AgVenture: A Farming Strategy Computer Game

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ABSTRACT

Agricultural production takes place in a risky, uncertain environment. Teaching students and agricultural producers how to manage these risks is difficult. Simulations or games have been used to provide students hands-on experience in managing hypothetical farms. AgVenture is a new computer program designed to teach risk management strategies and reinforce traditional farming management principles. The program allows teaching or extension faculty to develop a simulated crop farm appropriate for their area or educational interests. Students then choose the crops they would like to produce, determine profit-maximizing fertilizer applications, make machinery buy-sell-trade decisions, and manage their land and irrigation resources. After making their annual cropping and management decisions, AgVenture generates a variety of reports for students, including income statements, balance sheets, and cash flow reports. These reports are distributed to students, who then use the information to make decisions for the next simulated year of production. Up to 5 simulated years are possible in the game. Playing the game allows students to practice using principles presented by their instructor. A phase-in approach to decision-making in the game appears to be most effective, where students are asked first to focus on one specific decision area, and as the game progresses, students address additional decision areas. Students evaluated the game as being useful and helpful in learning farm management principles.

The economic principles of farm and ranch management are well-known by agricultural economists, and are taught to students (including agricultural producers, consultants, and other agricultural professionals) using a variety of methods. These principles include opportunity costs, marginal analysis, and expected returns under uncertainty. While these principles are simple to explain, it is hard to provide students with opportunities to practice using them in real-life situations. Without practice applying these principles, it is less likely that they will be used effectively in actual management situations.

Experiential learning is the process of gaining knowledge through experience and behavior (Kolb, 1984). Games are commonly used tools for experiential learning. The Association for Business Simulation and Experiential Learning (Gentry, 1990) lists 75 different games available for teaching business and economics, several of which apply to agricultural business management. An early review of agricultural economics games revealed that in 1965, teachers used 10 different games to teach 31 agricultural economics courses in 17 universities (Babb and Eisgruber, 1966). Most of these games were farm management games. Since then, a number of new or modified games have been developed. Boehlje et al. (1973) suggest that games become an increasingly important part of farm management education, based on their experience with a farm management game integrated with a budget generator and linear programming model. Menz and Longworth (1976) reinforce this sentiment in describing their farm management game developed in Australia. A farm management game developed in Oregon was documented by Conklin (1977). More recently developed programs include Harsh (1984), Babb (1985), and Babb (1987), to name a few.

A limitation of many previous farm management games is that they were typically developed for particular farm situations, and resources and management practices could not be changed by users. For example, the simulator developed by Conklin (1977) included a specific set of farm resources (including land and machinery) and seven possible crop enterprises. Changes in farm resources or crop alternatives required significant reprogramming of the simulator, making it costly and time consuming to update or change the program. Because many of these early programs were in mainframe computers, modifications required due to changes in hardware and operating system software were also expensive. Powerful desktop computers provide the opportunity to develop a flexible farm management game that can be tailored to represent almost any type of crop farm. This article describes a recently developed microcomputer-based farm management game called AgVenture. The objective of the program is to allow students to practice making management decisions for a model crop farm designed and administered by their instructor over a simulated 5-yr time period.

PROGRAM DESCRIPTION

The AgVenture system includes three menu-driven program modules. FSETUP allows the instructor to design model farms and specify crop alternatives, costs and returns, and farm resource requirements and availability. Students run FINPUT to enter their decisions for the coming year of the game, based on the case farm described by the instructor. Finally, FPROCESS is used to read students’ decisions, calculate results, and print reports. The three program modules are discussed below, followed by a brief discussion of methods in which the system has been used in Oregon.

FSETUP

The FSETUP module enables instructors to describe all the resources and alternatives available to students, including crop alternatives, cultural operations, land, machinery, irrigation, financing terms, and initial balance sheets. This module is used only by the instructor to create the simulated farm scenario desired. Students are not permitted to run FSETUP.
Crops. Up to 45 different crops may be entered, to provide students with ample opportunities for making enterprise selection decisions. The crops entered are determined by the instructor and may include any annual or perennial crops for which adequate data is available. A production function in the form of a table or equation, using up to two variable inputs is specified for each crop, along with production expenses, harvest units, soil requirements, irrigation expenses, and standard deviations of yields. The yield deviations represent production variability due to weather, disease, pests, and genetic variations in simulating the uncertain production environment farmers face. A cumulative price probability distribution is entered to simulate uncertain markets and prices over time for each crop. Price distributions are entered following a method employed by King (1989). Soil requirements for each crop are also specified by the instructor.

