ISM6137
Statistical Data
Mining

Factors Affecting Agriculture Producti on Value in Various Countries

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1. Executive Summary

The agriculture industry is crucial for the development and prosperity of most nations. According to world bank data from 2019, Agricultural development is one of the most powerful tools to end extreme poverty, boost shared prosperity and feed a projected 9.7 billion people by 2050.

Agriculture is also crucial to economic growth. In 2018, it accounted for 4 percent of global gross domestic product (GDP), and in some developing countries, it accounts for more than 25% of GDP. Growth in the agriculture sector is two to four times more effective in raising incomes among the poorest than other sectors. A significant share of people in low-income countries work in agriculture An average of 59% of people worked in agriculture in low-income countries compared to 38% in lower middle-income countries.

Our analysis examines data from 237 countries in the period 2011-2020. We included important variables, but are not limited to, trade, rainfall, irrigated land, FDI, bank credit, pesticides, and power irrigation.

Using panel models, our analysis quantifies and conveys insights into the impact of these variables on agricultural production. The key findings from our analysis can inform policies and strategies aimed at promoting sustainable, healthy, and accessible food systems, and ultimately help to end extreme poverty, boost shared prosperity, and ensure food security for a growing global population.

2. Problem Definition & Significance

Most recent Covid-19 related disruptions to extreme weather, pests and conflicts have resulted in increase of food prices and global hunger. Russia's invasion of Ukraine has accelerated a global food crisis that is driving millions more into extreme poverty, and around 205 million people across 45 countries have so little food that their lives are at risk.

Growth in agriculture sector can reduce poverty and hunger crisis across the world and more effective in raising incomes among poorest compared to other sectors.
By promoting agriculture and consumption, governments can increase food production and improve the overall economy. Increasing food production has been linked to all processing and improvement in the economy.

The value of agricultural production is our target variable. The purpose of our analysis is to identify the major factors that affect agriculture production and provide recommendations on how to improve the same.

3. Prior Literature

Agriculture is a crucial sector for many economies. Various studies have been conducted to determine the key factors that affect the value of production in this sector. One of the primary contributors to the revenue in the agricultural sector is government initiatives such as government expenditure, price support for crops, research spend, infrastructure and credit distribution. Many studies have found that government spending has a positive impact on the growth of the agricultural sector.

In this section, we summarize the findings from eight previous publications that analyzed the factors affecting agricultural production and a more detailed summary of each publication is included in appendix.

- For instance, Suryani Magdalena and Rony Suhatman (2017) found that government spending had a significant positive impact on the economic growth of the primary sector in Central Kalimantan.
- Foreign investment and agriculture imports are also important factors that affect the agricultural sector's value of production. Studies have shown that foreign direct investment (FDI) in agriculture is positively related to the agricultural market size in Chinese agriculture, while agricultural imports have a negative impact (Licai Lv, Simei Wen and Qiquan Xiong, 2015).
- Population growth is also an indirect factor that affects agricultural production, as it leads to an increase in the workforce available for agriculture. Badar et al. (2007)
- The price of agricultural products and commercial bank credits did not have a significant impact on agricultural productivity in Nigeria. Sunny Ibe Obilor (2012)
- government support prices for certain crops can have both positive and negative impacts on production and the economy (Hammad Badar, Abdul Ghafoor, and Sultan Ali Adil, 2014).
- Many studies have used OLS models with log transformations to analyze the factors affecting agricultural production. The Cobb-Douglas production function has been widely used to describe the relationship between inputs and outputs in agricultural production.

A common observation from the above studies is that they have mostly been done at a country or provincial level. Our study, on the other hand, is done at a higher level, using

data from all countries for a period ranging from 2011 and 2020, to identify the main factors affecting agricultural production.

Geographic factors such as the availability of labor, rainfall index, water availability and crop-related factors such as fertilizer consumption and pesticide usage have been found to influence the value of agricultural production. In our study, we used these additional variables also for getting a better prediction.

