R&D as Optimal Fiscal Policies for a Small Euro Area Economy: A Case Study for Slovenia

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Abstract

In this paper, we investigate how effective stabilization policies can be in a small open economy that is part of the Euro Area, namely Slovenia. In particular, we investigate fiscal policy effects on aggregate target variables of the Slovenian economy. Slovenia is an interesting case because it is the only small open economy from Central and Eastern Europe that was already in the Euro Area before the Great Recession. Simulating the SLOPOL10 model, an econometric model of the Slovenian economy, we analyse the effectiveness of various categories of public spending and taxes over a time horizon until 2030. Some of these instruments are targeted towards the demand side, while others primarily influence the supply side. Our results show that those public spending measures that entail both demand and supply side effects are more effective at stimulating real GDP and increasing employment than pure demand side measures. Next, we more closely analyse measures that increase R&D (research and development) and those that improve the education level of the labour force, which turn out to be relatively more effective than the other fiscal policy instruments. In particular, R&D related government expenditures are very effective at stimulating potential and actual GDP. Employment can also be effectively stimulated by cutting the income tax rate and the social security contribution rate, i.e. by reducing the tax wedge on labour income and positively affecting Slovenia's international competitiveness. This can also be shown by determining optimal fiscal policies for Slovenia over the same time horizon according to a macroeconomic loss function. Again, R&D and educational measures turn out recommendable for a strategy of sustained growth without unwanted side effects on public debt.

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1. Motivation

The Slovenian economy, although small, is of interest for the following reasons: First, it was part of the Yugoslav economy, a centrally planned economy with a unique system of workers' self-management, until the dissolution of Yugoslavia. Second, Slovenia has developed towards a parliamentary democracy and a capitalist economy much faster than any other of the successor states of Yugoslavia has. In particular, it became a member of the European Union in 2004 and, as the first former communist country, joined the Euro Area in 2007, which at the time was regarded as a major achievement. Third, the Slovenian economy is one of the small open economies within the Euro Area; hence, its economic policy problems may also be of interest to other economies of that type. For example, difficulties resulting from the particular policy architecture of supranational monetary policy versus a national fiscal policy occur not only in Slovenia but also in several other members of the Euro Area. Finally, Slovenia was hit very hard by the Great Recession and the ensuing sovereign debt crisis but managed to return to satisfactory growth relatively fast recently, so it can be regarded as a model for dealing with business cycles.

If we want to explain economic developments in a country like Slovenia, and even more so if we want to design economic policies for such a country, a model of the Slovenian economy is required. Such a model shall serve as a tool for forecasting macroeconomic developments over the short and medium run and for evaluating alternative policies aimed at influencing the business cycle, stabilizing unemployment and inflation, and enhancing growth and employment in Slovenia. Several modelling strategies are available for building a macroeconomic model that can fulfil these requirements. If a model builder believes in neoclassical or New Keynesian macroeconomic theory, a Dynamic Stochastic General Equilibrium (DSGE) model will be his/her choice. If, on the other hand, theories are distrusted and a "data-only" approach is preferred, a vector autoregression (VAR) model will be chosen. Here we follow a more traditional modelling approach and opt for an econometric model of the Cowles Commission type. These models compromise between the theory-first and the empirics-first approaches; they must be based on sound theoretical foundations and estimated using real data of the economy under consideration. Several models of this type have been estimated before by members of the present team of authors (Verbič 2006, Weyerstrass et al. 2007); here we follow this tradition.

To build such a model, it is important to have available a data base with sufficiently long time series to provide reliable estimates. For former communist countries like Slovenia, this poses a problem: data before 1991, when the country gained independence, are based on communist accounting rules and are not comparable to those of later years. Even for the early years of the transition process, many data (especially those from national income accounting) are of dubious quality. Therefore, estimations of behavioural equations for Slovenian aggregates have to be based on data starting in 1995 or later. In order to obtain estimations with sufficient degrees of freedom, an econometric model for Slovenia has to use quarterly or – where available – monthly or even higher-frequency data. Here we describe a quarterly macroeconometric model called SLOPOL10, which is a revised and updated version of a series of models that we have built since the late 1990s, with increasing degrees of sophistication and reliability. These models have been used for various purposes of forecasting and especially evaluating alternative policies, where simulation and optimization experiments were conducted to arrive at politically relevant insights and policy recommendations (see, e.g., Neck et al. 2011). Of particular importance with respect to Slovenia's position in the European

Union are evaluations of its fiscal policies, as the country has to fulfil the requirements of the EU Stability and Growth Pact (see Blueschke et al. 2016).

Like every structural econometric model, the SLOPOL10 model may be subject to the famous Lucas critique. Lucas (1976) argued that the relations between macroeconomic aggregates in an econometric model should differ according to the macroeconomic policy regime in place. In this case, the effects of a new policy regime cannot be predicted using an empirical model based on data from previous periods when that policy regime was not in place. Sargent (1981) argues that the Lucas critique is partly based on the notion that the parameters of an observed decision rule should not be viewed as structural. Instead, structural parameters in Sargent's conception are just "deep parameters" such as preferences and technologies. These parameters would be invariant, even under changing policy regimes. Providing for such "deep parameters" requires a different class of macroeconomic models, namely Computable General Equilibrium (CGE) or DSGE models. We consider the Lucas critique to a certain extent by following the so-called London School of Economics tradition initiated by Sargan (1964). According to this approach, economic theory guides the determination of the underlying long-run specification while the dynamic adjustment process is derived from an analysis of the time series properties of the data series. Error correction models involving cointegrated variables combine the long-run equilibrium and the short-run adjustment mechanism.

2. Model Description

SLOPOL10 (SLOvenian economic POLicy model, version no. 10) is a medium-sized macroeconometric model of the Slovenian economy. In its current version, SLOPOL10 consists of 75 equations, 23 of which are behavioural equations and 52 identities. In addition to the 75 endogenous variables, the model contains 41 exogenous variables. A list of the variables used in the SLOPOL10 model can be found in

Table 1. All data are available from the authors upon request. The model is constructed in order to allow for forecasts and policy simulations over the near future. Statistical tests will be presented that show the performance of the model in the past. In our view, these tests show that the model exhibits acceptable quality for such uses. Improvements in the light of new data will be continually made when using the model for these purposes.

Table 1. List of Variables

Endogenous Variables

AGWN	Average gross wage, euro per employee
AGWR	Average gross wage real
BALANCE	Budget balance
BALANCEGDP	Budget balance in relation to GDP
CAGDP	Current account balance in percent of GDP
CAN	Current account balance
CAPR	Real capital stock
CDEF	Private consumption deflator
CN	Private consumption, nominal
CPI	Consumer price index
CR	Private consumption, real

DEBT	Public debt stock
DEBTGDP	Debt level in relation to GDP
DEMAND	Final demand, real
EMP	Total number of employees
EMP1564	Employment, 15 to 64 years
EMP65PLUS	Employment, 65 years or older
EXPDEF	Export deflator
EXR	Exports of goods and services, real
GAP	Output gap in percent of potential GDP
GDEF	Public consumption deflator
GDPDEF	GDP deflator
GDPN	Nominal GDP
GDPR	Real GDP
GERDR	Real government R&D expenditures
GINVR	Real government investment
GN	Public consumption, national accounts, nominal
GOV10Y	10 year government bond yield
GOV10YR	Real government bond yield
GR	Public consumption, real
GRGDPR	Real GDP growth rate
GRYPOT	Growth rate of potential GDP
IMPDEF	Import deflator
IMPR	Imports of goods and services, real
INCOME	Disposable income of private households, nominal
INCOMER	Disposable income of private households, real
INCTAX	Total income tax revenues
INCTAXCORP	Corporate income tax revenues
INCTAXPERS	Personal income tax revenues
INFL	Inflation rate
INTEREST	Interest payments on public debt
INVDEF	Investment deflator
INVN	Gross fixed capital formation, nominal
INVR	Gross fixed capital formation, real
LF	Total labour force
LF1564	Labour force, 15 to 64 years
LF65PLUS	Labour force, 65 years or older
NETWAGEN	Net wage, nominal
NETWAGER	Average net wage, real
OILEUR	Oil price in euro
PRIMBALANCE	Primary budget balance
PRIMBALANCEGDP	Primary budget balance in relation to GDP
PRINVR	Real private investment
PROD	Labour productivity
REER	Real effective exchange rate (deflator: consumer price indices, 42 trading partners)
SITBOR3M	3 month interest rate before 2007, EURIBOR from 2007 onwards
SOCCOMP	Social security contributions by employers
SOCEMP	Social security contributions by employees
SOCTOTAL	Total social security contributions
TAXDIRECT	Other direct taxes
TAXINDIRECT	Other indirect taxes
TGEN	Total government expenditures
TGRN	Total government revenues
TRENDEMP	Trend of employment
TRENDTFP	Trend of total factor productivity
UCC	User cost of capital

ULC	Unit labour cost
UN	Total number of unemployed persons
UN1564	Unemployment, 15 to 64 years
UR	Unemployment rate
UR1564	Unemployment rate, 15 to 64 years
UTIL	Capacity utilisation rate
VAT	Value added tax revenues
WEDGE	Tax wedge on gross wages
YPOT	Potential output

Exogenous Variables not Controllable by Slovenian Policy Makers

BANKCAP	Capital injections into the banking sector, mill. euro
D1997	Dummy, 1 in 1997, 0 else
D1998	Dummy, 1 in 1998, 0 else
D1999	Dummy, 1 in 1999, 0 else
D2000	Dummy, 1 in 2000, 0 else
D2001	Dummy, 1 in 2001, 0 else
D2002	Dummy, 1 in 2002, 0 else
D2003	Dummy, 1 in 2003, 0 else
D2004	Dummy, 1 in 2004, 0 else
D2005	Dummy, 1 in 2005, 0 else
D2008	Dummy, 1 in 2008, 0 else
D2009	Dummy, 1 in 2009, 0 else
D2010	Dummy, 1 in 2010, 0 else
D2012	Dummy, 1 in 2012, 0 else
D2013	Dummy, 1 in 2013, 0 else
D2014	Dummy, 1 in 2014, 0 else
D199xQi	Dummy, 1 in quarter *i* of year 199*x*, 0 else
D200xQi	Dummy, 1 in quarter *i* of year 200*x*, 0 else
DEBTADJ	Change in debt level, not due to budget balance or bank capitalisation
DEPR	Capital stock depreciation rate
EUR10Y	10 year government bond yield, Euro Area average
EUR3M	3-month EURIBOR
EURUSD	Exchange rate, US dollar per euro
EXPREST	Remaining government expenditures
GN_REST	Public consumption, diff. between national account and fiscal stat.
INVENTR	Real changes in inventories
OIL	Oil price, USD per barrel Brent
NAIRU_EU	Non-accelerating inflation rate of unemployment, published by the EU Commission
POP1564	Population, 15 to 64 years
POP65PLUS	Population, 65 years or older
q1	Dummy, 1 in the first quarter of each year, 0 else
REVREST	Remaining government revenues
SITEUR	Exchange rate, euro per Slovenian tolar
TAXDIRRATE	Other direct taxes in relation to nominal GDP
TAXINDIRRATE	Other indirect taxes in relation to nominal GDP
WTRADE	World trade, CPB

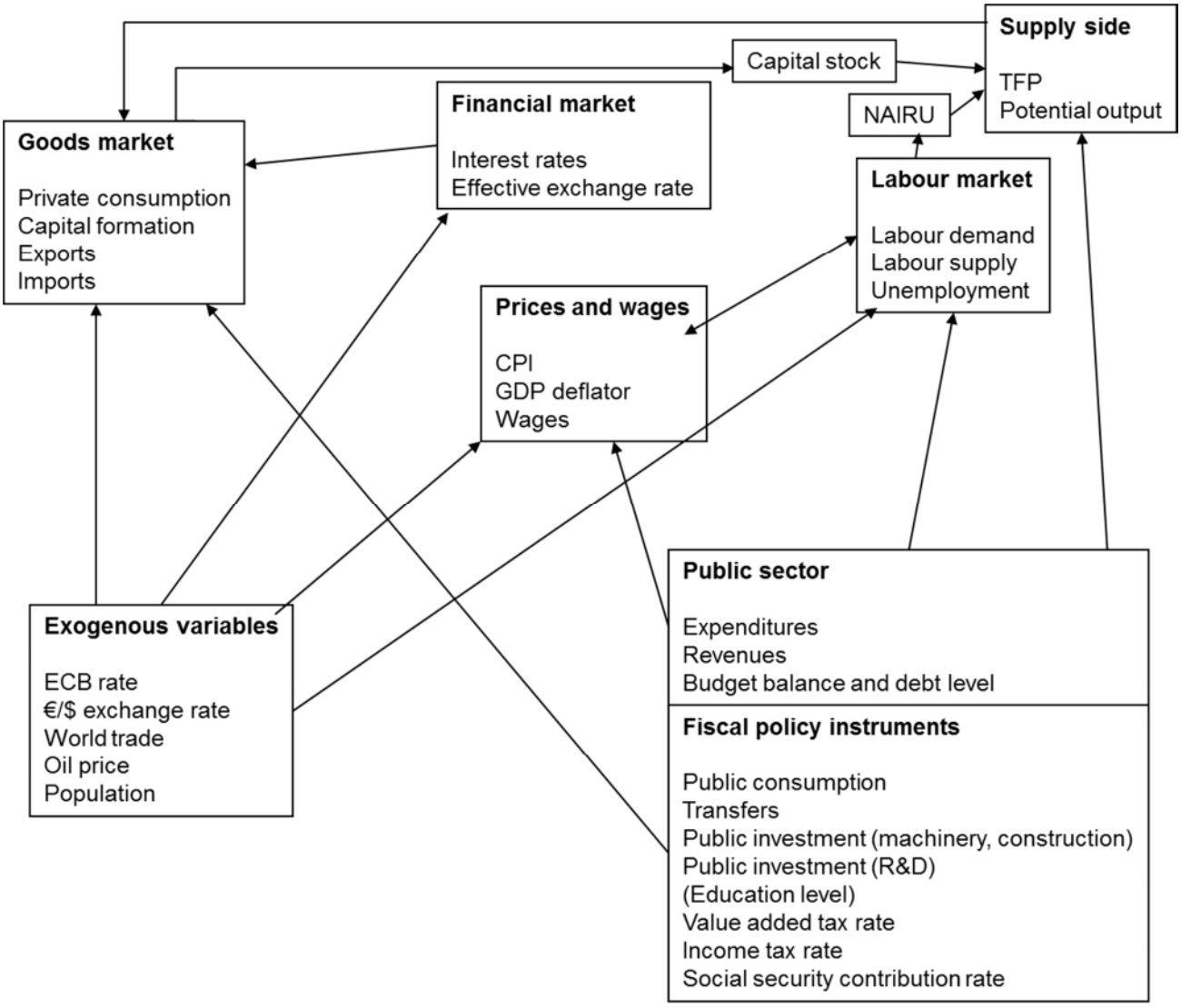
Policy Instruments

GERD	Public expenditures, Research & Development
GINVN	Public investment, nominal
GNFIN	Public consumption according to fiscal statistics, nominal
INCTAXRATE	Average personal income tax rate
LFTERSHARE	Active working population with tertiary education, % of total
SOCEMPRATE	Average social security contribution rate

TRANSFERSN	Transfers to individuals and households
VATAXRATE	Value added tax rate

The behavioural equations were estimated with the software program EViews, using quarterly data for the period 1995q1 to 2015q4. Data for Slovenia and for Euro Area aggregates as well as the oil price were taken from the Eurostat database, and those for world trade came from the CPB Netherlands Bureau for Economic Policy Analyses. The model contains behavioural equations and identities for the goods market, the labour market, the foreign exchange market, the money market and the government sector. Rigidities of wages and prices are taken into account. The model combines Keynesian and neoclassical elements, the former determining the short and medium-run solutions in the sense that the model is demand-driven and persistent disequilibria in the goods and labour markets are possible. In the following, the model equations are described verbally. A diagram of the building blocks of the model is given in
Figure 1.

Figure 1. SLOPOL10 – Building Blocks



The supply side incorporates neoclassical features. In accordance with the approach applied by the European Commission for all EU Member States (Havik et al. 2014), potential output is determined by a Cobb-Douglas production function with constant returns to scale. It depends on trend employment, capital stock and autonomous technical progress. Trend employment is defined as the labour force minus natural unemployment, the latter being defined via the non-accelerating inflation rate of unemployment (NAIRU). In line with the literature on production functions as well as international practice in macroeconometric modelling, the elasticities of labour and capital were set at 0.65 and 0.35 respectively. These elasticities correspond approximately to the shares of wages and profits respectively in national income. The NAIRU, which approximates structural unemployment, is estimated by applying the Hodrick-Prescott (HP) filter to the actual unemployment rate. For forecasts and simulations, the structural unemployment rate is then extrapolated with an autoregressive (AR) process. Capital stock enters the determination of potential GDP not with its trend level but with its actual one.

Several steps are required to determine technical progress. First, ex post total factor productivity (TFP) is calculated as the Solow residual, i.e. that part of the change in GDP that is not attributable to change in the production factors of labour and capital, weighted with their corresponding production elasticities. In a second step, the trend of technical progress is then determined by applying the HP filter, in a procedure similar to the NAIRU. For simulations and forecasts, the trend of the TFP is explained in a behavioural equation. In accordance with the endogenous growth literature, technical progress is influenced by the share of people with tertiary education in the labour force. In addition, trend TFP is influenced by the real investment ratio, i.e. gross fixed capital formation over GDP. As a third factor, lagged real government spending on research and development (R&D) is included in the TFP equation.

On the demand side, the consumption of private households is explained by a combination of a Keynesian consumption function and a function in accordance with the permanent income hypothesis and the life cycle hypothesis. Thus, private consumption depends on current disposable income and on the long-term real interest rate, the latter entering the consumption equation with a negative sign. Real gross fixed capital formation is influenced by the change in real disposable income (more or less in accordance with the accelerator hypothesis) and by the user cost of capital, where the latter is defined as the real interest rate plus the depreciation rate of capital stock. Changes in inventories are treated as exogenous in the SLOPOL model, as in many macroeconomic models in use around the world.

Real exports of goods and services are a function of the real exchange rate and foreign demand for Slovenian goods and services. Foreign demand is approximated by the volume of world trade. The real exchange rate is meant to capture the competitiveness of Slovenian companies on the world market. Real imports of goods and services depend on domestic final demand and on the real exchange rate. A real appreciation of the Slovenian currency (the Slovenian tolar until the end of 2006 and the euro following Slovenia's entry into the Euro Area on 1 January 2007) makes Slovenian goods and services more expensive on the world markets. On the other hand, foreign products become relatively cheaper; hence, domestic production is substituted by imports. Thus, a real appreciation stimulates imports while having a negative effect on exports. Even when Slovenia is part of the Euro Area, its real exchange rate can, of course, still appreciate or depreciate, not only against other currencies but also against other Euro Area countries due to inflation differentials.

On the labour market, both labour demand and supply are divided into the main age group (15 to 64 years) and older people (65 years and above). The labour demand of companies (actual employment) is modelled via the employment rates of the two age groups, i.e. employment as a share of the relevant age group in the total population. Both equations were estimated as Tobit models, the employment rates being limited to lying between 0 and 0.9 (15 to 64 years) and between 0 and 0.5 (65 years and above). Both employment rates are influenced positively by real GDP and negatively by the real net wage and additionally by the wedge between the gross and the net wage. The idea behind the latter is that increases in the tax wedge are borne partly by employers and partly by employees. Rising income tax rates or social security contribution rates increase the production wage, to which employers react by reducing their employment demand. Labour supply is modelled via the share of the labour force of the two age groups in the total population. These equations have also been estimated as Tobit models, with the restrictions of being positive but below 0.9 and 0.5 respectively. Labour supply depends positively on the real net wage and, as employment, negatively on the wedge between the gross and the net wage.

In the wage-price system, gross wages, the consumer price index CPI (to be precise, the harmonised index of consumer prices HICP for Slovenia), and various deflators are determined. The gross wage rate depends on the price level, labour productivity and the unemployment rate. This equation is based on a bargaining model of the labour market, where the relative bargaining power of the employees (or the trade unions) is negatively affected by unemployment. The consumer price index is linked to the private consumption deflator. The latter depends on domestic and international factors. Domestic cost factors comprise unit labour costs and the capacity utilisation rate. The inclusion of the capacity utilisation rate in the price equation represents a channel for closing an output gap by increasing prices in the case of over-utilisation of capacities and by decreasing prices if actual production falls behind potential GDP. Foreign influences on Slovenian consumer prices are approximated by the import deflator. The public consumption deflator is linked to the most important cost factor of the public sector, which is public consumption. Public consumption includes purchases of goods and services and the wage costs of public employees. Similarly to consumer prices, both the investment and the export deflators are influenced by domestic and imported cost elements. The former are approximated by the unit labour costs while the latter are captured by the import deflator. Finally, the import deflator is influenced by the oil price in euro as a proxy for international raw material prices, which constitute an important determinant of the price level in a small open economy like Slovenia.

On the money market, the short-term interest rate is linked to its Euro Area counterpart to capture Slovenia's Euro Area membership and the resulting gradual adjustment of interest rates in Slovenia towards the Euro Area average. In the same vein, the long-term Euro Area interest rate is included in the equation determining the long-term interest rate in Slovenia. In addition, the long-term interest rate is linked to the short-term rate, representing the term structure of interest rates. Furthermore, the long-term interest rate is influenced by the debt to GDP ratio, representing a risk premium that rises with the debt ratio. The foreign exchange market is modelled by the real effective exchange rate against a group of 41 countries. Due to Slovenia's membership of the Euro Area, the nominal exchange rate is exogenous for Slovenia. However, the real exchange rate is still endogenous, even for the Euro Area countries, since it also depends on domestic price developments. Furthermore, the real effective exchange rate is an important determinant of exports and imports. When determining the effective exchange rate for Slovenia, it has to be taken into account that the country has

only been a Euro Area member state since 2007. As the time series on which the estimations of the behavioural equations are based include the period before Slovenia's Euro Area accession in 2007, the bilateral exchange rate between the Slovenian tolar and the euro is included as one of the explanatory variables in the real effective exchange rate equation. In addition, the exchange rate between the euro and the US dollar is considered. Furthermore, inflation in Slovenia is a regressor. To be theoretically consistent, the inflation differential between Slovenia and the group of countries forming the base for the real effective exchange rate should have been taken. However, this would have involved information about price developments in 41 countries, and for these exogenous variables assumptions had to be made for ex post simulations.

In the government sector of the model, the most important expenditure and revenue items of the Slovenian budget are determined. Social security contributions by employees are calculated by multiplying the average social security contribution rate by the gross wage rate and the number of employees. In the same vein, income tax payments by employees are determined by multiplying the average income tax rate by the gross wage rate and the number of employees. In a behavioural equation, social security payments by companies are linked to social security contributions by employees. Profit tax payments by companies are explained by GDP as an indicator for the economic situation, taking account of the fact that profits and hence profit tax payments display a strongly pro-cyclical behaviour. Value added tax revenues depend on the value added tax rate and on private consumption. Other direct and indirect taxes are determined via their relation to nominal GDP, which is exogenous and has to be extrapolated in ex ante simulations, as for all other exogenous variables. Interest payments on public debt depend on the lagged debt level and on the long-term interest rate. Public consumption and transfer payments to private households as well as the remaining public expenditures and revenues are exogenous. By definition, the budget balance is given by the difference between total government revenues and expenditures. The public debt level is extrapolated using the budget balance equation. The model is closed by a number of identities and definition equations.

3. Tests for Stationarity of the Time Series

It turns out that most level variables are I(1). Only a few variables are stationary in levels. These are the output gap (be construction, this variable should be stationary), the real interest rate, the real GDP growth rate, the labour force and employment of older people (very small numbers), the user cost of capital, and changes in inventories (as expected). For the budget balance in relation to GDP, the stationarity tests are inconclusive, although in the longer term this variable should be stationary. Also for the average real gross and net wage, the stationarity results are inconclusive, although one would expect these variables to increase over time. However, according to the data in our database, the average real wage per employee declined between 1996 and 2003, then rose until 2011, before decreasing again somewhat.

We also tested for cointegration between those time series where we suspected long-run relations to hold. In those cases where cointegration seemed to be present, we used error-correction models as dynamic specifications for these relations while estimations in levels or first differences were tried when tests indicated the absence of long-run relations between stationary or between I(1) variables. The tests support our suspicion of cointegration between

the variables we included in the behavioural equations. The detailed results can be found in Table 32.

The following table shows the detailed results of the stationarity tests. We report the results of Augmented Dickey-Fuller tests (ADF), Phillips-Perron tests (PP) and Kwiatkowski-Phillips-Schmidt-Shin tests (KPSS) for stationarity. The decision on lag length was based on the Schwarz information criterion (SIC). The bandwidth was automatically selected using the Newey-West (1994) approach. We used the test model with a constant and without a deterministic trend. *, **, *** denote rejection of the null hypothesis of a unit root at the 10, 5, 1 percent level of significance respectively. +, ++, +++ denote rejection of the null hypothesis of no unit root at the 10, 5, 1 percent level of significance respectively.

Table 2. Results of Tests for Stationarity

Levels

Variable	ADF	Lags	PP	Bandwidth	KPSS	Bandwidth
AGWN	-1.773	4	-1.406	13	1.127+++	7
AGWR	-3.043**	4	-5.638***	2	0.174	6
BALANCE	-1.499	3	-5.872***	2	0.789+++	6
BALANCEGDP	-1.734	3	-6.893***	3	0.782+++	5
CAGDP	0.899	3	-2.588*	7	0.949+++	6
CAN	2.07	3	-2.632*	23	0.873+++	6
CAPR	-1.547	5	-1.463	6	1.115+++	7
CDEF	-1.358	4	-1.237	15	1.134+++	7
CN	-1.173	4	-1.598	14	1.121+++	7
CPI	-2.596*	5	-3.661***	8	1.218+++	6
CR	-1.747	8	-2.995*	19	1.199+++	6
DEBT	3.494	0	3.778	1	0.971+++	7
DEBTGDP	2.321	0	2.086	3	0.927+++	6
DEMAND	-1.437	5	-1.404	16	1.079+++	7
EMP	-1.656	4	-2.915*	16	0.348+	6
EMP1564	-2.134	4	-2.111	21	0.367+	6
EMP65PLUS	-3.523***	0	-3.573***	1	0.418+	5
EXPDEF	-0.651	4	-0.887	6	1.115+++	7
EXR	-0.446	5	-0.134	14	1.128+++	7
GAP	-5.023***	4	-8.500***	2	0.134	3
GDEF	-1.808	4	-1.259	14	1.127+++	7

Variable	ADF	Lags	PP	Bandwidth	KPSS	Bandwidth
GDPDEF	-1.286	4	-1.36	16	1.138+++	7
GDPN	-1.146	6	-1.281	14	1.113+++	7
GDPR	-1.645	6	-1.762	16	1.041+++	7
GERDR	-1.581	3	-8.808***	20	0.474++	10
GINVR	0.121	3	-7.910***	2	1.882+++	0
GN	-1.183	8	-1.097	14	1.112+++	7
GOV10Y	-1.384	1	-3.932***	3	1.014+++	6
GOV10YR	-4.225***	1	-3.109**	2	0.224	5
GR	-1.970	4	-1.625	14	1.063+++	7
GRGDPR	-3.556***	2	-2.789*	4	0.428+	6
GRYPOT	-2.189	0	-2.172	2	0.846+++	6
IMPDEF	-0.7	0	-0.78	3	1.051+++	7
IMPR	-1.314	4	-1.006	59	1.072+++	7
INCOME	-1.318	5	-1.3	14	1.127+++	7
INCOMER	-2.268	5	-4.746***	5	0.231	6
INCTAX	-1.636	3	-4.629***	22	1.04+++	6
INCTAXCORP	-1.52	3	-4.783***	2	0.616++	6
INCTAXPERS	-2.021	3	-5.053***	29	1.196+++	6
INFL	-0.944	4	-1.205	3	1.032+++	6
INTEREST	0.21	11	-7.885***	1	1.338+++	4
INVDEF	0.35	2	-0.343	21	1.125+++	7
INVN	-2.369	4	-2.098	82	0.74+++	6
INVR	-2.381	4	-2.181	82	0.433+	6
LF	-1.427	4	-2.934**	17	0.716++	6
LF1564	-1.396	2	-1.903	26	0.752+++	6
LF65PLUS	-3.523***	0	-3.573***	1	0.418+	5
NETWAGEN	-1.533	5	-1.479	14	1.113+++	7
NETWAGER	-2.988**	4	-3.233**	49	0.458+	6
OILEUR	-1.505	0	-1.505	0	0.977+++	7
PRIMBALANCE	-1.912	3	-5.552***	3	0.549++	6
PRIMBALANCEGDP	-2.03	3	-6.633***	3	0.557++	5
PRINVR	-2.124	4	-2.041	60	0.332	6
PROD	-2.189	7	-2.083	16	1.241+++	6

