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The Use of a Farm Simulation Game to Enhance Student Learning

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The Use of a Farm Simulation Game to Enhance Student Learning

Teaching a capstone class in farm management where over half the class plans to return to the family farm someday can be challenging due to the broad nature of the topic. Such a class must integrate topics from finance, production, and marketing while helping students develop their problem-solving skills. At this point in their collegiate careers, students have had classes learning about specific tools but they need an opportunity in one of their final major classes to put everything together and think like a farm manager. One option that can be used is a farm simulation game that combines financing, production, and marketing into a weekly exercise. This paper discusses a farm management simulation game that uses real data from the student's home state to help build their strategic management skills.

Background

There didn't appear to be any available farm management simulation games readily available that meant the instructors needs of: a focus on production and financing decisions, currently updated and suitable for Kansas, and that could be run as a series of weekly decisions. Thus, a simulation game was developed using the database/spreadsheet program Quantrix (www.quantrix.com).

Quantrix is a unique piece of software as it shares characteristics of both a spreadsheet and a database. The software has the look of a spreadsheet but formulas are entered not into the cells but into a separate formula window. Formulas can be applied to just single cells or to sections of tables or to entire tables at one time. Quantrix uses the concept of dimensions to help organize data. For example, financial data for a company might have one dimension for years and a subdivision for quarters while at the same time having dimensions for country and

product category. What makes Quantrix unique is that these dimensions can be rearranged without affecting the formulas to get new insights about the data.

Quantrix was chosen for the simulation game because it meant the needs of having a program that could incorporate Kansas farm data and represent production and financial data and be used in weekly decisions for the class. The biggest advantage of Quantrix though was the ability to expand the size of the game as needed. For example, running extra rounds of the game or adding more groups was not an issue and did not require any programming or formula changes. The only thing to do was to add more years under the year dimension and more groups under the group dimension.

The simulation game was based on Kansas farm data from southeast Kansas and represents Kansas Farm Management Association (KFMA) data from that area. Information about yields, crop prices, and cost of production from southeast Kansas were all used to develop the game. Some of the numbers were modified slightly so that student groups could usually earn a profit in a round of the game but not always be profitable.

The game was limited to a crop production game where students could plant corn, soybeans, wheat, or double-crop soybeans in each year. Students also had choices about buying or renting more land but only in years where the instructor allowed them these choices. Students could also borrow money in a year and choose the number of years of the loan. They could buy more machinery and at some point, they would have to as machinery depreciated over time. Machinery levels were actually a key variable as the average machinery investment per acre and the average age of their equipment drove the cost of production. Family living was

an input that needed a choice each year and students could also move money into either a savings or stock fund. These choices are detailed in the game handout at the end of this paper.

Every week of class represented one year of the game simulation and students made their decisions by Tuesday, and by Thursday the instructor would provide the results. The results were in the form of a set of financial statements (income statement, balance sheet, and cash flow statement). The instructor set up a Google spreadsheet via Canvas so that students could go online when they were ready and enter their game choices for that year. The instructor would then copy these input choices and paste them directly into the game simulation programs. Finally, the instructor would print the financial statements for each group and post them to Canvas.

Teaching Points

The purpose of the game was to tie everything the instructor was teaching in class together into a single model where students could practice strategic management and decision making. Before any rounds of the game were run, the instructor gave the students details about the farm including the farm size, the number of rented acres, the current balance sheet, and a 20 year history of yields and prices. The students were to assume they were going back to the family farm.

Students were divided into teams of their choosing with a maximum group size of 3 members. The instructor also allowed students to go alone if they preferred. Groups were first to develop a business plan that provided information about how the farm intended to incorporate a son or daughter returning to the family farm. Once the business plans were completed the instructor started the rounds of the game.

The next major topic in class was a discussion of the farm financial ratios. It was important to understand these and how to use them as the feedback from the game each week was a set of financial statements. Other class topics included budgeting, production decisions, asset replacement, and land control (both purchasing and renting).

