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Forecasting Stability and Growth Pact Compliance Using Machine Learning*

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The various reforms of the Stability and Growth Pact (1996) strengthened the European Commission's monitoring of EU member states' public finance. Failure to comply with the 3% public deficit limit triggers an audit. In this paper, we present a machine learning - based forecasting model for compliance with the 3% limit. We use data from 2006 to 2018 (a turbulent period including the Global Financial Crisis and the Sovereign Debt Crisis) for the 28 EU member states. After identifying 8 features as predictors among 138 variables, forecasting is performed using a support vector machine (SVM) algorithm. The proposed model achieves a forecasting accuracy of nearly 92 % and outperforms the logit model used as a benchmark.

For almost 25 years, enhancing fiscal discipline in the eurozone has been a bone of contention between European authorities and EU member states. European supranational fiscal discipline in the form of the Stability and Growth Pact (1996)[1] -SGP hereafter has been reformed several times and remains under debate. Since its inception, this set of fiscal rules aims two complementary objectives: "stability" of public finance promoting sound management of public finance on the one hand, and "economic growth" in the EMU, to ensure that national governments have the leeway to intervene when necessary (especially if a cyclical shock occurs), on the other hand. To achieve these two objectives, the SGP includes two instruments: a "dissuasive" arm intended to ensure strict compliance with the rules[2] and a "preventive" arm designed to encourage member states to maintain balanced and sound public finances in the medium term.[3] The eurozone has

[1] The Stability and Growth Pact (1996) succeeded the public finance criteria (public debt below 60% of GDP and public deficit below 3% of GDP) introduced by the Maastricht Treaty (1992) as one of the eligibility conditions for the European monetary union.

[2] The dissuasive arm consists in a public deficit ceiling with, barring exceptional economic circumstances, sanctions imposed in the case of non-compliance.

[3] The preventive arm consists of a multilateral surveillance procedure with "stability programs", multiannual programs

nevertheless experienced several periods of turbulence[4] that have fundamentally challenged fiscal discipline. In each case, the SGP was deemed imperfect and was reformed.

The purpose of this paper is to fill a gap in the fiscal rule compliance literature by using the groundwork on compliance to strengthen the preventive arm of the SGP in the euro area. In other words, strengthening the preventive arm may reduce the number of cases of excessive deficit. In this paper, we propose a model to forecast compliance with the 3% limit on public deficit. The model is built using machine learning, a method rarely used in macroeconomics, but which often outperforms traditional econometric approaches, especially in terms of forecasting accuracy (see Ince and Trafalis [2006], Plakandaras et al. [2013]).

Using machine learning

Machine learning methodologies for classification and forecasting are increasingly used in economics (see Gogas et al. [2015] or Gogas et al. [2018] for instance). Our study extends the application of machine learning to public policy issues. Machine learning models have a high forecasting power and should be considered in fiscal policy outcome forecasting and risk prevention. In our case, the machine learning models outperformed the standard econometric benchmark in all but one case. Our study may pave the way for a wider use of this type of model in macroeconomics.

Paper contribution

This paper makes several original contributions. First, it focuses on compliance with the European supranational fiscal rules of the SGP using machine learning. Macroeconomic studies involving machine learning methods are still rare in the literature but are becoming increasingly popular (see e.g. Medeiros et al. [2021], Yoon [2021], Gogas et al. [2022]). The use of machine learning to study SGP compliance is original. Second, the proposed method can handle the size limitation of datasets often encountered in macroeconomics studies. While early machine learning algorithms required large datasets that are typically unavailable in economics (with the exception of finance), many newer machine learning architectures (such as support vector machines (SVM), Random Forests, and various boosting-based methods) have more accessible data requirements and offer an interesting avenue in economic forecasting. Third, this study provides a geometric representation of the input set with a separation line as a valuable by-product. The model not only accurately forecasts compliance with the 3% limit, but also measures its distance from the separation line. This distance can be used to a) estimate the confidence of the forecast (the farther from the line, the greater the confidence in the classification is), and b) to outline the recommendations and policies most likely to change a country's forecasted negative outcome. This analysis focuses on the 28 EU member states from 2006 to 2018 and offers a new perspective in the debate on the relative weights of the dissuasive vs preventive arm of the SGP.

