KÄRNTNER INSTITUT FÜR HÖHERE STUDIEN UND WISSENSCHAFTLICHE FORSCHUNG

Carinthian Institute for Advanced Studies

After the Pandemic:

Optimal Fiscal Policies for Slovenia

Working Paper 2

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JEL: E37; E62; H62.

Ethical Statement: All ethical requirements are fulfilled. In particular, Reinhard Neck, Dmitri Blueschke, Klaus Weyerstrass, and Miroslav Verbič have contributed equally to this work.

Abstract

This paper derives implementable medium-run fiscal instrument paths for Slovenia, a small Euro-Area economy, in response to plausible transitory external shocks. We combine the macroeconometric model SLOPOL12 with a stochastic optimal-control framework in which the objective function is operationalized from a survey of Slovenian policy makers' macroeconomic priorities. Approximately optimal policies are computed using the OPTCON algorithm in relation to a baseline forecast and alternative shock scenarios. The results highlight a systematic trade-off between stabilizing output and employment and maintaining fiscal sustainability in terms of the deficit and public debt. Across scenarios, instruments that influence both the demand side and potential output, most notably direct taxes and public investment in physical and human capital (including R&D-related spending), are optimal for cyclical stabilization while instruments with predominantly demand-side or budgetary effects, such as VAT, government consumption, and residual revenues, primarily assigned to budgetary consolidation. The qualitative patterns are robust across shocks and clarify how differential instrument effectiveness shapes the optimal timing and composition of policy adjustment under explicit constraints and stated policy objectives.

Keywords: macroeconomics, fiscal policy, optimal control, policy optimization, Slovenia.

1 Introduction

Europe has been battered by a series of crises over the last two decades, both of global and regional origin: the Great Recession 2007–2009, the Euro and sovereign debt crisis 2010–2014, the COVID-19 pandemic 2020–2023, and the economic effects (energy crisis, inflation) of the Russian war against Ukraine (2022 and ongoing). At the beginning of 2024, it seemed as if the worst effects of the pandemic were over, but considerable sums of money were spent by European governments during this crisis, and many of them now face the challenges of high public debt and budget deficits. Moreover, problems of stabilizing employment and output remain to be tackled.

In an earlier paper (Weyerstrass et al., 2023), we investigated, in a quasi-ex-post evaluation, how fiscal policy in Slovenia could have dealt best with the economic problems caused by the pandemic. Now we ask how fiscal policy makers should design their policies in the aftermath of that event, especially when new transitory shocks hit the small open economy of this country.

We use an optimization approach to explore how to design fiscal policy – the only macroeconomic instrument available for a country whose monetary policy is determined at the level of the Euro Area – in the best possible way for the purpose of stabilizing its economy, both in "normal" times and under possible new demand and supply shocks due to global or European economic developments.

For the purpose of designing such fiscal policies, we determine optimal policies for Slovenia using an optimal control approach in the tradition of the theory of quantitative economic policy. We use an econometric model, called SLOPOL12, and an objective function based on answers provided by Slovenian policy makers concerning their economic policy goals. We then derive optimal fiscal policies for Slovenia for the next few years under various assumptions about positive and negative shocks. As a result, we can assess the appropriate course of budgetary policies for Slovenia, given the preferences of the policy makers and the econometric model.

In this paper, we deliberately do not rely on more recent approaches to determining optimal fiscal policies based on theoretically derived macroeconomic models, such as dynamic stochastic general equilibrium (DSGE) or New Classical or New Keynesian macroeconomic models. These models serve to develop optimal policies over a long-time horizon under assumptions about a steady state of the economy under consideration. "Optimal" policies in this case are those which maximize social welfare. By contrast, our interest lies in how fiscal policy instruments can best be used to fulfil policy makers' own goals in the short run, based on the preferences of those policy makers (such as the government) concerning macroeconomic objectives such as high and steady growth of output, low unemployment, price stability, sustainable public finances, etc. This question addresses not only policy makers' need for advice (a normative or prescriptive aspect) but also may serve to obtain information about how actual fiscal policy is designed, assuming policy makers behave as if they were optimizing an objective function (a positive or explanatory aspect). For this purpose, a more traditional structural macroeconometric model based on empirical estimations (of the Cowles Commission type) is more appropriate because it can allow for institutional and country-specific aspects of a particular economy without completely disregarding theoretical considerations, especially for a small open economy within the Euro Area like Slovenia. We admit that such models are relatively weak with respect to theoretical consistency and have some other shortcomings, but in our view, these count less for a short-term policy analysis. See, e.g., Fair (2012) for a similar view.

The structure of the paper is as follows: Section 2 reviews related academic literature. Section 3 introduces the SLOPOL12 model while Section 4 gives a brief overview of the optimal control approach, including the econometric model and the objective function. Section 5 describes different scenarios for macroeconomic developments depending on temporary exogenous shocks of small to medium size. The main results of the optimal policy experiments as reactions to these shocks are presented in Section 6. Section 7 deals with long-run aspects of the simulation and the optimization experiments and Section 8 concludes.

2 Related literature and our contribution

While the paper is motivated by an immediate policy problem, it is intended as a contribution to scholarly work on optimal fiscal policy and quantitative policy evaluation. In modern macroeconomics, "optimal fiscal policy" is often framed as a Ramsey problem: A government chooses taxes, spending, and/or debt to maximize a welfare criterion subject to equilibrium constraints (Ramsey, 1927; Lucas & Stokey, 1983; Chari & Kehoe, 1999). A central implication is tax smoothing: With distortionary taxation and temporary shocks, public debt optimally serves as a buffer so that tax rates and other distortions move smoothly over time (Barro, 1979; Lucas & Stokey, 1983). While our framework does not solve a full Ramsey problem by using microeconomically founded tax instruments, it is closely aligned to the tax-smoothing logic in two ways. First, the debt and deficit dynamics explicitly constrain feasible policy, making the intertemporal budget linkage central rather than peripheral. Second, by allowing multiple fiscal instruments to adjust over time, the optimization problem naturally becomes one of allocating adjustments across instruments and across time, which is exactly the practical counterpart of tax smoothing in applied settings.

A second influential strand of the optimal fiscal policy literature focuses on long-run optimal taxation and the structure of efficient tax systems. In canonical settings with commitment and perfect foresight, optimal policy can imply that the long-run capital income tax approaches (approximately) zero (Judd, 1985; Chamley, 1986). These results and their extensions underscore an important conceptual distinction: Long-run welfare-based optimal taxation is primarily about steady-state wedges and incentive distortions while our contribution is explicitly short- to medium-run and centered on feasible stabilization and consolidation within existing institutions. The paper therefore complements rather than substitutes for long-run optimal tax research. Instead, it asks a different question: Given the fiscal instruments that are realistically adjustable over a policy horizon, and given empirically estimated macroeconomic constraints, how should the policy path be shaped over time to balance stabilization and sustainability objectives?

The paper also relates to DSGE-based research that computes optimal stabilization policy under explicit microeconomic foundations, especially in New Keynesian settings with nominal rigidities. In such models, welfare-based objectives imply precise trade-offs among inflation stabilization, output-gap stabilization, and fiscal distortions, and optimal policy can depend on commitment and on the availability of state-contingent debt (Schmitt-Grohé & Uribe, 2004). That literature provides coherent welfare benchmarks while two classic cautions are relevant for applied short-horizon fiscal design. First, structural parameters and behavioral relations can shift with policy regimes, making policy evaluation sensitive to the Lucas critique (Lucas, 1976). Second, optimal plans derived under commitment can be time-inconsistent, motivating the distinction between rules and discretion (Kydland & Prescott, 1977). The approach in this paper does not claim to overcome these issues. Instead, it occupies a pragmatic middle ground, using an empirically estimated model suited to the policy horizon under study, applying robustness checks through scenario/sensitivity analysis, and interpreting the computed optimal paths as conditional on the maintained model and objective function. This is standard and defensible in the quantitative-policy tradition, provided the conditional nature of the results is explicit.

