Integrating System Dynamics with traditional management tools: a case study in the Apparel Industry

Hugo Herrera (hugojhdl@gmail.com)

Abstract:

This case presents an exploratory example of how System Dynamics can be combined with other management tools and modes in order to produce an effective and agile strategic analysis process. Since its inception (Forrester, 1961), System Dynamics has been successfully used to tackle strategic problems and support the strategic process (e.g. Rich et al., 1995; Vennix, 1995 or Warren, 2005). However their effectiveness is sometimes constrained by the short time available, high uncertainty and problems to integrate it with the current databases. This paper aims to increase the pool of successful cases analyzing System Dynamics based intervention conducted in an Apparel industry in Latin America. In this multi-method intervention System Dynamics was combined with other management tools to support an agile (six weeks) process of rethinking the company strategy.

1. Introduction

The present case was conducted on a big manufacturing company in Latin America operating in high competitive environment. JeansFactory[1] was founded in 2009 to offer products and solutions to competitive jeans brands in U.S. and Europe. Therefore, the company it is focused in the process and product design, rather than in marketing and distribution, and has not it own brand. However, since it creation in 2009 JeansFactory[1] has faced several challenges to keep a sustainable financial performance and achieve its goals. For this reason the top management team (TMT), constituted by the C.E.O. and the six main departments directors of the company, is concerned about the future of the business. In order to answer this concern, JeansFactory[1], decided to incorporate a system perspective to their current strategy.

> "Produce High quality Products by Developing Innovative Manufacturing Process and Products"
> (JeansFactory[1] Strategic Statement).

As JeansFractory[1] got acquainted with System Dynamics as a suitable method to manage complex problems and deal with uncertain, the C.E.O. made the decision to use it on its new strategic planning process. This process aimed to define the company strategy for the next three years. However, the pressures the TMT faced to quickly produce effective solutions added additional goals to the process. This goals were defined by the C.E.O., in the initial interview, as:

a) develop it quickly (one or two months)
b) produce a flexible model that could be operate by company experts in the future
c) produce a model that can be integrated with other models and tools the company is using on the daily basis

To attend these requirements of JeansFractory[1] the author designed the intervention presented in this paper. The intervention successfully developed in a short period of time a System Dynamics model to support JeansFractory[1] strategic decisions. More over, other management tools (sig sigma, Balance Scorecard, Monte Carlo and discrete simulations) already in use by the company at the moment of the intervention were combined with the System Dynamics model. Integrate the model with other tools not only smooth the implementation and communication process but also support the model process with detailed data produced by available models. In further sections a brief description of this multi-method intervention it is presented as well as some of the results.

2. Organization Challenges

In the initial interviews, the top management team (TMT) identified the negative trend observed in their gross profits as the main challenge JeansFactory[1] is facing for the upcoming years. As is shown in the Figure 1, the gross profits of the organization follow a season trend. Nevertheless, a negative trend can be observed in their average gross profits. In this sense, the TMT pointed out the high competitive environment and uncertainty in the demand as the main causes of the challenges they were facing. However, a System Dynamics perspective used for the intervention quickly reveal that endogenous factors were mainly responsible of the current behavior.

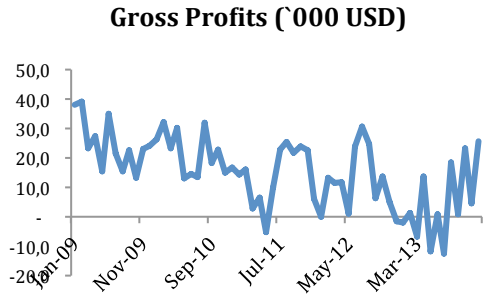


Figure 1. Profits[2] over time JeansFactory[1]

In this sense, the author helped the team to search for endogenous indicators that could help the team to understand the current behavior of the profits. The top management team (TMT) decided to use the main KPI`S of its balance score card as main measures of it internal performance. Those KPI`s are presented in the Table 2 and more detailed explain in further sections of this paper. However it is important to remark the important change on perspective the use of System Dynamics provided to the TMT whom stop to blame the environment and focus on endogenous elements on it system.

