The beer game in Stella 10

Designing the future from within

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Objective

To develop a learning laboratory or a business game for the supply chain to help us find the leverage points, which are the intervention places where a little change would lead us to a grate change in the systematic behavior. The levers are power points of influence.

Since the systems are counter-intuitive, finding these levers is the key as the motor of the sustainable sales growth for all business. Specially, it gives us the power to supervise the impact of our decisions and avoid, as far as possible, the unintended consequences of the intervention in any system.

The better way to discover the influence places is through a learning laboratory connected to the supply chain.

Keywords - Sustainability, supply chain, business game, dynamics of the system, modeling, simulation, learning laboratory, leverage point, places of influence or levers.

Índex

Objective 0

Keywords 0

Introduction 4

Concepts 4

Major problems 5

Complexity elements 5

The beer game 6

Great advantages of the game 7

Whip Effect or "Bullwhip" 7

Model 8

Model in Modules 8

Module for the Factory 8

Sections 9

General Parameters (Parameter Section) 9

Value Chain Information (Node data section) 10

Optimization (Optimization section) 10

Prices Policy (Prices section) 11

The Beer Game 12

Control Panel 12

Operating Instructions 12

Penalty Policy 15

Simulated Studied Cases 16

Case 1 – Not Optimized Simulation 16

Case 1 – Global Results – Not Optimized Simulation 17

Case 1- Chain Supply Productivity – Not Optimized Simulation. 17

Case 1 – Tables of global results – Not Optimized Simulation 18

Case 1 – Results of the Wholesaler - Not Optimized Simulation 18

More Cases of Study 19

Case 2 – Optimized Simulation 19

Case 3 – Optimized Simulation of the wholesaler, but not the other 19

Case 4 – Optimized Simulation for the Factory and the Retailer, but not the other............. 20

Case 5 – Playing the Retailer Taking Manual Decisions, Versus All the Other in Automatic .. 20

Case 6 – Playing the Wholesaler Taking Manual Decisions, versus All the Other in automatic. 21

Learning points.. 21

Learning Point 1 – (Bullwhip) 21

Learning Point 2 22

Learning Point 3 – Inventory Factor 22

Learning Point 4 22

Learning Point 5 – Transit Factor 23

Learning Point 6 23

Learning Point 7 – Demand Factor... 24

Learning Point 8 – Delivery capacity 24

Learning Point 9 25

Conclusions 26

Finally, it is time to see the world with new eyes, with faith and hope in a better future..... 26

Future Updates.. 26

Bibliography 27

Other References 28

Details of the Author and collaborators... 29

Introduction

Now we expand our modeling capacity of an individual business and its distribution of products to the complete supply chain, which starts in the factory, goes to the distributor, moves thru the wholesaler to the retailer, and the retailer is who assists the clients or final consumer to supply the products and services.

Concepts

We define a supply chaine as the whole set of activities in the supply of the products, from its manufacturing to its sale to the client. It includes the following structures:

1. Physical frame: From the purchase of the raw materials to the delivery of finished products and the payment of the client.
2. The demand frame: It covers from the reception of the demand and the decision making to the creation of the orders taken from this information.
3. Logistics frame: It analyzes the flow of information and the decision making thru the supply chain.

4. Financial frame: It administers the payment of the dealers and collects the income information of the costumers and other financial activities that support the building of physical facilities, services and other duties of the supply chain.
5. The business design frame: It makes easy to calculate the capacities of the physical storage volume and the delivery of the products, components that help to design new business or to redesign the current capacities.

Major problems

A key element is to visualize the supply chain as a system and it should be managed as a system, although nodes tend to operate independently. This can be seen in many different ways as follows:

1. Commonly, the communication between nodes is poor.
2. Even when the information is available from outside the node, the node could ignore the best usage of the information.
3. The performance metrics are focused on the node and not to the chain.
4. The decision making works correctly at the node level, but it's bad at the supply chain level.
5. Frequently, none has the authority to take decisions at the supply chain level. It's very important to promote team decisions. Every node tends to resist new ideas or decisions that make it seems that the local node would operate in a sub-optimal way.

Complexity elements

In a chain of real supply, three elements of complexity may be present.

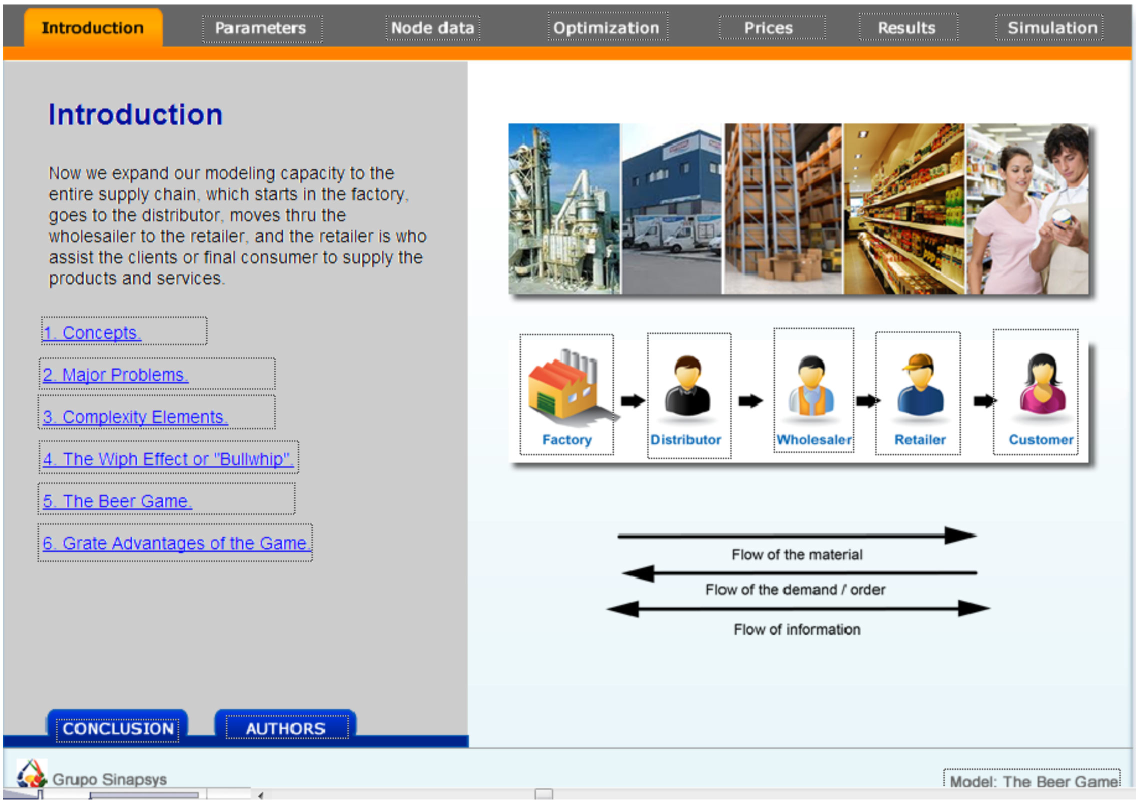
1. Downtimes: Sending materials from node to node takes its time. The orders can also take a while for moving from one node to the other.
2. Feedback loops: The performance of each node may be impacted by the results of another node. For instance, the node #3 is not available to

supply the products for node #4 if it hasn't already been supplied by the node #2.

3. Statistical variability: The production rate at the node level may fluctuate, the delay could change and, the transit times of supply of goods may be disrupted by a technical or human fault (illnesses, lack of staff, family issues of the employees, etc.) The delivery times of the orders can also vary, and some other things like those may occur.

The beer game

Many years ago, a simulation game that also produces the whip effect, best known in English as "Bullwhip", was developed in the Massachusetts Institute Technology (MIT) by the professor Jay W. Forrester. This game was named "The Beer Game", and has been played many times and fully described by Senge in 1990. This simulation process is totally covered in our model and many new features have been added, making it more flexible and strong.



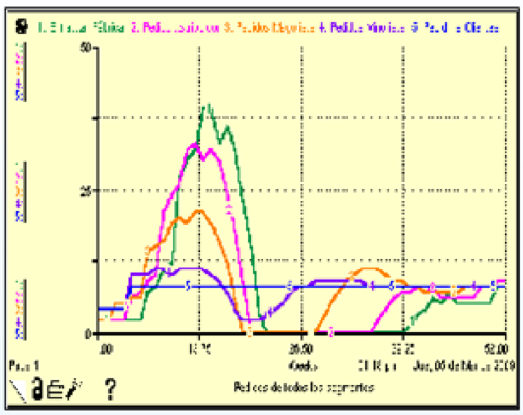
Great advantages of the game

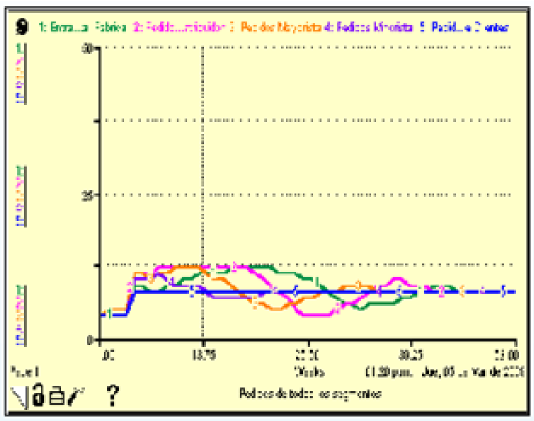
A Business Game is a method used to develop a rich understanding about "how" to take better decisions to obtain better results, such dynamics arise in the use of a flight simulator where you can learn how to fly. You may fall frequently without running real risks and costs as in a real consulting practice on earth.

The simulation model first provides a language in which you can describe an understanding of the structure of a value chain system through the simulation, then you can understand how a structure will probably execute answering your decisions. With a better understanding of the relationship between the structure and a system behavior, you will surely be better equipped for managing the system for superior results.