4. Data Source/Preparation

4.1 Source

The data used in this analysis was obtained for the years 2011 to 2020 from three websites, as follows:

FAOSTAT: https://www.fao.org/faostat/en/#data
(The Food and Agriculture Organization Corporate Statistical Database)
Features:

Fertilizer
Pesticides
Drained Organic Soil
Government expenditure
Export/Import
Production
Bank Credit
Foreign Direct Investment

WORLD BANK: https://data.worldbank.org/indicator/AG.LND.PRCP.MM
Feature:

Rainfall Index

AQUASTAT: https://www.fao.org/aquastat/en/
(FAO's Global Information System on Water and Agriculture)
Features:

Power Irrigation
Irrigated Land

4.2 Available variables - Data Dictionary

Variable	Definition	Type
Value of production	Value of agricultural production in USD	Int
Area	Name of the country	Chr

Year	The year for which the data is related to	Date
Rainfall Index	Amount of average yearly rainfall in mm	Int
Fertilizer.nitrogen	Total nitrogen (N) from all fertilizer products	Int
Fertilizer.potash	Total potash (K2O) from all fertilizer products	Int
Fertilizer.phosphate	Total phosphate (P2O5) from all fertilizer products	Int
Pesticide	Total pesticides, covering insecticides, fungicides, and bactericides (including seed treatments), herbicides, plant growth regulators, rodenticides, mineral oils, disinfectants and others. Kg/1000 USD	Int
Drained organic soil	Organic soils that are drained for agriculture	Int
Bank credit	Credit extended by banks in millions (USD)	Int
Capital central	Capital spending by central govt in millions (USD)	Int
Capital general	Capital spending by local government in millions (USD)	Int
Recurrent central	Continuing spending by central government in millions USD	Int
Power irrigation	Area equipped for irrigation where pumps are used for water supply from the source	Int
Irrigated land	Land used for farming and irrigation 1000 ha	Int
FDI inflows	Inflow of foreign direct investment in millions USD	Int
FDI outflows	Outflow of foreign direct investment in millions USD	Int
Import	Total value of product imports in millions USD	Int
Export	Total value of products exported in millions USD	Int

Predictor Table:

Predictor Variables	Sign of Effect on Dependent Variable	Rationale
Rainfall Index	Positive	The value of agricultural produce may rise due to higher crop yields brought on by more rainfall.
Fertilizer.nitrogen	Positive	Adding nitrogen to the soil can boost crop yields because it is a crucial ingredient for plant growth.
Fertilizer.potash	Positive	Potassium, which is also essential for plant growth, can increase crop yields when added to the soil.
Fertilizer.phosphate	Positive	Phosphorus is another essential nutrient for plant growth and can increase crop yields when added to the soil.
Pesticide	Negative	Pesticide overuse can have a negative impact on the environment and lower crop yields, which lowers the value of agricultural products overall.
Drained organic soil	Positive	Organic matter can improve soil fertility and increase crop yields, increasing agricultural production's value.
Bank credit	Positive	Access to loans can give farmers the means necessary to invest in their operations, raising crop yields and the value of agricultural output.
Capital central	Positive	The central government's investment in infrastructure and technology can raise agricultural productivity and the value of products while also reducing costs.
Capital general	Positive	Investment in infrastructure and technology by local governments can also improve agricultural productivity and increase the value of agricultural production.

Recurrent central	Positive	Continuing spending by the central government can support ongoing agricultural activities and increase crop yields and agricultural production value.
Power irrigation	Positive	Irrigation can provide crops with water, increasing crop yields and agricultural production value.
Irrigated land	Positive	Irrigation can increase crop yields and, therefore, the value of agricultural production by allowing crops to grow in areas that may not receive enough natural rainfall.
FDI inflows	Positive	Foreign direct investment can bring in new technologies and resources that can improve agricultural productivity and increase the value of agricultural production.
FDI outflows	Negative	Outflows of foreign direct investment can reduce the resources available for investment in agriculture and potentially decrease the value of agricultural production.
Import	Negative	High levels of imports can lead to increased competition for domestic agricultural products, which can decrease the value of agricultural production.
Export	Positive	Exports can bring in revenue for agricultural products, increasing the value of agricultural production.