3. Method

The method used for the project was System Dynamics in its Strategy Dynamics approach (Andersen et al. 2007). In addition to System Dynamics, the intervention included other management tools and models to support and complement the System Dynamics model. Since the company was already using other management tool in it daily operation, the model was able to provide good results in short time.

System Dynamics was originally develop by Jay Forrester as a method to explore and improve the performance of industrial systems (Forrester, 1961). In his book, Industrial Dynamics (Forrester, 1961), he explains the poor design of the system as one of the main reasons of the poor performance in the organizations. According to System Dynamics, this poor design is attributed to the lack of understanding of the feedback loops operating in the system (Sterman, 1994). Due to cognitive limitations, human mind is unable to successfully predict the behavior of complex systems (Sterman et al., 2007; Diehl & Sterman, 1995) and therefore, trying to manage such complexity, managers can make decisions with unexpected and undesired results (Sterman, 2000).

The System Dynamics approach used in this intervention was Strategy Dynamics. Warren (2000) presented Strategy Dynamics like a System Dynamics approach to improve organization performance over time. This tool helps the managers to focus not in static values, but instead in the history of the organization. To do it, a System Dynamics model is used to understand the possible future development of the organization, answering the question of "*what have made the organization be were it is now?"*

Based on this, the first question to answer in this intervention was: What performance over time we want to improve? (Warren, 2008). Then, after the objectives of the interventions were clear, the author worked with the TMT to attempt to answer three basic questions (Warren 2000, p. 1):

- "Why has business performance followed the time path that it has?
- Where is performance heading into the future under current policies?
- How can we act to alter that future for the better?"

To answer these questions, Warren propose to built system dynamic model representing the causal structure behind the historic behavior of the performance objectives. This causal structure is based on the accepted idea that strategic resources drive the performance of the company (Grant, 2005; Collis & Montgomery, 1995, Warren, 2008). Then, the analysis focuses on how these strategic resources are built over time, what makes them increase or decrease and how this changes can be controlled.

Unfortunately, since the strategic planning process deals with a lot of uncertainty and a lot of information, getting accurate values for the model is some times hard and time consuming. In this sense, the use of System Dynamics in strategic planning is, sometimes, constrained due to the need to produce quick plans. This was context of the current intervention, where the top management team (TMT) needed to achieve results and define strategies in a time frame of six weeks.

To overcome the time constrain challenge and make the process more adaptive to the internal organization process, this intervention combined a high level System Dynamics model with other management tools. A high level model is understood in this paper as a high aggregated and simple model, able to represent the main causal relationships and feedback loops acting in the activities of the company. The results of this model were combined with more detailed tools in order to support the overall decision-making process. Among the tools and models included in the intervention were: Balance Scorecard, Six Sigma, Discrete Queue Simulations and Monte-Carlo Simulations.
In the next sections a brief description of the process followed during the interventions and the model building steps are presented. Some data has been modified and some names have been changed for confidentiality reasons, but the main structure remains untouched.

3. Project outline

The modeler, the C.E.O., the finance director and the planning director of JeansFractory1 designed the project jointly. The goal of the project was defined as follow:

> *"Create a strategic framework to support sustainable profits growth for JeansFractory[1] in the upcoming three years by the design of concrete and measurable plans"* [3] (C.E.O JeansFractory1)

In order to achieve this, the management team stated two outcomes they expected from the project:

a) a simulation model able to capture the main dynamic of the business
b) concrete action projects to tackle current organizations' weaknesses, reduce threats and explore potential opportunities.