Once the game was over (8 weeks of simulations), groups had to write a report and, at a minimum, answer some basic questions (see description of the final report at the end of the paper). Included in this report was an analysis of the financial ratios and a discussion of how well they meant their business plan.

Sticking points

One of the biggest initial problems with the simulation game is getting students to understand double cropping. This is an unfamiliar concept to western Kansas students as the instructor has come to believe that some students think double cropping is planting crops two years in a row without a fallow period. The double cropping decision may be more complicated because what students decide about planting wheat in one year affects their planting decision the next year. The game keeps track of that but it takes some students long to realize the carryover effects of their prior year's decisions.

Purchasing land can be an issue as well. The instructor doesn't cover land purchasing and renting decisions until after the game has been going on for a while. Thus, the first time in the game the students have that option to buy more ground they don't fully have the tools to evaluate the decision. Sometimes students think that buying more ground is always good without realizing there may be better opportunities for their funds.

As discussed above, the amount of machinery investment per acre and the average age affects the cost of production. As the investment per acre decrease and the average age increases, the cost per acre rises. There is some delay before these factors start affecting a group's profit so many groups will let their equipment depreciate too much before they start replacing it.

Conclusions

Overall, students seem to enjoy the game and the instructor can see improvements in the decisions the groups make during the run of the game. The game does seem to combine the elements that are being taught in the class together into a single framework. Thus the game helps to achieve the strategic management of the class description.

The only problem the instructor sees is that topics being taught in lecture sometimes are being taught after the game has begun. There probably is no good solution for this since the game's aim is to integrate topics. Thus, many decision-making issues are in play before being formally discussed in class. Business planning is always discussed before the simulation begins though.

There are some potential changes being considered for future years. Currently, there is always one price for any land purchases or land rentals that become available. This is set before the game begins. It might be possible to base land purchase price and rental rates on average profits from the last few years.

Also missing is anything about crop insurance, forward contracting, or other marketing decisions. Some of these areas could be incorporated into the game as well but at a cost of making the game more complicated. It seems that some groups struggle with the concepts that

are currently in play. Perhaps these other areas could be added mid-point into the game simulation so as not to overwhelm students at the start.

APPENDIX 1 – HANDOUT TO STUDENTS ABOUT THE GAME
Information for Group Project – Fall 2016

Basic farm information

Farm size 1,400 acres (500 acres owned and 900 acres cash rented)
 Starting cash \$200,000
 Starting machinery \$500,000 - Age of 5 years
 Starting loans \$400,000 at a 4% interest rate – 10 years left on loan

Historical numbers

Yields

Year	Corn	Soybeans	Doublecrop soybeans	Wheat
A	106	39	38	45
B	103	35	15	38
C	88	36	28	40
D	172	43	42	68
E	119	33	13	57
F	118	35	6	47
G	149	32	30	59
H	147	35	35	64
I	131	33	19	46
J	139	40	29	67
K	164	35	35	52
L	137	29	24	47
M	130	29	21	53
N	117	31	25	16
O	150	42	36	38
P	144	48	46	45
Q	149	38	38	35
R	75	25	15	61
S	85	29	15	80
T	113	33	25	84
U	160	42	39	72

Prices

Year	Corn	Soybeans	Doublecrop soybean	Wheat
A	3.58	8.38	3.91	
B	3.80	7.05	4.39	
C	3.50	8.57	4.95	
D	3.36	8.73	3.80	
E	3.25	8.17	3.67	
F	3.80	7.73	3.35	
G	3.25	9.13	3.45	
H	3.36	7.65	4.45	
I	3.14	7.05	3.44	
J	3.47	8.25	3.49	
K	3.36	8.97	3.63	
L	3.80	7.77	3.38	
M	3.58	8.85	4.20	
N	3.35	9.45	3.96	
O	4.60	6.91	4.95	
P	3.68	6.69	3.58	
Q	3.75	6.63	3.45	
R	4.81	7.65	5.15	
S	4.77	8.25	5.27	
T	4.94	8.21	5.21	
U	3.92	8.33	4.42	