4.2 Data Joins and Cleansing

Joins: All the tables are joined using a combination of two foreign keys: Area and Year

Report	Description	Variables
Value of agricultural production	The gross production value of agriculture (in 1000 USD)	Value of production
Fertilizers by nutrient	Amount of fertilizers used in agriculture	Fertilizer.nitrogen Fertilizer.potash Fertilizer.phosphate
Pesticides indicators	Pesticides used per value of agricultural production	Pesticide
Government expenditure	Amount spent by government on agriculture	Capital central Capital general

		Recurrent central Recurrent general
Credit to agriculture	Amount of loans provided by private/commercial banks to agriculture producers	Bank credit
Foreign Direct Investment	FDI in agriculture	FDI inflows FDI outflows
Trade - Crops and live stock products	Import and export value of agricultural products	Import Export
Rainfall Index	Average rainfall per year in mm	Rainfall Index
Drained organic Soil	Amount of drained soil in hectares	Drained organic soil
Power irrigation	Area equipped for irrigation where pumps are used for water supply from the source	Power irrigation
Irrigated land	Total area of irrigated land for crop production	Irrigated land

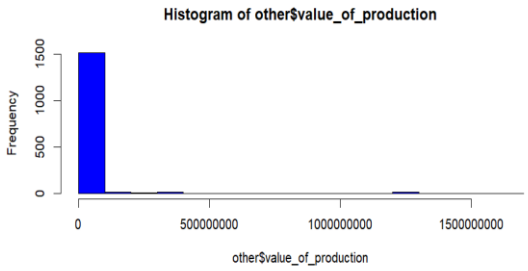
Cleansing:

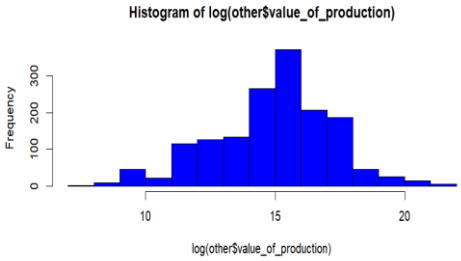
Constraints and Limitations

The dataset we had was limited when attempting to analyze credit and financial data along with agricultural data. Many of the lower income countries did not have extensive credit data aligning with agricultural data so we had to limit the analysis to those categories separately and could not determine sufficient interactions. We also cannot extend this to countries with limited amounts of irrigated land. Desert countries such as Egypt have little arable land and import a large selection of crops. There were also countries with 0 reported irrigated land for the analysis so for this reason we chose to exclude them.

The data doesn't have credit related information (viz. capital expenditure, bank credit) about many of the countries. In such a situation, we have chosen to discard the data considering the missing values for various years and the inability to produce a reliable model for these factors. Instead, we did a separate model to analyze the credit factors for the countries which have data.

The dependent variable, value of production, was not normally distributed. Log transformation was chosen for our model to correct the normality and homoscedasticity and a panel model to account for the yearly analysis of the data.





Data Modeling

The data contains multilevel data as well as a time element. Therefore, a panel model was chosen to handle the levels of the data for the country and year level.

Mixed effects model:

```
df = pdata.frame(other, index=c("area", "year"))

main = lmer(value_of_production~log(export) + log(export)+fertilizer.nitrogen +
            fertilizer.phosphate + fertilizer.potash + pesticide + log(import) +
            drained_organic_soil + irrigated_land + rainlog + year + (1 | area),
            data=other, REML=FALSE)
```