Methodologically, the paper belongs to the tradition of quantitative economic policy and control theory. In this tradition, policy design is based on (i) an empirically estimated macroeconomic model and (ii) an explicit intertemporal objective function, and optimal policy paths are computed using tools from dynamic optimization (Tinbergen, 1952; Theil, 1964; Chow, 1975; Kendrick, 1981). This allows more policy instruments and more target variables to be included than in the DSGE approach. This is relevant in situations in which actual policy makers design budgetary policies: They have to fix several instruments both on the expenditure and revenue side of the budget, and they usually take several policy objectives into account when doing so. This, and a finite time horizon, makes a control theory approach empirically more relevant, at least for explanatory and forecasting purposes. Another scientific value lies in transparency: The target variables, the weights placed on them, and the assumed constraints are all made explicit so readers can directly evaluate the implied trade-offs. In addition, the paper's numerical solution approach builds on established optimum-control algorithms for nonlinear stochastic models, such as OPTCON (Matulka & Neck, 1992). This anchors the technical component in a recognized methodological lineage rather than treating it as a bespoke computational device.

Within the control-theoretic tradition, some country applications exist that use estimated macroeconometric models to compute approximately optimal fiscal (and, more often, joint fiscal–monetary) policies and to quantify trade-offs among objectives (Blackburn, 1987). For Austria, for example, stochastic optimal control has been used to compute optimal budgetary and monetary policies under uncertainty within an estimated macro model (Neck & Karbuz, 1995), and optimal control has also been applied to Austrian fiscal policy in nonlinear dynamic frameworks (Neck & Karbuz, 1997). These studies share key design elements with the present paper: explicit objectives, empirically based constraints, and a focus on feasible instrument paths over a policy-relevant horizon. The present paper extends this family of work to the Slovenian setting and to the post-pandemic environment, where the combination of elevated debt, euro area monetary conditions, and new shocks makes the stabilization–sustainability trade-off particularly salient.

A further bridge to the broader academic literature comes from empirical research on fiscal transmission. Structural VAR and narrative approaches have documented that spending and tax measures can have different dynamic effects, and that multipliers can vary over the business cycle and across regimes (Blanchard & Perotti, 2002; Ramey, 2011; Auerbach & Gorodnichenko, 2012). These findings reinforce the paper's emphasis on optimizing a vector of instruments rather than a single "fiscal stance." They also provide an external reference point for interpretation: When the model-based optimal policy favors particular compositions or timings of adjustment, this can be discussed in relation to what the empirical literature suggests about differential output effects across instruments and states of the economy. Such connections help translate technical optimization outputs into academically interpretable mechanisms.

Finally, the paper's use of an objective function reflecting policy makers' stated priorities connects it to the political economy of fiscal policy. Governments need not behave like benevolent social planners, and political turnover and institutional constraints can generate persistent deficits or strategic debt accumulation (Alesina & Tabellini, 1990). Broader syntheses emphasize that fiscal outcomes reflect both economic shocks and incentive problems embedded in institutions (Alesina & Perotti, 1995; Persson & Tabellini, 2000). In that context, it is methodologically defensible, and arguably desirable, to treat the government's objective as an empirically grounded representation of policy priorities rather than an assumed representative-agent welfare function. The paper contributes here by making that objective explicit and operational, following recent work on how to elicit and implement policy-maker preferences in optimum-control settings (Blueschke et al., 2024).

3 The SLOPOL12 model

We consider the SLOPOL12 model, a medium-sized macroeconometric model of the Cowles Commission type, for the economy of Slovenia. It contains 75 equations, 23 of which are behavioral equations and 52 identities. The model includes 75 endogenous and 41 exogenous variables. Most behavioral equations are specified in error correction form. It was estimated with data up to the end of 2023. We decided for the equation-by-equation approach to estimate the behavioral equation, which relies on theoretical hypotheses and the cointegration methodology, and built the model by closing it through identities and definitions. This approach is more flexible than looking at the model as a whole from the beginning, as would be the case for DSGE and (S)VAR models. This may lead to inconsistencies in the model and problems relating to the long run, which we discuss briefly in Section 7, showing that simulations beyond the estimation horizon perform fairly well while optimal policies may suffer from the well-known problem of time inconsistency. We believe that policy makers' time horizon is relatively short; hence a short-run approach to determining optimal fiscal policies is quite realistic for our purpose. By no means should our results be interpreted to say something about social welfare, apart from showing that optimal policies can definitely deliver better results than "business as usual" as embodied in the simulation runs without optimization, given the assumed objective function of the policy makers of Slovenia, which is derived from a survey they responded to.

The model contains equations for the goods market, the labor market, the foreign exchange market, the money market, and the government sector. It consists of Keynesian and neoclassical elements; in the short and medium run, it is demand driven, and persistent disequilibria in the goods and labor markets are possible while the long run is determined by the supply side with a production function with partly endogenous technical progress. An earlier version of the model was used by Weyerstrass et al. (2023) for an analysis of optimal fiscal policies in Slovenia during the COVID-19 pandemic. A detailed description of the version used here can be found in the Online Appendix to this paper; a detailed explanation of the model equations, their estimation, and the performance of the earlier model, which has by and large the same structure as SLOPOL12, is given by Weyerstrass et al. (2018).

Potential GDP is determined by a Cobb-Douglas production function with the inputs being potential labor force, capital stock, and trend of total factor productivity (TFP). Trend TFP is explained by a behavioral equation containing public expenditures on research and development (R&D), the proportion of inhabitants with tertiary education, and the investment-GDP ratio as arguments. We treat public R&D expenditures and educational attainment (although the government can only influence these indirectly) as supply-side fiscal policy instruments that mainly affect potential GDP.

The fiscal policy instruments exert influence directly on the demand side of the goods market, especially GDP and its components (both real and nominal). Indirect effects also come from the supply side via real GDP, the capital stock, the labor market, and the wage-price system. Earlier simulations (Weyerstrass et al., 2020) showed that public expenditures affect GDP more strongly while government revenues (policy instruments: tax rates) have stronger effects on the labor market, especially unemployment. Side effects on public debt are exerted directly from the policy variables and indirectly from nominal GDP. In the long run, real GDP and its components grow at approximately the same rate, and nominal GDP and its components grow at the same rate plus an inflation rate of 2 percent. The long-run path demonstrated a solid growth performance for the Slovenian economy before the recent crises and is, therefore, used as the starting point for the “ideal” path (to be discussed below) from the viewpoint of the policy makers. By using appropriate policies affecting the determinants of potential GDP, actual GDP can be driven towards the latter in the long run.

4 The optimal control approach

The optimal control approach to quantitative economic policy design consists of two elements: an empirical macroeconomic model and an objective function to be optimized. The policy maker in this study is the Slovenian government. We assume that, at the beginning of 2024, it wants to determine optimal paths for fiscal policy instruments for the period 2024 to 2030 based on forecasts from the SLOPOL12 model under alternative assumptions about exogenous shocks. In the model, we have nine fiscal policy instruments, namely government consumption, transfers, government investments, public expenditures for R&D, the average personal income tax rate, the proportion of the active working population with tertiary education (a proxy for public investment in human capital), the average social security contribution rate, remaining government revenues, and the value added tax rate. These are the control variables to be optimized for an objective function under the restrictions of the SLOPOL12 model. In an earlier paper (Blueschke et al., 2024), we used a survey among Slovenian fiscal policy makers to obtain information about their goals. Their ordinal ranking of targets was then operationalized into the specification of a cardinal objective function, which is the one used here.

