# Introduction

## Setting the Stage

**Background**

Is raising the minimum wage really a good idea? Will it really increase the standard of living for those working for minimum wage? And what will the effects be on the businesses that are forced to pay their employees 18% more per hour. If we are able to accurately model a business and factor in a raise in minimum wage, we will be able to see what future effects will be. We can also find out if the raise in minimum wage will bring more help or harm to a business and it's employees.

**Purpose of the model**

Once we have perfected our model, there are a majority of people we could show it too. If the model proves that more harm is caused to a business and it's employees, we could give it to business owners or government officials so that they could study it the next time they are thinking of raising the minimum wage. I also think the taxpayers should have access to the information before they vote on another wage bill. The employees should also have access to the information so that they can see what the real effects will be on the business and their jobs.

**Identify the shareholders**

Every person that is a consumer, employer, or employee should have an interest in this model. The raising of minimum wage all of their lives.

## Resources Utilized

**People**

Tony Miller is an assistant manager at Fred Meyer Grocery in Portland, Oregon. We talked to Mr. Miller about the curves that our model showed. We also asked him if the drop in employee's and store profits were true with what actually happened at Fred Meyer after the raises in minimum wage. He told us that Fred Meyer was forced to fire some employees and they did take a drop in profits. This indicates that the data we received from our model was correct. We were able to accurately model the effects of raising minimum wage on a business.

**Reference material**

We gathered much of our data off of the Internet. Sites such as The Oregon Department of Labor and Industries (www.odli.or.us) and the United States Department of Labor (www.dol.gov). The Oregon Department of Labor was more useful to us because it is more local. We also used a Supply and Demand model by Diana Fisher to get an idea of the curves for our multipliers in our model.

**Data Sources**

We don't have actual data to compare our model too, but we knew that once the minimum wage was raised, the price of the product should be raised in order to keep the store's profits positive. We also knew that in order to keep the profits positive the store must lay off some employees to cut back on expenses. We set up the model so that it included all of the pieces of a supply and demand business model and once we were able to run it and get accurate, reasonable curves, we knew the model was correct.

## Challenges

The main problem we encountered while constructing our model was incorrect curves and multipliers. Our first hurdle was trying to get our model to start in equilibrium. We needed to make some calculations but it wasn't too difficult. Then came the hardest part of our model. We knew that all of the pieces were set up correctly, but the model wasn't behaving correctly. The price was going down, profits were dropping and all of the employees were being fired. We tried modifying our stocks and flows but nothing seemed to work. We turned all of our stocks and flows back to the original values we calculated and then switched the inventory ratio from desired inventory / inventory to inventory / desired inventory. This was the problem with our model because the inventory ratio causes the price to change based upon how many inventories the store has. When the stock read desired inventory / inventory, the value was always more than 1, telling the effect of Before the ratio was always larger than one which pushed the price inventory on price that the store had too much inventory and the price would be pushed way up. Once we switched the inventory ratio to inventory / desired inventory, the model began to run correctly. Now the priced based on inventory would go down as the inventory got higher instead the price going up as the inventory got higher.

## Reference Behavior

In our model, we expected at least one of two things to happen. Those were that the model's storeowner would increase revenue by raising the price and the model's store would decrease the revenue by decreasing the number of employees, starting on the 52nd week (January 1, 1998). We also expected the same thing to happen on the 104th week (January 1, 1999). Our expert said that the curves in our model were correct.

**What are Your Expectations?**

Our model was set up to see how a business would react to a raise in minimum wage. That is just an increase in their expenses. Because there is an increase in the outcome and no way for the store to increase the demand for their product, without dropping the price, the store must take cutbacks in other areas. For this reason, we knew that the store would have to make some cutbacks and we figured that the price would be raised. This would, we thought, force the inventory to go higher than the original inventory. Our expectations were that the number of employees fired from the store would depend on where the store chose to take its cutbacks. We figured that some employees would be fired.

When the stores expenses went up, we expected that the store would be forced to take a cut in profits.