Whip Effect or "Bullwhip"

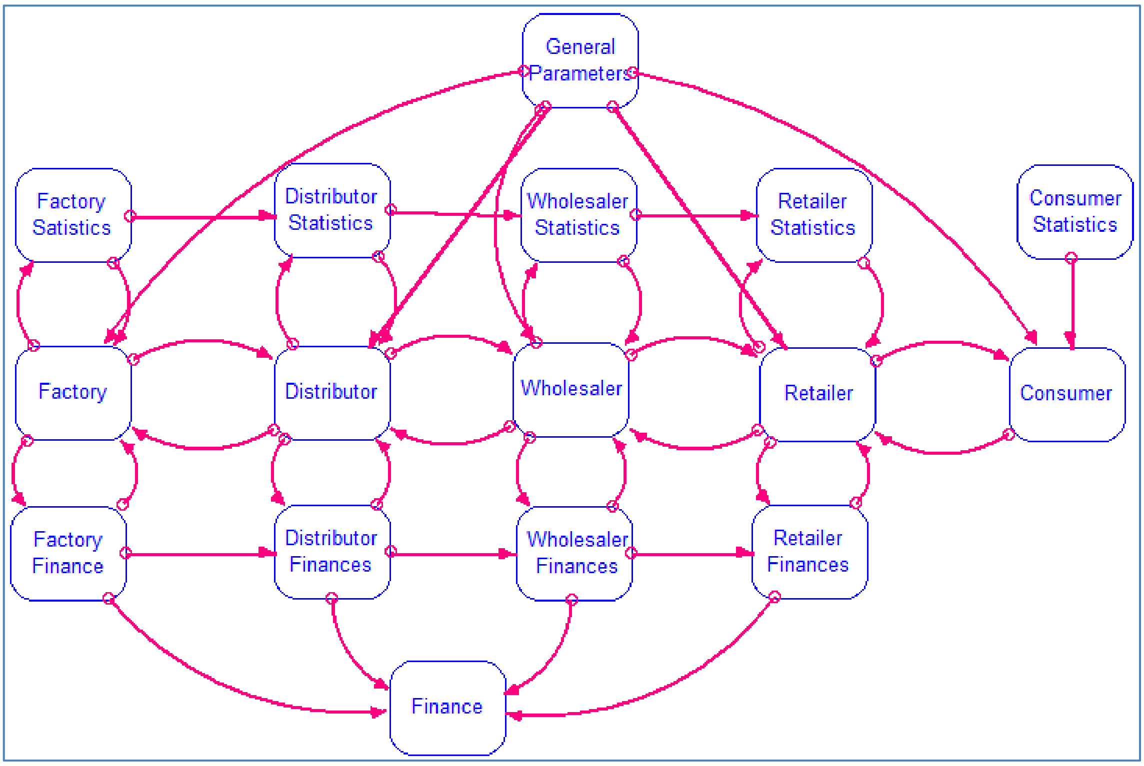
It is linked with the global coordination failure. For instance, a node has produced an excess of material or there is a large order from a previous node. Since every node works independently, there is a real possibility that these mistakes be wrongly managed globally. This can be a string error if it spreads to other nodes without control.



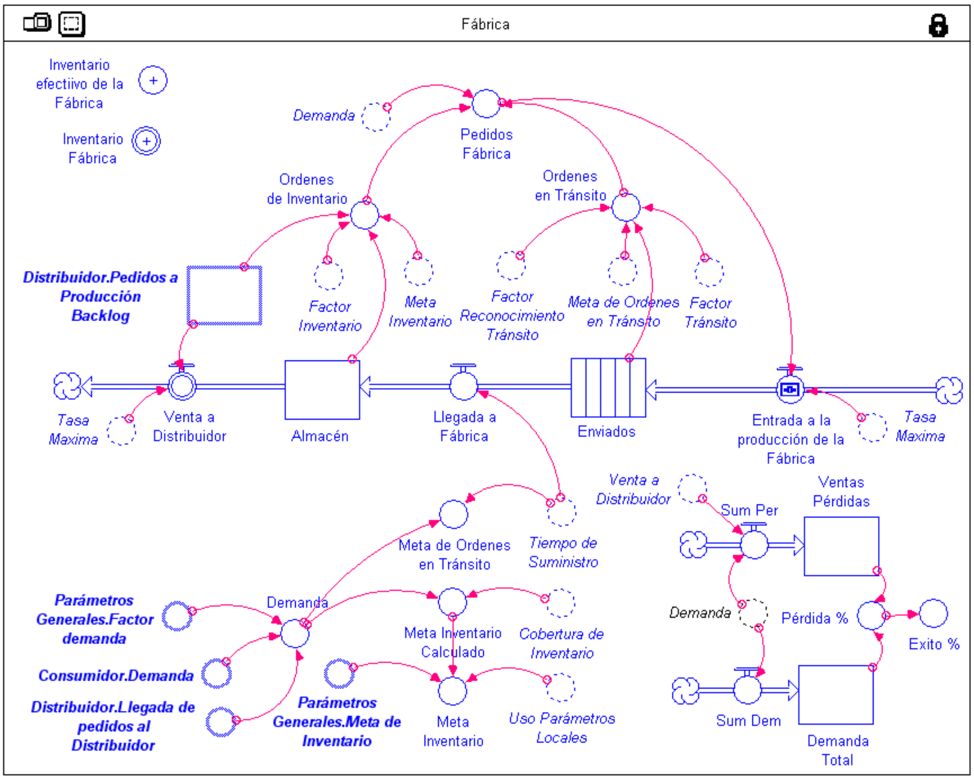


Model

Model in Modules



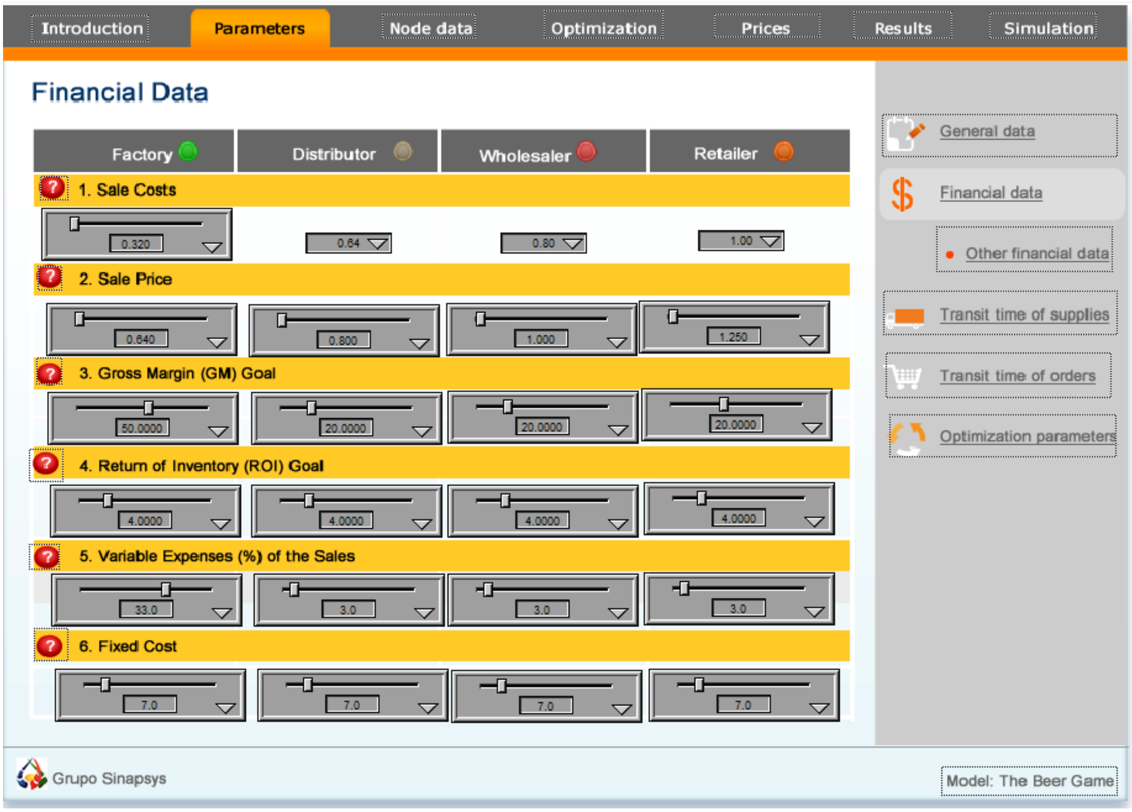
Module for the Factory



Sections

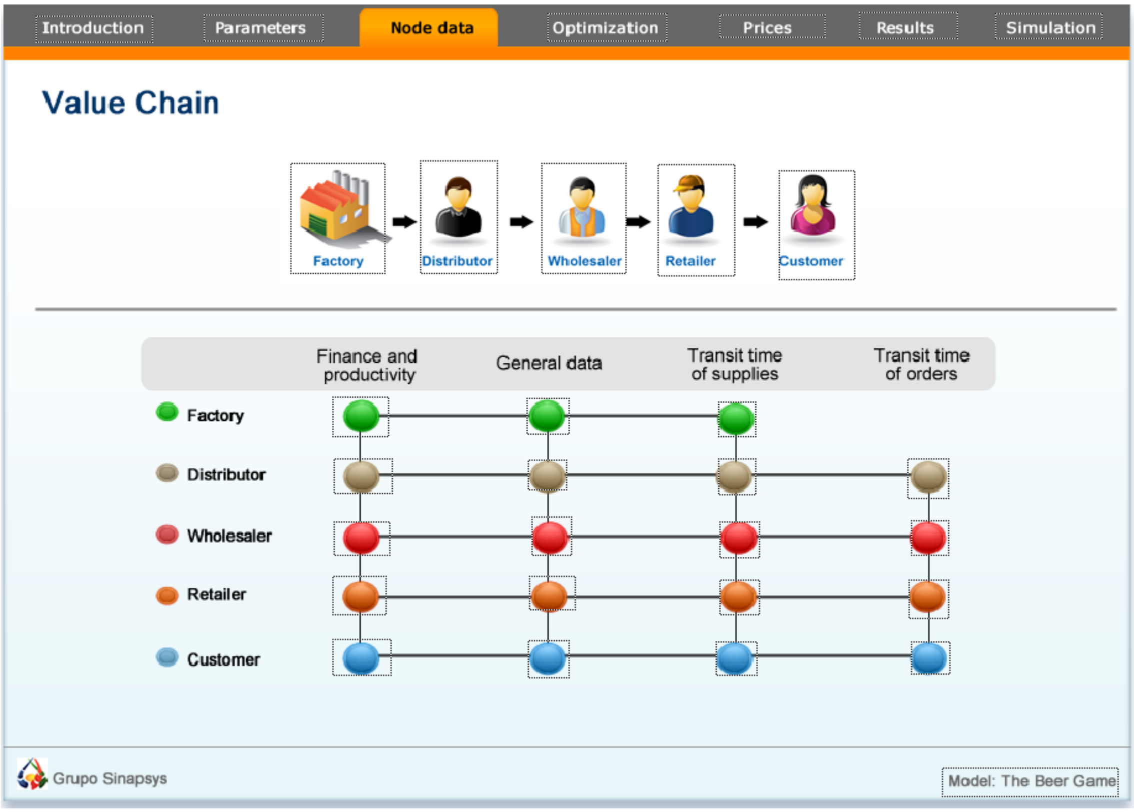
General Parameters (Parameter Section)

There are two ways to record the operating parameters of each node. This section is useful to define the parameters that will be applied to all the nodes equally. If you want to define specific parameters for each node, use the defined path in "Node data"