Fixed effects Panel model:

```
plmlog = plm(valuelg  ~ log(export) + (fertilizer.nitrogen + fertilizer.phosphate +
fertilizer.potash)*pesticide + log(import) + irrlog+ rainlog, data=df,
model="within")

plm= plm(value_of_production~log(export) + (fertilizer.nitrogen +
        fertilizer.phosphate +fertilizer.potash)*pesticide + log(import) +
        drained_organic_soil+irrlog+ rainlog, data=df, model="within")
```

```
Dependent variable:
       ---------------------------------------------------------------------------------------
                                value_of_production           valuelg               value_of_production
                                    linear                    panel                      panel
                                 mixed-effects           linear                        linear
                                   (1)                       (2)                           (3)
-------------------------------------------------------------------------------------------------------------------
log(export)              -1,417,636.000*(796,940.100)        0.204***(0.019)              -1,429,371.000*** (442,560.300)
fertilizer.nitrogen      21.081*** (1.880)                   0.00000** (0.00000)            -1.519 (2.508)
fertilizer.phosphate     6.397*** (2.225)                    -0.00000 (0.00000)             8.623 (6.727)
fertilizer.potash        -33.654*** (2.447)                  -0.00000 (0.00000)           137.996*** (4.468)
pesticide                222,998.000(504,199.000)            -0.293 (0.024)               2,369,659.000 (547,666.900)
log(import)              3,812,549.000* (1,229,414.000)      0.287* (0.026)               4,028,196.000* (600,293.100)
drained_organic_soil     0.850 (21.227)                                                   -14.729*** (2.316)
irrigated_land           6,620.978*** (807.577)
irrlog                                                        0.303*** (0.012)           1,113,882.000*** (282,436.500)
rainlog                          5,001,831.000 (6,528,752.000)  0.351 (0.028)           -138,279.000 (633,958.400)
fertilizer.nitrogen:pesticide                                 -0.00000* (0.00000)          3.875** (1.965)
fertilizer.phosphate:pesticide                                0.00000*** (0.00000)         19.781*** (5.060)
fertilizer.potash:pesticide                                   -0.00000 (0.00000)           -91.038*** (3.123)
Constant                  -65,794,210.000 (47,610,987.000)
-------------------------------------------------------------------------------------------------------------------
Observations                                1,083                       1,083                        1,083
R2                                                                      0.821                        0.956
Adjusted R2                                                             0.817                        0.955
Log Likelihood                           -18,791.230
Akaike Inf. Crit.                         37,606.460
Bayesian Inf. Crit.                       37,666.310
F Statistic                                   442.002*** (df = 11; 1062)  1,930.453*** (df = 12; 1061)
===================================================================
```

Credit

df2 = pdata.frame(credit, index=c("area", "year"))
creditplm = plm(logvalue ~ banklog + logcentral + recurrent_gen, data=df2,model="random")
creditplm2 = plm(logvalue ~ banklog + capital_general + recurrent_gen,
data=df2,model="random")

```
 Dependent variable:
 ---------------------------------
                                    logvalue
                                    (1)            (2)
---------------------------------------------------
banklog                        0.090*** (0.029)  0.091*** (0.029)
capital_central               -0.0005 (0.001)
capital_general                        -0.001 (0.001)
recurrent_gen      0.0003 (0.0003)   0.0003 (0.0003)
Constant           13.253*** (0.467) 13.254*** (0.463)
---------------------------------------------------
Observations          63              64
R2                  0.601           0.563
Adjusted R2           0.581           0.542
F Statistic         12.390***       12.683***
===================================================
```

Quality checks and Assumptions

Autocorrelation

We can see from the below tests that there is limited correlation based on the variables chosen in the model. However, since the data is yearly, there will be some autocorrelation from the year to year amounts. Hence the panel level model using year as an effect.

```
vif(main)
log(export)  fertilizer.nitrogen fertilizer.phosphate    fertilizer.potash      pesticide 1.142508
3.730087          3.035937          1.901509          1.007598

log(import) drained_organic_soil      irrigated_land      rainlog
1.151095          1.028642          1.507458          1.006788

vif(creditplm)
banklog    capital_central   recurrent_gen
1.036870       1.018163       1.054898
```

Recommendations

Based on the analysis, we recommend the following:

Fertilizers should be minimized due to the negative effects on the environment and production. Nitrogen fertilizers promote improved production but should be analyzed at the local level for use. Meanwhile, the potassium and phosphate fertilizers had a negative but insignificant effect. Since these have been associated with negative environmental outcomes, they should be limited to specific uses.

Pesticides have some negative correlation with our chosen model. Our data shows a twenty percent decrease in the value of production. Pesticides were not broken down so further research should include granular level detail of the group and

Imports and exports appear to have a meaningful effect. Healthy trading partners appear to promote agricultural production and the effects of specialization are a likely contributing factor.

