

# Food Flow Project

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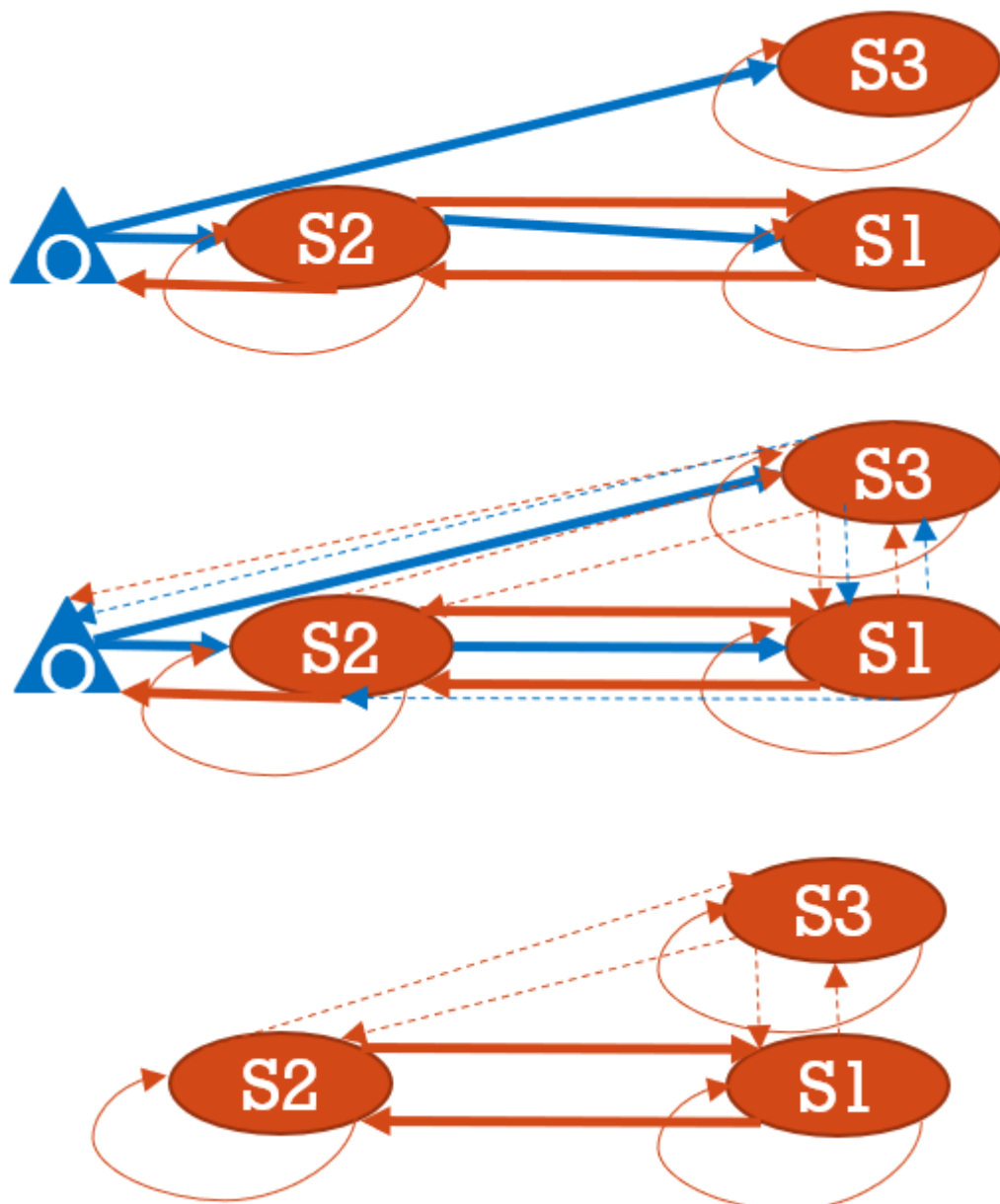
# Abstract

## Method

To estimate the bilateral food flow between state pairs, we employ Random forest and Neural Network model. A gravity model is used as baseline model.

### Random Forest

First of all, the FAF data needed to be expanded, because it does not include the case of no transaction, we will add the case of zero. To meet Kaggle's memory limitations, whether the products are imported, exported or produced domestically is ignored in RF model. We group the bilateral flow data by origination state, destination state, commodity type, transportation mode and year. As shown in Figure 1, the dotted-line is the no transaction situation, the flow from S2 to S1 in simplified figure is the sum of the flow export from foreign countries (transshipment via S2) and domestic flow produced in S2.