Ones the goals and expected outcomes of the process were settled, the author and the TMT defined the outline to develop it. The outline of the project was dived basically in two stages: a) Competitive Analysis and b) Tactical Analysis. In addition, the tactical stage was divided in two parts. The first part was meant to develop projects to support the strategy. The second part took care of evaluation, prioritization and operationalization of those projects. Concrete expected outcomes were defined for each stage, including intermediate products. Finally, the project was presented to the board of directors and multidisciplinary teams were designed from the directors of different departments. A brief outline of the project is presented in the Table 1.
The project started building a high-level (simple and aggregated) model to represent the core strategic architecture of the company. The model was built to identify policy alternatives and opportunities. Then these policies were translated into stochastic and deterministic models to construct business cases for each of them. Finally, in the last stage of the process, the model was used to assess the impact of the proposed projects and prioritize them in order to allocate the needed resources for them. This analysis was complemented with the use of an impact/effort gird previously used by the company in other projects.

Table 1: General Project Outline

Stage	Competitive Analysis	Tactical Analysis	
		Stage 1: Projects Design	Stage 2: Projects Evaluation
General Description			
Outcomes	System Dynamics Simulation Model	Business Case of Tactical projects	Projects outline, KPI`s and Implementation Gantt diagrams
Team members	C.E.O, Planning Director, Operations Director, Commercial Director, Financial Director.	Planning Director, Quality Director, Engineer Manager, Research and Develop Manager, Floor Engineering team, Brand Management Team	Financial Director, Operation Director, Operation Financial Analyst, Pricing Analyst, Commercial Director.
Dates	Week 1 and 2	Week 3 and 5	Week 4 to 6

4. Strategic Architecture

Like was described before, in order to asses the organizations challenges for the future it is important to completely understand the history of the organization. This performance over-time, is needed to: a) understand the behavior dependence on the resource levels (Warren, 2008), b) know the rate at with this resources are growing or depleting and c) explain the causes of those rates. The representation used to capture this causal explanation is known as "strategic architecture". In this sense, the strategic architecture is no more than a causal explanation of how the strategic resources drive the organization's performance over time.

It's important to emphasis that instead of trying to find correlations in between variables, the strategic architecture aims to find causal explanations with meaning in the real world. These kind of explanations are easy to understand and easy to explain because they have a meaning in the real world. Moreover, build the strategic architecture forces the managers to express assumptions they have about how the business work and what they expect form the external world. This is important, because once these assumptions are explicit; managers can evaluate, understand and reformulate them (Meadows, 1976).

In order to build the strategic architecture of JeansFactory[1], the intervention answered four main questions (Warren, 2008; Warren, 1999):

- **What** are the performance objectives we want to improve?
- **Why** the performance objectives have behaved in the way they did?
- **Where** the current performance is heading to?
- **How** the behavior of the performance objectives can be improved in the future?

4.1 What? The Performance objectives

The first step of the intervention was to define: *what is the performance we want to improve?* (Warren, 2008). The top management team (TMT) recognized the operation profits' trend, which has been decreasing in the past years, as they main concern.

In addition, the TMT proposed to use their current Balance Scorecard (BSC) to outline other performance indicators that could help to understand how the internal performance of the organization has drove the gross profits performance. The BSC is developed to communicate multiple objectives. With help of BSC the organization can translate their mission and strategy into objectives (Nielsen & Nielsen, 2008). Balance scorecard is a performance measurement system that represents a strategic map of the organization (Thomson & Mathis, 2008). A simplified version of the BSC, with the performance indicators of focus to JeansFactory[1], can be observed in the Figure 2. In the Table 2, the last 60 months KPI`s behavior is presented.