Stability and Growth Pact compliance in the European Union : stylized facts

There have been many studies of fiscal rule compliance. Some assess the level of compliance with fiscal rules based on fiscal rule databases maintained by the EU Commission or the IMF. These databases provide information on the fiscal rule and its coverage, its legal basis, monitoring bodies, correction mechanisms in cases of deviation, and records of compliance with the rule.

Composite indicators have been defined based on these data to assess the potential coercive power of fiscal rules (see for instance, the

setting fiscal guidelines over 3 years and providing visibility on public finances for the following 3 years, with the objective of achieving a balanced budget in the medium term.

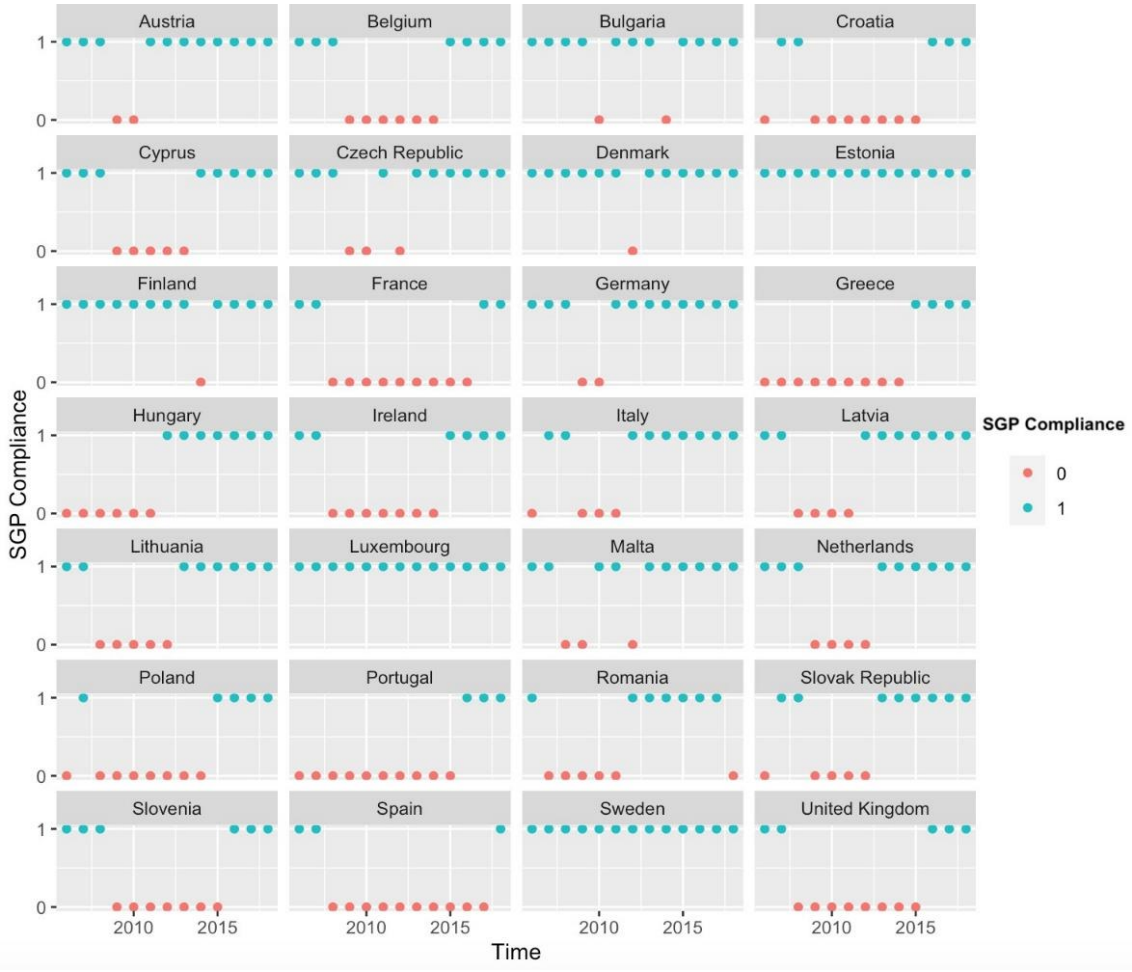
[4] A first crisis in 2004, the Great Recession from 2007 to 2009 with the subprime mortgage crisis followed by the Sovereign Debt Crisis, then the Covid-19 pandemic and the energy crisis since 2022.