**Figure 1:** Problem definition: (up) FAF data, (middle) real situation, (down), simplified for random forest.

Random forest (RF) is a tree-based algorithm. The RF algorithm generates several independent trees through bootstrapping. Each tree randomly select predictor variables. The final output is determined by the average results of all trees. There are 637245 examples in the datasets 7(categories)x51(importers)x51(exports)x5(years)x7(transportation modes) and 5 categorical variables ('origst', 'destst', 'mode', 'sctg2', 'year') and 27 numeric variables. We remove the variables with missing rate larger than 25% like rice production, rye production and sorghum production. Because we want to predict the trade "value", we need to find which variables are relevant to the trade. Meanwhile, for those variables have high correlation, we need to carefully consider it to avoid the multimillionaires problems. Here are some findings for correlations. The trade weight is inversely proportional to the distance between the two states and their total GDP, which conforms to the gravity model of transactions. Here are some observations from the histogram: firstly all the production values follows a edge peak distribution. We might need to normalize it when we build the model. The value is very similar for different transctions. There are few extreme large numbers. After deleting the variables with high missing ratio, we still have several nans for production variables in the datasets. There are two different possible explanations (1) This kind of product is not grown or produced there (2)Information is not disclosed for some reason. We cannot figure out the specific reason. So we assume that all the nans are due to reason(1) then we set all nans as zeros. Also in previous section, we have already dropped some columns with large missing data which decrease the bias introduced by set all nans as zeros. The nominal categorical variables in this Food flow datasat are transformed to a format that works better with the regression algorithms using one hot encoding method. Random Forests are good at dealing with outliers and different scale features but we also need to fit a linear model as baseline. In order to prevent close to 0 weights in base model due to different scales of features, we standardize the features to center the feature columns at mean 0 with standard deviation 1. After preparing the data for Random Forest model, we decide the hyperparameters for the RF model by applying the brute force grid search.

## Baseline Model

To validate our model, we also try the gravity model. The linear model like Ridge model is not suitable for the bilateral food flow estimation. Gravity model is one of the most robust empirical models to illustrate the drivers in international trade: bilateral trade between two countries is proportional to size, mostly measured in GDP and inversely proportional to "distance" between them, which commonly fitted through Poisson Pseudo Maximum Likelihood (PPML) method to deal with the zeros. We use the python GLE library to do Poisson Psedo Maximum Likelihood regression. The gravity model calculate the *origst*  $\times$  *year* and *destst*  $\times$  *year* fixed effect and the impact of variables used in RF model.

## Data

### Bilateral food flow

The FAF dataset includes every 5 years data from 1997 to 2017.