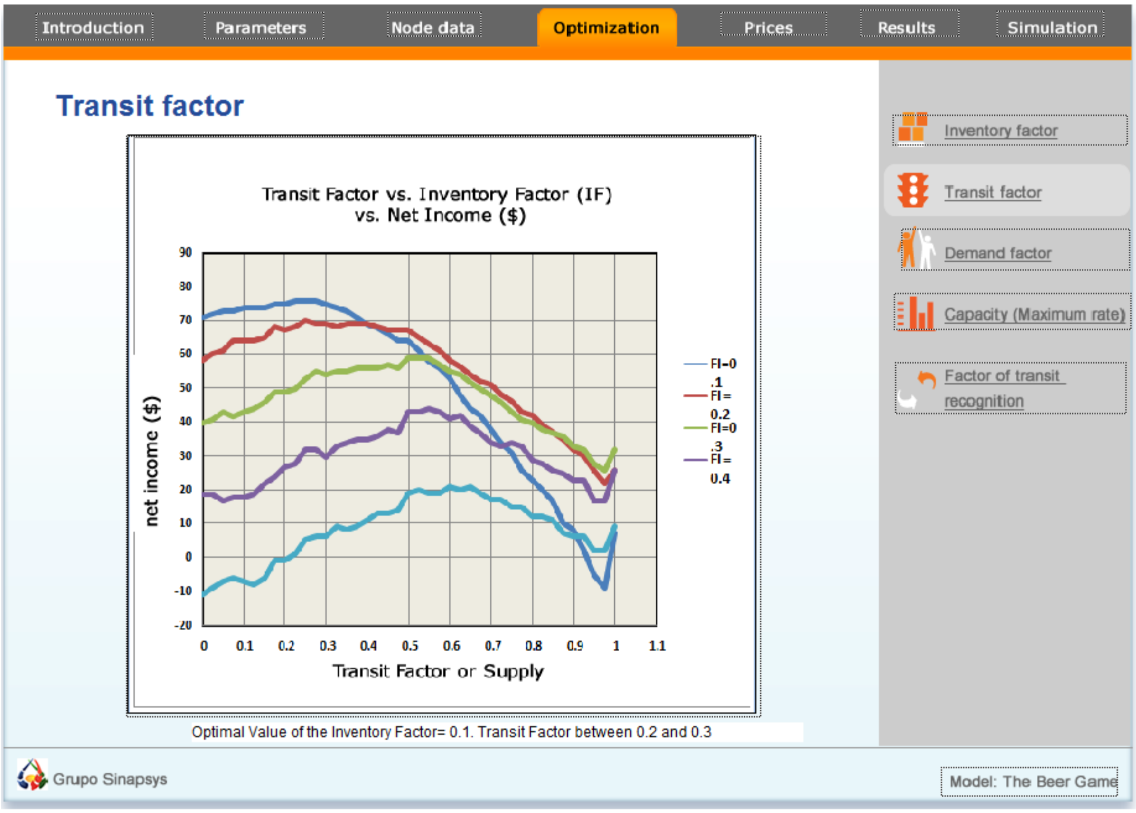
Value Chain Information (Node data section)

It's useful in the case where each node, member of the chain, desires to define the specific parameters of its node, in a single level to follow its own operating criteria.

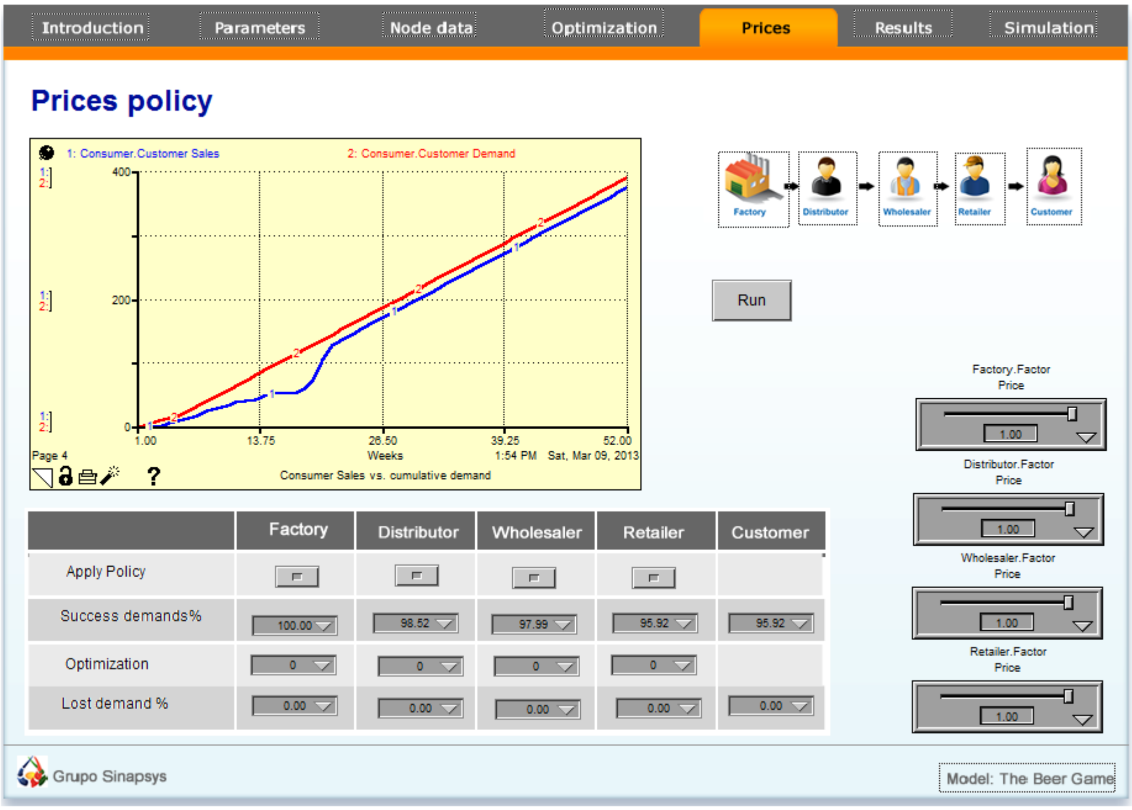


Optimization (Optimization section)

This section has been prepared to help those who takes decisions and integrate each node of the chain, to select the best operating parameters of the node. Those parameters have been found after an intense awareness of variables and many simulations to find the operating ranges of each variable and its impact in the economic performance of each node. Facilitating thereby, that any user can review these results in the graphs and take the value of the parameter that best meets your needs.



Prices Policy (Prices section)



The Beer Game

Control Panel

Game: Here, the operation of the Control Panel of the game or learning laboratory for the Supply Chain is explained. See below.

Operating Instructions

A. Select the Operation Mode:

   a. Simulate: It means that the simulator will run continuously, using the defined buttons in (C), the entire range of completely time, the data of each node and the purchase decisions taken are defined in (B) at that time. Thenceforth anything can be change, the simulation will operate continuously until the end of its simulation time.

   b. Game: The simulator will work step by step, then, after a short time span, it will stop, giving the opportunity that in (B), each player takes his/her own purchase decisions. When operating again the start button in (C), it will stop in the next point, doing so until the end. This means that the players placed en (B), may change their decision in each time span of the simulation, in a similar way as they make their purchase orders in real.

B. Orders: This is the main point of the game. Here is where the one who takes decisions in each node must be situated. The order is supplied here, here is where the purchase order is sent to every supplier. It's very important to know how to interpret the elements situated within the slider.

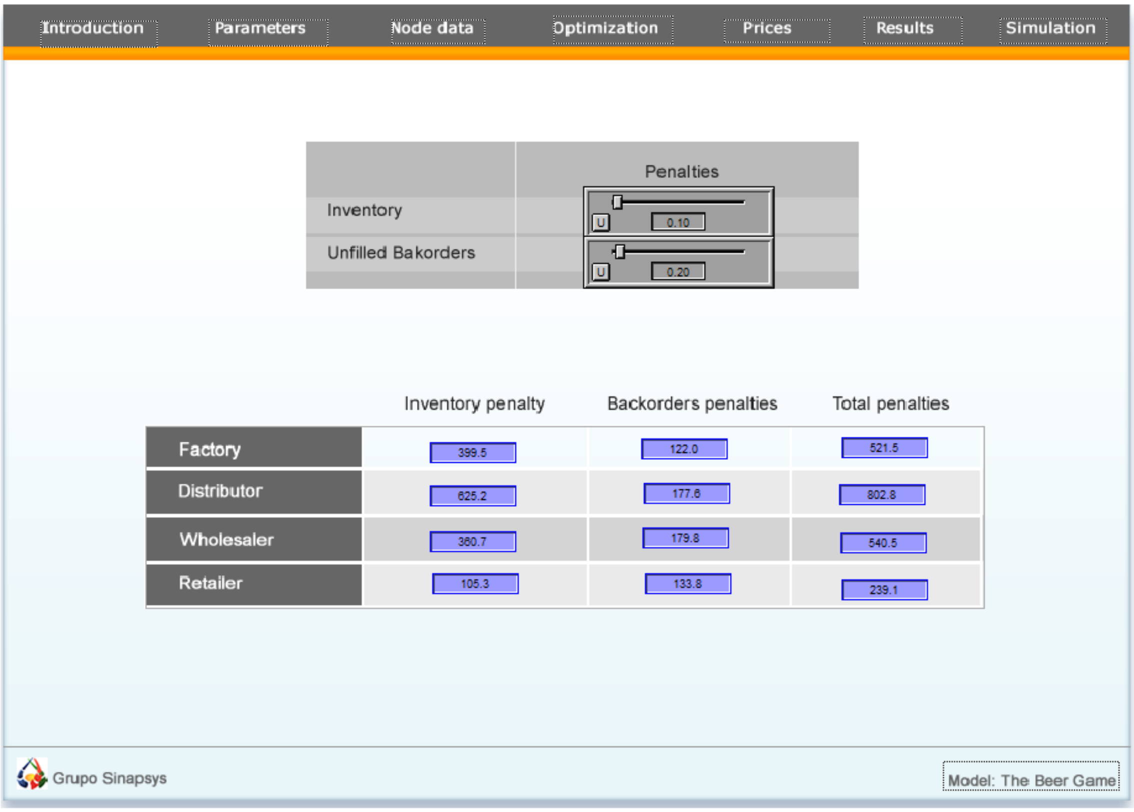
   a. The first button inside of the slider, contains a small letter called "tilde" in Spanish, shown with the "~". If this button is depressed, a space where the number chosen is found will appear, and also a sign that says "eqn on" which means that the user of this node has decided do not calculate the orders from the client, do not feed the supplier's purchase orders, but, to allowed the computer and its equations, be the one who evaluate the purchase order automatically, and to situate the purchase order to the supplier automatically, without human intervention.
   b. If we visualize the button defined in (a) for the retailer and it isn't pressed, immediately the slider will appear activated to feed the data of the purchase order by the user who takes the decision within the node called retailer. The other way to record this data is feeding it into the space where the sing "eqn on" appears. In this case, it was fed with a "20", this will be used to order the products of the retailer to the wholesaler in the next simulation time.
   c. The button with the sign of "?" helps to show the notes that describe and document the contents of the field.
   d. The triangle placed to the right of the component, takes us directly to the exact position occupied by the field, within the graphic model.