Table 1 shows the first data entry screen for crops, using irrigated wheat (*Triticum aestivum* L.) as an example. In this example, wheat yield is measured in kg ha⁻¹. Irrigation and production costs (excluding machinery operating and fixed costs and fertilizer costs) are entered by the instructor, as well as an equation to calculate yields. Yield equations may be specified using a quadratic form and two independent variables labeled $N$ and $P$ in the program. The variables $N$ and $P$ may represent nitrogen and phosphorus or any other pair of variable inputs that can be used to estimate production levels given alternative levels of the two inputs. Alternatively, two-way tables showing observed levels of $N$ and $P$ and resulting crop yields may be entered to represent crop production functions.

**Machinery.** Twenty-one different machine types can be entered by the instructor, based on the crops that are available to be produced. Machines may be self-propelled (such as combines, swathers, or trucks) or used to pull implements (such as tractors or crawlers). Multiple machines of each type may be owned and used on the model farm. The instructor specifies purchase prices, repair parameters, fuel costs, depreciation rates, and labor costs for operating each machine. In addition, ages, hours of previous use, and loan values are specified for used machinery on the model farm. Repair costs follow standards set by the American Society of Agricultural Engineers (1988). Depreciation rates are constant, resulting in declining balance depreciation patterns. An example of the type of data necessary for machines is shown in Table 2 for a 41 013-W (55-hp) tractor. In this example, the tractor was originally purchased for $15,000, depreciating at a rate of 25% annually. It is 5 yr old with 3,000 h of use. No loan balance is outstanding for this tractor. Fuel and labor costs of operation are shown as costs per hour of use, and the tractor is available for up to 1,000 h of use during each simulated year of the game. Repair parameters are specified based on agricultural engineering estimates.

**Operations.** Production activities are entered by instructors as operations, and up to twenty-one different types of activities are allowed. Operations are jobs performed on a crop using one machine type. The same operation may be specified for more than one crop and may be performed using any one of several machines. For example, one production activity might be plowing, and one or more crops entered by the instructor may require that they be plowed prior to planting. Plowing a grain crop (such as wheat) might ideally be accomplished using a 111 855-N (150-hp) tractor, but smaller tractors might ac-

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**Table 1.** Example data entered for a wheat crop in the FSETUP module, representing production and cost relationships for the crop.

<table>
<thead>
<tr>
<th>Input</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop name†</td>
<td>Wheat</td>
</tr>
<tr>
<td>Crop unit (kg, cwt, or other measure)††</td>
<td>kg</td>
</tr>
<tr>
<td>Is the crop irrigated? (yes or no)‡</td>
<td>Yes</td>
</tr>
<tr>
<td>Irrigation expenses ($ ha⁻¹)‡‡</td>
<td>88.88</td>
</tr>
<tr>
<td>Other crop expenses ($ ha⁻¹)‡‡</td>
<td>66.67</td>
</tr>
<tr>
<td>Standard deviation of yield unit ha⁻¹†††</td>
<td>538</td>
</tr>
<tr>
<td>Yield equation (unit ha⁻¹)</td>
<td>$Y = 4027 + 103.944N - 0.0667N²$</td>
</tr>
</tbody>
</table>

† Crop names are selected by instructors and can be up to 10 characters in length.
†† The crop unit represents the unit in which production of the crop is measured.
‡ Yes for irrigated crops and no for dryland crops. Irrigated crops cannot be produced on nonirrigated fields.
‡‡ The cost to apply the total water required by the crop during the crop year, including labor and irrigation system variable and fixed costs.
§ All other direct crop expenses excluding costs of irrigation, variable inputs $N$ and $P$, machinery operations, and interest on operating capital.
††† The program assumes yields are normally distributed, and uses the standard deviation of yield to estimate stochastic yield of each crop for each simulated year of the game.
‡‡‡ Yields are entered as production functions of up to two variable inputs, $N$ and $P$. The variable $Y$ represents the yield estimated for each student based on their desired levels of $N$ and $P$ for each crop. Yield deviations for each crop are then estimated based on the standard deviation of the crops.

