Background Information on Simulation Created for

Lesson 7: Hog Wild: Fluctuations in Commodities Markets

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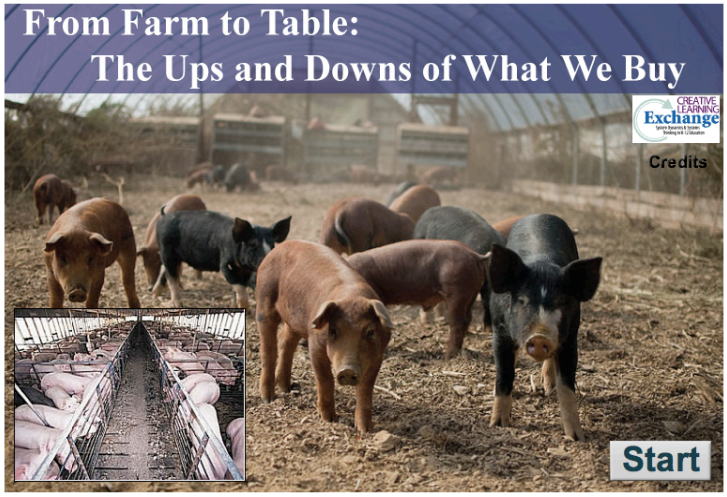
in collaboration with the Creative Learning Exchange



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Lesson 7: Hog Wild: Fluctuations in Commodities Markets

Note: While the screen images and parameter settings presented in this document refer to the C-level simulation, much of the information is still relevant to the B-level simulation.

Contents

Introduction

Commodities are a class of goods that can be produced in such a way that it is difficult or impossible to distinguish one instance of the commodity from another – corn from Iowa is considered the same as corn from Pennsylvania. The price of the commodity is determined as a function of the market as a whole, not in regard to who produced it or how it was produced. Commodities share a common problem in that prices and production exhibit repeating cycles. Examples of commodities include:

- Metals, such as aluminum, copper and tin
- Forest products, such as lumber, paper and pulp
- Crops, such as corn, coffee and sugar
- Livestock, such as beef cattle, hogs and chicken.

Fluctuations in commodity prices and production rates are problematic for producers themselves as well as other industries that depend on commodities as raw materials. The fluctuations illustrate how price seeks to balance supply and demand in systems that typically contain long time delays. These relationships are present, but are less obvious, for manufactured items because companies and retail stores keep inventory on hand to ensure they can meet varied demand from consumers. Many commodities are unable to be stored for the long term. Commodities are also different from manufactured goods in that they must be extracted from the ground, planted and harvested according to nature's schedule, or birthed and raised to an ideal weight before becoming useful. Delays between wanting more of a commodity and actually getting it may be a matter of months, a few years or even decades, making commodities prone to cycles as supply and demand seek to equalize.

This simulation introduces students to the concept of commodity cycles by comparing two types of hog farms:

- Large; over 2000 hogs produced per year and primarily serving the price-conscience consumer
- Small; fewer than 2000 hogs per year and primarily serving the quality-conscience consumer.

Some characteristics of large hog farms that are described in the simulation interface[1] are:

- Often keep sows indoors in individual stalls
- Breed one type of hog (known as the "domestic pig")
- Give medicine (antibiotics) to keep individuals from getting sick and infecting the whole herd
- Breed sows as often as possible (year-round)
- Through careful breeding, try to increase average number of piglets born per litter
- Control the hog environment to increase the average number of piglets that survive to maturity
- Have succeeded in reducing the time needed for hogs to reach ideal slaughter weight
- Have lower costs per hog raised compared to small farms
- Typically sell their hogs on the commodity market where consumers are sensitive to the price of pork.

[1] The lists for large and small farms are accessed from the Introduction screen. Click "Read about large (small) hog farms" and then click on the hog picture on the page that appears. A text box will pop up that includes this list.

Some characteristics of small hog farms that are described in the simulation interface are:

- Often keep hogs outdoors; a shelter allows hogs to enter and exit whenever they want
- Could be raising any of a number of different breeds (called heritage breeds) that can survive outdoors
- Give medicine (antibiotics) only when absolutely necessary
- Breed sows twice a year, as hogs naturally do in the wild
- May have fewer piglets per litter than large farms, depending on the heritage breed being raised
- Keep hogs in family units with less human intervention during early stages (more piglets are likely to die before reaching maturity compared to the sterile conditions of large farms)
- May be raising heritage breed(s) that take a longer time to reach ideal slaughter weight (compared to the domestic pig)
- Have higher costs per hog raised compared to large farms
- Typically sell their hogs to local niche markets where consumers are not sensitive to the price of pork.

Note that these characteristics are not absolutes in real life; there are farms that share characteristics across these two lists. Wherever possible, we have incorporated data from hog industry sources to populate the model with regard to using heritage breeds and the domestic pig in the production of pork. We encourage independent student learning about the challenges farmers face in feeding the nation, the reasons many small farms have been replaced by large farms and the quality/price trade-offs consumers face in virtually all their purchasing decisions.

