**PhD in Information Technology and Electrical Engineering**
**Università degli Studi di Napoli Federico II**

# PhD Student: Vincenzo Lanzetta

**Cycle: XXXVII**

## Training and Research Activities Report

**Academic year: 2022-23 - PhD Year: Second**

Vincenzo Lanzetta

**Tutor: prof. Roberto Prevete**

Roberto Prevete

**Co-Tutor:**

**Date: October 23, 2023**

# Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

**Cycle:** **Author:**

## 1. Information:

- **PhD student: Vincenzo Lanzetta**
- **DR number:**
- **Date of birth: 25/08/74**
- **Master Science degree: Chemistry University: Federico II of Naples**
- **Doctoral Cycle: XXXVII**
- **Scholarship type: *no scholarship***
- **Tutor: Prof. Roberto Prevete**
- **Co-tutor:**

## 2. Study and training activities:

| Activity | Type[1] | Hours | Credits | Dates | Organizer | Certificate[2] |
|---|---|---|---|---|---|---|
| Using deep learning properly | Course | 10 | 4 | January 2023 | Andrea Apicella | Y |
| English B2 | Course | 40 | 6 | From march 2023 to June 2023 | CLA (Unina) | Y |
| Quantum Complexity | Seminar | 1,5 | 0,3 | November 10, 2022 | G. Ascione, F. Bajardi, and S. Mancini | Y |
| Complex network systems: introduction and open challenges | Seminar | 1,5 | 0,3 | November 17, 2022 | G. Ascione, F. Bajardi, and S. Mancini | Y |
| GINGER, Gyroscopes IN GEneral Relativity | Seminar | 1,5 | 0,3 | December 1, 2022 | G. Ascione, F. Bajardi, and S. Mancini | Y |
| Entangled relativity | Seminar | 1,5 | 0,3 | December 15, 2022 | G. Ascione, F. Bajardi, and S. Mancini | Y |
| Industry 4.0 Fundamentals in Bosch Applications | Seminar | 10 | 2 | January 23 - 26, 2023 | *Bosch* and the *Decision and Control Laboratory* (Bari polytechnic) | Y |
| Attention Mechanism in Neural Networks; Transformers and their applications | Seminar | 2,5 | 0,5 | February 8, 2023 | Giovanni Pezzulo (CNR – ISTC) | Y |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Blockchain in business and 5G in business** | **Seminar** | **2,5** | **0,5** | **February 13, 2023** | **Prof. Antonia Maria Tulino** | **Y** |
| **I principi della comunicazione** | **Seminar** | **3** | **0,6** | **March 2, 2023** | **Prof. Antonia Maria Tulino** | **Y** |
| **Symbiotic analysis: ordinal patterns in time series analysis** | **Seminar** | **1** | **0,2** | **March 2, 2023** | **G. Ascione, F. Bajardi, and S. Mancini** | **Y** |

1) Courses, Seminar, Doctoral School, Research, Tutorship
2) Choose: Y or N

### 2.1. Study and training activities - credits earned

| | Courses | Seminars | Research | Tutorship | Total |
|---|---|---|---|---|---|
| Bimonth 1 | | **1,2** | **4** | | |
| Bimonth 2 | | **3** | **5** | | |
| Bimonth 3 | | **0.8** | **6** | | |
| Bimonth 4 | | | **12** | | |
| Bimonth 5 | | | **15** | | |
| Bimonth 6 | **10** | | **3** | | |
| **Total (year 1 + year 2)** | **31** | **10,2** | **78** | **0** | **119,2** |
| **Expected (year 1 + year 2 + year 3)** | **30 - 70** | **10 - 30** | **80 - 140** | **0 – 4.8** | **180** |

## 3. Research activity:

I have developed research activity with respect to following 2 topics:

- Topic 1: deep learning methods for analysis and prediction of financial data
- Topic 2: new neural network methods for what-if policy analysis on regional innovation data

**Methodology for topic 1:**

I have followed a systematic approach to review previous studies (28 analyzed papers) in order to understand how Transfer Learning has been applied for financial market predictions, and in order to know which are the challenges and potential future directions of the transfer learning methodologies for financial market predictions.