Rain has a significant effect on production as does exports. Since influencing rain is not feasible, more effort should go to irrigation efforts and ensuring available water sources. The effects of powered irrigation use were inconclusive. Further research will be needed to properly examine the potential benefits of powered irrigation systems.

Government spending has a negative correlation with production whereas bank credit improves production value by 9 percent. Therefore, the focus should be to

support a strong banking system that lends money to agriculture as opposed to government spending.

Expanding on previous work by Tijani et. Al., (2015), we found that consistent, recurring spending by central government did not support constant growth within the sector. This supports their findings that capital investment and specific projects for the agricultural sector are better suited for long-term growth.

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Appendix A

Source	Research Question	Predictors	Findings
The Effect of Government Expenditures, Domestic Investment and Foreign Investment to the Economic Growth of Primary Sector in Central Kalimantan - Suryani Magdalena, Rony Suhatman	How does the economic growth of primary sector (agriculture, farm field, forestry, fisheries, mining and quarrying) be affected by Government Expenditures, Domestic Investment and Foreign Investment	Government Expenditures Domestic Investment (DI) Foreign Investment (FI) Data Source: BPS of Central Kalimantan Province, 2020	• Used OLS with log transform on X variables. • Govt spending has a positive impact on economic growth whereas DI and FI have no impact. • Investments are mainly diverted to industries like manufacturing and construction. • If investors are encouraged by providing a conducive climate, it can help in improving the economic growth in the primary sector.
The Impact of Government Expenditure in Agriculture and Other Selected Variables on the Value of Agricultural Production in South Africa (1983–2019): Vector Autoregressive Approach - Etian Ngobeni and Chiedza L. Muchopa	What is the effect of the predictors on the value of production, with a special focus on govt expenditure in agriculture from 1983-2019	Govt expenditure Annual average rainfall Consumer price index (CPI) Food import value (FIV) Population Data Source: Food and Agricultural Organisation (FAO)-Population South African Reserve Bank (SARB)-Yearly Govt expenditure The World Bank - Annual average rainfall, CPI Quantec databases-Value of agricultural production, FIV	Johansen cointegration test is used to find the long-run relationship among the variables. Granger causality test is used to test for causality among the variables. Govt expenditure and rainfall have a positive impact on the value of agricultural production. Increase in population increases the labor force and thereby has an indirect impact in increasing the production. FIV has positive impact in the short run and detrimental in the long run. CPI has negative impact.
CONTRIBUTION OF FOOD PRODUCTION SECTOR TO THE INCREASE OF EMPLOYMENT – COMPARATIVE ANALYSIS OF SLOVENIA, CROATIA, AND SERBIA2	How does an increase in operating income increase employment in food production and related sectors and how is it related to national employment?	Companies Operating revenue Source: Official financial statements for 2012 Original data from authors	• Large percentage of enterprises are small to med sized. Contributes to rural economic development in these countries. Shown to have a Linear link in Slovenia and Croatia but no relationship in Serbia.
Public sector expenditure in agriculture and economic growth in Nigeria: An empirical investigation	What is the effect of expenditures on agriculture to the economy and how do changes affect the	Government expenditures Capital spending Recurrent spending Government support programs Total revenue	• Capital spending was found to have a direct and sustained influence on agriculture and total GDP and growth rate..