Overview of Model Behavior

The Default Behavior Pattern – Commodity Cycles

To reveal the default behavior pattern of the model, click the "Run" button without making any changes to the buttons or slider bars (see Figure 1, next page). There are five pages of graphs. Click the white triangle in the lower left corner of the graph to page through them. Page 5 is a comparative graph. Each time you click the "Run" button to simulate the model, the comparative graph will show the new run in a different color. Click the "Reset" button to clear the graphs and reset parameter values to the default settings.

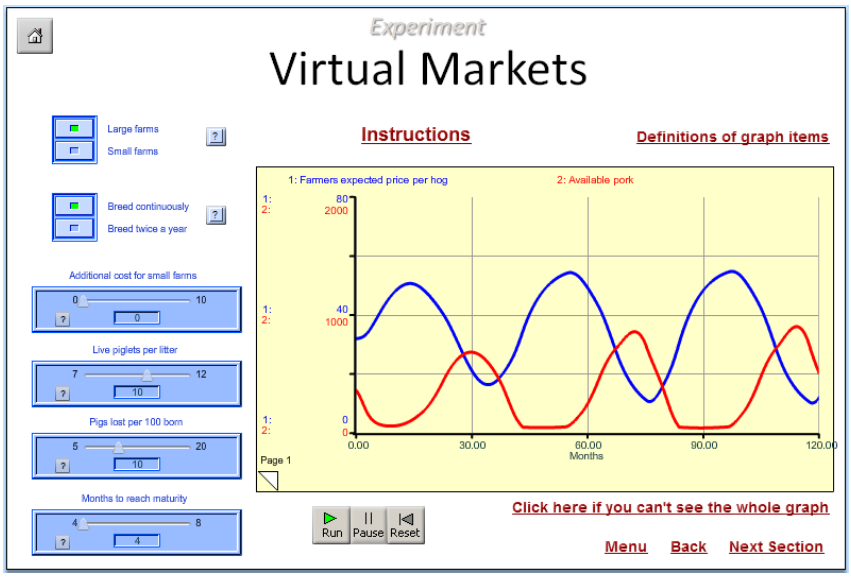

Figure 1: This graph shows the default behavior of the model for "Farmers expected price per hog" and "Available pork."

The behavior pattern shown on Page 1 in Figure 1 is cyclical; it represents "Large farms" that sell their pork on the commodity market. The variables "Farmers expected price per hog" and "Available pork" move in the opposite direction; when one is high, the other is low and vice versa. The variable "Farmers expected price per hog" represents the price farmers expect to receive for each live animal sent to slaughter. The variable "Available pork" is the amount of pork available in the market for retail customers to purchase. This graph shows that farmers anticipate being paid more for their animals when the supply of pork is low and less when the supply of pork is high.

An assumption built into the model is that farmers form expectations about price based on the actual market price (called "Live-hog price" in the model). That is, they do not react to every price blip that is reported daily in the financial news, but instead pay attention to the trend in the live-hog price. For farmers to be profitable, their costs in raising hogs must be less than the total revenue they receive when the animals are slaughtered. Ideally, hog farmers would like to have a large herd available for slaughter when conditions are favorable[2].

[2] The model assumes a constant price per bushel of corn, but in reality, "favorable" market conditions are a function of many factors, including both live-hog prices and the cost of corn, which itself is a commodity and subject to price swings.

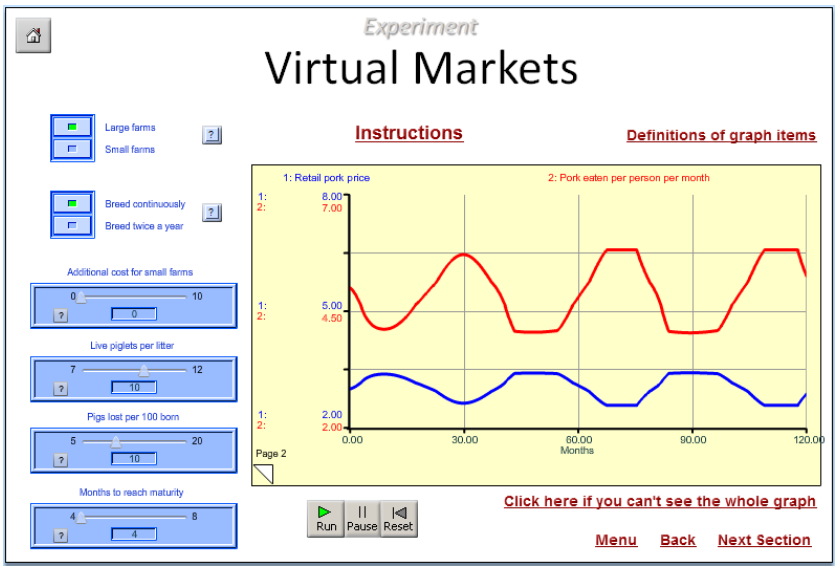

Figure 2: The second page of the graph plots "Retail pork price" and pork consumption, represented by "Pork eaten per person per month."