We consider the so-called tracking problem of finding those trajectories of the control variables that minimize an intertemporal objective function, which is the sum, over time, of squared deviations of the values of the objective (target, i.e., politically relevant endogenous, and control) variables from some prespecified "ideal" paths. We assume a quadratic objective function with an annual discount factor of 3 percent. To specify the objective function, we have to fix the weights of the different objective variables and the "ideal" paths for these variables.

Starting from the results of Blueschke et al. (2024), we choose eight "major" state variables as arguments of the objective function: the growth rate of real GDP, the debt to GDP ratio, the current account balance to GPD ratio, the unemployment rate, real private consumption, real private investment, the budget balance to GDP ratio, and the inflation rate. We also define four "minor" target variables that were not named by the policy makers: the level of real GDP, the level and the growth rate, of potential GDP, and the ratio of government expenditures on R&D to GDP. These serve to ensure that the optimal time paths are sufficiently smooth and include the supply side of the economy. To formulate a well-defined optimal control problem, we also have to include the nine control variables as "minor" objectives in the objective function. Apart from the mathematical requirements of formulating an optimal control problem for the solution algorithm, these weights for the control variables (and the resulting costs of applying the controls) can serve as a substitute for inequality constraints on the values of the instruments, which cannot be handled by our algorithm. The eight "major" objective variables are assigned weights from 9 to 2 in descending order; the thirteen "minor" ones are assigned the weight of 1, except for the income tax and social security contributions rates, which are more difficult to change in practice and, hence, are assigned a much higher weight (50), and the remaining tax revenues, which only affect the other budgetary variables in the model and, hence, are assigned a small weight (0.01).

We also have to assume "ideal" paths for all the objective variables to be reached as closely as possible by the optimal policies. The "ideal" paths imply smooth growth in the income variables and low values for the rates of unemployment and inflation. We choose 2.5 percent as the "ideal" annual growth rate for real GDP and the other real aggregates, 4 percent for the growth rate of potential output, 2 percent for the inflation rate, the official goal of the European Central Bank (ECB), and 4.5 percent for all nominal variables, apart from government expenditures on R&D, which is assigned 5.5 percent. The "ideal" values of the tertiary education (human capital) variable grow by 0.2 percentage points per quarter from the 2023 level. The "ideal" values for the budget are rather modest: The "ideal" budget deficit to GDP ratio starts at 3.5 percent and decreases by 0.1 percentage points per year, and the "ideal" public debt to GDP ratio stays at its initial value in 2023 of 71 percent. Simulations with more ambitious goals for these variables result in austerity policies for most of the instruments, with negative effects on more important objective variables such as GDP and private consumption, which are considered politically unacceptable in Slovenia. The details of the objective function are summarized in Table 1.

Control variables	Weight	"Ideal" path
public expenditures in R&D	1	growth rate 5.5%
share of active working population with tertiary education	1	0.421 + 0.002 per quarter
public investment	1	growth rate 4.5%
public consumption	1	growth rate 4.5%
transfers	1	growth rate 4.5%
income tax rate	50	12.81% (current)
social security contribution rate	50	18.94% (current)
value added tax rate	1	22% (current)
remaining government revenues	0.01	growth rate 4.5%
State (target) variables		
growth rate of real GDP	9	2.50%
government debt to GDP ratio	8	71%
current account to GDP ratio	7	0.067 - 0.001 per year
unemployment rate	6	0.034 - 0.0005 per year
real private consumption	5	growth rate 2.5%
real private investment	4	growth rate 2.5%
government budget balance to GDP ratio	3	0.035 - 0.001 per year
inflation rate	2	2%
real GDP	1	growth rate 2.5%
ratio of government expenditures on R&D to GDP	1	0.47 + 0.1 per year
growth rate of potential GDP	1	4%
potential GDP	1	growth rate 4%

Table 1 Specification of the objective function. All growth rates are annual unless otherwise indicated

5 Simulations of different scenarios

We first use the SLOPOL12 model to simulate a baseline and several macroeconomic shock scenarios over the period 2024 to 2030, with the shocks assumed to be transitory and lasting for two years (2024–2025). We include a longer time horizon for the simulation and optimization than for the shock period because the results for the last years of the forecast are less reliable than the earlier ones and last-period effects are usually less valid for optimizations due to the neglect of a scrap value.

The *baseline scenario* (called "basic" in the figures) was constructed using the most recent available forecast for Slovenia at the time of writing the paper, the IMAD Spring Forecast 2024 (IMAD, 2024). This results in a fairly optimistic view for the years after the COVID-19 pandemic, with real GDP growing between 2 and 3 percent per year and a sharply decreasing inflation rate. However, it also contains a fall in the human-capital variable by about 0.25 percent due to the long-term effects of COVID-19 induced measures (school closures, etc.), an increasing unemployment rate, high budget deficits above the EU Stability and Growth Pact reference value of 3 percent of GDP, and, hence, increasing public debt. A decreasing current account surplus is due to increasing import demand from forced savings during the pandemic. This scenario is the baseline for the other simulations and the optimization experiments.

The shock scenarios, both negative and positive, are created by changing (mostly globally determined) exogenous variables by some plausible values in relation to developments of the global economy. In particular, we assume:

1. A decrease in the annual growth rate of *world trade* by 10 percent in volume in 2024 and 2025. This may be caused, for instance, by reduced global trade due to political measures (tariffs) in the United States and/or Europe. This primarily has a negative effect on Slovenian exports, aggregate demand variables, and the unemployment rate but has nearly no effect on the price level and inflation, which are largely determined by Euro Area monetary policy. Although less likely, unfortunately, we also construct a scenario with world trade increasing in exactly the same way as the negative shock, namely an increase in the growth rate of world trade by 10 percent in volume in 2024 and 2025. The effects mirror those of the negative world trade shock, showing that in spite of the nonlinear

structure of the model, these negative and positive shocks affect the simulations in a qualitatively symmetric way.

2. An *appreciation of the euro* versus the US dollar by 20 percent. This may be caused, for instance, by expansionary monetary policies in the United States without parallel developments in the European Union. This has a temporary but weak recessionary effect on the Slovenian economy. The reverse is true for a depreciation of the euro by 20 percent against the US dollar.
3. An increase in the *oil price* by 50 percent. Although such a large change in the oil price does not seem to be very likely, it turns out that only a change of this magnitude can have effects similar to the decrease in the growth of world trade. This shows that this supply shock is relatively weaker than the demand effects of the trade shock, at least when it is temporary, as assumed here. A decrease in the oil price by the same percentage again has effects that are the opposite of the increase and of similar size.
4. An increase in the size of the working-age (15 to 64 years) *population* by 2 percent. This may be caused by people immigrating, who can be absorbed into the labor force only gradually with considerable lags. For the temporary shock, this has a small (mostly expansionary) effect on most aggregate variables (especially potential output) for the duration of the shock and afterwards. Again, the opposite effect occurs for a decrease in the working-age population.
5. An increase in *total factor productivity* (TFP) by 0.1 percent. This may be caused by an innovation or a one-time increase in the quality of capital or the labor force. Although the size of this temporary shock is tiny, it has a positive effect on the level of potential output in the medium run as well; the effect on the growth rate of real GDP is only temporary, however. Otherwise, the effects are similar to those of the increase in the working-age population. The effects of an equivalent decrease in TFP again mirror those of the increase.
6. Finally, a *crisis* scenario, with a simultaneous decrease in world trade by 10 percent, an increase in the oil price by 50 percent, a depreciation of the dollar against the euro by 20 percent, and a decrease in TFP by 0.1 percent. As most shocks have both a demand and a supply component, such a scenario is probably more realistic for a global crisis. Although this scenario entails sizable and lasting effects on the objective variables, they are far from the catastrophic ones of the Great Depression in the 1930s.