# The Core Model

## Model Description

**Key Variables**

The most important variables in our model are the multipliers that determine the effects of one stock or converter to another. The effect of inventory on price determines what the change in price should be based upon theratio of inventory to the initial inventory. The effect of demand on price and effect of profits on price are also key variables. These flows determine the price of the product and the price of the product effects the profits of the store, the demand of the consumers and the way that the business is run. Other key variables are our stocks. Price, inventory, employees and profits are the four key areas of a business and the backbone of our model.

**Core model flow Diagram**

The main diagram is shown below.

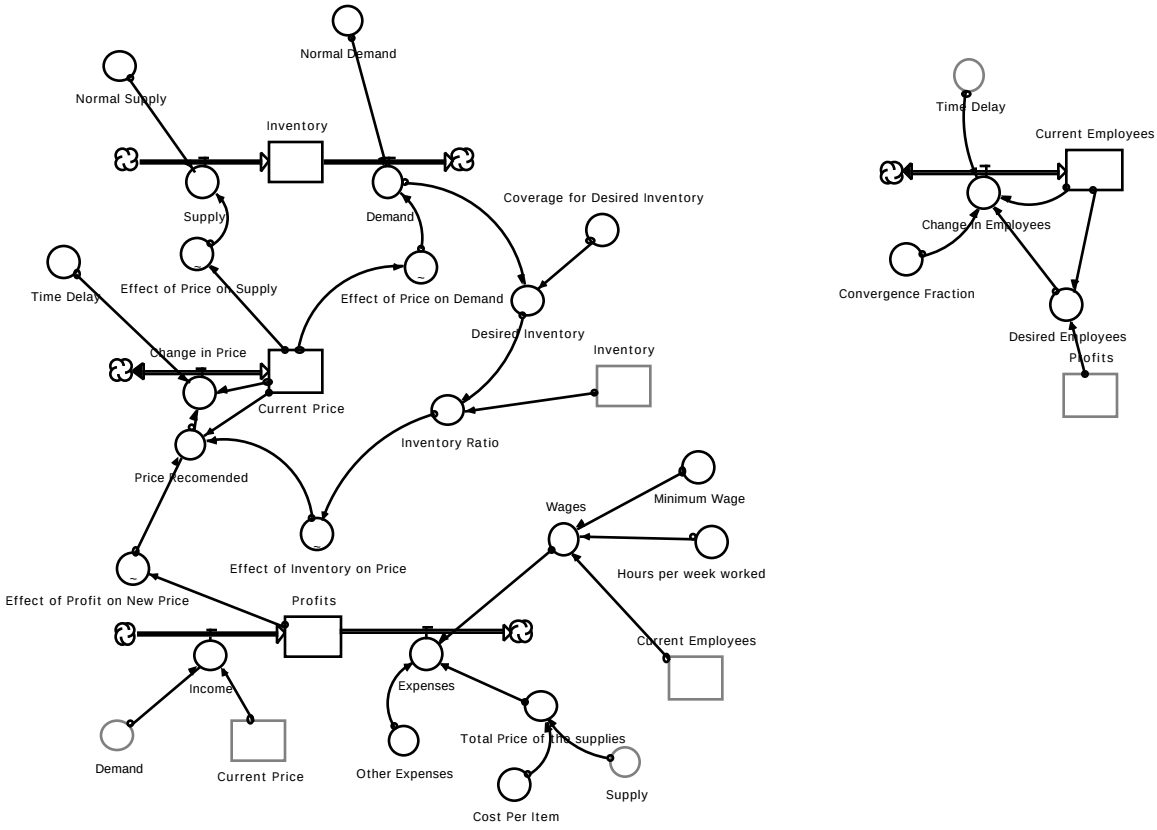


Figure 1: The Model. See Appendix A for Larger Diagram.

**Core Model Logic and Key Equations**

This model is a supply and demand model set up to find the effects on a business after a raise in minimum wage. The product the store is selling is CD's. The initial price of a CD is 15 dollars. The initial inventory is 1200 and the initial demand and initial supply are both 400. When the inventory and demand are at their normal values, the business is in equilibrium. If the demand goes up or down due to an increase or decrease in price, the inventory will be affected. When the price is lowered, consumer interest is increased and the inventory is decreased. Now the business must increase the supply in order to fill all of the demand. With a low inventory, the business must increase the price because they don't want to sell out. On the other hand, if the inventory is high, the price must be lowered in order to sell off all of the extra supplies. If the stores profits are normal or above normal, the model will remain in equilibrium. If profits drop, the store will try and correct the drop by taking cuts in other areas and decreasing the expenses. Or the store will raise the price of the product. Inventory and profits effect price, demand and supply effect inventory, and price and demand effect profits.