Page 2 of the graph in the Control Panel is shown in Figure 2. This graph plots pork price on the retail level ("Retail pork price") against consumption by consumers ("Pork eaten per person per month"). This is also a cyclical behavior pattern; it shows that people tend to consume less of a product when the price is high and more when the price is low. Notice that pork consumption reaches a "ceiling" and a "floor" in the second and third cycles. An assumption built into the model is that people have other food choices in addition to pork. They do not increase their per-capita consumption indefinitely when the price is low and they switch to "something else" when the price is high. Because the model does not represent the full spectrum of consumer responses to the price of pork, the result is the flat, floor/ceiling appearance shown in the graph.

The default slider settings are intended to reflect average values for large farms as a group. As stated in the Introduction section, our categorization of large and small farms and their operations is very general and the values used should not be taken as absolutes.

Pages 3 – 5 of the graph show other variables that tell the story of commodity cycles. The number of piglets and mature hogs in the system, along with the amount of pork available, is shown on Page 3. "Monthly profit" is shown against the "Breakeven point" on Page 4, and "Cumulative profit" over the course of the simulation time is shown on Page 5. The link, "Definitions of graph items," opens a text box that describes each variable and its unit of measure.

Going Faster, Getting Worse

The overall trend on large farms in the United States has been and continues to be toward greater productivity. Productivity is a valued trait in this and many cultures, but this simulation shows it to be a double-edged sword. For example, increasing "Live piglets per litter" from the default value of 10 to 11 and decreasing "Pigs lost per 100 born" from 10 to 8 produces the graph shown in Figure 3. The result of greater productivity, which one could imagine would help farmers respond quickly to changing market conditions, actually creates cycles that are more severe. Compared to the default behavior, we can see that

"Farmers expected price per hog" experiences a smaller first cycle that then reaches new low points for the second and third cycles. The reason is that "Available pork" reaches new peak values for the second and third cycles as compared to the default behavior. Greater supply due to the increased productivity of the large farms thus drives prices lower for everyone in the market.

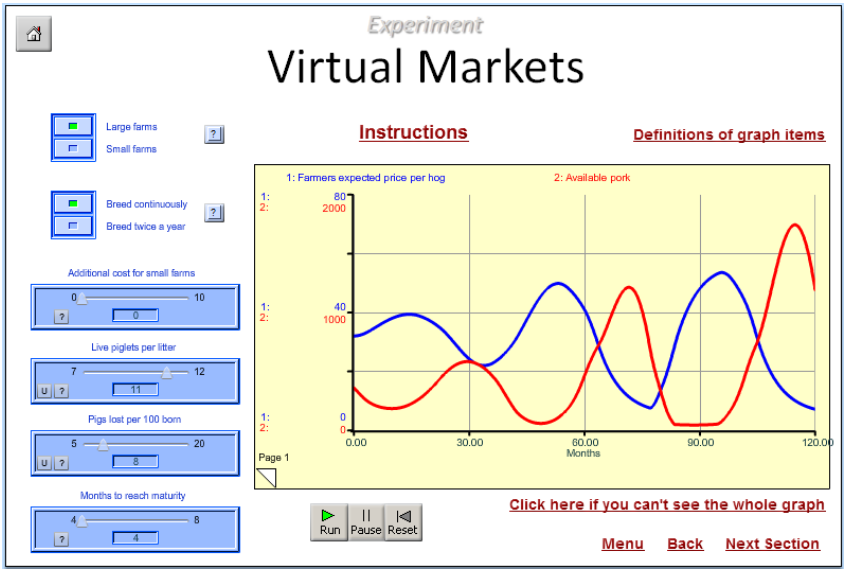

Figure 3: This behavior is created by changing the parameters "Live piglets per litter" to 11 and "Pigs lost per 100 born" to 8.

The graph in Figure 4 shows that pork consumption stays at the high and low limits for longer in this experiment than in the default behavior pattern. The increase in pork production has nowhere to go – the model does not include efforts to increase pork consumption, either by expanding the market (exports to other countries, for example) or encouraging people to eat more pork (marketing campaigns). The retail price of pork simply stays low until the excess supply is consumed.

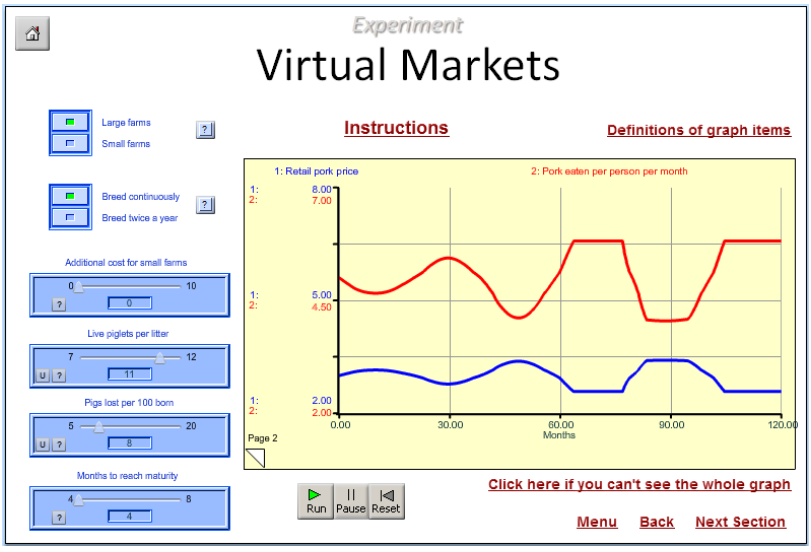

Figure 4: Greater productivity on large farms can be a double-edged sword.