C. Operating Buttons: The buttons are activated from here (running, stop, resume, reset). They control the operation of the simulator.

D. Graphic Results: In this area, the results of the simulation are shown graphically.
E. The goal is to run the supply chain as efficiently as possible. The team with the lowest score over 52 weeks is the winner.
F. Specific Parameters: When the switch is selected with the mouse, the button will appear with a green color. This means that the node's player took the decision of using the defined data in a specific way for that node, otherwise the general data will be taken without distinction for all the nodes.
G. Optimization: If an interrupter of a node starts, it means that for its own simulation, the parameters that warranty the best results will be used, this means that the best values of its defined parameters have been selected in the appendix "C".
H. Value Chain: The Graphic results of each node can be reviewed here and also, the specific data of the node can be modified. Results of each node: All the time is possible to see the financial and productive results for each node individually and the global performance of the entire supply chain can be reviewed.
I. Help: Selecting any red button with the "?" sign, any specific data of the node can be modified. This change will be applied only to the current node.
J. Indicators: Is a small space used to present some numeric results of the simulation.
K. Not applicable.
L. Penalty policy, see the following section.

Penalty Policy

The goal is to run the supply chain as efficiently as possible. Each team's four stations are penalized for an accumulation of inventory (10 cents per case of beer, per week), and for unfilled backorders (20 cents per case of beer, per week). The team with the lowest score over 52 weeks is the winner.



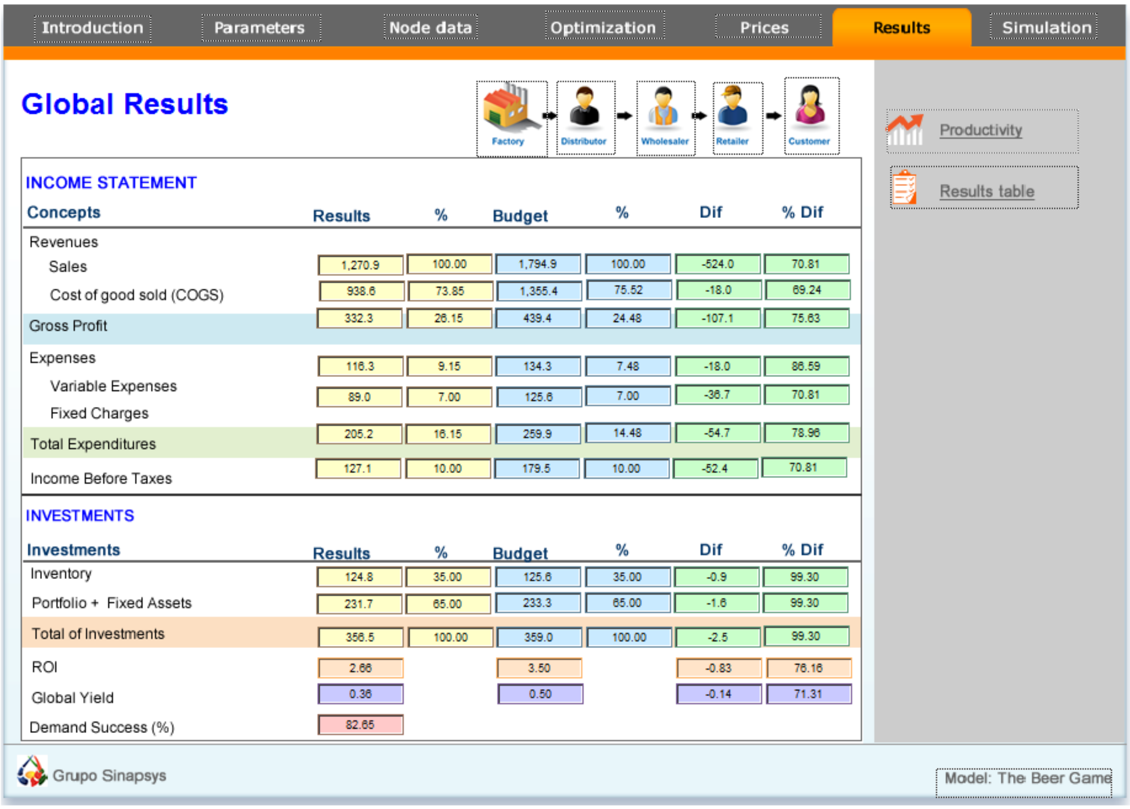
Simulated Studied Cases

Case 1 – Not Optimized Simulation

In this case an automatized simulation will be applied, without human intervetion, using the general parameters defined in the appendix "A" and applying to every node. The operation Mode of the simulator is to simulate continuously.

In the Chart, we see the undesired result (Bullwhip effect), The oscillation of a node is propagated to the others. There are serious problems of communication between the nodes.

Case 1 – Global Results – Not Optimized Simulation



INCOME STATEMENT

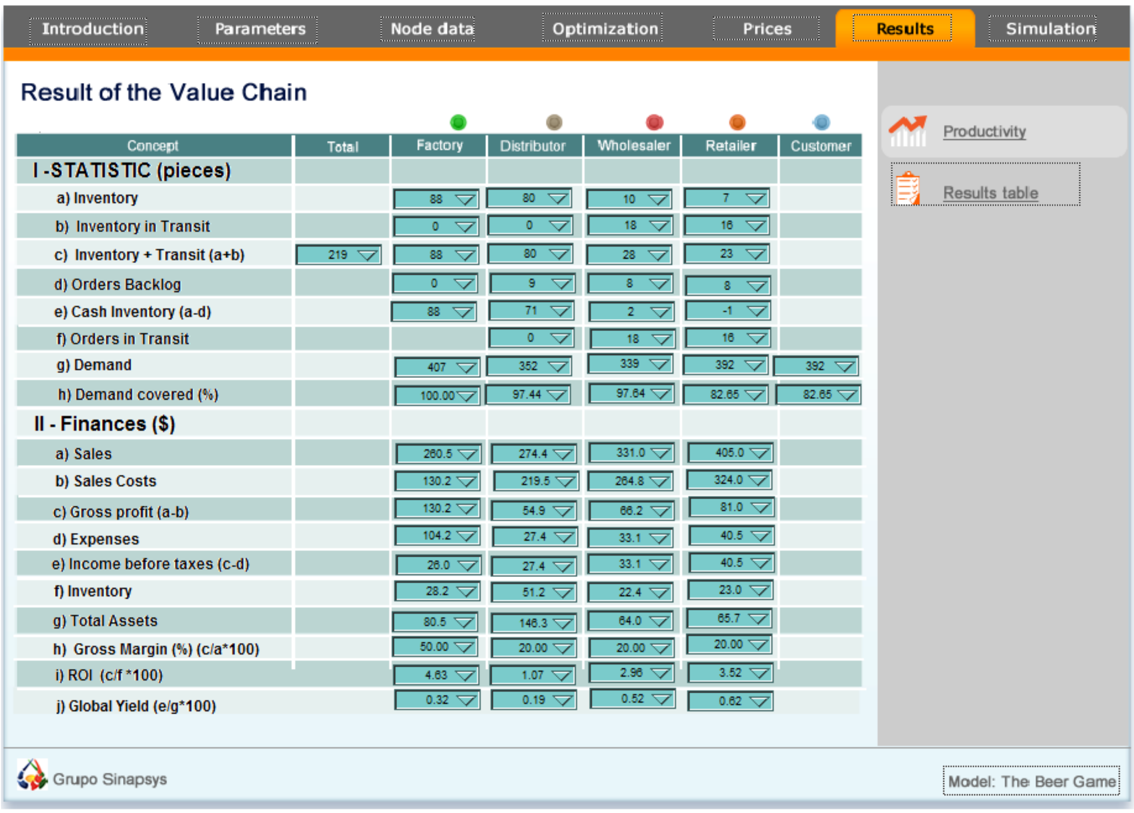
Concepts	Results	%	Budget	%	Dif	% Dif
Revenues						
Sales	1,270.9	100.00	1,794.9	100.00	-524.0	70.81
Cost of good sold (COGS)	938.6	73.85	1,355.4	75.52	-18.0	69.24
Gross Profit	332.3	26.15	439.4	24.48	-107.1	75.63
Expenses	116.3	9.15	134.3	7.48	-18.0	86.59
Variable Expenses	89.0	7.00	125.6	7.00	-36.7	70.81
Fixed Charges						
Total Expenditures	205.2	16.15	259.9	14.48	-54.7	78.96
Income Before Taxes	127.1	10.00	179.5	10.00	-52.4	70.81

INVESTMENTS

Investments	Results	%	Budget	%	Dif	% Dif
Inventory	124.8	35.00	125.6	35.00	-0.9	99.30
Portfolio + Fixed Assets	231.7	65.00	233.3	65.00	-1.6	99.30
Total of Investments	356.5	100.00	359.0	100.00	-2.5	99.30
ROI	2.66		3.50		-0.83	76.16
Global Yield	0.36		0.50		-0.14	71.31
Demand Success (%)	82.65					

