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## **Appendix A:** Equilibria derivation

$BS$ is Breeding Stock (Variable)

$LPH$ is Litters per hog (Constant and equal to 0.17)

$PSL$ is Piglets save by litter (Constant and equal to 7)

$WSF$ is Weaning survival factor (Constant and equal to 0.7)

$LW$ is the hogs live weight (Constant and equal to 240 pounds or 108.86 in Kg)

$DY$ is the hogs dressing yield (Constant and equal to 0.58)

$Hog\ Cost$ is hogs individual cost (Constant and equal to 11.84)

$EC$ is the market expected consumption (Constant and equal to 1000 pounds or 453.59 in Kg)

*Prerequisites*

By assuming the market is in equilibrium, we can express the following relationships in the supply side:

$$Hogs\ slaughtered = \frac{MatureStock}{2} + \frac{BreedingStock}{36} \quad (1)$$

$$Maturation\ rate = \frac{MatureStock}{2} \quad (2)$$

$$Maturation\ rate = BS * LPH * PSL * WSF \quad (3)$$

By replacing 3 in 2, we have:

$$Mature\ Stock = 2 * BS * LPH * PSL * WSF \quad (4)$$

$$Hogs\ slaughtered = BS * LPH * PSL * WSF + \frac{BS}{36} \quad (5)$$

Since the market is assumed to be in equilibrium, we can also establish the following relationships on the demand side:

$$Inventory = Pork\ production \quad (6)$$

$$Pork\ production = Hogs\ slaughtered * LW * DY \quad (7)$$

By replacing 5 into 7, we have

$$Pork\ production = \left( BS * LPH * PSL * WSF + \frac{BS}{36} \right) * LW * DY \ (7)$$

$$Inventory = \left( BS * LPH * PSL * WSF + \frac{BS}{36} \right) * LW * DY \ (8)$$

**Joint Maximization equilibrium**

Farmers' profits are determined by the difference between the hog price and the hog cost, multiplied by the number of hogs that were slaughtered in the farms.

$$Profits = Hogs\ slaughtered * (Hog\ price - Hog\ Cost) \ (9)$$

$$Hog\ price = \frac{-15{,}54 * \left( BS * LPH * PSL * WSF + \frac{BS}{36} \right) * LW * DY}{EC * DC} + 31{,}81 \ (10)$$

By replacing 10, 5 and including the value for $Hog\ Cost$ in 9, we have

$$Profits = \left( BS * LPH * PSL * WSF + \frac{BS}{36} \right) * \frac{-15{,}54 * \left( BS * LPH * PSL * WSF + \frac{BS}{36} \right) * LW * DY}{EC * DC} + 31{,}81 - 11{,}84 \ (11)$$

By deriving 11 with respect to BS to find the maximum value for the expression, we have

$$\frac{dprofits}{dBS} = \left( BS * LPH * PSL * WSF + \frac{BS}{36} \right) * \frac{-15{,}54 * \left( LPH * PSL * WSF + \frac{1}{36} \right) * LW * DY}{EC * DC} + \left( LPH * PSL * WSF + \frac{1}{36} \right) * \left( \frac{-15{,}54 * \left( BS * LPH * PSL * WSF + \frac{BS}{36} \right) * LW * DY}{EC * DC} + 31{,}81 - 11{,}84 \right) = 0 \ (12)$$

By replacing all the constants values in equation 12, we can know the value for BS that corresponds to Joint maximization equilibrium

$$BS = 1{,}9305\ (Millions\ of\ hogs)$$

**Nash Equilibrium**

For this equilibrium we assume that, by definition, every market actor maximizes his own profit assuming that the other players are going to do the same (Best response). Therefore, the total market variation is the result of individual maximization. In mathematical terms this is represented by

$$\frac{dBS}{dbs} = \frac{dbs}{dbs} = 1$$

Where $bs$ is the Breeding stock of one player. Since we are considering 6 in the market we have that

$$BS = 6 * bs \ (13)$$

By replacing 13 in 11, we have

$$Profits = \left(6 * bs * LPH * PSL * WSF + \frac{6 * bs}{36}\right) * \frac{-15{,}54 * \left(6 * bs * LPH * PSL * WSF + \frac{6 * bs}{36}\right) * LW * DY}{EC * DC} + 31{,}81 \ - Hog\ cost \ (14)$$

By rearranging 14, we have

$$Profits = 36bs^2 * \left(LPH * PSL * WSF + \frac{1}{36}\right)^2 * \frac{(-15{,}54 * LW * DY)}{EC * DC} + (31{,}81 - Hog\ cost) * 6 * bs * \left(LPH * PSL * WSF + \frac{1}{36}\right) \ (15)$$

Where

$$36bs^2 = 6 * bs * 6 * bs = 6 * bs * BS \quad (16)$$

By deriving equations 15 and considering the best response requisite for Nash equilibrium, we have

$$\frac{dProfits}{dbs} = 42 * bs * \left(LPH * PSL * WSF + \frac{1}{36}\right)^2 * \frac{(-15{,}54 * LW * DY)}{EC * DC} + (31{,}81 - Hog\ cost) * 6 * \left(LPH * PSL * WSF + \frac{1}{36}\right) = 0 \ (17)$$

