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Tiago Alves | João Amador
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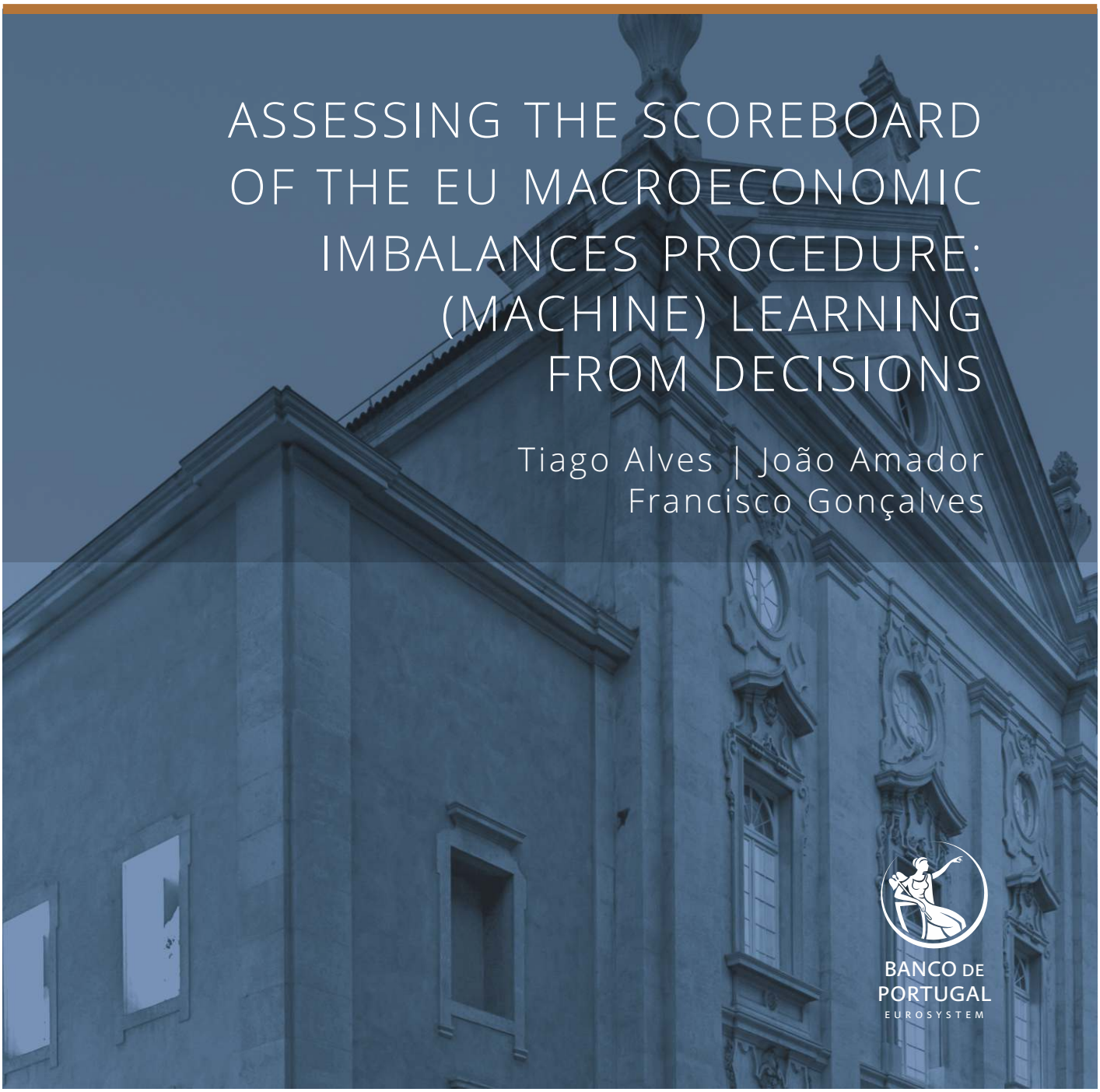

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Lisboa, 2020 • www.bportugal.pt

Working Papers | Lisboa 2020 • **Banco de Portugal** Av. Almirante Reis, 71 | 1150-012 Lisboa • www.bportugal.pt •
Edition Economics and Research Department • **ISBN (online)** 978-989-678-747-9 • **ISSN (online)** 2182-0422

Assessing the Scoreboard of the EU Macroeconomic Imbalances Procedure: (Machine) Learning from Decisions

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October 2020

Abstract
This paper uses machine learning methods to identify the macroeconomic variables that are most relevant for the classification of countries along the categories of the EU Macroeconomic Imbalances Procedure (MIP). The random forest algorithm considers the 14 headline indicators of the MIP scoreboard and the set of past decisions taken by the European Commission when classifying countries along the macroeconomic imbalances categories. The algorithm identifies the current account balance, the net international investment position and the unemployment rate as key variables, mostly to classify countries that need corrective action, notably through economic adjustment programmes.

