

 Supporting Material is available for this work. For more information, follow the link from the Table of Contents to "Accessing Supporting Material".

## **Ten Steps to Simulate your Strategic Architecture**

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### **Abstract**

The topic of this paper is to present a solution to the problem of introducing system dynamics into a traditional strategic management course. In this paper we provide an example set of assignments that introduce undergraduate business students to system dynamics modeling. Students provide feedback on what they liked and disliked about these assignments. Overall, the students were very positive about this learning experience. It is hoped that these lessons learned may help others to integrate system dynamics into their strategy courses.

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## Ten Steps to Simulate your Strategic Architecture

Introducing new material into a course is always a problem due to the uncertainty with which one's approach will be effective. It is often helpful, then, to look over someone else's approach and reflect on their feedback. With this in mind, the following presents our attempt to introduce systems thinking and system dynamics modeling in a traditional, undergraduate strategic management course.

The overall goal for the construction of the assignment was to take the student from zero knowledge of system dynamics modeling, to building a model and running a basic simulation of a firm's growth, and comparing the model with actual data. All in ten steps. Thus, ten models were created such that the first model is very simple, and each subsequent model builds upon the previous one. A series of multiple choice questions were developed for each step, to verify the learning in that step. Overall, the steps were grouped into three assignments. One week was given to complete each, as a take-home assignment. The professor obtained real data for these assignments from the annual reports, form 10-k, filed by Home Depot Inc. with the Security & Exchange Commission's (SEC) EDGAR database of corporate information:

<http://www.sec.gov/edgar/searchedgar/companysearch.html>.

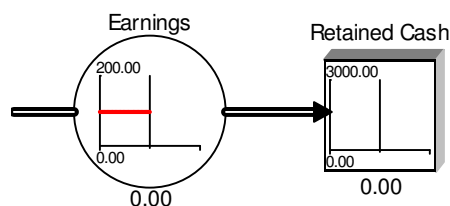
The assignments are presented below. Undergraduate business students completed these assignments in the Fall 2003 and Spring 2004 semesters. A sample of these students provided feedback on this assignment, and this is presented at the end of the paper.

### Assignment #1

Answer all the questions based on your simulation analysis, using the Mystrategy program. The models are available in \_\_\_\_\_ (the SDS Proceedings supplementary material section).

Download & open simulation model "step1.msf"

*Note: Retained Cash is a resource that **accumulates** over time, so it is represented as a **3-D BOX**. The **rate** at which the 3-D BOX is filled is determined by the flow (or valve that regulates the flow) and this is represented by a **CIRCLE**. In this case, the rate of Earnings (represented by a circle) determines exactly how fast the Retained Cash accumulates. In this model, Earnings are steady at \$100 per year (this firm has earned exactly \$100 every year for the last 12 years). We don't know what the earnings will be in the future (the future is the right-hand side of the graph; the vertical line in the center of the graph indicates today – the current year), so the right-half of the Earnings graph is left blank, for now. The simulation will automatically project future values for you, based on data for the last reported year (which is what we want in this case).*



<Run> the simulation of this model (*don't change anything, just run it as is...*).

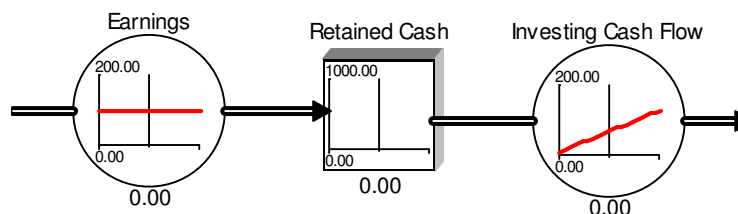
1. What is the total dollar amount of Retained Cash after 24 years of operations?
  - a. 100
  - b. 240
  - c. 1,200
  - d. 2,400
  - e. 120,000
2. What is the dollar amount of Earnings in year 24 of operations?
  - a. 100
  - b. 240
  - c. 1,200
  - d. 2,400
  - e. 120,000

<Stop> the simulation (*it will then reset to starting values*). Now use the “Run Step” button to step through the simulation.

3. What is the total dollar amount of Retained Cash at 9 years of operations?
  - a. 100
  - b. 240
  - c. 900
  - d. 1,800
  - e. 2,400

Download & open simulation model “step2.msf”

*Note: Investing Cash Flow regulates the flow of cash out of the firm (for purchases of plant and equipment). Thus, this is the rate at which accumulated Retained Cash depletes. The rate (amount) of investment has changed each year, starting at \$10 and increasing \$5 each year thereafter. It is expected that this investment policy will continue into the future, so planning data has been entered for future years 1 through 12 (the right-side of the graph). Earnings are again steady at \$100 per year (this firm has earned exactly \$100 every year for the last 12 years) and the plan is to earn \$100 per year for the next 12 years. (to view the actual values for Investing Cash Flow, double click on that variable and then select the “Graph” tab).*



<Run> the simulation of this model (*don't change anything, just run it as is...*).