Students may think this result is unrealistic given the important factors that are omitted from the model; include those factors, and greater productivity would indeed stabilize the cycles. In reality, organizations such as the National Pork Board do work to expand the market for pork producers, and the United States does export pork on the world market. Commodity cycles still exist, however, despite these factors and the fact that pork producers have been very successful in increasing pork production over the past four or five decades. You can help students understand what is happening in the simulation model by examining all the graphs. Notice in particular that both "Monthly profit" and "Cumulative profit" show flatter cycles in the short run (the first one-third of the graph) but more pronounced cycles in the long run.

Price can be thought of as a signal. Prices that are increasing signal producers to produce more. Prices that are decreasing signal them to produce less. When farmers can produce more pigs in the same amount of time, it is as if the signal to "produce more" has been amplified. Each large farm, following the same or similar set of best practices for hog farming, does its best to respond to increasing prices, with the result that more pork ends up on the market than otherwise would have been there. A hallmark of commodities is that individual producers are not rewarded based on the attributes (quality) of their particular output. So when the model shows that more productivity leads to prices lingering in the trough, it is actually reflective of what has historically occurred in commodity markets. The phrase used in U.S. agriculture is "get big or get out.[3]" Being unable to compete on quality, the emphasis is on quantity; some producers survive the inevitable decline in prices that follows increased production, while many do not. The industry as a whole consolidates into fewer, larger producers with each downturn in the cycle.

Please note that this simulation features an extremely simplified view of the hog (or any) commodity cycle. The goal is that students become aware of the concepts of supply and demand and the role that price plays in balancing them. The theme of this series of lessons in oscillation is that "the cause of the problem is within the system." Students should recognize that farmers, despite their best efforts, are part of a system that is inherently oscillatory in nature.

The Rejection of "Get Big or Get Out"

The previous section described how the farm sector faces hardship in a cyclical market; the trend in U.S. agriculture is toward fewer, larger farms in an attempt to withstand the downturns in the cycle. The option to simulate "Small farms" is included to highlight the type of agriculture that once was widespread[4]. The "Instructions" link on the simulation Control Panel encourages students to check the "?" symbols for clues about how to set the parameters for simulating small farms. They may notice the pattern that small farms (assumed to breed specific breeds called "heritage breeds") are less productive than large farms. Setting the parameter values as shown in Figure 5 will produce the graph shown on the right in the same figure. Access this graph by clicking the link "Click here if you can't see the whole graph" on the simulation Control Panel. This second graph features vertical scales that update for each simulation run (with the exception of Page 4).

[3] Please see http://en.wikipedia.org/wiki/Agricultural_policy_of_the_United_States for more information.
[4] We have purposely avoided the term "factory farm/farming" because of the negative connotation it carries, but teachers may wish to tackle the topic head-on.

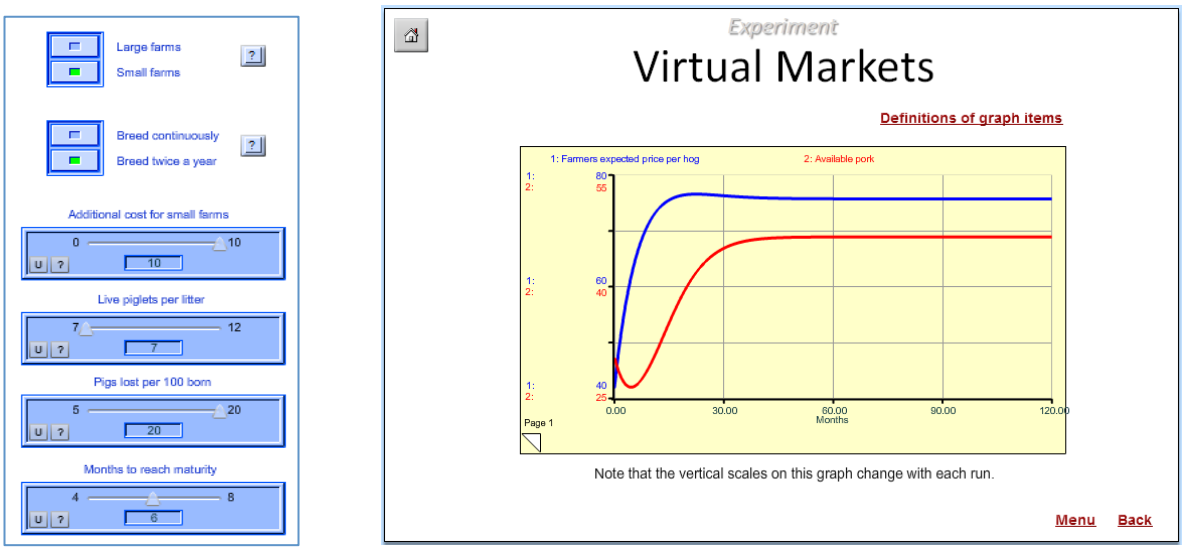

Figure 5: The settings for "Small farms" are shown on the left. The graph is accessed via the link "Click here if you can't see the whole graph."

