Work Force Inventory System Dynamic Lab

What to hand in: Open a Microsoft word document, put the above title on it and your name underneath the title. Then answer questions (use complete sentences and whole thoughts please) and cut and paste as you go through the numbered instructions. The places where you are expected to have something to say are printed in this font (though some passages are instructional commentary and do not require any response from you), the instructions in a sans serif font.

1. If Vensim is not on this computer, download it again and re-install. Start the program and open user guide to chapter 3.

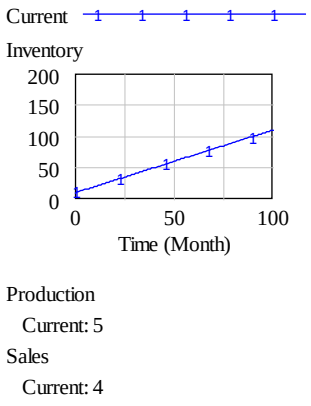
The manual speaks of SIMPLICITY and REFERENCE MODES and REALITY CHECKS and DYNAMIC HYPOTHESES. In your own words what is the take-away version of each of these?

SIMPLICITY
REFERENCE MODES
REALITY CHECKS
DYNAMIC HYPOTHESES

2. Start with a new model (accept the defaults on the Model Settings. Create an **Inventory** stock with a **production** flow in and a **sales** flow out. Set the equation for production to a constant 5 and its units to **frames/month** and the equation for sales as a constant 4 and its units to **frames/month**. Make the equation for Inventory the cumulative sum (integral) of production minus sales with an initial value of 10. Set its units to **frames**.

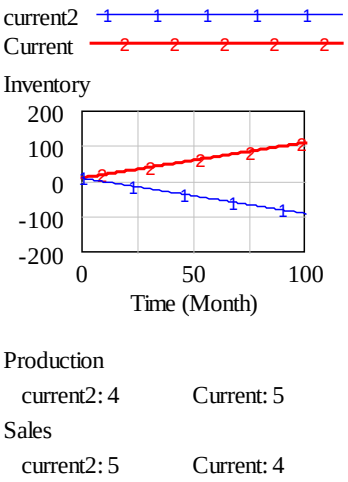
What do you predict will happen?

3. Click on the run button and then on the "causes strip" button on the left side of the window.



4. Switch the values of Production and sales and run the model again. Tell Vensim NOT to overwrite the old data and call the new dataset CURRENT2. Stop and think – what will

Inventory look like over time this time? Make Inventory the workbench variable and look at the causes graph again.



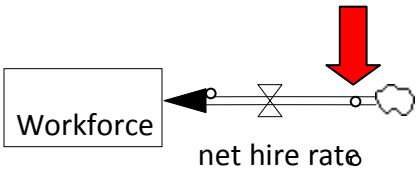
5. Close the causes strip and make a full-size graph with the graph button. Then make a table with the table button.. Then do a "table time down." What's the difference? Close the various extra windows.

Where does production come from? Adding a WORKFORCE stock/level

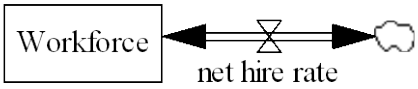
6. Create a **Workforce** stock.

7. Create a flow to Workforce called **net hire rate**

8. Make this flow two-way by grabbing the hand tool and control-clicking on the handle (little circle) on the non-arrow end of the flow and then checking the arrowhead box



9. The result should look like this:



How is Workforce related to production? More workers mean more product. The ratio of product to workers is **productivity** – the number of window frames per worker per unit of time.

10. Add this as a Variable auxiliary/constant. Set its value to 1 and units to `frames/month/person` (that is, for now we'll assume each worker produces one window frame per month).

11. Now use the arrow tool to connect **workforce** and **productivity** to **production**. Change the equation for production to `workforce*productivity`.

The components of any system are connected either physically or informationally. The three flows we have made so far are physical – frames flow into and out of inventory, workers flow into and out of the workforce. Now we will add some information connections – representations of how parts of the system respond to information about what is happening in other parts of the system.

The hiring rate, for example, depends on how many people we think we need and how many people we have and our knowledge of how long it takes to get new workers hired and trained, or, in the other direction, how much notice must be given to workers we want to lay off.