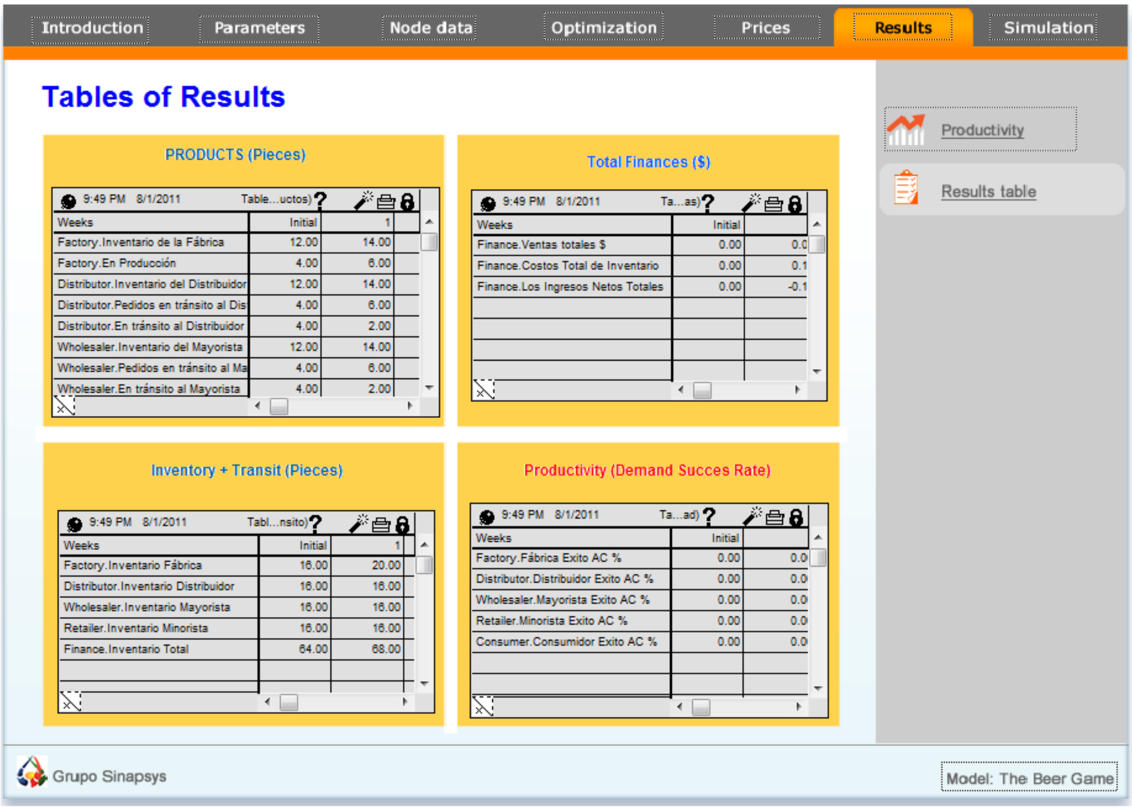
Case 1- Chain Supply Productivity – Not Optimized Simulation.

Similarly, we obtain the results of the other nodes.



Concept	Total	Factory	Distributor	Wholesaler	Retailer	Customer
I -STATISTIC (pieces)						
a) Inventory		88	80	10	7	
b) Inventory in Transit		0	0	18	16	
c) Inventory + Transit (a+b)	219	88	80	28	23	
d) Orders Backlog		0	9	8	8	
e) Cash Inventory (a-d)		88	71	2	-1	
f) Orders in Transit			0	18	16	
g) Demand		407	352	339	392	392
h) Demand covered (%)		100.00	97.44	97.64	82.65	82.65
II - Finances ($)						
a) Sales		260.5	274.4	331.0	405.0	
b) Sales Costs		130.2	219.5	264.8	324.0	
c) Gross profit (a-b)		130.2	54.9	66.2	81.0	
d) Expenses		104.2	27.4	33.1	40.5	
e) Income before taxes (c-d)		26.0	27.4	33.1	40.5	
f) Inventory		28.2	51.2	22.4	23.0	
g) Total Assets		80.5	146.3	64.0	65.7	
h) Gross Margin (%) (c/a*100)		50.00	20.00	20.00	20.00	
i) ROI (c/f *100)		4.63	1.07	2.96	3.52	
j) Global Yield (e/g*100)		0.32	0.19	0.52	0.62	

Case 1 – Tables of global results – Not Optimized Simulation



PRODUCTS (Pieces)

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Weeks	Initial	1
Factory.Inventario de la Fábrica	12.00	14.00
Factory.En Producción	4.00	6.00
Distributor.Inventario del Distribuidor	12.00	14.00
Distributor.Pedidos en tránsito al Dis	4.00	6.00
Distributor.En tránsito al Distribuidor	4.00	2.00
Wholesaler.Inventario del Mayorista	12.00	14.00
Wholesaler.Pedidos en tránsito al Ma	4.00	6.00
Wholesaler.En tránsito al Mayorista	4.00	2.00

Total Finances ($)

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Weeks	Initial	
Finance.Ventas totales $	0.00	0.0
Finance.Costos Total de Inventario	0.00	0.1
Finance.Los Ingresos Netos Totales	0.00	-0.1

Inventory + Transit (Pieces)

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Weeks	Initial	1
Factory.Inventario Fábrica	16.00	20.00
Distributor.Inventario Distribuidor	16.00	16.00
Wholesaler.Inventario Mayorista	16.00	16.00
Retailer.Inventario Minorista	16.00	16.00
Finance.Inventario Total	64.00	68.00

Productivity (Demand Succes Rate)

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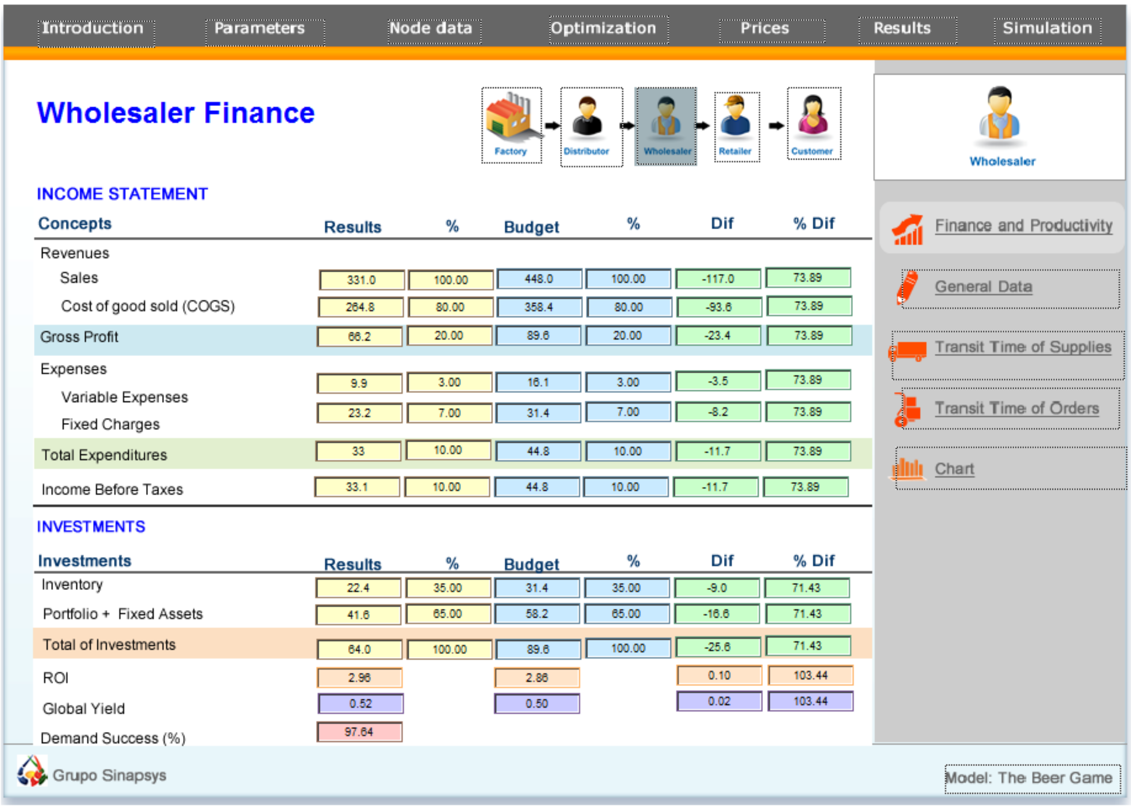
Weeks	Initial	
Factory.Fábrica Exito AC %	0.00	0.0
Distributor.Distribuidor Exito AC %	0.00	0.0
Wholesaler.Mayorista Exito AC %	0.00	0.0
Retailer.Minorista Exito AC %	0.00	0.0
Consumer.Consumidor Exito AC %	0.00	0.0

Case 1 – Results of the Wholesaler - Not Optimized Simulation

Similarly, we obtain the results of the other nodes.



INCOME STATEMENT

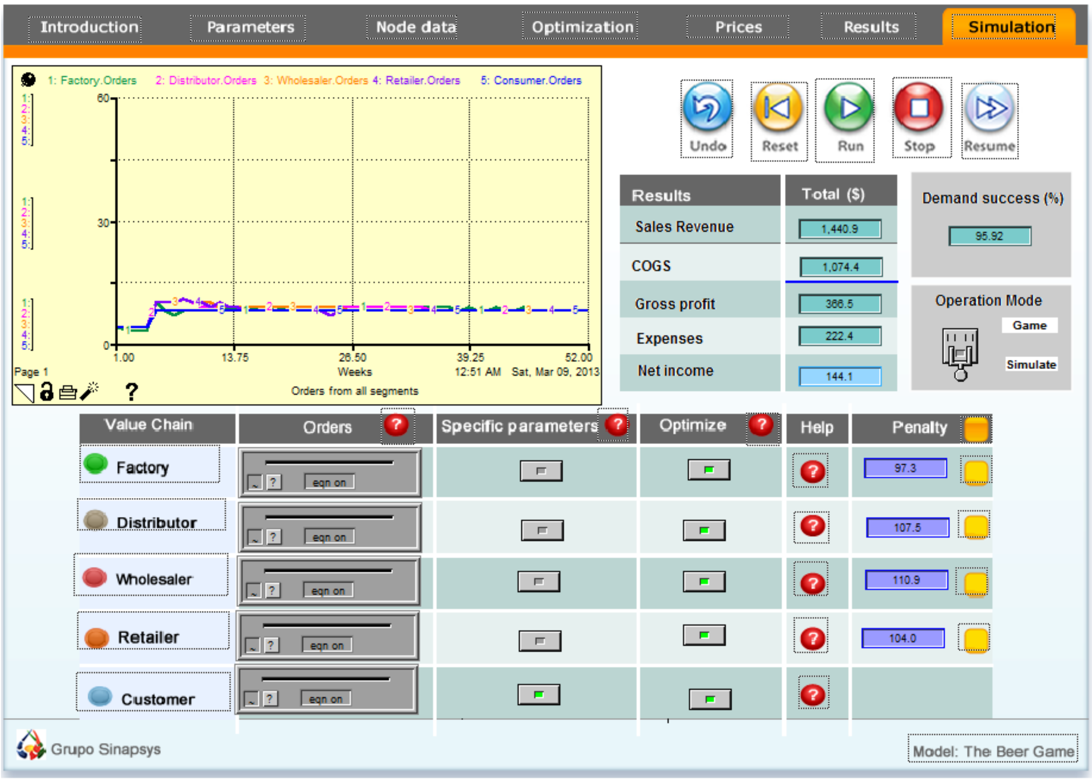
Concepts	Results	%	Budget	%	Dif	% Dif
Revenues						
Sales	331.0	100.00	448.0	100.00	-117.0	73.89
Cost of good sold (COGS)	264.8	80.00	358.4	80.00	-93.6	73.89
Gross Profit	66.2	20.00	89.6	20.00	-23.4	73.89
Expenses						
Variable Expenses	9.9	3.00	16.1	3.00	-3.5	73.89
Fixed Charges	23.2	7.00	31.4	7.00	-8.2	73.89
Total Expenditures	33	10.00	44.8	10.00	-11.7	73.89
Income Before Taxes	33.1	10.00	44.8	10.00	-11.7	73.89

