# AGEC622 - Agribusiness Analysis and Forecasting

## 10_Exercises

- Complete the exercises in the provided notebook "10_exercises.xlsx". a
- If there is more than one question, note that each will have its own tab in the workbook.
- Work vertically down the sheet within your notebook. Separate the individual parts of the question(s) (a, b, c, ....) using dividing rows like the blue example dividers in the file.
- Submit your completed .xlsx file via Canvas.

The overall objective of this exercise is to evaluate several acreage decision and revenue protection insurance options for a farm that produces corn and soybeans and choose the scenario that you believe is the best. You will be using 4 marginal distributions for this exercise: $Beta$, $Uniform$, $Normal$ and $Empirical$.

**Part I**.

a) **Build a model for corn price.** Assume that a logarithmic transformation of corn price is a good idea. Check if the log transformation make data stationary, that is check if $ln(P_{corn})$ is stationary. If not, take the first difference, $\Delta ln(P_{corn})$. Check the transformed data for normality. Using log differences, compare CDFDEV values of 3 distributions: **normal**, **beta** and **uniform**. If the transformed data are normally distributed and CDFDEV value is not much different from the ones of the other 2 distributions, you can assume that these log differences are drawn from a **normal** distribution. If not, use a probability distribution that you deem appropriate.

b) **Build a model for corn yield.** Use a simple linear trend to model corn yield. Check the residuals for normality. Using the residuals, generate CDFDEV values from **normal**, **beta** and **uniform** distributions. Pick a probability distribution that you deem appropriate.

c) **Build a model for corn variable cost ($VC_{corn}$).** Assume that $VC_{corn}$ is a function of the diesel price (not the natural logarithm of $P_{diesel}$) and $Year$. That is:

$$VC_{corn} = \beta_0 + \beta_1 \times P_{diesel} + \beta_2 \times Year + \epsilon$$

Set up a multiple linear regression model. You will assume that these residuals are drawn from an **empirical** distribution.

d) **Build a model for soybean price.** Again, assume that a logarithmic transformation of soybean price is a good idea. Check if the log transformation make data stationary, that is check if $ln(P_{soybean})$ is stationary. If not, take the first difference, $\Delta ln(P_{soybean})$. Check the transformed data for normality. Using log differences, compare CDFDEV values of 3 distributions: **normal**, **beta** and **uniform**. If the transformed data are normally distributed and CDFDEV value is not much different from the ones of the other 2 distributions, you can assume that these log differences are drawn from a **normal** distribution. If not, use a probability distribution that you deem appropriate.

e) **Build a model for soybean yield.** Use a simple linear trend to model soybean yield. Check the residuals for normality. Using the residuals, generate CDFDEV values from **normal**, **beta** and **uniform** distributions. Pick a probability distribution that you deem appropriate.

f) **Build a model for soybean variable cost ($VC_{soybean}$).** Assume that $VC_{soybean}$ is a function of the diesel price (not the natural logarithm of $P_{diesel}$) and $Year$. That is:

$$VC_{soybean} = \beta_0 + \beta_1 \times P_{diesel} + \beta_2 \times Year + \epsilon$$

Set up a multiple linear regression model. You will assume that these residuals are drawn from an **empirical** distribution.

g) **Set up stochastic simulation for the diesel price.** Same as in case of corn and soybean prices, assume that a logarithmic transformation of the diesel price is a good idea. Check if the log transformation make data stationary, that is check if $ln(P_{diesel})$ is stationary. If not, take the first difference, $\Delta ln(P_{diesel})$. Check the transformed data for normality at **90%** level. If the transformed data are normally distributed, assume that these log differences are drawn from a **normal** distribution. If not, use an **empirical** distribution.

h) **Preparation for mixed marginals simulation.**

- Generate $u$ variables corresponding to all of the recovered historical values from parts a) through g) together in seven columns, using the appropriate $F_i(y)$ for each. **Be sure these are aligned correctly, with all observations on a row corresponding to the same observation date.** If you get a $u$ value $\geq 1.00$, replace it with 0.999. If you get a $u$ value $\leq 0.00$, replace it with 0.001.

  Depending on which distribution is appropriate for a given variable, you should use one of the following approaches to generate $u$ series:

  - $Beta = BETA.DIST(x, \alpha, \beta, TRUE, Min, Max)$
  - $Normal = NORM.DIST(x, \mu, \sigma, TRUE)$
  - $Uniform = UNIFORMDIST(x, Min, Max, TRUE)$
  - $Empirical = PERCENTRANK.INC(data, x)$
- Generate seven $z$ variables corresponding to the seven $u$ variables.
- Estimate a sample correlation matrix for the $z$ variables.

i) **Mixed marginals simulation calculations**

- Jointly generate all stochastic variables.
- Use the $u$ draws, along with each series' respective $F_i^{-1}(u)$ to calculate stochastic values for each series.
- Use the stochastic errors to calculate stochastic forecasts for the crop prices, crop yields, diesel price, and variable costs for year 2022 only.
- Simulate all 7 stochastic variables for year 2022 and generate the correlation matrix. Looking at the correlation matrix, do the relationship between the prices and yields look as expected?

