Optimal Exchange Rate and Fiscal Policies for Slovenia on its Way into the Euro Area

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This paper analyzes the design of macroeconomic policies for Slovenia on its way into the Euro Area. We simulate different policy scenarios, distinguishing in particular between different exchange rate regimes. For this purpose, we use the model SLOPOL4, a macroeconometric model for Slovenia. We determine 'optimal' exchange rate and fiscal policies for Slovenia as solutions of optimum control problems with a quadratic objective function and the model SLOPOL4 as a constraint. Several optimization experiments are carried out under different assumptions under a fixed exchange rate, a flexible exchange rate and a crawling peg regime approximating Slovenia's entry into the Euro Area. The sensitivity of the results is examined with respect to several assumptions.

Key Words: optimal control, econometric model, macroeconomic policy, Slovenia, sensitivity analysis.
JEL *Classification:* E5, E6, C5, O5

Introduction

In this paper, we report about an application of optimum control theory to macroeconomic policy design for Slovenia. The OPTCON algorithm is applied to determine solutions for optimum control problems with a quadratic objective function and the non-linear dynamic model SLOPOL4, a macroeconometric model for Slovenia. Optimization experiments are carried out under different assumptions about the exchange rate regime. The results are politically relevant because Slovenia was the first of the Central and Eastern European (CEE) EU member states to enter the Euro Area on January 1, 2007. Indeed, it was an explicit objective of Slovenian policy-makers to introduce the euro as early as possible, and

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Slovenia participated in the exchange rate mechanism ERM-II from June 2004 onwards. This paper analyses whether the decision to participate in the ERM-II so soon after EU accession was a good strategy in terms of macroeconomic performance.

The structure of the paper is as follows: the second section describes the econometric model SLOPOL4. In the third section, we discuss different exchange rate regimes (two of them counterfactual) for the period of Slovenia's preparing to adopt the euro as legal tender. The fourth gives a brief account of the OPTCON algorithm used to derive deterministic and stochastic optimum control solutions. Details about the optimization experiments conducted are given in the fifth section, and the main results of these experiments are summarized in the sixth section. Finally, the seventh section concludes.

The SLOPOL4 Model

For our analysis, we use the SLOPOL4 model of the Slovenian economy. It was originally developed as SMEEM, a combination of a macroeconomic model and an energy system model for carrying out analyses relating to the energy sector. Based on this blueprint, a structural econometric model of the Slovenian economy was built, called SLOPOL*i* (SLOvenian economic POLicy model, version no. *i*, with *i* denoting the version $i = 1, 2, \ldots$). The choice of an econometric model to represent the Slovenian economy and the need to update it continuously are motivated by the fact that major problems typically arise when constructing models of CEE countries due to short and unreliable time series and structural breaks during the transformation period and subsequent catching-up processes.

The version used here, SLOPOL4, is a medium-sized macroeconometric model of the small open economy of Slovenia. It consists of 45 equations: 15 behavioral equations and 30 identities. The former were estimated by ordinary least squares (OLS) using quarterly data for the period 1992:1 (where available; 1994:1 otherwise) to 2001:4. Data for Slovenia were provided by the Slovenian Statistical Office, the Institute of Macroeconomic Analyses and Development (IMAD) and the Bank of Slovenia. Euro Area data were taken from the EUROSTAT database, except for the short-term interest rate in the Euro Area which was extracted from the database of the German Bundesbank.

The model includes behavioral equations for several markets (goods, labor, foreign exchange, money) and various rigidities (wages, prices).

It combines Keynesian and neoclassical elements. The former determine the short and medium run solutions in the sense that the model is demand driven and persistent disequilibria in the goods and labor markets are possible. The supply side incorporates neoclassical features. Most of the behavioral equations contain lagged dependent variables, reflecting adaptive expectations and costs of adjustment. In this section, the behavioral equations are sketched very briefly. For more details, see Neck, Weyerstrass, and Haber (2004); a more detailed description of an earlier version of the model can be found in Weyerstrass, Haber and Neck (2001).