Variable	ADF	Lags	PP	Bandwidth	KPSS	Bandwidth
REER	-1.949	0	-2.121	1	0.741+++	6
SITBOR3M	-2.687*	1	-2.103	4	0.86+++	6
SOCCOMP	-0.961	4	-1.017	15	1.107+++	7
SOCEMP	-1.721	4	-1.415	14	1.119+++	7
SOCTOTAL	-1.378	4	-1.221	14	1.116+++	7
TAXDIRREST	-2.534	4	-2.988**	20	0.629++	6
TAXINDIRREST	-1.138	3	-1.752	26	1.134+++	7
TGEN	-1.692	5	-1.343	14	1.125+++	7
TGRN	-1.822	4	-1.786	15	1.114+++	7
TRENDEMP	-1.568	4	-3.151**	13	0.575++	6
TRENDTFP	-1.877	8	-5.521***	6	1.009+++	7
UCC	-4.266***	1	-3.154**	2	0.216	5
ULC	-1.500	4	-1.549	19	1.033+++	7
UN	-2.472	8	-1.639	5	0.483++	7
UN1564	-2.306	8	-1.505	5	0.553++	6
UR	-2.406	8	-1.717	7	0.408+	7
UR1564	-2.472	8	-1.611	6	0.464++	6
UTIL	-5.023***	4	-8.500***	2	0.134	3
VAT	-1.399	3	-4.813***	12	1.251+++	6
WEDGE	-2.666*	3	-2.025	16	1.127+++	7
YPOT	-2.068	4	-2.094	14	1.085+++	7
DEBTADJ	-13.689***	0	-13.711***	3	0.147	0
DEPR	-0.415	4	-0.319	85	0.449+	6
EUR10Y	-2.193	1	-2.336	4	1.067+++	6
EUR3M	-2.414	1	-1.855	4	0.988+++	6
EURUSD	-2.035	1	-1.624	2	0.382+	6
EXPREST	-0.89	4	-2.477	19	1.147+++	7
GERD	-1.504	3	-8.284***	7	1.362+++	0
GINVN	0.469	3	-7.201***	0	1.552+++	3
GN_REST	-0.316	3	-4.877***	4	0.565++	6
GNFIN	-2.125	4	-1.784	15	1.09+++	7
INCTAXRATE	-3.075**	3	-7.214***	1	0.942+++	5
INVENTR	-3.137**	4	-5.843***	1	0.228	5

Variable	ADF	Lags	PP	Bandwidth	KPSS	Bandwidth
LFTERSHARE	2.803	4	3.037	4	1.123+++	6
NAIRU_EU	-0.733	9	-0.807	4	1.164+++	7
OIL	-1.557	2	-1.616	3	0.863+++	7
POP1564	-0.521	5	-0.133	4	0.287	6
POP65PLUS	0.112	1	2.799	30	1.189+++	6
REVREST	-0.709	3	-4.133***	13	1.336+++	6
SITEUR	-2.689*	8	-7.179***	9	0.901+++	7
SOCEMPRATE	-3.082**	4	-5.357***	42	1.108+++	6
TAXDIRRATE	-1.929	4	-2.733**	36	0.249	6
TAXINDIRRATE	-1.487	3	-3.223**	8	0.954+++	6
TRANSFERSN	-2.19	4	-1.663	14	1.175+++	7
VATAXRATE	-1.729	3	-11.539***	2	0.656+++	27
WTRADE	-1.029	2	-0.938	1	1.185+++	7
YPOT	-2.068	4	-2.094	14	1.085+++	7

First Differences

Variable	ADF	Lags	PP	Bandwidth	KPSS	Bandwidth
AGWN	-2.312	3	-33.323***	47	0.254	13
AGWR	-2.334	3	-31.946***	28	0.096	13
BALANCE	-13.39***	2	-28.624***	17	0.109	15
BALANCEGDP	-14.273***	2	-30.893***	16	0.104	15
CAGDP	-11.625***	2	-22.159***	19	0.303	18
CAN	-5.417***	3	-15.823***	17	0.338	16
CAPR	-1.864	4	-2.287	51	0.398+	6
CDEF	-3.172**	3	-11.877***	14	0.192	14
CN	-2.898**	3	-21.676***	13	0.142	13
CPI	-0.838	3	-8.512***	2	1.28+++	2
CR	-2.123	7	-28.605***	14	0.218	13
DEBT	-4.499***	1	-8.642***	4	0.709++	5
DEBTGDP	-4.478***	1	-8.394***	4	0.495++	5
DEMAND	-3.641***	4	-21.409***	42	0.185	15
EMP	-3.816***	3	-10.045***	26	0.128	25

Variable	ADF	Lags	PP	Bandwidth	KPSS	Bandwidth
EMP1564	-3.727***	3	-9.087***	27	0.165	29
EMP65PLUS	-9.544***	0	-12.997***	14	0.157	17
EXPDEF	-3.273**	3	-9.309***	7	0.072	7
EXR	-4.754***	4	-9.687***	12	0.098	15
GAP	-5.356***	6	-42.042***	23	0.128	13
GDEF	-2.872*	3	-21.594***	27	0.176	14
GDPDEF	-3.353**	3	-13.965***	17	0.221	15
GDPN	-3.437**	5	-17.76***	16	0.148	13
GDPR	-4.001***	5	-19.49***	33	0.216	14
GERDR	-28.757***	2	-20.675***	13	0.091	12
GINVR	-40.618***	2	-24.808***	13	0.16	13
GN	-1.841	7	-27.178***	4	0.151	13
GOV10Y	-2.888*	10	-12.684***	3	0.333	8
GOV10YR	-7.119***	0	-7.091***	3	0.089	3
GR	-2.279	3	-29.073***	2	0.195	14
GRGDPR	-5.946***	3	-8.009***	3	0.037	3
GRYPOT	-9.439***	0	-9.449***	2	0.037	2
IMPDEF	-8.791***	0	-8.840***	3	0.084	3
IMPR	-3.214**	3	-13.062***	10	0.23	37
INCOME	-2.802*	4	-14.353***	14	0.14	13
INCOMER	-2.717**	4	-14.622***	14	0.079	14
INCTAX	-12.354***	2	-31.134***	19	0.165	13
INCTAXCORP	-13.754***	2	-25.119***	16	0.113	14
INCTAXPERS	-15.093***	2	-44.113***	17	0.175	13
INFL	-6.092***	3	-6.855***	3	0.036	3
INTEREST	-3.058**	10	-29.74***	13	0.101	13
INVDEF	-12.284***	1	-9.487***	27	0.11	20
INVN	-2.602*	3	-12.377***	18	0.246	23
INVR	-2.753*	3	-13.303***	46	0.272	19
LF	-11.16***	1	-10.608***	26	0.15	25
LF1564	-10.165***	1	-10.062***	27	0.164	29
LF65PLUS	-9.544***	0	-12.997***	14	0.157	17
NETWAGEN	-2.883*	4	-20.567***	14	0.156	13

Variable	ADF	Lags	PP	Bandwidth	KPSS	Bandwidth
NETWAGER	-3.306**	3	-16.111***	14	0.124	13
OILEUR	-7.438***	0	-7.351***	3	0.179	0
PRIMBALANCE	-10.064***	2	-37.165***	40	0.149	20
PRIMBALANCEGDP	-11.229***	2	-35.294***	25	0.131	18
PRINVR	-2.938**	3	-10.627***	19	0.358+	18
PROD	-5.074***	6	-24.469***	25	0.287	14
REER	-7.864***	0	-7.904***	1	0.047	1
SITBOR3M	-6.426***	0	-6.414***	1	0.083	4
SOCCOMP	-4.44***	3	-22.854***	26	0.124	14
SOCEMP	-2.726	4	-23.800***	23	0.199	13
SOCTOTAL	-3.8	3	-23.724***	23	0.169	13
TAXDIRREST	-3.387	3	-14.619***	15	0.328	14
TAXINDIRREST	-15.542	2	-29.294***	17	0.19	15
TGEN	-2.794	4	-33.417***	14	0.116	13
TGRN	-5.585	3	-41.022***	15	0.166	13
TRENDEMP	-11.161	1	-10.692***	26	0.15	25
TRENDTFP	-1.712***	7	-1.668	6	0.767+++	7
UCC	-7.164***	0	-7.137***	3	0.085	3
ULC	-2.849*	3	-17.118***	32	0.163	15
UN	-1.853	7	-9.096***	9	0.082	10
UN1564	-2.713*	3	-8.385***	8	0.11	9
UR	-2.029	7	-9.325***	12	0.086	14
UR1564	-1.572	7	-8.359***	11	0.112	13
UTIL	-5.356***	6	-42.042***	23	0.128	13
VAT	-19.866***	2	-42.366***	14	0.094	13
WEDGE	-5.984***	3	-42.232***	15	0.197	13
YPOT	-2.609*	3	-8.314***	8	0.555++	6
DEBTADJ	-8.254	5	-36.099***	5	0.114	17
DEPR	-9.447	3	-9.466***	26	0.361+	19
EUR10Y	-6.358	0	-6.291***	2	0.207	4
EUR3M	-5.024	0	-5.099***	1	0.063	4
EURUSD	-6.762	1	-6.323***	8	0.131	3
EXPREST	-6.328	3	-25.289***	13	0.084	13

Variable	ADF	Lags	PP	Bandwidth	KPSS	Bandwidth
GERD	-28.241	2	-21.678***	13	0.063	13
GINVN	-44.566	2	-27.355***	13	0.175	13
GN_REST	-22.335	2	-24.487***	14	0.237	13
GNFIN	-2.573	3	-29.785***	55	0.213	13
INCTAXRATE	-22.203	2	-37.677***	14	0.187	13
INVENTR	-4.443	3	-24.159***	22	0.108	15
LFTERSHARE	-2.365	3	-7.962***	1	0.909+++	3
NAIRU_EU	-3.005	8	-4.262***	2	0.062	4
OIL	-7.291	1	-6.852***	9	0.159	4
POP1564	-2.873	4	-8.365***	4	0.508++	4
POP65PLUS	-13.868	0	-14.307***	8	0.489++	47
REVREST	-17.644	2	-38.455***	14	0.082	14
SITEUR	-2.372	7	-6.142***	4	1.02+++	5
SOCEMPRATE	-3.622	3	-25.702***	13	0.252	13
TAXDIRRATE	-2.925	3	-10.84***	28	0.277	18
TAXINDIRRATE	-14.309	2	-27.146***	20	0.131	15
TRANSFERSN	-3.346	4	-26.334***	17	0.346	13
VATAXRATE	-19.501	2	-50.457***	14	0.098	13
WTRADE	-5.956	1	-4.453***	9	0.061	1

4. Model Equations

In this section, the model equations are listed in detail, starting with the behavioural equations.

Behavioural Equations

R^2 is the adjusted coefficient of determination, BG(p) is the Breusch-Godfrey Lagrange Multiplier statistic, a test for serial correlation up to lag p; *, **, *** denote rejection of the null hypothesis of no serial correlation at the 10, 5, 1 percent significance level respectively; t-statistics are given in parentheses below coefficients.

Trend TFP

LOG(*TRENDTFP*) = –4.588302 + 0.009127 * LOG(*GERDR*(–1)) + 0.384806 * LOG(*LFTERSHARE*)
(–145.3956) (3.105505) (28.58483)

+ 0.309750 * LOG(*INVR*/*GDPR*)
(15.03015)

Adj. R^2 = 0.923320 F-stat = 318.0849 BG(2) = 40.364***

Private Consumption

LOG(*CR/CR*(–4)) = 0.321936 + 0.282529 * LOG(*INCOMER/INCOMER*(–4))
(1.108405) (5.481512)

– 0.121486 * LOG(*CR*(–4)) + 0.081661 * LOG(*INCOMER*(–4))
(–7.369967) (2.362665)

– 0.006417 * *GOV10YR* – 0.062606 *D2013q1*
(–5.068519) (–3.531924)

Adj. R^2 = 0.612852 F-stat = 24.74484 BG(2) = 6.503145**

Private Gross Fixed Capital Formation

LOG(*PRINVR/PRINVR*(–4)) = –0.000824 + 0.542725 * LOG(*PRINVR*(–1)/*PRINVR*(–5))
(–0.106209) (6.891356)

+ 0.404963 * LOG(*INCOMER*/*INCOMER*(–4))
(2.163258)

– 0.018054 * (*UCC*(–1) – *UCC*(–5)) – 0.163850 * *D2010*q3
(–4.114459) (–2.41256)

– 0.141658 * *D2014*q4
(–2.174659)

Adj. R^2 = 0.672624 F-stat = 29.76431 BG(2) = 3.772958

Exports

LOG(*EXR*/*EXR*(–4)) = 0. 549852+ 0.277227 * LOG(*EXR*(–1)/*EXR*(–5))
(4.119548) (5.136417)

+ 0. 815406* LOG(*WTRADE*/*WTRADE*(–4))
(13.78450)

– 0.321950* LOG(*REER*(–4)/*REER*(–8)) – 0.287643 * LOG(*EXR*(–4))
(–3.401803) (–4.888083)

+ 0.411336 * LOG(*WTRADE*(–4)) + 0.033620 D2007 – 0.026177 (*D2013*+*D2013*)
(4.991134) (2.831993) (–2.808663)

Adj. R^2 = 0.917547 F-stat = 120.2305 BG(2) = 3.249562

Imports

LOG(*IMPR*/*IMPR*(–4)) = –5.038052 + 1.315281 * LOG(*DEMAND*(–1)/*DEMAND*(–5))
(–3. 231196) (9.747473)

+ 0.801468* LOG(*REER*(–2)/*REER*(–6))
(2.011144)

– 0.831232* LOG(*REER*(–3)/*REER*(–7)) – 0.480082 * LOG(*IMPR*(–4))
(–2.024690) (–2.652671)

+ 0.649493 * LOG(*DEMAND*(–4)) + 0.642609 * LOG(*REER*(–4))
(2.294327) (1.909966)

+ 0.090691 * *D1998*q1 – 0.200624 * *D2009*q1
(1.739119) (–4.110804)

Adj. R^2 = 0.684522 F-stat = 21.61303 BG(2) = 1.195105

Employment 15 to 64

EMP1564/*POP1564* = –0.617752 + 0.473440 * *EMP1564*(–4)/*POP1564*(–4) + 0.200109 *
LOG(*GDPR*)
(–3.013194) (5.660659) (7.137335)

– 0.044223 * LOG(*NETWAGER*) – 0.071028 * LOG(*WEDGE*)
(–1.931810) (–5.892452)

Employment 65+

EMP65PLUS/*POP65PLUS* = –0.088596 + 0.601889 * *EMP65PLUS*(-1)/*POP65PLUS*(-1)
(–0.684680) (6.271412)

+ 0.057105 * LOG(*GDPR*) – 0.048881 * LOG(*NETWAGEN*+*WEDGE*)
(1.928939) (–2.436480)

Labour Supply 15 to 64

LF1564/*POP1564* = 0.216732 + 0.694325 * *LF1564*(-4)/*POP1564*(-4)
(4.602100) (10.31312)

+ 0.145252 * LOG(*NETWAGER*/*NETWAGER*(–4))
(4.829452)

Labour Supply 65+

$$LF65PLUS/POP65PLUS = \underset{(-1.207595)}{-0.170715} + \underset{(3.843020)}{0.380958} * LF65PLUS(-1)/POP65PLUS(-1)$$
$$+ \underset{(2.213463)}{0.036490} * LOG(NETWAGER) \underset{(-3.537480)}{- 0.018406} D2015$$
$$\underset{(-2.216665)}{- 0.010935} * LOG(WEDGE) \underset{(-2.812858)}{- 0.011630} * (D2012+D2013)$$

Average Gross Wage

$$LOG(AGWN/AGWN(-4)) = \underset{(2.517697)}{0.238652} + \underset{(7.324412)}{0.599927} * LOG(AGWN(-1)/AGWN(-5))$$
$$+ \underset{(2.223294)}{0.133776} * LOG(CPI/CPI(-4)) + \underset{(2.480250)}{0.114755} * LOG(PROD/PROD(-4))$$
$$\underset{(-2.503514)}{- 0.003440} * UR \underset{(-2.175832)}{- 0.055291} * LOG(AGWN(-4)/CPI(-4))$$
$$\underset{(-2.402247)}{- 0.030158} * D2012q2$$

Adj. $R^2 = 0.828677$ F-stat = 61.46166 BG(2) = 2.439687

CPI

$$LOG(CPI/CPI(-4)) = \underset{(-0.520422)}{-0.000764} + \underset{(16.41307)}{0.860254} * LOG(CPI(-1)/CPI(-5))$$
$$+ \underset{(2.347029)}{0.119368} * LOG(CDEF/CDEF(-4))$$
$$\underset{(-2.247985)}{- 0.024320} * LOG(CPI(-4))\text{-}LOG(CDEF(-4)) \underset{(-3.425420)}{- 0.024477} * D2008q4$$

Adj. $R^2 = 0.942442$ F-stat = 303.9159 BG(2) = 7.259309**

Private Consumption Deflator

$$LOG(CDEF/CDEF(-4)) = \underset{(-2.801746)}{-0.635911} + \underset{(2.994393)}{0.270101} * LOG(AGWN/AGWN(-4))$$
$$+ \underset{(2.534036)}{0.129630} * LOG(IMPDEF(-6)/IMPDEF(-10))$$
$$\underset{(-3.637782)}{- 0.268560} * LOG(CDEF(-4)) + \underset{(3.249838)}{0.101022} * LOG(AGWN(-4))$$
$$+ \underset{(2.641737)}{0.133540} * LOG(UTIL(-1)) + \underset{(1.854469)}{0.091529} * LOG(IMPDEF(-4))$$

Adj. $R^2 = 0.571235$ F-stat = 17.20944 BG(2) = 16.17359***

Public Consumption Deflator

$$\begin{aligned}\text{LOG}(GDEF/GDEF(-4)) = {} & 0.119450 + 0.544327 * \text{LOG}(GDEF(-1)/GDEF(-5)) \\ & (1.851414) \quad (6.264521) \\ & + 0.090745 * \text{LOG}(GNFIN/GNFIN(-4)) - 0.086096 * \text{LOG}(GDEF(-4)) \\ & (2.283731) \qquad\qquad (-3.041525) \\ & + 0.038165 * \text{LOG}(GNFIN(-4)) \\ & (3.062869)\end{aligned}$$

Adj. $R^2 = 0.680608$ F-stat = 42.55355 BG(2) = 1.793151

Investment Deflator

$$\begin{aligned}\text{LOG}(INVDEF/INVDEF(-4)) = {} & 0.010428 + 0.216076 * \text{LOG}(ULC/ULC(-4)) \\ & (5.262049) \quad (4.098676) \\ & + 0.141856 * \text{LOG}(IMPDEF/IMPDEF(-4)) \\ & (2.601534) \\ & + 0.042883 * D1997q1 + 0.046206 * D1998q4 \\ & (2.655108) \qquad\qquad (2.855100) \\ & - 0.052778 * D2000q4 \\ & (-3.160315)\end{aligned}$$

Adj. $R^2 = 0.342428$ F-stat = 9.227795 BG(2) = 31.20401

Export Deflator

$$\begin{aligned}\text{LOG}(EXPDEF/EXPDEF(-4)) = {} & 0.691182 + 0.477104 * \text{LOG}(IMPDEF/IMPDEF(-4)) \\ & (5.368551) \quad (13.53162) \\ & - 0.636126 * \text{LOG}(EXPDEF(-4)) + 0.403268 * \text{LOG}(IMPDEF(-4)) \\ & (-6.693435) \qquad\qquad (6.843747) \\ & + 0.046780 \text{ LOG}(AGWN(-4)) \\ & (3.329078)\end{aligned}$$

Adj. $R^2 = 0.785893$ F-stat = 73.49374 BG(2) = 10.24065***

Import Deflator

$$\begin{aligned}\text{LOG}(IMPDEF/IMPDEF(-4)) = {} & 1.688217 + 0.064189 * \text{LOG}(OILEUR/OILEUR(-4)) \\ & (6.514300) \quad (8.883464) \\ & - 0.427363 * \text{LOG}(IMPDEF(-4)) + 0.070433 * \text{LOG}(OILEUR(-4)) \\ & (-6.675438) \qquad\qquad (7.561347) \\ & - 0.040262 * D2009 + 0.028375 * D2010 \\ & (-3.950683) \qquad (2.861353)\end{aligned}$$

Adj. $R^2 = 0.698642$ F-stat = 37.62936 BG(2) = 28.40523***

Short-term Interest Rate

$$SITBOR3M–SITBOR3M(–4) = 0.072921 + 0.583728 * (SITBOR3M(–1) – SITBOR3M(–5))$$
$$(1.110144)\ (10.69963)$$

$$+ 0.510182 * (EUR3M–EUR3M(–4))$$
$$(7.271125)$$

$$– 0.453068 * (SITBOR3M(–4) – EUR3M(–4))$$
$$(–6.395199)$$

Adj. $R^2 = 0.859096$ F-stat = 159.5222 BG(2) = 23.92325***

Long-term Interest Rate

$$GOV10Y–GOV10Y(–4) = –0.116529 + 0.218874 * (SITBOR3M–\text{SITBOR3M}(–4))$$
$$(–0.780286)\ (2.522239)$$

$$+ 2.021775 * (EUR10Y–EUR10Y(–4))$$
$$(10.71268)$$

$$+ 1.694831 * \text{LOG}(DEBTGDP/DEBTGDP(\text{-}4)) – 1.856888 * D2004$$
$$(1.704599) \qquad (–3.693687)$$

$$+ 1.992136 * D2012 + 1.624226 * D2013$$
$$(4.029161) \qquad (3.083994)$$

Adj. $R^2 = 0.679935$ F-stat = 23.30579 BG(2) = 17.72585***

Real Effective Exchange Rate

$$\text{LOG}(REER/REER(–4)) = –0.007941 + 0.084268 * \text{LOG}(EURUSD/EURUSD(–4))$$
$$(–2.789133)\ (4.503065)$$

$$+ 0.280321 * \text{LOG}(SITEUR/SITEUR(–4))$$
$$(4.729566)$$

$$+ 0.678165 * \text{LOG}(GDPDEF/GDPDEF(–4)) + 0.037226 * D1998$$
$$(6.623438) \qquad (4.447943)$$

$$+ 0.031405 * D1999$$
$$(3.946994)$$

Adj. $R^2 = 0.701605$ F-stat = 38.14987 BG(2) = 31.90596***

Employers' Social Security Contributions

$$\text{LOG}(SOCCOMP/SOCCOMP(–4)) = –0.418600 + 0.941308 * \text{LOG}(SOCEMP/SOCEMP(–4))$$
$$(–7.290584)\ (14.45902)$$

$$– 0.646844 * \text{LOG}(SOCCOMP(–4))$$
$$(–17.69022)$$

$$+ 0.682561 * \text{LOG}(SOCEMP(–4))$$
$$(19.67186)$$

Adj. $R^2 = 0.888454$ F-stat = 210.7419 BG(2) = 3.277950

Corporate Income Tax Payments

$$INCTAXCORP - INCTAXCORP(-4) = -1717.275 + 1168.325 * \text{LOG}(GDPR/GDPR(-4)) - 0.341519 * INCTAXCORP(-4) + 193.6532 * \text{LOG}(GDPR(-4))$$
$$(-3.778722) \quad (5.918436) \qquad (-4.077339) \quad (3.780993)$$

Adj. $R^2 = 0.421035$ F-stat = 20.15009 BG(2) = 0.591128

Value Added Tax Revenues

$$\text{LOG}(VAT) = -5.491826 + 1.054549 * \text{LOG}(CN) + 1.054032 * \text{LOG}(VATAXRATE) - 0.336750 * D2000q1 - 0.630827\ D2001q1 - 0.926044\ D2002q1$$
$$(-7.238066) \quad (19.42491) \qquad (4.267224) \qquad (-2.658629) \qquad (-4.981327) \qquad (-7.337844)$$

Adj. $R^2 = 0.883668$ F-stat = 127.0950 BG(2) = 4.614928*

Interest Payments on Public Debt

$$\text{LOG}(INTEREST) = -1.966945 + 0.832199 * \text{LOG}(INTEREST(-4)) + 0.242440 * \text{LOG}(DEBT(-4) * GOV10Y) + 1.454346 * (D2010q2 + D2010q3) + 0.2866858 * q1$$
$$(-1.894332) \quad (17.18193) \qquad (2.378300) \qquad (5.976520) \qquad (3.071885)$$

Adj. $R^2 = 0.859831$ F-stat = 122.1512 BG(2) = 1.288664

Identities

$AGWR = AGWN / CPI * 100$

$BALANCE = TGRN - TGEN$

$BALANCEGDP = BALANCE / GDPN * 100$

$CAGDP = CAN / GDPN * 100$

$CAN = EXR * EXPDEF / 100 - IMPR * IMPDEF / 100$

$CAPR = (1 - DEPR / 100) * CAPR(-1) + INVR$

$CN = CR * CDEF / 100$

$DEBT = DEBT(-1) - BALANCE + BANKCAP + DEBTADJ$

$DEBTGDP = DEBT / (GDPN + GDPN(-1) + GDPN(-2) + GDPN(-3)) * 100$

$DEMAND = INVR + CR + GR + EXR$

$EMP = EMP1564 + EMP65PLUS$

$GAP = (GDPR - YPOT) / YPOT * 100$

$GDPDEF = GDPN / GDPR * 100$

GDPN = *CN* + *GN* + (*INVR* + *INVENTR*) * *INVDEF* / 100 + *CAN*

GDPR = *CR* + *GR* + *INVR* + *INVENTR* + *EXR* – *IMPR*

GERDR = *GERD* / *INVDEF* * 100

GINVR = *GINVN* / *INVDEF* * 100

GN = *GNFIN* + *GN_REST*

GOV10YR = *GOV10Y* – *INFL*

GR = *GN* / *GDEF* * 100

GRGDPR = *GDPR* / *GDPR*(–4) * 100 – 100

GRYPOT = (*YPOT* / *YPOT*(–4) – 1) * 100

INCOME = *GDPN*+*TRANSFERSN*–*SOCTOTAL*–*INCTAX*–*VAT*–*TAXDIRREST*–*TAXINDIRREST*

INCOMER = *INCOME* / *CPI* * 100

INCTAX = *INCTAXPERS* + *INCTAXCORP*

INCTAXPERS = *INCTAXRATE* * (*AGWN* * *EMP* / 1000) / 1000

INFL = (*CPI* / *CPI*(–4) – 1) * 100

INVN = *INVR* * *INVDEF* / 100

INVR = *PRINVR* + *GINVR* + *GERDR*

LF = *LF1564* + *LF65PLUS*

LOG(YPOT) = 0.65 * *LOG*(*TRENDEMP*) + (1 - 0.65) * *LOG*(*CAPR*) + *LOG(TRENDTFP)*

NETWAGEN = *AGWN* – *WEDGE*

NETWAGER = *NETWAGEN* / *CPI* * 100

OILEUR = *OIL* / *EURUSD*

PRIMBALANCE = *BALANCE* + *INTEREST*

PRIMBALANCEGDP = *PRIMBALANCE* / *GDPN* * 100

PROD = *GDPR* / *EMP* * 100

SOCEMP = *SOCEMPRATE* * (*AGWN* * *EMP* / 1000) / 1000

SOCTOTAL = *SOCCOMP* + *SOCEMP*

TAXDIRREST = *TAXDIRRATE* * *GDPN* / 100

TAXINDIRREST = *TAXINDIRRATE* * *GDPN* / 100

TGEN = *GNFIN* + *GINVN* + *TRANSFERSN* + *INTEREST* + *EXPREST*

TGRN = *VAT* + *SOCTOTAL* + *INCTAX* + *TAXDIRREST* + *TAXINDIRREST* + *REVREST*

TRENDEMP = *LF* * (1 – *NAIRU_EU* / 100)

UCC = *GOV10YR* + *DEPR*

ULC = *AGWN* / *PROD*

UN = *LF* – *EMP*

UN1564 = *LF1564* – *EMP1564*

UR = *UN* / *LF* * 100

UR1564 = *UN1564* / *LF1564* * 100

$UTIL = GDPR / YPOT * 100$

$WEDGE = AGWN * (INCTAXRATE + SOCEMPRATE)$

The following table shows the results of the cointegration tests for the behavioural equations finally adopted. *, **, *** means that the null hypothesis (ADF and Phillips-Perron: no stationarity of the residuals; KPSS: stationarity of the residuals) can be rejected at the 10, 5, 1 percent level of significance respectively. Similarly to the tests for stationarity, we chose the models with a constant, but without a trend. As before, the decision on lag length was based on the Schwarz information criterion. The bandwidth was selected automatically using the Newey-West (1994) approach.

Table 3. Tests for Cointegration – Tests for Stationarity of Residuals of the Equations

Equation	ADF	Lags	PP	Bandwidth	KPSS	Bandwidth
Trend TFP	-2.012	4	-3.872***	5	0.176	6
Consumption	-6.536***	0	-6.546***	3	0.065	2
Investment	-7.636***	0	-7.913***	5	0.195	5
Exports	-7.243***	0	-7.267***	1	0.092	1
Imports	-9.165***	0	-9.156***	4	0.124	4
Employment 15-64	-4.250***	0	-4.250***	0	0.184	4
Employment 65+	-7.983***	0	-7.984***	1	0.109	2
Labour supply 15-64	-5.241***	0	-5.260***	1	0.264	3
Labour supply 65+	-7.965***	0	-7.965***	1	0.098	1
Wage rate	-8.002***	0	-7.999***	1	0.060	0
CPI	-6.739***	0	-6.806***	2	0.048	3
Cons. Deflator	-5.007***	0	-5.039***	2	0.082	3
Gov. cons. deflator	-8.062***	0	-8.062***	0	0.093	1
Investment deflator	-4.739***	0	-4.739***	0	0.217	4
Export deflator	-6.105***	1	-6.288***	4	0.074	2
Import deflator	-5.127***	3	-4.563***	5	0.124	5
Short-term int. rate	-5.080***	0	-5.080***	0	0.086	4
Long-term int. rate	-3.865***	5	-4.357***	4	0.205	4
Real eff. exch. rate	-4.592***	0	-4.550***	2	0.131	5
Soc. sec. revenues	-7.798***	0	-7.869***	3	0.130	4
Company taxes	-9.062***	0	-9.161***	5	0.105	5
VAT revenues	-2.920**	3	-8.474***	8	0.175	3

Equation	ADF	Lags	PP	Bandwidth	KPSS	Bandwidth
Interest payments	-9.239***	0	-9.244***	2	0.216	2

5. Ex post Simulation

The following figures show the results of a dynamic ex post simulation of the model over the period 1999 to 2015.

