periphery is a small member of the currency union, nominal interest rates in the Periphery and the Core are essentially unaffected (as can be seen from the upper panels). As a result, inflation and output falls substantially more when credibility is impaired and progress to reduce debt is significantly slower, implying that a large wedge between actual and the target level of government debt opens up. This is particularly the case under "No credibility", when debt is essentially unaffected for almost three years in our calibration. The unresponsiveness of government debt to GDP ratio in this case reflects lower tax revenues and higher service costs of debt, plus the fact that GDP itself falls.

4.4 Results with Endogenous Spreads

In the benchmark calibration of the model, we assumed that interest rates faced by the government and banks in the Periphery and Core were equal to the currency area interest rate set by the CU central bank (notwithstanding a tiny difference to imply stationary dynamics of Periphery net foreign assets). To examine conditions under which fiscal consolidation may be expansionary, we follow Erceg and Lindé (2010) and Corsetti, Kuester, Meier and Muller (2012) and assume that the interest rate faced by the government and banks in the Periphery equals the interest rate set by the CU central bank plus a risk-spread which depends positively on the government deficit and debt level. If we let i_t^{Per} denote the interest rate in Periphery, we thus have

$$i_t^{Per} - i_t = \psi_b(b_{Gt+1} - b_G) + \psi_d(b_{Gt+1} - b_{Gt}), \tag{22}$$

where we recall that b_{Gt+1} is the end-of-period t government debt level and i_t the interest rate set by the CU central bank. The specification in (22) is motivated by the spread equation estimated by Laubach (2010) for the Euro area, and captures the idea that countries with high government deficits and debt levels face higher spreads due to a higher risk of default. There is a substantial empirical literature that has examined the question of whether higher deficits and debt lead to increasing interest rates, but it has provided at best mixed evidence in favor of positive values of ψ_b and ψ_d, see e.g. Evans (1985, 1987). However, the papers in this literature have typically used data from both crisis periods and non-crisis periods, and as argued by Laubach (2010) this approach is likely to bias downward the estimates, as the parameters tend to be positive in crisis periods only (close to zero in non-crisis periods). As we are examining the effects of fiscal consolidations under fiscal stress (i.e. high actual and projected debt and deficit) periods, we believe it is worthwhile to entertain the assumption that ψ_b and ψ_d are both positive.

As a tentative calibration, we set $\psi_b = 0.025$ and $\psi_d = 0.05$, implying that a one percent decline in government debt decreases the spread by 2.5 basis points, and that a one percent decline in the budget deficit decreases the spread with 5 basis points. While these elasticities are somewhat on the upper side relative to the evidence reported by Laubach (2010), they are nevertheless useful to help gauge the potential implications of this channel. All other aspects of the experiment remains the same as in Section 4.3.

The results with endogenous spreads are reported in Figure 7. As seen from the figure, the output costs of aggressive spending-based consolidation can be reduced substantially if long-term interest rate spreads fall (upper left panel), especially when the degree of credibility to follow through and make the spending cuts permanent is high. In our specific calibration, long-term spreads in the Periphery fall enough in order for the consolidation to have expansionary effects on the economy after roughly two years even under imperfect credibility (dash-dotted red line).

Consequently, these results present a favorable case for the view that aggressive consolidation can be an efficient tool to reduce public debt at low output cost. However, it is important to point out that this finding hinges crucially on how the consolidation program is implemented, and the results may be much less benign under an alternative – arguably equally empirically realistic – modeling of the consolidation program.

Specifically, we assume the government drops the gradual labor income tax rule (20) and instead uses government spending entirely to achieve its fiscal targets. Thus, total government spending (g_t^{tot}) is now comprised of an endogenous component, denoted g_t^{endo} henceforth, as well the discretionary component g_t which is the same as before. Following Erceg and Linde (2013), g_t^{endo} is assumed to adjust endogenously according to the rule:

$$g_t^{endo} = \nu_{g_0} g_{t-1}^{endo} + (1-\nu_{g_0}) \left[\nu_{g_1} \left(b_{Gt} - b_{Gt}^* \right) + \nu_{g_2} \left(\Delta b_{Gt+1} - \Delta b_{Gt+1}^* \right) \right]. \tag{23}$$

In this alternative specification, the Periphery labor income tax rate is assumed to be constant (at its steady state value of τ_N); however, the Core is still assumed to use the labor income tax rule to stabilize debt. We assume rather aggressive coefficients in the spending rule (23) by setting $\nu_{g_0} = 0.8$, $\nu_{g_1} = -1$ and $\nu_{g_2} = -0.5$. Given our steady-state share of government spending (0.23), these coefficients imply that g_t^{endo} in the long-run is decreased by 0.25 and 0.125 percent of trend GDP, respectively, in response to target deviations from debt ($b_{Gt} - b_{Gt}^*$) and deficit ($\Delta b_{Gt+1} - \Delta b_{Gt+1}^*$). In the short-run, our choice of ν_{g_0} implies that the response is reduced by 4/5.

In Figure 8 we compare results of the gradual labor income tax rule with the above-mentioned more aggressive spending-based rule to stabilize debt and defcits around their targets when interest rate spreads are endogenous. We focus on the case with imperfect credibility, implying that the results for the solid blue lines just restate the results in the dash-dotted red lines in Figure 7.

From the figure, we see that the results for the more aggressive spending-based rule are much less benign. In a nut-shell, the government ends up chasing its own tail and cuts spending too much in the near-term and therefore cause output to fall a lot and debt to rise in the short- and medium term. Reflecting the rise in government debt and deficits, interest rate spreads therefore go up in the short– and medium-term before starting to fall. The results in Figure 8 highlights that the short-run costs can be substantial if policymakers implement too aggressive and front-loaded spending-based consolidations when aggregate demand is weak and credibility is impaired. They also suggest that it may take quite some time before the consolidation efforts carry fruit and have the desired effects under unfavorable conditions.

[**Remains to be done: Compare front-loaded with gradual consolidation?**]

5 Conclusions

Our paper has focused on the economic implications imperfect credibility may have for expenditure-based fiscal consolidation. We have found that the role of credibility is likely to be less of an issue if monetary policy can provide suitable degree of accommodation, whereas imperfect credibility may be a source of substantially larger output losses when monetary policy is constrained by CU membership (or the ZLB). In this latter situation, progress in reducing government debt as share of GDP may also be significantly slower.

Although we have focused on only one type of spending cuts to highlight the importance of monetary constraints for fiscal consolidation, actual consolidation programs deploy a wide array of fiscal spending adjustments. The transmission of these alternative fiscal measures to the real economy may differ substantially from the one considered, with potentially important consequences. For instance, infrastructure spending presumably boosts the productivity of private capital, while spending on education enhances the longer-term productivity of the workforce. Accordingly, cuts in these areas would presumably have more adverse effects on the economy's longer-term potential output than in our framework which does not take account of these effects, and possibly weaken aggregate demand more even at shorter horizons. On the other hand, reducing certain types of transfers might have less adverse effects than the cuts we consider, particularly in the long-run. For example, a gradual tightening of eligibility requirements for unemployment benefits might well reduce the natural rate of unemployment in the long-run, and hence raise potential output.[11] In future research, it would be desirable to extend our modeling framework to better capture the implications of a wider range of potential spending cuts.

Some other extensions of the basic modeling framework would also seem useful. First, it would be of interest to extend our approach to imperfect credibility with the approach of Debortoli and Nunes (2012). Finally, our model assumes that the government issues only one period nominal debt. Allowing for multi-period nominal liabilities could have potentially important consequences for the evolution of government debt.

[11] The near-term effects of transfers is likely to depend on how the transfers are distributed across households. In this vein, recent research using large-scale policy models (Coenen et al, 2012) suggests that cuts in transfers that are concentrated on households facing liquidity constraints – the HM households in our setup – are likely to be associated with a larger multiplier compared to cuts to general transfers to all households.