4. What is the *pattern of change* in the total dollar amount of Retained Cash over 24 years of operations?
  - a. Linear increase
  - b. Linear decrease
  - c. Nonlinear increase

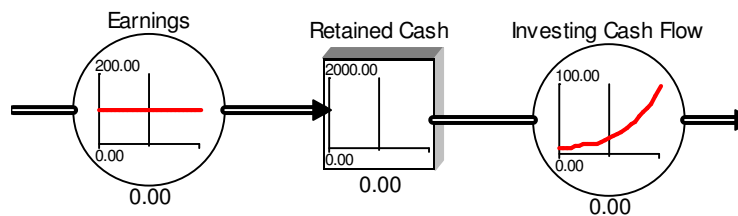
- d. Nonlinear decrease
- e. Nonlinear increase then nonlinear decrease

<Stop> then <Run Step> the simulation of this model.

5. What is the total dollar amount of Retained Cash at the *current* year (year 12) of operations?
  - a. <100
  - b. 100 to 200
  - c. 201 to 500
  - d. 501 to 1,000
  - e. >1,000
6. What is the total dollar amount of Retained Cash at 24 years of operations?
  - a. <100
  - b. 100 to 200
  - c. 201 to 500
  - d. 501 to 1,000
  - e. >1,000

Download & open simulation model “step3.msfl”

*Note: I have “sketched” the historical and planned values for Investing Cash Flow. In this new case, the management policy for Investment calls for increasing spending at an increasing rate. We want to see if this investment policy, that has been followed for the last 12 years, will be sustainable for the next 12 years...*



<Run> the simulation of this model (*don't change anything, just run it as is...*).

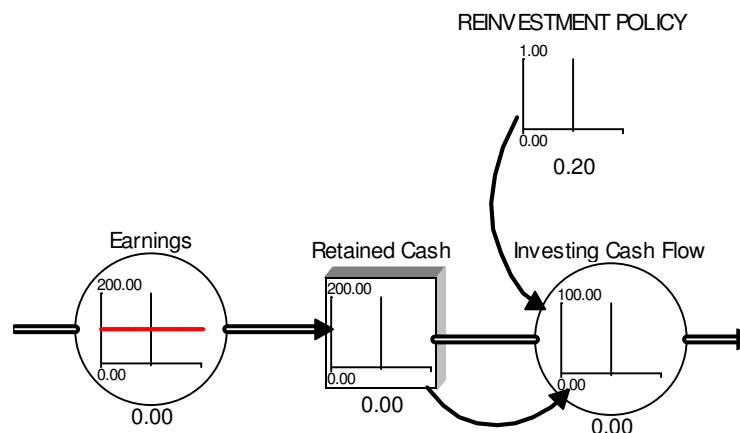
7. Is this management policy, for investment, sustainable for the next 12 years (will the firm still have some cash left)?
  - a. Unknown. (the simulation won't run with nonlinear planning targets)
  - b. No. (the firm runs out of cash before the end of the 24<sup>th</sup> year)
  - c. Yes, the firm will still have cash and the accumulation is increasing at an increasing rate at year 24.
  - d. Yes, the firm will still have cash and the accumulation is increasing, but at a decreasing rate at year 24.
  - e. Yes, the firm will still have cash but the accumulation started decreasing at year 15.

<Run> the simulation of this model, with the following change: The future earnings are now expected to be \$125 per year from now on (from year 13 to year 24).

8. What is the total dollar amount of Retained Cash at the *current* year (year 12) of operations?
  - a. <100
  - b. 100 to 500
  - c. 501 to 1,000
  - d. 1,001 to 2,000
  - e. >2,000
  
9. What is the total dollar amount of Retained Cash at 24 years of operations?
  - a. <100
  - b. 100 to 500
  - c. 501 to 1,000
  - d. 1,001 to 2,000
  - e. >2,000

Download & open simulation model “step4.msf”

*Note: In this new model, the policy for Investment is based on spending a proportion of the existing Retained Cash accumulation. To do this, we have added a new variable REINVESTMENT POLICY, which indicates the proportion of the cash balance we want to spend on investment. In this new case, the management policy has been to spend 20% of the Retained Cash each year on investment. (To model this policy, we need info on the level of cash as well as the proportion to be spent, and so you can see two new arrows pointing to Investing Cash Flow. These arrows tell the program that we want to compute a simulation based on this causality. To see the formula, double click on Investing Cash Flow and look at the Equation box). We want to compare this investment policy, that has been followed for the last 12 years, with an alternative policy...*



<Run> the simulation of this model (*don't change anything, just run it as is...*).

10. Is this management policy, for investment, sustainable for the next 12 years (will the firm still have some cash left)?
- Unknown. (the simulation won't run because no data is entered in Investing Cash Flow).
  - No. (the firm runs out of cash before the end of the 24<sup>th</sup> year)
  - Yes, the firm will still have cash but the accumulation stops increasing and begins decreasing at an increasing rate by year 24.
  - Yes, the firm will still have cash and the accumulation is increasing at an increasing rate at year 24.
  - Yes, the firm will still have cash and the accumulation levels off, maintains, by year 24.