The time paths of the simulated scenarios are shown in Figures 1 to 8 in the next section, together with those from the optimizations for the same shocks. This is the best way to see how fiscal policy should react to the shocks if the assumed objective function is to be optimized.

6 Optimal fiscal policy without and with shocks

To calculate the optimal time paths for the fiscal policy instruments and the endogenous objective variables, we use the OPTCON algorithm (Blueschke-Nikolaeva et al., 2012; Blueschke et al., 2021). This algorithm allows us to determine approximately optimal numerical solutions for optimum control problems with a quadratic objective function and a nonlinear multivariate dynamic system. Because of the nonlinearity of the model, which is our dynamic system, exact solutions for these problems are not known, but the approximations obtained by the OPTCON algorithm result in exact solutions for linear models, which may be taken as an indicator that they are close to the true solutions, at least for "tame" nonlinearities such as those in the SLOPOL12 model.

The problem with the nonlinear system is tackled iteratively in the OPTCON algorithm. This means that we repeatedly linearize the nonlinear problem, solve this linear approximation in each step, and take the linear solution as a new tentative path. Once a convergence criterion is fulfilled, the solution of the last iteration is taken as (an approximation to) the optimal solution of the nonlinear problem, and the algorithm stops. Every iteration, i.e., every solution of the problem for the linearized system, has the following structure: The objective function is minimized using Bellman's principle of optimality to obtain the parameters of the feedback control rule. This uses known results for the optimal control of LQ problems (the optimization of *l*inear systems under a *q*uadratic objective function). A backward recursion over time starts in order to calculate the controls for the first period. Next, the approximately optimal values of the state and the control variables are calculated by applying forward recursion, and the resulting time paths are used for the next iteration, and so on, until the solution converges.

In our optimization runs, the weights and the "ideal" paths of the control and target variables are the same for all scenarios (Table 1 above). We present simulation and optimization results for the baseline and the shock scenarios for some relevant control and target variables in Figures 1 to 8 to show the different impact of the shocks on the policy design and their effects on the Slovenian economy according to the SLOPOL12 model. First, Figures 1 to 5 show the effects of a decrease in the growth of world trade by 10 percent in 2024 and 2025 relative to the baseline, with simulated trajectories for the baseline and the shock scenario and with optimal trajectories for both scenarios.

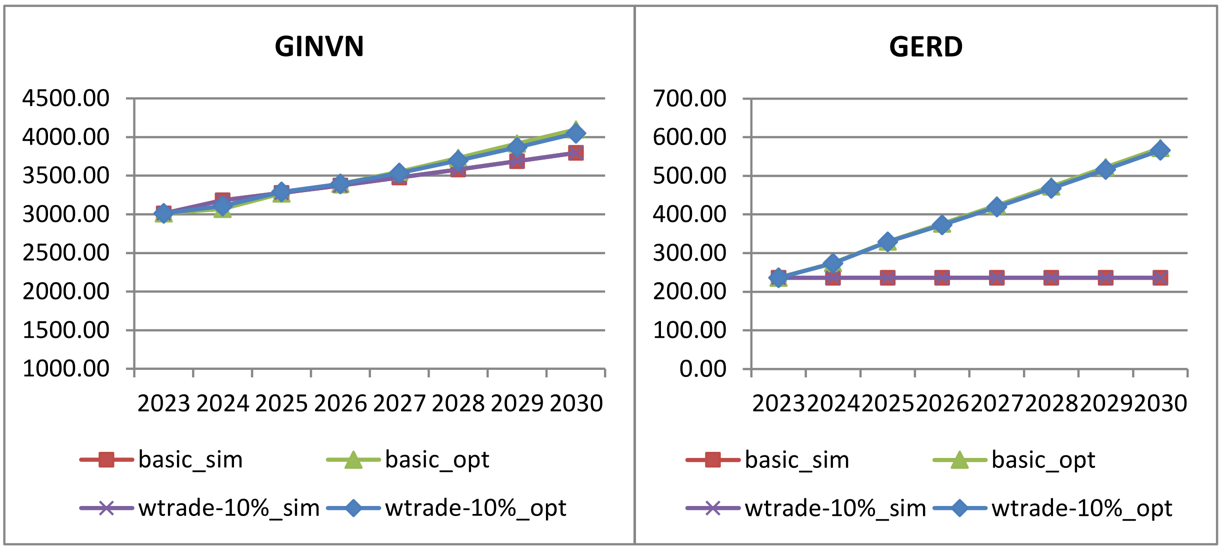

Fig. 1 Baseline scenario and decrease in world trade growth, control variables: public investment (GINVN), public investment in R&D (GERD)

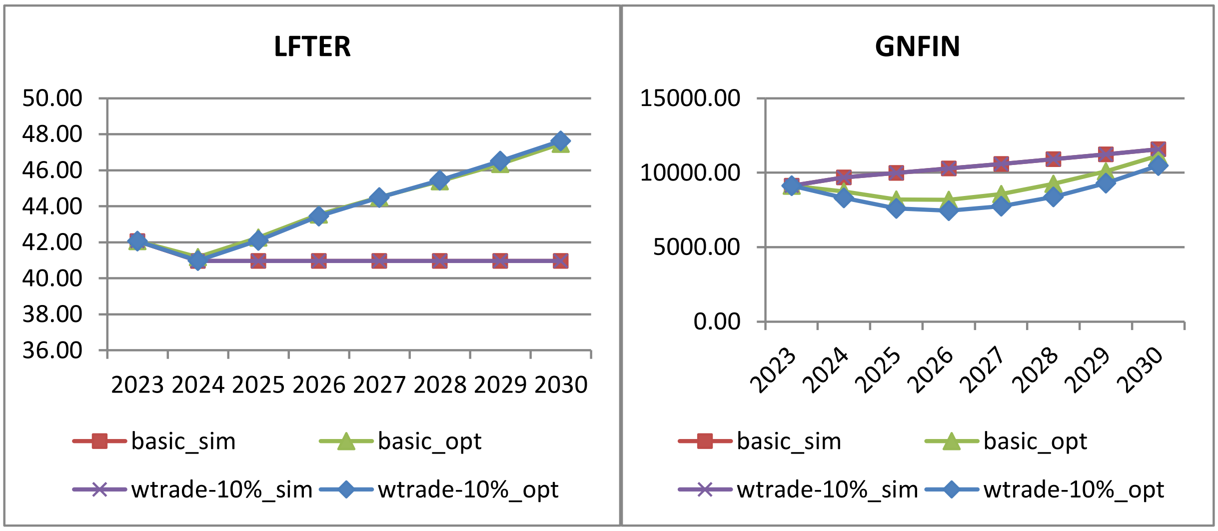

Fig. 2 Baseline scenario and decrease in world trade growth, control variables: percentage share of active working population with tertiary education (LFTER) and public consumption (GNFIN)