Figure 2. Real GDP

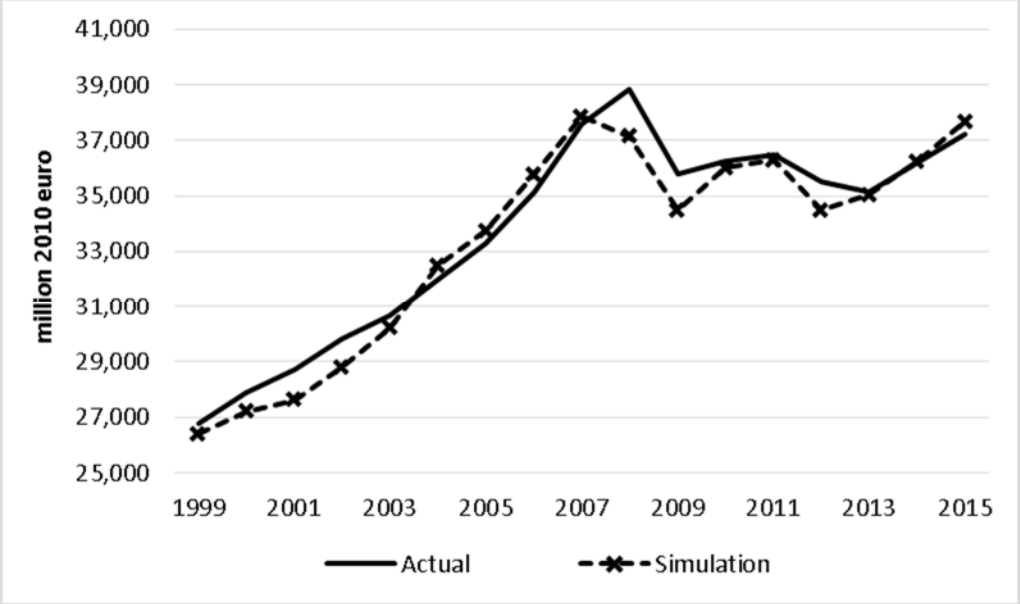


Figure 3. Potential GDP

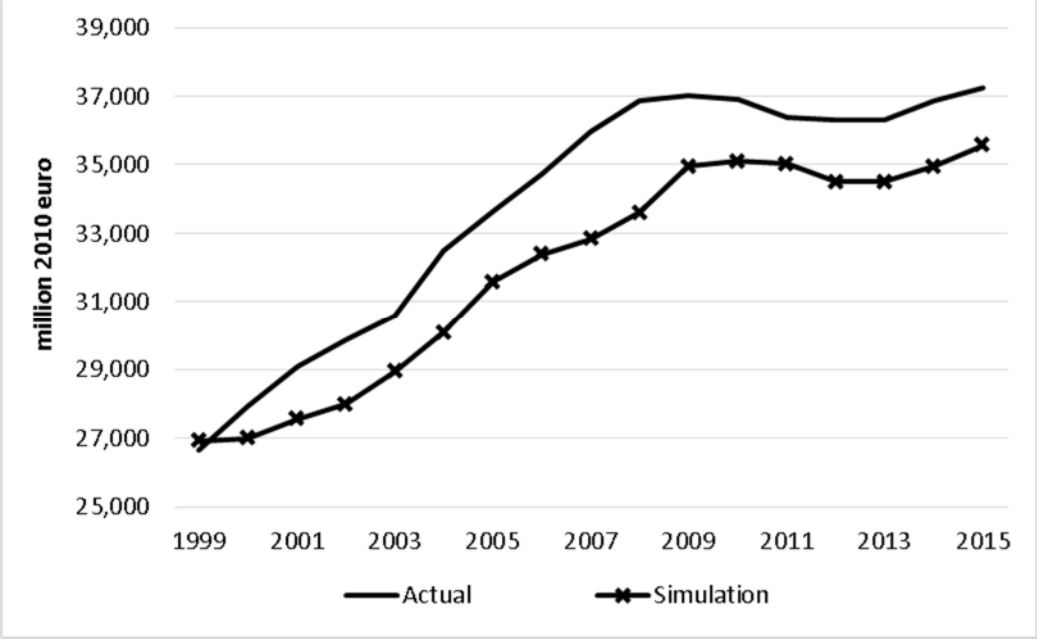


Figure 4. Real GDP Growth

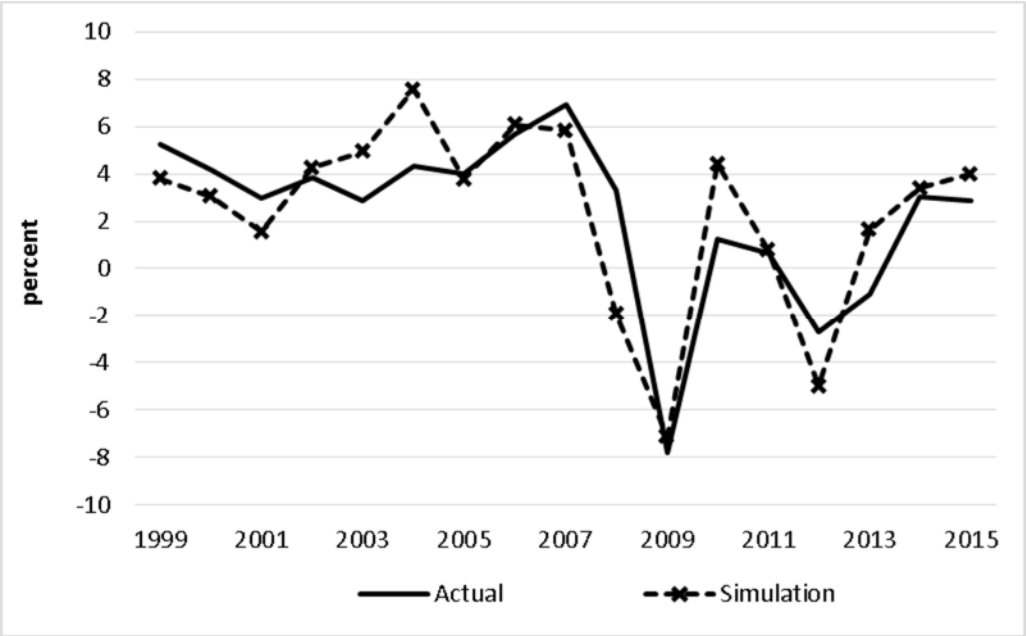


Figure 5. Real private consumption

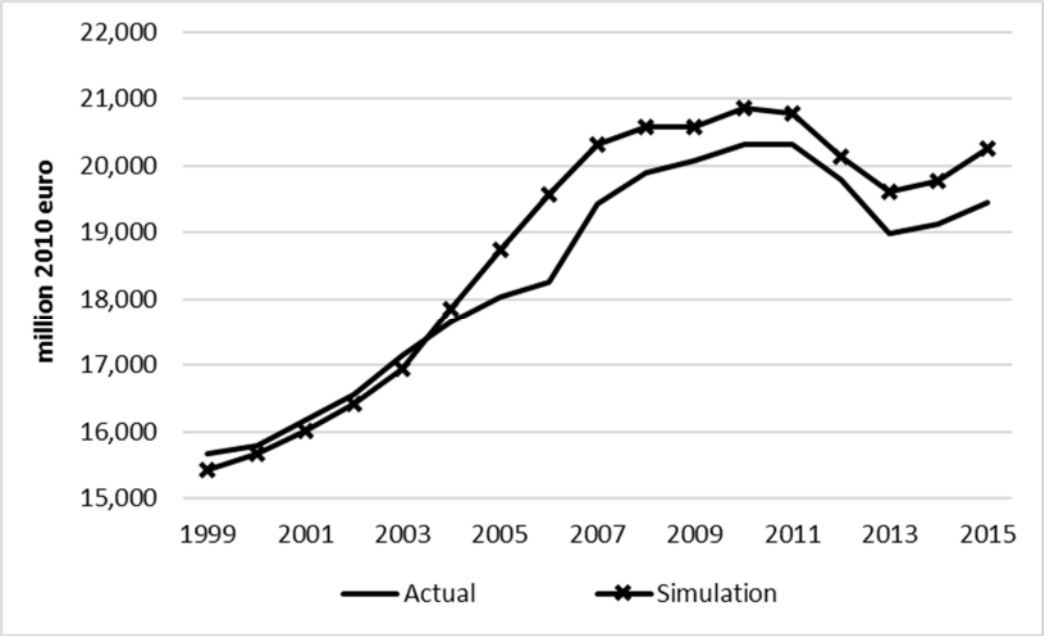


Figure 6. Real investment

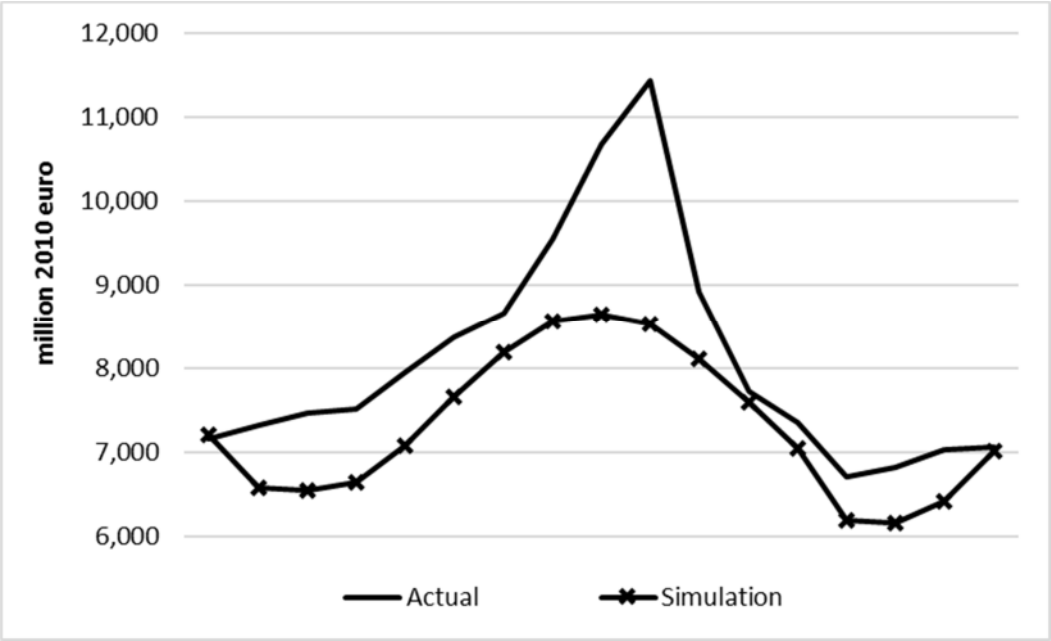


Figure 7. Consumer Price Index

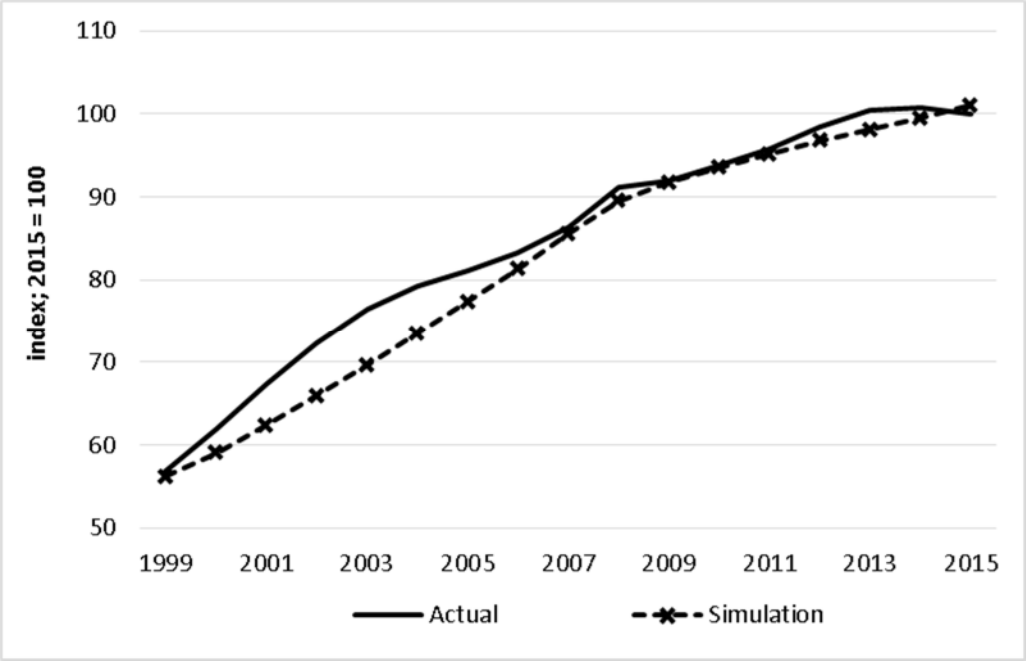


Figure 8. Inflation Rate

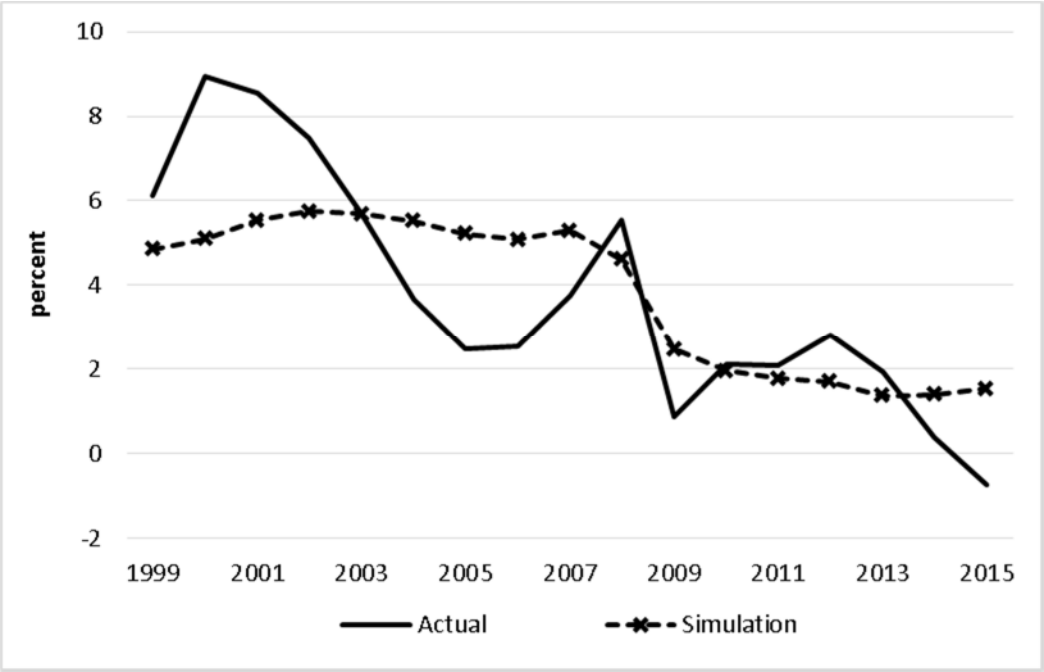


Figure 9. Employment

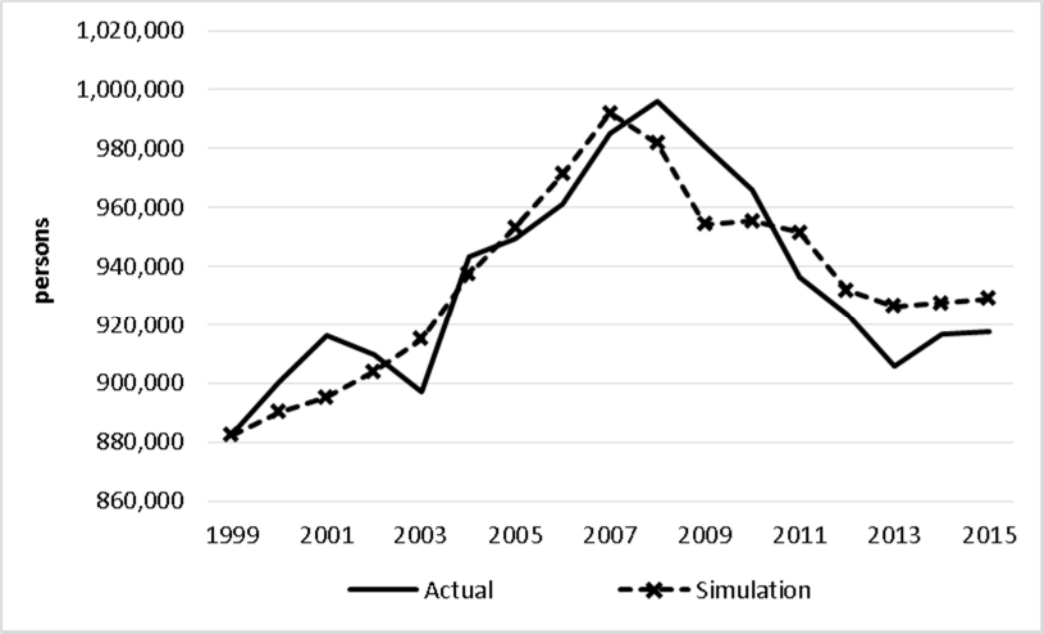


Figure 10. Unemployment Rate

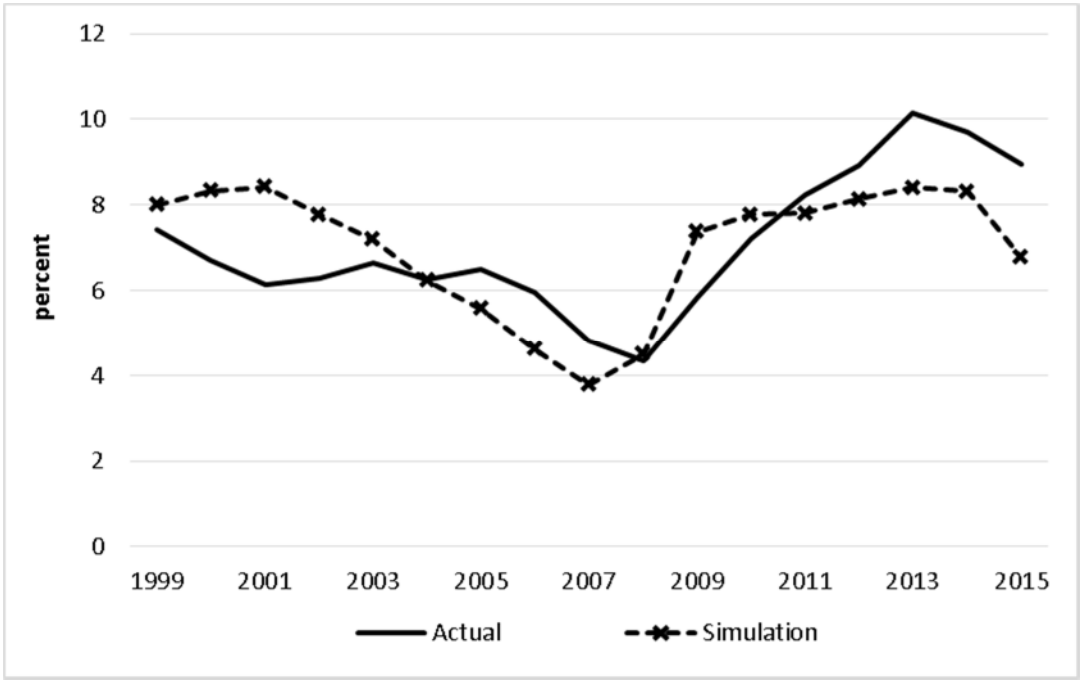


Figure 11. Public Debt in relation to Nominal GDP

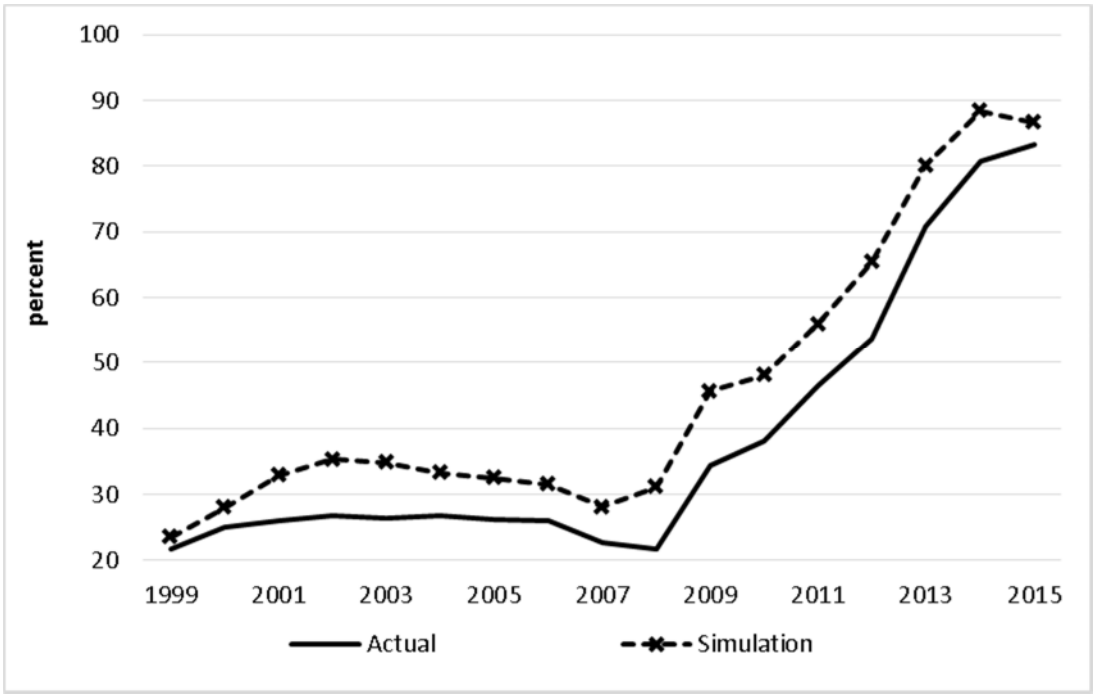


Figure 12. Budget balance in relation to Nominal GDP

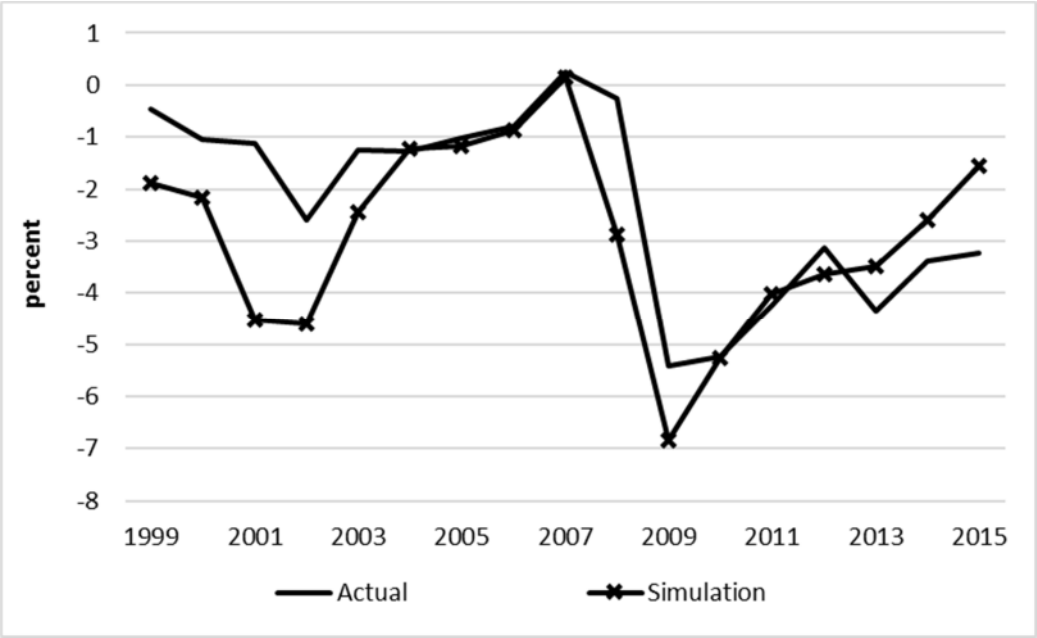
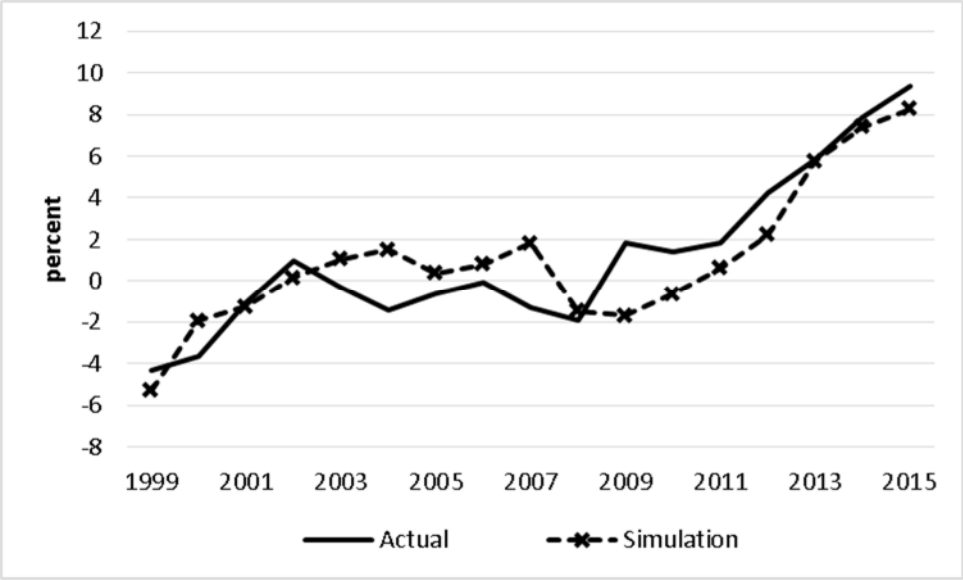


Figure 13. Net Exports in relation to Nominal GDP



In addition to the visual inspection, we tested the quality of the ex post forecasting performance of the model formally. As quality criteria, we chose the root mean squared error (RMSE) or the root mean squared percent error (RMSPE), the mean absolute percent error (MAPE) or the mean absolute error (MAE), and Theil's inequality coefficient (THEIL).

Regarding the Theil coefficient, we chose the U2 coefficient, defined by the following formula:

$$\text{THEIL} = \frac{\sqrt{\sum_{i=1}^{n}(F_i - A_i)^2}}{\sqrt{\sum_{i=1}^{n} A_i{}^2}}$$

A_i and F_i denote the actual realisations and forecasts of changes in the underlying variables. The benchmark is the no-change forecast. In this case, THEIL will take the value 1. Values below 1 show an improvement over the simple no-change forecast (Theil 1966).

The RMSE, the RMSPE, the MAE and the MAPE are defined as follows (Shcherbakov et al., 2013):

$$\text{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(F_i - A_i)^2}$$

$$\text{RMSPE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left[100 * \left(\frac{(F_i - A_i)}{A_i}\right)^2\right]}$$

$$\text{MAE} = \frac{1}{n}\sum_{i=1}^{n}|F_i - A_i|$$

$$\text{MAPE} = \frac{1}{n}\sum_{i=1}^{n} 100 * \frac{|F_i - A_i|}{F_i}$$

We took the RMSE and the MAE for interest rates, ratios (net exports, budget balance and public debt in relation to GDP), growth rates, interest rates, the inflation rate and the unemployment rate, and the RMSPE and the MAPE for all other variables.

The results of these tests ascertaining the quality of the ex post simulation are shown in Table 4. Overall, the results are quite promising. The high values of the error statistics for the budget balance and net exports can be explained by the fact that in some cases the simulation misses the correct sign, leading to large errors. Among the demand components, for investment and imports the model simulation is worse than for the other GDP components. Employment and unemployment are in general tracked satisfactorily, with the exception of the labour market indicators of the older people, which is due to the very small absolute numbers of these variables.