We wanted to have our model to begin in equilibrium so we based the demand and supply on how many expenses the store uses per

week. Our expenses are; the bosses' salary, the employees' wages, the price of the stores supplies, taxes and other such expenses. The employees' wages are based upon the number of employees multiplied by the number of hours they work and the minimum wage. The store profits begin at 1000 dollars. The beginning number of employees is 10. The numbers of employees are based upon the amount of profit the store takes in each week. If the profit drops from the initial profits, the store manager may chose to take a cut inexpenses by firing some employees. If the profits rise back up the following week, the manager may hire back some of the fired employees.

The model revolves around the profits of the store. If the profits are up, the store remains in equilibrium and nothing changes. If the profits go down below the beginning profits, the effect of profits on price, which is a multiplier, causes the price to rise and throws the model out of equilibrium.

**Identification and Analysis of Feedback Loops**

This model, we have 10 feedback loops. The most important one is a feedback loop that includes Current Employees, Wages, Expenses, Profits, Desired Employees, and Change in Employees. As the number of current employees goes down, then the wages go down. The decrease in wages causes the expenses to go down which causes an increase in profits. This increase in profits causes the Desired Employees to go up which causes the change in employees to go up. This will cause the current employees to go up. Therefore, this is a counteracting feedback loop. The feedback loop is shown below.

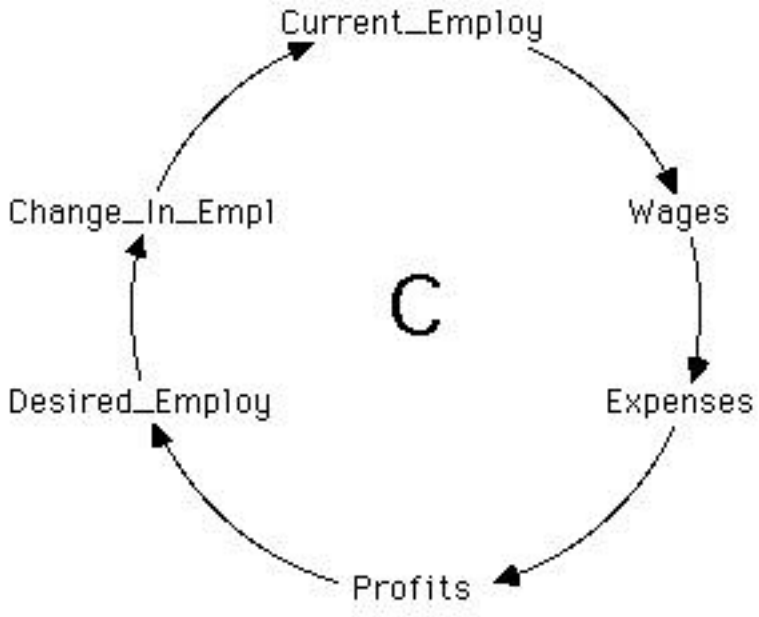


Figure 2: The first major feedback loop

The second feedback loop includes the current price, the effect of price on demand, the desired inventory, the inventory ratio, the effect of inventory on the new price, the recommend, and the change of price. As the current price goes up, the effect of price on the demand goes down, which causes the demand to go down. The decrease in demand causes the Desired inventory to go down which causes the inventory ratio to go down and the effect of inventory on price to go down. This decrease on the effect of inventory on price causes the recommended price to go down, which causes the change in price to go down. This effect causes the current price to go down. Therefore this is a counteracting feedback loop. The feedback loop is shown below.