Except for the relatively small dip in "Available pork" at the beginning of the simulation run, the overall dynamic for this market is growth (as it has been in real life). Small farms are assumed to sell their pork directly to consumers via farmers markets, buying clubs and similar direct-buy arrangements. This is a niche market that is considered to be insignificant in size compared to the commodity market. That is, large producers do not try to compete with small producers[5] so the model does not include one market "stealing" market share from the other.

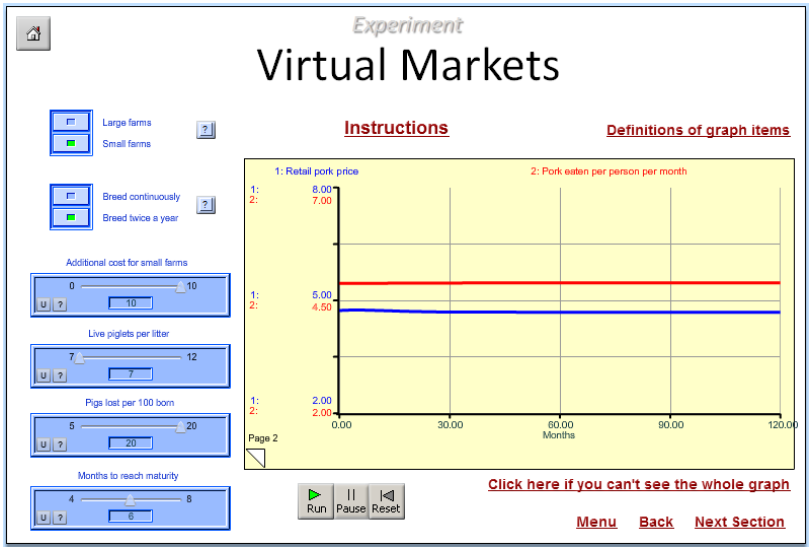

Figure 6: In the niche market, consumers are steady purchasers of heritage pork, despite the relatively high price (compared to commodity pork).

[5] There is evidence of this in real life, although a few producers of heritage pork do distribute their products nationally. See Eden Farms (http://www.betterpork.com/Eden_Farms/Eden_Farms_Berkshire_Pork.html) and Niman Ranch (http://www.nimanranch.com/Index.aspx) for two examples.

Consumers in the niche market are not as price-conscience as consumers in the commodity market, as can be seen from the relatively high retail price shown in Figure 6. As stated earlier, this simulation provides a simplified view of complex real-life economic relationships. Students can be encouraged to investigate the real development of the market for heritage pork.

Small Farms and Price/Production Cycles

It is reasonable to assume that, over time, farmers producing heritage pork will find ways to improve efficiency. After all, the domestic pig used on large farms today is mostly descended from the European wild boar. It once shared many characteristics with the breeds that are considered heritage breeds today. These characteristics have been changed by humans via selective breeding to produce the pink, hairless pigs and light-colored pork that is common today.

One way to test whether the niche market could exhibit cycles similar to the commodity market is to increase productivity for small farms. This can be done by increasing "Live piglets per litter" from 7 to 9 and decreasing "Pigs lost per 100 born" from 20 to 15. The results of these changes are shown in Figure 7.

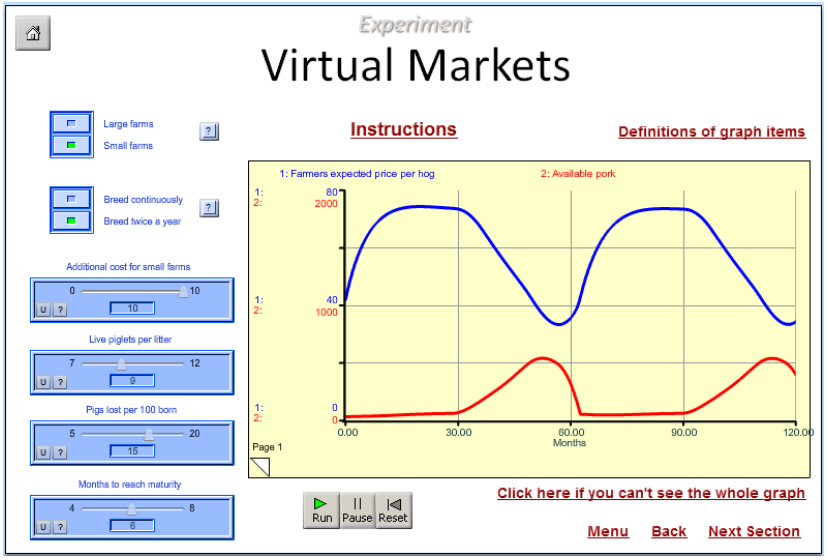

Figure 7: This graph shows that it is plausible for the niche market to experience cycles, given certain conditions.