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Appendix A The Large-Scale Open Economy Model

Following Erceg and Lindé (2013), this appendix contains a complete description of the large-scale model used in Section 4.

As the recent recession has provided strong evidence in favor of the importance of financial frictions, our model also features a financial accelerator channel which closely parallels earlier work by Bernanke, Gertler, and Gilchrist (1999) and Christiano, Motto, and Rostagno (2008). Given that the mechanics underlying this particular financial accelerator mechanism are well-understood, we simplify our exposition by focusing on a special case of our model which abstracts from a financial accelerator. We conclude our model description with a brief description of how the model is modified to include the financial accelerator (Section A.6).

A.1 Firms and Price Setting

A.1.1 Production of Domestic Intermediate Goods

There is a continuum of differentiated intermediate goods (indexed by $i \in [0,1]$) in the Periphery, each of which is produced by a single monopolistically competitive firm. In the domestic market, firm i faces a demand function that varies inversely with its output price $P_{Dt}(i)$ and directly with aggregate demand at home Y_{Dt}:

$$Y_{Dt}(i) = \left[\frac{P_{Dt}(i)}{P_{Dt}}\right]^{\frac{-(1+\theta_p)}{\theta_p}} Y_{Dt}, \tag{A.1}$$

where $\theta_p > 0$, and P_{Dt} is an aggregate price index defined below. Similarly, firm i faces the following export demand function:

$$X_t(i) = \left[\frac{P^*_{Mt}(i)}{P^*_{Mt}}\right]^{\frac{-(1+\theta_p)}{\theta_p}} M^*_t, \tag{A.2}$$

where $X_t(i)$ denotes the quantity demanded of domestic good i in the Core block, $P^*_{Mt}(i)$ denotes the price that firm i sets in the Core market, P^*_{Mt} is the import price index in the Core, and M^*_t is an aggregate of the Core's imports (we use an asterisk to denote the Core's variables).

Each producer utilizes capital services $K_t(i)$ and a labor index $L_t(i)$ (defined below) to produce its respective output good. The production function is assumed to have a constant-elasticity of substitution (CES) form:

$$Y_t(i) = \left(\omega_K^{\frac{\rho}{1+\rho}} K_t(i)^{\frac{1}{1+\rho}} + \omega_L^{\frac{\rho}{1+\rho}} (Z_t L_t(i))^{\frac{1}{1+\rho}}\right)^{1+\rho}. \tag{A.3}$$

The production function exhibits constant-returns-to-scale in both inputs, and Z_t is a country-specific shock to the level of technology. Firms face perfectly competitive factor markets for hiring capital and labor. Thus, each firm chooses $K_t(i)$ and $L_t(i)$, taking as given both the rental price of capital R_{Kt} and the aggregate wage index W_t (defined below). Firms can costlessly adjust either factor of production, which implies that each firm has an identical marginal cost per unit of output, MC_t. The (log-linearized) technology shock is assumed to follow an AR(1) process:

$$z_t = \rho_z z_{t-1} + \varepsilon_{z,t}. \tag{A.4}$$

We assume that purchasing power parity holds, so that each intermediate goods producer sets the same price $P_{Dt}(i)$ in both blocks of the currency union, implying that $P^*_{Mt}(i) = P_{Dt}(i)$ and that $P^*_{Mt} = P_{Dt}$. The prices of the intermediate goods are determined by Calvo-style staggered contracts (see Calvo, 1983). In each period, a firm faces a constant probability, $1 - \xi_p$, of being able to re-optimize its price ($P_{Dt}(i)$). This probability of receiving a signal to reoptimize is independent across firms and time. If a firm is not allowed to optimize its prices, we follow Christiano, Eichenbaum and Evans (2005) and Smets and Wouters (2003), and assume that the firm must reset its home price as a weighted combination of the lagged and steady state rate of inflation $P_{Dt}(i) = \pi_{t-1}^{\iota_p} \pi^{1-\iota_p} P_{Dt-1}(i)$ for the non-optimizing firms. This formulation allows for structural persistence in price-seeting if ι_p exceeds zero.

When a firm i is allowed to reoptimize its price in period t, the firm maximizes:

$$\max_{P_{Dt}(i)} \mathbb{E}_t \sum_{j=0}^{\infty} \psi_{t,t+j} \xi_p^j \left[\prod_{h=1}^{j} \pi_{t+h-1} (P_{Dt}(i) - MC_{t+j})(Y_{Dt+j}(i) + X_t(i)) \right]. \tag{A.5}$$

The operator $\mathbb{E}_t$ represents the conditional expectation based on the information available to agents at period t. The firm discounts profits received at date $t+j$ by the state-contingent discount factor $\psi_{t,t+j}$; for notational simplicity, we have suppressed all of the state indices.[A.1]

[A.1] We define $\xi_{t,t+j}$ to be the price in period t of a claim that pays one dollar if the specified state occurs

The first-order condition for setting the contract price of good i is:

$$\mathbb{E}_t \sum_{j=0}^{\infty} \psi_{t,t+j} \xi_p^j \left(\frac{\prod_{h=1}^{j} \pi_{t+h-1}(i) P_{Dt}(i)}{(1+\theta_p)} - MC_{t+j} \right) (Y_{Dt+j}(i) + X_t(i)) = 0. \tag{A.6}$$

A.1.2 Production of the Domestic Output Index

Because households have identical Dixit-Stiglitz preferences, it is convenient to assume that a representative aggregator combines the differentiated intermediate products into a composite home-produced good Y_{Dt}:

$$Y_{Dt} = \left[\int_0^1 Y_{Dt}(i)^{\frac{1}{1+\theta_p}} di \right]^{1+\theta_p}. \tag{A.7}$$

The aggregator chooses the bundle of goods that minimizes the cost of producing Y_{Dt}, taking the price $P_{Dt}(i)$ of each intermediate good $Y_{Dt}(i)$ as given. The aggregator sells units of each sectoral output index at its unit cost P_{Dt}:

$$P_{Dt} = \left[\int_0^1 P_{Dt}(i)^{\frac{-1}{\theta_p}} di \right]^{-\theta_p}. \tag{A.8}$$

We also assume a representative aggregator in the Core who combines the differentiated Periphery products $X_t(i)$ into a single index for foreign imports:

$$M_t^* = \left[\int_0^1 X_t(i)^{\frac{1}{1+\theta_p}} di \right]^{1+\theta_p}, \tag{A.9}$$

and sells M_t^* at price P_{Dt}.

A.1.3 Production of Consumption and Investment Goods

Final consumption goods are produced by a representative consumption goods distributor. This firm combines purchases of domestically-produced goods with imported goods to produce a final consumption good (C_{At}) according to a constant-returns-to-scale CES production function:

$$C_{At} = \left(\omega_C^{\frac{\rho_C}{1+\rho_C}} C_{Dt}^{\frac{1}{1+\rho_C}} + (1-\omega_C)^{\frac{\rho_C}{1+\rho_C}} (\varphi_{Ct} M_{Ct})^{\frac{1}{1+\rho_C}} \right)^{1+\rho_C}, \tag{A.10}$$

in period $t+j$ (see the household problem below); then the corresponding element of $\psi_{t,t+j}$ equals $\xi_{t,t+j}$ divided by the probability that the specified state will occur.

where C_{Dt} denotes the consumption good distributor's demand for the index of domestically-produced goods, M_{Ct} denotes the distributor's demand for the index of foreign-produced goods, and φ_{Ct} reflects costs of adjusting consumption imports. The final consumption good is used by both households and by the government. The form of the production function mirrors the preferences of households and the government sector over consumption of domestically-produced goods and imports. Accordingly, the quasi-share parameter ω_C may be interpreted as determining the preferences of both the private and public sector for domestic relative to foreign consumption goods, or equivalently, the degree of home bias in consumption expenditure. Finally, the adjustment cost term φ_{Ct} is assumed to take the quadratic form:

$$\varphi_{Ct} = \left[1 - \frac{\varphi_{M_C}}{2}\left(\frac{\frac{M_{Ct}}{C_{Dt}}}{\frac{M_{Ct-1}}{C_{Dt-1}}} - 1\right)^2\right]. \tag{A.11}$$

This specification implies that it is costly to change the proportion of domestic and foreign goods in the aggregate consumption bundle, even though the level of imports may jump costlessly in response to changes in overall consumption demand.