JEL: F15, C40

Keywords: European Union; Economic integration; Machine learning; Random forests.

Acknowledgements: The opinions expressed in this article are those of the authors and do not necessarily coincide with those of Banco de Portugal or the Eurosystem. The authors thank António R. dos Santos for useful comments and suggestions. Any remaining errors and omissions are the sole responsibility of the authors. Address: Banco de Portugal, Economics and Research Department, R. Francisco Ribeiro 2, 1150-165 Lisboa - Portugal.

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1. Introduction

The euro area sovereign debt crisis of 2010-2011 demonstrated the need for stronger economic governance and enhanced policy coordination between EU member states in order to avoid the accumulation of serious imbalances, with an impact on the overall macroeconomic stability. Until the sovereign debt crisis, different economic policy coordination procedures were implemented without articulation. Afterwards, member states were asked to synchronize their timetables and existing processes were streamlined in order to align national fiscal, growth and employment policies. This materialized into the designated "European Semester". In this context, the supervision and coordination of macroeconomic policies was expanded to include external imbalances, as well as labour market and credit developments. The designated "Macroeconomic Imbalances Procedure" (MIP) operationalized this inherently complex process. Overall, the main goal of the European Commission is to classify countries in terms of the seriousness of macroeconomic imbalances, using a set of common macroeconomic variables.

Random forest algorithms are one of the most powerful machine learning methods and are suited for exercises of classification of observations into categories. They also allow for the identification of the most important variables to classify the observations along the different MIP categories. The classification of the Commission regarding the seriousness of macroeconomic imbalances in each country in a specific year cannot be confirmed or dismissed by any objective economic criterion because the real situation of countries is not directly observable. Therefore, the methodology only takes into account the underlying decision process of the European Commission, which is necessarily complex and includes non-economic information. This said, our research question is to know if there are key macroeconomic variables in the underlying decision process or if all variables in the scoreboard have been equally important.

2. The Macroeconomic Imbalances Procedure

The MIP is part of the annual European multilateral surveillance cycle and aims at identifying, preventing and eliminating excessive macroeconomic imbalances that are likely to affect economic stability in an individual member state, the euro area or the EU as a whole. The legal framework is based on regulations 1176 and 1174 of 2011, which are legislative pieces of the so-called "six-pack".

The MIP is based on a scoreboard with 14 macroeconomic indicators (plus 25 auxiliary indicators) where the situation in each country is compared with pre-established thresholds. The assessment leads the Commission to classify countries in a four-tiered scale starting in the category "no imbalances" and ending with "excessive imbalances with corrective action".

3. The Random Forest

This section briefly describes the methodological options taken to construct the random forest. Firstly, only the 14 headline indicators of the MIP scoreboard are used. Secondly, we label the decisions regarding imbalances in four categories: 1- no imbalances (where we include the status of "no in-depth review"), 2- macroeconomic imbalances, 3- strong macroeconomic imbalances, 4- excessive imbalances with corrective action - program country.

We use data regarding the scoreboard indicators and Commission's decisions since the beginning of the procedure. The final dataset comprises 220 observations ranging the period 2011 to 2018, comprising 101, 73, 28, and 18 records in categories 1, 2, 3, and 4, respectively.

The methodological procedure requires splitting the dataset into training and validation sets. The latter block represents 20 per cent of the observations available. As suggested in Pedregosa *et al.* (2011), a stratified split is used, thus the training set maintains the original percentage share of observations in each category. In the preparation of the hyperparameter tuning, we create 100 stratified randomized folds by sampling from the training set. Moreover, the train and test portions of each fold represent 75 and 25 per cent of the observations, respectively, with the latter portion being used to test different combinations of hyperparameters. Finally, to minimize the effect of imbalanced classification dataset, we perform over-sampling with the adaptive synthetic sampling technique (ADASYN), as suggested in He *et al.* (2008) and Lemaître *et al.* (2017).