12. Create variables for **time to adjust workforce** (value = 3, units = month) and **target workforce** (units = persons) and connect them with arrows to **net hire rate**. Also connect **workforce** to **net hire rate** with an arrow.

13. Insert an equation into the workforce stock: it's initial value can be 100 and the equation should simply be the integral of the `net hire rate`.

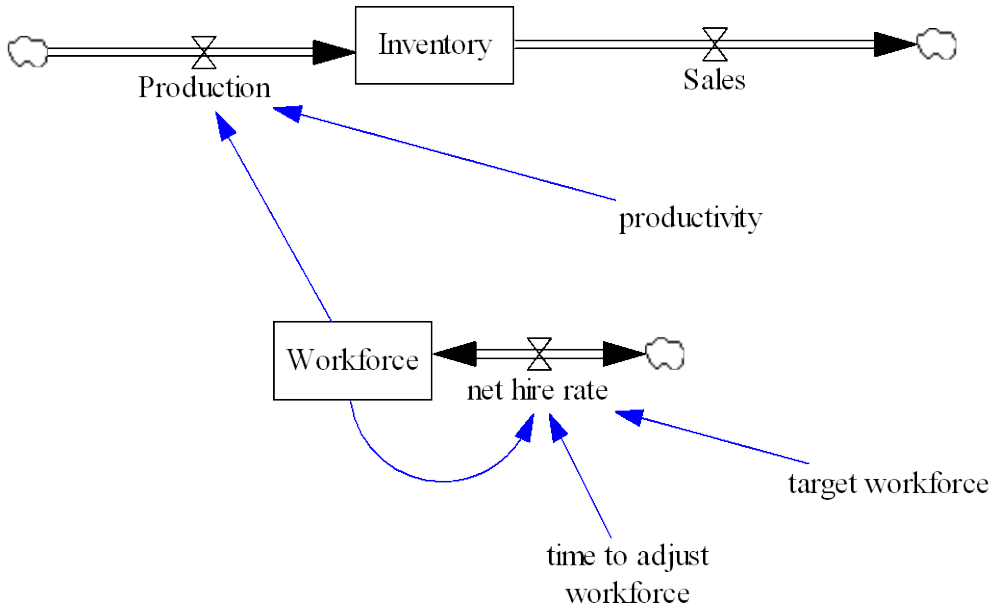
Let's think about what these variables mean. The rate of new hires should be something like

$$rate = \frac{(target - current)}{time\ to\ adjust}$$

That is, we look at our situation and decide how many workers we need. Then we look at how many we have. This tells us how many we need to hire (or fire). If we divide this by the amount of time it takes to happen, we have the rate at which workforce grows or shrinks.

14. Insert this equation into the **net hire rate flow**.

You should be looking at something like this at this point:



Where does target work force come from? Signaling Part Two

We assume that our manager takes a look at current sales figures to determine what level of target production she should aim for and that she combines this target with her knowledge of current productivity levels to determine her target workforce. Adding these variables will complete our first version of the model.

15. Add variable **target production** and connect them as just described. Be sure to connect to **target workforce** too.

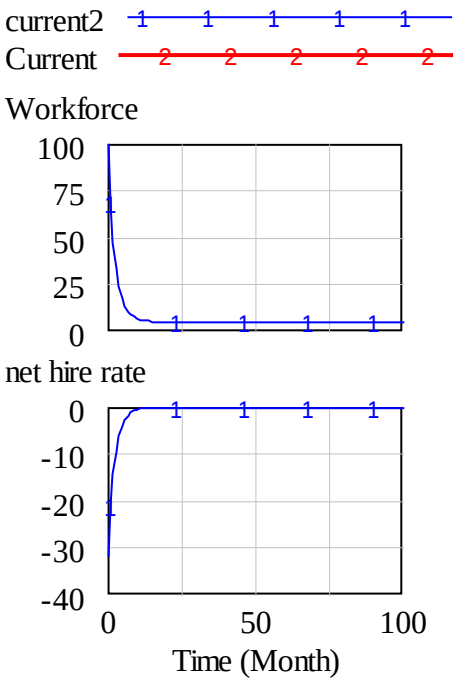
16. What should the units be for target production? Given the units of productivity and target production and target workforce, determine what the correct equation for target work force would be.