Once again supply and demand struggle to find a balance and the result is reflected in price and production cycles. In this experiment "Farmers expected price per hog" never reaches the level seen in the previous run for small farms (Figure 5). Yet "Available pork" explodes after approximately 30 months have passed. In essence, the loyal consumers of the niche market have unknowingly put pressure on small farms. Consider the graph on Page 2, shown in Figure 8 (click the link "Click here if you can't see the whole graph").

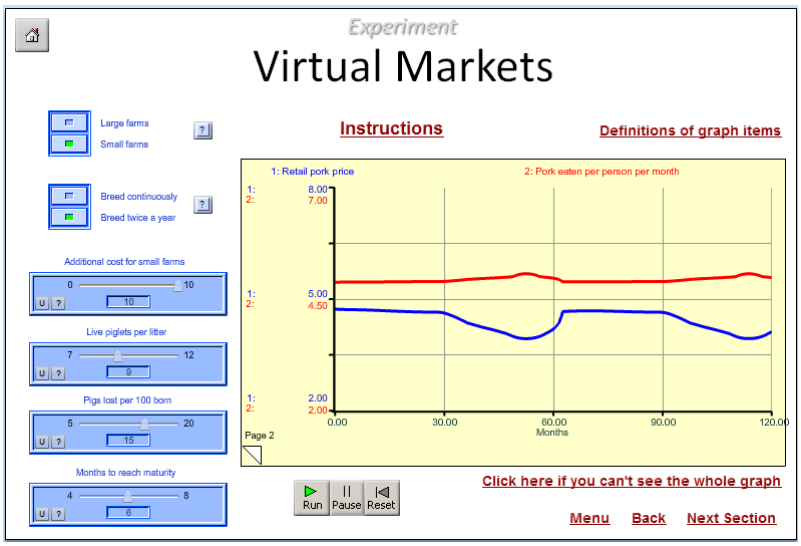

Figure 8: Examine this graph in more detail by clicking the link to "…see the whole graph" in the bottom right of the screen.

Niche market consumers are less concerned with price than commodity market consumers, but they are not completely immune to it. We see in Figure 8 that the increase in production slowly drives the retail price downward, and consumers slowly increase their per-capita consumption in response. Farmers are anticipating favorable live-hog prices so they expand their breeding capacity to meet demand. It takes time for hogs to be raised, however. The full effects of increased production are not apparent until approximately 30 months into the simulation run. For the next 30 months, "Available pork" explodes and declines rapidly (Figure 7). The glut of pork that arrives on the market depresses prices so that even the steady niche market consumers find more uses for the pork they love. They consume the excess inventory and then the cycle starts again.

Encourage students to examine all the pages of the graph for this or a similar experiment. We have highlighted the differences between these two markets, but ask them to take the story full circle and explain how the markets are similar as well. For example, the basic relationships between supply, demand and price are present in both markets. If demand for quality pork continues to grow, won't farmers find ways to supply more of it? If supply increases, won't the price (currently keeping many people from trying heritage pork) come down, perhaps enough to make it a viable option for current consumers in the commodity market? Could the niche market eventually grow to serve most pork consumers, as the commodity market does now? If so, would it also end up as a cyclical market?

Model Structure and Assumptions

The screen shown in Figure 9 is the portal screen for learning about the underlying model structure. The diagram is a simplified conceptual view of the model. It is interactive so that a click of the mouse on each element provides explanatory text in a pop-up box. Detailed information about the model and the feedback loops are accessed via the links in the bottom left corner.

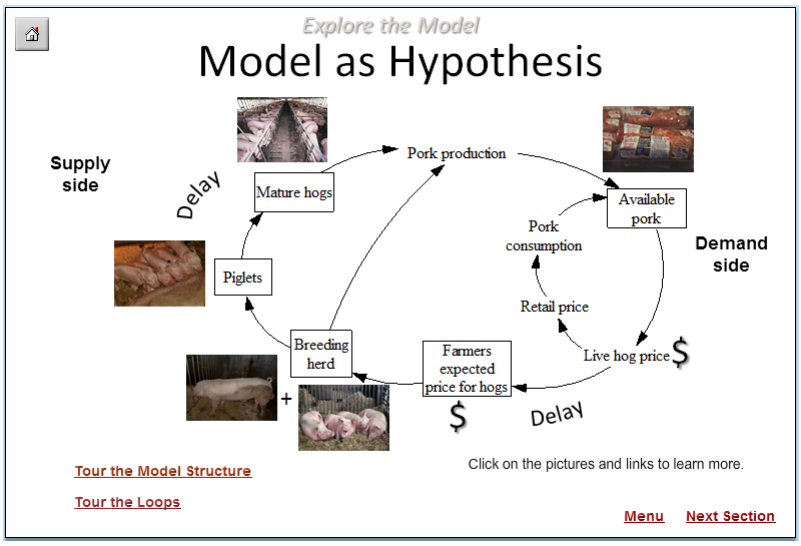

Figure 9: This screen provides a conceptual overview of the model structure.