<Run> the simulation of this model, with the following change: Try this alternative Reinvestment Policy; spend 80% of the accumulated cash (simulate from year 0 to year 24).  
*Note: to change the REINVESTMENT POLICY, double click on it and then select the Equation tab. In the Equation box, change the value from .20 to .80 and then click OK.*

11. Simulating the 80% reinvestment policy, what is the total dollar amount of Retained Cash after 24 years of operations?
- <80
  - 81 to 100
  - 101 to 500
  - 501 to 1,000
  - >1,000
12. Is the total dollar amount of Retained Cash at 24 years of operations the same as the level achieved under the 20% reinvestment policy?
- Yes
  - No, the 80% reinvestment policy results in greater accumulated cash
  - No, the 80% reinvestment policy results in less accumulated cash
13. Simulating the 80% reinvestment policy, what is the dollar amount of Investing Cash Flow at 24 years of operations?
- <80
  - 81 to 100
  - 101 to 500
  - 501 to 1,000
  - >1,000
14. Simulating the 20% reinvestment policy, what is the dollar amount of Investing Cash Flow at 24 years of operations?
- <80
  - 81 to 100
  - 101 to 500
  - 501 to 1,000
  - >1,000

15. What do these simulations imply about this style of reinvestment policy?
- Retained Cash is always positive.
  - Maximum Retained Cash is *greater* as the investment policy specifies a *lower* percent of accumulated cash.
  - Ultimately, in the long run, the maximum rate of Investing Cash Flow per year is actually the same for alternative policies.
  - All of the above.
  - A and B

## Assignment #2

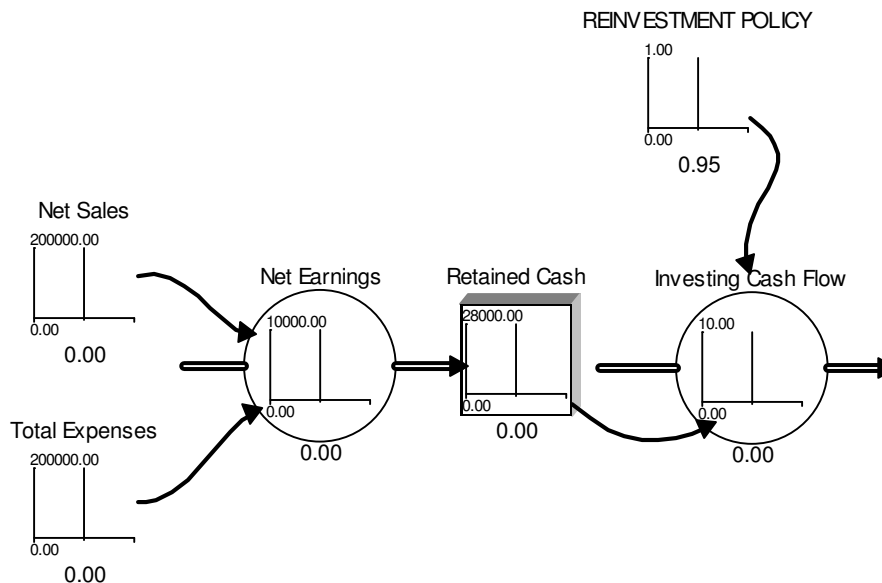
Download & open simulation model 'Step5.msf'

Download and open the Excel data file for this assignment: HDdata.xls

*Instructions: Copy from HDdata.xls and paste into the Mystrategy simulator the Home Depot data on Net Sales, Total Expenses, and Net Earnings. To enter the data into the model, first copy the relevant Excel data (Net Sales for 1990 through 2002), then switch to Mystrategy and double-click the appropriate variable (Net Sales), select the Graph tab, and then paste the data into the Value column. The data should automatically appear as a time series graph, in red.*

*Note: The Home Depot data is reported in millions of dollars. Keep this in mind when answering the remaining questions.*

<Run Step> the simulation [make sure the Net Earnings are properly calculated by looking at the overlap of red (real data) with green (simulated data). If the red and green lines don't overlap, then check your data to ensure you copied the right data categories].



16. What is the total dollar amount of Retained Cash after 20 years of operations?
- <100 million
  - 100 to 500 million
  - 501 to 1,000 million
  - 1,001 to 3,000 million
  - >3,000 million



17. What is the general problem with this simulation?
- No problem. Works fine.
  - Not realistic. Future trends are flat (after historical data ends).

<Stop> the simulation.

*Instructions: Using the spreadsheet, create data for the next 12 years by calculating future values based on the most recent annual growth rate (% change) in the last 2 years of actual data. Do this for Net Sales and Total Expenses.*

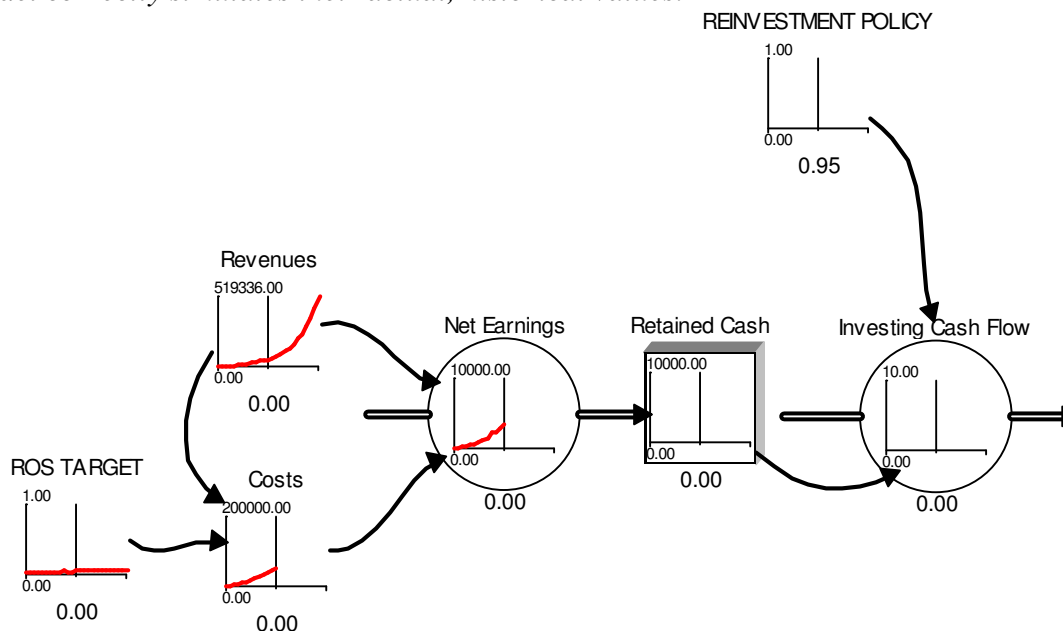
<Run> the simulation of this model.