Before we go on, let's do a units check. This is under Model on the menu bar. It's pretty likely that something is out of whack or that we have left something out. It's a good habit to be extra careful with units as they help you catch logical mistakes. Here's what I got when I ran it while trying this out:

```
************************************************
ERROR:  No units specified for - net hire rate
************************************************
Error in units for the following equation:
Production  =  productivity * Workforce
Production  --> frames/Month
productivity  --> frames/(Month*person)
Workforce  --> persons

Analysis of units error:
Right hand and left hand units do not match
Production has Units: frames/Month
productivity  * Workforce has Units:
frames*persons/(Month*person)

************************************************
Error in units for the following equation:
target production  =  Sales
target production  --> frames
Sales  --> frames/Month

Analysis of units error:
Right hand and left hand units do not match
target production has Units: frames
Sales has Units: frames/Month

************************************************
Error in units for the following equation:
target workforce  =  target production / productivity
target workforce  --> persons
target production  --> frames
productivity  --> frames/(Month*person)

Analysis of units error:
Right hand and left hand units do not match
target workforce has Units: persons
target production / productivity has Units: Month*person
```

The problem with production is that I wrote person in one case and persons in the other. There's a way to tell Vensim about synonyms, but I'll just make them both person. The problem with target workforce is the same. I just need to change "persons" to "person." I do this and then run the units check again and it finds a few new errors. This is because the first ones "hid" the second one (have you ever experienced this in other contexts?). So, keep running units check until you get an A.O.K.

Remember what we said about dynamic hypotheses back at the start? That means how we expect the system to behave when something changes. We can run the system now and it will run but it won't be very interesting. Here's what the causes graph looks like. What do we make of it?



Think back (or look back) to what value we left in the sales flow. What's going on here? Be sure you can answer this before continuing.

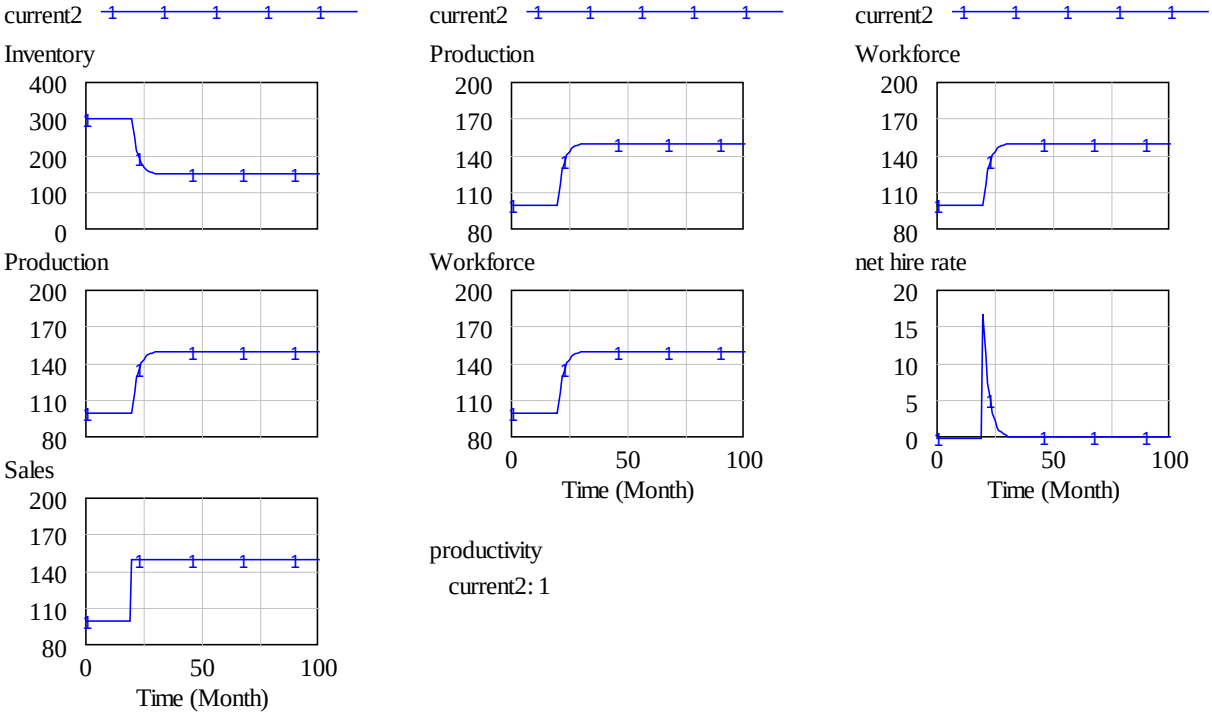
To make the model dynamic, we want to add some changes on the "input" side and so we modify the equation for sales. Vensim provides functions, just like Excel, that return values to our models. We'll use one here called "STEP." Here's what the Vensim help has to say about it:

> STEP(height,step time) STEP test input
>
> Returns 0 until the step time and then returns height. It is the same as:
>
> ```
> IF THEN ELSE ( Time plus > step time,height,0)
> time plus = Time + ( TIME STEP / 2.0 )
> ```
>
> **NOTE** The value returned by STEP does not change except at TIME STEP intervals regardless of the integration method used.
>
> See also: RAMP, PULSE
>
> Units: STEP(units,time) → units (step time has the same units as Time, the result of STEP has the units of the step height)
>
> Example
>
> STEP(10,20) is 0 till time 20, then 10.

We'll use **`sales=100+STEP(50,20)`** which means that sales will be at 100 frames per month until month 50 when it will become 150.

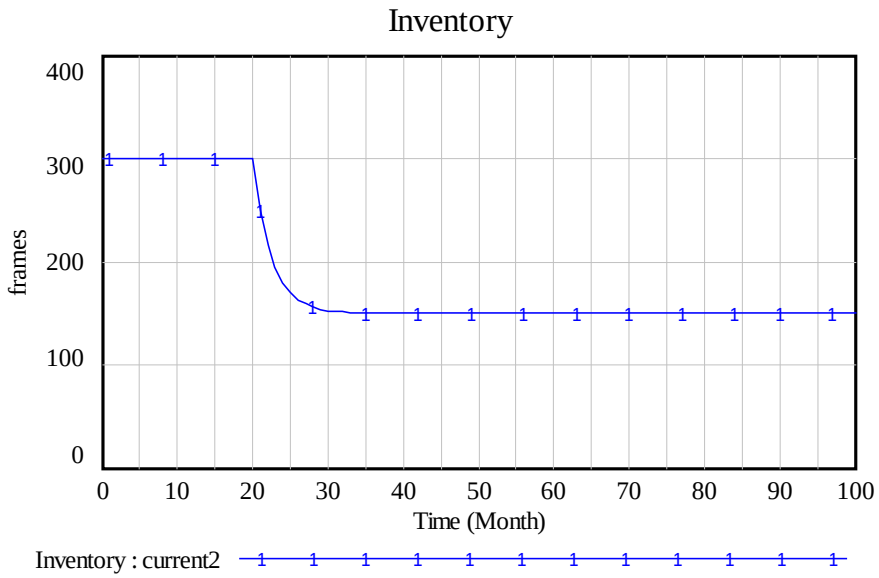
17. Make this change to the equation for **sales** and set the initial value of **inventory** to 300.

18. Run the model, select **Inventory**, **production** and then **workforce** as workbench variable and have a look at the causes strip.



Can you explain what each of these tells us?

And how about inventory – what do you make of it?



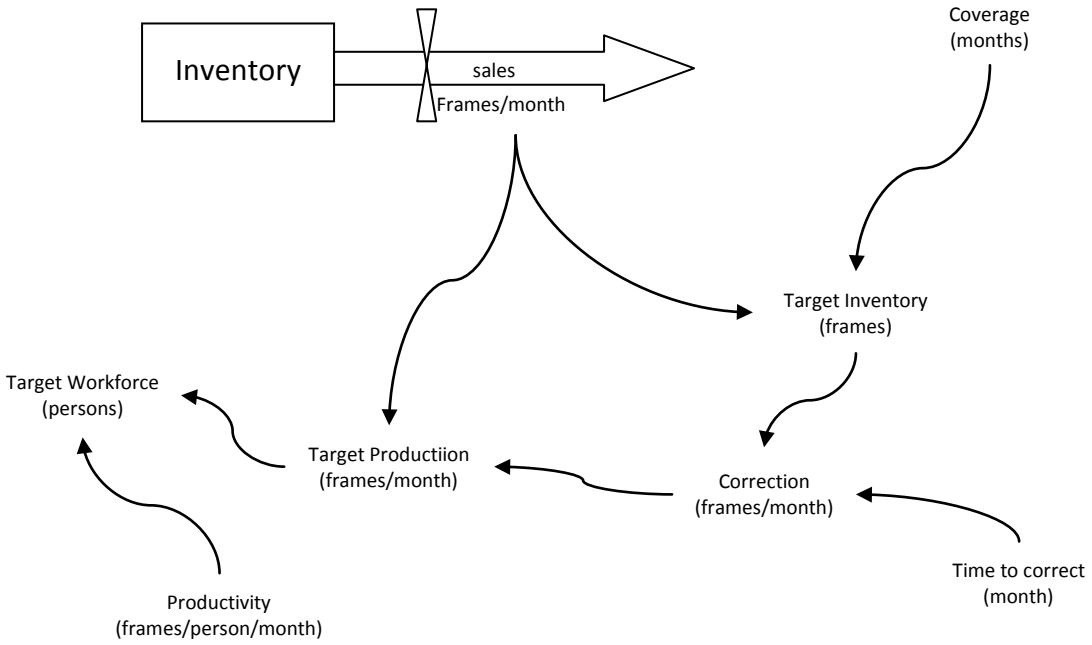
Be sure you can describe the dynamic behavior of the system before continuing.