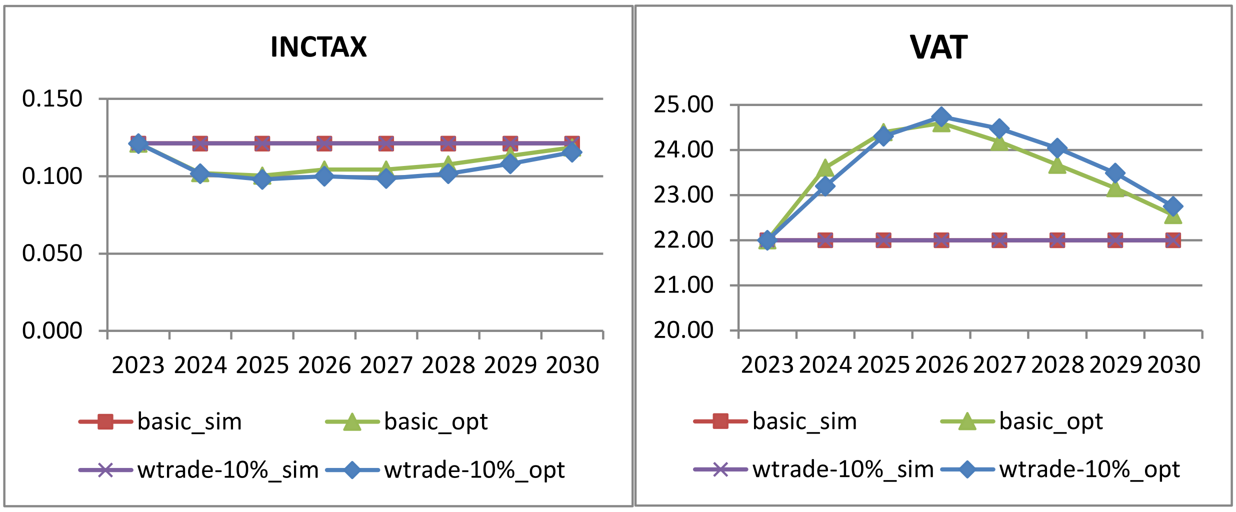

Fig. 3 Baseline scenario and decrease in world trade growth, control variables: income tax rate (INCTAX) and value added tax (VAT) rate

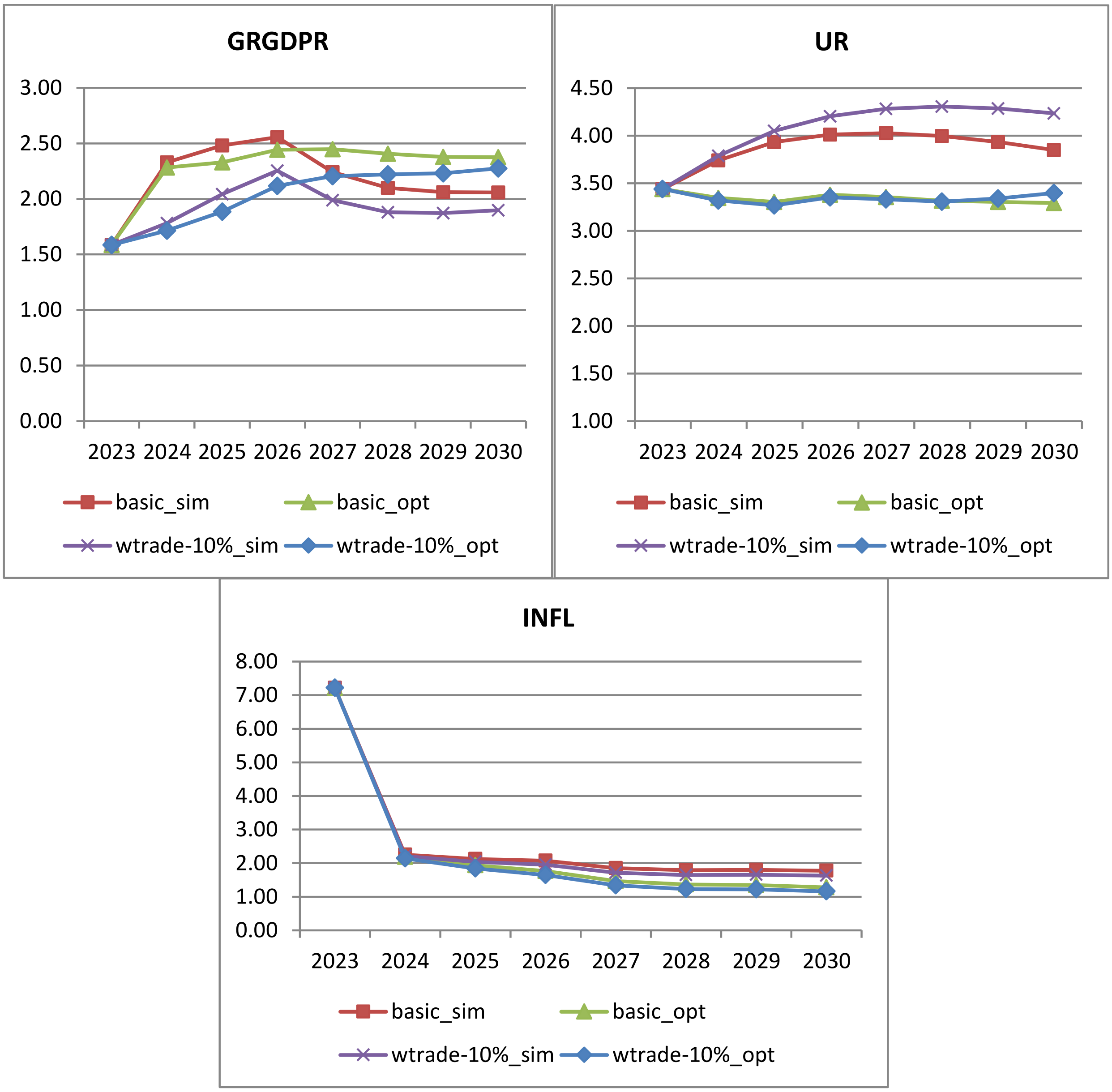

Fig. 4 Baseline scenario and decrease in world trade growth, target variables: growth rate of real GDP (GRGDPR), unemployment rate (UR), and inflation rate (INFL)

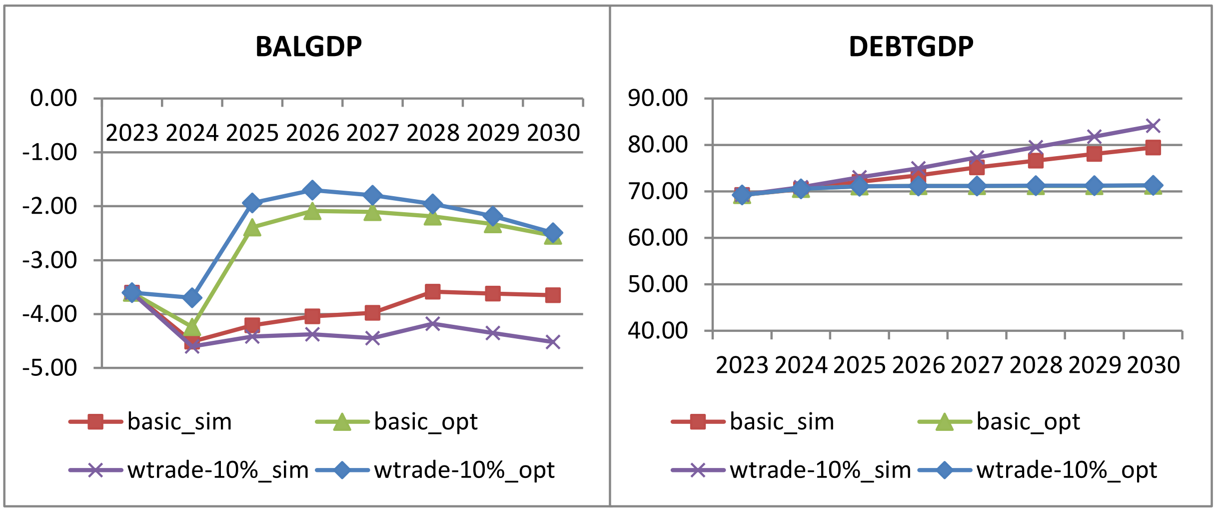

Fig. 5 Baseline scenario and decrease in world trade growth, target variables: government budget balance to GDP ratio (BALGDP) and government debt to GDP ratio (DEBTGDP)