18. What is the *pattern of change* in the total dollar amount of Net Earnings over the 24 years of operations?
- Nonlinear increase at an increasing rate
  - Nonlinear increase at a decreasing rate
  - Nonlinear decrease at an increasing rate
  - Nonlinear decrease, at a decreasing rate
  - Nonlinear increase then nonlinear decrease
19. Thus, based on this simulated, *future pattern of change* in Net Earnings, what do we conclude (at this point) about the current strategy?
- Based on the most current trends, the strategy is ok.
  - Based on the most current trends, the strategy is not ok.
20. What is the expected dollar amount of Net Earnings at 24 years of operations?
- <3,000 million
  - 3,000 to 6,000 million
  - 6,001 to 9,000 million
  - 9,001 to 12,000 million
  - >12,000 million
21. On the spreadsheet data, look at the Net Sales Increase(%) values. Based on the trend in this data series (over the last 4 years), do you think it's realistic to simulate future values using the historical trend calculated with the last two years of actual data?
- Yes, this seems to adequately approximate the historical rates of change.
  - No, projecting the Net Sales increase of last two years seems unrealistic because it appears to overestimate Net Sales increases, based on the historical trend.
  - No, projecting the Net Sales increase of last two years seems unrealistic because it appears to underestimate Net Sales increases, based on the historical trend.
  - There exists insufficient data to draw a conclusion.

Download & open simulation model 'Step6.msf'

*Instructions: Copy from HDdata.xls and paste into the Mystrategy simulator the Home Depot data on Total Expenses, and Net Earnings. Next, calculate 12 years of future Net Sales at 20% growth, per year, and then paste this entire data series into the simulation Net Sales (now covering 1990 through 2014).*

*Note: In this case, we are interested in modeling a Return on Sales (ROS) policy. If we can realistically simulate a generic ROS policy, with historical data, then we have some confidence that can realistically explore the impact of alternative future ROS policies. Thus, in this model, Total Expenses are driven entirely by the assumption that Management's ROS target is met. To see how well this model holds up, you have entered the actual data for Net Sales, Total Expenses, and Net Earnings. Of these, only the Net Sales data will drive the simulation. The historical data for Total Expenses and Net Earnings serve only as a baseline to determine if the model correctly simulates their actual, historical values.*



<Run Step> the simulation to the current year.

22. Look at the model's ability to correctly replicate Total Expenses and Net Earnings. Has the model correctly replicated actual performance of Home Depot?

- Yes, exactly.
- Yes, fairly well (looks adequate)
- No, Net Sales are off.
- No, simulated Total Expenses are too high.
- No, simulated Earnings are too high.

23. Try alternative ROS TARGETS. Which of the following ROS TARGETS best replicates the actual data for Home Depot?

- 9%
- 7%
- 5%
- 3%
- 1%

<Run> the simulation, using the best historical ROS TARGET (found in the question above).

24. What is the expected amount of Net Earnings in the 24<sup>th</sup> year of operations?
- <1 million
  - 1 to 10 million
  - 10.1 to 100 million
  - 101 to 800 million
  - >800 million

Instructions: Using the spreadsheet, calculate the actual, historical ROS from 1990 to 2002 (calculate using Net Earnings and Net Sales). Then, copy and paste this into the simulation ROS TARGET. Next, delete the number entered in the Equation box, for ROS TARGET (if not, this equation value will override your data entered in the Graph).