Remember that we are trying to simulate a factory in which managers try to adjust the workforce in response to changes in demand and where we have observed (reference mode!) that production seems to vary more than sales and we are trying to figure out hwo the extra variability creeps into the system.

To investigate this we spend a little ethnographic time and realize that we have left something out of the picture. Our manager typically has a level of inventory coverage she wants to maintain. She thinks of it in terms of a number of months of sales that she always wants to have on hand. Based on this and current sales data she comes up with a target inventory. She compares this to current inventory to compute an inventory correction.

When thinking about upcoming production targets she has to consider both current sales and this inventory correction. Aware that the inventory correction will not happen instantaneously she sets a rate she'd like the system to try to achieve (this will give guidance to the production people and the folks in personnel).

We can sketch out the logic of this as shown below. Make sure it makes sense. Note how the units help us to follow what's going on.



Follow this through with units to make sure you understand it.

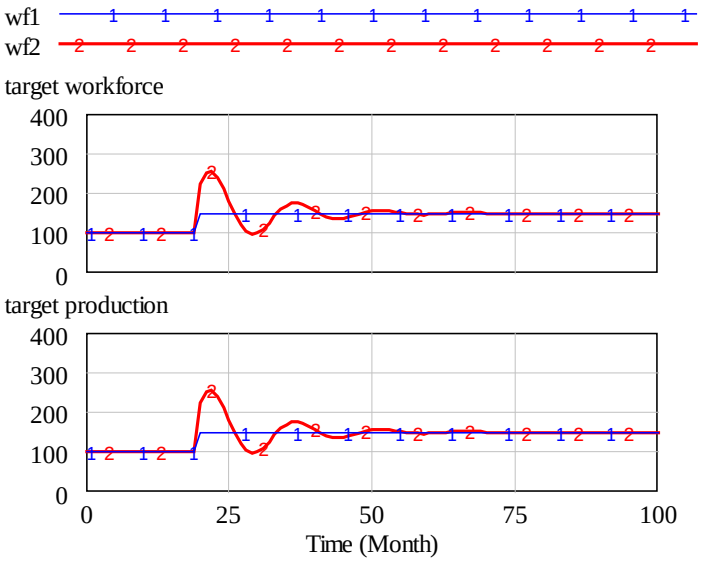
19. Now we are going to play with the simulation itself. We'll start off with a clean plate by clicking on the control panel icon and the datasets tab on the dialog box that opens. Then we'll move any datasets on the right over to the left and delete them. Then close the dialog and use the open model button to open the model WFINV1.MDL in the directory Vensim>models>mguide>2WFINV. This is the same model you just built but just in case there were any minor errors, we'll start out with a version we know.

20. Type the name WF1 in the text box next to the little person with "set" on her/his back. Let's first very quickly run the model once and take a quick look at causes strip to confirm that it ran.

21. Now open WFINV2 and run it. Click on control panel and load the data set WF1 so we can look at both together.

22. Click on the causes strip with Workforce as the workbench variable.

Describe the dynamic we see in this chart.