Given the presence of adjustment costs, the representative consumption goods distributor chooses (a contingency plan for) C_{Dt} and M_{Ct} to minimize its discounted expected costs of producing the aggregate consumption good:

$$\min_{C_{Dt+k}, M_{Ct+k}} \mathbb{E}_t \sum_{k=0}^{\infty} \psi_{t,t+k} \Bigg\{ \left(P_{Dt+k} C_{Dt+k} + P_{Mt+k} M_{Ct+k}\right) \tag{A.12}$$

$$+ P_{Ct+k}\left[C_{A,t+k} - \left(\omega_C^{\frac{\rho_C}{1+\rho_C}} C_{Dt+k}^{\frac{1}{1+\rho_C}} + (1-\omega_C)^{\frac{\rho_C}{1+\rho_C}} \left(\varphi_{Ct+k} M_{Ct+k}\right)^{\frac{1}{1+\rho_C}}\right)^{1+\rho_C}\right]\Bigg\}.$$

The distributor sells the final consumption good to households and the government at a price P_{Ct}, which may be interpreted as the consumption price index (or equivalently, as the shadow cost of producing an additional unit of the consumption good).

We model the production of final investment goods in an analogous manner, although we allow the weight ω_I in the investment index to differ from that of the weight ω_C in the consumption goods index.[A.2]

[A.2] Notice that the final investment good is not used by the government.

A.2 Households and Wage Setting

We assume a continuum of monopolistically competitive households (indexed on the unit interval), each of which supplies a differentiated labor service to the intermediate goods-producing sector (the only producers demanding labor services in our framework) following Erceg, Henderson and Levin (2000). A representative labor aggregator (or "employment agency") combines households' labor hours in the same proportions as firms would choose. Thus, the aggregator's demand for each household's labor is equal to the sum of firms' demands. The aggregate labor index L_t has the Dixit-Stiglitz form:

$$L_t = \left[\int_0^1 (\zeta N_t(h))^{\frac{1}{1+\theta_w}} \, dh \right]^{1+\theta_w}, \tag{A.13}$$

where $\theta_w > 0$ and $N_t(h)$ is hours worked by a typical member of household h. The parameter ζ is the size of a household of type h, and effectively determines the size of the population in the Periphery. The aggregator minimizes the cost of producing a given amount of the aggregate labor index, taking each household's wage rate $W_t(h)$ as given, and then sells units of the labor index to the production sector at their unit cost W_t:

$$W_t = \left[\int_0^1 W_t(h)^{\frac{-1}{\theta_w}} \, dh \right]^{-\theta_w}. \tag{A.14}$$

The aggregator's demand for the labor services of a typical member of household h is given by

$$N_t(h) = \left[\frac{W_t(h)}{W_t} \right]^{-\frac{1+\theta_w}{\theta_w}} L_t/\zeta. \tag{A.15}$$

We assume that there are two types of households: households that make intertemporal consumption, labor supply, and capital accumulation decisions in a forward-looking manner by maximizing utility subject to an intertemporal budget constraint (FL households, for "forward-looking"); and the remainder that simply consume their after-tax disposable income (HM households, for "hand-to-mouth" households). The latter type receive no capital rental income or profits, and choose to set their wage to be the average wage of optimizing households. We denote the share of FL households by $1\text{-}\varsigma$ and the share of HM households by ς.

We consider first the problem faced by FL households. The utility functional for an optimizing representative member of household h is

$$\mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \left\{ \frac{1}{1-\sigma} \left(C^O_{t+j}(h) - \varkappa C^O_{t+j-1} - \nu_{ct} \right)^{1-\sigma} + \frac{\chi_0 Z^{1-\sigma}_{t+j}}{1-\chi} (1 - N_{t+j}(h))^{1-\chi} + \mu_0 F \left(\frac{MB_{t+j+1}(h)}{P_{Ct+j}} \right) \right\}, \tag{A.16}$$

where the discount factor β satisfies $0 < \beta < 1$. As in Smets and Wouters (2003, 2007), we allow for the possibility of external habit formation in preferences, so that each household member cares about its consumption relative to lagged aggregate consumption per capita of forward-looking agents C^O_{t-1}. The period utility function depends on an each member's current leisure $1 - N_t(h)$, his end-of-period real money balances, $\frac{MB_{t+1}(h)}{P_{Ct}}$, and a preference shock, ν_{ct}. The subutility function $F(.)$ over real balances is assumed to have a satiation point to account for the possibility of a zero nominal interest rate; see Eggertsson and Woodford (2003) for further discussion.[A.3] The (log-linearized) consumption demand shock ν_{ct} is assumed to follow an AR(1) process:

$$\nu_{ct} = \rho_\nu \nu_{ct-1} + \varepsilon_{\nu_c,t.} \tag{A.17}$$

Forward-looking household h faces a flow budget constraint in period t which states that its combined expenditure on goods and on the net accumulation of financial assets must equal its disposable income:

$$\begin{gathered} P_{Ct}(1+\tau_{Ct}) C^O_t(h) + P_{It} I_t(h) + MB_{t+1}(h) - MB_t(h) + \int_s \xi_{t,t+1} B_{Dt+1}(h) \\ -B_{Dt}(h) + P_{Bt} B_{Gt+1} - B_{Gt} + \frac{P^*_{Bt} B_{Ft+1}(h)}{\phi_{bt}} - B_{Ft}(h) \\ = (1-\tau_{Nt}) W_t(h) N_t(h) + \Gamma_t(h) + TR_t(h) + (1-\tau_{Kt}) R_{Kt} K_t(h) + \\ P_{It} \tau_{Kt} \delta K_t(h) - P_{Dt} \phi_{It}(h). \end{gathered} \tag{A.18}$$

Consumption purchases are subject to a sales tax of τ_{Ct}. Investment in physical capital augments the per capita capital stock $K_{t+1}(h)$ according to a linear transition law of the form:

$$K_{t+1}(h) = (1-\delta) K_t(h) + I_t(h), \tag{A.19}$$

where δ is the depreciation rate of capital.

[A.3] For simplicity, we assume that μ_0 is sufficiently small that changes in the monetary base have a negligible impact on equilibrium allocations, at least to the first-order approximation we consider.

Financial asset accumulation of a typical member of FL household h consists of increases in nominal money holdings $(MB_{t+1}(h) - MB_t(h))$ and the net acquisition of bonds. While the domestic financial market is complete through the existence of state-contingent bonds B_{Dt+1}, cross-border asset trade is restricted to a single non-state contingent bond issued by the government of the Core economy.[A.4]

The terms B_{Gt+1} and B_{Ft+1} represents each household member's net purchases of the government bonds issued by the Periphery and Core governments, respectively. Each type of bond pays one currency unit (e.g., euro) in the subsequent period, and is sold at price (discount) of P_{Bt} and P^*_{Bt}, respectively. To ensure the stationarity of foreign asset positions, we follow Turnovsky (1985) by assuming that domestic households must pay a transaction cost when trading in the foreign bond. The intermediation cost depends on the ratio of economy-wide holdings of net foreign assets to nominal GDP, P_tY_t, and are given by:

$$\phi_{bt} = \exp\left(-\phi_b\left(\frac{B_{Ft+1}}{P_tY_t}\right)\right). \tag{A.20}$$

If the Periphery is an overall net lender position internationally, then a household will earn a lower return on any holdings of foreign (i.e., Core) bonds. By contrast, if the Periphery has a net debtor position, a household will pay a higher return on its foreign liabilities. Given that the domestic government bond and foreign bond have the same payoff, the price faced by domestic residents net of the transaction cost is identical, so that $P_{Bt} = \frac{P^*_{Bt}}{\phi_{bt}}$. The effective nominal interest rate on domestic bonds (and similarly for foreign bonds) hence equals $i_t = 1/P_{Bt} - 1$.