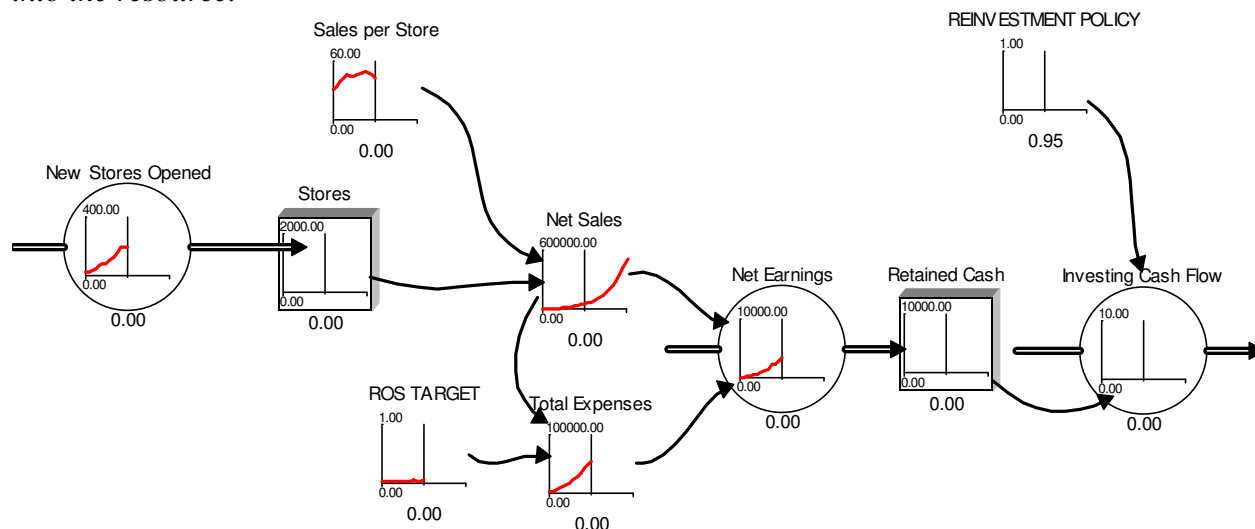
<Run> the simulation, using the actual ROS values for Home Depot (*allow the simulation to project the last ROS value into the future*).

25. What is the expected amount of Net Earnings in the 24<sup>th</sup> year of operations?
- <1 million
  - 1 to 10 million
  - 10.1 to 100 million
  - 101 to 500 million
  - >500 million

Download & open simulation model ‘Step7.msf’

*Instructions: Copy from HDdata.xls and paste into the simulator the historical data for Total Expenses, Net Earnings, ROS, New Stores Opened, and Sales per Store. Calculate future Net Sales growing at 20% per year, and then copy and paste the entire data series (historical and future values) into the simulation.*

*Note: In this case, we add a strategic resource (Stores) to the simulation model in order to better understand what is causing the performance of the firm. Since we are adding an accumulating resource, you will note that we correspondingly add a “rate” to control the flow into the resource.*



<Run> the simulation.

26. What is the expected amount (in millions) of Net Earnings in the 24<sup>th</sup> year of operations?

- <1 million
- 1 to 10 million
- 10.1 to 100 million
- 101 to 500 million
- >500 million

27. What is Home Depot's potential problem, as illustrated by the simulation?

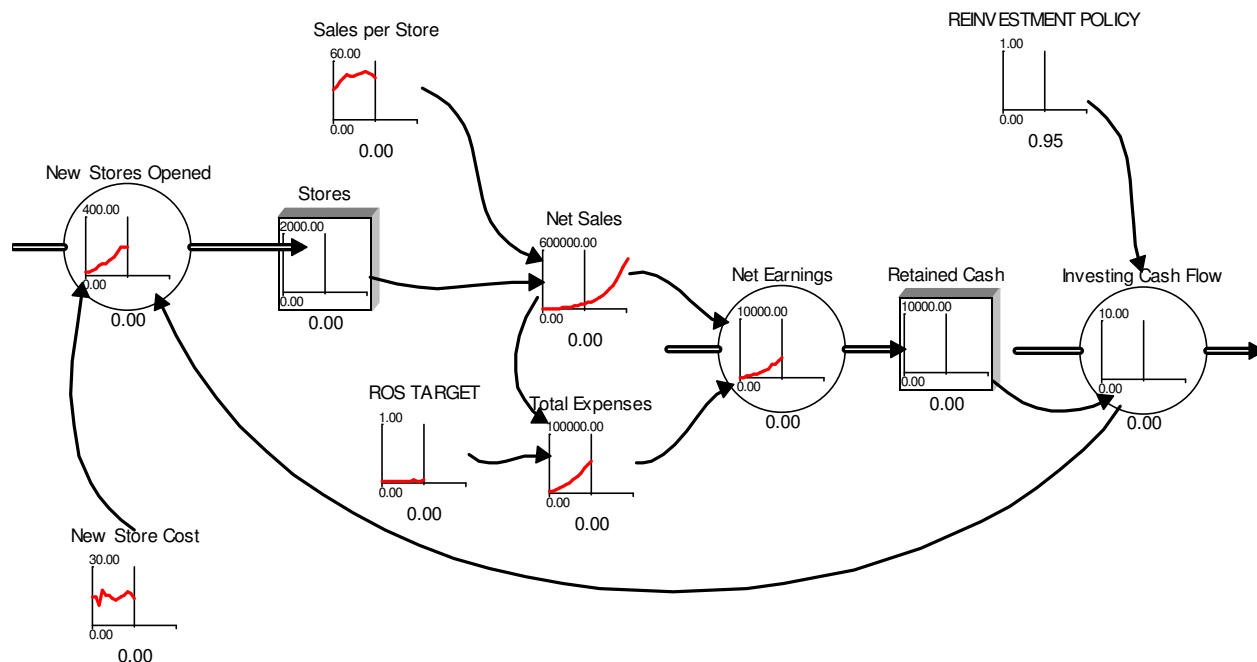
That is, why has Net Sales, in the 24<sup>th</sup> year of operations, dropped from our planned Net Sales growth performance (of 20% per year)?