Net Farm Income

Year	NFI
A	20,317
B	-102,555
C	-47,317
D	196,075
E	-76,405
F	-89,571
G	48,415
H	71,197
I	-91,750
J	64,739
K	103,004
L	-19,519
M	-6,295
N	-68,318
O	134,204
P	82,074
Q	23,347
R	-83,136
S	9,960
T	140,656
U	215,254

Beginning of game balance sheet

Balance Sheet			
Current Assets			Current Liabilities
Cash	200,000	Loan Principal due	
Savings	0	< 12 months	33,316
Stocks	0		
Investment in growing crops	\$0		
TOTAL CA	\$200,000	TOTAL CL	\$33,316
Non-Current Assets			Non-Current Liability:
Machinery	500,000	Loan Principal due	
Land	1,400,000	> 12 months	366,684
TOTAL NCA	\$1,900,000	TOTAL NCL	\$366,684
TOTAL ASSETS	\$2,100,000	TOTAL LIABILITIES	\$400,000
		OWNERS EQUITY	\$1,700,000
		TL + EQUITY	\$2,100,000

Information for each student group to enter each round of the game

Corn acres	Soybean acres	Double crop soybean acres	Wheat acres	Additional cash rent acres	Acres to purchase	Debt (loan)	Years of loan	Machinery purchase	Family living	Savings	Stock
1	2	3	4	5	6	7	8	9	10	11	12

Boxes 1-4 (Crop acres)

- Crop allocation decisions (and all other decisions) are made the first week of January
- Total acres for growing crops are equal to the original acres owned (500 acres) plus the original cash rented acres (900 acres) plus any additional purchased or rented land.
 - When the acreage decision is being made for corn and conventional soybeans, remember that your group may have planted wheat the year before. Any ground in wheat cannot be planted into corn or conventional soybeans.
 - Any and all wheat acres from the year before may be planted with double crop soybeans
 - Wheat acreage for the current year has no restrictions other than your group cannot exceed the total acres on the farm.
 - Currently there are no restrictions or penalties for growing continuous crops
 - This could change during the game so that a yield penalty is invoked for growing the same crop on the same acreage two years in a row.

- Crop Income = crop price * crop acres * crop yield
 - You won't know what the yields and prices are for the crops until after the game period is over. However, the historical numbers provided in the first table should give you a guideline for the ranges that could occur.
 - Wheat acres were allocated in the previous year but the revenue is realized in the current year

- Crop expenses – two parts: variable and fixed expenses
 - Variable expenses
 - Crop specific expenses each year consist of 2 components – Repair & maintenance and other variable expenses. These are the per acre cost and are added together to get the total variable expenses per acre
 - Other variable expenses (seed, chemicals, fertilizer, fuel, etc).
 - Corn \$257.59
 - Soybeans \$132.80 (this applies to double crop soybeans as well)
 - Wheat \$130.49

 - Repair & maintenance
 - Corn \$35
 - Soybeans \$27 (this applies to double crop soybeans as well)
 - Wheat \$25
 - While the other variable expenses are constant, the repair and maintenance number can change depending on the machinery base per acre and also the weighted average age of machinery (see table below). An analysis of recent KFMA farms shows that the average farm has around \$300 machinery value per acre. Thus this is a value you should keep track of. If the machinery investment per acre starts to drop below \$300 per acre, the repair and maintenance cost per acre increases by a factor indicated in the table below. This increase reflects more repair and maintenance and also the use of custom operations. The repair and maintenance adjustment also is dependent upon the average age of machinery.

 - Non-specific variable crop expenses
 - Cash rent per acre – \$110 per acre

- Fixed expenses – Depreciation
 - Tax and management depreciation are the same. Depreciation reflects the actual decline in asset value each year. Depreciation follows a declining balance equation. The table below shows the year to year change in asset value. Each asset is expected to last 13 years.