Figures 1–3 show the simulated and optimal paths of the instrument variables. For the instruments, the simulated paths for the baseline (basic_sim) and the shock scenario (wtrade-10%_sim) coincide. On the expenditure side of the government budget, we can distinguish four categories of instruments:

1. Public investment in R&D (Figure 1) and in human capital (the proxy variable, Figure 2) have higher growth rates of the "ideal" values because these items are intrinsically of great importance and have long-run supply-side effects on growth and employment. As a result, their optimal paths (basic_opt and wtrade-10%_opt) are equal to their "ideal" value paths. They are assigned to the target variable potential GDP as they are among its determinants.
2. Optimal values for general public investment (Figure 1) are close to the simulated values, with a slight tendency towards procyclical movements. This instrument is not applied very actively. The reason for this is the two-fold effect of this instrument on both the demand and the supply side: It boosts both real GDP and potential GDP, which have different "ideal" growth paths but are designed not to diverge too much to avoid disequilibria in the goods and labor markets.
3. Optimal public consumption (Figure 2) is considerably lower than simulated, which is counterintuitive at first sight. The reason is the low effectiveness of this instrument with respect to output and employment; therefore, it is assigned to the goals of government budgetary policy. The same argument holds *mutatis mutandis* for government

expenditures in general (with the exception of investment in R&D and human capital); hence, they are not assigned to the stabilization of goods and labor markets.

4. The only expenditure variable with an optimal countercyclical path is transfers but as is the case with public investment, this instrument is not used actively but remains close to the simulated path. The reason for this behavior is the same as for other government expenditures, namely its low effectiveness for stabilization purposes.

In contrast to the expenditure side of the public budget, its revenue side plays a more active role in the design of stabilization policy in a Keynesian sense. We can distinguish two categories of government revenues:

1. The optimal values for the income tax (Figure 3) and social insurance contributions rates are considerably lower than the simulated ones. Tax reductions for these items diminish the wedge between employers' expenditures and employees' incomes and, therefore, have strong effects on the goods and labor markets. In the optimal policy mix, these taxes, consequently, play an active role in supporting output growth and employment.
2. In contrast, value added tax (VAT, Figure 3) is one of the most important positions in the public budget and does not damage output or employment. This explains why this variable is assigned to the government budget. This means that the optimal policy path of VAT is higher than the simulated path (by up to more than 2 percentage points) for both the baseline and the shock scenarios. The case is similar for the remaining government revenues, which are largely decoupled from the rest of the model (they work like lump-sum taxes). The optimal policy design for this variable is driven by the budgetary goals of the government in view of the sizeable tax reductions required for decreasing the tax wedge.

The results of the optimal policy mix are quite successful. Both the optimal level and the growth rate (Figure 4) of GDP are, on average, higher than in the simulations, and the same is true for the level and the growth rate of potential real GDP. The most impressive improvement is obtained for the unemployment rate (Figure 4): Although the decline in world trade growth entails an increase in the unemployment rate by one half of a percentage point, also in the medium run, the optimal path is nearly constant, and even for the shock scenario, optimal unemployment is clearly below the simulated one, even when comparing optimal unemployment in the shock scenario with the simulated one in the baseline. On the other hand, the inflation rate (Figure 4) is not substantially affected by fiscal policy as it is largely determined by the ECB. According to the forecast, there is not much need to reduce inflation as Slovenia (like most other countries in the Euro Area) achieves price stability very quickly through ECB monetary policies. It is remarkable that the favorable results of the optimal fiscal policy mix are not obtained at the expense of a worse government budget: Both the optimal budget deficit and the optimal public debt (Figure 5) are lower than their uncontrolled counterparts.

From the other optimization exercises we mostly obtained similar insights as for the world trade shock, and in each case, the positive and the negative shocks are symmetric for the optimal and simulated scenarios alike. This shows that the SLOPOL12 model is only "mildly" nonlinear; for highly nonlinear models, asymmetric behavior could be expected. Instruments that directly affect both the supply and the demand side of the economy are mostly more effective than those that influence only one of them. As a policy conclusion, the optimization experiments suggest designing the fiscal policy mix primarily in relation to the trade-off between output and sustainable public finances. Instruments for stabilizing output and employment are direct taxes and government investment in physical and human capital, which behave countercyclically while VAT and remaining government revenues, and especially government consumption, exhibit procyclical paths in order to keep the government budget deficit and debt down. If the SLOPOL12 model is an adequate model of the Slovenian economy, Slovenian fiscal policy makers can be advised to divert a larger amount of the government budget to expenditures increasing the physical and human capital of the country, combined with reducing personal taxes, social security contributions, and consumptive expenditures; this should then lead to smooth growth without adverse effects on the state budget and debt. Assigning the instruments direct taxes to the stabilization of the business cycle and public consumption and indirect taxes to budget consolidation may seem counterintuitive at first sight; it can be explained by the combined supply and demand effect of the former and the low effectiveness of the latter with respect to output and employment with their purely demand-side effect.

As the qualitative results of the optimizations under different shocks are very similar, we do not show them in detail. Instead, we present the results for the growth rate of real GDP only, which can be regarded as one of the most central objective variables and was chosen by policy makers in the survey as their primary objective. Figure 6 shows the path of real GDP in the different scenarios introduced in Section 5. Especially the crisis scenario might be regarded as a realistic future possibility.