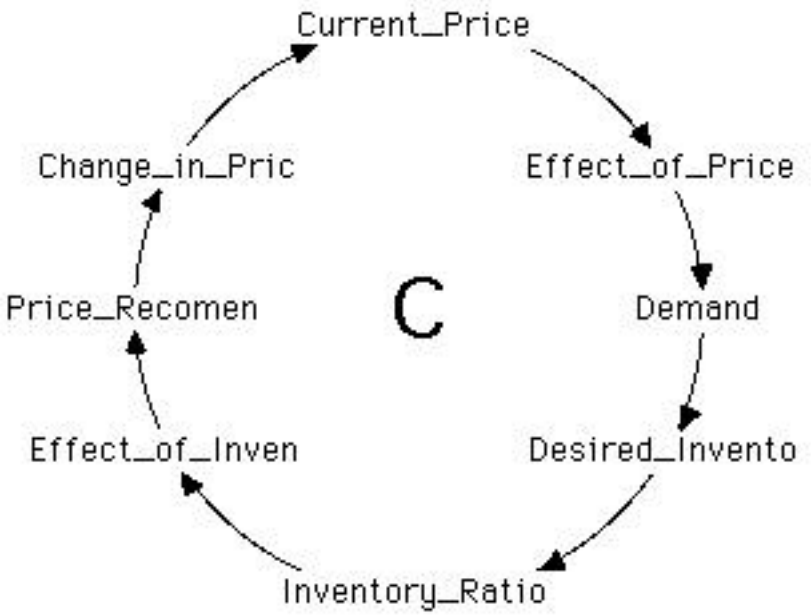


Figure 3: The second major feedback loop

## Additional Considerations

**Major Assumptions**

No companies wanted to give us data on their profits, so we needed to make a totally hypothetical business. The number of employees, the price of the product and all of the stocks were values that we calculated. We had to assume what effect the inventory and profits had on the price of the product. We used data from a pervious supply and demand model to check if our multipliers were correct. We also needed to make sure that the store was making profits before the minimum wage was raised. The assumptions we made were all based upon other assumptions in our model and everything is connected so that the model will work.

**Parameter Values**

To find the initial values for our stocks, we inserted the major expenses a business pays onto our supply and demand model. We

also figured, based upon the price of our product, what the demand should be in order to give the business a steady, reasonable profit. One of our main parameters was our minimum wage converter. After 52 weeks our model changed the minimum wage from 5.5 dollars per hour to 6.0 dollars per hour. After the 104 week the minimum wage changed from 6.0 to 6.5 dollars per hour. We got this data from the actual raise that occurred in Oregon over the last 3 years. Our initial number of employees was based upon how many the store could hire on their current income. The effect on price from inventory and the effect on price from profits multipliers were curves that we had taken from the previous supply and demand model and used that data to calculate for our data to get the same curve. The effect of price from profits multiplier we calculated so that it made sense.

**Choice of Time**

This simulation runs for 156 weeks or 3 years. The basic time unit was weeks because it was what our data suggested. Also it is more constant than months. The beginning time was 0 because weeks aren't numbered. This corresponds to the first week of January 1997. We chose to keep the stock values in equilibrium for one year before the first minimum wage increase took place. The ending time is 156. This corresponds to the last week of December 1999. We chose this to be one year after the last minimum wage increase goes in effect. Our DT is .1 in order for our model to be more accurate. The integration method is Runge-Kutta 4 because Runge-Kutta 4 is designed to calculate the average values for each DT and this gives us more accurate results.

## Core Model Results

The initial simulation is in equilibrium until the $52^{ND}$ week. One the $52^{ND}$ week we inserted a raise in the minimum wage. This increases the stores expenses and the profits go down. The model reacts almost immediately by firing some employees and jacking up the price. The increased price causes the demand to go down and the stores inventory to go up. With an increased inventory, the store is forced to drop the price back down. After 10 weeks of turmoil, the model is restored back into equilibrium until the next raise in wages, the $104^{TH}$ week. On the $104^{Th}$ week the wages are raised again and the model reacts the same as it had on the previous wage raise. In the end, 15.4% of the original employees were fired. Price remained the same. The store profits took a 15.4% drop. Inventory went up 11.3%. The stores income remained the same, but the outcome was increased, and the employees' salaries were raised 18%. This data agrees with our assumptions. We knew that once the minimum wage had been raised, the store would need to take cutbacks in other areas. We did not know where the store would take the cutbacks, but we are pleased with the results.