	economy in the short and long run.	Data Source: Sources: CBN Statistical bulletin (2001) and (2005) National Bureau of Statistics (NBS) (2007) The Nigerian Statistical Fact Sheets on Economic and Social Development	• Data separated into recurrent and sustained spending required altering model to account for variable changes.. • There was a direct and significant relationship on long term growth • This also promoted overall growth in the economy through development of rural areas with agricultural workers and support of government programs.
FACTORS AFFECTING AGRICULTURAL PRODUCTION OF PUNJAB (PAKISTAN) - Hammad Badar, Abdul Ghafoor and Sultan Ali Adil	Punjab province contribute 60% of national agricultural production. What are the factors affecting the agricultural production ? What is their impact on productivity and efficiency of the agricultural sector?	cropped area agricultural labour distribution of improved seed budgetary expenditure on agricultural research land reclamation wheat price support fertilizer consumption expenditure on food trading services Model :- Multiple linear regression is used with a log transform on DV and all IV because of the nonlinear relationship Data Sources:- Data is sources from official publications of various offices of Govt. of Pakistan and Govt. of Punjab such as Federal Bureau of Statistics, Islamabad, Ministry of Finance, Islamabad, Ministry of Food, Agriculture and Livestock, Islamabad, Planning and Development Department and Bureau of Statistics.	• Cobb-Douglas production mathematical formula is used to describe the relationship between inputs and outputs in the production of goods or services. Expenditure on food trading services(procurement, subsidies, promotion of export and import, management, and distribution of output) affects production. • Some governments provide support prices for certain crops based on region. This affects production positively because farmers tend to produce more because of the guaranteed returns. Also, on the other hand, if there is surplus produce, the government budget gets burdened, so it should encourage the export of goods. • For export, the quality of the output should be high, which again depends on the quality of the seed available and research on production practices. All the factors have an interconnected effect on one another.

Determinants and performance index of foreign direct investment in China's agriculture - Licai Lv, Simei Wen and Qiquan Xiong	To examine the determinants of FDI and evaluate the inward FDI performance in China's agriculture. Only 1% of total FDI inflows into china is on agriculture. Finding the determinants and real situation of FDI in agriculture is very important	Agriculture Market Size Agriculture import Agricultural Export Agricultural fiscal expenditure Industrial Policy **Model –** Multi Variable Regression with log transformation **DataSources:-** China Statistical Yearbook and China, Foreign Economic Statistical Yearbook, China Foreign Economic and Trade Yearbook, the United Nations Commodity Trade Database (COMTRADE), Ministry of Commerce of China database	• The UNCTAD inward FDI performance index measures a country's share of global FDI flows relative to its share of global GDP. • In China, agricultural market size has a significant positive effect on FDI in agriculture. • The model used to study this may have issues with multiple related variables and can be improved with stepwise regression analysis. • Agricultural GDP is the most important factor in determining FDI in Chinese agriculture. • Agricultural market size is positively and significantly correlated with FDI in Chinese agriculture, indicating its importance in attracting FDI. • Empirical results suggest that agricultural market size has a positive impact on FDI in Chinese agriculture, while agricultural import has a negative impact.
Obilor, S. I. (2013). The impact of commercial banks' credit to agriculture on agricultural development in Nigeria: An econometric analysis. *International Journal of Business, Humanities and Technology*, *3*(1), 85-94.	the impact of Agricultural Credit Guarantee Scheme Fund, agricultural product prices, government fund allocation and commercial banks' credit to agricultural sector on agricultural productivity.	Commercial Bank's Credit to the Agricultural Sector Agricultural Credit Guarantee Scheme loan by purpose Government Financial Allocation to Agricultural sector Agricultural Produce Price. **Datasources:** the CBN Statistical Bulletin, data on the banks credit to agricultural sector, interest rates, published data on seminars, journals, magazines, newspapers	• Important to check for stationary of series before regression. • Unit test method and dickey-fuller test is used for analysing stationary of series. • Commercial bank credits and price of agricultural products have not made any significant impact on agricultural productivity, • Agricultural Credit Guarantee Scheme Loan and government financial allocation had made positive impact.

Abdul Rehman, Abbas Ali Chandio, Imran Hussain, Luan Jingdong, Fertilizer consumption, water availability and credit distribution: Major factors affecting agricultural productivity in Pakistan, Journal of the Saudi Society of Agricultural Sciences, Volume 18, Issue 3, 2019.	To examine the various factors effecting agriculture production in Pakistan over the period 1978-2015.	cropped area water availability fertilizer consumption Improved seeds distribution credit distribution Data Source: Pakistan Bureau of Statistics, the Statistical Year Books and the Economic Survey of Pakistan	• fertilizer consumption has signification impact on agriculture production. • improved seed distribution and credit distribution are positive and significantly influence crop production • water availability had a negative impact, but no significant relationship with Agricultural Gross Domestic Product(AGDP) • share of the agricultural sector decreased due to technical developments.