- ROS is now unrealistic
- Insufficient number of New Stores Opened planned.
- The Sales per Store performance is low.
- All of the above.
- B and C

Download & open simulation model ‘Step8.msf’

*Instructions: Copy from HDdata.xls and paste into the simulator the historical data for Total Expenses, Net Earnings, ROS, New Stores Opened, Sales per Store, and New Store Cost. Calculate future Net Sales growing at 20% per year, and then copy and paste the entire data series (historical and future values) into the simulation.*

*Note: In this case, we add a feedback loop to control the flow into the strategic resource (Stores) in order to better understand the performance of the firm. Since we are adding a feedback loop, you will note that the REINVESTMENT POLICY will now have an effect on performance.*



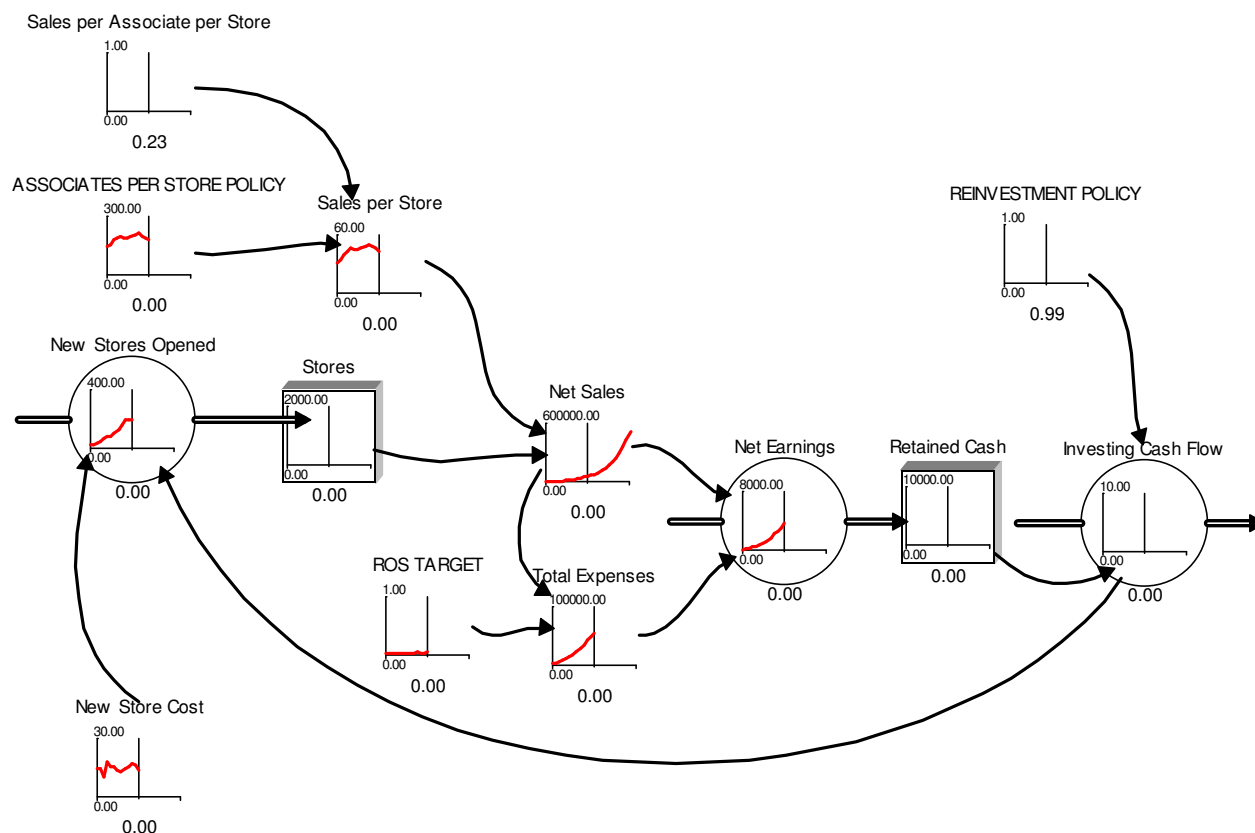
28. Which REINVESTMENT POLICY *best* replicates actual, historical performance?

- a. 20%
- b. 50%
- c. 80%
- d. 90%
- e. 99%

Download & open simulation model 'Step9.msf'

*Instructions: Copy from HDdata.xls and paste into the simulator the historical data for Total Expenses, Net Earnings, ROS, New Stores Opened, Sales per Store, New Store Cost, and Associates per Store. Calculate future Net Sales growing at 20% per year, and then copy and paste the entire data series (historical and future values) into the simulation.*

*Note: We have not fixed the "realism" problem with REINVESTMENT POLICY, yet. We will fix this in the next assignment. For now, in this case, we add a new management policy; ASSOCIATES PER STORE POLICY, and corresponding Sales per Associate per Store to help us understand Sales per Store performance over time.*



29. Run several simulations to determine which Sales per Associate per Store value *best* replicates actual, historical performance of Sales per Store:
- .13
  - .18
  - .23
  - .28
  - .33

<Run> the simulation, using your answer to the question above.

30. Does the ASSOCIATES PER STORE POLICY effectively explain the deterioration in performance in Sales per Store?
- Yes, but only for Years 1 through 6.
  - Yes. Sales per Store is approximated fairly well.
  - No.
  - No, it actually has no effect at all (due to Sales per Associate per Store).