**Graph for the Core Model**

The graph is shown below.

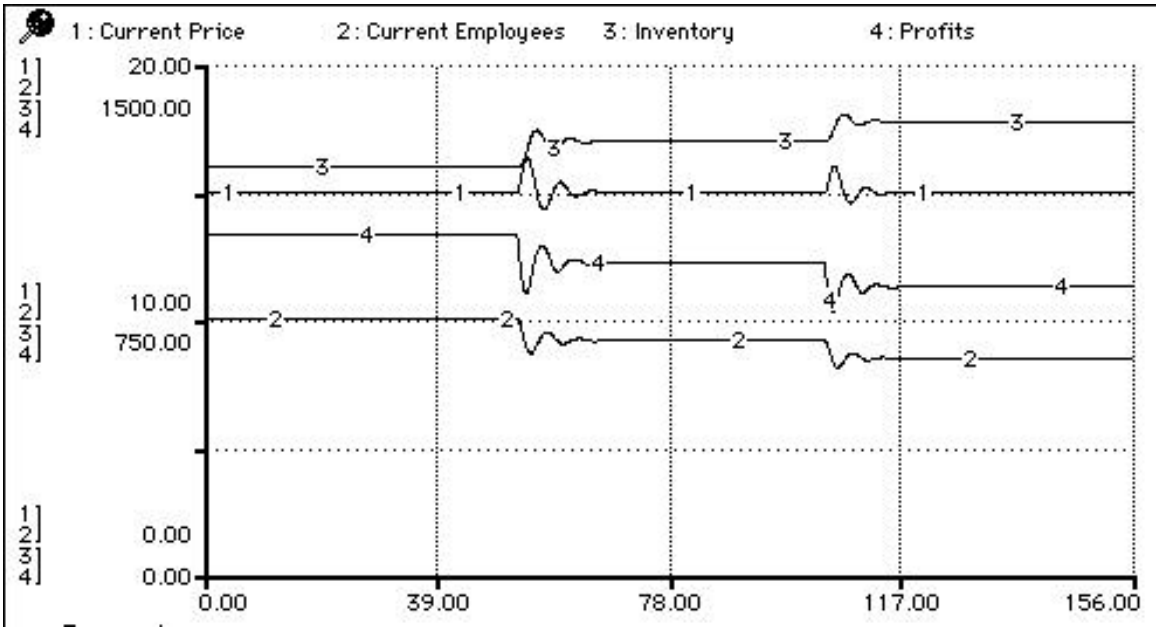


Figure 4: The graphical output of our model

**Interpretation of the Graph**

When we set up our model we didn't know how it was going to behave. We had ideas of how some of our stocks should react but we had no idea how high, low or fast they would react to the change in minimum wage. On the 52nd week (January 1, 1997) the minimum wage was increased from 5.5 to 6.0 dollars per hour. This caused our stores expenses to go up and the profits to go down. The store immediately reacted by firing 13% of their employees and increasing the price of the product. When the store increased the price, the demand went down and the stores inventory went up, causing the store to drop the price back down in order to get rid of the extra inventory. After ten weeks of the store figuring out how to cope with the raise in minimum wage, they returned the price back to the original price and hired back 40% of the employees that they fired. The store also took an 8% drop in profits and a small raise in inventory. For the next 40 weeks, the store remained in equilibrium until the 104th week (January 1, 1998). On the 104 week, the minimum wage was raised from 6.0 to 6.5 dollars per hour. The store reacted the almost the same was as it had done before. They immediately fired 12% of their employees and raised the price 6%. This again caused the demand to go down and the inventory to go up. As the inventory went up, the store was forced to drop the price and take another cut in profit.