**Table 2.** Example data entered for a 41 013-W (55-hp) tractor in the FSETUP module, illustrating the input requirements for machinery entered in the program.

<table>
<thead>
<tr>
<th>Input</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine name†</td>
<td>55-hp tractor</td>
</tr>
<tr>
<td>Purchase price ($#)§§</td>
<td>15,000</td>
</tr>
<tr>
<td>Depreciation rate (% yr⁻¹)§§</td>
<td>25</td>
</tr>
<tr>
<td>Cost of fuel used during machinery operation ($ h⁻¹)§§</td>
<td>5.90</td>
</tr>
<tr>
<td>Cost of labor used during machinery operation ($ h⁻¹)§§</td>
<td>8.00</td>
</tr>
<tr>
<td>Age of machine (yr)§§</td>
<td>5</td>
</tr>
<tr>
<td>Current loan balance ($#)§§</td>
<td>0</td>
</tr>
<tr>
<td>Hours available each year†††</td>
<td>1,000</td>
</tr>
<tr>
<td>Accumulated use (h)§§</td>
<td>3,000</td>
</tr>
<tr>
<td>Repair parameter 1‡‡‡</td>
<td>0.029</td>
</tr>
<tr>
<td>Repair parameter 2‡‡‡</td>
<td>1.500</td>
</tr>
</tbody>
</table>

† Machine names are selected by instructors and can be up to 15 characters in length.
§§ The purchase price is used as a starting point for calculating depreciation. It also is the price students must pay to buy a new machine.
†† The declining balance depreciation method is used to calculate annual depreciation and book values of machinery.
‡ The age is entered for an existing machine. New machines purchased by students are 0 yr of age at the time of purchase.
§§ An outstanding loan balance may be specified for each machine at the beginning of the game. Loans are paid off during the game, and new loans may be obtained for purchases of new machinery.
††† If estimated machinery use for a machine exceeds its maximum hours available each year, another machine is used or remaining hours of machine time are custom-hired.
‡‡‡ The accumulated use on an existing machine should be consistent with the age specified above. Accumulated use for machines purchased new is 0.
‡‡‡‡ An agricultural engineering function is used to estimate repair costs, and two repair equation parameters are entered for each machine.
Table 3. Example data entered in the FSETUP module for a light land preparation operation for wheat using a 41 013-W (55-hp) tractor.

<table>
<thead>
<tr>
<th>Input</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation name†</td>
<td>Light land prep.</td>
</tr>
<tr>
<td>Machine name‡</td>
<td>55-hp tractor</td>
</tr>
<tr>
<td>Crop name</td>
<td>Wheat</td>
</tr>
<tr>
<td>Time required to perform operation (h ha⁻¹)</td>
<td>1</td>
</tr>
<tr>
<td>Implement operating cost ($/h)§</td>
<td>1.20</td>
</tr>
<tr>
<td>Implement depreciation cost ($ h⁻¹)¶</td>
<td>0.95</td>
</tr>
<tr>
<td>Preference rating (1-3)#</td>
<td>3</td>
</tr>
<tr>
<td>Custom charge ($/ha⁻¹)††</td>
<td>26.67</td>
</tr>
</tbody>
</table>

† Operation names are specified by instructors and can be up to 20 characters in length.  
‡ The machine and crop specified for each operation must have been entered in the FSETUP module machinery and crop data, as described in Tables 1 and 2.  
§ The program assumes that an appropriate set of implements is available for each machine owned. The repair and maintenance cost of operating these implements must be entered, consistent with the size of the machine, the operation performed, and the time required to perform the operation.  
¶ Implements are assumed to depreciate following the straight-line method based on hours of annual use.  
# Preference rating is based on a scale with 1 representing the most preferred machine and 3 as the least preferred machine. For example, a large tractor may be preferred over a small tractor for performing heavy tillage operations, but both can perform these operations using different sets of implements and at different rates of performance. AgVenture allocates machines to operations by first considering their preference rating, and secondly by considering the time available for each machine.  
†† If no machine time is available to perform the operation, it will be custom-hired at the rate specified. If no custom-hire rate is specified, the program assumes no custom-hire option is available and any land area on which no machine time is available to perform the operation results in no crop production.