Table 4. Results of Ex post Model Evaluation

Variables in levels

Variable	RMSPE	Theil	MAPE	Variable	RMSPE	Theil	MAPE
AGWN	4.1	0.359	3.6	INTEREST	9,463.4	0.660	18.1
AGWR	2.0	0.516	1.8	INVDEF	1.8	0.459	1.2
BALANCE	247.8	0.689	293.7	INVN	10.6	0.814	8.6
CAN	467.9	1.062	447.9	INVR	11.0	0.838	9.2
CAPR	7.2	0.373	6.5	LF	0.9	0.767	0.7
CDEF	2.0	0.570	1.5	LF1564	0.9	0.795	0.6
CN	5.1	0.543	4.2	LF65PLUS	9.4	0.726	7.2
CPI	4.4	0.436	3.3	NETWAGEN	4.1	0.369	3.6
CR	3.2	0.557	2.7	NETWAGER	2.0	0.381	1.8
DEBT	22.8	0.160	21.1	OILEUR	0.0	0.000	0.0
DEMAND	2.0	0.328	1.6	PRIMBALANCE	9,081.8	0.679	339.0
EMP	1.4	0.787	1.3	PRINVR	12.3	0.854	10.4
EMP1564	1.3	0.778	1.2	PROD	2.0	0.610	1.7
EMP65PLUS	16.2	1.034	12.2	REER	2.2	0.697	1.9
EXPDEF	0.8	0.484	0.7	SOCCOMP	5.2	0.430	4.6
EXR	2.1	0.197	1.7	SOCEMP	4.5	0.387	3.9
GDEF	2.0	0.431	1.7	SOCTOTAL	4.8	0.392	4.2
GDPDEF	8.2	0.366	0.8	TAXDIRREST	2.9	0.257	2.5
GDPN	2.8	0.513	2.4	TAXINDIRREST	3.0	0.366	2.6
GDPR	2.3	0.525	1.9	TGEN	0.5	0.056	0.4
GERDR	1.6	0.054	1.2	TGRN	3.8	0.458	3.0
GINVR	1.8	0.080	1.4	TRENDEMP	0.9	0.759	0.7
GN	0.0	0.000	0.0	TRENDTFP	3.8	1.164	0.0
GR	1.9	0.532	1.6	UCC	49.4	1.134	40.9
IMPDEF	1.7	0.451	1.5	ULC	3.6	0.682	3.0
IMPR	4.4	0.418	3.8	UN	18.7	1.044	15.9
INCOME	2.5	0.463	2.1	UN1564	17.1	0.896	14.9
INCOMER	5.2	0.621	3.8	VAT	7.2	0.653	5.7
INCTAX	8.8	0.699	7.4	WEDGE	4.1	0.250	3.6

INCTAXCORP	32.4	0.955	27.0	YPOT	5.8	0.639	5.5
INCTAXPERS	4.6	0.296	4.0				

Variables in percent

Variable	RMSE	Theil	MAE
BALANCEGDP	1.4	0.777	1.0
CAGDP	1.7	1.121	1.4
DEBTGDP	7.8	0.324	7.3
GAP	5.7	0.971	4.9
GOV10Y	0.6	0.471	0.5
GOV10YR	1.8	1.140	1.5
GRGDPR	2.1	0.695	1.6
GRYPOT	1.9	1.706	1.5
INFL	1.9	0.862	1.6
PRIMBALANCEGDP	1.5	0.758	1.2
SITBOR3M	1.0	0.828	0.7
UR	1.3	1.030	1.1
UR1564	1.2	0.892	1.0
UTIL	5.7	0.969	4.9

6. Multiplier analysis

In this section, we analyse the effectiveness of fiscal policies in Slovenia. For this purpose, we perform an ex post simulation of the SLOPOL10 model over the period 1999 to 2015. We distinguish between temporary and permanent fiscal policy measures. For the scenarios with temporary measures, we change the fiscal policy instruments in the year 2010 only. The permanent measures are implemented from 2010 onwards, i.e. the instruments are changed in 2010 and then kept at the new level afterwards. Although for most variables used in the model the time series start in 1995, for some variables data are available from 1999 onwards only; therefore, we chose a simulation period for which reliable data are available. Regarding the implementation of fiscal policies, we chose 2010 as the starting year since this was the first year after the period of quite rapid growth prior to the Great Recession and after the Great Recession itself.

For the simulations, we consider the following instruments:

(i) *GNFIN*: Government consumption, nominal

(ii) *TRANSFERS*: Transfers, nominal

(iii) *GINV*: Public investment, nominal

(iv) *GERD*: Government expenditures on R&D, nominal

(v) *LFTER*: Proportion of people with tertiary education in the labour force

(vi) *VAT*: Value added tax rate

(vii) *INCTAX*: Personal income tax rate

(viii) *SOCEMP*: Employees' social security contribution rate

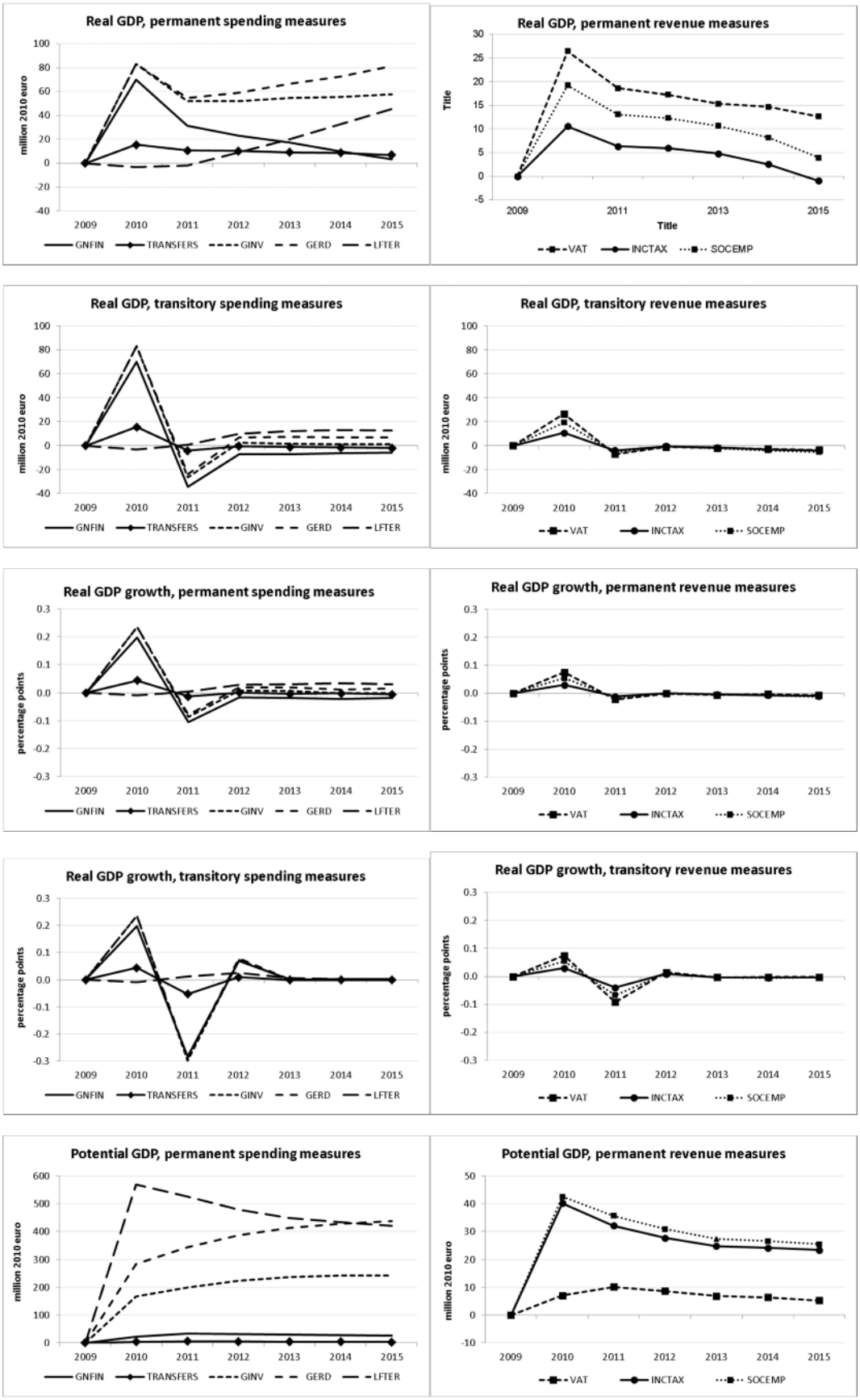
These fiscal policy instruments operate via diverse channels. By definition, public consumption and transfers initially trigger pure demand effects, either directly or via private consumption. Public investment also enters the GDP expenditure identity directly, but in addition, it enters the capital stock and hence potential output. Furthermore, the investment ratio, i.e. real investment divided by real GDP, influences TFP and thereby potential GDP. Public R&D spending also influences total factor productivity and is part of investment; hence this spending category initiates both demand and supply effects as well. The difference between the impacts of *GINV* and *GERD* is that the former affects the TFP only indirectly via the investment ratio, while the latter has also a direct effect on total factor productivity. In accordance with endogenous growth theory, the proportion of people with tertiary education in the labour force (*LFTER*) influences TFP and hence potential output. In contrast to the other instruments considered here, *LFTER* is not an instrument per se, but it can be viewed as an intermediate goal that can be reached by different policies, e.g. higher spending on education.

Ceteris paribus, a higher VAT rate raises revenues from indirect taxes, which in turn reduce disposable income that is one determinant of private consumption. Changes in the income tax rate influence the tax wedge, i.e. the difference between the gross and the net wage. A higher tax wedge has negative effects on both labour demand and labour supply. Increases in the income tax rate, in addition, reduce disposable income. Finally, the social security contribution rate influences the tax wedge and disposable income in the same way as the income tax rate. Additionally, changes in employees' social security contributions also influence employers' contributions.

For each of the instruments listed, a separate *ceteris paribus* simulation is performed with expansionary policy measures (increases in expenditures, decreases in taxes). In the following, the results of these simulations are compared to a baseline simulation where the instruments are unchanged from their actual development. For the simulations, spending items (i) to (iv) are increased by 25 million euro per quarter, i.e. 100 million euro per year, either in 2010 only (transitory change) or from 2010 onwards (permanent change). For simulation (v) the proportion of the labour force with tertiary education is increased by 1 percentage point (pp). For simulation (vi), the VAT rate is reduced by 1 percentage point, and for simulations (vii) and (viii), the income tax rate or the social security contribution rate, respectively, is reduced by 0.5 percentage points.

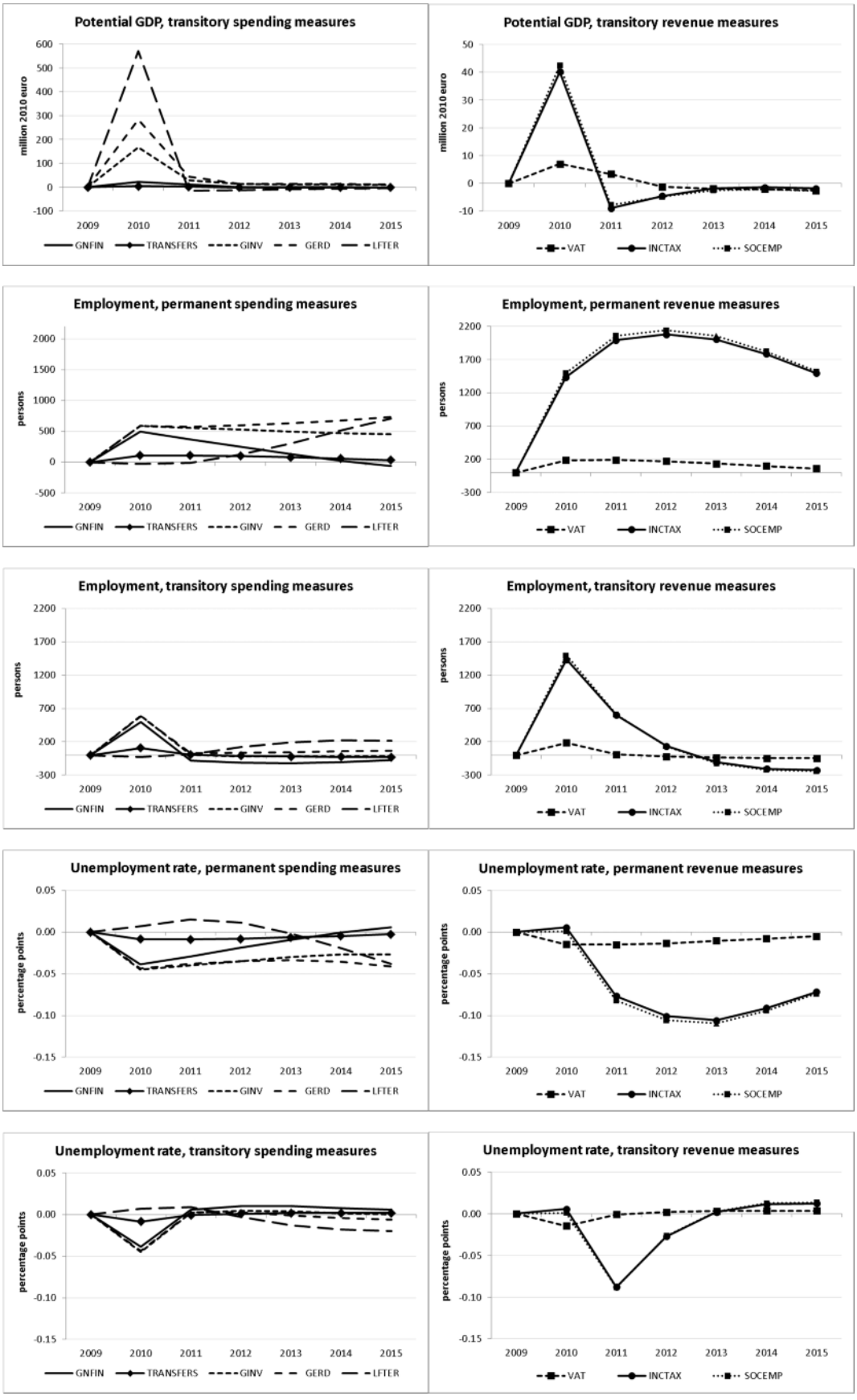
The following figures show the resulting dynamic multipliers (impulse response functions) as absolute deviations from the baseline (the solution without any discretionary policy measures) of important macroeconomic aggregates which are generally regarded as policy targets (real GDP, employment, unemployment rate, debt to GDP ratio) in the various policy simulations. Supply side effects are captured by analysing changes in potential GDP. In addition, we show the effects on net exports (exports minus imports according to national accounts relative to GDP) as a proxy for the trade balance effects, which are relevant for a small open economy. In order to keep the figures legible, transitory and permanent measures are shown separately, as are the scenarios targeting the expenditure and revenue side of the budget.

Figure 14a. Fiscal multipliers in the SLOPOL model



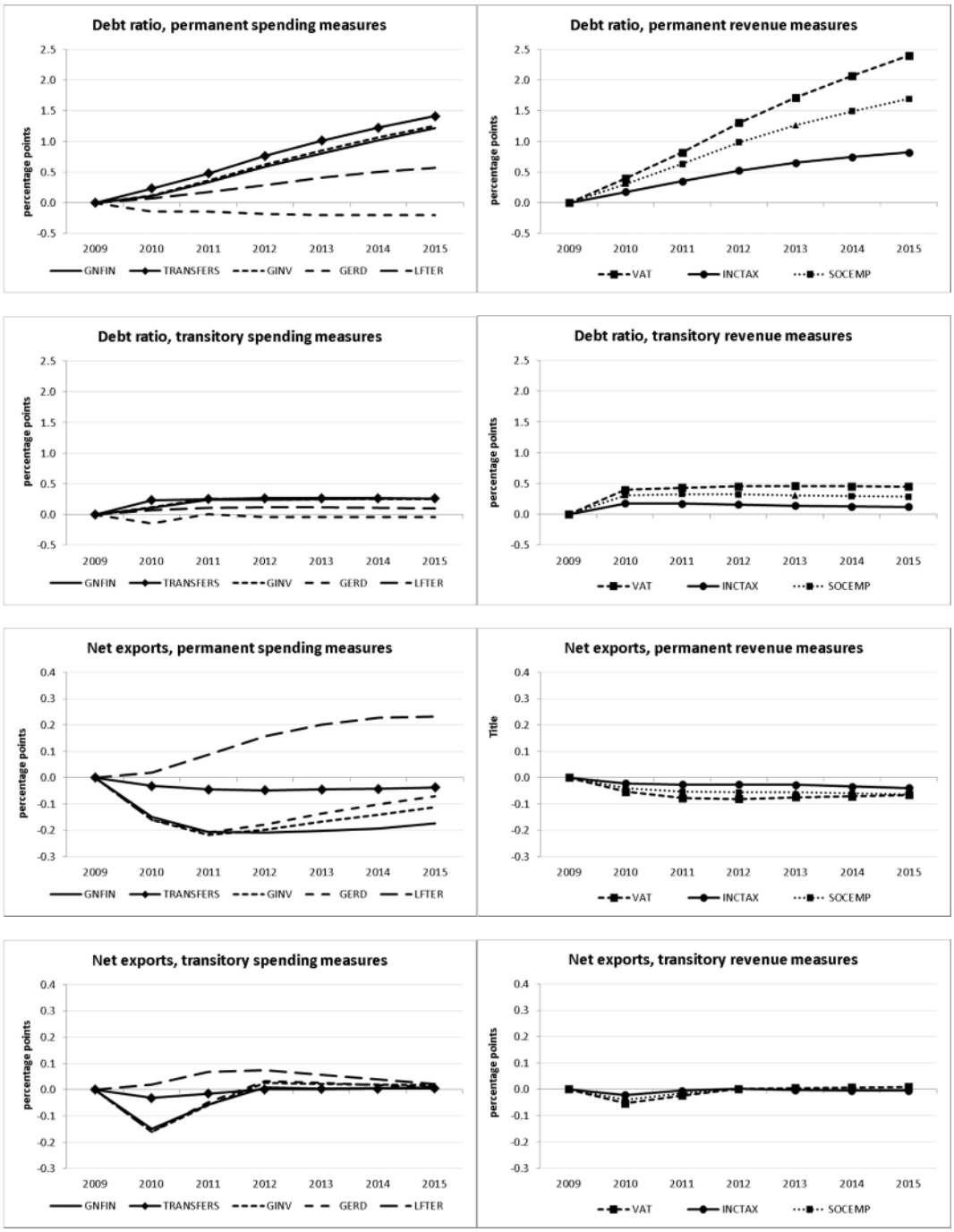
Source: authors' own calculations and illustrations

Figure 14b. Fiscal multipliers in the SLOPOL model (continued)



Source: authors' own calculations and illustrations

Figure 14c. Fiscal multipliers in the SLOPOL model (continued)



Source: authors' own calculations and illustrations

Regarding real GDP, the effects of the transitory spending measures converge towards zero over time or even become slightly negative, with the exception of public investment in R&D (*GERD*) and the proportion of the population with tertiary education (*LFTER*). The effect of the latter even increases over time, in contrast to all other spending measures. The tax multipliers also decrease over time and become negative after two years. Regarding the permanent measures, the effects on real GDP are, as expected, largest for the investment variables. The effects of government R&D spending and human capital improvement even increase over time,

while the multipliers of public consumption and transfer payments remain more or less constant and only slightly above zero. On the revenue side of the budget, the effects of cuts in the income tax rate, the social security contribution rate and the VAT rate peak in the first year of the implementation and decline afterwards. As to be expected, the temporary measures increase real GDP growth only temporarily. For the temporary measures, GDP growth is lower than in the baseline in the second year, and then the deviation from the baseline converges towards zero. In the case of the permanent measures, GDP growth also falls slightly below the baseline in the second year, with the exception of human capital improvements.

Turning to the price level and inflation (not shown in the figures because of the small size of all the respective multipliers), the transitory public investment measures result in a lower price level, although the deviations from the baseline are very small. On the other hand, increases in those instruments triggering only a demand effect raise the price level, as expected. The same is true for tax cuts, although the effects are very limited. A similar pattern emerges from the permanent measures, but here the price depressing effect of tax cuts due to the reduction in the tax wedge lasts longer. The inflation rate is temporarily lower than in the baseline in the case of the increases in investment-related public expenditures. The same is true for the income tax and social security contribution rate cuts, but in these scenarios, inflation is higher from the third year onwards and then again converges towards the baseline result. The permanent increases in investment-related public spending lower inflation permanently due to their positive impact on potential output. On the other hand, income and social security contribution rate cuts result in lower inflation only in the first two years and in higher inflation thereafter. VAT rate hikes influence inflation and hence the price level only marginally in our model.

As expected, employment can be improved by cuts in the tax wedge. However, if these measures are only implemented temporarily and then withdrawn suddenly, employment even falls below the baseline. Employment can also be raised effectively by increasing the education level of the labour force. In this case, the positive employment effects grow over time, even if the proportion of the population with tertiary education is raised only temporarily. The permanent increases lead to permanently lower unemployment, although the largest effect emerges from cuts to income tax and social security contribution rates. Out of the transitory measures, tax cuts decrease the unemployment rate only until the third year. Out of the expenditure measures, public investment and public R&D spending have larger and longer lasting impacts on the unemployment rate. The most significant effect on the unemployment rate can be achieved by raising the education level of the labour force permanently. In this scenario, the unemployment rate is even higher than in the baseline in the first three years, but then falls more and more below the baseline.

The dynamic multipliers show also the impact of the policy changes on imports and exports. The effects of transitory policy actions are over after one or two periods at the most, with the exception of raising the education level the effect of which lasts longer. Permanent changes lower net exports relative to the baseline solution, which is mainly caused by increasing imports because of growth in aggregate demand. The only exception is the increase in the level of tertiary education, a supply side measure that primarily raises potential output and labour productivity and hence international competitiveness, leading to an improvement in the trade balance.

All the fiscal policy measures analysed raise the public debt to GDP ratio, except for increased public spending on R&D. However, the profile of the effects on the debt ratio vary between measures and between temporary and permanent implementations. In the case of the

permanent measures, the debt ratio deviates more and more from the baseline over time. The strongest increase in the debt to GDP ratio comes from the decrease in the VAT rate, which shows the importance of this tax as a source of financing public expenditures. Given this and the small effects on output and employment of changing the VAT rate, this instrument may serve to soften the adverse effects of expansionary measures on government debt by using it in a more restrictive way that is, by accompanying increases in expenditure and decreases in other taxes by an increase in the VAT rate.

7. Could the Great Recession have been mitigated by fiscal policy?

Based on the multiplier analysis in the previous section, we now address the question as to whether the severe downturn in real GDP in 2009 and possibly the recession of 2012-2013 could have been mitigated by fiscal policy. Specifically, we reduced the social security contribution rate and the income tax rate (revenue side instruments) and increased the expenditure side instruments (public investment in equipment and construction, spending on R&D, public consumption, transfers and spending on human capital). However, as the previous multiplier analysis already indicated, Slovenian policy makers would have had to implement rather drastic measures because of the relatively small size of most of the fiscal policy multipliers. We analysed three alternative scenarios, S1 to S3, with different policy mixes. The deviations in the policy instruments from the baseline simulation (in which we took the actual development of the instruments) are shown in Tables 5 to 7.

Table 5. Fiscal policy measures in scenario S1

	GINV	*GERD*	*GNFIN*	*TRANSFERS*	*LFTER*	*VAT*	*INCTAX*	*SOCEMP*
2009	+50%	+50%	--	--	--	--	--	-0.5 pp
2010	+32%	+32%	--	--	--	--	--	-0.5 pp
2011	+12%	+12%	--	--	--	--	--	-0.4 pp
2012	+8%	+8%	--	--	--	--	--	-0.2 pp
2013	+5%	+5%	--	--	--	--	--	-0.2 pp
2014	+3%	+3%	--	--	--	--	--	-0.2 pp
2015	+1%	+1%	--	--	--	--	--	-0.2 pp

Table 6. Fiscal policy measures in scenario S2

	GINV	*GERD*	*GNFIN*	*TRANSFERS*	*LFTER*	*VAT*	*INCTAX*	*SOCEMP*
2009	+50%	+50%	--	--	--	--	--	-0.5 pp
2010	+32%	+32%	--	--	--	--	--	-0.5 pp
2011	+12%	+12%	--	--	--	--	--	-0.4 pp
2012	+8%	+8%	--	--	--	+5 pp	--	-0.2 pp
2013	+5%	+5%	--	--	--	+5 pp	--	-0.2 pp
2014	+3%	+3%	--	--	--	+5 pp	--	-0.2 pp
2015	+1%	+1%	--	--	--	+5 pp	--	-0.2 pp

Table 7. Fiscal policy measures in scenario S3

	GINV	*GERD*	*GNFIN*	*TRANSFERS*	*LFTER*	*VAT*	*INCTAX*	*SOCEMP*
2009	+50%	+50%	+20%	+10%	+1 pp	+5 pp	-0.2 pp	-0.2 pp
2010	+32%	+50%	+10%	+10%	+1 pp	+5 pp	-0.3 pp	-0.3 pp
2011	+12%	+50%	+5%	+10%	+2 pp	+5 pp	-0.4 pp	-0.4 pp
2012	+50%	+80%	+20%	+10%	+2 pp	+5 pp	-0.5 pp	-0.5 pp
2013	+50%	+100%	+20%	+10%	+2 pp	+5 pp	-0.5 pp	-0.5 pp
2014	+40%	+100%	+20%	+10%	+2 pp	+5 pp	-0.5 pp	-0.5 pp
2015	+30%	+100%	+10%	+10%	+2 pp	+5 pp	-0.5 pp	-0.5 pp

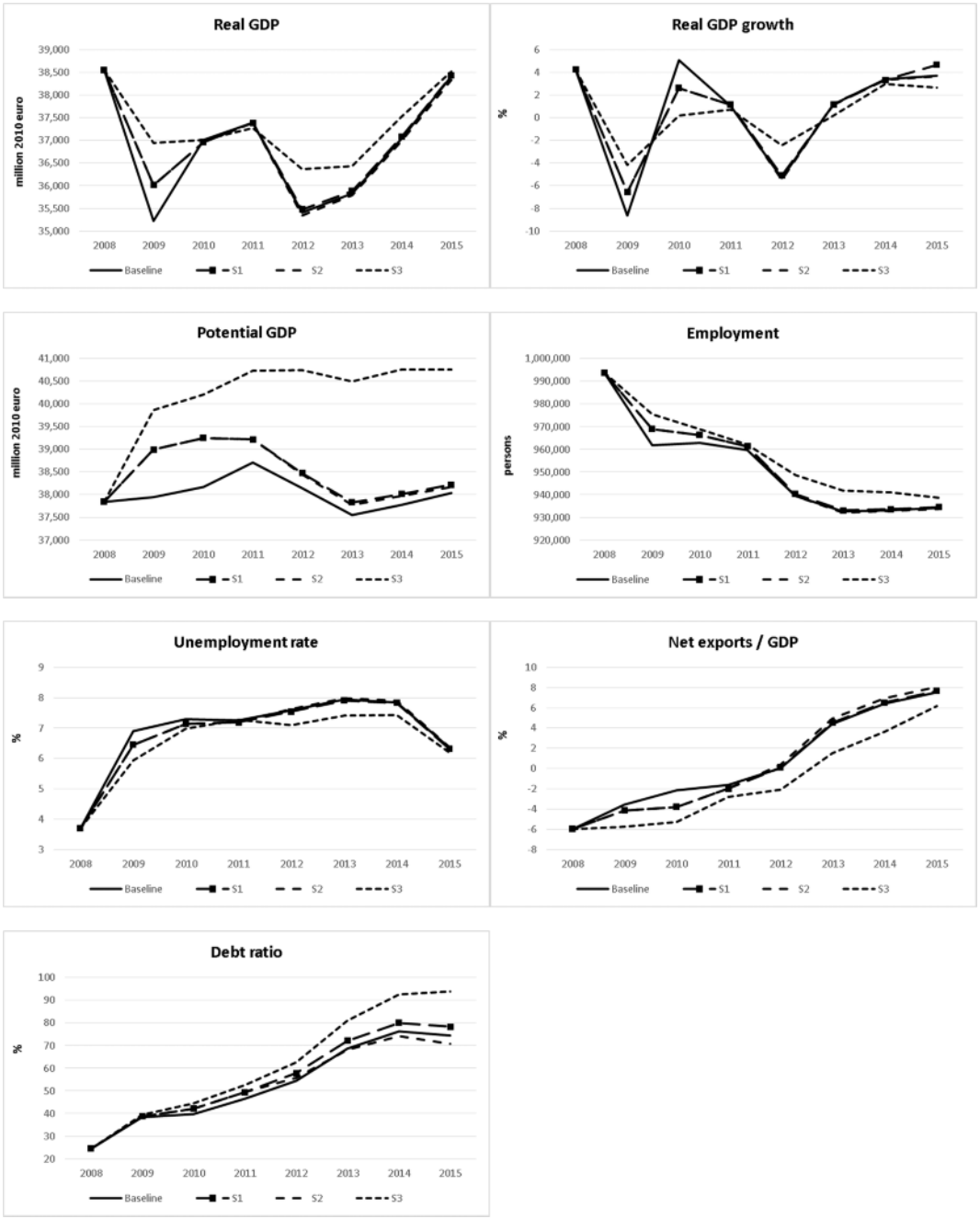
In the first alternative scenario (S1), we only used public investment and spending on R&D as well as the social security contribution rate as policy instruments. Since all the measures that were implemented are expansionary, this policy results in a considerable increase in public debt. Therefore, in scenario S2 we additionally increased the VAT rate from 2012 (the first year where public debt surpassed the Maastricht criterion of a 60 percent ratio to GDP) onwards to 25 percent. In both scenarios S1 and S2, the focus is on the attenuation of the Great Recession of 2009. Afterwards the fiscal stimulus is gradually reduced.

In scenario S3, we tried to mitigate the second recession as well with its real GDP decline in 2012 and 2013. Hence, we implemented an additional fiscal stimulus in those years. In particular, we increased public R&D spending, the most effective measure to stimulate output, rather drastically (doubling it during the last three years). Furthermore, in this scenario, we reduced the income tax rate in addition to the social security contribution rate, and we raised the proportion of the population with tertiary education. To reduce the effect of this package on government debt, the VAT rate was increased to 25 percent from the beginning of the simulation period. Finally, we also increased the non-investment components of government expenditures, i.e. public consumption and transfers to private households.

Figure 15 shows the evolution of real GDP (level and growth), employment, the unemployment rate, net exports in relation to GDP, and the debt ratio to GDP in the baseline and the three alternative scenarios. As usual, the model is not able to track the endogenous variables perfectly so we decided to use the baseline simulation rather than actual development as the basis for comparison.