Appendix B – R code

```
library(stargazer)
library(tidyverse)
library(rio)
library(plm)
library(dplyr)
library(lme4)
rm(list=ls())
getwd()
setwd("C:/Users/mdsou/Downloads")
library(readxl)

#Import separate datasets

production = read_excel("datasets (1)/value of production.xls")
pesticide = read_excel("datasets (1)/pesticide.xls")
central = read_excel("categories divided.xlsx", sheet="Sheet1")
general = read_excel("categories divided.xlsx", sheet="Sheet2")
recurrent = read_excel("categories divided.xlsx", sheet="Sheet3")
recgen = read_excel("categories divided.xlsx", sheet="Sheet4")
imp = read_excel("categories divided.xlsx", sheet="Sheet5")
exp = read_excel("categories divided.xlsx", sheet="Sheet6")
fertn = read_excel("categories divided.xlsx", sheet="Sheet7")
fertp = read_excel("categories divided.xlsx", sheet="Sheet8")
fertpt = read_excel("categories divided.xlsx", sheet="Sheet9")
fdi = read_excel("datasets (1)/fdi.xls")
inflow = subset(fdi, Item=="Inflow")
outflow = subset(fdi, Item=="Outflow")
inflow = inflow[ -c(2) ]
```

```
outflow = outflow[-c(4)]

#Subdivide and correct

names(inflow)[names(inflow) == 'fdi'] = 'fdi_inflows'
names(outflow)[names(outflow) == 'fdi'] = 'fdi_outflows'

#Import remaining

soils = read_excel("datasets (1)/drained organic soil.xls")
irrigation = read_excel("datasets (1)/area under actual irrigation.xlsx")
bank = read_excel("datasets (1)/bank credit.xls")
rainfall = read_excel("datasets (1)/national rainfall index.xlsx")
powerirr = read_excel("datasets (1)/power irrigation.xlsx")

#Inner join each data set

df_list <- list(bank, central, exp, fertn, fertp, fertpt, general, imp, inflow, outflow, pesticide, production,
recgen, soils)
combined = df_list %>% reduce(full_join, by=c("Area", "Year"))

#By country

df_list2 <- list(irrigation,powerirr,rainfall)
list2 = df_list2 %>% reduce(full_join, by=c("Country","Year"))

#Create combined dataframe

combined$Year = as.factor(combined$Year)
list2$Year = as.factor(list2$Year)
Final <- combined %>% full_join( list2, by=c('Area'='Country', 'Year'='Year'))

colnames(Final)=tolower(gsub(" ", "_",colnames(Final)))
#Cut for production values
Values = Final[!is.na(Final$value_of_production),]
#x = x[complete.cases(x), ]

#Output file

install.packages("xlsx")
library(xlsx)
write.xlsx(Final, "Completedataset.xlsx")
write.xlsx(Values, "ProductionValues.xlsx")

df=Complete[3:9]
pairs(df)
df=Complete[10:16]
#Clean and subset new dataframe
Complete=read_excel("Completedataset.xlsx", sheet="Sheet1")

# Check for missing values
```

```
colSums(is.na(Complete))
colSums(is.na(other))                    # Check for missing values
#Completeset <- na.omit(Complete)
#rm(Completeset)
Complete = Complete[-c(1)]

Complete$area=as.factor(Complete$area)
colSums(is.na(Complete))

credit=Complete[,c("year","area","bank_credit","capital_central","capital_general",
          "fdi_inflows","fdi_outflows","recurrent_gen","value_of_production")]
other=Complete[,-c(3,4,9,11,12,15,18)]
colSums(is.na(credit))
credit=credit[!is.na(credit$capital_central),]
credit=credit[!is.na(credit$capital_general),]
other$area=as.factor(other$area)
table((other$drained_organic_soil))
range(other$drained_organic_soil)
other=subset(other, other$drained_organic_soil!=0)
other$area=as.factor(other$area)
other$year=as.factor(other$year)
range(log(other$drained_organic_soil))
other=other[!is.na(other$fertilizer.nitrogen),]
other=other[!is.na(other$fertilizer.phosphate),]
other=other[!is.na(other$fertilizer.potash),]
other=other[!is.na(other$import),]
other=other[!is.na(other$pesticide),]