Clicking "Tour the Model Structure" brings the user to the screen shown in Figure 10. It is the same diagram as Figure 9 except the numbered sections indicate the order in which the tour should be completed. Click anywhere within the gray boxes and then use the spacebar to toggle through the presentation of the structure.

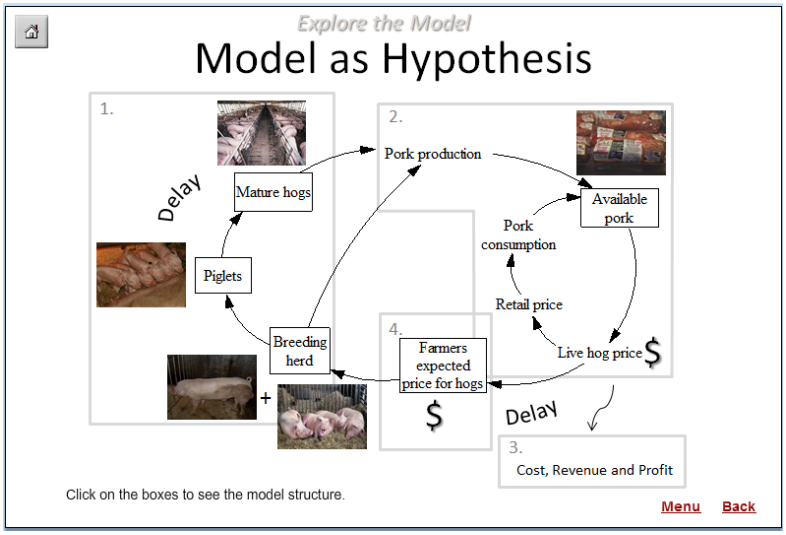

Figure 10: Click on the numbered sections in sequential order to view the entire tour of the model structure.

The completed first section is shown in Figure 11. Completing the entire tour reveals that there are no outside influences that drive the commodity cycles. The population of pork consumers does not change during the simulation, nor does the price that hog farmers expect to pay for corn. The relationships between supply, demand and price represented in the model are sufficient to produce the cycles.

Variables colored green indicate parameters that are set on the Control Panel of the simulation. The remaining variables are defined internally, based on relationships indicated by the red arrows. Some

variables that appear in two or more places in the full structure, such as "Desired breeding herd," have colors other than blue or green for easy identification. Using copies of variables avoids stretching links across the diagram and helps the appearance of the model.

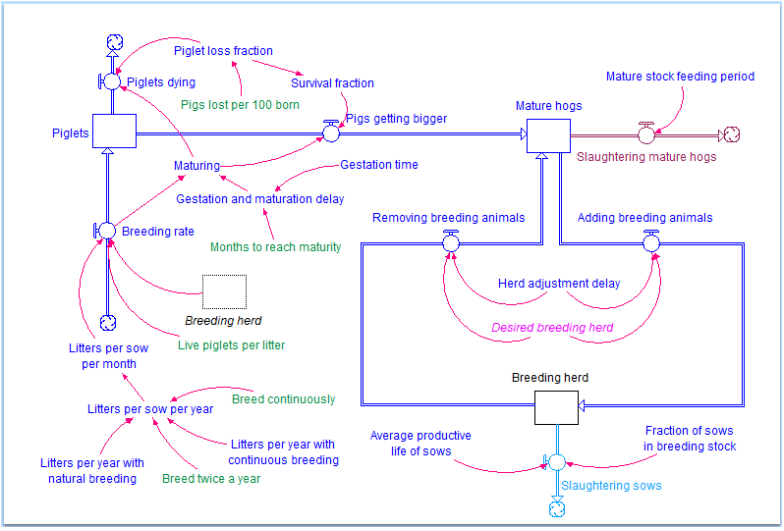

Figure 11: This screen shows the hog production section of the model.

Limitations of the Model

The simulation model featured in this lesson is closely based on the "Dynamic Hog Cycle Model" presented in the book, *Dynamics of Commodity Production Cycles*[6]. The model was created to address how and why most commodities exhibit fluctuating price and production rates. In this simulation, we have deviated from the original study by using values reflective of hog production today rather than 1970, the year of publication.

The simulation and accompanying lesson juxtapose the production of pork for the commodity market ("large farm" production) with the production of pork for the niche market ("small farm" production). The same model structure is used for both situations, but in reality the differences between these two production systems and the markets they serve are vast. We strive only to illustrate some of the differences found in these two systems. Students should come away with the understanding that farmers face pressure to continually improve the efficiency of their farms, but doing so can unleash unintended consequences both for farmers and consumers of their products. Producing "more" and "faster" (increasing the number of piglets per litter; decreasing the time needed for a pig to mature) has not alleviated the cyclical nature of the business. With each downturn in production, some farms fail and the survivors absorb the production capacity. The resurgence of small farms that specialize in niche products (ostrich meat, goat milk, free-range chickens, grass-fed beef, and so on) is a reaction to this "get big or get out" trend.