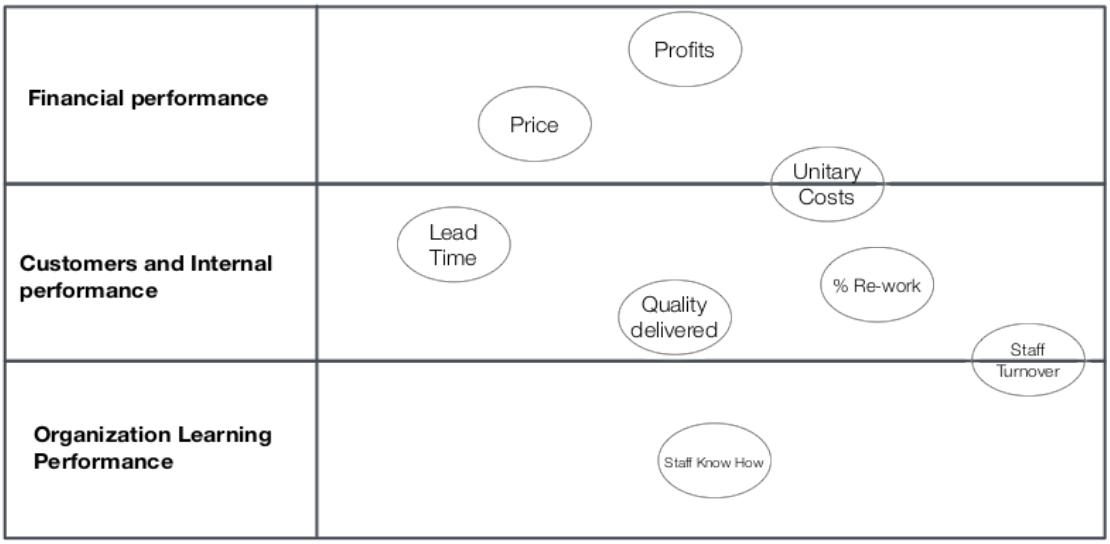
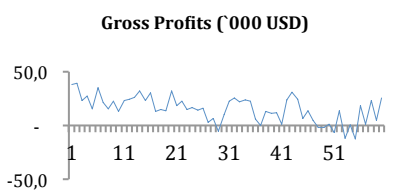
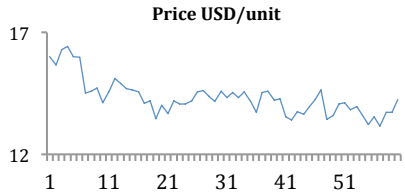
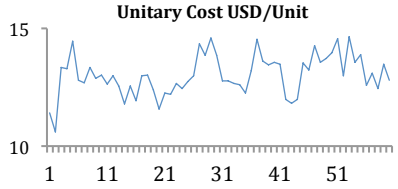
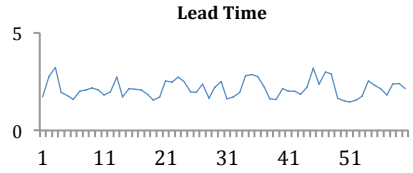
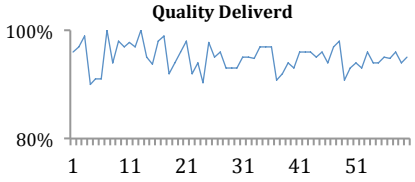
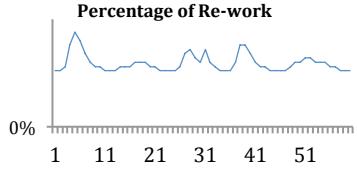
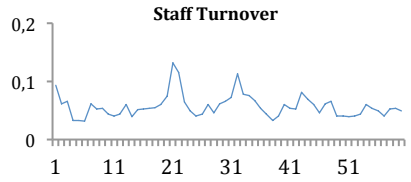
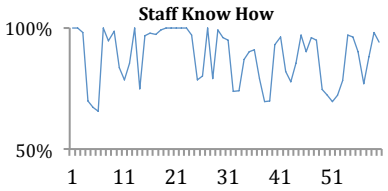


Figure 2. Balance Scorecard Performance Indicators[3] JeansFactory[1]