**Tabular Output for the Core Model**

The table is shown below

| Weeks | Current Employees | Current Price | Inventory | Profits | Minimum Wage |
|---|---|---|---|---|---|
| .0 | 10.00 | 15.00 | 1,200.00 | 1,000.00 | 5.50 |
| 10.0 | 10.00 | 15.00 | 1,200.00 | 1,000.00 | 5.50 |
| 20.0 | 10.00 | 15.00 | 1,200.00 | 1,000.00 | 5.50 |
| 30.0 | 10.00 | 15.00 | 1,200.00 | 1,000.00 | 5.50 |
| 40.0 | 10.00 | 15.00 | 1,200.00 | 1,000.00 | 5.50 |
| 50.0 | 10.00 | 15.00 | 1,200.00 | 1,000.00 | 5.50 |
| 60.0 | 9.05 | 15.29 | 1,279.18 | 911.07 | 6.00 |
| 70.0 | 9.16 | 15.02 | 1,277.43 | 915.62 | 6.00 |
| 80.0 | 9.17 | 15.00 | 1,277.88 | 916.62 | 6.00 |
| 90.0 | 9.17 | 15.00 | 1,277.92 | 916.67 | 6.00 |
| 100.0 | 9.17 | 15.00 | 1,277.92 | 916.67 | 6.00 |
| 110.0 | 8.55 | 15.04 | 1,323.80 | 834.54 | 6.50 |
| 120.0 | 8.47 | 15.00 | 1,335.51 | 845.97 | 6.50 |
| 130.0 | 8.46 | 15.00 | 1,335.84 | 846.15 | 6.50 |
| 140.0 | 8.46 | 15.00 | 1,335.84 | 846.15 | 6.50 |
| Final | 8.46 | 15.00 | 1,335.84 | 846.15 | 6.50 |

Figure 5: The Tabular Output for our model

**Interpretation of the Table**

The table supports what our graph is telling us. At week 52, the system goes out of the equilibrium. The system, which is in oscillation, is steadily declining in its oscillation and eventually gets back into equilibrium. At week 104, the model comes out of equilibrium again. It also continues stabilize over time. The price levels out to be the same. The profits go down. This is telling us that because of this minimum wage increase, the storeowner is losing money that he would have normally made. The current employees go down. This tells us that the storeowner either reduces hours on the employees or fires some full time employees. The only thing that increases is the inventory. This is occurs because at the points where the owner raised the price of the product, the demand went down and caused an increase in the inventory. The price never went low enough to increase the demand and allow the entire extra inventory to be bought. The high inventories causes a decrease in price and a decrease in profits which causes an increase in price, so they cancel each other out and the price remains the same.

# Verification and Validation

## Preliminary Testing

**Verification** Since our model was just an extension of a previous model, everything beyond the first model came conceptually. We had no data on which to base our extensions on, for our knowledge of what a business's expenses and income should include. The model was built to what we wanted. If we thought there should be a separate model for the employees' jobs, we put it in. Therefore our conceptual model was exactly the same as our computer model.

**Validation** In a real world situation of this business, the numbers won't be this perfect, but the curve of the graph did what we were expecting. One expert said, "Two Studies have shown that two things might happen when the minimum wage goes up. These are that the employer will fire employees to lower expenses, or raise the price to increase revenue. Initially the system raises prices to compensate for the loss in revenue." The owner tried raising the price of the product but then the demand dropped and the inventory increased. The price eventually evens back out at $15.00 per CD. This is because the increased demand decreased profits cancel each other out. The manager also fires employees, which is what we expected.

**Error Analysis** This model agrees with our expectations. We expected the manager to do at least one of two things, increase revenue by raising the price, or decrease the expenses by firing employees. The model's store manager initially did the first of the two, but then fired the employees the price back down where it was. We did, however, expect the price to be a little bit higher than before. This didn't happen because the manage of our store fires extra employees to get the price back down to $15.00 per CD

## Sensitivity Testing-Exercising the Model

The Sensitivity graph is down below.