Year	% yearly change in asset value	Example of asset declining value
Start	0%	\$100.00
1	15%	\$85.00
2	15%	\$72.25
3	15%	\$61.41
4	15%	\$52.20
5	15%	\$44.37
6	15%	\$37.71
7	15%	\$32.06
8	15%	\$27.25
9	15%	\$23.16
10	20%	\$18.53
11	30%	\$12.97
12	50%	\$6.49
13	100%	\$0

- Assets cannot be sold or traded in and will appear on the balance sheet until they are totally used up at the end of 13 years.
- New assets can be bought in a given year but must be purchased in increments of \$100,000
- The yearly financial statement will list the average asset age at the end of the year. This is a weighted average.
- Not having enough machinery on your farm will increase the yearly repair and maintenance cost.
- The following table contains the repair and maintenance adjustment factor. This is based on 2 criteria:
 - The left hand column is the average machinery investment per acre
 - The row header is the average machinery age.
 - The machinery investment per acre and the average machinery age are recomputed after you make any machinery purchases for the year. Thus, any new purchases for the year will affect the repair and maintenance adjustment factor.

Column\	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
0	300%	303%	306%	309%	312%	315%	318%	321%	324%	327%	330%	333%	336%	339%	342%
25	295%	298%	301%	304%	307%	310%	313%	316%	319%	322%	325%	327%	330%	333%	336%
50	290%	292%	295%	297%	299%	302%	304%	306%	309%	311%	313%	316%	318%	320%	322%
75	275%	277%	279%	282%	284%	286%	288%	290%	293%	295%	297%	299%	301%	304%	306%
100	250%	252%	254%	256%	258%	260%	262%	264%	266%	268%	270%	272%	274%	276%	278%
125	230%	232%	234%	236%	237%	239%	241%	243%	245%	247%	248%	250%	252%	254%	256%
150	225%	227%	229%	230%	232%	234%	236%	238%	239%	241%	243%	245%	247%	248%	250%
175	220%	222%	224%	225%	227%	229%	231%	232%	234%	236%	238%	239%	241%	243%	245%
200	180%	181%	182%	183%	184%	185%	185%	186%	187%	188%	189%	190%	191%	192%	193%
225	150%	151%	152%	152%	153%	154%	155%	155%	156%	157%	158%	158%	159%	160%	161%
250	120%	121%	121%	122%	122%	123%	124%	124%	125%	125%	126%	127%	127%	128%	128%
275	105%	106%	106%	107%	107%	108%	108%	109%	109%	110%	110%	111%	111%	112%	112%
300	100%	100%	101%	101%	101%	102%	102%	102%	102%	103%	103%	103%	104%	104%	104%
325	100%	100%	101%	101%	101%	102%	102%	102%	102%	103%	103%	103%	104%	104%	104%
350	100%	100%	101%	101%	101%	102%	102%	102%	102%	103%	103%	103%	104%	104%	104%
375	95%	95%	96%	96%	96%	96%	97%	97%	97%	98%	98%	98%	98%	99%	99%
400	90%	90%	91%	91%	91%	91%	92%	92%	92%	92%	93%	93%	93%	94%	94%
425	90%	90%	91%	91%	91%	91%	92%	92%	92%	92%	93%	93%	93%	94%	94%
450	90%	90%	91%	91%	91%	91%	92%	92%	92%	92%	93%	93%	93%	94%	94%
475	80%	80%	80%	81%	81%	81%	81%	82%	82%	82%	82%	83%	83%	83%	83%
500	80%	80%	80%	81%	81%	81%	81%	82%	82%	82%	82%	83%	83%	83%	83%

Box 5 (additional cash rent acres)

- The end of the year printout will indicate if you can rent additional ground the following year
- You can rent some or all of the available land to cash rent in the upcoming year
- Once you rent land, it's your ground throughout the game. That is, you don't have to indicate the next year that you are re-renting the same ground again.

Box 6 (acres to purchase)

- The end of the year printout will indicate if you can purchase additional ground the following year.
- The purchase price for ground will come from your cash account. More than likely, you'll need some additional cash, so loans are available as indicated in the next two boxes

Boxes 7 and 8 (new loan and the years of the loan)

- You can borrow any amount of money you want during each year of the game. You are also free to choose the loan maturity. Loans have a different interest rate depending upon the length of the loan.