The consumption of private households is explained by a simple Keynesian consumption function, depending on current disposable income and on lagged consumption (in accordance with the habit persistence hypothesis). Capital formation is derived from the profit maximization of firms. Real gross fixed investment is influenced by the change in total domestic demand (an accelerator hypothesis), the user cost of capital approximated by the real interest rate and by the capacity utilization rate, i. e. the ratio of actual to potential GDP. Real exports of goods and services are a function of the real exchange rate and of foreign demand for Slovenian goods and services. As the aggregate Euro Area is Slovenia's largest trading partner by far (in 2001, according to balance of payments data, the Euro Area accounted for 60 percent of Slovenian foreign trade), the rest of the world is approximated by the Euro Area. Therefore, foreign demand is measured by Euro Area real GDP, and we only consider the exchange rate between the Slovenian tolar and the euro. Slovenian real imports of goods and services depend on domestic final demand and on the real exchange rate.

Money demand depends on real GDP and the short-term interest rate. The long-term interest rate is linked to the short-term rate in a term structure equation. The exchange rate equation combines elements from the uncovered interest parity and the purchasing power parity theories. Thus, the nominal exchange rate between the Slovenian tolar and the euro depends on the interest differential and the price ratio between Slovenia and the Euro Area.

Labor demand (actual employment) is influenced by final demand for goods and services and by the real gross wage, while labor supply depends on the real net wage and on the size of the population. The wage rate is determined by the price level, by the difference between the actual unemployment rate and a proxy for the natural rate of unemployment (or the NAIRU), by labor productivity and by the average labor tax rate, which is defined as the difference between the average gross and net wages as a percentage of the gross wage (hence 'labor taxes' include income taxes and social security contributions). Consumer prices depend on domestic and international factors. The former comprise unit labor costs, the capacity utilization rate and the nominal money stock. In addition, Slovenian prices depend on the oil price and on the nominal exchange rate. For Slovenia as a small open economy, import prices are important, and they rise when the domestic currency is devalued (equaling an increase in the exchange rate).

Total government expenditures are linked to government consumption and to transfer payments to households; total government revenues are linked to labor tax revenues. The budget deficit is given by the difference between total government expenditures and revenues. Potential output, which is determined by a Cobb-Douglas production function with constant returns to scale, depends on trend employment, the capital stock, and autonomous technical progress. Trend employment is defined as the labor force minus natural unemployment. The NAIRU is approximated by a four-quarter moving average of the actual unemployment rate.

Exchange Rate Regimes

When setting up the optimization experiments, we consider three scenarios simulated over the period 2004 to 2009 according to the different exchange rate regimes assumed during the phase of transition into the European Economic and Monetary Union. The baseline scenarios were generated by simulating the model, using historical values of all exogenous variables including the control variables as inputs. Although baseline simulations were carried out over the period 2004 to 2009 for each exchange rate regime, the different exchange rate regimes were assumed to hold for 2004–2006 only, because in 2007 Europe's common currency, the euro, was introduced in Slovenia. Exchange rate regimes were set up as (1) fixed exchange rates (unilateral peg), (2) flexible exchange rates (free floating) and (3) a crawling peg with a decreasing rate of depreciation (2004: 1.5 percent; afterwards –0.5 percentage points per year). For the period 2007 to 2009, after the euro had been introduced, completely fixed exchange rates were modeled for each scenario. Table 1 summarizes these scenarios.

TABLE 1 Exchange rate regime scenarios

2004–2006	Fixed exchange rates Flexible exchange rates Crawling peg
2007–2009	EURO

For the purpose of simulating these three scenarios, historical values or (where not available) forecasts of the exogenous and the control variables over the simulation period were taken and used as inputs into the model to obtain forecast values for the endogenous variables. We used more or less plausible values for these variables; for example, we assumed a slowly decreasing short-term rate of interest, constant growth rates of Euro Area variables and Slovenian government expenditures, a constant labor tax rate, etc. This exercise can be regarded as simulating 'business as usual,' i. e. the continuation of previous trends, in particular for the policy instruments, but under different exchange rate regimes.

In order to explore the implications of the exchange rate system during the preparation period for adopting the euro, a regime of completely flexible exchange rates is compared to the crawling peg regime and to a regime of completely fixed exchange rates which may be interpreted as early introduction of the euro or as mimicry of Slovenia's membership in the ERM of the EMS-II until 2006. For the optimization runs with fixed exchange rates, the Slovenian tolar was fixed at the actual conversion rate of the tolar to the euro. In the flexible exchange rate scenario, the short-term rate of interest is available as an active monetary policy instrument for internal stabilization purposes. In the other regimes, the interest rate and hence monetary policy have to be adjusted to stabilize the exchange rate or are directly determined by European developments in financial markets and can therefore not be considered as an active policy instrument.