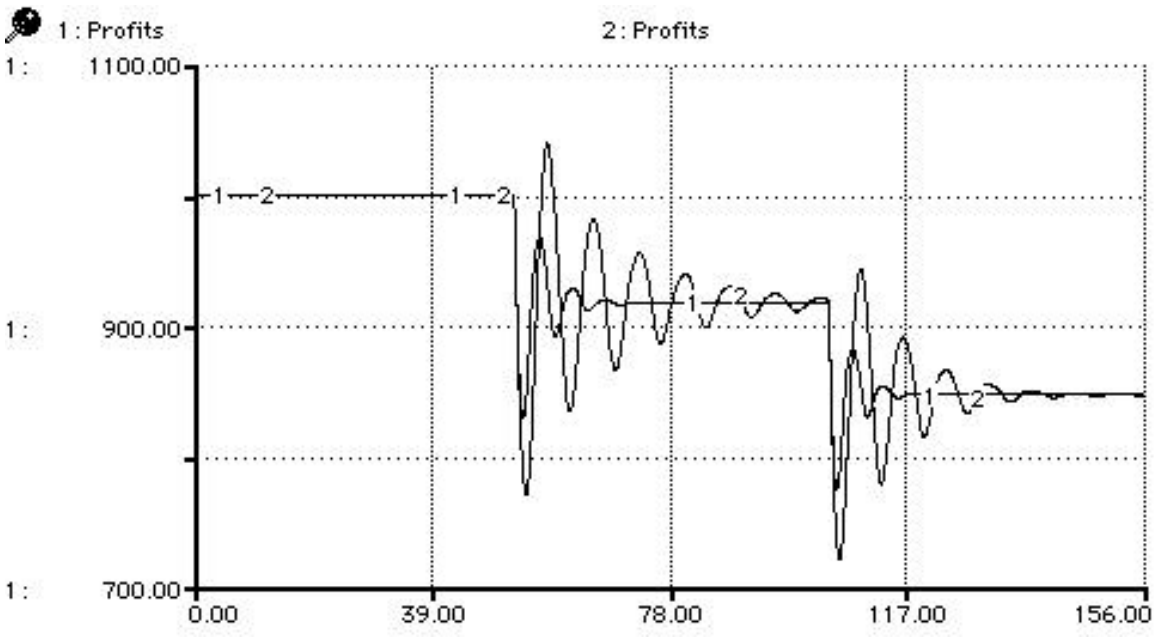


Figure 6: The Sensitivity Graphs. For the complete Sensitivity Graphs see Appendix B

**Test each Parameter Separately**

In order to see what our model would do if the manager waited a different number of weeks to change price and hire/fire employees, we ran sensitivity graphs. We started with delays of one through 5 weeks. The first two of that graph is shown here. Then we made another graph for delays between 6 and 10 weeks. The full two graphs are in appendix B. You can se by the graphs that the time delay is a leverage point in the model. With this time delay, anything over one week does not reach equilibrium before one year.

## Conclusion and Future Plans

Is raising minimum wage worth it? If the employees' knew that 15.5% of them would be fired would they still have wanted to raise the wages? If the business owners knew that they would be losing 15.4% of their profits, what would they have done differently? If the taxpayers knew what the real effects of the wage raise would be, would the bill still have passed? These are questions that we must ask ourselves. If this model is accurate, I think nothing would have changed. The employees would still want to be paid

more money and the employers knew beforehand that by increasing the wages, they would be taking a drop in profits. The taxpayers however are the ones that I'm not sure about. They are consumers and seeing that the price of the product was not raised might prompt them to side with the employees. On the other hand, the might see that after 15.5% of the employees are fired for an 18% increase, it's not really worth it. It is up to the voters to decide and that is why I think this information should be available to all of them in the future.

This model can also be altered to test a variety of different ideas. We could factor in a strike and see what the effects of a supply shortage would be on a business. Also if the number of employees were to change suddenly (increase in hiring or firing), we could see what the effects would be on a business. This model is set up to model a business and we could alter any part of it to find what the effects would be.

We have to remember that our model outcomes are limited by our assumptions that simplified the problem. Those assumptions were the expenses and profits of the business, the cost price and price of the product and the effect of profit on the number of employees.

# Source Materials

## References

Cox, J. Rouge River Press, Oregon. Online. Internet. February 15, 1999. http://www.rogueriverpress.com/1-3-99/1-3-99_state.htm

Fisher, Diana. Supply and Demand Portland, Oregon. ©1998

Mello, John P. Jr. Inc Online Local Business News—Portland, OR. Online Internet. February 15, 1999. http://www.incmagazine.com/news/portland.

# Appendices

MODEL—A

GRAPH—B

TABLES—C

EQUATIONS—D

FEEDBACK LOOPS—E