I list all the steps of the process aimed at selecting the relevant papers, with the relative adopted criteria, in next table.

| Step | Step description | Our adopted criteria |
|---|---|---|
| 1 | Defining filters (years, subject area, search words, exclusion criteria and Journal selection criteria) | |
| 2 | Defining the columns headers of the data extraction form | problem taxonomy, used dataset and related characteristics, methodology description, model architecture, main results, journal name, ScimagoJR journal classification, title, authors, year |
| 3 | Conducting the systematic research in order to populate the extraction form of the previous point | |
| 4 | Summary of the reviewed papers | |
| 5 | Answer to research questions | |
| 6 | Conclusion | Critical and strength points about current approaches on how Transfer Learning has been applied for financial market predictions; challenges and potential future directions of the transfer learning methodologies for financial market predictions |
| 7 | Experimenting step, based on what is emerged from literature review, aimed at performing financial markets predictions | |

**Results of topic 1:**

Several researchers have developed transfer learning models in order to overcome the financial data scarcity issue; as example, by starting from the observation that the common financial markets characteristics are able to explain the capability of technical indicators for providing financial forecast signals, some scholars used transfer learning models in order to extract the general pattern underlying financial data of different securities markets, and in which the neural network architecture is then re-trained on the specific data of the stock, to be predicted, for a fine-tuning step. Furthermore, literature highlighted the role of transfer learning as a method for accelerating the training [Nakagawa et al.], and for discovering asymmetric causal structure between different domains. Several studies have also pointed out the transfer learning capability to address the over-fitting problem, by means of leveraging source of data belonging to different domains. About challenges and potential future directions of the transfer learning methodologies for financial market predictions, literature highlighted the relevance to go deeper into the factors influencing the selection of source domain data, by considering also the number of domains to be used [68]; furthermore, literature have also highlighted the need to address the possible error propagation issue related to the usual transfer learning process, as it involves sequential training of models that can adversely affecting the performance of downstream models. In the end, literature suggested to investigate the impact of different learning mechanism, such as the attention mechanisms as example, on the transfer learning performance. As last point for challenges and potential future directions, we highlight the need to study Transfer learning techniques within the explainable Artificial intelligence framework.

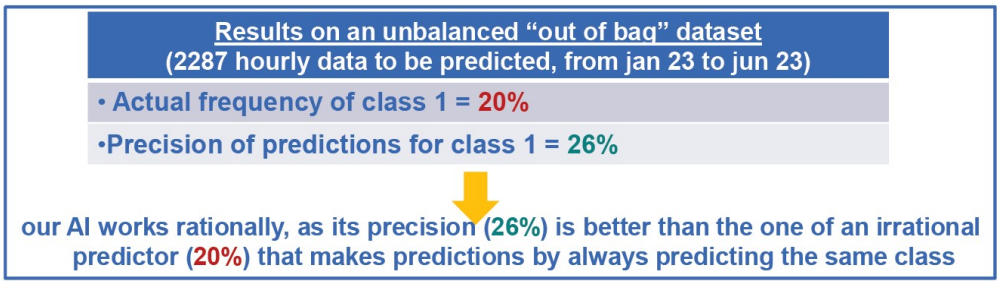
The conducted review has been completed and will be submitted to a journal (to be still defined) as soon as possible.

Review results have been used for the experimenting step aimed at performing financial markets predictions with respect to datasets and Machine Learning methods presented in the following box:

| | Tested dataset |
|---|---|
| 1 | Daily index market data |
| 2 | Daily stock data |
| 3 | Daily Forex data |
| 4 | Hourly index market data |
| 5 | Hourly Forex data |

| | Experimented ML Techniques |
|---|---|
| 1 | Feed Forward NN |
| 2 | CNN |
| 3 | LSTM |
| 4 | CNN-LSTM |
| 5 | XGBoost |

Results – on hourly AUD/USD currency pair - are reported in the following figure:

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**Methodology for topic 2:**

Literature highlights that Neural Network (NN) is a very useful tool for developing what-if analysis on complex labelled dataset, as its capability to infer complex and non linear relationship between input variables and labels.