### Other features

income data

gdp data

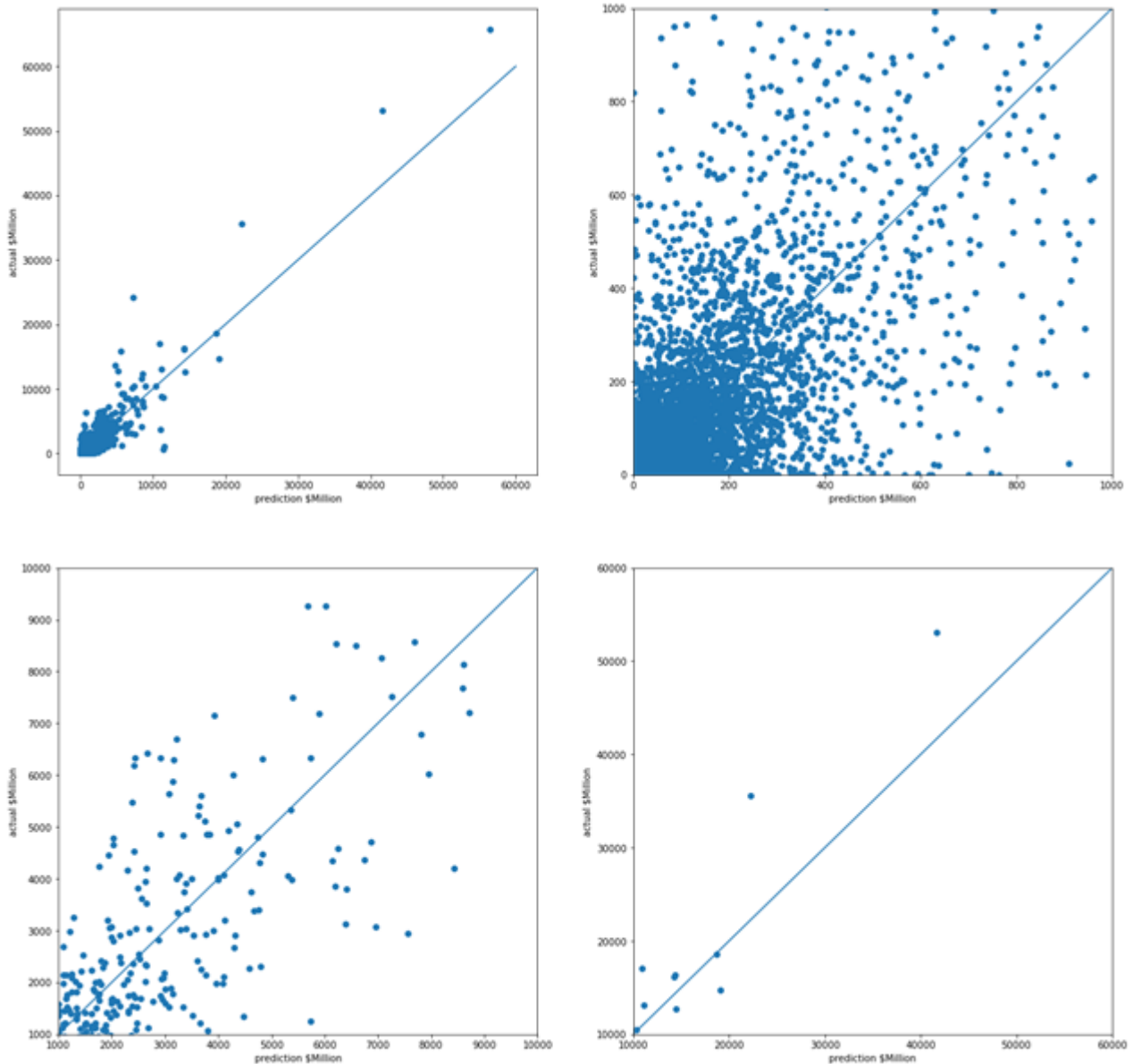
production data

distance

# Result

## Random Forest

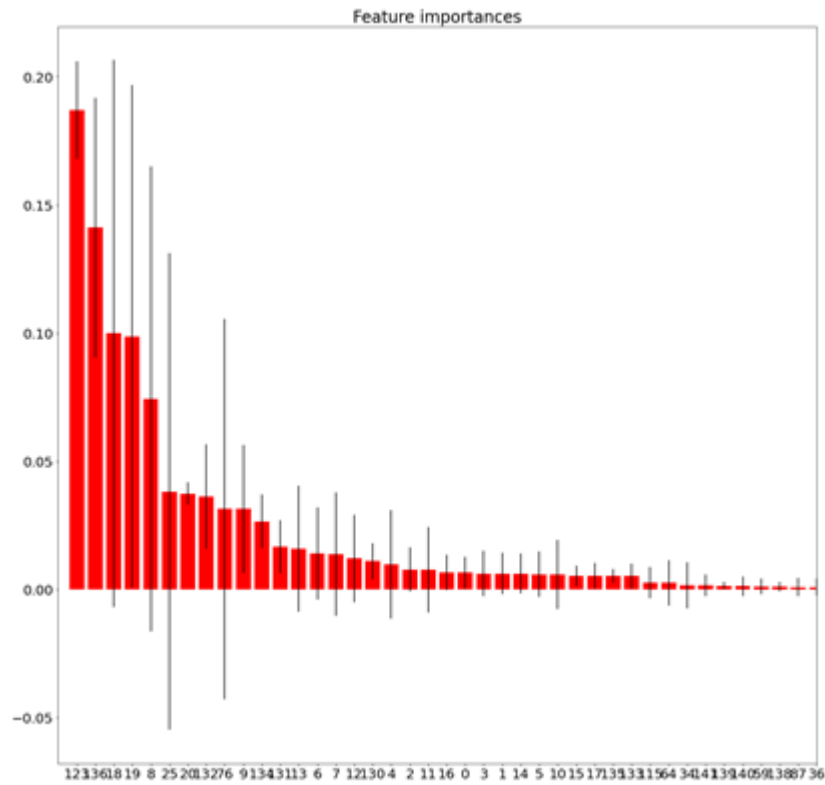
Through GridSearching, the hyperparameters we selected was 20 for max depth of tree and 50 for number of independent tree. Figure 2 shows the estimation results. The validation  $r^2$  is 0.86. RF model shows the better performance for the large flow.