The simulations under the three different assumptions about the exchange rate regime result in smooth time paths for the endogenous variables, with decreasing unemployment and increasing current account surplus and government budget deficit. The behavior of money supply and the price level depends on the exchange rate regime. Government consumption and transfers grow in parallel to each other. These simulation experiments can be regarded as benchmarks for the optimization experiments to be described in the fifth section.

The OPTCON Algorithm

We want to calculate time paths of macroeconomic policy instruments that are 'optimal' according to an objective function of a hypothetical policy-maker for Slovenia. Many theoretical (e. g. Petit 1990) and empirical (e. g. Chow 1981) studies have been carried out using optimum control theory to obtain recommendations concerning monetary or exchange rate and fiscal policies for stabilization purposes. To obtain optimal economic policies for our model, we apply the OPTCON algorithm, which was developed by Matulka and Neck (1992). OPTCON determines approximate solutions of optimum control problems with a quadratic objective function and a nonlinear multivariable model.

The objective function has to be quadratic in the deviations of the state and control variables from their desired values. It has the following form:

$$L = \frac{1}{2} \sum_{t=1}^{T} \begin{bmatrix} x_t - \tilde{x}_t \\ u_t - \tilde{u}_t \end{bmatrix} W_t \begin{bmatrix} x_t - \tilde{x}_t \\ u_t - \tilde{u}_t \end{bmatrix}, \tag{1}$$

$$W_t = a^{t-1} W, \; t = 1, 2, \ldots, T, \tag{2}$$

where x_t denotes the vector of state variables, u_t denotes the vector of control variables, $\tilde{x}_t$ and $\tilde{u}_t$ are the desired values of the state and control variables, W_t is the matrix containing the weights given to the deviations of the state and control variables from their desired values respectively, and α denotes the discount factor. The dynamic system has to be given in a state space representation. OPTCON can solve both deterministic and stochastic optimum control problems.

OPTCON starts by approximating a deterministic solution of the nonlinear dynamic system. Then, the nonlinear system is optimized. This is done iteratively, starting with the previously calculated approximation, by running a backward recursion and applying Bellman's principle of optimality in order to obtain the parameters of a policy feedback rule. Afterwards, a forward projection (simulation) of the model is performed.

Optimization Experiments

In this paper, five 'main' and several 'minor' objectives are considered. The 'main' objective variables cover the most important macroeconomic challenges Slovenian policy-makers are confronted with. With respect to the Slovenian participation in the EU, catching up with incumbent EU members in terms of per-capita GDP was of great importance during the adjustment period. In addition, reducing the rate of unemployment and the rate of inflation were obvious goals over the years under consideration. These objectives ought to be reached with a balanced government budget and external equilibrium. For the optimization experiments, a desired real GDP growth rate of 4.5 percent p. a. is assumed. Optimizations are carried out for the period 2004 to 2009, but the final year is ignored to avoid terminal point effects; hence, the period of interest is 2004 to 2008. The desired rate of unemployment is assumed to be reduced by one percentage point per year from 9 percent in 2003 to 4 percent in 2008. The desired rate of inflation declines gradually from 6 percent in 2003 to 2 percent in 2008. It is assumed that the aim is to balance the government budget and the current account (both in percent of nominal GDP).

As 'minor' objective variables, real GDP and its components (consumption of households, investment, government consumption, exports and imports) are considered. For these variables, ideal values are specified consistent with the desired 4.5 percent growth rate of real GDP. The introduction of 'minor' objective variables reflects the policy-makers' aim of obtaining smooth paths for the main macroeconomic aggregates, but also serves as a substitute for introducing inequality constraints on state variables, which is not feasible in OPTCON. In addition, the policy instrument (control) variables are regarded as minor objective variables to reflect costs to the policy-makers of changing instruments, but also due to formal requirements of the OPTCON algorithm and in order to prevent erratic fluctuations.

In the weight matrix of the objective function, all off-diagonal elements are set to zero. In addition, all endogenous variables of the model which are not mentioned are given the weight zero, implying that they are not of direct relevance to policy-makers. The 'main' variables are assigned the weight 10,000, while the 'minor' objective variables are given a weight of 1, except for the control variables, which get weights of 1,000 for the short-term interest rate, 10 for the tax rate and 10 for the others. These weights reflect both the relative importance of the 'main' and 'minor' objective variables and their different orders of magnitude. The discount rate is set as 1, implying equal weights for all periods. This was set in view of the relatively short time horizon of the optimizations.