Scenario S1 shows that even the extremely expansionary fiscal policy implemented here is only able to mitigate the recession to a rather low degree while the debt ratio rises above the baseline values. This result is not surprising for a small and very open economy like Slovenia, as demand side effects are absorbed to a large extent by imports of goods and services. If, however, the VAT rate is increased in addition (Scenario S2), this increase in public debt can be avoided and even reversed in the years after the end of the recession without adverse effects on output and employment. This suggests that increasing indirect taxes may allow for an even more expansionary policy, both from the revenue and the expenditure side, without secondary effects on government debt.

Figure 15. Evolution of important macroeconomic indicators in the scenarios



Source: authors' own calculations and illustrations

The policy package assumed for Strategy S3, however, shows that this is not true. Even under this policy mix, output remains considerably below potential output during the entire simulation period and the debt to GDP ratio rises by about 20 percentage points towards the end of that period. The figures shows the main reason for the small output multiplier: The increase in real GDP due to additional spending and tax reductions is more than matched by the increase in imports resulting from higher aggregate demand. The effects on employment and unemployment are more satisfactory, although they do not completely sweep off the recession shock either. It is remarkable that the reduction in direct tax rates leading to a decrease in the

tax wedge has stronger effects on employment and the unemployment rate than those of combined expenditure and revenue side demand management policies.

Similar results were obtained when considering changes in other categories of taxes or public expenditures. Thus, we have to conclude that fiscal policy measures, whether on the revenue side or on the expenditure side, can only partly mitigate but not eliminate the effects of a crisis like the Great Recession or the (European) recession following it when applied in an isolated way in a country like Slovenia with its strong international links. In addition, our simulations show that there should be some assignment of targets to instruments in the situation of a severe crisis, at least under the conditions similar to those of the Slovenian economy during and after the Great Recession. Tax policies are most effective when used to lower the burden of direct taxation on employment, while government spending should be used with the objective of raising not only aggregate demand but also potential output. It remains to be shown whether this particular case of a solution to the old assignment problem in the theory of economic policy (see Mundell 1962, Fleming 1968) can be generalized to other models.

8. A Medium-Run Projection of the Slovenian Economy

The focus of this section lies on an analysis of the relative effectiveness of spending and tax policies in Slovenia during the period 2017 to 2030. As we are interested in comparing the effects of these fiscal policy measures with the trajectory of the Slovenian economy without such discretionary policies, we first have to determine a baseline simulation. Since the model is based on data until 2015, our forecast has to start in 2016. To this end, we have to make assumptions about the future development of all exogenous variables in the model. These can be divided into international variables (world trade, the oil price and Euro Area interest rates), Slovenian variables largely beyond policy makers' control (population), and Slovenian policy instruments (tax rates, various government spending items).

For the interest rates, we assume that the European Central Bank will not start to raise its policy rates until 2018; hence, the three-month Euribor is assumed to become positive only in 2018. Afterwards it will gradually rise further, reaching 2 percent in 2023 and staying at this level until the end of the simulation period. At present, it is expected that US macroeconomic policies will be more expansionary than those in the EU will and that the Federal Reserve will increase its discount rate earlier than the ECB. Furthermore, due to the expectation of an expansionary fiscal policy in the US under the current administration, long-term interest rates have already started to rise in the US but also globally. Therefore, the Euro Area long-term interest rate is assumed to rise gradually from 2017 onwards, reaching 4 percent from 2025 onwards. The exchange rate between the euro and the US dollar is held constant at 1.10 dollar per euro. For world trade, growth rates are assumed of 1.1 percent in 2016, 1.8 percent in 2017, and 3 percent from 2018 onwards. After a decline of 18.5 percent in 2016 (annual average), the oil price is assumed to rise by 26 percent in 2017, by 10.5 percent in 2018, and by 2.0 percent p.a. thereafter.

According to existing projections, Slovenia's working-age population will decline by around 0.75 percent per year until 2022, by 0.5 percent in 2023 and by 0.4 percent per year afterwards. Conversely, as is the case all over Europe, the population aged 65 and over will continue to rise. According to population projections, this growth will decrease slightly and more or less steadily from almost 3 percent p.a. in 2016 to 1.6 percent in 2030.

Turning to the fiscal policy instruments, we assume that the tax and social security contribution rates will not be changed from their 2015 values, with the exception of the value added tax rate, which was raised from 20 to 22 percent in 2016. In the baseline, it is held constant at 22 percent over the entire simulation period. Government consumption, public investment in equipment and machinery, public spending on research and development, transfer payments to private households, as well as residual government expenditures and revenues are all assumed to increase by 3.5 percent p.a. from 2017 until the end of the simulation period. For 2016, the assumed development of the policy instruments and the other exogenous variables aims at matching actual developments as far as possible, to the extent that the data are already available.

These settings of the exogenous variables lead to the following baseline simulation results until 2030. According to recent forecasts (IMAD[5] 2016, European Commission 2017), real GDP in Slovenia increased by about 2.5 percent in 2016, and growth will reach around 3 percent in 2017 and in 2018. Our model projects real GDP growth of 2.5 percent in 2017, 3.0 percent in 2018 and 2.8 percent in 2019. Projected GDP growth then declines to 1.6 percent in 2023 and 2024. Afterwards, growth picks up again and stabilises at around 2 percent per year. Due to the projected population decline and the slightly lower GDP growth, employment is forecast to decline after 2020. However, due to the decreasing labour force, the unemployment rate will also decline from 8.4 percent in 2016 to 2.8 percent in 2030. After negative and then zero inflation until 2018, the inflation rate is forecast to rise slightly to 1.4 percent in 2024 and 2025, before it declines again to 1.2 percent p.a. in the last three years of our simulation period. Despite the overall favourable real economic development, the ratio between public debt and nominal GDP is projected to rise from 83 percent in 2016 to 123 percent in the final year of the simulation period. This increase is partly attributable to the low inflation, but the main driver of this development is the fact that our model predicts that total government expenditures will rise faster than revenues.

Our model predicts a rather pessimistic development of the trend total factor productivity. According to the simulation, trend TFP would stagnate on average between 2017 and 2030. As we regard this as being too pessimistic, we exogenously raised trend TFP via an add factor such that it increases by 1.6 percent per year on average during the simulation period. Furthermore, with the aim of strengthening potential GDP growth we reduced the non-accelerating inflation rate of unemployment (NAIRU). According to the recent forecast by the European Commission, the Slovenian NAIRU will decrease from 7.0 percent in 2016 to 6.0 percent in 2025. For our simulations, we assumed a more pronounced decrease to 4.0 percent in 2025 and to 0.5 percent in 2030.

9. Can Growth in Slovenia be boosted by means of Fiscal Policies?

In this section, we run three alternative simulations with different policy mixes during the period 2017 to 2030. We again distinguish between four spending instruments and three tax rates. In addition, we analyse the effects of an increase in the share of people with tertiary education in the labour force. We subsume this instrument under spending measures, although due to the lack of adequate data our model does not contain a specific instrument directly related to the

[5] IMAD is the Institute of Macroeconomic Analysis and Development of the Republic of Slovenia.

education level, such as the number of teachers at high schools or the amount of public spending on universities.

For the simulations, we consider the following instruments:

(i) *GN*: Government consumption, nominal

(ii) *TRANSFERS*: Transfers, nominal

(iii) *GINVN*: Public investment, nominal

(iv) *GERD*: Government expenditures on R&D, nominal

(v) *LFTER*: Share of people with tertiary education in the labour force

(vi) *VAT*: Value added tax rate

(vii) *INCTAX*: Personal income tax rate

(viii) *SOCEMP*: Employees' social security contribution rate

(ix) *REVREST*: Other government revenues

The changes in the fiscal policy instruments with respect to the baseline are summarized in Table 1 (scenario S1),

(scenario S2) and

Table (scenario S3). The tables show deviations in a particular instrument variable from baseline values in percent or percentage points. Changes in *LFTER*, *INCTAX*, *SOCEMP* and *VAT* are measured in percentage points, while changes in all other variables are measured in percent. We defined the policy measures of the expenditure aggregates in absolute terms, i.e. in million euros; hence, the percentage deviations as shown in the tables were calculated endogenously.

Table 8. Fiscal policy measures in scenario S1

	GERD	*GINVN*	*GN*	*TRANSFERS*	*REVREST*	*LFTER*	*INCTAX*	*SOCEMP*	*VAT*
2018	0%	0%	0%	0%	0%	0.0	0.00	0.00	3.0
2019	0%	0%	0%	0%	0%	0.0	0.00	0.00	3.0
2020	2%	2%	2%	2%	0%	0.1	0.00	0.00	3.0
2021	4%	4%	4%	4%	0%	0.2	0.00	0.00	3.0
2022	6%	6%	6%	6%	0%	0.3	0.00	0.00	3.0
2023	8%	8%	8%	8%	41%	0.4	0.00	0.00	3.0

2024	11%	11%	11%	11%	48%	0.5	0.00	0.00	3.0
2025	15%	15%	15%	15%	55%	0.6	0.00	0.00	3.0
2026	19%	19%	19%	19%	62%	0.7	0.00	0.00	3.0
2027	23%	23%	23%	23%	69%	0.8	0.00	0.00	3.0
2028	28%	28%	28%	28%	76%	0.9	0.00	0.00	3.0
2029	34%	34%	34%	34%	83%	1.0	0.00	0.00	3.0
2030	41%	41%	41%	41%	90%	1.1	0.00	0.00	3.0

Note: The table shows deviations from the baseline in percent or percentage points.

Table 9. Fiscal policy measures in scenario S2

	GERD	*GINVN*	*GN*	*TRANSFERS*	*REVRESTR*	*LFTER*	*INCTAX*	*SOCEMP*	*VAT*
2018	136%	7%	-2%	-1%	9%	0.5	-0.25	-0.25	3.0
2019	263%	13%	-3%	-3%	18%	0.8	-0.50	-0.50	3.0
2020	382%	19%	-4%	-4%	26%	1.0	-0.75	-0.75	3.0
2021	492%	24%	-6%	-5%	33%	1.3	-1.00	-1.00	3.0
2022	594%	29%	-7%	-6%	40%	1.5	-1.25	-1.25	3.0
2023	689%	34%	-8%	-7%	46%	1.8	-1.50	-1.50	3.0

2024	776%	38%	-9%	-8%	52%	2.0	-1.75	-1.75	3.0
2025	857%	42%	-10%	-9%	58%	2.3	-2.00	-2.00	3.0
2026	932%	46%	-11%	-10%	63%	2.5	-2.25	-2.25	3.0
2027	1000%	49%	-11%	-10%	67%	2.8	-2.50	-2.50	3.0
2028	1063%	52%	-12%	-11%	71%	3.0	-2.75	-2.75	3.0
2029	1120%	55%	-13%	-12%	75%	3.3	-3.00	-3.00	3.0
2030	1173%	58%	-13%	-12%	79%	3.5	-3.25	-3.25	3.0

Note: The table shows deviations from the baseline in percent or percentage points.

Table 10. Fiscal policy measures in scenario S3

	GERD	*GINVN*	*GN*	*TRANSFERS*	*REVREST*	*LFTER*	*INCTAX*	*SOCEMP*	*VAT*
2018	136%	0%	0%	0%	0%	0.5	-0.13	-0.13	3.0
2019	263%	0%	0%	0%	0%	0.8	-0.25	-0.25	3.0
2020	382%	3%	2%	2%	0%	1.0	-0.38	-0.38	3.0
2021	492%	6%	4%	4%	0%	1.3	-0.50	-0.50	4.0
2022	594%	9%	7%	6%	0%	1.5	-0.63	-0.62	4.0
2023	689%	11%	9%	10%	41%	1.8	-0.75	-0.75	4.0

2024	776%	14%	11%	12%	48%	2.0	-0.88	-0.88	5.0
2025	857%	16%	15%	15%	55%	2.3	-1.00	-1.00	5.0
2026	932%	18%	19%	19%	62%	2.5	-1.13	-1.13	5.0
2027	1000%	20%	23%	23%	69%	2.8	-1.25	-1.25	5.0
2028	1063%	21%	28%	28%	76%	3.0	-1.38	-1.38	5.0
2029	1120%	23%	34%	34%	83%	3.3	-1.50	-1.50	5.0
2030	1173%	24%	41%	41%	90%	3.5	-1.63	-1.63	5.0

Note: The table shows deviations from the baseline in percent or percentage points.

Scenario S1 is characterised by increases in public investment, both in equipment and construction and in the education of the work force. Furthermore, government consumption and transfers to private households are raised. These higher expenditures are financed by increasing “other” revenues, namely revenues from taxes without direct effects on aggregate demand, such as property taxes (or – ideally – “lump-sum” taxes). Here we consider an expansionary (Keynesian) fiscal policy mix of moderately higher expenditures, which are distributed approximately proportionately over expenditure categories, financed partly by higher taxes with only indirect restrictive effects.

In scenario S2, we shift public expenditures from “unproductive” public consumption and transfers to “productive” expenditures on research and development and increase the share of people with tertiary education. Moreover, we assume reductions in income tax rates and social security contributions (both from employees and employers) in order to provide incentives for higher employment. This scenario can be interpreted as a “supply side” fiscal policy, aiming at (1) simultaneously strengthening aggregate demand and aggregate supply in the goods market (potential output) and (2) increasing employment by reducing the tax wedge in the labour market i.e. the average income tax rate and the social security contribution rate. These two tax rates are lowered by 0.25 percentage points (pp) with respect to the baseline in 2018, and the deviation from the baseline is increased over time to reach 3.25 pp in 2030. In order to prevent public debt from increasing, these expansionary fiscal policies are financed by reducing public consumption and transfers to private households.

In scenario S3, we rather drastically raise those public spending items that entail both demand and supply effects, namely public spending on R&D and fixed capital formation. Both of these spending categories are part of domestic demand, but they also positively influence potential GDP via the capital stock and technical progress. Furthermore, we lower the tax wedge on labour income as in scenario S2 but only by half as much. To deal with the resulting government budget deficit, we assume that the Slovenian government increases the VAT rate to 27 percent. In addition, the remaining government revenues are increased from around the middle of the simulation period onwards, since otherwise the debt ratio would explode. Here the deviation from the baseline rises from 41 percent in 2023 to 90 percent in 2030.

The following figures show the evolution of some macroeconomic indicators usually relevant for policy makers as well as the general public: real GDP and potential output in million euro at previous year's prices, reference year 2010; persons employed, the unemployment rate, the consumer price index, the inflation rate, net exports in relation to GDP and the public debt to GDP ratio. All figures depict the paths of the relevant variables in the baseline and in the three alternative scenarios (denoted S1, S2 and S3 respectively).

Figure 146. Real GDP level 2017–2030

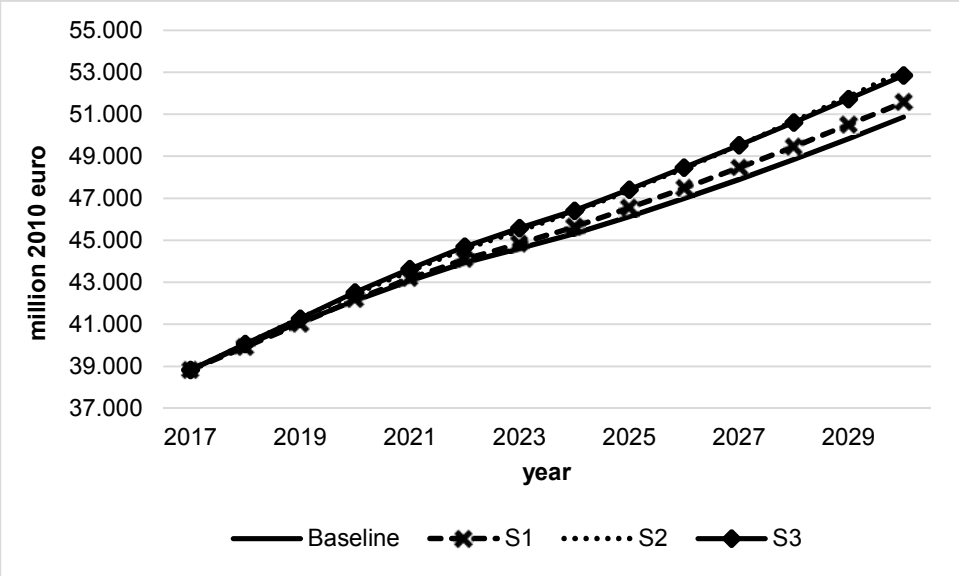


Figure 17. Real GDP growth 2017–2030

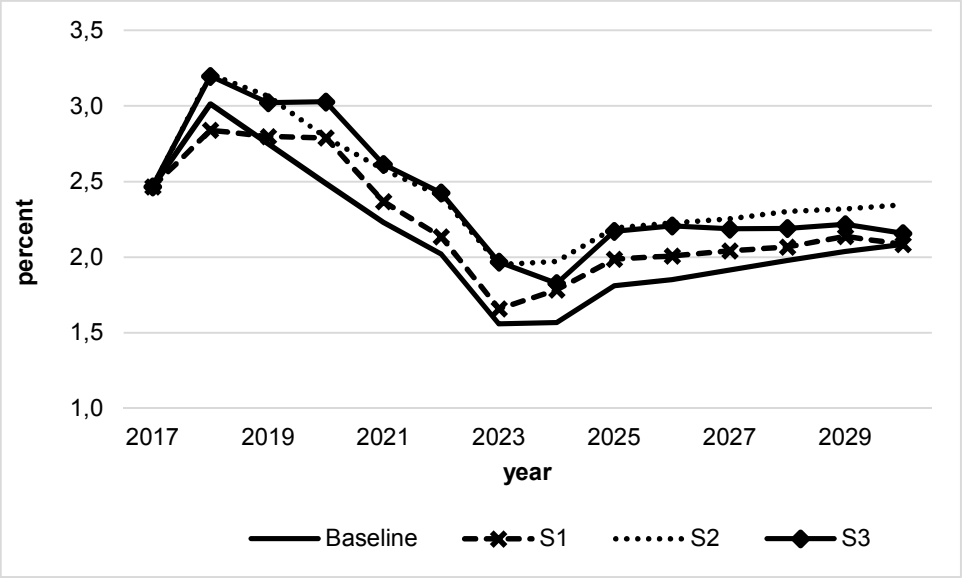


Figure 17. Potential output 2017–2030

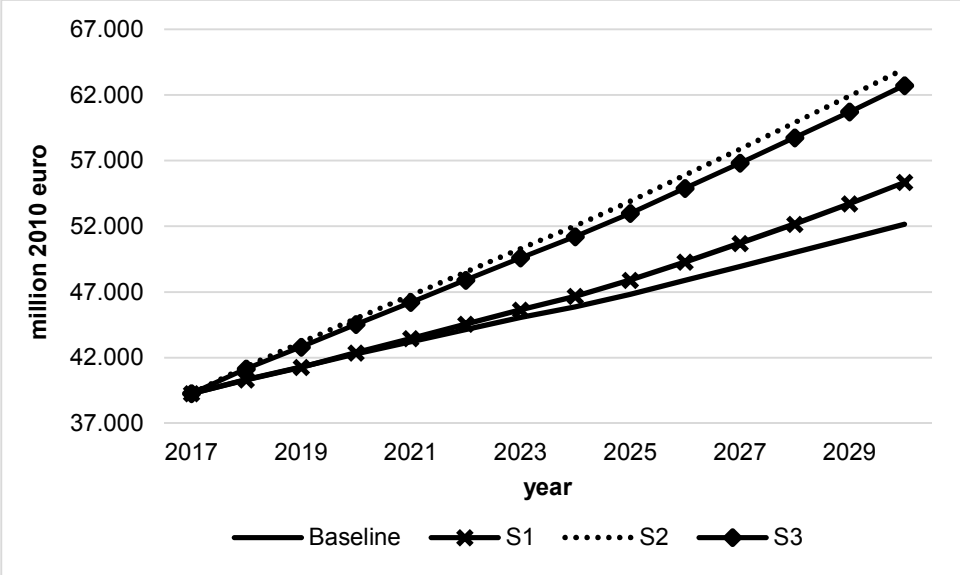


Figure 18. Consumer price index (CPI) 2017–2030

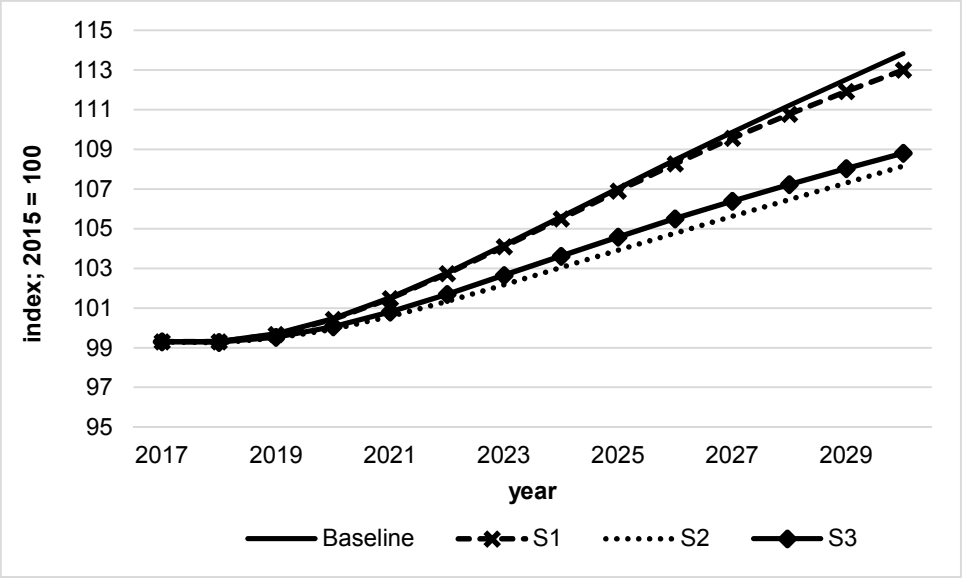


Figure 19. Inflation rate 2017–2030

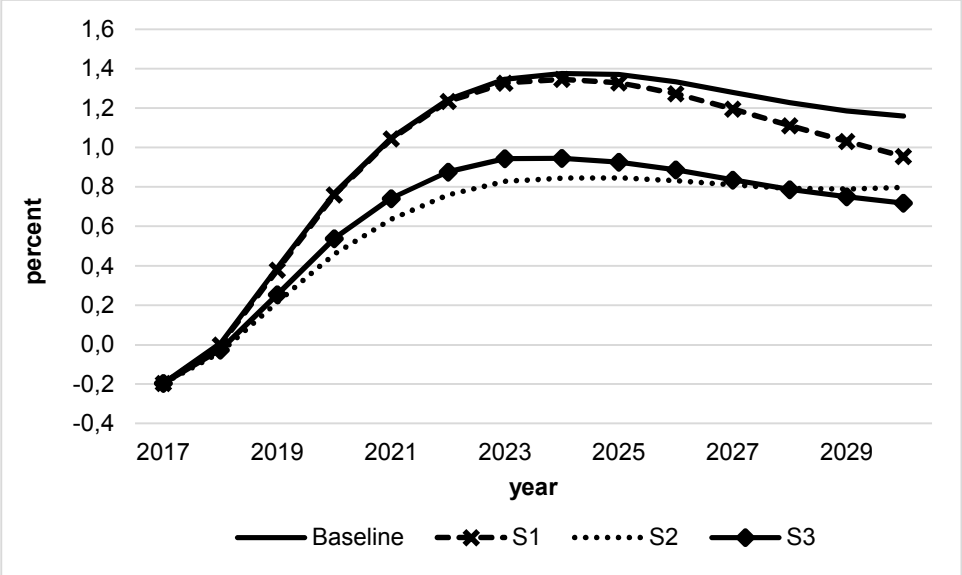


Figure 20. Employment 2017–2030

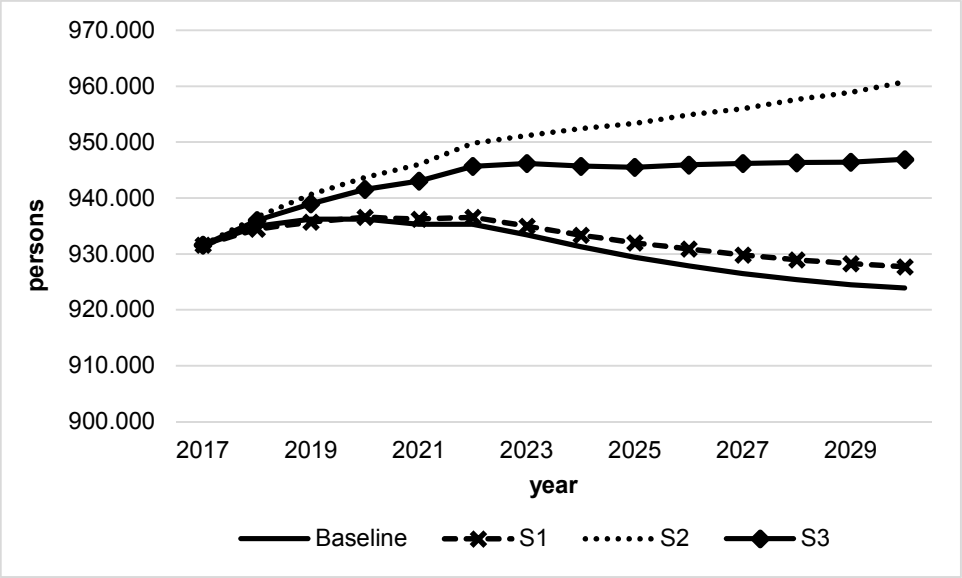


Figure 21. Unemployment rate 2017–2030

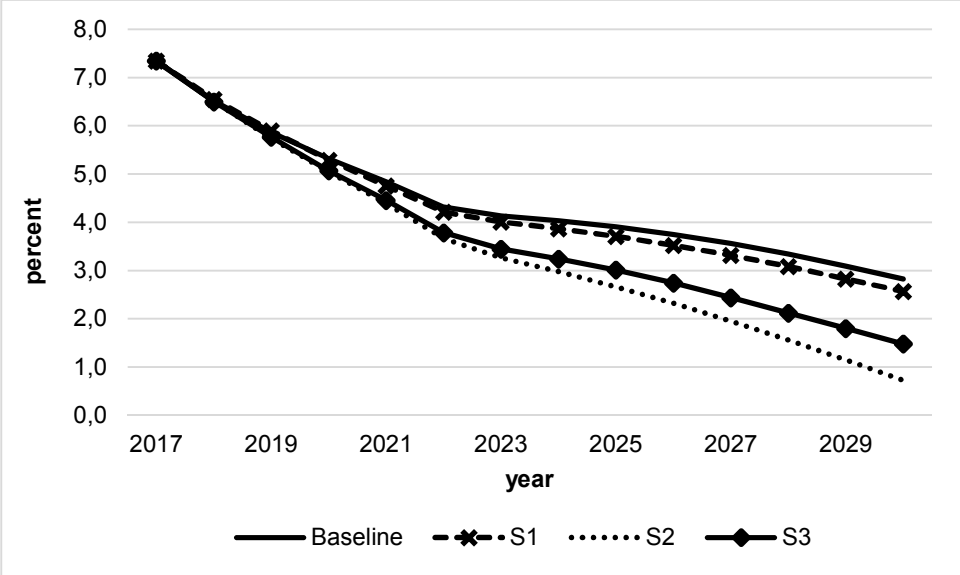


Figure 22. Net exports in relation to GDP 2017–2030

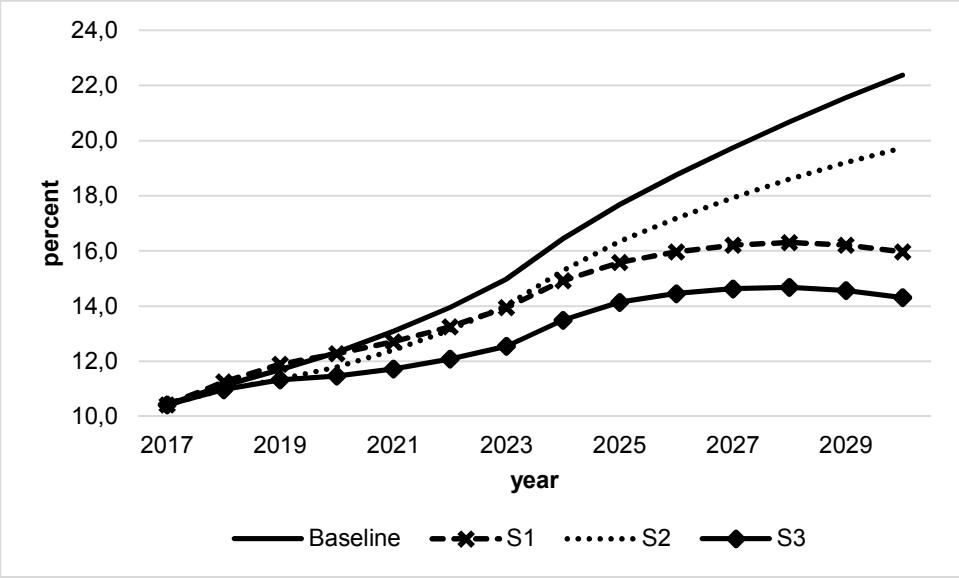
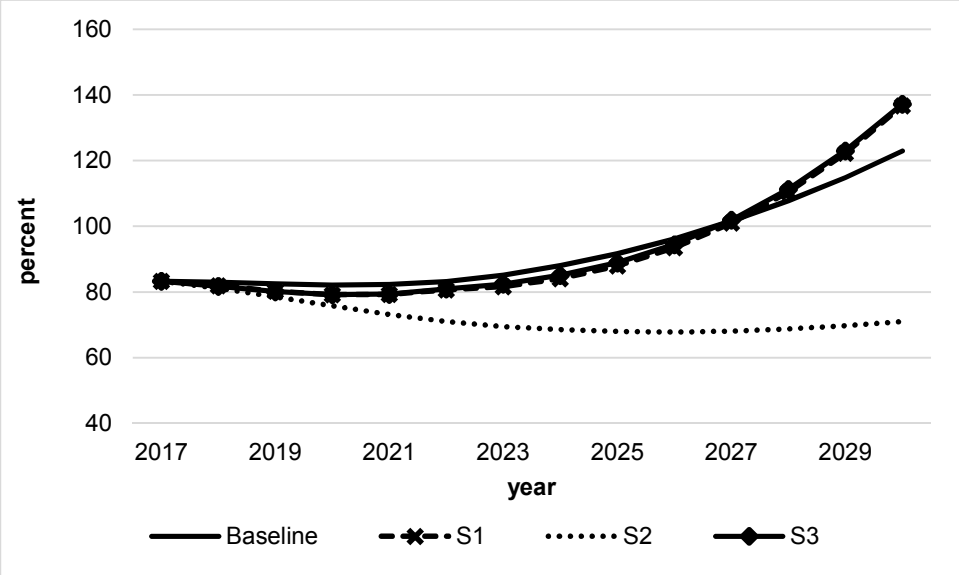


Figure 23. Public debt to GDP ratio 2017–2030



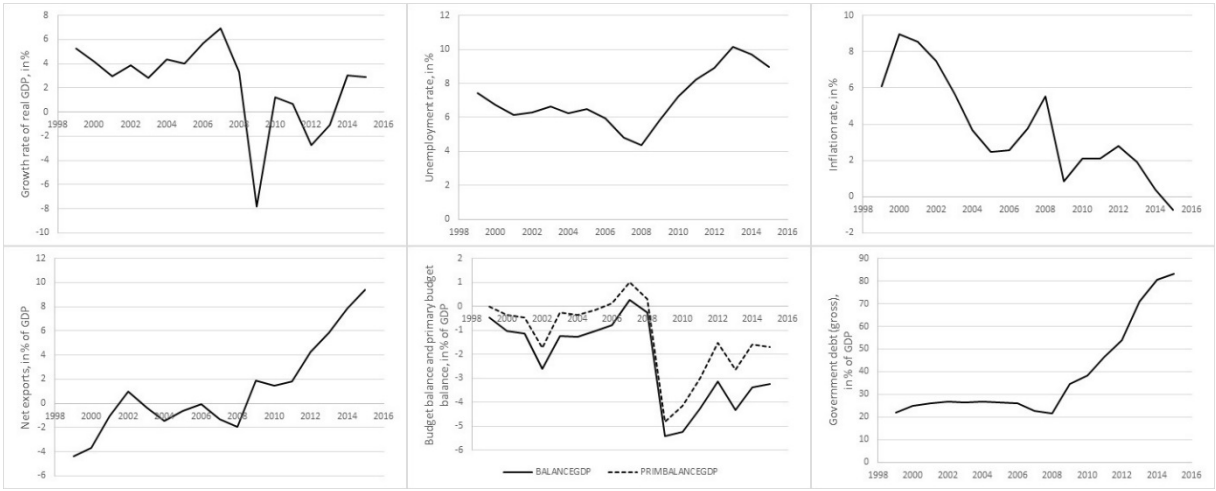
Comparing the three policy scenarios with the baseline ("business as usual") and to each other, we can identify scenario S2 as being the clear winner. It entails sustained higher GDP growth (both actual and potential) than the baseline and scenarios S1 and S3, higher employment and lower unemployment as well as low inflation and – what is particularly remarkable – the lowest public debt (even a decrease in the debt to GDP ratio by about 10 percentage points). At first glance, this result is unexpected as our econometric model is mainly a Keynesian demand side model where more expansionary effects of increases in expenditures like public consumption and transfers as implemented in scenario S3 might be expected. However, the combination of supply side policies stimulating productivity growth in the goods market and employment in the labour market leads to supply and demand effects that bring about virtual full employment without negative side effects on the government budget. Long run considerations in designing

fiscal policies as suggested by growth theory thus turn out to be adequate as well in dealing with the short and medium run problems of stabilizing aggregate demand.