Each member of FL household h earns after-tax labor income, $(1 - \tau_{Nt})W_t(h)N_t(h)$, where τ_{Nt} is a stochastic tax on labor income. The household leases capital at the after-tax rental rate $(1 - \tau_{Kt})R_{Kt}$, where τ_{Kt} is a stochastic tax on capital income. The household receives a depreciation write-off of $P_{It}\tau_{Kt}\delta$ per unit of capital. Each member also receives an aliquot share $\Gamma_t(h)$ of the profits of all firms and a lump-sum government transfer, $TR_t(h)$ (which is negative in the case of a tax). Following Christiano, Eichenbaum and Evans (2005), we assume that it is costly to change the level of gross investment from the previous

[A.4] Notice that the contingent claims B_{Dt+1} are in zero net supply from the standpoint of the Periphery as a whole.

period, so that the acceleration in the capital stock is penalized:

$$\phi_{It}(h) = \frac{1}{2}\phi_I \frac{(I_t(h) - I_{t-1})^2}{I_{t-1}}. \tag{A.21}$$

In every period t, each member of FL household h maximizes the utility functional (A.16) with respect to its consumption, investment, (end-of-period) capital stock, money balances, holdings of contingent claims, and holdings of domestic and foreign bonds, subject to its labor demand function (A.15), budget constraint (A.18), and transition equation for capital (A.19). In doing so, a household takes as given prices, taxes and transfers, and aggregate quantities such as lagged aggregate consumption and the aggregate net foreign asset position.

Forward-looking (FL) households set nominal wages in staggered contracts that are analogous to the price contracts described above. In particular, with probability $1 - \xi_w$, each member of a household is allowed to reoptimize its wage contract. If a household is not allowed to optimize its wage rate, we assume each household member resets its wage according to:

$$W_t(h) = \omega_{t-1}^{\iota_w} \omega^{1-\iota_w} W_{t-1}(h), \tag{A.22}$$

where ω_{t-1} is the gross nominal wage inflation in period $t-1$, i.e. W_t/W_{t-1}, and $\omega = \pi$ is the steady state rate of change in the nominal wage (equal to gross price inflation since steady state gross productivity growth is assumed to be unity). Dynamic indexation of this form introduces some element of structural persistence into the wage-setting process. Each member of household h chooses the value of $W_t(h)$ to maximize its utility functional (A.16) subject to these constraints.

Finally, we consider the determination of consumption and labor supply of the hand-to-mouth (HM) households. A typical member of a HM household simply equates his nominal consumption spending, $P_{Ct}(1 + \tau_{Ct}) C_t^{HM}(h)$, to his current after-tax disposable income, which consists of labor income plus lump-sum transfers from the government:

$$P_{Ct}(1 + \tau_{Ct}) C_t^{HM}(h) = (1 - \tau_{Nt}) W_t(h) N_t(h) + TR_t(h). \tag{A.23}$$

The HM households are assumed to set their wage equal to the average wage of the forward-looking households. Since HM households face the same labor demand schedule as the forward-looking households, this assumption implies that each HM household works the same number of hours as the average for forward-looking households.

A.3 Monetary Policy

We assume that the central bank follows a Taylor rule for setting the policy rate of the currency union, subject to the zero bound constraint on nominal interest rates. Thus:

$$i_t = \max\left\{-i, (1-\gamma_i)\left(\tilde{\pi}_t + \gamma_\pi(\tilde{\pi}_t - \pi) + \gamma_x \tilde{x}_t\right) + \gamma_i i_{t-1}\right\} \tag{A.24}$$

In this equation, i_t is the quarterly nominal interest rate expressed in deviation from its steady state value of i. Hence, imposing the zero lower bound implies that i_t cannot fall below $-i$. $\tilde{\pi}_t$ is price inflation rate of the currency union, π the inflation target, and $\tilde{x}_t$ is the output gap of the currency union. The aggregate inflation and output gap measures are defined as a GDP-weighted average of the inflation rates and output gaps of the Periphery and Core. Finally, the output gap in each member is defined as the deviation of actual output from its potential level, where potential is the level of output that would prevail if wages and prices were completely flexible.

A.4 Fiscal Policy

Intertemporal Budget Constraint The government does not need to balance its budget each period, and issues nominal debt B_{Gt+1} at the end of period t to finance its deficits according to:

$$\begin{aligned} P_{Bt}B_{Gt+1} - B_{Gt} = P_{Ct}G_t + TR_t - \tau_{Nt}W_tL_t - \tau_{Ct}P_{Ct}C_t - (\tau_{Kt}R_{Kt} - \delta P_{It})K_t \\ -(MB_{t+1} - MB_t), \end{aligned} \tag{A.25}$$

where C_t is total private consumption. Equation (A.25) aggregates the capital stock, money and bond holdings, and transfers and taxes over all households so that, for example, $TR_t = \int_0^1 TR_t(h)dh$. The taxes on capital τ_{Kt} and consumption τ_{Ct} are assumed to be fixed, and the ratio of real transfers to (trend) GDP, $tr_t = \frac{TR_t}{P_tY}$, is also fixed.[A.5] Government purchases have no direct effect on the utility of households, nor do they affect the production function of the private sector.

[A.5] Given that the central bank uses the nominal interest rate as its policy instrument, the level of seigniorage is determined by nominal money demand.

A.5 Resource Constraint and Net Foreign Assets

The domestic economy's aggregate resource constraint can be written as:

$$Y_{Dt} = C_{Dt} + I_{Dt} + \phi_{It}, \tag{A.26}$$

where ϕ_{It} is the adjustment cost on investment aggregated across all households. The final consumption good is allocated between households and the government:

$$C_{At} = C_t + G_t, \tag{A.27}$$

where C_t is total private consumption of FL (optimizing) and HM households:

$$C_t = C_t^O + C_t^{HM}. \tag{A.28}$$

Total exports may be allocated to either the consumption or the investment sector abroad:

$$M_t^* = M_{Ct}^* + M_{It}^*. \tag{A.29}$$

Finally, at the level of the individual firm:

$$Y_t(i) = Y_{Dt}(i) + X_t(i) \qquad \forall i. \tag{A.30}$$

The evolution of net foreign assets can be expressed as:

$$\frac{P_{B,t}^* B_{F,t+1}}{\phi_{bt}} = B_{F,t} + P_{Mt}^* M_t^* - P_{Mt} M_t. \tag{A.31}$$

This expression can be derived from the budget constraint of the FL households after imposing the government budget constraint, the consumption rule of the HM households, the definition of firm profits, and the condition that domestic state-contingent non-government bonds (B_{Dt+1}) are in zero net supply.

Finally, we assume that the structure of the foreign country (the Core) is isomorphic to that of the home country (the Periphery).

A.6 Production of capital services

We incorporate a financial accelerator mechanism into both country blocks of our benchmark model following the basic approach of Bernanke, Gertler and Gilchrist (1999). Thus, the intermediate goods producers rent capital services from entrepreneurs (at the price R_{Kt}) rather than directly from households. Entrepreneurs purchase physical capital from competitive capital goods producers (and resell it back at the end of each period), with the latter employing the same technology to transform investment goods into finished capital goods as described by equations A.19) and A.21). To finance the acquisition of physical capital, each entrepreneur combines his net worth with a loan from a bank, for which the entrepreneur must pay an external finance premium (over the risk-free interest rate set by the central bank) due to an agency problem. Banks obtain funds to lend to the entrepreneurs by issuing deposits to households at the interest rate set by the central bank, with households bearing no credit risk (reflecting assumptions about free competition in banking and the ability of banks to diversify their portfolios). In equilibrium, shocks that affect entrepeneurial net worth – i.e., the leverage of the corporate sector – induce fluctuations in the corporate finance premium.[A.6]

A.7 Calibration of Parameters

Here we report calibration of the parameters not discussed in the main text.