other=other[!is.na(other$value_of_production),]
other=other[!is.na(other$drained_organic_soil),]
other=other[!is.na(other$irrigated_land),]
other=subset(other, other$irrigated_land != 0)

other=other[!is.na(other$rainfall_index),]

other$exportlog=log(other$export)
other$valuelg=log(other$value_of_production)
hist(other$valuelg)
table(other$valuelg)
#other$fertnlog=log(other$fertilizer.nitrogen)
#other$fertpllog=log(other$fertilizer.phosphate)
#other$fertpotlog=log(other$fertilizer.potash)
#other$drainedlog=log(other$drained_organic_soil)
other$irrlog=log(other$irrigated_land)
other$rainlog=log(other$rainfall_index)
range(log(other$rainfall_index), na.rm=TRUE)
range(other$irrigated_land)
range(other$irrlog)
Agriculture =other
#options(scipen=999)
range(Agriculture$export)

boxplot(Agriculture$export ~ Agriculture$year, Main="Exports by Year",
      xlab="Year", ylab="Exports", col="Red", notch=TRUE, outline=FALSE)
```

```
hist(other$value_of_production, Main="Production", outline=FALSE, col="Blue")
boxplot(Agriculture$value_of_production ~ Agriculture$year, Main="Value
      of production by year", xlab="Year",
      ylab="Total Production", col="Red", notch=TRUE, outline=FALSE)

df = pdata.frame(other, index=c("area", "year"))

main = lmer(value_of_production~log(export) + log(export)+fertilizer.nitrogen +
   fertilizer.phosphate +fertilizer.potash+ pesticide +log(import)+
    drained_organic_soil+irrigated_land+rainlog + year+ (1 | area),
   data=other, REML=FALSE)

plmlog = plm(valuelg~log(export)+(fertilizer.nitrogen +
            fertilizer.phosphate +fertilizer.potash)*pesticide +log(import)+
            irrlog+rainlog,
           data=df,model="within")

plm= plm(value_of_production~log(export)+(fertilizer.nitrogen +
         fertilizer.phosphate +fertilizer.potash)*pesticide +log(import)+
         drained_organic_soil+irrlog+ rainlog,
       data=df, model="within")

summary(plm)
stargazer(main, plmlog, plm,type="text", single.row=TRUE)

#Assmuption and quality checkcs
hist(other$export)
hist(log(other$export))
cor(other$value_of_production, other$export)

library(AER)
library(car)

durbinWatsonTest(main)
durbinWatsonTest(plmlog)

ranef(plm)
ranef(plmlog)
stargazer(glm1, glm2, glm3, type="text", single.row=TRUE)
vif(plmlog)
vif(plm)
vif(main)
plmtest(plm, effect="twoways", type="bp")
pFtest(plm, main)


library(ggplot2)
library(tidyverse)
library(dplyr)
plot(credit$value_of_production, credit$recurrent_gen,
    pch = 19,
    xlab="Production", ylab="Recurrent Spending",
    col = factor(credit$year))
```

```
legend("topleft",
      legend = levels(factor(credit$year)),
      pch = 19, cex=.6,
      col = factor(levels(factor(credit$year))))

range(other$value_of_production)
mean(other$value_of_production)
values=subset(other, subset=value_of_production<23772382)
values=subset(values, subset=irrigated_land<2500)
plot(values$irrigated_land, values$value_of_production, pch = 19,
    xlab="Land Area in Hectares", ylab="Total Production",
    col = factor(values$area))
options(scipen=3)

########################
#Credit
#################

colSums(is.na(credit))
cor(credit[3:9])
hist(log(credit$recurrent_gen))
credit$logcentral=log(credit$capital_central)
credit$banklog=log(credit$bank_credit)
credit$logrecurrent=log(credit$recurrent_gen)
credit=credit[!is.na(credit$recurrent_gen),]
credit$logvalue=log(credit$value_of_production)
df2 = pdata.frame(credit, index=c("area", "year"))
creditplm = plm(logvalue ~ banklog + capital_central + recurrent_gen
          , data=df2,model="random")
summary(creditplm)
vif(creditplm)
```