Table 3 contains an example of an operation called light land preparation. Using the 41 013-W (55-hp) tractor to perform light land preparation for a wheat crop requires 1 h ha⁻¹ of tractor time. Implements used to perform this operation cost $1.20 h⁻¹ and $0.95 h⁻¹ for operating and depreciation expenses, respectively. The preference rating of 3 indicates that this machine is not highly desirable for performing this operation. The custom charge represents the cost of hiring an off-farm contractor to perform this operation.

Land and Irrigation. Land in AgVenture is divided into distinct fields, and each field can be from 0.4 to 400 ha (1-999 acres). The instructor also identifies which fields are owned, and which fields (if any) are vacant. Vacant fields are those which students can choose to rent or purchase, at costs specified by their instructor. Each field can be defined as dryland farmed or irrigated, with two different irrigation systems available. Irrigation systems may be defined as labor-intensive or capital-intensive, representing hand-move systems and center-pivot systems, for example. Irrigation system purchase prices and useful lives are also specified. The program permits students to add irrigation systems to dryland fields at costs specified by the instructor.

AgVenture allows the instructor to define two generic soil categories. These are referred to in the program as high quality soil and low quality soil. Obviously, this is a gross simplification compared to real-world soil types. However, with two general soil categories defined, students are responsible for matching up crops with soil requirements, a decision also made in the real world. The two soil categories could be used to represent differences in drainage, soil depth, or slope, to name a few examples.

One of the two soil categories is identified for each field in the farm. All crops may be produced on fields with high quality soil. The instructor may restrict one or more crops from being produced on low quality soil.

Overhead. Overhead parameters and expenses defined by the instructor include property tax rates, income tax rates, fertilizer prices, interest rates and loan repayment terms, insurance rates, and family living expenses. Loans are classified as operating, intermediate, and long-term. The cash on hand and operating loan balance at the beginning of the game is also entered, and the remainder of the balance sheet is calculated based on asset and loan values entered for machinery, land, and irrigation systems.

After the farm resources and options are entered, reports are generated to acquaint students with the model farm they will manage. These reports include summaries of all crop, machinery, and operation information, as well as a beginning balance sheet. With this information they can begin to analyze their alternatives and make decisions for the first year of the game.

FINPUT

Each student or team of students receives a disk with the FINPUT program on it, as well as data files created by their instructor using the FSETUP program. FINPUT is used to solicit students' decisions for 1 yr of the game. Students make decisions in three major areas: crops, land, and machinery.

Students first select the crops (if any) they would like to produce on each field for their model farm. Fertilizer levels for these crops are also entered. The program does a minimal amount of error-checking in this process, ensuring that students enter valid crops selections and apply nonnegative amounts of fertilizer. Students must be careful to only plant irrigated crops on irrigated fields, and they must also match up soil requirements with soils available on each field.

Next, students enter decisions about land and irrigation systems. Owned land may continue to be owned, or it may be sold if it is not planted to a crop. Vacant land is available for rent or purchase. Irrigation systems may be added to dryland fields. Purchases of land and irrigation systems also require decisions about financing. Capital for land and irrigation system purchases may be borrowed with a minimum of 10% down, or may be paid from the current year's cash flow and beginning cash balance. Any cash shortfalls during the year are automatically borrowed as operating credit.

The final decisions made by students relate to machinery. Existing machines may be sold or traded for new machines, and new machines may be purchased outright. Financing decisions are again made by specifying a down payment, which can range from 10 to 100%. FINPUT
limits students to one transaction per machine per simulated year. Students run FINPUT as many times as they want for 1 yr. When they are satisfied with the decisions they have made, they return their disks to their instructor for processing and updating. After the instructor processes their disks, their data files are updated to reflect the transactions they have decided on, such as land purchases or machinery sales. As subsequent years of the game are played, the FINPUT program continues to maintain each student’s farm model as a unique business.