Table 2: Operative definition [3] and historical behavior [2] of Performance Objectives

Performance Indicators	Operational Definitions (JeansFactory [1] BSC [3])	Behavior over time [2]
Performance Objective: Gross Profits	The difference between the amount of revenues and the amount of costs for an accounting period.	
Price	The monetary value paid FOB for one garment.	
Unitary Cost	The monetary expenses enquired during an accounting period to cover administrative and operational work of the organization per unit. Financial costs, amortizations and depreciations are not included in the equation.	
Production Lead Time	Time an order spends in the manufacturing process since its release to be produced until its shipment to the customer.	
Quality delivered	Average percentage of garments in the orders shipped which meet customers' quality standards.	
% Re-work	Average percentage of products that have to undergo more than one time in the manufacturing process in order to make them meet the customers' quality standards.	

Staff turn over	Rate of employees leaving the organization.	
Staff Know-How	Average level of technical and specific skills of the labor force. The Human Resources and Engineering departments every month measure the "Staff Know-How" jointly, picking a random sample of employees.	

It is important to remark some of the main concern expressed by the top management team at the moment to analyze those KPI`s. First, regardless automation, the apparel industry it is still characterized by high labor force dependency, with participation of 60% to 80% of the final cost. Competitors in countries whit weak labor regulations and lower wages have an advantage in terms of cost and hence on the price they can offer. To compensate this disadvantage, JeansFactory[1] has focused it efforts on differentiate it products. However, even the company's official strategy is not focused on low prices, JeansFractory[1] has faced a reduction on their prices that has directly impacted their margins. The Figure 3 shows JeansFractory[1] unitary price vs. the benchmark for the region.

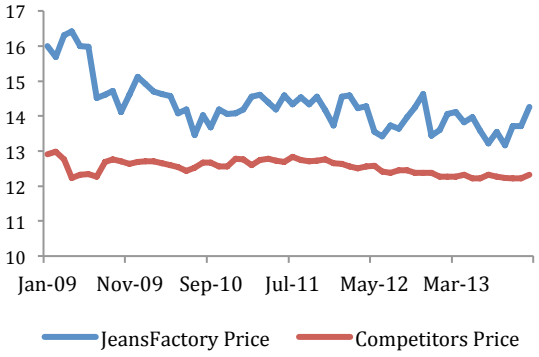


Figure 3: JeansFractory[1] unitary price[2] vs. the benchmark for the region.

An important part of the differentiation strategy of JeansFractory[1] has been the offer of short lead times and quick response to their customers. With competitors in Asia and in Latin America offering low price products and producing in massive scale, JeansFractory[1] has turned its efforts on exploit its location and nearness to US customers as competitive opportunity. Since the fashion marked is relatively unpredictable, some brands are willing to pay more for quick response to their orders. As the commercial director of JeansFractory[1] stated in one of the initial interviews:

"We deliver right to the store, our product is not going to a warehouse for storage and posterior distribution….the customer stores receive the product, open the box and sale it the same day" [3] (Commercial Director JeansFactory[1])

This quick response expectation could be until just eight weeks since the order is placed until the final product is received. With short production and delivery lead-times the clients reduce their inventory costs and increase the accuracy of their demand projections. These benefits are sensible improvements for clients who are willing to pay more in case some supplier is able to meet it requirements.

However, this quick response could represent sometimes a real challenge, because eight weeks (2 months) for production and shipping require detailed and exact planning process and the right amount of resources ready in the moment they receive the purchase orders. In the previous years JeansFractory[1] has tried to develop a flexible manufacturing system with low work in process (WIP) ratio and high efficiency. Regardless those efforts, the production lead-time continued to be, on average, over the two months they promise to their customers. These continuous delays have damaged their reputation and created mistrust among the customers. Even worse, the work in progress has continued to increase no matter with high cost of maintenance. In addition, the increase of work in progress caused an increase in the working capital of the company. The performance over time of WIP and Production Lead-Time are shown in the Figure 4.