**Part II**.

A farm rents 1350 acres and plants corn and soybeans. You will choose a particular acreage combination from among several available options that you believe is the best.

- **Scenario 1**: 675 acres of corn and 675 acres of soybean.
- **Scenario 2**: 900 acres of corn and 450 acres of soybean.
- **Scenario 3**: 800 acres of corn and 550 acres of soybean.
- **Scenario 4**: 450 acres of corn and 900 acres of soybean.

You need to set up a table with 2 rows (1st for corn and 2nd for soybeans) with four values in each row for corresponding acreage, and use the SCENARIO function to incorporate these values into the calculations of net returns (NR).

In addition to variable expenses, the farm also has fixed annual expenses of $550,000, which includes land rent, labor and other costs.

j) **Simulate 2022 ending cash under four scenarios.** Simulate ending cash for the five scenarios. For ending cash for all five scenarios, generate a stoplight chart and plot the CDFs. For stoplight chart, give lower cut-off value of 0 and upper cut-off value of $150,000.

k) **Interpret.** Which scenario do you prefer (based only on the stoplight output)? Note there may be some better scenarios among which your choice would depend on what criterion you use (that is, depends on your personal risk preferences).

**Part III.**

In this part, after you determine which acreage scenario is the best, you will evaluate several available options for revenue protection with harvest price exclusion (RPHPE) crop insurance, and choose one that you believe is best.

You will choose a particular coverage level for RPHPE crop insurance from among several available options. For some coverage level $c$, you would pay a fixed premium

$P_c$, and would receive a positive indemnity $I_c$ if your actual crop revenue falls below a threshold that is some proportion of your established revenue guarantee for each crop. Specifically, per acre revenue guarantee (RG) for each crop is determined as follows:

$$RG_{c,corn} = c \times 5.5 \times 175$$
$$RG_{c,soybean} = c \times 14.1 \times 52$$

the \$5.5 and \$14.1 are assumed level for what is known as the projected price at harvest time for corn and soybeans, respectively. The 175 and 52 are approved yields per acre for corn and soybeans, respectively. Finally, $c$ is a coverage level, which is one of the following:

$$0.75, 0.80, 0.85$$

Therefore, there are 9 possible scenarios (i.e. scenario 1: 75% coverage for corn and 75% for soybeans; scenario 2: 75% coverage for corn and 80% for soybeans, etc.).

Then, the indemnity for given crop per acre for coverage level $c$ is

$$I_{c,corn} = max(0, RG_{c,corn} - \tilde{P}_c \times \tilde{Y}_c)$$
$$I_{c,soybean} = max(0, RG_{c,soybean} - \tilde{P}_s \times \tilde{Y}_s)$$

where $\tilde{P}$ is your stochastic price and $\tilde{Y}$ is your stochastic yield for a given crop,

l) **Calculate financial variables for the enterprise.** Using the best acreage that you determined in **Part II**, now you will add components reflecting crop insurance choices. NR for each year should now reflect a crop insurance premium (a cost) for each crop and an indemnity (income). The indemnity should be calculated based on the information above and your simulated price and yield. The premiums for the different coverage levels for given crop are presented in the schedule below. You need to set up a table of four rows (first 2 rows will be for $c$ and the last 2 rows will be for premiums for each crop). Using $c$ and the corresponding premiums, use the SCENARIO function to incorporate these values into the calculations for the indemnity and NR (and, ultimately, these are reflected in ending cash). The premiums per acre are:

- for $c$=0.75, the premium for $P_{corn}$ = \$6.9 and the premium for $P_{soybean}$ = \$5.0
- for $c$=0.80, the premium for $P_{corn}$ = \$8.5 and the premium for $P_{soybean}$ = \$7.5
- for $c$=0.85, the premium for $P_{corn}$ = \$19.8 and the premium for $P_{soybean}$ = \$18.6

m) **Simulate 2022 ending cash under 9 scenarios**. Simulate ending cash for the 9 scenarios. For ending cash for all 9 scenarios, generate a stoplight chart and plot the CDFs. For soplight chart, use lower and upper cutoff values of \$0 and \$150,000, respectively.

n) **Interpret.** Which scenario do you prefer (based only on the stoplight output)? Note that there are some clearly wrong answers, but there may be some better scenarios among which your choice would depend on what criterion you use (that is, depends on your personal risk preferences). How effective was the RPHPE insurance in reducing risk for the operation? How do you think risk might be better reduced?

o) **Calculate 5% VaR.** After you pick the best insurance scenario, calculate a 5% VaR on 2022 ending cash (i.e. calculate the amount of capital reserves that should be held to avoid cash flow deficit).