FPROCESS

As students turn in their disks, their decisions are read and recorded using the FPROCESS program. FPROCESS updates their data files and prevents students from changing their decisions for any previous years. Students cannot access prior years’ decisions to maintain consistency with the real world, in which decisions cannot be changed once they are made and outcomes are known. The student data is accumulated by FPROCESS in a data file on the instructor’s fixed disk until all disks have been read for 1 yr of the game. After all students have made their decisions, the simulator is executed to calculated results for each student. The simulator then generates a complete set of reports (see below) for each student, which are typically returned along with their disks.

FPROCESS also generates the stochastic prices and yields used in calculating results. Yield variations are calculated as deviations from the production function using the standard deviations entered for each crop’s yield, assuming all yields are normally distributed. Prices are generated according to the cumulative price probability distribution entered for each crop. Complete sets of prices and yield deviations are generated for the simulated 5-yr game. In addition, instructors may change any calculated price or yield deviation to a value they desire. This is useful in simulating a contracted price option for certain crops, ensuring yields under a simulated crop insurance program, or setting prices for government program commodities.

Reports available for each student include machinery reports (both costs and hours of use), detailed capital summaries of all assets and associated liabilities, production reports, cash flow summaries, income statements, and balance sheets. Instructors also receive summary reports, which provide the prices and yield deviations in effect for each crop that year. Students are ranked according to net income for the current year, and ending equity for the game to date. All reports may be output to a printer or disk file. After the disks and reports are returned to students, they run FINPUT again to make the next year’s decisions, and the cycle continues until the end of the 5-yr game.

USING AGVENTURE

AgVenture supports annual and perennial crop enterprises, but does not handle livestock enterprises. The program provides feedback to students during each simulated year of the game so that they can refine their decision-making skills as the game progresses, based on economic principles taught by the instructor. Annual summary reports of student performance are generated to provide feedback to instructors throughout the game, providing a basis for student evaluation as well as class discussion.

AgVenture was originally envisioned strictly as an undergraduate teaching tool. It has been used in farm management classes for 3 yr at Oregon State University and Eastern Oregon State College. Undergraduates consistently rate the program highly, and seem to enjoy the chance to practice their management skills. A real sense of competition develops if students are grouped in teams, and this competition can serve as a motivating force for those students who are unimpressed with economics in general. The ability to provide hands-on practice also enlivens the presentation of economic principles, which are less than exhilarating to many students.

Two recent extension workshops have also used AgVenture in teaching the principles of risk management. Agricultural producers were placed in teams and instructed to manage them using risk management strategies discussed over the course of the 2-d workshops. This proved to be a very good way of encouraging producers to analyze their production, marketing, and financial alternatives and provide them almost immediate feedback on their decisions. Participants in these workshops enjoyed playing the game, and appeared able to use the information presented in making their decisions.

Experience with AgVenture to date indicates that a gradual phase-in of decisions, in conjunction with the corresponding economic principles being taught, is beneficial. In cases where students have been given total freedom in decision-making, the sheer multitude of possibilities is so great as to be intimidating. The preferred approach is to focus on one or two decisions to start with, and build on those in subsequent years of the game.

In farm management courses at Oregon State University, the first decision year is usually restricted to enterprise selection and fertilizer levels. No land, irrigation, or machinery decisions are allowed, forcing students to focus on the principles involved in enterprise selection. The primary focus of this set of decisions is on marginal analysis and the concepts of diminishing returns, stages of production, and profit-maximization. In the second year, students are given the opportunity to make adjustments to their machinery complements, using the economic principles of opportunity cost and economic substitution. Machinery investments also require the use of investment analysis and an understanding of the time value of money. Finally, in Years 3 through 5, students are free to make all decisions, including land and irrigation decisions. In these years, additional attention is placed on risk management strategies and expected outcomes.

The AgVenture system is written in the C programming language, and is compiled for distribution. It requires an IBM-compatible computer with 640K RAM, a fixed disk drive (for the instructor only), and DOS 3.0 or greater. A color monitor is also suggested but not required. AgVenture was developed in cooperation with a private programmer, who maintains the distribution rights to the
software. Contact Stan Taylor at 503-753-1005 for more information about AgVenture.

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Harsh, S. 1984. The use of management gaming models as educational tools. In Computer applications in feeding and management of animals. NCCI, Madison, WI.