As interesting application, literature suggests Neural Network architectures as tools for modelling relationships between regional innovation indicators (features) and regional innovative capacity (label). Indeed, NN can be used as simulation tool for evaluating the potential effectiveness of selected policies (to understand, for example, what can be done - by a region - to be able to move from a less innovative cluster to a more innovative one). Accordingly, I developed a research, on the above topic, in order to study NN as a what-if tool for policy analysis on regional innovation data; the related methodology is presented in next table:

| | |
|---|---|
| 1 | Identification of key variables (regional innovation indicators) |
| 2 | Data Collection |
| 3 | Clustering the regions |
| 4 | Labelling the regions |
| 5 | NN for what-if analysis |

**First results for topic 2**

List of literature evidences are presented in the following table:

- Regional innovation capability is periodically labelled, in Europe, through the un-weighted average of innovation indicators used in the European Union Regional Innovation Scoreboard (EURIS).
- presence of correlated innovation indicators can push the un-weighted average towards biased values
- need to operate according to non-linear models, as processes underlying the development of the regional

innovative capacity are non linear and complex

- the EURIS scoreboard has to be considered as a measuring tool for the over time analysis of each specific indicator, and not as a document for the definition of policy options
- Clustering methodologies operate according to the similarity of the entire set of indicators, and non-linearly are able to bring regions in clusters.

According to the above framework, I have developed the clustering of European regions (in 4 classes) by using k-means, tandem analysis and Factorial K-mean.

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## 4. Research products:

I have developed PredictionLabs.ai, a fintech start up project - for the investment industry sector - with the mission to integrate breakthrough and customized Artificial Intelligence technologies into the investment and risk management processes of asset management companies. PredictionLabs.ai offer a suite of AI-powered investment solutions - designed specifically to support asset managers in their investment decision-making process - including tailored risk management solutions to provide alerts for potential issues, and customized predictive analytics ones to give actionable insights for our clients. PredictionLabs.ai has developed a minimum viable product (MVP) for "rate of return" predictions (Technology Readiness Level 8, as it is ready for implementation as cloud-delivered custom solution). My MVP is a deep learning-based algorithm for classification of financial market data. Hourly data of the AUD.USD currency pair have been used as dataset; after the training of the model, I have also developed the so-called "financial backtesting", that is a kind of additional test set usually used - for financial prediction test - in Finance.
I have submitted the business plan of PredictionLabs.ai to the StartCupCampania 2023 competition (Business Plan Competition for spinoffs of researchers and students, organized by the seven universities of Campania region). PredictionLabs.ai has been selected for the regional final (to be done on October 25th 2023).

## 5. Conferences and seminars attended

None.

## 6. Periods abroad and/or in international research institutions

None. 0 months spent abroad.

## 7. Tutorship

None.

## 8. Plan for year three

**Research activities:**

Topic 1 - deep learning methods for analysis and prediction of financial data: I'm developing new deep learning architectures for financial market predictions with respect to the critical aspect that are emerged from the conducted survey on transfer learning methodologies applied to financial prediction.

Topic 2 – new neural network methods for what-if policy analysis on regional innovation data: there is the need to integrate the current methodology of the European Union Regional Innovation Scoreboard with new specific methodological tools for policy purposes. Indeed, as highlighted above, the current European Union Regional Innovation Scoreboard is only methodologically valid to answer to the following question: What is the regional level of local innovation resources and competencies?

So, according to our idea, the development of new operational models, and their synergistic use with the European Regional Innovation Scoreboard, should be addressed to answer the following further questions:

1) Which is the belonging cluster of each region ?
2) What are the most effective policies to be implemented for each region?

### Research periods abroad:

I plan to spend a period abroad in order to start an international collaboration

### Spin off/Start up development:

I plan to start the operational activities of Predictionlabs.ai by means of seed capital/business angels committment and/or by means of the establishment/recognition of the Spin Off qualification at our University and/or by means of Smart&Start measure of Invitalia National Agency.