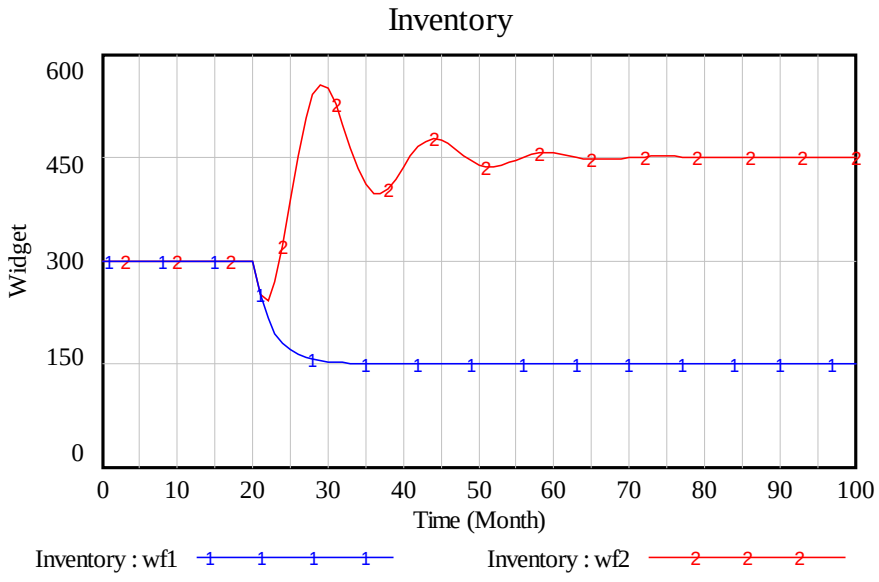
productivity

wf1: 1 wf2: 1

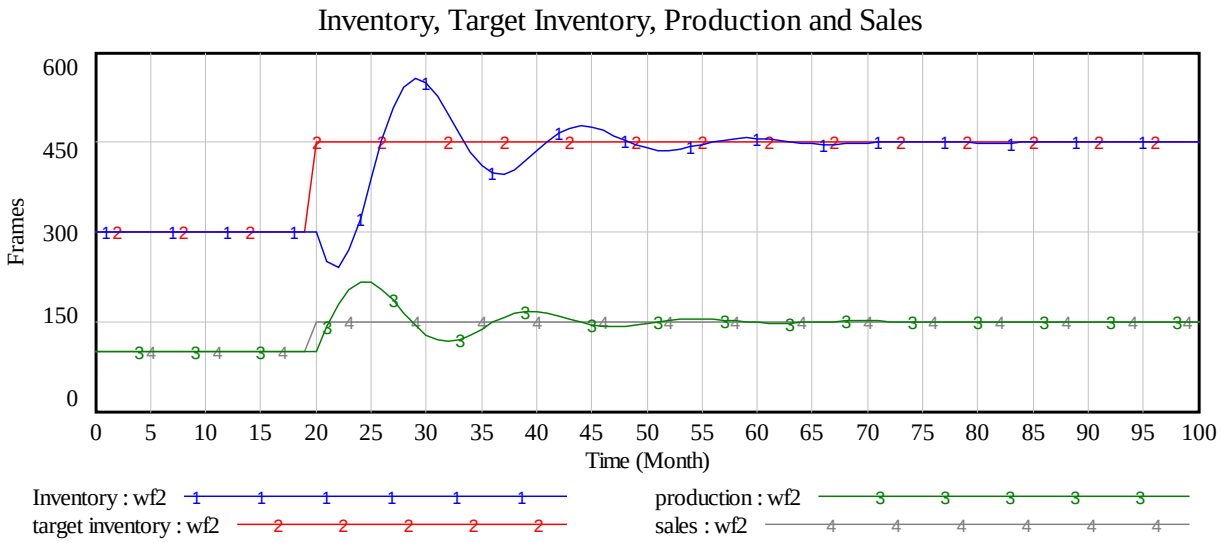
23. Repeat for target production.

Why does the strip for inventory correction not have any "1" line on it?