INVESTMENTS

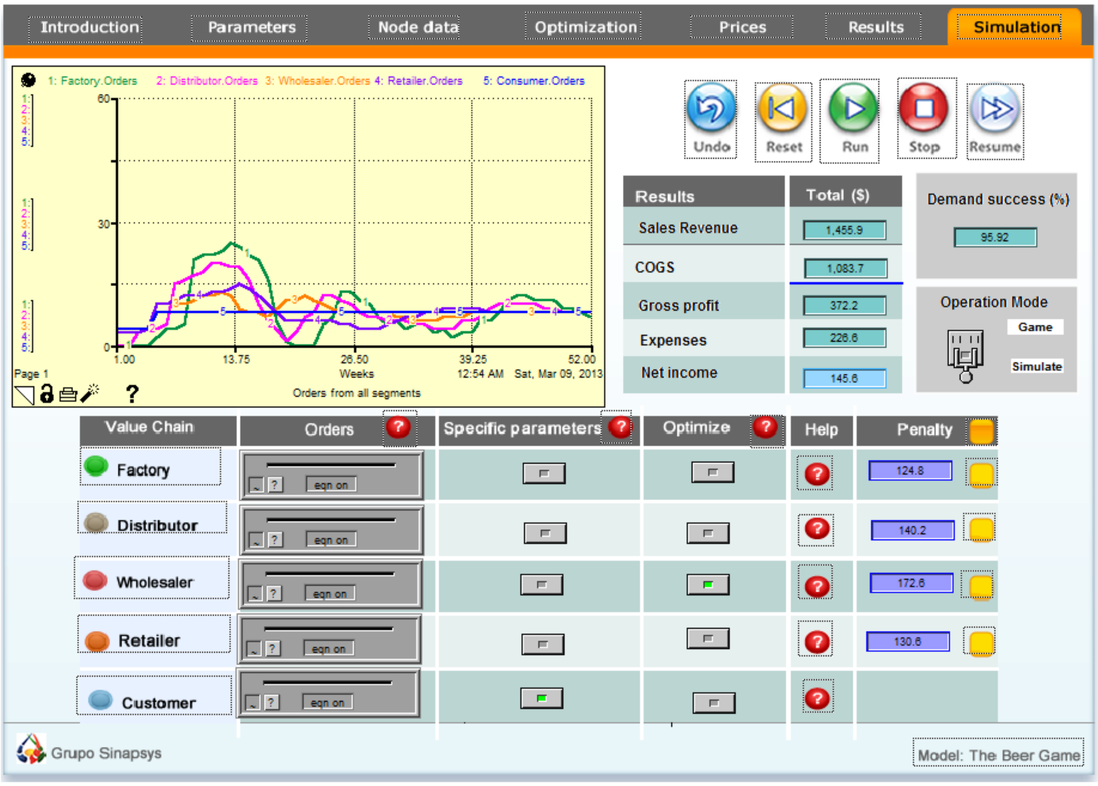
Investments	Results	%	Budget	%	Dif	% Dif
Inventory	22.4	35.00	31.4	35.00	-9.0	71.43
Portfolio + Fixed Assets	41.6	65.00	58.2	65.00	-16.6	71.43
Total of Investments	64.0	100.00	89.6	100.00	-25.6	71.43
ROI	2.96		2.86		0.10	103.44
Global Yield	0.52		0.50		0.02	103.44
Demand Success (%)	97.64					

More Cases of Study

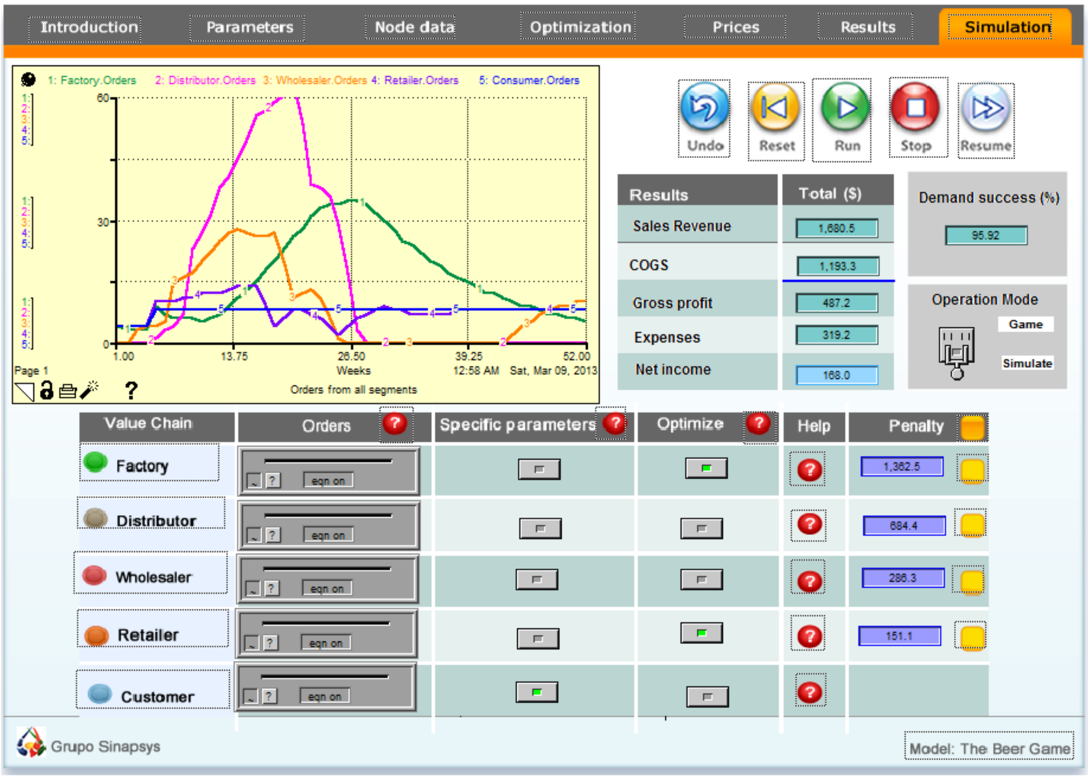
Case 2 – Optimized Simulation



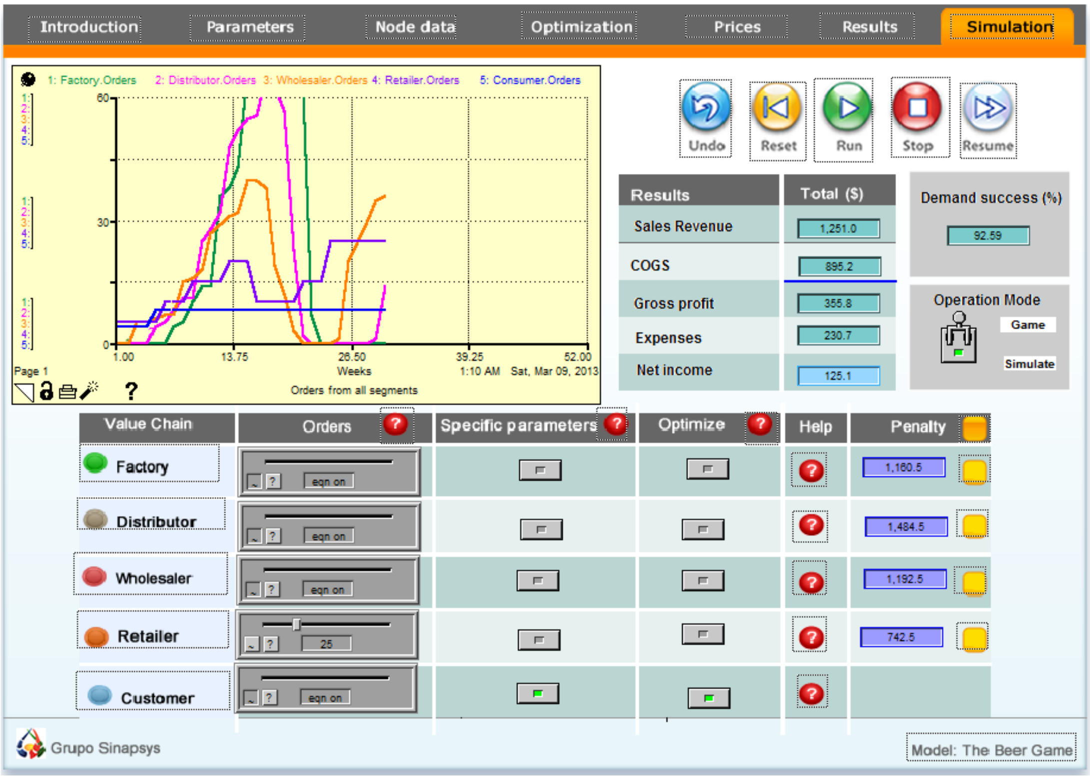
Case 3 – Optimized Simulation of the wholesaler, but not the other



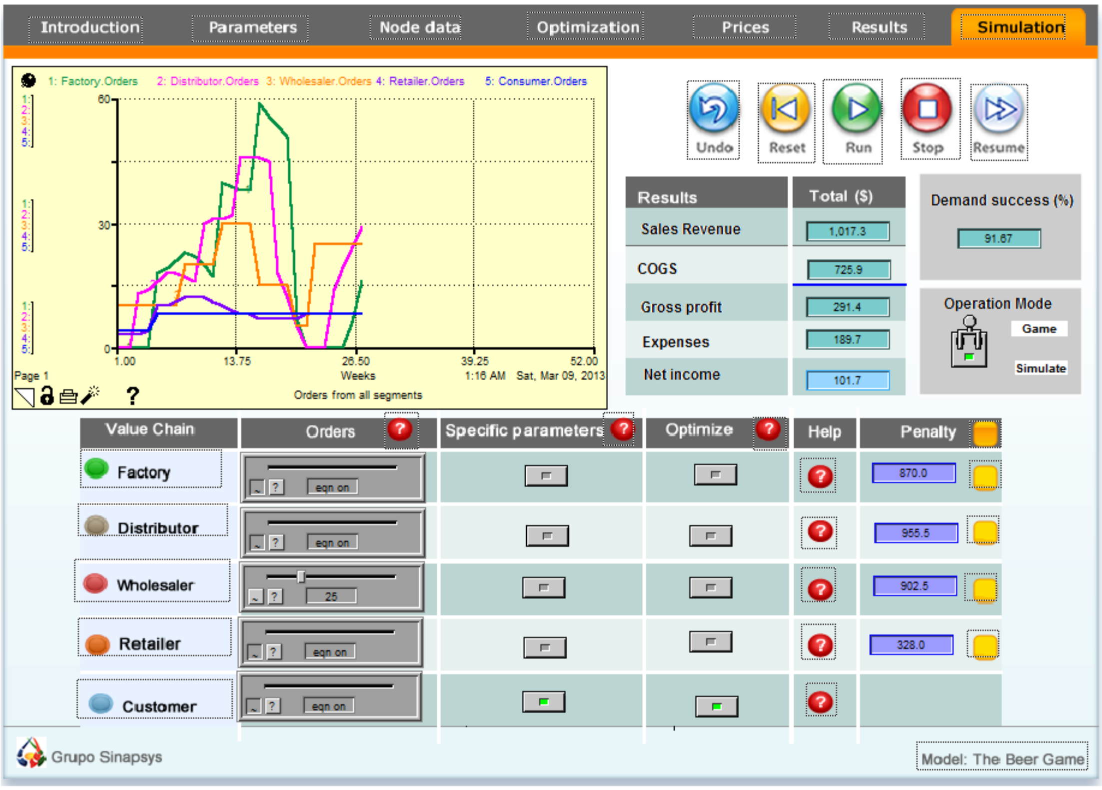
Case 4 – Optimized Simulation for the Factory and the Retailer, but not the other



Case 5 – Playing the Retailer Taking Manual Decisions, Versus All the Other in Automatic



Case 6 – Playing the Wholesaler Taking Manual Decisions, versus All the Other in automatic.