### Assignment #3

Download & open simulation model 'Step10.msf'

Download and open the Excel data file for this assignment: HDdata.xls

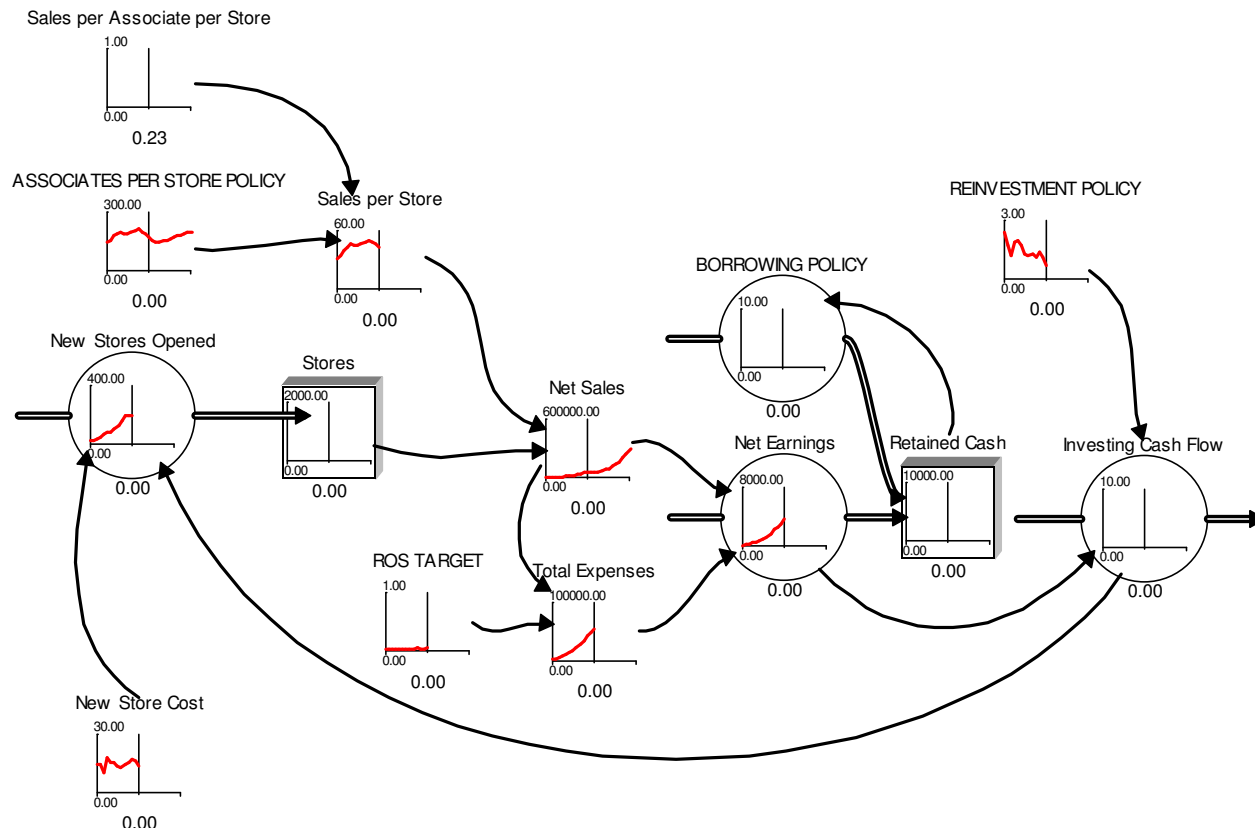
*Note: We want to fix the REINVESTMENT POLICY, so that it replicates actual earnings performance. To do this, we are going to make changes to the model. Currently, the REINVESTMENT POLICY is based on the level of Retained Cash. The problem with this is that we may want to invest more than 100% of our Retained cash; we want a BORROWING POLICY that allows us to pursue a rate of investment that exceeds our ability to generate cash internally.*

*Instructions: First, change the causal arrow running from Retained Cash to Investing Cash Flow, to run from Net Earnings to Investing Cash Flow. To do this, delete the existing arrow (and close the error window, we'll fix the error next...). Then, create a new arrow by clicking on the Mystrategy LINK button (on the far left side of the program) and then connecting the arrow first to Net Earnings, and then to Investing Cash Flow. Don't worry if the arrow crosses through Retained Cash, because you can bend the arrow around Retained Cash by clicking on the arrow and then dragging the adjustment bars.*

*Now, that the link is in place we need to update the formula in Investing Cash Flow. To do this, double click on Investing Cash Flow and then select the Equation window. In the Equation field, delete Retained\_Cash and enter Net\_Earnings. The formula should now read: Net\_Earnings \* Reinvestment\_Policy. Click <OK> and now Investing Cash Flow should be a green color (indicating the error has been fixed).*

*Next, we need to add a new FLOW, of borrowed funds, into Retained Cash. To do this, click on the Mystrategy FLOW button and place the new FLOW just above the Net Earnings FLOW. Next, click on the end of the FLOW arrow, and drag it until it connects to Retained Cash. Now create a new LINK (arrow) running from Retained Cash to the new FLOW. Select the new FLOW by double clicking it, and then select the Equation window. Name the new flow BORROWING POLICY. In the Units field, enter: Dollars/Year. In the equation field enter: IF(Retained\_Cash<0, Retained\_Cash \*(-1),0). This policy is intended to provide borrowed funds whenever our REINVESTMENT POLICY requires funds that exceed Retained Cash.*

Next, we want to update *REINVESTMENT POLICY* to use actual, historical reinvestment rates. From *HDdata.xls*, copy *Capital expenditures - % of Net Earnings*, and paste into *REINVESTMENT POLICY* (be sure to update the Y-Axis scale from 1 to 3).