24. Finally, let's look at the graph for inventory.



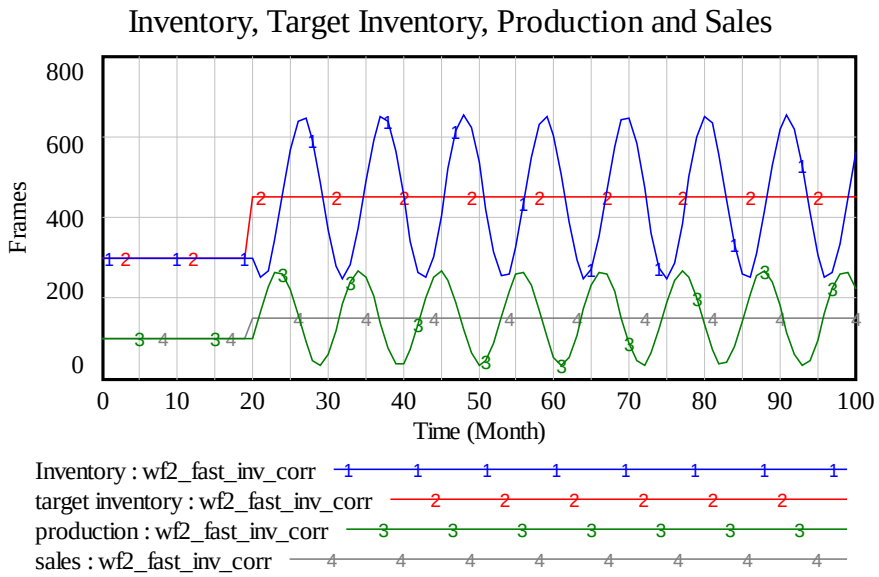
Let's take a little closer look at the system. Go to the control panel dialog and select the graphs tab. Click on new. Call the graph WFINV and give it the title "Inventory, Target Inventory, Production and Sales." Use the sel buttons to grab the four variables. Check the "scale" box in front of each. Type "Frames" in under the units for each. Go to the datasets tab and click on WF2 to bring it to the top of the list. Go back to the graphs tab and press display.

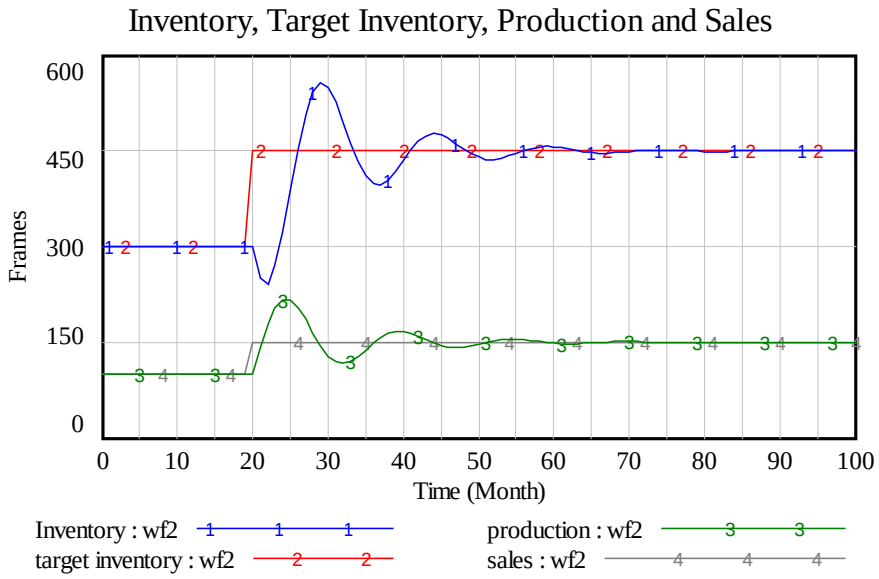


How long does it take for inventory to return to the desired coverage level? How long does it take for production to reach the new level of sales? How much does production overshoot at its maximum? How long does it take for production to settle down? How long does it take the inventory to settle down?

Sensitivity to Changes in Parameters

Suppose the manager looks at these results and says "what we need to do is respond more quickly when we see a change in sales" and then implements changes to more aggressively correct deviations from inventory. Simulate this by changing the value of time to correct inventory. Change the value to 1 and do a run and save the data as wf2_fast_inv_corr. Repeat again with that variable changed back and then halving the time it takes to hire and fire.





Testing changes

25. Go to control panel>datasets and move all the existing datasets over to the left and close. Next click the runner with the lines behind (automatically simulate on change). You get sliders on your variables and little graphs appear on the elements in the model.

26. Consider the problem posed at the end of the manual chapter as a possible start to a semester project.