By finding the value for $bs$ in equation 17, we have that

$$bs = 0{,}5510$$

$$BS = 6 * bs = 3{,}3096\ (Millions\ of\ hogs)$$

**Perfect Competition Equilibrium**

For the players to not earn above the normal profit, the following condition must be satisfied

$$Hog\ price - Hog\ cost = 0 \quad (18)$$

Therefore, by replacing 10 in 18 we have

$$\frac{-15{,}54 * \left( BS * LPH * PSL * WSF + \frac{BS}{36} \right) * LW * DY}{EC * DC} - Hog\ cost = 0\ (19)$$

By finding the value for $BS$ in 19, we have that

$$BS = 3{,}8610\ (Millions\ of\ hogs)$$

***Equilibria summary***

| | BS (Millions of hogs) | Number (in millions) of hogs in the farms | Profits |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Joint Maximization | 1.93 | 5.15 | 16.59 |
| Nash equilibrium | 3.31 | 8.82 | 8.12 |
| Perfect Competition | 3.86 | 10.29 | 0.00 |

## **Appendix B:** Instructions [3]

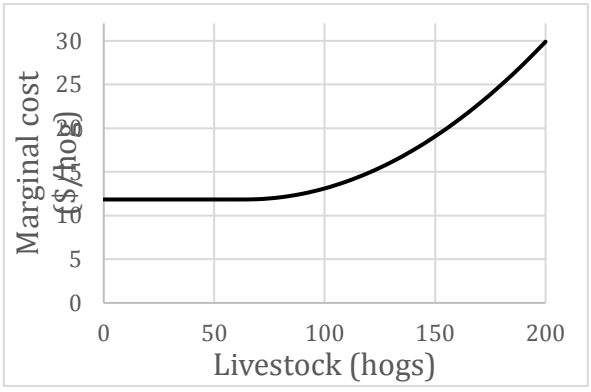
[3] We changed the term "hog" for "pig" and the term "breeding stock" for "livestock" to make the instructions easier to understand, given that most of our participants were not native English speakers.

Welcome! In this experiment you will play the role of a pig farmer. Every third month you will make a decision that influences how many pigs you will have ready for slaughtering at a later point in time. Your farm is one of six identical farms that supply hogs to the slaughtering houses. Your goal as a manager is to maximize your farm's accumulated profits over a 16-year period. Your payoff depends on the accumulated profits and can range from NOK 40 to NOK 500.

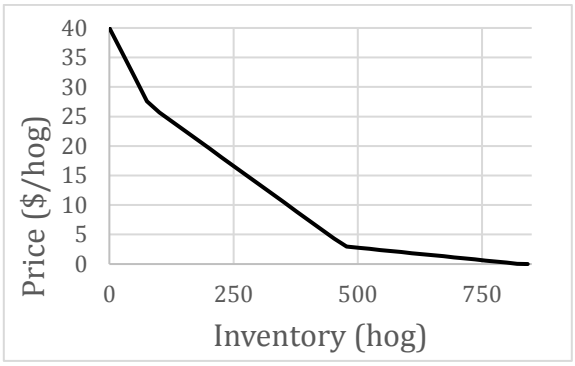
To help you manage, take a look at the computer screen and note the following information. On the left-hand side you find information about your own farm. The first item is the number of livestock, which is the number of sows (female pigs) that can give birth to piglets (offspring). On average, each litter has 5.8 piglets (number of siblings each time a sow gives birth). Each sow gives birth every 10th month. The sows' productive life is 3 years, after which sows are sold to a slaughtering house.

The next item is the number of piglets up to the age of 10 months. Below that you see the number of mature pigs between 10 and 12 months old. When these pigs reach 12 months of age, they are either sold to a slaughterhouse or female pigs may become livestock. To simplify, only pigs that survive birth and breeding are counted for.

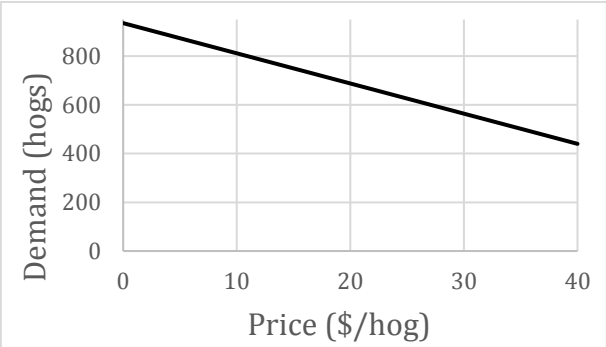
Then you get information about the number of pigs and livestock that are sold in the last three-month period. Selling is automatic and happens exactly when pigs reach the slaughter age. The marginal cost per pig increases with the number of pigs on your farm, the number you see is for the last three-month period. The per unit cost increases because your farm has limited room for pigs, and limited capacity for feeding and cleaning. The below graph shows how the marginal costs vary with the number of sows in the livestock.