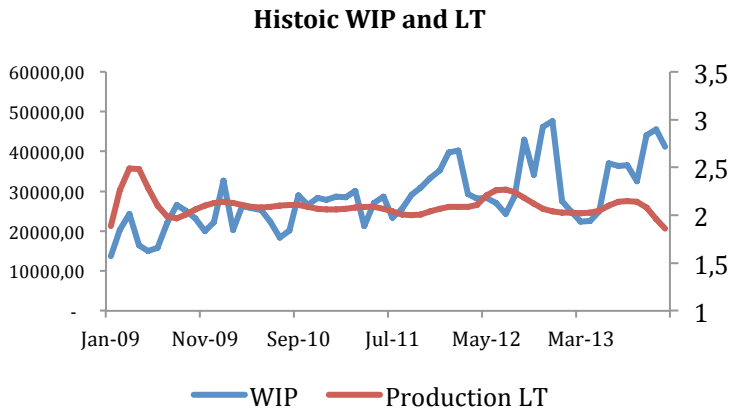


Figure 4: Average diary WIP[2] and average lead-time[2]

Another area of differentiation for JeansFactory[1] has been the quality of their products. Working with a highly qualify team in the Research and Development (R&D) department, the company has tried to develop processes to produce high quality products from the first attempt. With a goal of 5% of re-work and a fully implemented Six Sigma process, JeansFactory[1] expected to reduce their lead time and their operative costs at the same time it improves the quality of their products. However, as the Figure 5 presents, these efforts have not give results yet and the average percentage of re-work continues to be over 10%, far away from JeansFactory[1] goal.

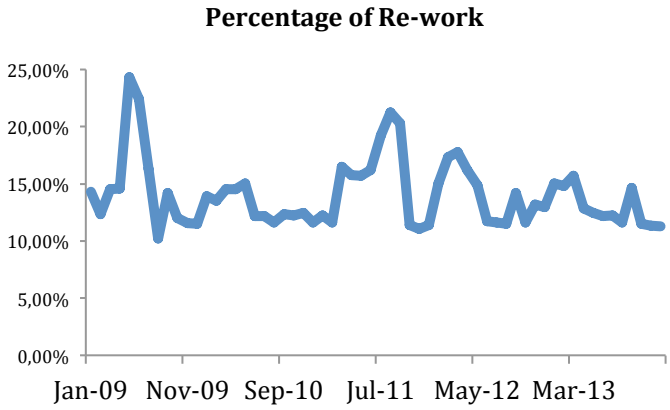


Figure 5. Percentage of Re-work[2]

4.2 Why? The Strategic Architecture

Once the performance objectives were clear for the team the next question was: why is the performance indicator behaving like that? (Warren, 2008). In order to solve this question, the author propose to the team management team start by understand which were the strategic resources driving the performance. To do it, the author and the team designed to participate in the first stafe of the project worked together to build a System Dynamics model able to represent the current performance of the organization's gross profits.

The System Dynamics model was built on a participatory way, during four sessions of two hours each. In these sessions the participants discussed the data, causal relationships and decision rules of their daily activities. The model built is briefly presented in the further sections, for simplicity, small structures will be explained to uncover the strategic architecture of the business. All the resources, affecting one of the performance indicators, will be explained in the same frame as respective architecture. A general overview will be presented at the end of the description.

4.2.1 Profits architecture

Starting from the performance objective Gross profits, the strategic architecture built by the "competitive analysis team" is shown in the Figure 6. The historic behavior of the profits has shown a trend to decrease, and the model shown if the business continues working as usual in less than five years the company will be operating in red numbers.