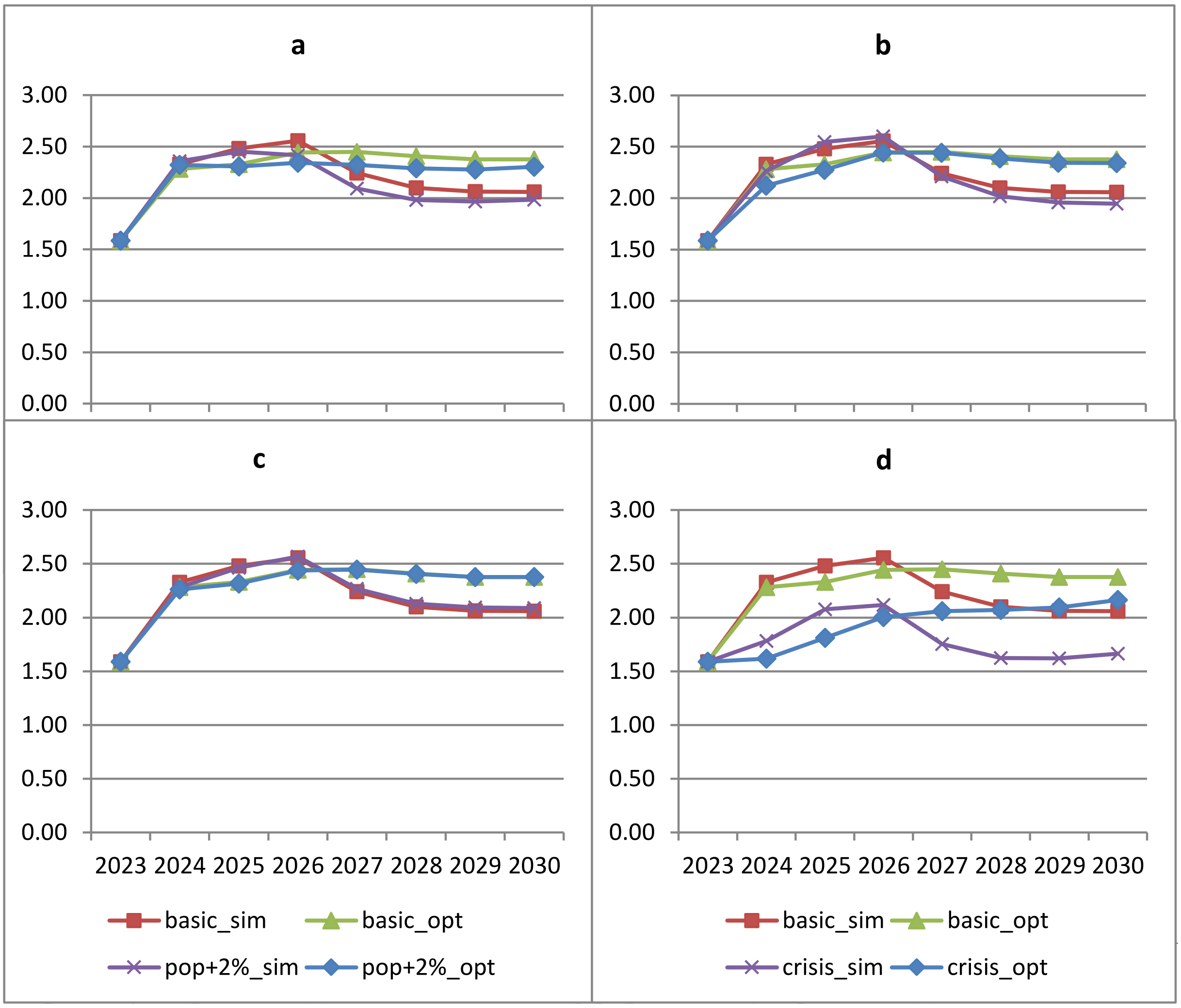

Fig 6 Growth rate of real GDP, different scenarios: (a) appreciation of the euro; (b) increase in oil price by 50 percent; (c) increase in working population by 2 percent; (d) crisis scenario

The main quantitative results can be summarized as follows. Across the baseline and benchmark shock, the composition of the optimal policy package is highly stable: Labor-tax instruments and supply-side levers are used primarily to stabilize output and employment while indirect taxes, residual revenues, and public consumption provide the main adjustment margins for fiscal sustainability.

On the supply side, two prescriptions are particularly robust and largely invariant across scenarios. First, public expenditure on R&D is shifted onto a substantially higher and persistent path: Relative to a simulated trajectory that remains roughly flat in the mid-200s, the optimal trajectory increases strongly from 2024 onward and reaches the mid-500s by 2030. Second, the human-capital proxy (the share of the active working population with tertiary education) moves away from the simulated near-stagnation around 41% and instead increases steadily over the horizon, reaching roughly 47–48% by 2030. These adjustments are not used as short-lived "stimulus" but as structural commitments that support potential output while improving the feasibility of stabilization with limited debt accumulation.

The most operationally precise stabilization prescription is a front-loaded reduction in the labor-tax wedge. The average personal income tax rate is reduced in 2024–2025 by about two percentage points (from just above 12% to around 10%), and social security contributions are cut even more strongly in 2024 by roughly three to four percentage points (from about 18.9% to the mid-15% range). Both are then gradually normalized toward baseline levels later in the decade. Under the benchmark shock, the initial cut, especially in contributions, is somewhat deeper and the return slightly slower but the qualitative pattern is unchanged.

These wedge reductions are financed by a temporary increase in indirect taxation and by expenditure restraint. The VAT rate rises above the simulated constant 22% by up to more than two percentage points in the mid-20s (peaking around 24½–24¾%) and then declines gradually toward the low-22% range by 2030. Remaining government revenues are also used as a flexible balancing item, increasing relative to the simulated path in the early years and rising further toward the end of the horizon. On the expenditure side, public consumption is the main adjustment margin: It is reduced substantially below its simulated trajectory in 2024–2026 (with stronger restraint in the shock scenario), before partially converging back toward the simulated path by 2030. Transfers and general public investment remain close to their simulated paths, implying that the optimizer does not rely on large discretionary swings in these items for cyclical stabilization.

The macro-fiscal implications are sizeable: Unemployment is kept close to a nearly flat, lower trajectory relative to the uncontrolled simulations, and fiscal sustainability improves despite stabilization, most clearly in the debt-to-GDP ratio, which is stabilized around its target level (approximately 71%) rather than rising markedly in the baseline and even more so under the benchmark shock (Blueschke et al., 2024).

Altogether, the main policy recommendations are:[1] Assign the instruments to targets by using three groups:

1. Stabilize the economic cycle by using the income tax rate and the social security contributions rate.

[1] This formulation was suggested to us by an anonymous referee.

2. For fiscal consolidation, use public consumption, the VAT rate, and the other revenues.
3. To influence potential output growth, use public investment in R&D and tertiary education attainment.
4. The appropriate assignment is more ambiguous for the remaining two fiscal instruments, other public investments, and transfers. These may be used for other political goals and/or for both stabilizing the cycle and budget consolidation.

7 Long-run effects

As our macroeconomic model does not rely on assumptions securing convergence to a long-run steady state, it is important to examine the long-run solution of simulation and optimization experiments. Following a suggestion made by a referee of this journal, we look at a time horizon until 2040 to find out whether key target variables diverge against plus or minus infinity, which would reveal instability in the model or the optimal policies. In addition to the simulation and optimization for the period 2024–2030, we consider developments over the next decade (2030–2040) for the baseline solution: a simulation with "business as usual" values for the (controlled and uncontrolled) exogenous variables (basic_sim_40), continuing our simulation until 2030 (basic_sim_30); an optimization over the entire time horizon 2024–2039 (basic_opt_24_39), and an optimization from 2029 to 2040 (basic_opt_29_40). The latter is motivated by the question as to whether, from the viewpoint of the end of the first optimization in 2028, optimal policies until 2040 continue those which were optimal until 2028 or not. Given the results in relation to time inconsistency, one would conjecture that this is not the case. Figures 7 and 8 show these time paths for the most important "major" target variables growth rate of real GDP, unemployment rate, inflation rate, and current account balance (note: the scales differ from the previous figures).