European Commission's or the IMF's Fiscal Rule Index (FRI)[5]). However, to assess the effective coercive power of a fiscal rule, the level of relevant fiscal aggregates needs to be compared with the limits set by the rule. Reuter [2015] and Larch and Santacroce [2020] found that numerical fiscal rules are complied with in 50% of cases. In the same vein, Delgado-Téllez et al. [2017] have analyzed compliance at the subnational level in Spain and Cordes et al. [2015] have investigated compliance with public expenditure rules in advanced and emerging countries.

Figure 1 plots the SGP compliance of the 28 European countries between 2006 and 2018. It highlights substantial differences in government behavior toward the SGP. As pointed out by the European Commission, the European fiscal framework and the SGP have become extremely complex for member countries to implement. Indeed, in addition to the target public finance indicators, many macroeconomic variables are monitored on which governments cannot intervene directly. Concurrently, since the early 1990s, the number of national fiscal rules self-imposed by EU member states has increased substantially, adding an extra layer of rules to be respected.

Figure 1: Overview of SGP compliance for the 28 EU countries between 2006 and 2018

("0" means non-compliance and "1" means compliance)



[5] The European Commission's FRI is based on five parameters: 1) legal basis, 2) binding character, 3) compliance monitoring bodies, 4) correction mechanisms, and 5) resilience to shocks.

The persistent non-compliance with the SGP, despite its reforms, suggests that the way in which public finances are monitored should be changed. A simple solution to improve the monitoring process would be to strengthen the preventive arm of the SGP, focusing on the forecasting and surveillance process. In our analysis we therefore consider i) that a simpler rule would be easier for Member States to comply with, ii) that the focus should be on the preventive arm, and iii) that the key drivers of non-compliance should be identified. The proposed forecasting procedure involves two steps : i) identifying the key determinants of compliance using a feature selection procedure, ii) training a machine learning model to forecast compliance.

Identification of the key determinants of SGP compliance using a feature selection procedure

The feature selection step revealed the 8 key variables (out of 138 variables considered) that governments and institutions in charge of fiscal surveillance should monitor because they appear to be crucial for forecasting SGP compliance, i.e. the general government fiscal balance in the preceding year, the fiscal space, the output gap, oil prices, bond yields, financial liabilities of the corporate sector, and crisis dummies.

Forecasting SGP compliance

The optimal model identified (the linear SVM model with hold-out cross-validation method) can be used to forecast SGP (non-)compliance with better than 98% accuracy as underlined in the following table 1. By including the key determinants of SGP compliance in the model, predicted deviations from the rule can be prevented. Moreover, the distance of each country from the model's decision boundary can be used to adjust recommendations toward the SGP compliance.

Table 1: "Compliance with 3% limit" forecasting accuracy with only Best Predictors (%)

Model	Features selected by LASSO	Features selected by LASSO
Linear SVM model	90.4	98.1
Quadratic SVM model	84.6	87.0
RBF SVM model (γ = 12)	86.5	88.9
Logistic model	78.5	76.3
Cross-validation method	k-fold	hold-out

Note: Hold-out splits the dataset into a 'training set' (85%) and a 'test set' (15%). The results are from the 'test set'. For k-fold cross-validation the process was repeated 5 times; the values shown are the mean results. Parameter C in the SVM algorithm is equal to 21 and was obtained using a power of 2 grid search.

Policy implications

This paper offers a new perspective in the debate on the dissuasive vs the preventive arm of the fiscal rule in the European Union, the Stability and Growth Pact : we propose a simpler but more powerful preventive arm to minimize the number of cases in which the dissuasive arm is required. Indeed, the proposed method can be used to tailor recommendations from the central authority to non-compliant countries. Instead of sanctions, the central authority could preemptively propose a set of well-targeted interventions, one year in advance, to move a country from the non-compliant to the compliant subspace of the model.

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