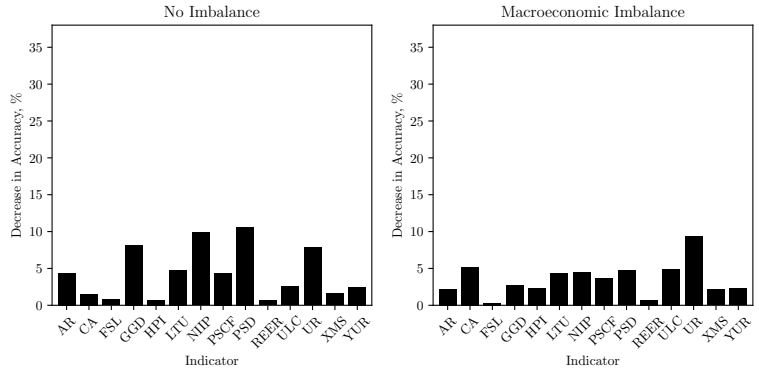
The random forest is a complex object whose interpretation is simple yet too cumbersome to perform realistically. It can be used to solve regression and classification problems where the dependent variable is categorical, as in our case. Since our goal is the identification of the variables that emerge as most important in the classification process, the model is used as a feature selection tool using its variable importance feature. We use the R package *randomForest* (Liaw and Wiener (2002)). In order to maximize the accuracy of the model, several values for hyperparameters were tested, notably the number of trees to grow, the number of variables to randomly sample as candidates at each split, the minimum size of terminal nodes, whether sampling takes place with or without replacement, as well as the size of the sample to draw. We decided on the combination of hyperparameters by selecting the one that produces the highest average balanced accuracy across the 100 cross-validation folds. Balanced accuracy, which measures the average accuracy calculated on a per-category basis, suits our imbalanced multi-category problem. The balanced accuracy of our random forest is 82.5 per cent while the standard accuracy is 88.9 per cent.

4. Results

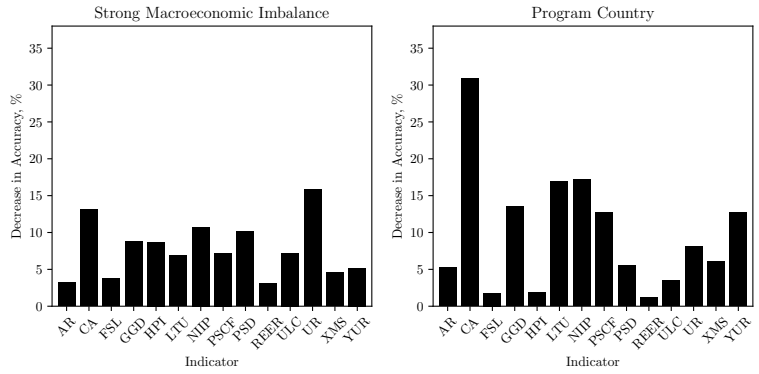
The random forest algorithm takes the 14 headline indicators in the scoreboard to classify countries. Some of these indicators possess stronger information content and are thus used more often in the underlying Commission's decision process. In addition, as it would be expected, the importance of the indicators differs for each macroeconomic imbalance category. The four panels of figure 1 present the percentage decrease in accuracy from removing each scoreboard indicator in each imbalance category.

As for the "no-imbalance" category (panel a) the most important variables are the net international investment position as a percentage of GDP and the private sector debt (consolidated) as a percentage of GDP with decreases in accuracy close to 10 per cent. The variable whose removal would imply a larger loss of accuracy in the "macroeconomic imbalance" category is the 3-year backward moving average of the unemployment rate (9.4 per cent). At a large distance, the second variable in this category is the the 3-year backward moving average of the current account as a percentage of GDP (5.2 per cent). The relevance of the scoreboard variables increases in the final two categories. In the "strong macro imbalance case" the current account and the unemployment rate are again the most important indicators with decreases in accuracy of 15.9 and 13.1 per cent, respectively. In this category the net international investment position comes third with a value of 10.7 per cent. Finally, in what regards the category "excessive imbalances with corrective action - program country" the current account balance, the net international investment position and the unemployment rate clearly stand out as key indicators, with percentages of 50.7, 42.3 and 41.2 per cent, respectively.

Figure 2 presents the mean decrease in accuracy for each indicator across the four macroeconomic imbalances categories, i.e., it averages the results presented in the four panels of figure 1. This picture highlights the relevance of the external imbalances, measured in terms of flows (current account) and stocks (net international investment position), and the cyclical position of the economy (proxied by the unemployment rate) as flags for the seriousness of macroeconomic imbalances. On the other extreme, the 3-year percentage change in the real effective exchange rate and the year-on-year changes in total financial sector liabilities seem to convey somewhat less important information for the classification of countries in terms of macroeconomic imbalances.



(a) No imbalance (b) Macro imbalance



(c) Strong macro imbalance (d) Program country

Figure 1: Relevance of scoreboard indicators

Note: CA: 3-year backward moving average of the current account balance in % of GDP; NIIP: Net international investment position in % of GDP; LTU: 3-year change in p.p. of the long-term unemployment rate; UR: 3-year backward moving average of unemployment rate; PSD: Private sector debt (consolidated) in % of GDP; XMS: 5-year percentage change of export market shares; HPI: year-on-year changes in house price index; ULC: 3-year percentage change in nominal unit labour cost; REER: 3-year percentage change of the real effective exchange rates based on HICP/CPI deflators, relative to 41 other industrial countries; PSCF Private sector credit flow in % of GDP; GGD: General government sector debt in % of GDP; FSL: Year-on-year changes in total financial sector liabilities; AR:3-year change in p.p. of the activity rate; YUR: 3-year change in p.p. of the youth unemployment rate.