The team made some conclusions about the behavior of the performance objective. First, despite the increase of 35% in sales, the revenues have increased by just 9%. This difference occurs mainly due to the constant decrease of the unitary price. The commercial manager recognized that due to the pressure of the competitors' price and the undistinguished performance of the company on quality and short lead-time, the value of the product perceived by the customers has decreased in the past years. In order to keep their market share the commercial department has been pushed to lower the prices. In this part, the team identified the value of the product perceived by the customer as an

important strategic resource. At least an effort is done to improve this perception, it will be impossible to increase or at least keep the prices at the current levels.

Regarding the costs, the unitary costs have increased 15% in the past five years. While the “wages” have increased only 7% per unit. The “WIP cost” has increased 29% in the past years. Advocating for scale production, JeansFactory[1] has pushed their commercial department to increase the sales at the pace of the market growth. However, the team realized this policy didn´t work as it was intended. As the “normal productivity” of the labor force has remained almost constant (see Figure 8), the wages have increased meanly due to the inflationary adjustment JeansFactory[1] does every year and the increase on the production rate. Though the WIP has increased significantly in the past years carrying more expenses to manage it. In 2013 the administrative structure needed to manage the WIP included a manager, twelve supervisors and 106 employees plus 332 square meters dedicated to the storage of work in progress in between process. For this reason, the WIP was identified as another important resource to manage in order to improve the performance of the gross profits.