Learning points

Learning Point 1 – (Bullwhip)

The whip effect or "Bullwhip" in the supply chain is the tendency for the variability of production and the increasing of the orders as we move toward the factory to a signal of the customer demand.

How to Reduce the Whip Effect

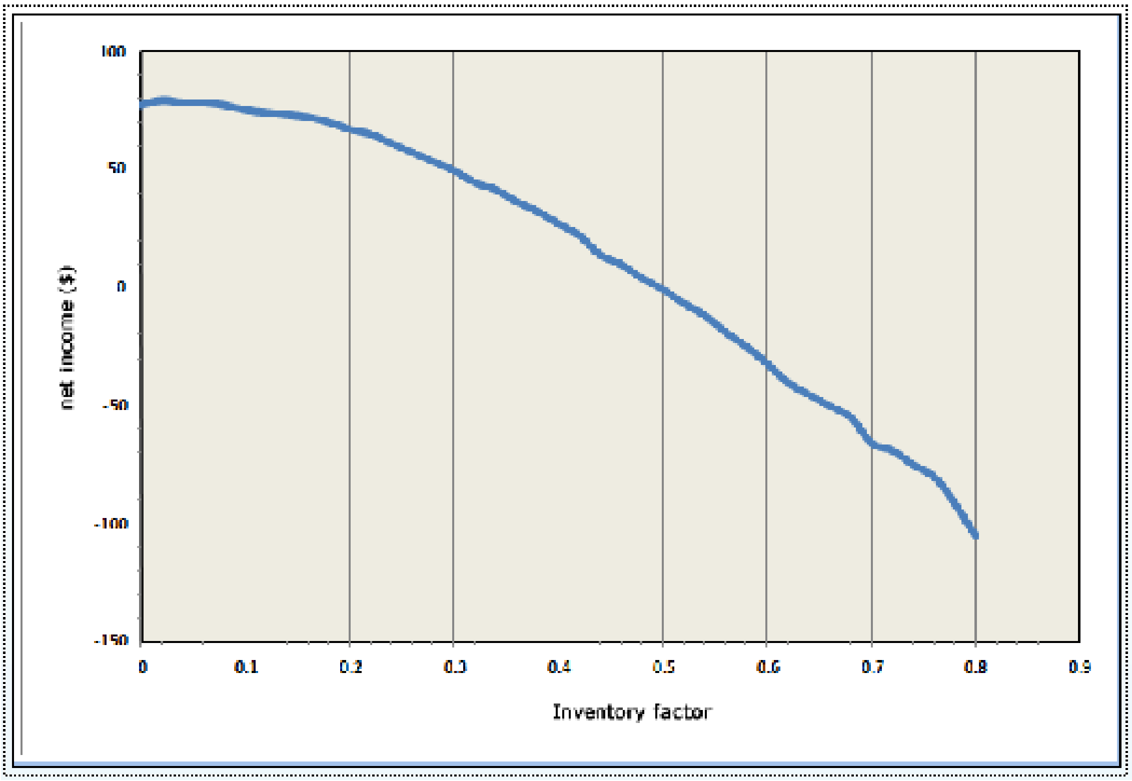
This phenomenon is considered a key aspect in the behavior of potential real supply chains, it is very important to have the capacity of reproducing this effect in the simulator, and especially to discover how this effect can be reduced, due to the great damage it causes since it can paralyze the production of a factory or a company for months, making shutdowns into operations, causing a great damage to the workforce.

Learning Point 2

Since the random variations of time ordering and delivery traffic will increase the measure of the bullwhip effect in a supply chain, we do not need to include random variations to reproduce the behavior of whip or "Bullwhip" effect.

Learning Point 3 – Inventory Factor

Determining the value of the "**Inventory Factor**" or sometimes also called “Inventory Adjustment Factor" depends on each player's perception of the relative costs of the high inventory versus the costs of running out the stock.

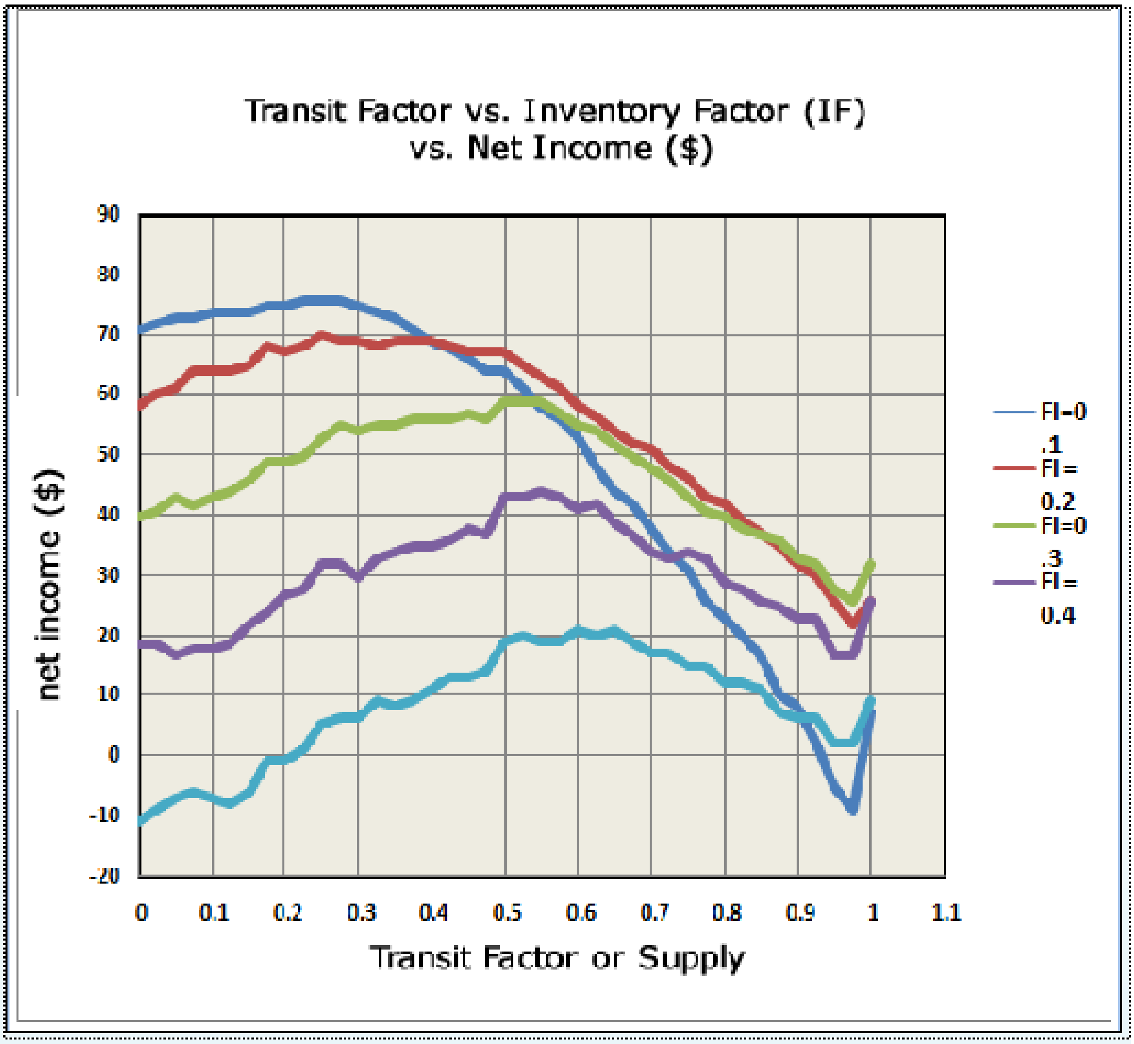


Learning Point 4

Driving a small amount of the "Inventory Factor" (between 0.1 and 0.2) is the best strategy to optimize the performance of a supply chain, even when logic dictates the opposite, the higher values of the "Inventory Factor" guarantees that we react more quickly to fluctuations in inventory when the supply is in a critical state.

Learning Point 5 – Transit Factor

In practical situations, the value of the "**Traffic Factor**" or sometimes called "Supply Factor" will tend to be low, due to the players probably won't be willing to calculate a rate of expected orders from the supply line. (Usually a value between 0.2 and 0.3 guarantees us optimum results.)