In the optimization experiments, we once again distinguish between the three exchange rate regimes as discussed in the third section. Therefore, we have one scenario with the short-term rate of interest as a policy instrument (the flexible exchange rate case) and two scenarios without this instrument of monetary policy. The standard economic policy variables are used as instruments: public consumption, transfers, the labor tax 'wedge' (i. e. the difference between the average gross and net wages as a percentage of the gross wage) and the interest rate (partly – depending on the monetary regime).

Results of the Optimization Experiments

In this section, we briefly describe some results of the optimization experiments. Table 2 displays the time paths of key macroeconomic variables under the scenarios of a flexible exchange rate (FLEX), a fixed exchange rate (FIX) and a crawling peg (CRAWL). All values of the variables shown are deviations from the corresponding simulation time paths (baseline solutions) in order to show the potential of the optimum control approach for each of the possible scenarios. Although the model is a quarterly one, the results are converted to annual data for all experiments in order to avoid showing seasonal influences, which may hide the main insights to be gained from the exercise. We first show the main results of the deterministic control problems. Here no stochastic elements are taken into consideration.

Although the development of the Slovenian economy already looks favorable in the simulation with historical values for exogenous and control variables, it can be improved still further under an optimal policy. In particular, the optimization experiments call for an investment in the inflation-unemployment trade-off: fiscal policies should first be applied in a restrictive way, reducing inflation and the budget deficit at the cost of lower growth and higher unemployment during the first few years. Afterwards, it may turn towards a more expansionary path (although still less so than in the baseline simulation), thereby gradually leading the economy to higher real growth rates, lower unemployment and slightly higher inflation, all compared to the baseline values. The reduction in the budget deficit reduces the rate of interest, especially at the beginning of the optimization period. The current account is activated, both by lower import demand due to the lower domestic inflation rate and lower aggregate demand and by higher exports, again caused by the lower price level. The Slovenian tolar appreciates in nominal terms (except in the fixed-exchange rate scenario) but depreciates (except in the first period) in real terms due to the lower inflation rate (all relative to the baseline solution).

In previous work, the sensitivity of optimum control results for Slove-

TABLE 2 Time paths of key macroeconomic variables

Scenario	2004	2005	2006	2007	2008	2009
Unemployment rate (percentage points)						
FLEX	0.093	0.113	0.103	0.093	0.082	0.072
FIX	0.088	0.108	0.080	0.058	0.043	0.031
CRAWL	0.074	0.109	0.097	0.082	0.076	0.063
Real GDP growth rate (percentage points)						
FLEX	–0.478	0.198	0.073	0.091	0.094	0.111
FIX	–0.431	–0.001	0.411	0.190	0.164	0.157
CRAWL	–0.475	0.103	0.225	0.116	0.113	0.110
Inflation rate (percentage points)						
FLEX	–0.170	–0.197	0.071	–0.010	0.026	0.039
FIX	–0.160	–0.063	0.051	0.051	0.062	0.070
CRAWL	–0.188	–0.133	0.053	0.019	0.048	0.071
Budget deficit (percentage points of GDP)						
FLEX	–0.761	–0.772	–0.664	–0.548	–0.406	–0.232
FIX	–1.663	–1.818	–1.368	–1.038	–0.622	–0.118
CRAWL	–1.516	–1.075	–0.885	–0.648	–0.667	–0.140

Continued on the next page

nia with respect to variations in the objective function, the vector of the control variables and the discount rate has been thoroughly examined. The main conclusion from these calculations was that a higher weight of the main objectives generally leads to more active optimal economic policies without much loss of stability (Weyerstrass and Neck 2002). A shorter time horizon, on the other hand, produces less expansionary policies at the beginning and more expansionary activity at the end of the optimization horizon. Reducing labor taxes improves the results, significantly so in the case of employment, as compared to a setting without this policy instrument. Flexible exchange rates are generally an advantage as they allow monetary policy to be used as an additional instrument to influence domestic policy objectives but the loss of this instrument (as actually occurred due to Slovenia's participation in the European Monetary System ERM-II and finally in the Euro Area) results in only a minor deterioration in the country's macroeconomic performance. These results also hold under the present setup. Therefore, they are not shown here in detail.