The rectangle with market information shows market prices per pig for the last three months. The price varies with the number of slaughtered pigs that the slaughter houses have in their inventories. When inventories are nearly full, prices are low. This stimulates consumption of pork (pig meat) and help reduce inventories. When inventories are low, prices are high and reduce the demand for pork. The below graph shows the exact relationship between inventory and price in this market.




There is an immediate effect of price on consumption. The figure below shows the assumed relationship between hog price and demand (a linear demand curve).




Price minus marginal unit cost per pig gives the unit profit per pig sold. Total profits for a sale is given by the average unit profit times the number of pigs sold. The last piece of farm information shows the total profits earned over the last three-month period.

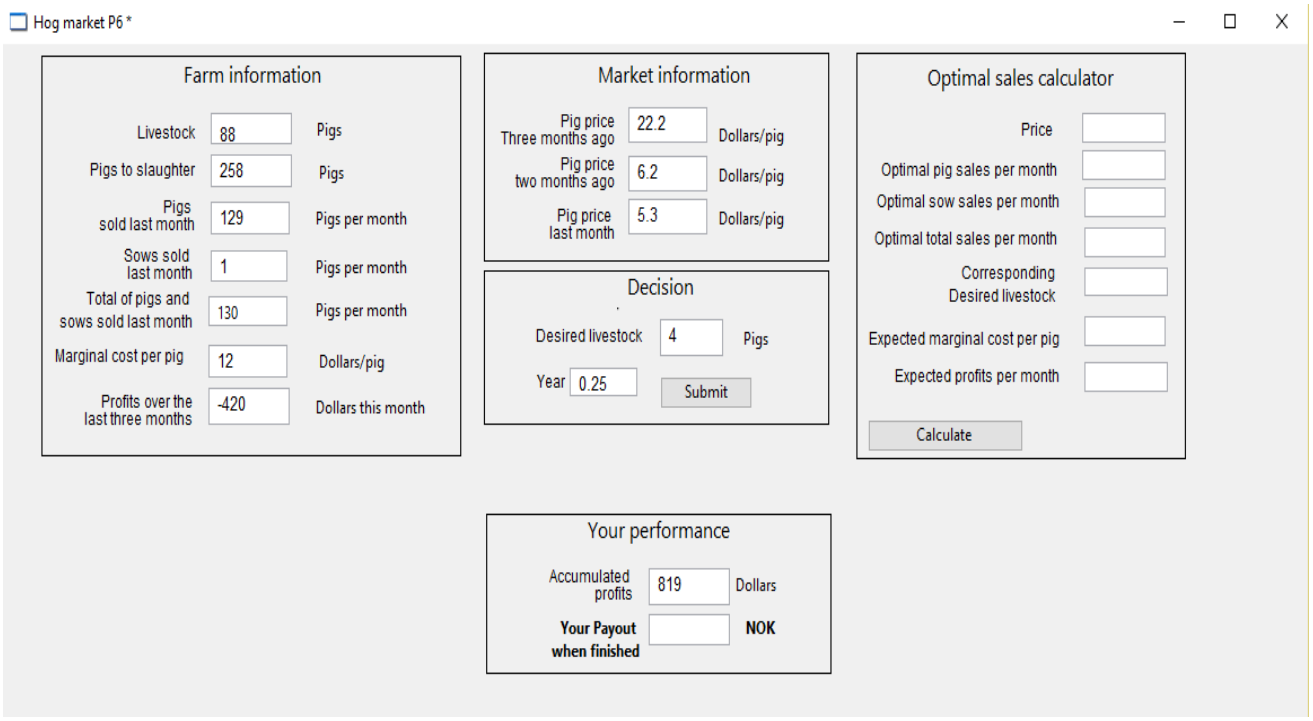
Your decision is to set the desired number of livestock. Once you set the desired livestock, it will take on average five months before the livestock reaches the desired size and the sows begin to produce piglets. It also takes time to reduce the livestock because pregnant sows will not be slaughtered before they have given birth. You can set a desired livestock from 0 to 200 pigs.

Below the rectangle for decisions you see the accumulated profits for all years. It is the accumulated profits in the last year that determines your payoff. Time is denoted in years such that three months show up as 0.25 year.

On the right-hand side you see a tool that can help you make decisions about the size of the livestock. You enter an assumption about the future price and the tool calculates the profit maximizing sales from your farm. This calculation takes account of the fact that marginal costs per pig rises with the number of pigs on your farm. As a further help, the tool also calculates the needed size of the livestock to reach the optimal sales numbers. Once you have entered a new assumption about the future price, click on the button “Calculate” to see the new recommendations.

Note that the recommendations you receive reflect your own assumptions about what the future price will be, which in turn depends on how many pigs you and your competitors sell to the slaughter houses.
Please use the answers sheet (columns for time period and desired livestock) to record your desired livestock every time.

## **Appendix C:** Experiment interface [4]




[4] We changed the term "hog" for "pig" and the word "breeding stock" for "livestock" to make the experiment more understandable, since most of our participants were not native English speakers.