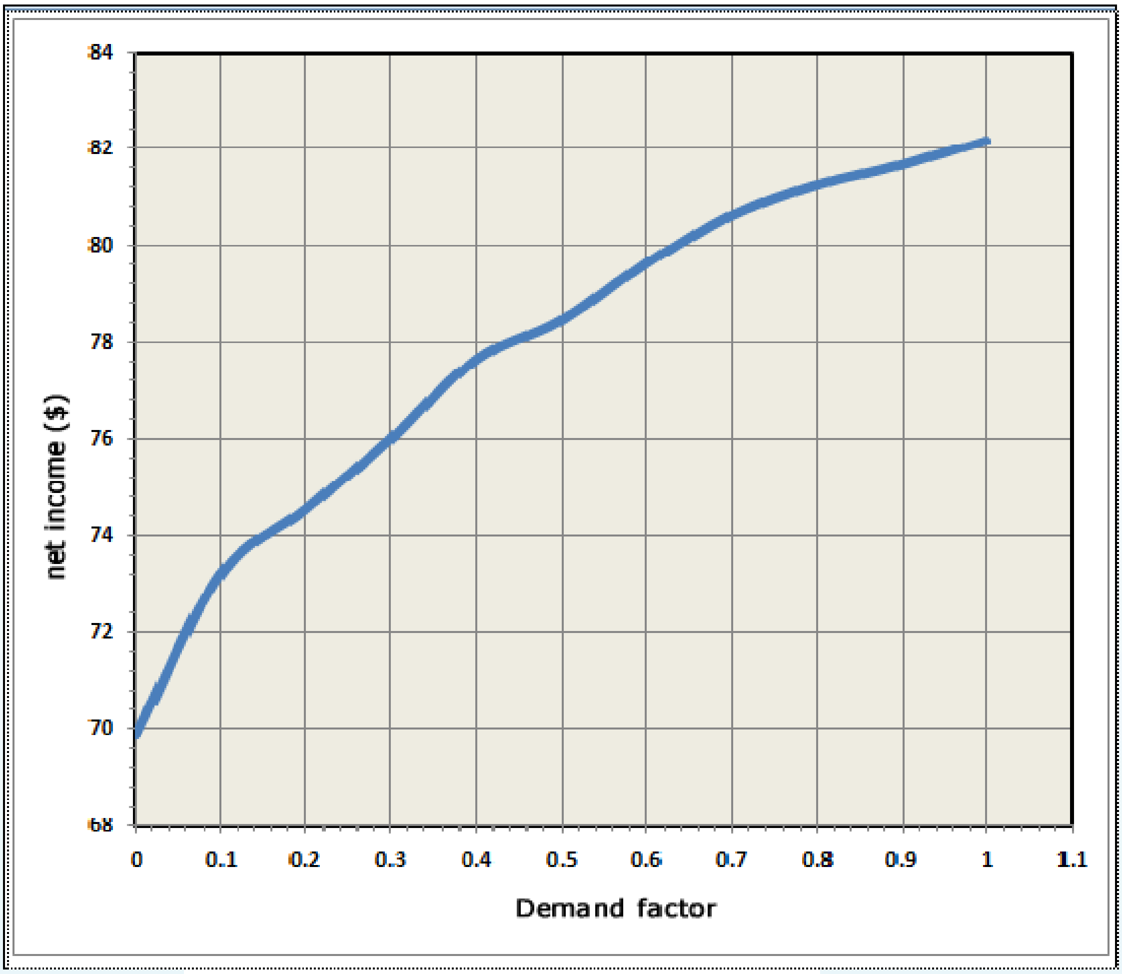
Optimal Value of the Inventory Factor= 0.1. Transit Factor between 0.2 and 0.3

Learning Point 6

In a supply chain, the simple case of making information available to the nodes is not enough to guarantee a better performance of the chain. The algorithm to process information must also be optimized for the information provided and the supply chain to be managed. Therefore we recommend the use of an "Inventory Factor" between 0.1 and 0.2 and a "Traffic Factor" between 0.2 and 0.3, in addition the "Demand Factor" that allows the customer demand to be visible to all the nodes of the chain is 1 and the " Factor of Transit Recognition " is also 1, all these numbers optimize correctly the calculation of the algorithm mentioned and ensure better results in the entire supply chain.

Learning Point 7 – Demand Factor

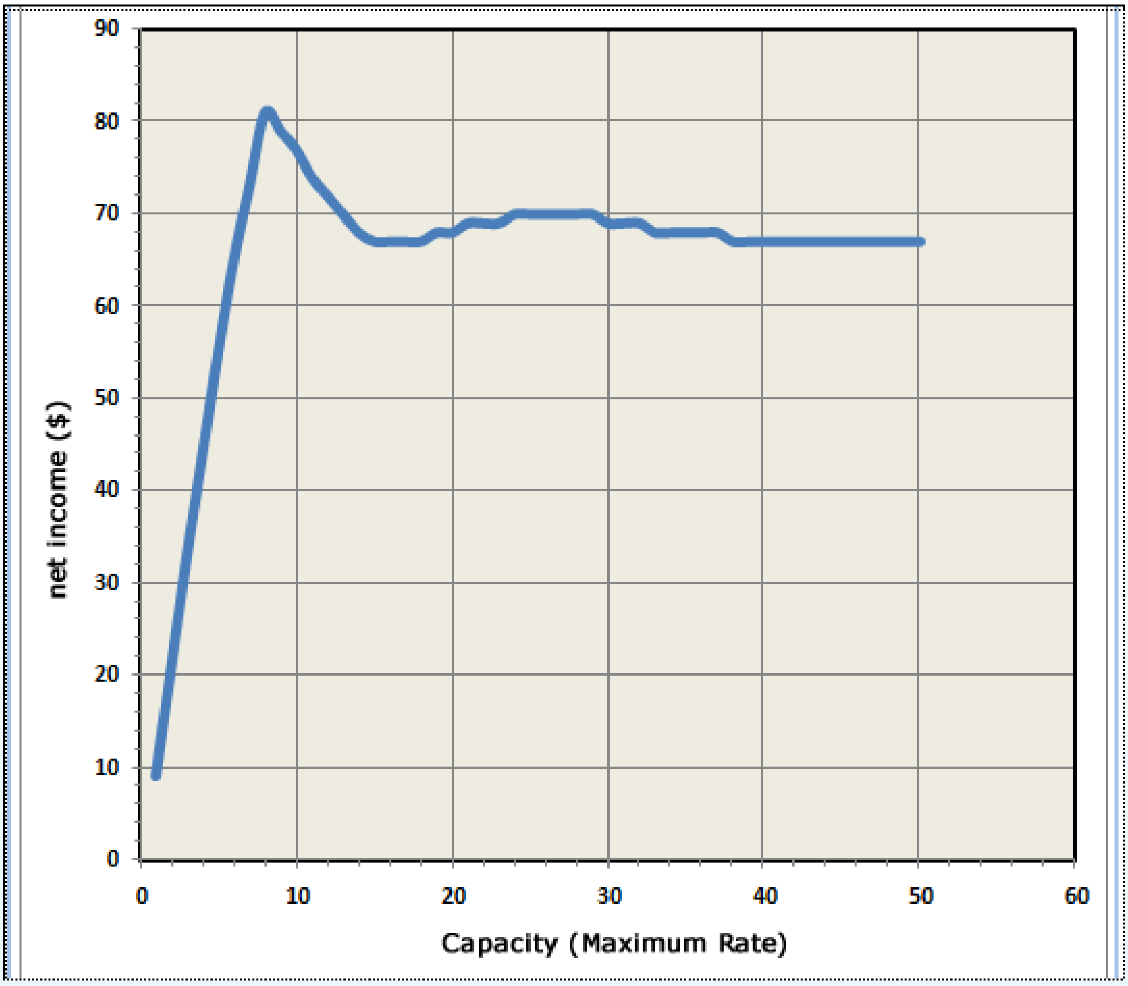
Sharing the data of the customer demand between different nodes of the chain can improve its operation (for this to occur, in the model the "**Demand Factor**" should be 1, to assign a value of 0 means that the demand is not visible to all the nodes, values between 0 and 1 means that customer demand is partially visible to the nodes), It is clearly assumed that that the shared data is true and that a node may use it properly to calculate its new product orders.



Bigger is better. Optimal Demand Factor=1

Learning Point 8 – Delivery capacity

In a dynamic system, the processes restrictions (like warehouses size or load capacity, etc.) can now improve the time of the performance process. In the game of beer, this is shown by the way in which the restriction of the delivery capacity may lead to product to improve the net income generated.



Learning Point 9

Even if some of the players had the knowledge of how to behave to maintain a good performance for the supply chain, this is not enough to guarantee a good globally performance. All the nodes in the chain must submit the correct behavior in order to ensure the success. If simply one of the nodes operates poorly, this is enough to spoil all the work of the entire string.

One of the most interesting aspects of this game that can be illustrated when the simulator runs in the game mode, will occur if you have players who know the game and know how to play it, if you have only one player and takes control of the node "Distributor" and the other nodes have no human players but the player is the computer. If we configure these virtual players with the following factors in inventory values of 0.5, transit factor and demand factor of 0, which are the worst performance parameters, then thinking in experienced players who know what they do, It won’t be possible to them to maintain a good performance in the chain, because the other nodes are predefined to have a worse performance. Thus we can conclude that the chain is only as good as its weakest link.

Conclusions

Meditation about Remedy or Heal:
Solutions that create more problems:

They suggest a fast solution, and the patch helps momentary but doesn't solve the underlying problem. To mend means applying an endless series of patches that never fixes anything certainly.

Fundamental Solution

Healing will look for solving deeply the causes rather than the effects. It involves a profound change of attitude. To be healed it's required to precise the hidden patterns that match the different elements and consider them as an important part of the solution.

Finally, it is time to see the world with new eyes, with faith and hope in a better future.

Watch the development of an innovative model that allows users to operate the simulation in a distributed way, being able to play in different physical locations, to manage data through a graphical user interface connected to a database server, which in once you connect with The Beer Game, and access this new application directly from the web using mobile devices such as Ipad, Iphone and any Android tablet. And above all, giving access to this type of learning colabotativo, many low-income youth, of the world.

Future Updates

1. Adding aleatory variations to the restriction of the transport capacity to deliver the product orders from one node to other and to the final consumer.
2. Similar to (1) for the reception capacity of products in the inventory node.
3. For points (1) and (2) the restrictions of capacity are physical and about human behavior, having to do with the calculations of the work productivity of the human resource.

4. To incorporate in the algorithms of assessment of productivity, the indices of emotional involvement of the employee.
5. To evaluate the probability of purchase again of a client or his/her productivity. Add in its calculation the indices of emotional involvement of the employee.
6. To improve the quality of human performance, apply the Human Sigma Method.
7. To evaluate the human performance, incorporate the technique of the Balanced Scorecard.
8. To simplify the reading and comprehension of the human performance evaluation, incorporate the administration technique of a page.
9. To include other methods of financial evaluation to discover new indicators that measures the performance of the Global Supply Chain.
10. Include evaluating techniques about the life cycle of the client to recognize the costs of finding new clients and retain them and intangible value added.
11. To use different time delays in the orders and the supply times of every node to find out if there is a relation between the chain and the impact of the delay parameters.
12. To incorporate recruitment, selection, and firing techniques, as succession plans for dynamic management of the human resources.
13. To identify the exact calculation algorithms of the fixed costs and the variables that incorporates the defined costs in (12).

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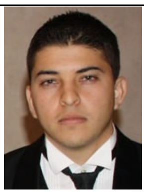	Modeling: **Ramiro Luis Almaguer Navarro** Education: Licenciado en Administración de Empresas Email: rmalmaguer@gmail.com
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