We assume that the discount factor $\beta = 0.995$, consistent with a steady-state annualized real interest rate $\overline{r}$ of 2 percent. By assuming that gross inflation $\pi = 1.005$ (i.e. a net inflation of 2 percent in annualized terms), the implied steady state nominal interest rate i equals 0.01 at a quarterly rate, and 4 percent at an annualized rate.

The utility functional parameter σ is set equal to 1 to ensure that the model exhibit balanced growth, while the parameter determining the degree of habit persistence in consumption $\varkappa = 0.8$. We set $\chi = 4$, implying a Frisch elasticity of labor supply of 1/2, which is roughly consistent with the evidence reported by Domeij and Flodén (2006). The utility parameter χ_0 is set so that employment comprises one-third of the household's time endowment, while the parameter μ_0 on the subutility function for real balances is set at an arbitrarily low value (so that variation in real balances do not affect equilibrium allocations).

[A.6] We follow Christiano, Motto and Rostagno (2008) by assuming that the debt contract between entrepreneurs and banks is written in nominal terms (rather than real terms as in Bernanke, Gertler and Gilchrist, 1999). For further details about the setup, see Bernanke, Gertler and Gilchrist (1999), and Christiano, Motto and Rostagno (2008). An excellent exposition is also provided in Christiano, Trabandt and Walentin (2007).

We set the share of HM agents $\varsigma = 0.47$, implying that these agents account for about 20 percent of aggregate private consumption spending (the latter is much smaller than the population share of HM agents because the latter own no capital).

The depreciation rate of capital δ is set at 0.03 (consistent with an annual depreciation rate of 12 percent). The parameter ρ in the CES production function of the intermediate goods producers is set to -2, implying an elasticity of substitution between capital and labor $(1+\rho)/\rho$, of 1/2. The quasi-capital share parameter ω_K – together with the price markup parameter of $\theta_P = 0.20$ – is chosen to imply a steady state investment to output ratio of 15 percent. We set the cost of adjusting investment parameter $\phi_I = 3$, slightly below the value estimated by Christiano, Eichenbaum and Evans (2005). The calibration of the parameters determining the financial accelerator follows Bernanke, Gertler and Gilchrist (1999). In particular, the monitoring cost, μ, expressed as a proportion of entrepreneurs' total gross revenue, is set to 0.12. The default rate of entrepreneurs is 3 percent per year, and the variance of the idiosyncratic productivity shocks to entrepreneurs is 0.28.

Our calibration of the parameters of the monetary policy rule and the Calvo price and wage contract duration parameters – while within the range of empirical estimates – tilt in the direction of reducing the sensitivity of inflation to shocks. These choices seem reasonable given the resilience of inflation in most euro area countries in the aftermath of the global financial crisis. In particular, we set the parameters of the monetary rule such that $\gamma_\pi = 1.5$, $\gamma_x = 0.125$, and $\gamma_i = 0.7$, implying a considerably larger response to inflation than a standard Taylor rule (which would set $\gamma_\pi = 0.5$). The price contract duration parameter $\xi_p = 0.9$, and the price indexation parameter $\iota_p = 0.65$. Our choice of ξ_p implies a Phillips curve slope of about 0.007, which is a bit lower than the median estimates in the literature that cluster in the range of $0.009 - 0.014$, but well within the standard confidence intervals provided by empirical studies (see e.g. Adolfson et al (2005), Altig et al. (2010), Galí and Gertler (1999), Galí, Gertler, and López-Salido (2001), Lindé (2005), and Smets and Wouters (2003, 2007)). Our choices of a wage markup of $\theta_W = 1/3$, a wage contract duration parameter of $\xi_w = 0.85$, and a wage indexation parameter of $\iota_w = 0.65$, together imply that wage inflation is about as responsive to the wage markup as price inflation is to the price markup.[A.7]

[A.7] Given strategic complementarities in wage-setting, the wage markup influences the slope of the wage

We assume that $\rho_C = \rho_I = 2$, consistent with a long-run price elasticity of demand for imported consumption and investment goods of 1.5. The adjustment cost parameters are set so that $\varphi_{M_C} = \varphi_{M_I} = 1$, which slightly damps the near-term relative price sensitivity. Finally, the financial intermediation parameter ϕ_b is set to a very small value (0.00001), which is sufficient to ensure the model has a unique steady state.

Phillips Curve.

Figure 1: Debt and Growth in Peripheral Economies and the Euro Area

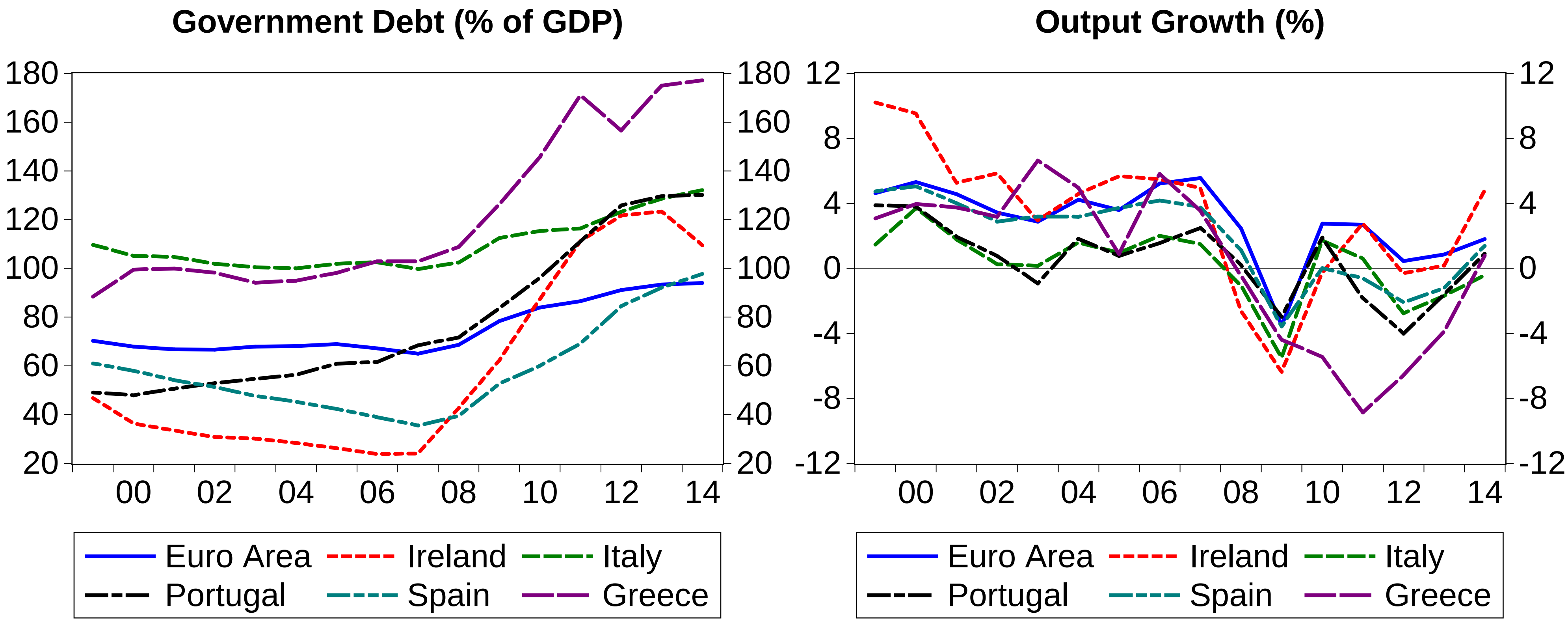

Figure 2: Decomposing Government Consumption (as share of trend GDP).