Please note that the population of pork consumers does not change during the simulation. Consumer preferences between pork and other food are also not included. In reality, pork consumption is a function

[6] Please see Meadows, Dennis. *Dynamics of Commodity Production Cycles.* Cambridge, Wright-Allen Press, 1970.

of many factors, including demographic changes as well as trends in food consumption[7]. Excluding these factors means learning can focus on price as the driving factor behind consumption. The model includes a simple representation of how price increases tend to decrease consumption and vice versa. This price relationship is another illustration of how the drive for efficiency seen on many large farms can be self-defeating. Farmers who have animals to slaughter when pork is relatively scarce and live-hog prices are high will soon see overall pork consumption decrease because of high retail prices. Any long-term trend toward greater profitability (for instance, when corn prices are trending downward) is met with similar reactions across the industry – farmers increase their herds. When their actions have percolated through the pork production system, the flood of pork on the market simply drives prices down because it cannot be stored for long. Certainly, some farmers get it right and survive, but others do not. This tendency for price to adjust supply and demand toward each other, coupled with delays in the system, creates the characteristic oscillations of almost all commodities.

Talking Points – Linking the Simulation to Real Life

Some useful questions for discussion with students include the following:

- What are the benefits of farming on a large scale? For example, farmers need fewer hogs today than what was needed several decades ago to produce the same amount of pork. Sows produce more piglets per litter and more of them survive to maturity. We are a nation of meat-eaters. Does that mean this is a "good" system for people? Is it a "good" system for hogs? What determines whether or not a food production system is good or bad?
- What are the costs of farming on a large scale? For example, there are parallels that can be drawn with the Industrial Revolution. In earlier times, farmers were their own bosses. Farms were owned by the farmers themselves. Waste from one part of these farms became input to other parts. How are large farms run today? Who owns them and who makes the important decisions? Do farmers know a lot about all aspects of the farm, or are farms managed literally as factories, with specialized labor and as much mechanization as possible? What happens to the waste produced by five to ten thousand hogs on a single farm? What effect does pollution have on the neighbors of large farms?
- If you were a pig, what type of farm would you want to call home, and why?
- If you were a farmer, what type of farm would you like to run, and why?
- What is the role of advertising in food production systems? Does it give consumers more choices by making them aware of new possibilities that could enhance their lives? Does it give them an accurate view of the food we eat so that we can make better choices for our health?
- Does it matter that pork produced on large farms is almost always from a single breed of pig, the "domestic pig?" Do we need diversity in our food systems? What type of farm would be better able to handle an outbreak of a disease that spreads from pig to pig? What is the significance of heritage breeds (of any livestock animal) going extinct?
- What, if anything, is our responsibility to animals that are under our care? If an animal is destined to be killed for human consumption, does it matter if it is allowed to live a "natural life?" What is

[7] For example, the National Pork Board's campaign "Pork: The Other White Meat" (http://en.wikipedia.org/wiki/Pork._The_Other_White_Meat) is estimated to have helped boost pork consumption by 20%, despite pork not actually being a white meat according to the U.S. Department of Agriculture.

a "natural life" for a domesticated species? Since they have never lived in the wild, should we assume that they have a better (less stressful) life when they are inside, eating a nutritious diet on schedule, or outside in the elements, foraging and perhaps fighting for their own food?

- How do views about animal rights vary around the world?

The Cause of the Problem is Within the System

The overall goal of the Oscillation curriculum is to teach a principle of complex systems: The cause of the problem is within the system. Socioeconomic systems that oscillate are often not recognized as oscillating due to their intrinsic structure. Explanations often point to outside influences that are themselves oscillating, or to a particular combination of outside factors believed to "drive" the oscillation. Yet we know that a physical system such as a spring (presented in Lesson 1) oscillates because it is made to do so. It does not oscillate because a hand or other force continually pushes it in an up-and-down or back-and-forth motion. A spring gets set into motion with a push or a pull, and it oscillates due to its own structure.

Most of us do not realize the important role commodities play in our everyday lives. The process of growing, gathering or mining these products and placing them within our reach is of little concern. Price increases at the grocery store may prompt us to substitute a less expensive alternative for the desired item. We hear about farms that don't survive the "latest downturn" in the economy, but we might think they were the poorly-managed ones. It's hard to put such events into a broad context; it's easy to place blame on outside factors. After all, how can there not be "enough hogs" in the country to meet demand? Pork prices must be rising because farmers have gotten greedy, not through the interactions of supply and demand. Our sense of time is often focused on the immediate past and the immediate future. We react to price changes but rarely analyze them fully.

Placing economic factors into context that is relevant to our everyday lives is challenging. This simulation and other lessons in this series were created to offer students such context so that they may recognize and understand cyclical behavior patterns. Understanding underlying causes of any behavior pattern is the first step to being able to think about relevant and appropriate changes that may work to produce a more desirable behavior pattern. With context, the tendency to blame factors that are "outside" will fade as students grow in their understanding of how structure creates behavior: "The cause of the problem is within the system." Other lessons in this series illustrate these ideas using oscillating systems in physics (Spring-mass system), biology (Predator-prey cycles) and social well-being (Burnout cycles).