10. Budget Consolidation in a Small Open Economy: An Optimal Control Approach for Slovenia

In Figure 24, a summary presentation of the dynamics of main Slovenian macroeconomic aggregates in the period 1998-2016 is presented. After a brief transformational recession in 1991-1992, high real GDP growth rates were achieved until 2008, and per capita income converged to the EU average faster than in any other transitional country in Central and Eastern Europe. According to Okun's law, the high growth rates corresponded to a falling unemployment rate, which in 2008 reached its lowest point at 4.3 percent. Despite the decline in the unemployment rate, the rate of inflation initially dropped, although most recently the rise in inflation to 5.5 percent indicated the problem of possible overheating. The current account was broadly balanced, as was the primary balance of the general government budget, while the actual budget balance was in deficit, but always below the "Maastricht limit" of 3 per cent of GDP. As a result, government debt remained essentially stable in relation to GDP and far below the 60 per cent of GDP allowed under the EU Stability and Growth Pact (Neck 2017: 96–97).

Figure 24. Dynamics of main macroeconomic aggregates in Slovenia, 1998-2016, top left: growth rate of real GDP; top middle: unemployment rate; top right: inflation rate; bottom left: net exports; bottom middle: budget balance and primary budget balance; bottom right: government debt.



In this section, we analyse the effects of different fiscal policy scenarios in Slovenia over the next 15 years and evaluate them according to their effects on macroeconomic target variables. We also determine optimal fiscal policies for Slovenia and, using the OPTCON algorithm, calculate approximately optimal policies under different scenarios. These analyses highlight trade-offs between the design of countercyclical fiscal policies and the requirements of fiscal

solvency and point to the current projections and future paths for solving the pressing public finance situation in Slovenia.

The significant increase in public debt as a legacy of the crisis – and partly due to weak macroeconomic policy response to the crisis – may also be of interest to other former Yugoslav countries that intend to become members of the European Union. One may conjecture that even a successful transformation to a market economy is not sufficient for compliance with EU standards in the case of a severe global economic disturbance. For instance, public finances may be insufficiently prepared to deal with a sharp drop in aggregate demand if political authorities are under pressure from trade unions to pay continuously excess wages to public employees. Therefore, we are interested in how fiscal policies should be designed in a country like Slovenia in order to reduce public debt without affecting its macroeconomic performance.

A large body of literature has been published in the last couple of years on the role of fiscal policies and the specific problems of countries within the Euro Area (see, for instance, Coenen et al. 2008, 2012, Cogan et al. 2010, Taylor 2009, Romer and Romer 2010, Martin 2018, Alesina et al. 2018). It is well known that fiscal policy effects are smaller ceteris paribus in small open economies than in larger economies that are less open, but the empirical evidence is also mixed for open economies. Slovenia is an interesting case because it is a small open transition economy that was already in the Euro Area before the Great Recession.

To analyse the effects of different fiscal policy scenarios in Slovenia over the next 15 years and evaluate them, we use the SLOPOL10 model. Next, we determine optimal fiscal policies for Slovenia, using the SLOPOL10 model and assuming an intertemporal objective function for Slovenian policy makers containing output, unemployment, inflation, the budget deficit, public debt and the current account as arguments. Using the OPTCON algorithm, approximately optimal policies are calculated under different scenarios. We analyse both demand side and supply side orientated policies.

We analyse the macroeconomic and fiscal performance of the Slovenian economy over the period 2017 to 2030. To this end, we first run a projection of the SLOPOL10 model, which requires assumptions regarding the exogenous variables. Since the model is based on data until 2015, our projection has to start in 2016, but when interpreting the results we focus on the period starting in 2017. The simulation requires assumptions on the exogenous variables. The exogenous variables comprise those (totally or largely) outside the influence of Slovenian policy makers (e.g. world trade, oil price, exchange rate, Euro Area interest rates, population development) and the fiscal policy instruments.

Table 51 shows the assumed paths of the fiscal policy instruments: public consumption according to fiscal statistics, nominal (*GNFIN*), transfers to individuals and households (*TRANSFERSN*), remaining government expenditures (*REVREST*), public investment, nominal (GINVN), public expenditures on research & development (*GERD*), average personal income tax rate (*INCTAXRATE*), average social security contribution rate (*SOCEMPRATE*), value added tax rate (*VATAXRATE*), and active working population with tertiary education, % of total (*LFTERSHARE*). As we had to start the simulation in 2016, assumptions also had to be made for 2016 and 2017 for which now – at least provisional – data are available. Thus, the table also shows the actual realizations of the instruments in 2016 and 2017. For government expenditures on research and development, data for 2017 are not yet available.

Table 51. Assumptions for fiscal policy instruments

	Assumptions		Actual development	
	2016	**2017 - 2030**	**2016**	**2017**
		Growth rates		
GNFIN	1.1%	3.5%	4.0%	6.6%
TRANSFERSN	3.5%	3.5%	2.0%	2.6%
REVREST	3.5%	3.5%	–16.2%	-0.5%
GINVN	2.1%	3.5%	–29.2%	3.5%
GERD	3.5%	3.5%	1.8%	n.a.
		Absolute values		
INCTAXRATE	12.7%	12.7%	11.9%	11.7%
SOCEMPRATE	18.2%	18.2%	17.4%	17.2%
VATAXRATE	22.0%	22.0%	22.0%	22.0%
LFTERSHARE	32.8%	incr. to 39.5%	33.9%	35.1%

As mentioned, in addition to the policy instruments, assumptions had to be made for the truly exogenous variables (those not controlled by the government of Slovenia). They are summarized in

Table 16. Here, realizations for 2016 and 2017 are shown in brackets. In addition to the variables in the table, population projections were needed. According to current projections[6], Slovenia's working-age population will decline by around 0.75% per year until 2022 and by around 0.5% per year after that. Conversely, as is the case all over Europe, the population aged 65 and over will continue to rise due to increased life expectancy. According to population projections, this growth will decrease more or less steadily from about 3% in 2017 to 1.5% in 2030.

Table 16. Assumptions for the exogenous variables

	2016	**2017**	**2018 - 2030**
World trade growth (%)	1.1 (1.5)	1.8 (4.5)	3.0
Oil price(USD / barrel)	42.56 (45.06)	53.63 (54.80)	incr. to 75
3 months Euribor (%)	–0.27 (–0.27)	–0.25 (–0.33)	incr. to 0.75

[6] We used the EUROPOP population projection from the Eurostat database; this projection is also available from the Statistical Office of the Republic of Slovenia.

10 year Euro Area gov. bond yield (%)	0.87 (0.87)	1.01 (1.09)	incr. to 2.00
USD / EUR	1.11 (1.11)	1.09 (1.13)	1.10

These settings of the exogenous variables lead to the baseline simulation results as summarized in

Table 17. As can be seen, our model underestimated the rather fast recovery in 2017 from the previous slow and stagnating development of the Slovenian economy and the return to lower public debt.

Table 17 Results of the baseline simulation (for 2016 and 2017, actual realizations are shown in brackets)

	Real GDP growth	Employment growth	Unemploy-ment rate	Inflation rate	Budget Balance / GDP	Public Debt / GDP
2016	2.1 (*3.1*)	0.9 (*–0.3*)	8.3 (*8.0*)	–0.5 (*–0.2*)	–2.3 (*–1.6*)	82.6 (*78.5*)
2017	2.9 (*5.0*)	0.9 (*4.8*)	7.2 (*6.6*)	–0.2 (*1.6*)	–2.1 (*–0.7*)	82.2 (*73.5*)
2018	3.3	0.5	6.3	-0.1	–1.9	81.2
2019	3.1	0.3	5.5	0.3	–1.6	79.8
2020	3.0	0.2	4.9	0.6	–1.4	78.1
2021	2.8	0.1	4.3	0.9	–1.3	76.3
2022	2.7	0.2	3.6	1.0	–1.3	74.7
2023	2.4	0.0	3.3	1.1	–1.2	73.3
2024	2.4	0.0	3.0	1.2	–1.1	71.8
2025	2.3	–0.1	2.8	1.2	–1.0	70.4
2026	2.2	–0.1	2.5	1.1	–1.1	69.1
2027	2.2	–0.1	2.3	1.1	–1.2	68.0
2028	2.2	–0.1	2.1	1.0	–1.3	67.1
2029	2.2	–0.1	1.8	1.0	–1.4	66.4
2030	2.2	–0.1	1.5	0.9	–1.6	65.8

In addition to the long-run projections as described in the previous paragraph, we run several optimal control exercises to obtain optimal fiscal policy trajectories. Solving an optimum control

problem means finding certain paths of control variables that minimize an objective function involving deviations of the values of the politically relevant variables from some pre-specified target paths. As usual in economic policy applications, we assume a quadratic objective function. The problem is described as follows:

$$\min J = \sum_{t=1}^{T} L_t(x_t, u_t), \tag{1}$$

$$L_t(x_t, u_t) = \frac{1}{2}\begin{pmatrix} x_t - \tilde{x}_t \\ u_t - \tilde{u}_t \end{pmatrix}' W_t \begin{pmatrix} x_t - \tilde{x}_t \\ u_t - \tilde{u}_t \end{pmatrix}.$$

Here x_t is an *n*-dimensional vector of state variables that describes the state of the economic system at time *t*; u_t is an *m*-dimensional vector of control (policy instrument) variables; $\tilde{x}_t \in R^n$ and $\tilde{u}_t \in R^m$ are given "ideal" (desired) levels of the state and control variables respectively. *T* denotes the terminal period of the finite planning horizon; W_t is a matrix specifying the relative weights of the state and control variables in the objective function.

The optimization is restricted by the dynamics of the system given in the form of a system of nonlinear difference equations:

$$x_t = f(x_{t-1}, x_t, u_t, \theta, z_t) + \varepsilon_t, \; t=1,\ldots,T, \tag{2}$$

where θ is a *p*-dimensional vector of estimated parameters and z_t denotes a vector of exogenous non-controlled variables. In this study, the dynamic system *f* is given by the SLOPOL10 model.

The dynamic system (2) and the objective function (1) define a multivariable nonlinear-quadratic optimum control problem, which has to be solved. An exact solution to such a problem is not possible, so we have to resort to numerical approximations. To this end, the OPTCON2 algorithm is used (for more details see Blueschke-Nikolaeva et al. (2012)). This algorithm determines approximate solutions to optimum control problems with a quadratic objective function and a nonlinear multivariate dynamic system under additive and parameter uncertainties. Although this algorithm allows for a rather elaborate menu of stochastic extensions, here we confine ourselves to deterministic optimal control, assuming the model parameters and the model equations to be exactly true.

The policy maker in this optimal control experiment is the government of Slovenia, which calculates the optimal trajectories of policy instruments until 2030. It has nine control variables at its disposal: government consumption, transfers, government investment, public expenditures for research and development, the average personal income tax rate, the proportion of the active working population with tertiary education, the average social security contribution rate, remaining government revenues and the value added tax rate. We selected eleven state variables for which certain "ideal" paths are defined and which enter the objective function (1), namely the growth rate of GDP (*GRGDPR*), the level of real GDP (*GDPR*), the unemployment rate (*UR*), the inflation rate (*INFL*), the budget balance ratio to GDP (*BALANCEGDP*), the debt level ratio to GDP (*DEBTGDP*), the current account balance ratio to GDP (*CAGDP*), real private consumption (*CR*), real private investment (*PRINVR*), the growth rate of potential GDP (*GRYPOT*) and the level of potential GDP (*YPOT*). The target paths of the main objectives are shown in

Table 1814.

Table 18. Targets for the optimizations

	Budget balance / GDP	Net exports / GDP	Public Debt / GDP	Output gap	Real GDP growth	Potential GDP growth	Inflation rate	Unemploy-ment rate
2017	–2.1%	9.4%	82.0%	-0.8%	3.0%	3.6%	–0.2%	7.1%
2018	0.0%	9.5%	78.0%	0.0%	3.0%	3.0%	1.0%	6.1%
2019	0.0%	9.4%	74.0%	0.0%	3.0%	3.0%	1.0%	5.1%
2020	0.0%	9.3%	70.0%	0.0%	3.0%	3.0%	1.0%	4.6%
2021	0.0%	9.2%	66.0%	0.0%	3.0%	3.0%	1.0%	4.1%
2022	0.0%	9.1%	62.0%	0.0%	2.6%	2.6%	1.0%	3.6%
2023	0.0%	9.0%	61.0%	0.0%	2.5%	2.5%	1.0%	3.4%
2024	0.0%	8.9%	60.0%	0.0%	2.5%	2.5%	1.0%	3.1%
2025	0.0%	8.8%	59.0%	0.0%	2.5%	2.5%	1.0%	2.9%
2026	0.0%	8.7%	58.0%	0.0%	2.5%	2.5%	1.0%	2.7%
2027	0.0%	8.6%	57.0%	0.0%	2.5%	2.5%	1.0%	2.5%
2028	0.0%	8.5%	56.0%	0.0%	2.5%	2.5%	1.0%	2.3%
2029	0.0%	8.4%	55.0%	0.0%	2.5%	2.5%	1.0%	2.1%
2030	0.0%	8.3%	54.0%	0.0%	2.5%	2.5%	1.0%	1.9%

The choice of targets is meant to represent the most important goals of macroeconomic policy making. The “ideal” paths imply smooth growth in the income variables and low values for the rates of unemployment and inflation. In addition to the targets depicted in the table, for the levels of real GDP, potential output, private consumption and investment, target paths in accordance with the “ideal” real growth rates had to be specified. Furthermore, “ideal” paths had to be given to the instruments in order to prevent erratic fluctuations in these variables.

Regarding the choice of the weights of the objective variables (the matrix W in (1)), we take the simplest possibility of giving all variables the same weight of 1. Of course, these raw weights are normalised according to the time-series characteristics of the variables.

Using the specified targets and weights, we are able to carry out the optimal control exercise and to calculate optimal fiscal policies according to the assumptions made. The optimal paths of the control variables are given in Figures 25–33 and denoted by “opt_sc0”. The optimal

paths of the state variables are given in Figures 34–39. In addition, the figures include the non-controlled (projected) simulation paths as described in above, denoted by “baseline”.

Figure 25. Government consumption (*GNFIN*), mio euro

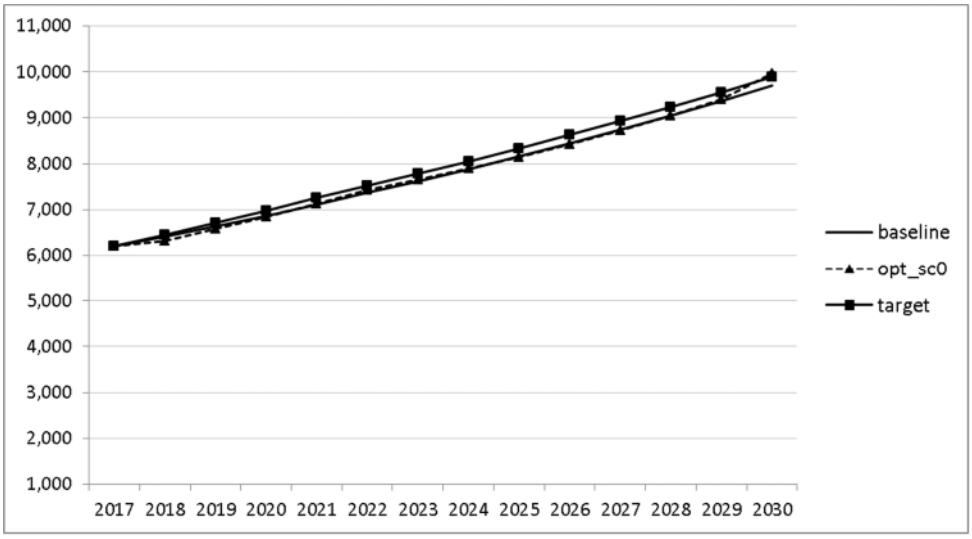


Figure 26. Transfers (*TRANSFERS*), mio euro

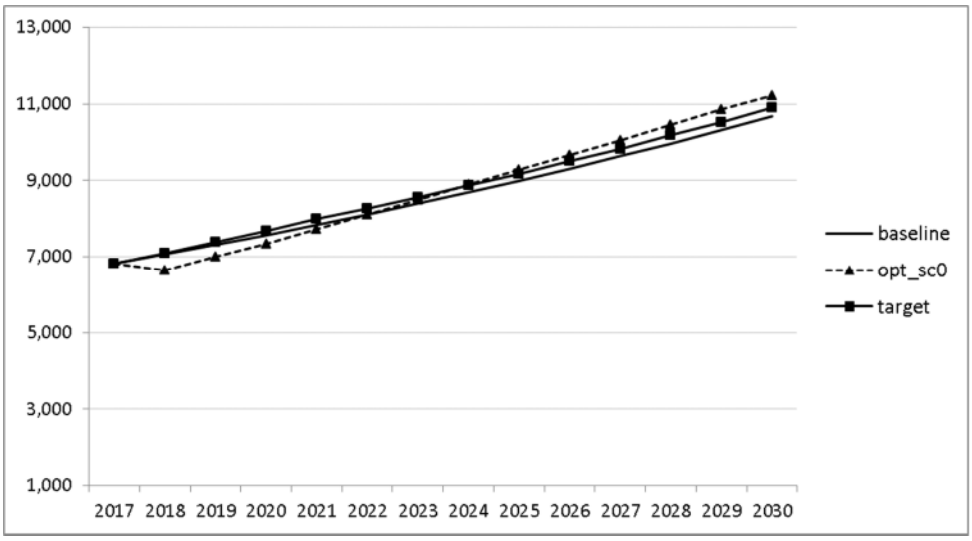


Figure 27. Government investment (*GINVN*), mio euro

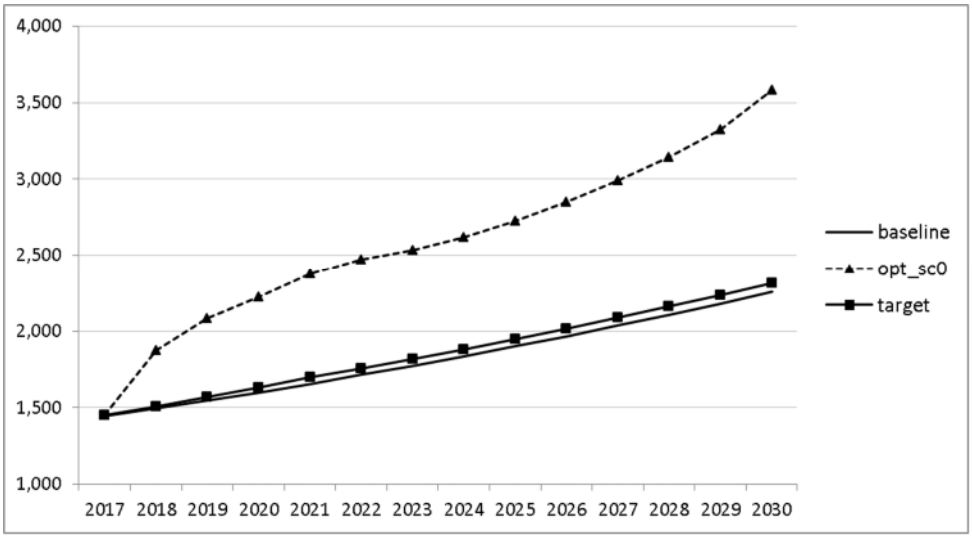


Figure 28. Public expenditures for R&D (*GERD*), mio euro

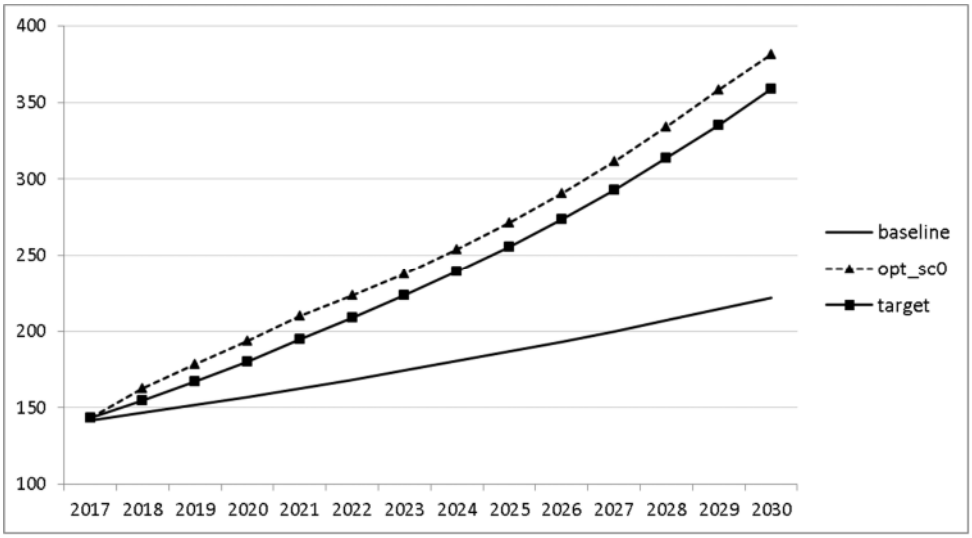


Figure 29. Average personal income tax rate (*INCTAXRATE*), %

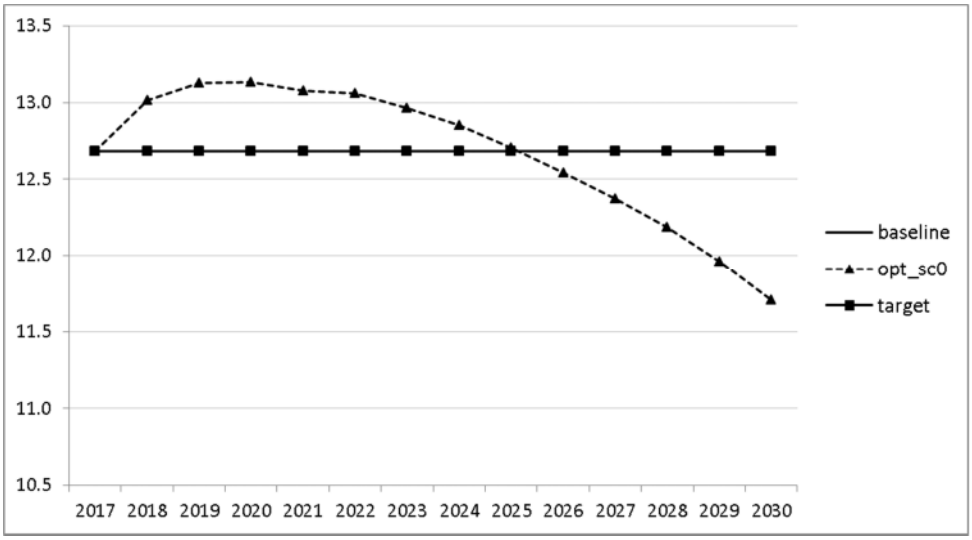


Figure 30. Average social security contribution rate (*SOCEMPRATE*), %

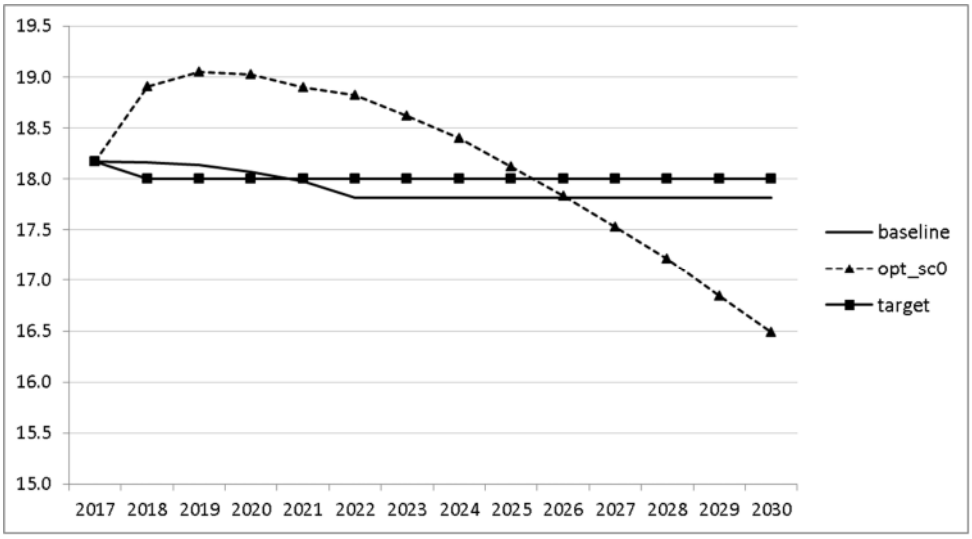


Figure 31. Active working population with tertiary education (*LFTERSHARE*), %

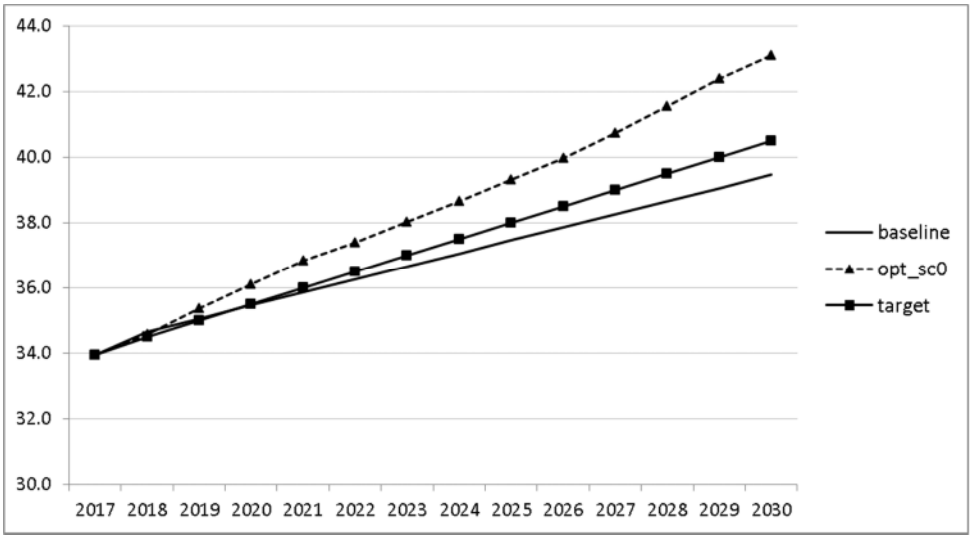


Figure 32. Remaining government revenues (*REVREST*), mio euro

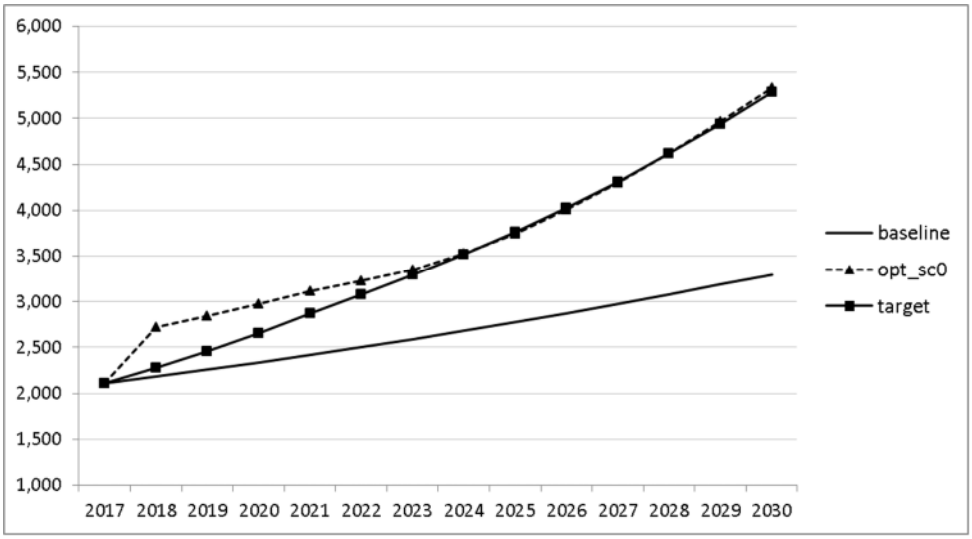
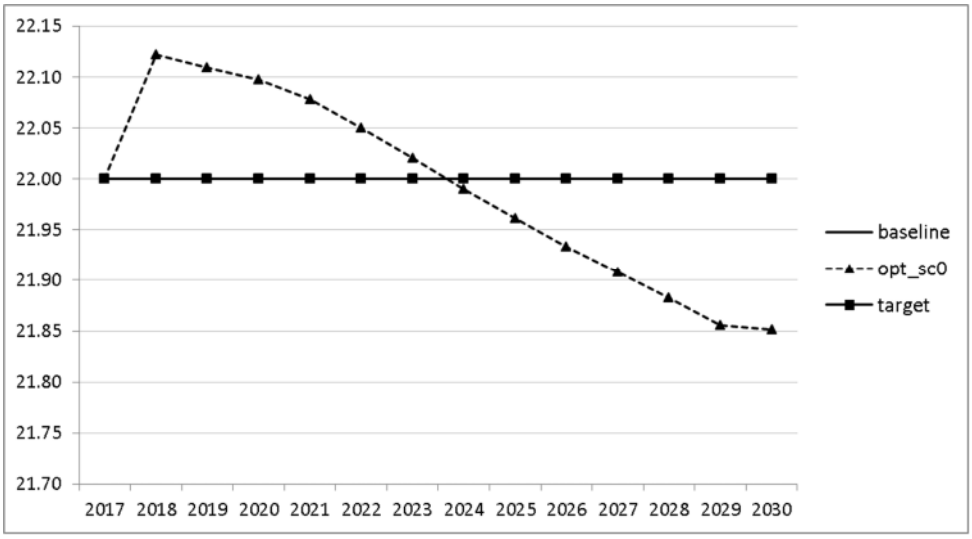