<Run> the simulation [make sure the Net Earnings are properly calculated by looking at the overlap of red (real data) with green (simulated data). The model should simulate New Stores Opened and Net Earnings fairly well at this point].

<PRINT> your simulation run. Mark it Page #1

Next, sketch *future values* of ASSOCIATES PER STORE POLICY to simulate what would happen to Home Depot if the current policy trend continued to decrease; to 100 associates per store, by year 24.

<PRINT> this simulation run. Mark it Page #2

Next, sketch *future values* of ASSOCIATES PER STORE POLICY to simulate what would happen to Home Depot if the current policy trend continued to decrease to 150 by year 15, but then reversed and increased to 200 associates per store, by year 24.

<PRINT> this simulation run. Mark it Page #3

Next, sketch *future values* of REINVESTMENT POLICY to simulate what would happen to Home Depot if the current policy trend continued to decrease to .50 by year 15, and then leveled off through year 24.

<PRINT> this simulation run. Mark it Page #4

At this point, you have earned a score of 80%

\*\*\*\*\*

To *attempt* to earn a score above 80%, do the following:

1. Add an Associates (employees) *resource*.
  - a. Add a New Associates *flow* into Associates.
  - b. Enter actual, historical data into Associates and New Associates
  - c. Modify the model so that ASSOCIATES PER STORE is now caused by the Associates and Stores resources.
2. Add a Total Assets *resource*.
  - a. Ensure there is an appropriate *flow* into Total Assets.
  - b. Enter actual, historical data into Total Assets
  - c. Create a new variable: Return on Assets
  - d. Enter actual, historical data into Return on Assets
3. <Run> your model.
  - a. <PRINT> this simulation run. Mark it Page #5
4. Sketch new planning targets for your model.
  - a. Create a TABLE, and add in the table the following variables:
    - i. New Employees
    - ii. New Stores Opened
    - iii. ROS TARGET
    - iv. REINVESTMENT POLICY
    - v. BORROWING POLICY
  - b. <Run> your model.
  - c. <PRINT> this simulation run. Mark it Page #6
  - d. <PRINT> the simulation data in your table. Mark it Page #7

### **Student Comments & Feedback**

#### ***Negative aspects of the assignment:***

- ☐ The assignment moved too slowly (I wanted more challenging assignments to further my knowledge of the software).
- ☐ I would have liked to implement more of the whole business process into the model, to try and model a complete firm.
- ☐ Sometimes had to back track because of the way the questions were organized.
- ☐ Better explanation of how sales per store, associates per store, & sales per associate per store interact (the basic fundamentals of the process of the three).
- ☐ Need some more information about policies and how they are used.
- ☐ Data that was to be entered needed to be cleaner, better format of the Excel file.



- ❑ More information on how different variables can be changed.
- ❑ Can't back up the "step function."
- ❑ Software only available on one computer. (*Note: the students wanted to load their copies of Mystrategy onto more than one computer, but did not know how to do this*).

***Positive aspects of the assignment:***

- ❑ I like that the software gave a graphical representation of the performance of the firm.
- ❑ Modeling helped me see how values were derived.
- ❑ In the final model I found the reinvestment exercise demonstrated for me the value of reinvesting for future success.
- ❑ Seeing how the backwards flow works in business.
- ❑ Resources & flows – this gave me a better understanding of the business process.
- ❑ Continued with the original company's data gave a real world example of modeling. (*Note: just prior to this assignment, the students studied Home Depot as a case assignment, using their annual report form 10-k, available from the SEC EDGAR database*).
- ❑ Assignment 2 – mentions a possible error / problem, how to identify it, and a possible solution.
- ❑ Use actual stocks and flows while learning the concepts to make them familiar.
- ❑ Questions check your understanding of each step.
- ❑ Questions ask about patterns of change.
- ❑ Graphical (visual) representation - helps to see patterns (not all people in the field of business are mathematically oriented, and this makes it accessible).
- ❑ Active learning.
- ❑ Concrete context of abstract concepts.
- ❑ Visual, graphical representation of how variables affect key resources.
- ❑ Linear vs nonlinear projections – displayed long term effects of present decisions.
- ❑ Seeing how they use cash flow.
- ❑ Looking at different time periods/future helpful.
- ❑ Helpful in evaluating investment policies.
- ❑ Good way to better understand how policies affect a business.

**Professor's comments**

This was the students' first exposure to system dynamics, and the level of learning and the overall reaction was quite positive. The current plan is to continue this exercise in all future sections of the course. Based on the student feedback, the following changes are being considered:

1. combine assignments #1 and #2 into one assignment (assignment #1 was too easy).
2. create another assignment that depicts a more detailed, complete representation of the business processes.
3. hold back some data and see how well the class can plan/project actual performance.
4. use a class computer lab one day, to allow students to ask questions and try solutions for themselves, with immediate feedback.