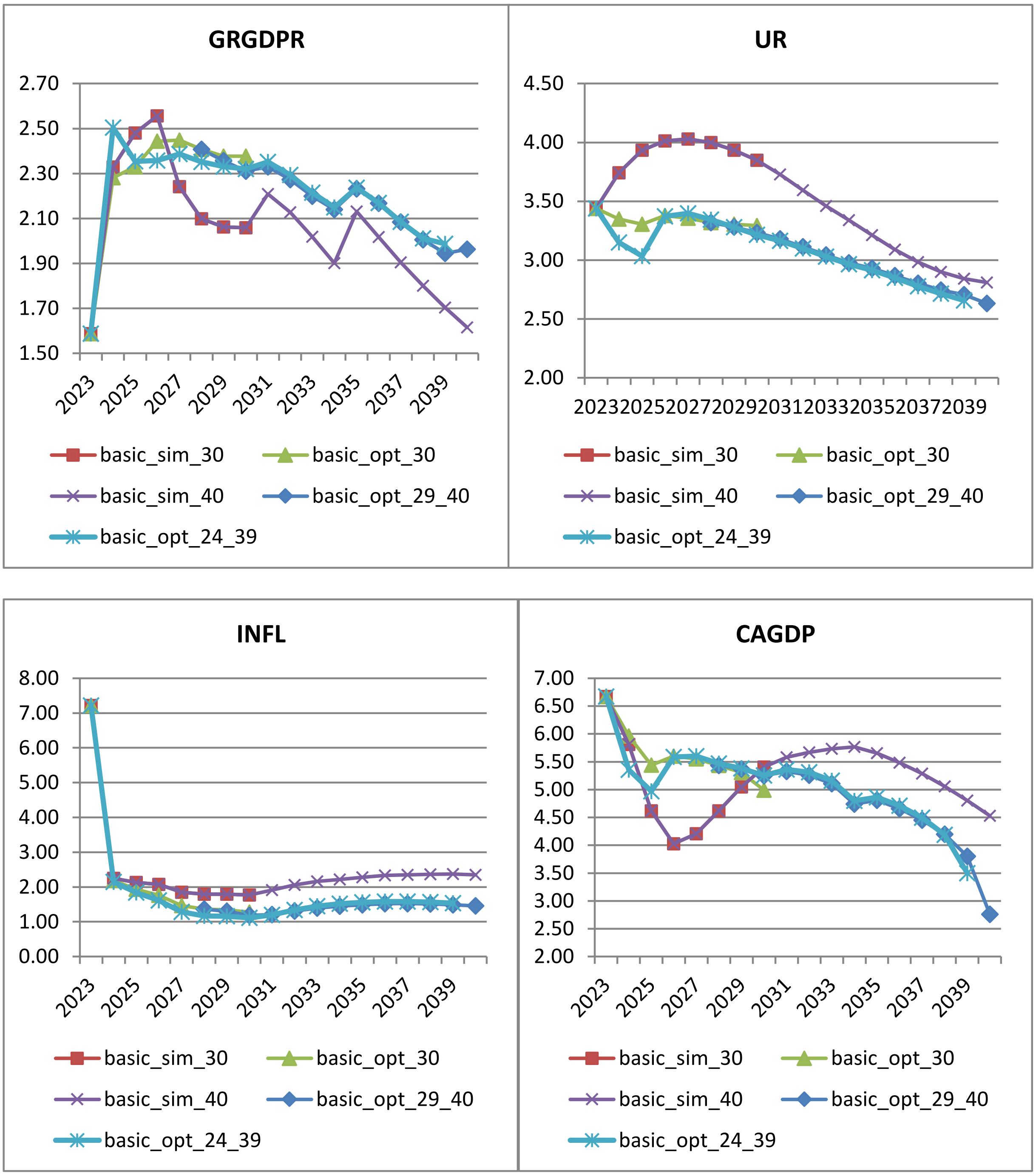

Fig. 8 Simulations and optimizations over different time horizons, target variables: Inflation rate (INFL) and current account balance (CAGDP)

Looking first at the simulations until 2040, we see that for none of these variables does the time path explode; hence, the hypothesis that they are stable is not rejected. The paths from 2031 to 2040 are continuations of those until 2030 and move around values before the crises. The decline in GDP growth, unemployment, and current account in the last years before 2040 may be explained by the expected employment shortages due to the age structure of the Slovenian population and the resulting reduction in productivity. Therefore, we cannot exclude the possibility that a regime change (with a lower natural rate of unemployment and hence natural output) will take place in the late 2030s, but a return to the long-run regime of the pre-crises years is also a possibility.

As for the optimizations, a continuation of the path until 2030 cannot be expected for the new optimization from 2028 due to the time inconsistency problem. However, the new optimization path also entails improvements over the simulation concerned, which is particularly clear for the unemployment rate. The discrepancies between the different optimal paths in the overlapping years is not serious for any of the four target variables. The decline in the optimal paths for unemployment and GDP growth in the last years may have the same reason as for the simulation. In addition, and especially for the current account balance, there may be a last period effect familiar from optimal control applications that is due to the neglect of developments after the terminal period (2040 in our case). Introducing a scrap value or assuming a terminal period far later than 2040 may help with this problem.

7 Conclusions

This paper designs medium-run optimal fiscal policy paths for Slovenia using the macroeconometric model SLOPOL12 and an explicit objective function that operationalizes policy makers' stated priorities. Approximately optimal instrument trajectories are computed in a nonlinear stochastic optimal-control framework using the preference-operationalization approach proposed in Blueschke et al. (2024). The results are best interpreted as conditional on the maintained econometric relationships and the stated objective; they provide a transparent quantification of feasible stabilization–sustainability trade-offs rather than a welfare-based benchmark.

Across the baseline forecast and transitory shock scenarios, the optimal solution implies a stable and interpretable policy package. Stabilization relies primarily on a front-loaded reduction in the labor-tax wedge: The average personal income tax rate is reduced by about two percentage points in 2024–2025 and social security contributions by roughly three to four percentage points in 2024, with gradual normalization thereafter. Medium-run capacity building is pursued through persistently higher R&D spending and a steadily rising share of the population with tertiary education, both of which support potential output and improve the medium-run feasibility of meeting debt objectives. Consolidation and financing are achieved mainly through a temporary increase in VAT, higher residual revenues, and multi-year restraint in public consumption; in contrast, general public investment and transfers remain relatively close to their simulated paths.

The economic logic is consistent with the model's transmission mechanisms: Labor-tax instruments are selected for stabilization because they affect employment and output through the wedge channel with comparatively high effectiveness per unit of fiscal cost while VAT is used for consolidation because it delivers revenue with comparatively limited labor-market effects in the model structure. Supply-side instruments (R&D and human capital) are treated as structural rather than cyclical levers because they raise potential output and thereby ease the stabilization–sustainability trade-off over the horizon.

In outcome terms, the optimal package smooths GDP growth, keeps unemployment on a nearly flat and lower trajectory even under adverse shocks, and improves fiscal sustainability. Most notably, the debt-to-GDP ratio is stabilized around its target level rather than rising substantially in the uncontrolled simulations. The qualitative assignment of instruments is robust across shocks and time horizons.

From the viewpoint of the theory of economic policy, the trade-off between output stabilization and the sustainability of budgetary policy as well as the relatively low sensitivity of optimal fiscal policy with respect to negative and positive shocks are worth mentioning. Assigning policy instruments with effects on both potential output and real GDP to the task of stabilizing output, employment, and other policy instruments for the purpose of budgetary consolidation turns out to be optimal. Simple Keynesian recipes (just expanding public expenditures and decreasing taxes) do not seem to be appropriate; instead, a more specific way of targeting the trade-offs, especially between output and employment stabilization and preserving budgetary sustainability, should be followed.

A more comprehensive analysis would involve systematically entering into a dialogue with policy makers, presenting them with the results of this and similar analyses, and obtaining feedback and more valid information about their preferences with respect to their macroeconomic goals. Moreover, other areas of public policy, such as climate and other environmental policies, industrial policies, and cultural policies, for instance, would also have to be taken into account for a more comprehensive approach to a decision support system for policy makers. This will be a rewarding task for further research.

Acknowledgments

The authors gratefully acknowledge financial support from the Austrian Science Fund FWF (project no. I 2764-G27) and the Slovenian Research Agency ARRS (contract no. 630-31/2016-1). An earlier version of this paper was presented at the Annual Conference of the Austrian Economic Association (NOeG), BOKU University, Vienna, 2–3 September 2024. Comments from participants at this meeting and especially from two anonymous referees are gratefully acknowledged. The usual caveat applies.

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