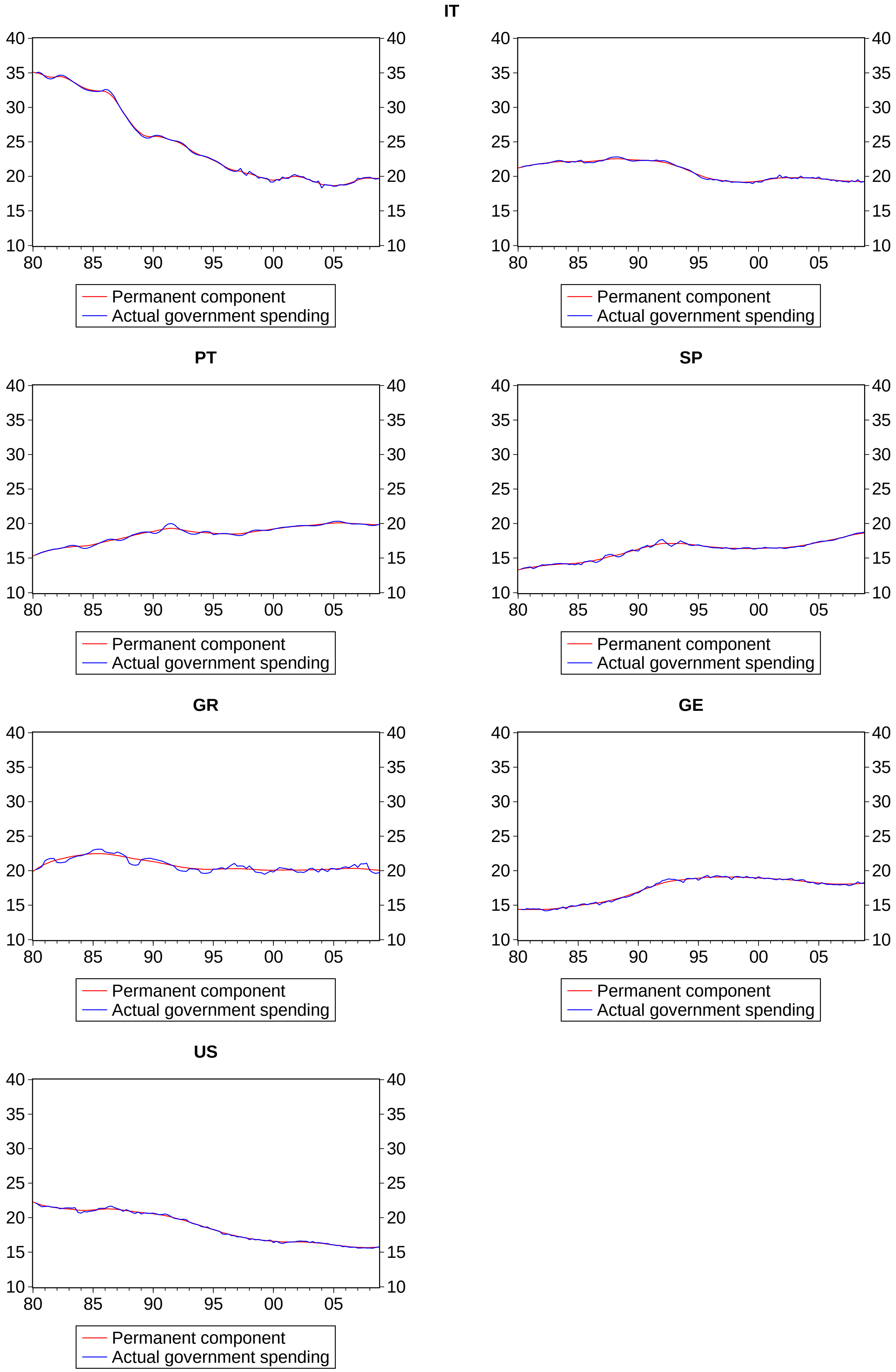

Figure 3: Fiscal Consolidation Under Alternative Assumptions About Credibility: Independent Monetary Policy.

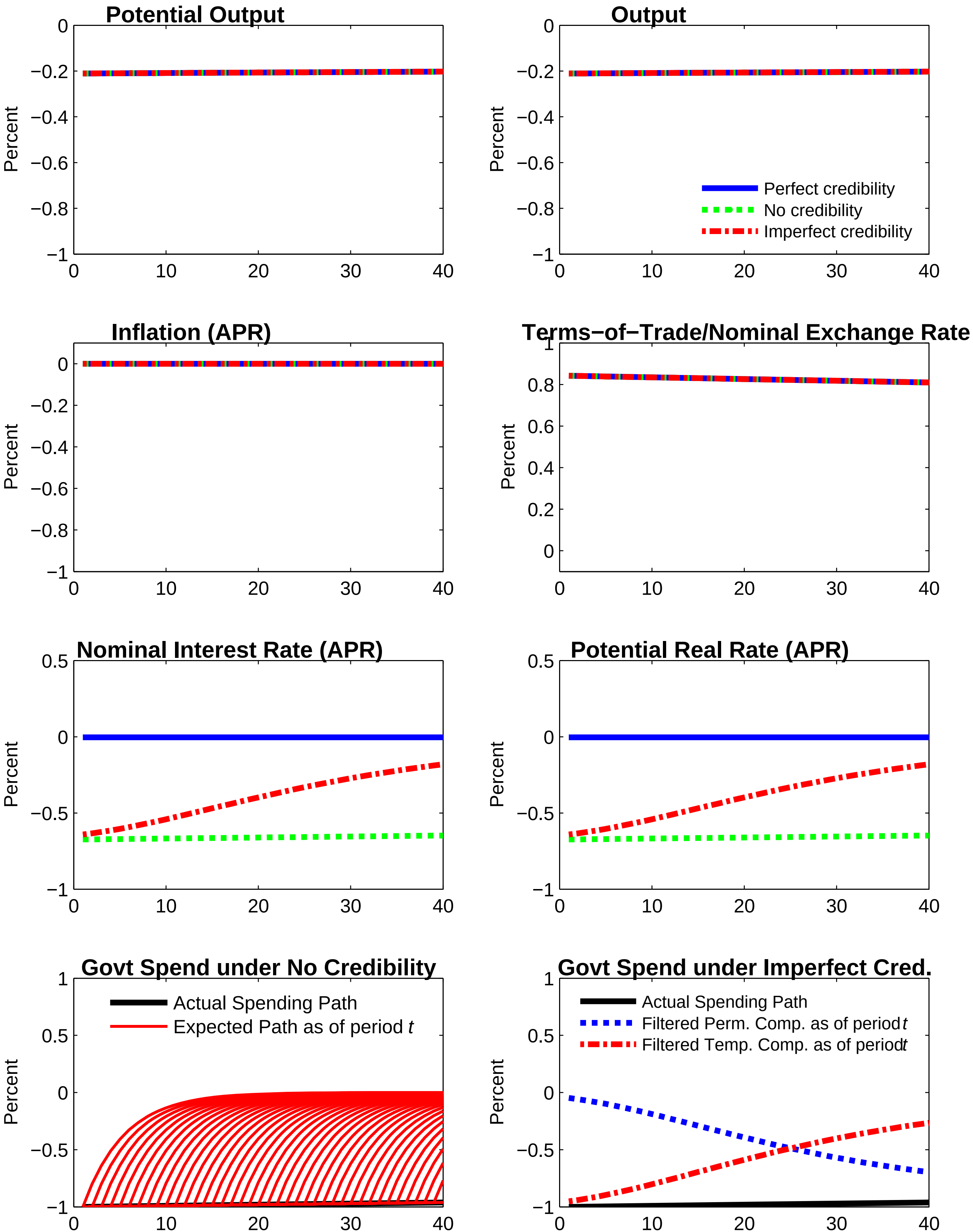

Figure 4: Fiscal Consolidation Under Alternative Assumptions About Credibility: Currency Union Membership.

