**Recurrent Neural Network Analysis of International Trade**

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**PURA Statement**: I am working with Dr. Nair-Reichert to analyze current and past industrial-level trade relationships using recurrent neural networks. We will use analyses to suggest potential future relationships that will be stable and have consistent growth. As a step towards this goal, we will use recurrent neural networks to improve the prediction accuracy of overall international bilateral trade amounts between nations in the Spring 2019 semester. Neural networks may have an advantage over technical analysis because they easily capture complex, non-linear relationships and make no assumptions about the inputs. The only two studies to apply neural networks to trade data on an international scale were published fairly recently and simply show that they will be useful in this field. As globalization and interdependency between nations continue to rise, accurate predictions of international trade for the upcoming few years will inform important trade policy and investment decisions. Furthermore, these predictions will complement existing trade analysis with more nuanced insights about complex trading relationships, identify existing strong trade relationships, and help suggest future sustainable trade expansion paths.

**Background**: A neural network is simply an algorithm that finds underlying relationships between input and output variables by modeling the human brain. Neural networks can be broken down into three layers: input, hidden, and output. The hidden layer performs the actual prediction by taking in a set of weighted inputs and producing an output through an activation function. Recurrent neural networks, a specialized type of neural network, work well with time series data and are able to make multiple predictions. With recurrent neural networks, we can predict trade values for several years in the future, instead of just one year ahead.

The two existing research studies on machine learning and trade data on an international scale focus on comparing the performance of neural networks to current methods of analysis, and they have found that neural networks are generally more accurate. In the first study, published in 2014, neural networks are shown to be better than the panel method in both describing and forecasting trade data between 15 countries in the European Union. Most importantly, the neural network produced 150 times less error than the panel data when forecasting (Ref 1). Using data from CEPII’s BACI database, the same set we plan to use, a preliminary study by Wohl and Kennedy has proven neural networks to be generally more accurate than OLS and Poisson pseudo maximum likelihood estimators, two widely used methods used to project international trade (Ref 2). These studies warrant a further exploration of the intersection of neural networks and international trade, especially now that accurate, comprehensive international trade data is now available from CEPII and machine learning libraries have improved immensely.

Neural networks are effective in predicting international trade data for a few reasons. They can easily detect complex nonlinear relationships between independent and dependent variables that even technical analysis fails to find. Furthermore, neural networks do not presume any limitations or make underlying assumptions on the input information, as technical analysis does. The primary disadvantages are their large computational cost and the fact that they are ‘black boxes’; it is difficult to describe or fully understand how they map the inputs to the outputs. Yet, predictions from neural networks have been proven to be effective in nearly every industry, including economics. For example, recurrent neural networks have been used extensively to in the forecasting of the stock market and the foreign exchange market (Ref 3 & 4).

Our research is unique from other research in the field in three ways: we are employing recurrent neural networks, we are making predictions for several years in the future, and we are conducting analysis on a worldwide scale. Our forecasts will help policymakers design effective trade policy and help businesspeople make prudent investment decisions. In addition to this and our future work on industrial-level trade relationships, we believe that our forecasts will further prove that neural networks can be applied effectively to trade data and international economics in general. As a result, more research in the intersection of these fields will follow.

**Methods**: We will use Stata for all data manipulation and statistical analyses. In addition, we will use Python 2.7 and Keras, a high-level machine learning library, to implement our recurrent neural network.

We are currently working on the first of three phases and plan to complete it over the next eight weeks. We have already cleaned the data and transformed it into a format usable for our project. We are currently in the process of using partial autocorrelation, which measures how much data from one year is affected by each prior year, to determine how many years ahead we will predict.

Our second phase will be an exploratory; we will extract the data where the United States is the exporter and experiment with it to determine the process we will use for the next phase. We will train several neural networks on the data, each time varying our transformations on our input data and our hyperparameters. Hyperparameters are parameters that must be preset for the neural network, such as the architecture of the hidden layers. Between tests, we will vary which hyperparameters are tuned and how they are tuned. We will evaluate which inputs and hyperparameters give us the most accurate results on our test data. Each training will likely take a few hours. We expect this phase to take 6-8 weeks.

Our third phase will mirror the second phase but for all available trade data. However, due to the large increase in data the network must be trained on, each training will take days to weeks. As a result, we will still vary the transformations on our inputs and hyperparameters but to a lesser extent. We expect this phase to take the remainder of the semester, or 10-12 weeks.

**Experience**: This project combines both my passions: computer science, my major, and economics, my minor. This project relies heavily on big data and machine learning, which is the intersection of my two threads in computer science, information internetworks and intelligence. As a result, I have taken several relevant courses. I also have experience in both of these fields and am familiar with machine learning libraries from working in Big Data Club. I became interested in answering this question when I was taking International Economics with Dr. Nair-Reichert this summer. So, we have been working on this project since June. I would love to continue applying my experiences and passion to this project.

**Future Work**: Our research will enable us to develop valuable insights about the strength of potential trading relationships, and reduce search costs. Previous research has revealed the complexity of trading relationships. It confirms the existence of significant search and sunk costs in the formation of trading relationships, as well as the fragility of such relationships. The data also indicates that many trade relationships start up again after a period of dormancy, involving additional sunk costs. By diving in deeper and exploring trade relationships on an industry-level, Dr. Nair-Reichert and I will be able to suggest trade relationships that will be consistent and long-lived.

References

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