Years	Planned	Emergency
0	3.25%	8.00%
1	3.25%	8.00%
2	3.25%	8.00%
3	3.50%	8.00%
4	3.50%	8.00%
5	3.50%	8.00%
6	4.00%	8.00%
7	4.00%	8.00%
8	4.00%	8.00%
9	4.50%	8.00%
10	5.00%	8.00%
11	5.00%	8.00%
12	5.00%	8.00%
13	5.50%	8.00%
14	5.50%	8.00%
15	5.50%	8.00%
16	5.50%	8.00%
17	6.00%	8.00%
18	6.00%	8.00%
19	6.00%	8.00%
20	6.50%	8.00%
21	6.50%	8.00%
22	6.50%	8.00%
23	6.50%	8.00%
24	6.50%	8.00%
25	6.50%	8.00%
26	6.50%	8.00%
27	6.50%	8.00%
28	6.50%	8.00%
29	6.50%	8.00%
30	6.50%	8.00%
31		8.00%

- Loan rates are also adjusted by the new debt-to-asset ratio as computed by your group's planned borrowing. As long as the D/A ratio is below 40%, there is no additional interest cost. However, if the D/A ratio is between 40% and 50%, there is an additional 1% added to the above interest rate. Any D/A ratios above 50% will incur an additional 2% charge.
- The emergency loan interest rate is for those situations where you end up the year with a negative cash balance. As you can never have negative cash, your group is automatically assessed an emergency loan equal to the negative cash
 - Emergency loans are always for 1 year.
- All borrowing is assumed to take place in early January, those there will be interest and a principal payment due the first year. This interest and principal payment is for a full time frame. Thus you can look at the interest and principal amounts in year 1 as what will occur in the year you take out a loan.
- At this time, there is no way to pay off a loan early.

Box 9 – machinery purchases

- Machinery can be purchased in any or all of the years
- Machinery follows the depreciation schedule as listed above
- Machinery is considered to be purchased in early January so the first year will have a full depreciation amount
- Tax and management depreciation are the same number
- Machinery last 13 years before fully depreciating
- As this time, there is no way to trade equipment (i.e., you are always purchasing new without any tradeins)
- Keeping around \$300 of machinery value per physical acre will keep the repair and maintenance cost at around 100%. Letting this value drop will start to significantly increase the rate on repair and maintenance.
 - The machinery value per acre is calculated from the total physical crop acres not the actual acres in production. For example, you start the game with 1,400 acres but with double cropping, you farm 2,000 acres. The value per acre calculation is based on the 1,400 acres.

Box 10 – family living

- Every year your group needs to take some money out for family living.
- Family living can vary every year as needed to account for a previous bad year
- Family living should reflect your business plan
- Taking out more in family living than your farm earned is not a problem as long as there is the cash available to account for the withdrawal

Box 11 and 12 – savings and stock purchases

- These are the only two places where you can enter a negative number in addition to a positive number
 - A positive number means you are adding cash to either a savings account or a stock fund
 - A negative number means you are taking money out of the account and back to cash
- Cash will not automatically come out of savings if you run out of cash. Running out of cash even with money in savings will still result in an emergency loan the next year.
- Money in savings will earn 2% per year.
- Money in the stock fund will earn 5% per year
- Money can be moved in or out of savings with no additional fee
- Money moved out of the stock fund will incur a 10% expense charge (e.g., if you take \$100 out of the stock fund, you will only get back \$90)

Other important information

- The farm is based on a typical farm from Wilson County, Kansas
- The historical yields and prices have been adjusted to reduce variability
- There is no inflation during any of the game
- Machinery can only be purchased in \$100,000 increments
- Land has a value of \$2,800 per acre
- Cash rents are \$110 per acre
- Once you rent additional land, it's yours through out the rest of the game (i.e., you don't have to re-rent the next year)
- You can only rent or purchase land when available (i.e., I will tell you at the start of a given year if there is land available to either rent or purchase)
- If you run out of cash during the year (e.g., your ending cash balance is less than zero), you will start the year with an emergency 1-year loan that is equal to the amount of negative cash.
- It is very likely that some errors still exist in this simulation game, I reserve the right to make any changes
 - Some of these changes might affect previous financial statements
 - Some of the adjustment tables might have to be tweaked