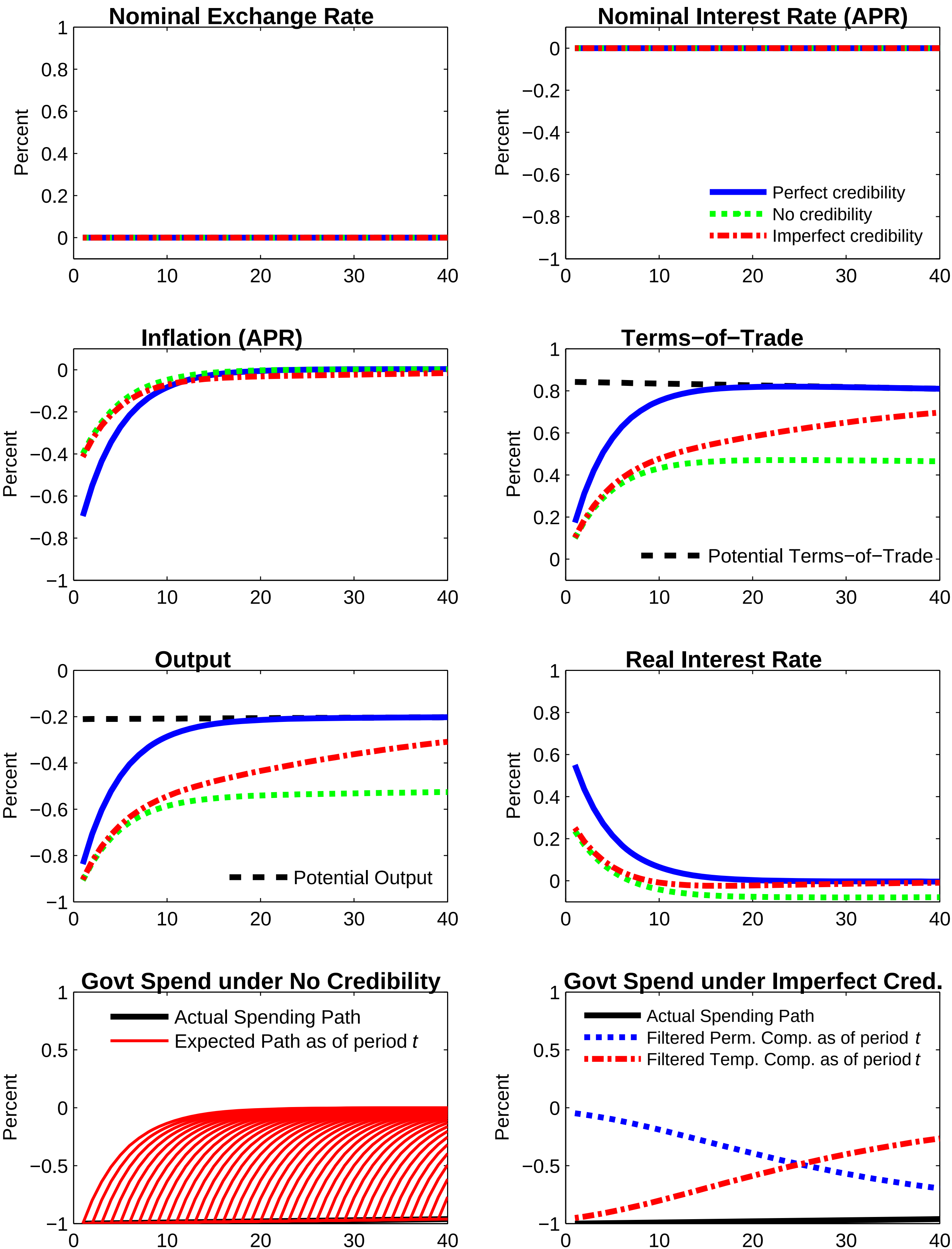

Figure 5: Gradual Fiscal Consolidation Plan Under CU Membership.

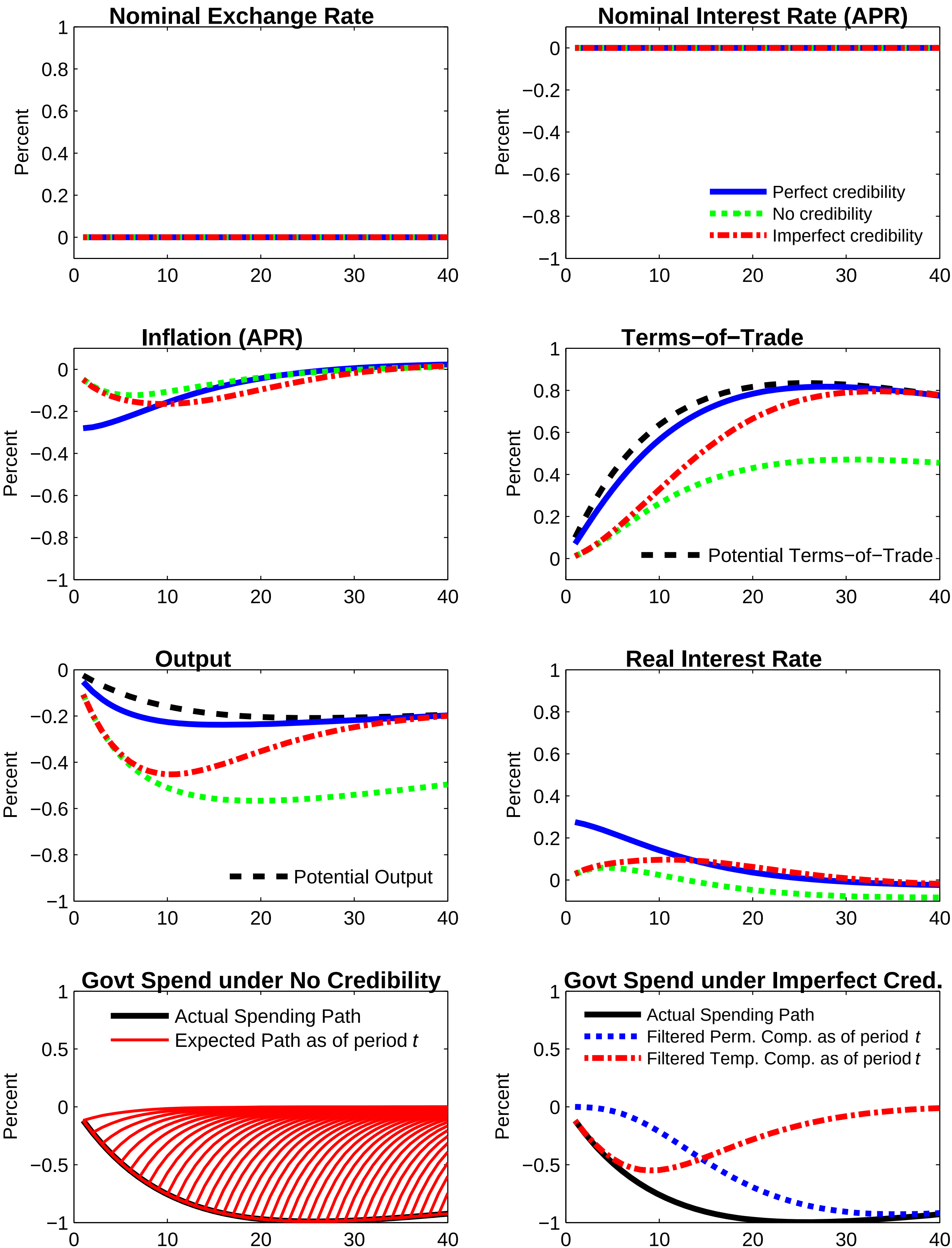

Figure 6: Fiscal Consolidation In Large Scale Model in a Currency Union Under Alternative Credibility Assumptions for the Periphery.

