Suptech BDA feedback, Bank of Spain.

Below are the activities and feedback obtained from the suptech workshops with the Bank of Spain.

It is important to remark that the original supervisor contacted by Spain was the Comisión Nacional del Mercado de Valores (CNMV), that is the Spanish market supervisor. However, due to agenda reasons they turned down the offer to take part in the Suptech workshops. By the end of march, Bank of Spain and National Treasure were contacted, and they were interested in participating in the project and in the Suptech Workshops.

Bank of Spain was going to host the workshop as it has more people interested in them.

I. Activity log

Bank of Spain decided to split the use cases in two different seminars, because they understood that different people from the Bank would be interested in the two sets of use cases. As a result, herein we present the feedback from the regulators.

A. Suptech I. Seminar I

Cases:

Use case I: Network based scoring models to improve credit risk management in P2P lending (Giudici, Hadji-Misheva and Spelta, UNIPV and ZHAW, 2019)

Use case II: Factorial network models to improve P2P credit risk management (Ahelegbey, Giudici and Hadji-Misheva, UNIPV and ZHAW, 2019)

Use Case IV: Loan screening and default prediction with machine learning and deep neural networks (Aste and Turiel, UCL, 2019)

Department of the Bank of Spain in charge: Financial innovation.

Use cases sent to the regulator: April 3, 2019

Feedback reception: April 22, 2019

Seminar: June 10, 2019

Number of participants: 25

B. Suptech II. Seminar II

Cases:

Use case I_III: Spatial regression models to improve P2P credit risk management (Agosto, Giudici and Leach, UNIPV, 2019)

Use case II_V: Measuring bank contagion in Europe using binary spatial regression models (Calabrese, Elkink and Giudici, BSUE, UCD, UNIPV, 2017)

Involved Areas: Financial Stability

Use cases sent to the regulator: May 13, 2019

Feedback reception: May 31, 2019

Seminar: June 26, 2019

Number of participants: 6

II. Feedback Supetch I

The discussion focused on the following aspects:

- interpretability,
- data bias,
- sensitivity to the hyperparameters,
- data treatment,
- dynamic calibration.

It is considered that interpretability is one of the most relevant aspects to be considered in a model. Interpretable models build-up trust. Interpretability is key to ensure transparency and accountability for regulators. Machine learning models need to be explained and the effect of variables better understood. If they perform slightly better, but they are opaque they won't be considered. Theoretical support is required, that is, each variable needs to be explained economically or financially, as it was the case of the connectivity and community variables in the use cases.

For example, connectivity variables were useful to predict default risk, however, there is no clarity about how it would function for the acquisition of obligations of new companies not included in the construction of the models.

At the same time, we discussed about regularization processes, which aim to generate a trade off between bias and variance on model prediction and a simpler model. Focusing on regularization neglects parameter estimation and consequently the model loses interpretative power.

Derived from the interest of the Bank of Spain in interpretability, we explained the different alternatives of explainability in machine learning models: such as partial-dependency graphs, permutation feature importance, shappley additive explanation, Local Interpretable Model Agnostic Explanations, researches on regularizing Black-box models for Improved Interpretability, among others. We identify a research opportunity on explainability, propose them to work on it and contact them later to explain the results.

In the subject of bias in the data, the regulators considered vital to know the details about the measurement and construction of the indicators in the models, together with their validation in the case of companies.

These proposals require a thoroughly characterization of the sample and evidence of its representativeness of the population under study. This characterization, reduces the possibility of introducing sampling and algorithmic biases.

The regulators were also concerned about the hyperparameters used in the machine learning models and how they affect the performance of the model. It is discussed that finding a "good" set

of hyperparameters using cross validation (for example, nested cross validation) and meta-heuristic optimization is important. Differences in terms of performance using "good" sets are often negligible.

In the aspect of data processing, it is highlighted the importance of having a consistent position regarding the treatment of outliers, data imputation and missing data. We comment that some machine learning methods are robust when dealing with outliers, such as decision trees or SVM when increasing margin width.

The incorporation of the temporal dynamics of the analysis event and the variables used is also demanded, as is the incorporation of forward looking elements.

Finally, it is considered important to build models and evaluation tools through interdisciplinary teams (alliances and strategic synergies) between different actors such as Banks, Fintech, regulatory bodies, researchers (research centers and universities), information sources administrators. This,ensures the consistency, implementation, vigilance and transparency of these modeling proposals.

III. Feedback Suptech II

For this session the feedback from the regulator focused on:

- the stability of the network structure,
- the endogeneity of the variables used, and
- the need to include a temporal dynamics to the model

About the first topic, the network had to be derived in both use cases, since it does not seem feasible to have access to the exposures between individual banks or exchange between companies. Its construction has used certain assumptions that assume a homogeneous (proportionality) network. Therefore, they suggest evaluating how robust the conclusions can be in the face of changes in the network structure and construction. They also mention than in the use case of banks they would be able to create the network with exposure data and are interested in the models for testing them with their data.

An aspect that they consider relevant for this type of models is sensitivity analysis, being able to simulate shocks on the included variables and identifying the most affected companies or banks, which allows them to foresee measures in that case of relevant consequences.

Regarding the second topic, they consider that the macroeconomic variables also have a component of endogeneity that has not been contemplated in the model. The global (i.e. international) dimension of the banks is highlighted, so that their variables must go beyond the country dimension in its relation with macroeconomic components, for example, in a very simple way, obtain the average GDP of the countries in which they have banking obligations.

They consider extremely important for the models to be explainable from theoretical point and with parameter values reasonable. To illustrate this argument, they say that they tests a vast battery of models, they discard all those in which the signs of the variables do not make sense.

Finally, it is suggested the inclusion of temporal information (temporal lags), together with spatial information. In other words, combining models with these two components. They also propose to

incorporate forward looking elements. Furthermore, they suggest the use of a sequential approach, trying to anticipate which bank could have problems and what would be the effect of that bank in the network, in other words, they carry out a simulation.

As an alternative proposal, they suggest investigating relationships between banks derived from companies they share through credit obligations, and how these relationships are associated with the risk of bankruptcy. In other words, they suggest studying interbank "second-order" relationships. Study the interconnections of banks with other financial actors.

It is important to mention also that three types of public have been identified:

- Regulators that seek to understand more about the product, how it works, how accountable it is, and how to put it in production.
- Statistical and computer scientists who are concerned about the methodology, the classification performance and perhaps some inference
- Econometricians who are very concerned about the methodology, the theoretical and contextual support, interpretability, among others.