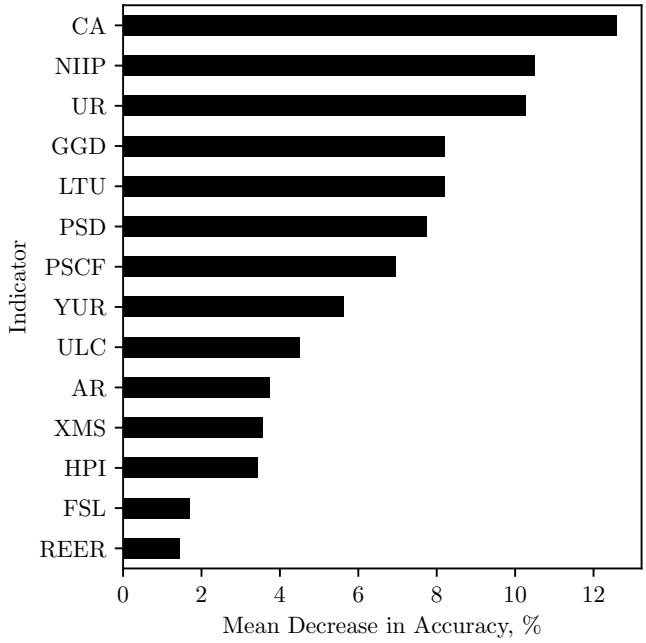


Figure 2: Mean relevance of scoreboard indicators

Note: CA: 3-year backward moving average of the current account balance in % of GDP; NIIP: Net international investment position in % of GDP; LTU: 3-year change in p.p. of the long-term unemployment rate; UR: 3-year backward moving average of unemployment rate; PSD: Private sector debt (consolidated) in % of GDP; XMS: 5-year percentage change of export market shares; HPI: year-on-year changes in house price index; ULC: 3-year percentage change in nominal unit labour cost; REER: 3-year percentage change of the real effective exchange rates based on HICP/CPI deflators, relative to 41 other industrial countries; PSCF Private sector credit flow in % of GDP; GGD: General government sector debt in % of GDP; FSL: Year-on-year changes in total financial sector liabilities; AR:3-year change in p.p. of the activity rate; YUR: 3-year change in p.p. of the youth unemployment rate.

5. Concluding remarks

We conclude that the three most important indicators in the MIP scoreboard are the current account deficit, the net international investment position, and the unemployment rate, mostly in what concerns the category related with the most serious imbalances. This result confirms the widely accepted notion that external imbalances are the ultimate indicators of economic fragility, combined with the cyclical position of the economy, as proxied by the unemployment rate.

Findings can inform policy-makers regarding the process of improving the EU MIP scoreboard and the paper also stands as an illustration of the utilization of increasingly common machine learning methods to economic problems. Although the EU surveillance procedures have been adjusted to accommodate the challenges posed by the current pandemic crisis, in the future they will be at least as important as they were in the past.

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Appendix: Scoreboard indicators

The headline indicators and indicative thresholds, covering the major sources of macroeconomic imbalances, are:

- 3-year backward moving average of the current account balance as a percentage of GDP, with thresholds of +6% and -4%
- Net international investment position as percent of GDP, with a threshold of -35%
- 5-year percentage change of export market shares measured in values, with a threshold of -6%
- 3-year percentage change in nominal unit labour cost, with thresholds of +9% for euro area countries and +12% for non-euro area countries
- 3-year percentage change of the real effective exchange rates based on HICP/CPI deflators, relative to 41 other industrial countries, with thresholds of -/+5% for euro area countries and -/+11% for non-euro area countries
- Private sector debt (consolidated) as a percentage of GDP, with a threshold of 133%
- Private sector credit flow as a percentage of GDP with a threshold of 14%
- Year-on-year changes in house prices relative to a Eurostat consumption deflator, with a threshold of 6%
- General government sector debt as a percentage of GDP, with a threshold of 60%
- 3-year backward moving average of unemployment rate, with a threshold of 10%
- Year-on-year changes in total financial sector liabilities, with a threshold of 16.5%
- 3-year change in percentage points of the activity rate, with a threshold of -0.2%
- 3-year change in percentage points of the long-term unemployment rate, with a threshold of +0.5%
- 3-year change in percentage points of the youth unemployment rate, with a threshold of +2%

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