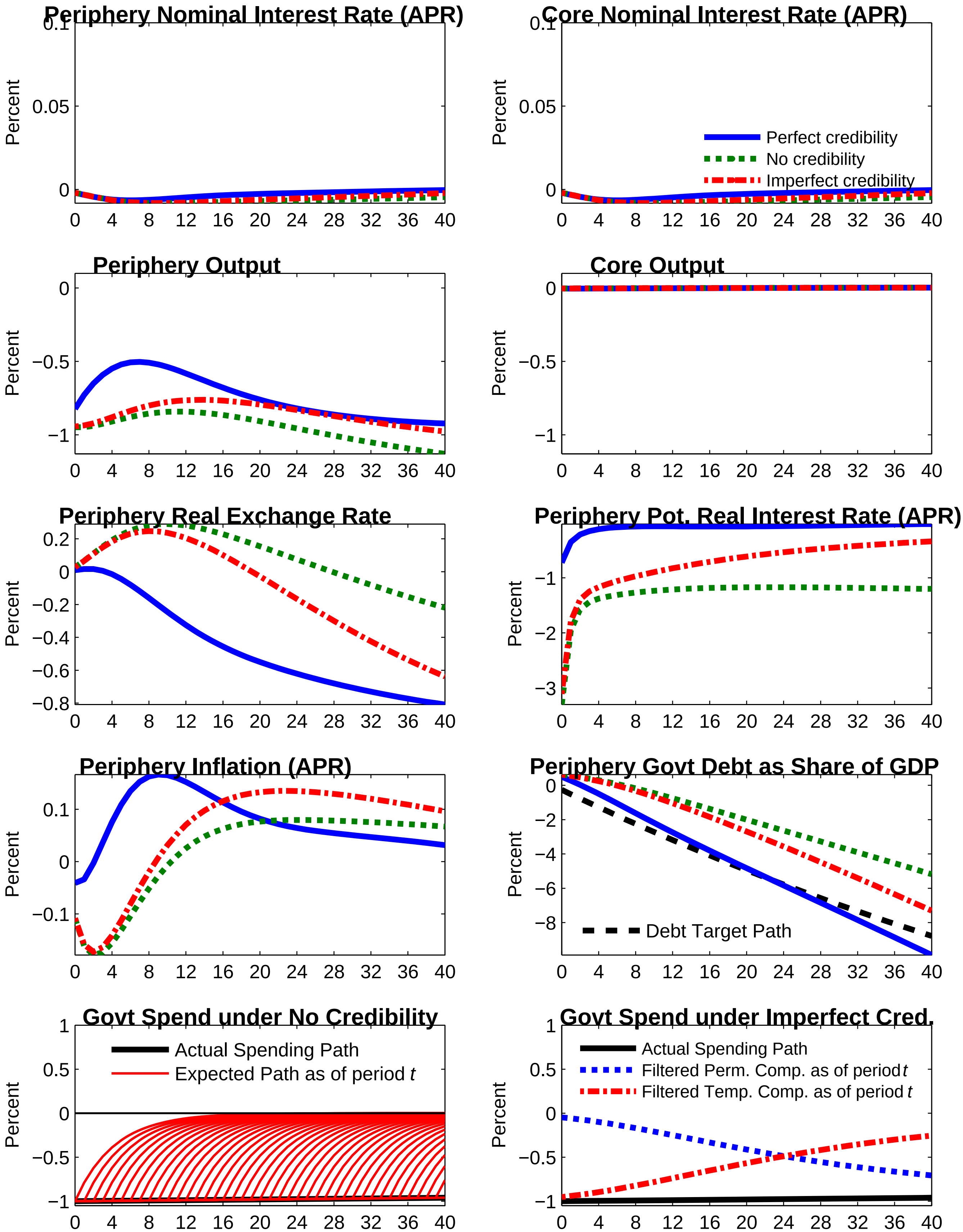

Figure 7: Fiscal Consolidation In Large Scale Model in Currency Union When Allowing For Endogenous Interest Rate Spreads: Gradual Tax Debt Rule.

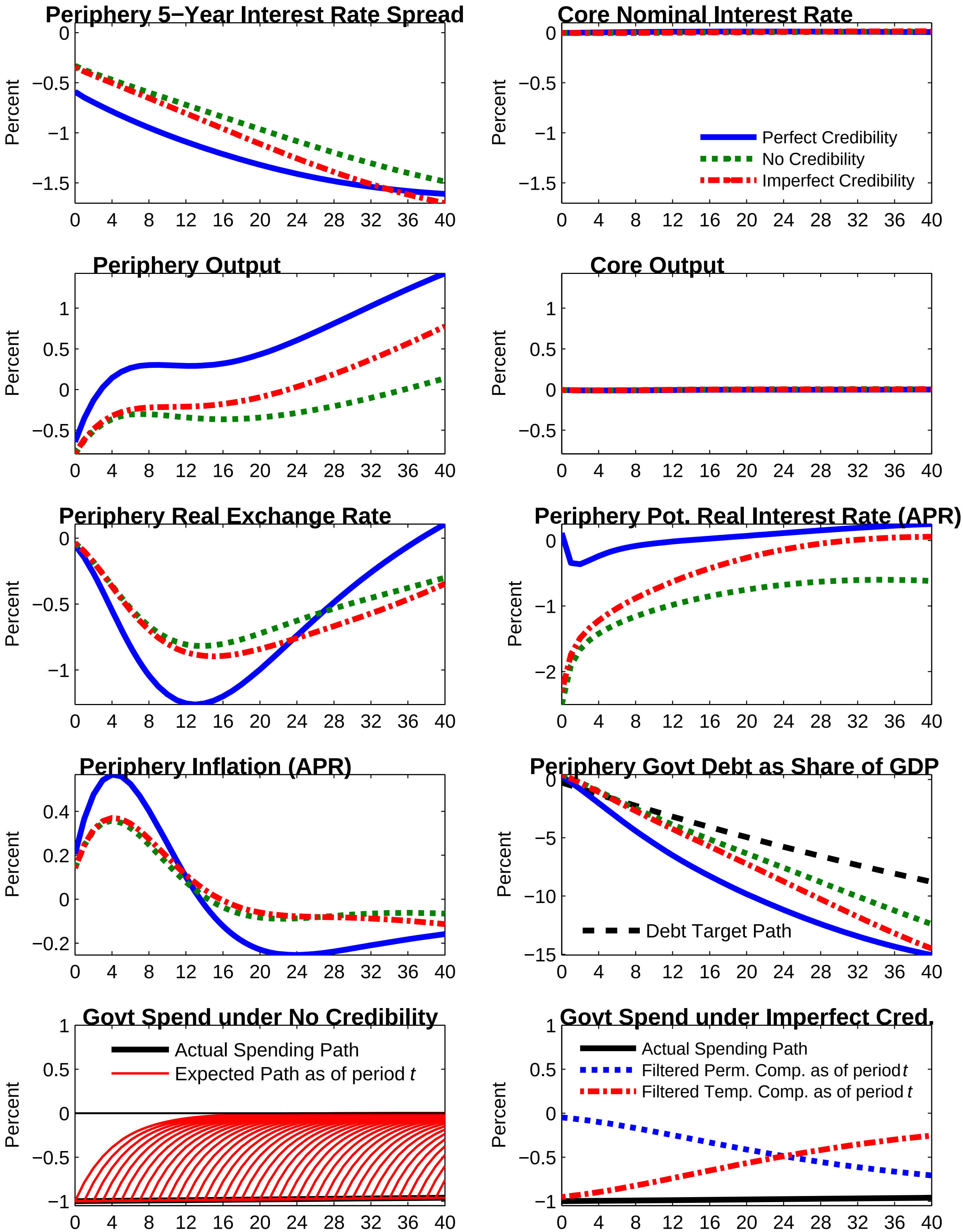

Figure 8: Fiscal Consolidation In Large Scale Model in Currency Union With Endogenous Int. Rate Spreads: Aggressive Spending vs. Gradual Tax Debt Rule.