TABLE 2 *Continued from the previous page*

Scenario	2004	2005	2006	2007	2008	2009
Current account (percentage points of GDP)						
FLEX	–0.058	0.196	0.150	0.125	0.076	0.014
FIX	0.273	0.354	0.185	0.028	–0.125	–0.281
CRAWL	0.104	0.313	0.158	0.079	–0.025	–0.124
Nominal exchange rate (percent)						
FLEX	–0.40	–0.13	–0.18	–0.17	–0.16	–0.14
CRAWL	–0.17	–0.06	–0.09	–0.10	–0.07	–0.07
Real exchange rate (percent)						
FLEX	–0.24	0.22	0.10	0.13	0.11	0.09
FIX	0.15	0.21	0.16	0.11	0.05	–0.02
CRAWL	–0.05	0.27	0.15	0.16	0.06	0.04
Real long–term interest rate (percentage points)						
FLEX	0.059	0.012	–0.249	–0.165	–0.177	–0.145
FIX	–0.768	–1.263	–1.082	–0.758	–0.376	0.061
CRAWL	–0.317	–0.614	–0.703	–0.414	–0.245	–0.048

It should be mentioned, however, that our result of only minor negative macroeconomic effects (if at all) of the loss of monetary sovereignty due to Slovenia's membership in the Euro Area was corroborated by a study using ex post data and applying a slightly different methodology. If the impact of Euro Area integration on the supply side of the Slovenian economy is taken into account more explicitly, we even obtain gains in terms of macroeconomic performance (Weyerstrass and Neck 2008). Similar results are obtained from simulations of econometric models for Serbia and Bosnia and Herzegovina and from simulation and optimization experiments with a global macroeconometric model (see Neck 2011 for an overview). Hence, we expect that entering the Euro Area will benefit other EU member states, too, provided the Eurozone preserves its stability under the conditions of the recent crisis.

With OPTCON, it is possible to deal with stochastic parameters (in addition to additive stochastic error terms in the model equations, which are of less interest) when calculating optimal policies. To study the sensitivity of the optimal policies with respect to the stochastics of the model, we proceed as follows. We introduce stochastic terms either (a) for all parameters in the model ('symmetric case'), or (b) for only some of the parameters, where the selection of the parameters assumed to be stochastic is random ('asymmetric cases'). To explore how an 'increase' in the amount of uncertainty affects the results of the optimization experiments, we start from the solutions of the deterministic optimization experiments and gradually introduce a rising number of stochastic parameters until the 'symmetric case' is reached. To carry out this task, a fairly large number of stochastic optimization experiments were performed (for more details, see Neck, Haber and Weyerstrass 2010). It turns out that in the symmetric case, the maximum deviation of the values of the calculated variables from their deterministic counterparts is much smaller than if only a small number of stochastic terms are introduced. Increasing the number of stochastic terms (switching to a 'more symmetric' setup) thus reduces these deviations and drives the stochastic optimum control solution towards the corresponding deterministic one. This result is similar to the ones obtained by systematically varying the stochastic nature of the parameters of another model (Neck and Karbuz 2000). It may be interpreted to mean that the results of stochastic optimizations can be misleading if they only take a very restricted amount of uncertainty into account, assuming that the deterministic optimal solution comes close to the 'true' optimum. Whether the latter assumption is true, however, has to be examined by further studies.

Conclusions

In this paper, we have shown how optimum control theory can be used to obtain insights into the design of economic policy decisions for a country on its way into the Euro Area. We used the OPTCON algorithm and SLOPOL4, a medium-sized structural macroeconometric model of the Slovenian economy. Assuming that over the optimization horizon of 2004 to 2009, Slovenian policy-makers aimed at high GDP growth rates, low rates of inflation and unemployment, balanced budgets and balanced current accounts, we investigated the effects of different assumptions about the exchange rate regime and other elements of the optimization context on optimal policies and on the objective variables. It turned out that the differences between the exchange rate regimes are relatively small and the loss of the monetary policy instrument resulting from adopting a fixed exchange rate regime can be compensated for by adjusting the fiscal policy instruments, which can secure high GDP growth, decreasing unemployment and low inflation without endangering the aim of an almost balanced budget. Next, a sensitivity analysis was conducted with respect to some basic elements of the objective function and to the stochastic nature of the parameters. With respect to variations in the objective function, deterministic optimizations turned out to be quite robust. On the other hand, the results may be significantly altered by introducing (asymmetric) uncertainty, while increasing the number of stochastic parameters in the model generally leads to lower deviations of the stochastic results from the deterministic case.

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