Figure 33 Value added tax rate (*VATAXRATE*), %



The calculated optimal policy mix is more or less obvious here, with a more restrictive fiscal policy in the first 5–6 years and a more expansionary policy afterwards. This is due to a relatively high level of debt and the necessity for budget consolidation. Two aspects attract attention: first, the optimal choice of budgetary policy entails a significant shift in priorities from transfers and general government consumption towards public investment, R&D related and education related expenditures. *GERD*, for example, grows from 150 mio euro to nearly 400 mio euro and *GINVN* should be increased by a factor of 2. Compared to other fiscal instruments, these instruments also affect the supply side (*YPOT*), are more effective with respect to aggregate output and should be used more actively by the government. Second, quite often the optimal paths are very close to the non-controlled simulation, which shows that the Slovenian Stability Programme, which calls for budget consolidation, seems to be a reasonable choice for fiscal policy. This is supported by the resulting paths of the state variables.

Figure 34. Growth rate of GDP (*GRGDPR*), %

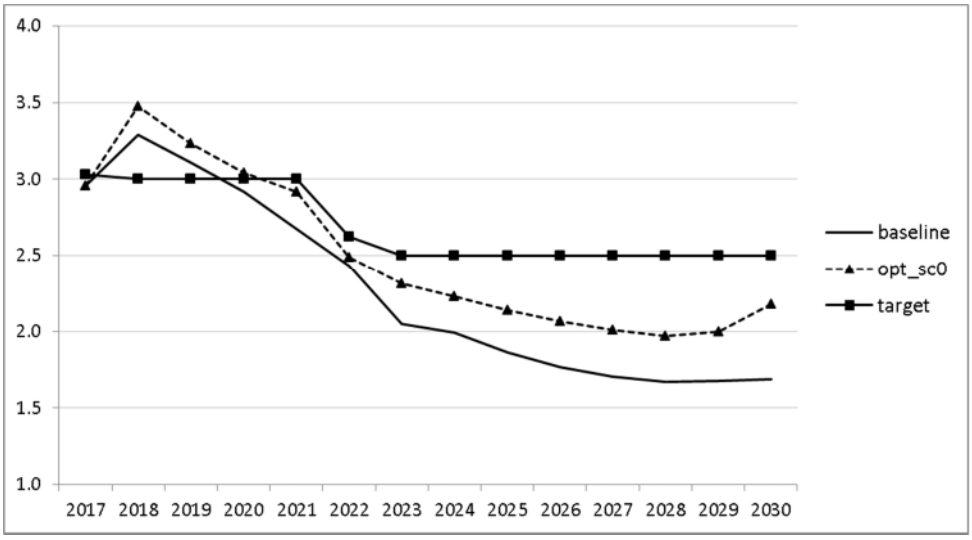


Figure 35 Growth rate of potential GDP (*GRYPOT*), %

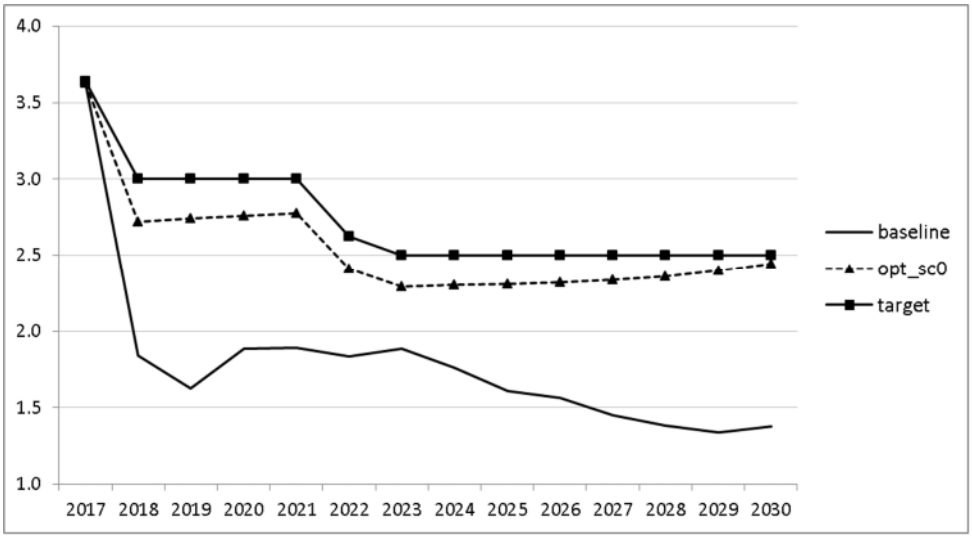


Figure 36 Unemployment rate (*UR*), %

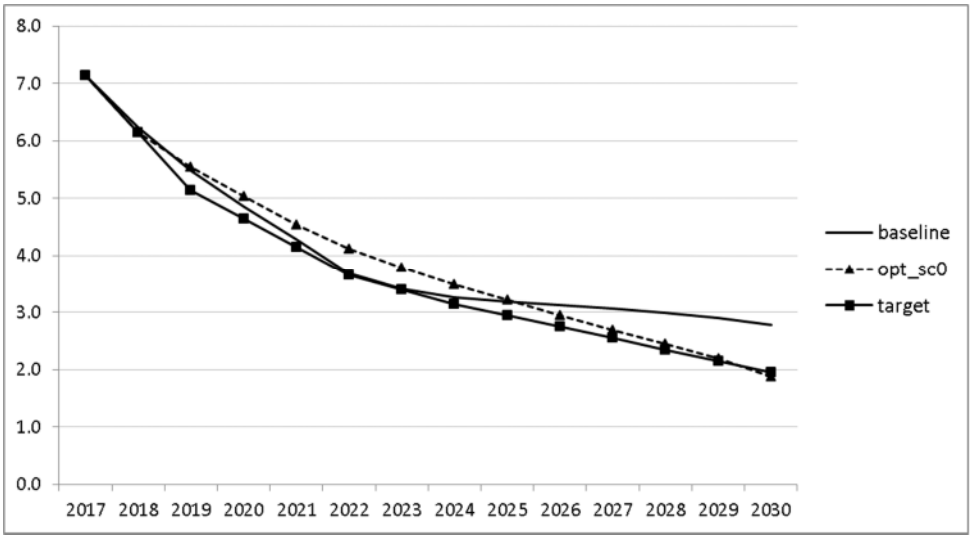


Figure 37 Inflation rate (*INFL*), %

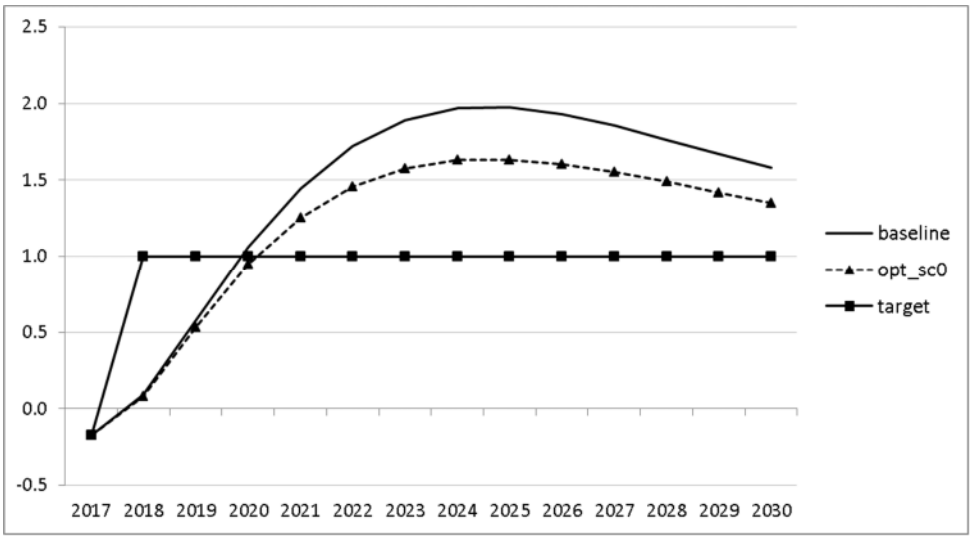


Figure 38 Budget balance ratio to GDP (*BALANCEGDP*), % of GDP

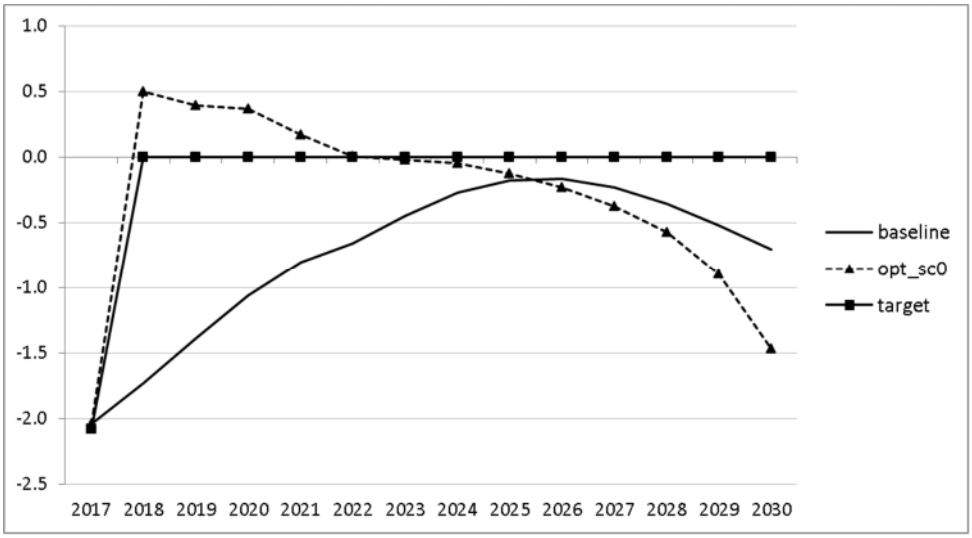
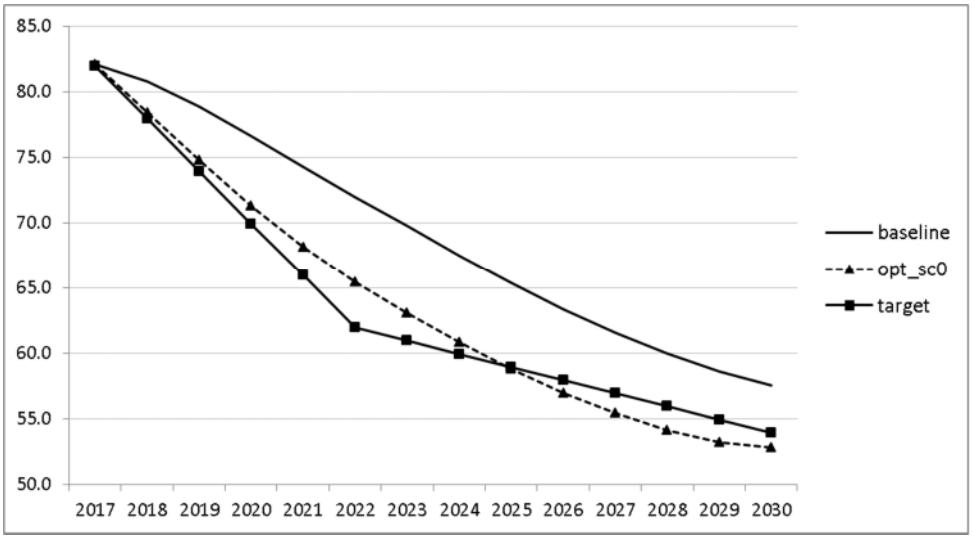


Figure 39 Public debt (*DEBTGDP*), % of GDP



The resulting paths of the state variables show a favourable forecast for the Slovenian economy. Despite a slightly restrictive fiscal policy in the next 5–6 years, GDP grows by around 3% per year. The unemployment rate decreases steadily, which is due to both the positive economic performance and the declining working-age population; it arrives at the desired 2% level in 2030. The inflation rate starts from a very low level and increases steadily until 2025 but stays below the ECB threshold of 2%. The budget is nearly balanced, with small surpluses in 2018–2021 and small deficits in 2025–2030. Although the highest budget deficit is achieved at the end of the planning horizon, it is only 1.5% of GDP. Relatively high growth rates of GDP and nearly balanced budgets allow the policy makers to deal with the problem of the high initial public debt relatively quickly. Already in 2025, a debt level below 60% of GDP is achieved. In the non-controlled baseline scenario, this happens in 2028.

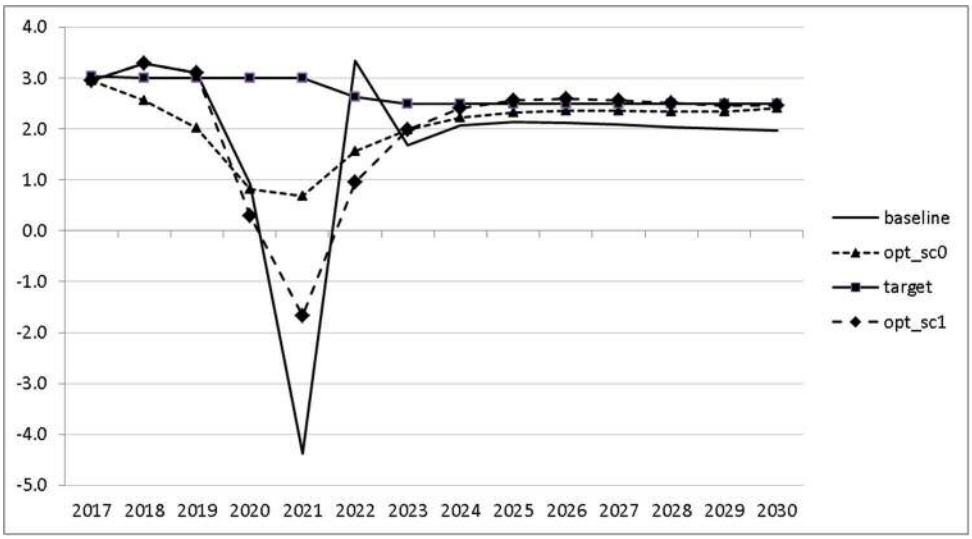
Altogether, the optimal solution and the non-controlled projections show a very fortunate picture of the development of the Slovenian economy. As a small open economy, Slovenia is heavily dependent on external factors. The economic outlook for Slovenia, which was very pessimistic a few years ago, has changed a lot as the European economy shows strong

upward dynamics. The Economic Sentiment Indicator (ESI), which describes the economic environment in Europe, is now at 111.9 points, the highest value in the last ten years. However, as was shown by the optimization results, it is important to shift some resources from sectors that are less to those that are more dynamic by increasing, for example, R&D related and education related expenditures.

11. What to do if a New Crisis Appears?

In Section 10, a relatively optimistic picture was presented for the Slovenian economy. This goes in line with the upward development of the European economy. However, it is important to be prepared for bad times. In this section, we analyse a situation in which a similar crisis to that of 2008–2010 occurs. We model this crisis by introducing a drop in world trade growth. We assume that the crisis breaks out in 2020. Starting in 2020q3 and continuing until the end of 2021, we calculate world trade by using the same growth rates as between 2008q3 and 2009q4, namely 2.5, -6.2, -17.7, -17.7, -12.9, -1.1. Using the adjusted world trade, we recalculate the uncontrolled projection (denoted again by "baseline") and calculate two optimal scenarios. In scenario "opt_sc0" we assume that the government already predicts in 2018 that a crisis will occur and calculate the optimal fiscal response for that case. In scenario "opt_sc1" the outbreak of the crisis in 2020 is not predicted by the government. In Figure 40, the resulting paths are given for the growth rate of GDP in these scenarios.

Figure 40. Growth rate of GDP (*GRGDPR*), %



In the uncontrolled projection, the outbreak of a new crisis in 2020 leads to a drop in GDP by more than 4%. If the government reacts to it properly, it is able to mitigate this negative effect largely. Of course, this mitigation is much smoother if the government expects such a crisis (in 2021 *GRGDPR* is 0.7 in the opt_sc0 scenario as compared to -1.7 in the opt_sc1 scenario). In the first instance, anticipating the crisis does not seem to be a realistic assumption, but having experienced the Great Recession a few years ago, the government might learn from it and could immediately adjust its policy by reacting to the first signs of a bursting bubble.

In Figures 41–49, we present these optimal trajectories of the fiscal instruments.