**Figure 2:** Random Forest Prediction Result.

Figure 3 shows the importance of features on this bilateral food flow regression problem.

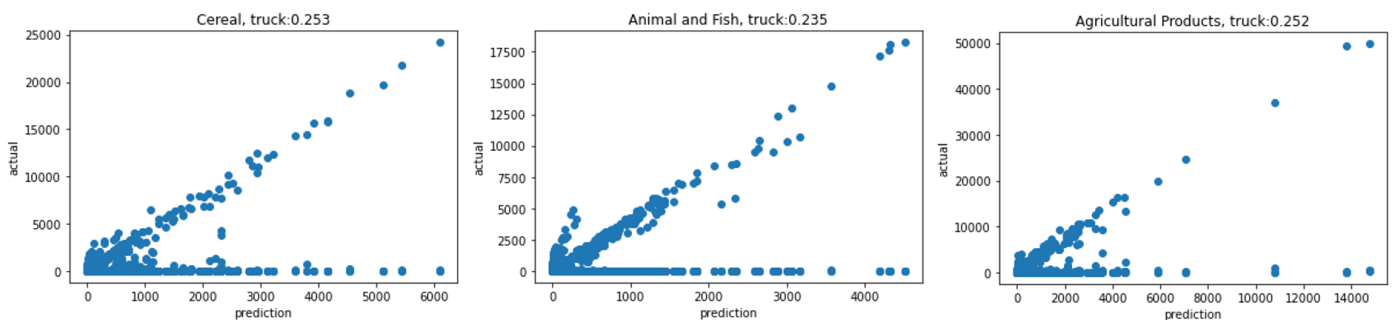
The red bars are the importance of the forest with inter-trees variability. As expected, commodity type, gdp of importors and gdp of exporters are informative. Surprisingly, distance and year shows less impact on the regressiom results. The performance of the distance variable is inconsistent with the law of the gravity model. We consider that this may be becaues we use the log of harversine distance.



**Figure 3:** Random Forest Feature Importance. features 0:21('value', 'income\_dms\_origst', 'income\_dms\_destst', 'animaltotal\_dms\_origst', 'animaltotal\_dms\_destst', 'barley\_dms\_origst', 'barley\_dms\_destst', 'corn\_dms\_origst', 'corn\_dms\_destst', 'crop\_total\_dms\_origst', 'crop\_total\_dms\_destst', 'honey\_dms\_origst', 'honey\_dms\_destst', 'milk\_dms\_origst', 'milk\_dms\_destst', 'oats\_dms\_origst', 'oats\_dms\_destst', 'wheat\_dms\_origst', 'wheat\_dms\_destst', 'gdp\_dms\_origst', 'gdp\_dms\_destst', 'distance'), 22:72 (dms\_origst), 73:123 (dms\_destst), 124:130 (transportation mode), 131:137 (commodity type), 138:142 (year)

## Baseline

Using the same data as RF model mentioned above, the validation accuracy  $r^2$  of Ridge model is 0.049 because there are so many zeros in the dataset. We fitted gravity model to bilateral food flow data with PPML estimator, as shown in Figure 4. As we specified the commodity type and transportation mode, there is no group variance. But the average  $r^2$  for different commodity and transportation condition is about 0.25.



**Figure 4:** Gravity model for specific commodity and transportation mode.

## Discussion

### Comparing the models

We compared the different model results. Among three models we employed, Random Forest showed the best prediction performance. We assume that the good performance of RF is due to (1) RF is good

at deal with noise (2) RF can capture the nonlinear relationship, Also, NN and RF models both showed better prediction performance for larger trade flow. We thinks that small trade flow might be impacted on more complex variables, which cannot be predicted by the

## **Limitations**

There are several limitations in this study. Firstly, the distance used in this study is haversine distance. Also we didn't adjust the food flow value using GDP deflator to eliminate the impact of inflation. In other words, we don't consider the transportation network connected each state. We don't consider the commodities trade mode(Domestic, imports or exports) in Random Forest model. Meanwhile, we cannot predict zero value weight flow with Neural Network model.

## References

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