Financial information for year ending 2017 A

	Corn	Soybeans	DC_beans	Wheat	Farm acreage			Land values/rents – next year	
					Owned	Cash rented	Total acres	Land value	Cash rent
Yields	87.5	36.0	27.5	39.8					
Prices	\$4.10	\$9.92	\$9.92	\$5.72	500	900	1,400	2,800	110

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Cash flow statement

Cash – Beginning of year	\$291,512
INFLOWS	
Grain sales	715,397
Borrowing	0
Redemption from savings	0
TOTAL INFLOWS	715,397
OUTFLOWS	
Cash crop expenses	391,636
Repairs and maintenance	66,700
Cash rent	99,000
Loan principle	36,035
Loan interest	13,281
Family living	
Addition to savings	0
Land purchases	
TOTAL OUTFLOWS	606,652
Net Change in Cash	\$108,744
Cash – End of year	\$400,256

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Income statement

REVENUE	
Crops	\$715,397
INTEREST EARNED	
Savings	
Stocks	
Gross Revenue / VFP	\$715,397
EXPENSES	
CASH OPERATING EXPENSES	
Crop production	\$391,636
Repair & maintenance	\$66,700
Cash rent	\$99,000
Depreciation	\$88,272
Stock fees	
Total Operating Expenses	\$645,608
Interest	\$13,281
TOTAL EXPENSES	\$658,889
NFIFO	\$56,507
Gain/loss sale asset	\$0
NFI	\$56,507

Average age of machinery 5.6 Years

Balance Sheet

Current Assets		Current Liabilities		Additional loan information
Cash	400,256	Loan Principal due		
Savings	0	< 12 months	37,476	
Stocks	0			
Investment in growing crops	\$16,311			
TOTAL CA	\$416,567	TOTAL CL	\$37,476	
Non-Current Assets		Non-Current Liabilities:		
Machinery	500,208	Loan Principal due		
Land	1,400,000	> 12 months	258,523	
TOTAL NCA	\$1,900,208	TOTAL NCL	\$258,523	
TOTAL ASSETS	\$2,316,775	TOTAL LIABILITIES	\$296,000	
		OWNERS EQUITY	\$2,020,776	
		TL + EQUITY	\$2,316,775	

Example of the financial statements your group will receive each year.

APPENDIX 2 – INFORMATION ABOUT THE FINAL REPORT

Group Project Requirements and Questions to Answer

Below are the questions your group should answer. I expect #1 to be an excel spreadsheet. The other 6 questions should be answered in the space of around 4 to 5 double spaced pages. This group project is due on Monday , December 5th.

1. Calculate the 16 financial ratios discussed in class for the first year of the simulation game and for the last year. Some of the ratios need a value of unpaid labor so for these ratios use \$50,000. Also some of the ratios use the average of the beginning and ending balance sheet numbers. For these ratios, just use the ending balance sheet number (e.g., ROA calculation is based on the average of the beginning and ending assets in the denominator. Just use the end of the year assets in the calculation).
2. Based on the historical yields and prices plus the yields and prices you've seen during the game, discuss your choice of crop allocation throughout the game. As part of this discussion be sure to discuss which crop is the most/least profitable and which is the most/least risky.
3. Based on what you've seen through the game, discuss the amount of cash that your farm should maintain.
4. Did your group use any of the saving options (i.e., savings account, stock mutual fund)? Discuss why or why not.
5. Discuss your group's decision to purchase land throughout the game. Did your group purchase all the land offered? Why or why not.
6. Discuss your group's financing decisions during the game. What was the reasoning for amounts borrowed and the length of the loans.
7. Discuss how your decisions during the game were influenced by your business plan. Did you feel you meet your business goals after all rounds of the game were completed.