Figure 41. Government consumption (*GNFIN*), mio euro

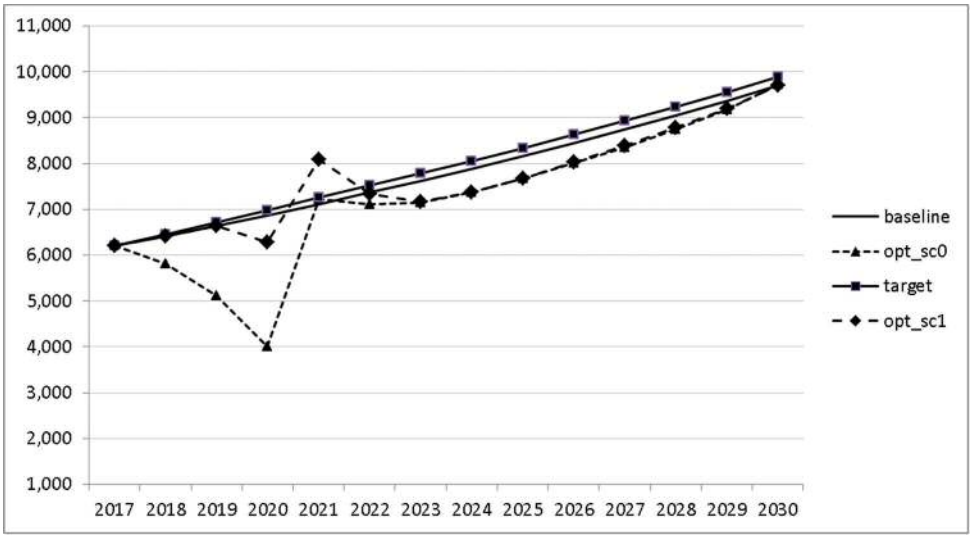


Figure 42. Transfers (*TRANSFERS*), mio euro

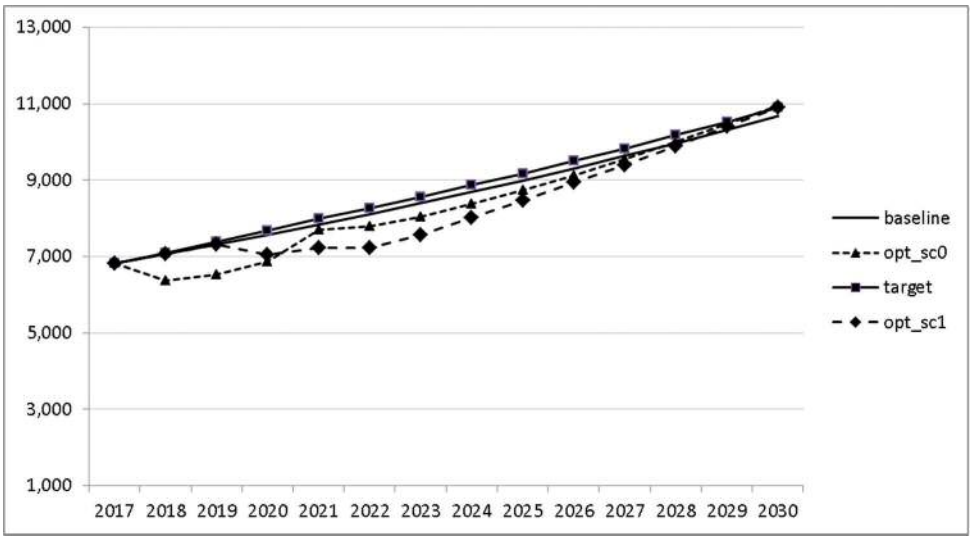


Figure 43. Government investment (*GINVN*), mio euro

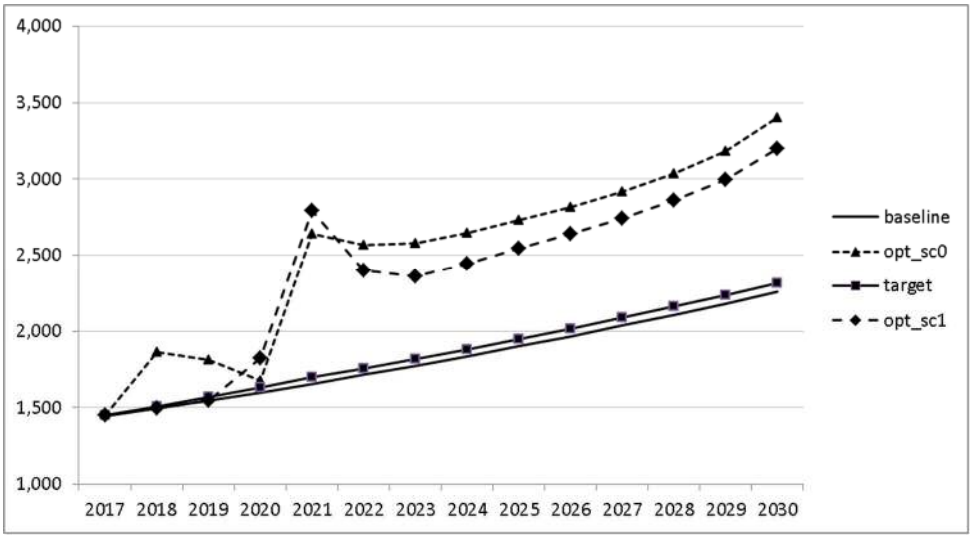


Figure 44. Public expenditures for R&D (*GERD*), mio euro

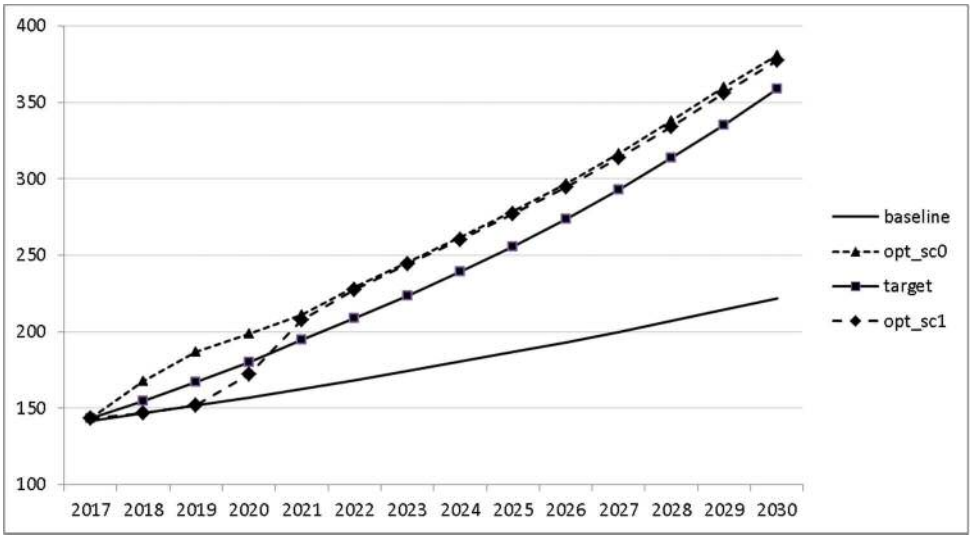


Figure 45. Average personal income tax rate (*INCTAXRATE*), %

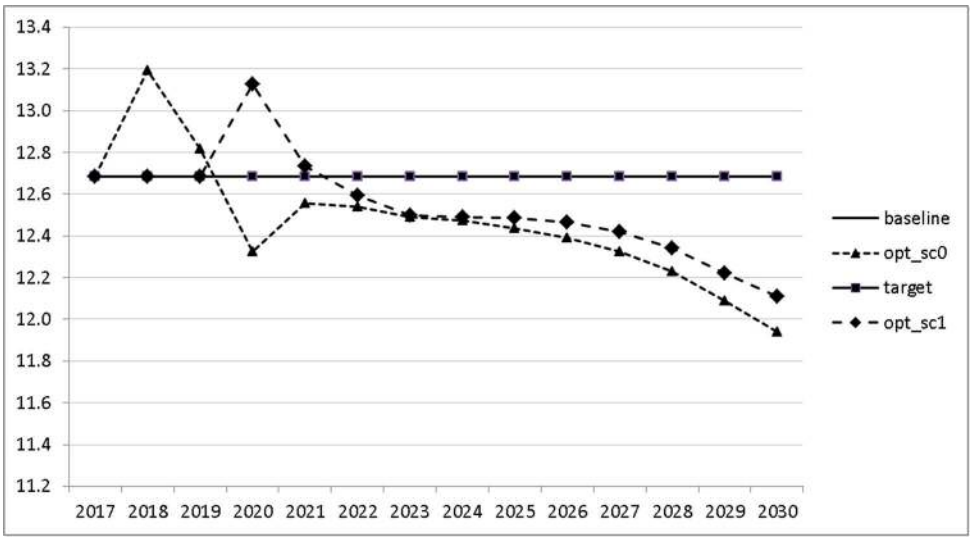


Figure 46. Average social security contribution rate (*SOCEMPRATE*), %

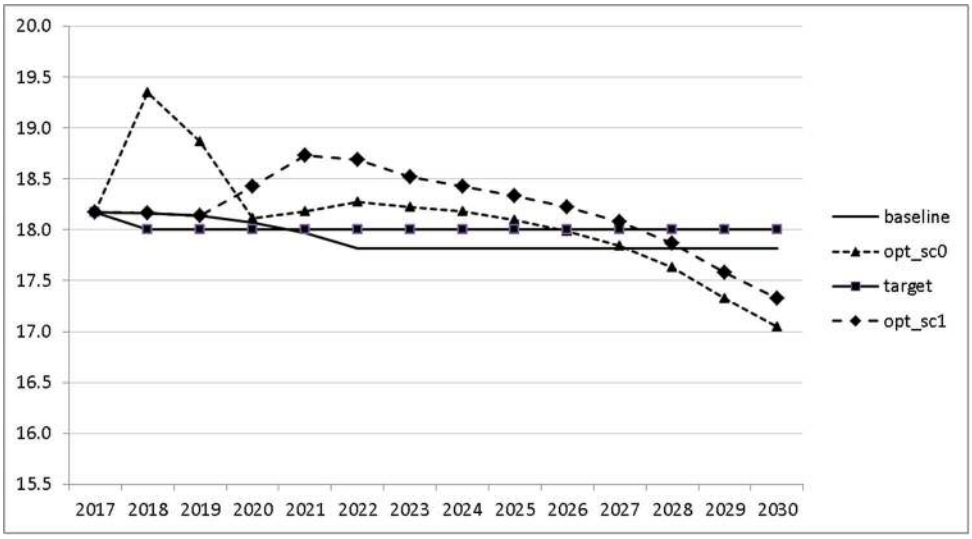


Figure 47. Active working population with tertiary education (*LFTERSHARE*), %

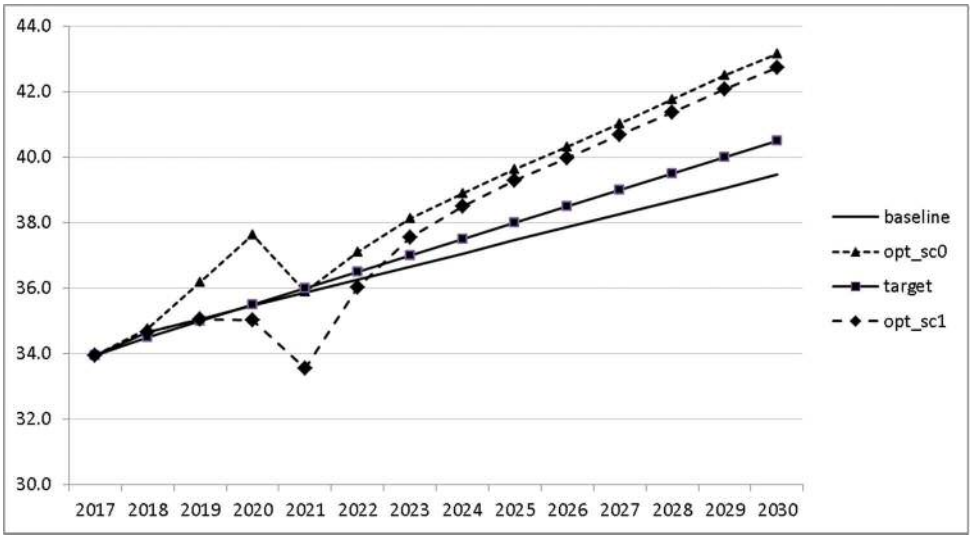


Figure 48. Remaining government revenues (*REVREST*), mio euro

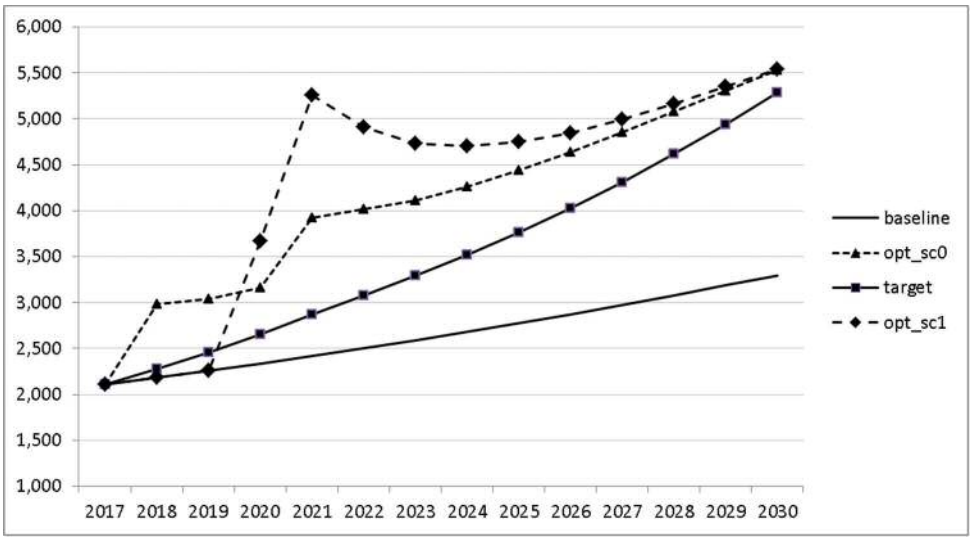
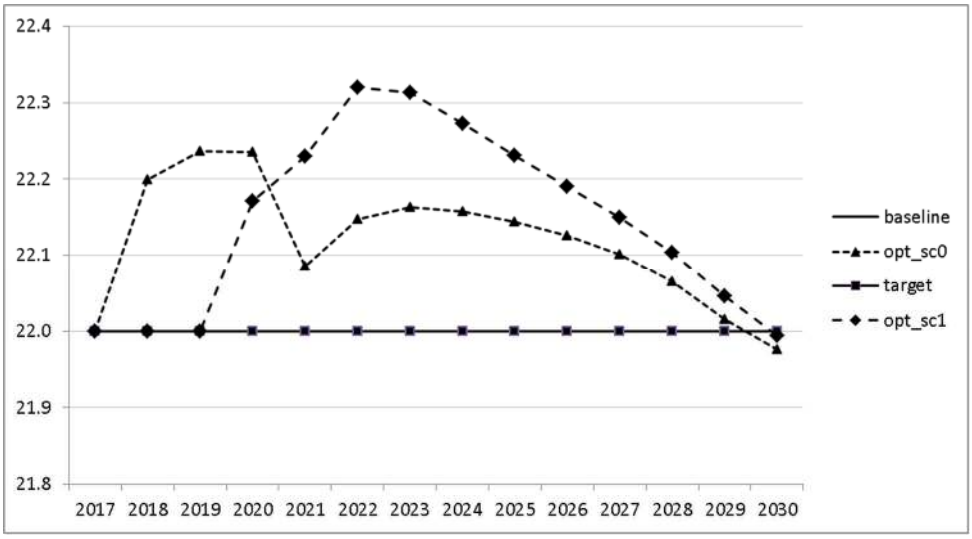


Figure 49. Value added tax rate (*VATAXRATE*), %



Interestingly, the main difference between the scenarios with the negative shock and the scenario without the shock is a more restrictive stance on fiscal policy as shown by all the controls with the exception of public investment and expenditures for R&D and for human capital. The latter shows again the importance for output of supply side government expenditures. If the shock is expected, the government is asked to run a more restrictive fiscal policy right from the start. This is done to consolidate the budget as soon as possible and to be able to apply a more countercyclical fiscal policy during the crisis. In contrast, if the shock is unexpected, the government is required to be more restrictive even during the crisis, resulting in a larger drop in GDP.

The other state variables behave in a parallel way to GDP; the unemployment rate is higher (Figure 50) and the inflation rate is lower (Figure 51) than in the absence of the shock. In the uncontrolled projection the government is confronted with high budget deficits (Figure 52) and quite sharply rising public debt (Figure 53), arriving at the level of 110% of GDP in 2030. This explains why a more restrictive fiscal policy is calculated to be optimal in the crisis scenario. This is the only way to have government finances under control, with relatively small negative side effects on output and employment.

Figure 50. Unemployment rate (*UR*), %

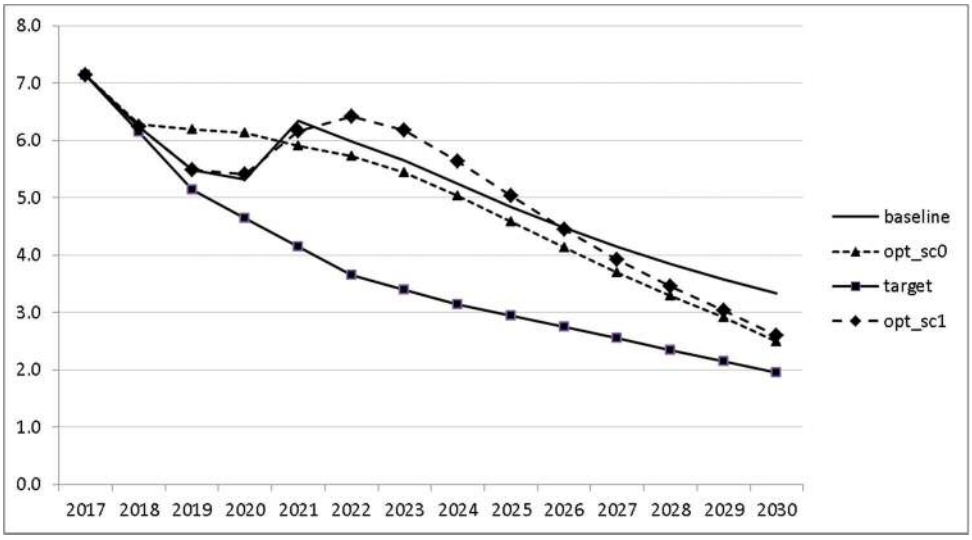


Figure 51. Inflation rate (*INFL*), %

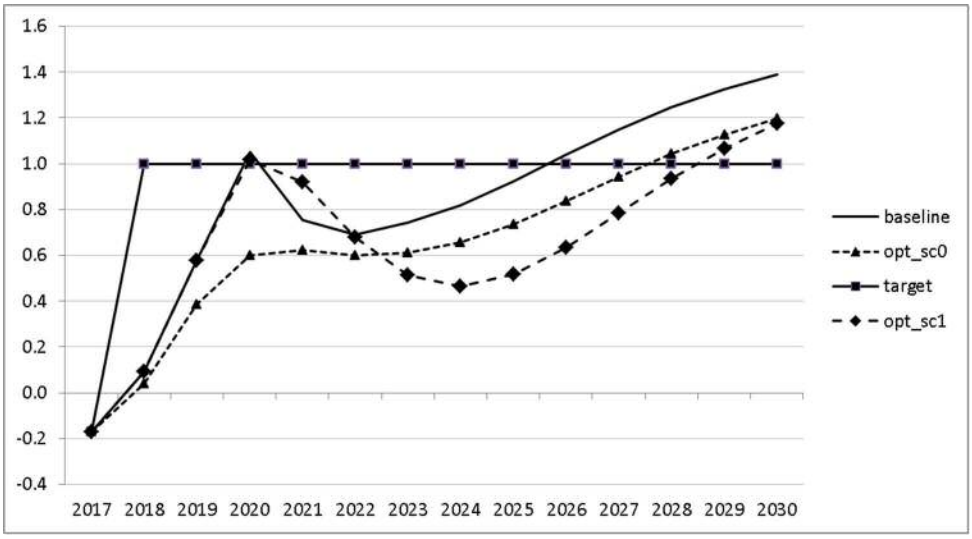


Figure 52. Budget balance ratio to GDP (*BALANCEGDP*), % of GDP

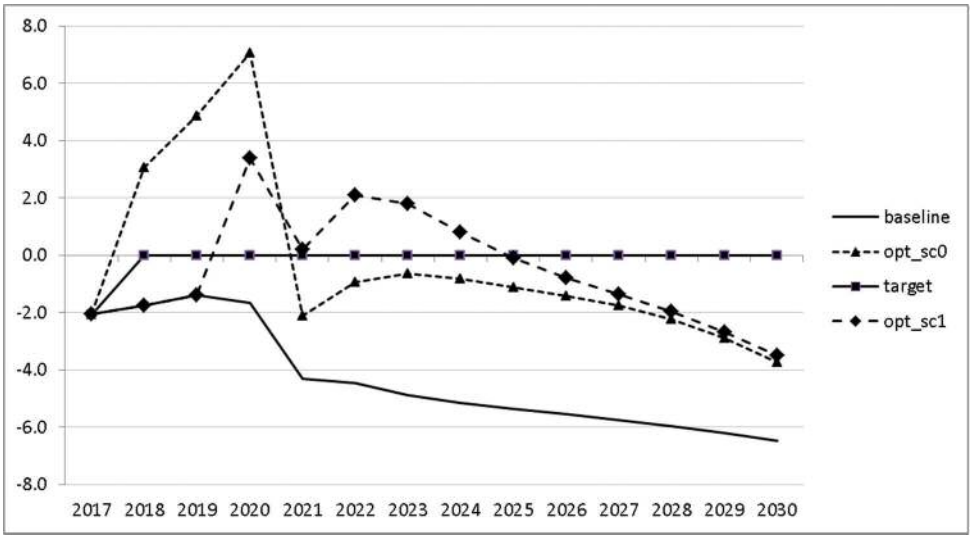
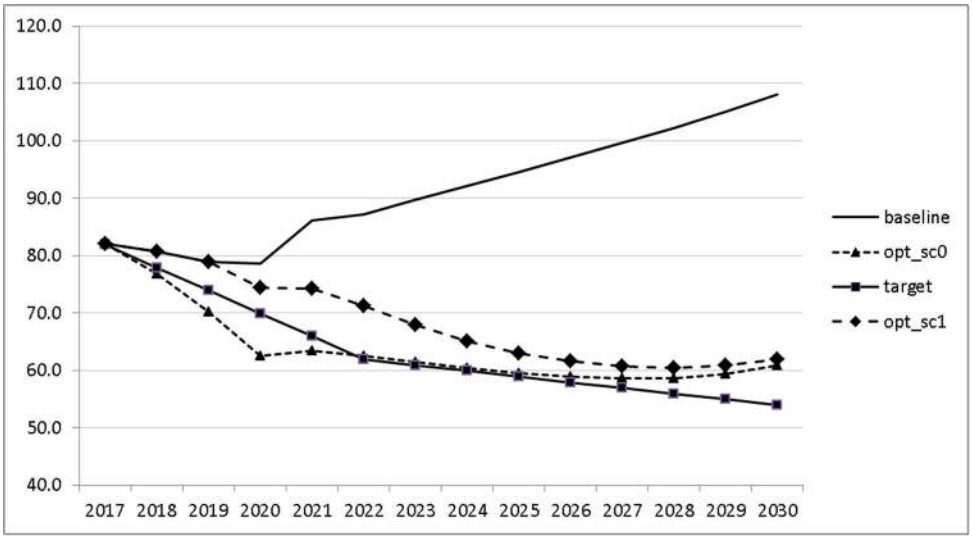


Figure 53. Public debt (*DEBTGDP*), % of GDP



In this and the previous section, we used the macroeconometric model SLOPOL10 to calculate simulations of the development of the Slovenian economy until 2030. Starting from the present favourable prospects of the European economies, the forecast is very optimistic but it can nevertheless be improved by optimal fiscal policies as calculated using the OPTCON2 algorithm. If a negative shock to world trade of a size comparable to the Great Recession occurs, it will entail a decline in GDP and a slow recovery, as has to be expected. In this case, optimal fiscal policies should not act in an expansionary way as the effectiveness of fiscal policy with respect to output and employment is rather limited in a small open economy like Slovenia. Instead, the goal of budget consolidation will call for a more restrictive fiscal policy; at least if (as assumed) the shock is temporary. Thus typical Keynesian fiscal policy advice is not optimal even in a model with strong Keynesian features the one used here.

12. R&D as Optimal Fiscal Policies

In addition to the control experiments of the previous sections, we conduct various additional policy optimization experiments with varying emphasis on R&D related government expenditures. In particular, we compare the results from an optimal control run with equal weights for the different fiscal policy instruments (scenario opt_sc0) to those where R&D related expenditures (opt_sc1), education related expenditures (opt_sc2), or both (opt_sc3) are given a very low weight in the objective function (are more free to vary), and those where R&D related expenditures (opt_sc4), education related expenditures (opt_sc5), or both (opt_sc6) are more restrained (are assumed to be exogenous at their target values). These experiments show that especially fiscal policy measures enhancing R&D are recommended as primary instrument not only for boosting potential output (on the supply side), but also actual GDP and related demand side aggregates. Moreover, these expenditures can be increased by a considerable amount and have nevertheless positive effects on government budget deficits and debt when combined with a more restrictive course for other fiscal instrument variables. Thus we conclude that R&D enhancement is not only a policy that pays off in the long run but is also the best way of stabilizing the economy in the short run (over the business cycle).

The following graphs show the design and the effects of various strategies resulting from optimizing an objective function with varying weights on supply side fiscal policy variables as explained above.

Figure 54. Time paths of R&D related government expenditures (mill. EUR)

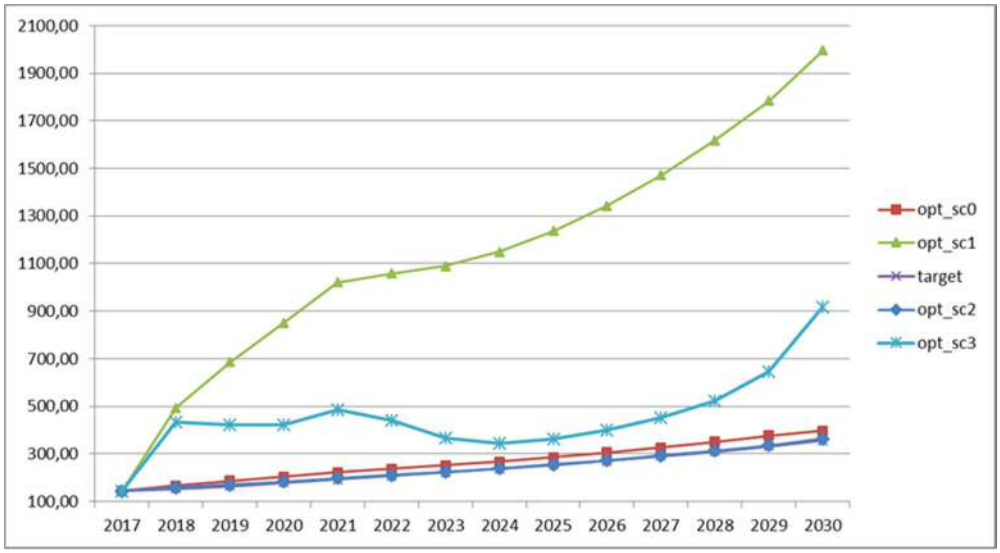


Figure 55. Time paths of a measure of education related expenditures (percentage of population with tertiary education)

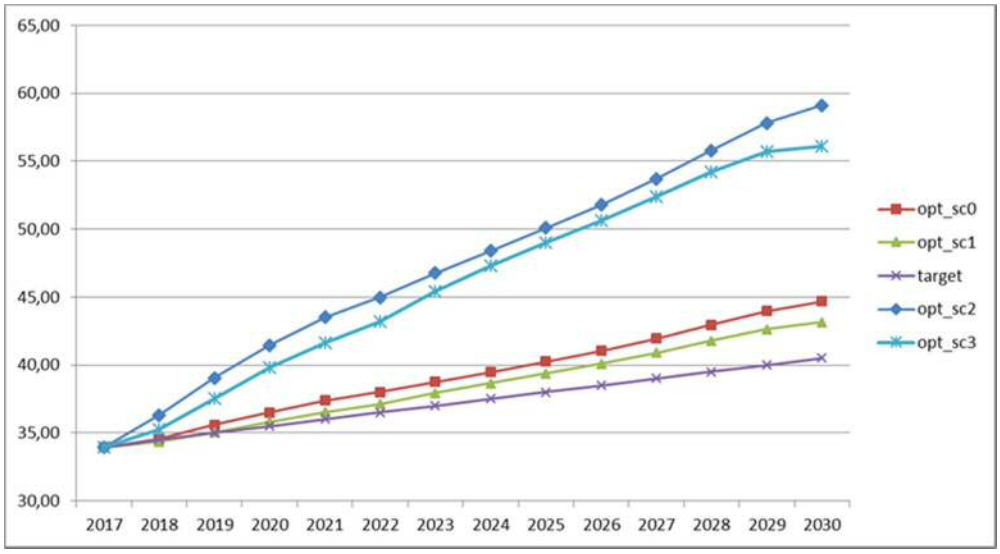


Figure 56. Time paths of growth of potential output (percent p.a.)

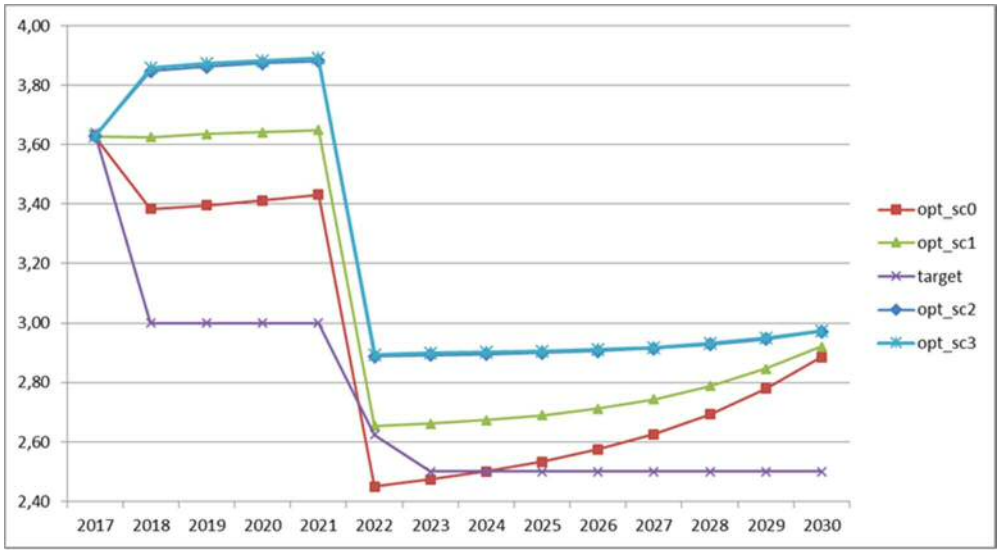


Figure 57. Time paths of real GDP growth (percent p.a.)

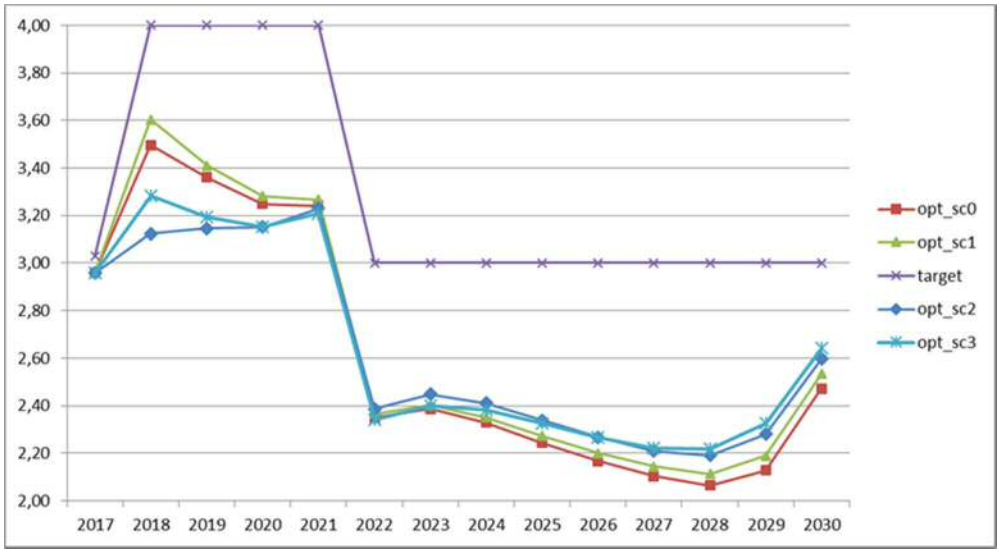


Figure 58. Time paths of government budget deficit (percent of GDP)

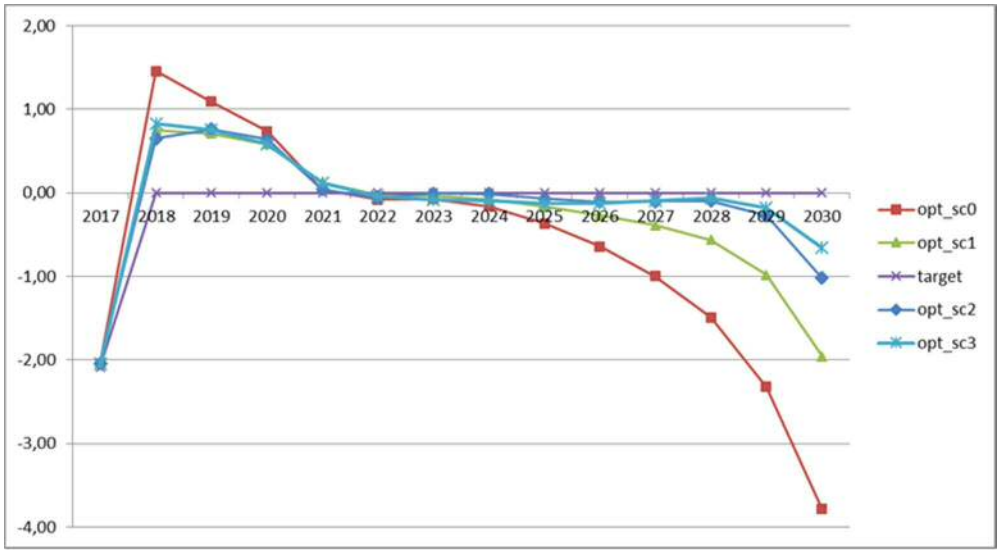
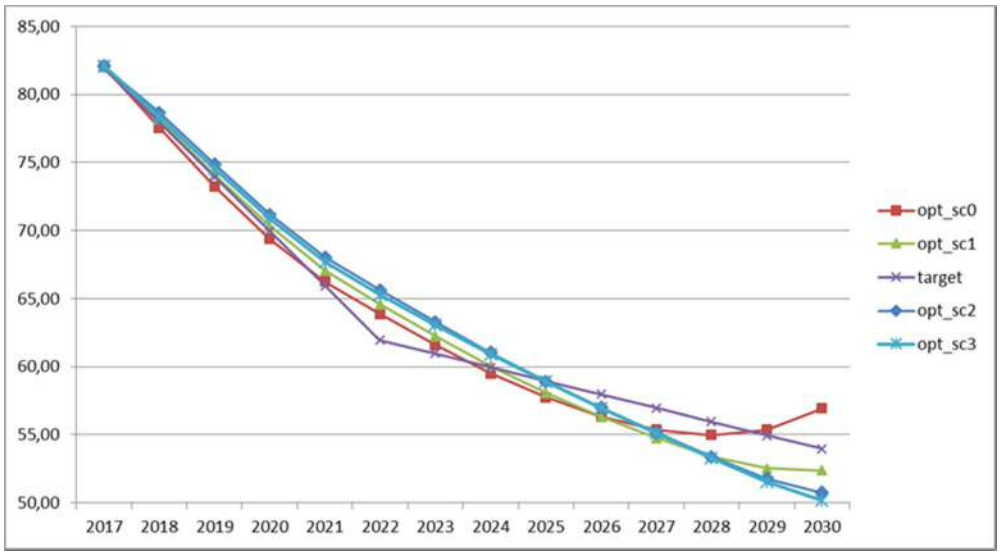


Figure 59. Time Paths of public debt (percent of GDP)



13. Concluding Remarks

In this paper, we used the macroeconometric model SLOPOL10 to calculate simulations of the development of the Slovenian economy. Starting from the present favourable prospects of the European economies, the forecast is very optimistic but it can nevertheless be improved by optimal fiscal policies as calculated using the OPTCON2 algorithm. If a negative shock to world trade of a size comparable to the Great Recession occurs, it will entail a decline in GDP and a slow recovery, as has to be expected. In this case, optimal fiscal policies should not act in an expansionary way as the effectiveness of fiscal policy with respect to output and employment is rather limited in a small open economy like Slovenia. Instead, the goal of budget consolidation will call for a more restrictive fiscal policy, at least if (as assumed) the shock is temporary. Thus typical Keynesian fiscal policy advice is not optimal even in a model with strong Keynesian features the one used here.

The main contributions of the paper are the following. We present the first simulation of different scenarios for the movements of Slovenian macroeconomic aggregates based on the information before and during the economic crisis. We present one of the rare analyses of fiscal policies simulations for a former Yugoslav country, which could be of interest to other countries that intend to become members of the European Union. In addition, our analysis provides information on macroeconomic policies in situations of a recession that counter the classical Keynesian arguments and present important information for the macroeconomics of a small open economy without autonomous monetary policy.

Our analysis opens up important questions, which could be explored in future research. On the one hand, the model could be extended in macroeconometric terms to allow for stochastic components, mixed frequency data (which would allow including additional control variables) and non-equilibrium (e.g. agent-based) approaches. In addition, the findings could be put in a macroeconomic context of other countries of comparable macroeconomic characteristics. The finding that the typical expansionary Keynesian fiscal policy advice is not optimal even in a model with strong Keynesian features should be tested and explored on other macroeconomic situations and contexts, verifying it in similar situations for other countries and other types of crisis contexts (possibly, supply-side based). Finally, the time horizon could be extended to allow for long-term projections, with the help of other forecasting modelling approaches.

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