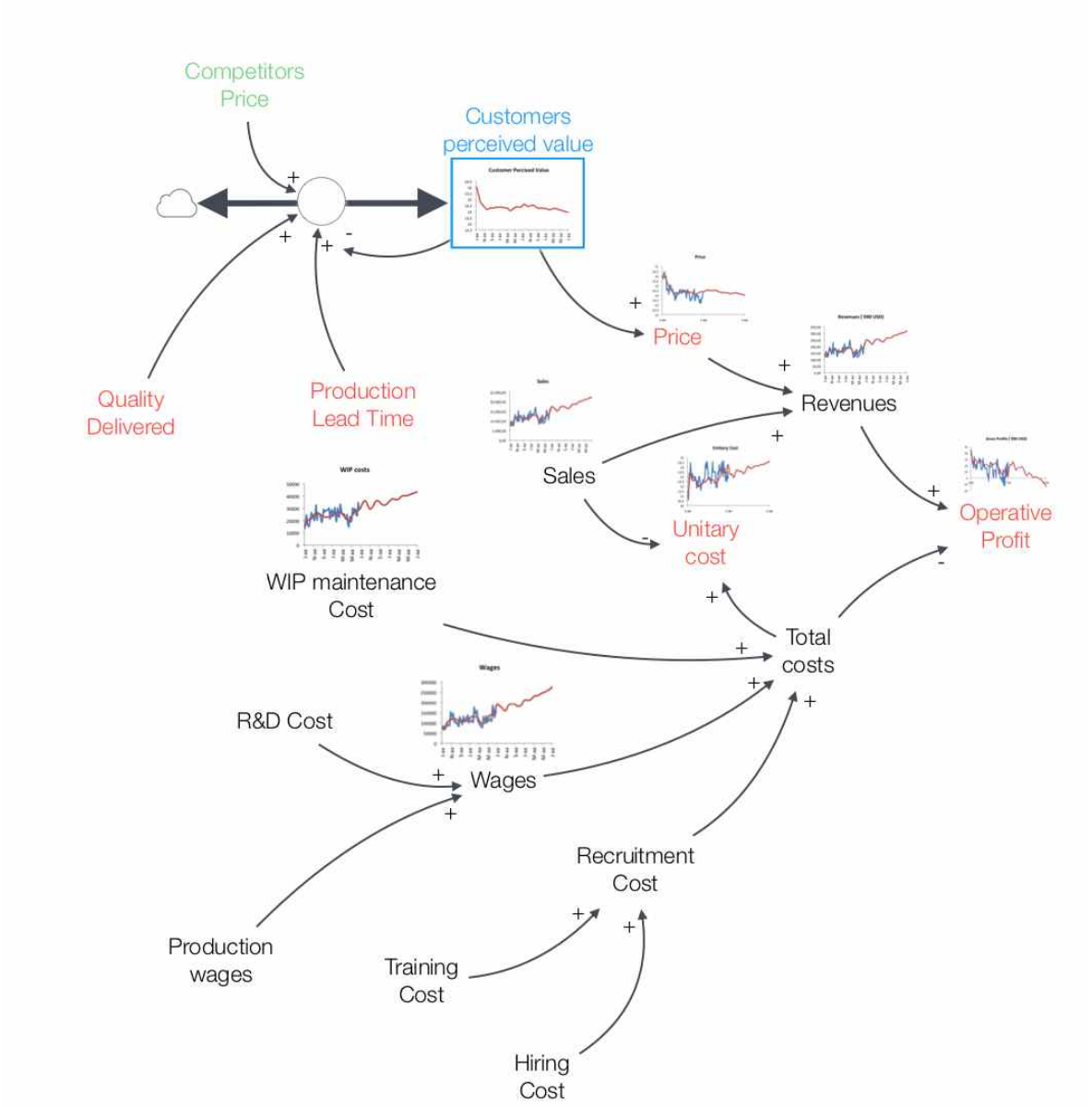


Figure 6. Gross Profit Architecture.[2]

4.2.2 Operations Architecture

The operations architecture was represented in a simple and agregated way with the purpose of producing a comprehensive model. Currently, JeansFactory[1] has detailed simulation models exclusivly dedicated to represent their production processes. In that sense, the deatalis included in this model were only at the level needed to understand the behavior of the main performance indicators and to ilustrate the main strategic resource. The resulting operations architecture is shown in the Figure 7.

The heart of the strategic architecture is the work in progress (WIP). This stock represents the untis that are in the plant floor in process or waiting to be processed. The WIP increase through the orders released by the R&D department. When one order is allocated, the Research and Development department has to develop the process needed to reproduce the product in an industrial scale. The orders that are under this process are represented in the stock "Preproduction process". Once R&D has develop all the operational procedures and instructions to produce the produc in the factory, the order is released and the units are part of the WIP. The WIP is decreased by the shipping rate that, in this simplified model, only depends of the production capacity.

The average production average lead-time needed to process one unit- can be calculated as the WIP divided by the shipping rate.

As the company can access additional equipment, if needed, really fast through its rental agreements and all the production is currently working only in one shift, the production capacity has been depicted as depended only of the ammount of staff working in the organization. Due to piculiarities of some of the operations they perform, the staff starts with a low productivity and need special training and supervision during the first six weeks in order to achieve their normal productivity. In their efforts to ensure quality and a flexible manufacturing system, JeansFactory[1] paid attention to the "Staff Know How" or level of technical and specific skills of the labor force. JeansFactory[1] aimed to increase this "staff Know How" by investing in the training of their new employess. "Staff Know How" is measured every month through skills evaluation of a random sample of employees and. For this reasson the stocks of "Trained Staff" and "Untrained Staff" were recogniced as important strategic resources of the company. These stocks define the level of "Staff Know How", which is closely related with the quality delivered and the productivity of the organization.

In addition, JeansFactory also pays attention to their "staff turnover". JeansFactory recognize the value of their skillfull employees and want to create a "good work environment" (Human Resources Manager) in order to retain them.

4.2.3 Commercial Architecture

The commercial architecture was one of the most complex parts of the model. Explaining why the customers choose JeansFactory[1] over their competitors needed the use of soft and qualitative variables. However, System Dynamics has proved to be suitable for tackling problems with soft variables and represent them in a quantitative way (Sterman, 2000; Warren, 2002). In fact, System Dynamics have been conceived to represent managers' decisions as well as quantitative elements of the system (Forrester, 1961). The resulted model is shown in the Figure 8.

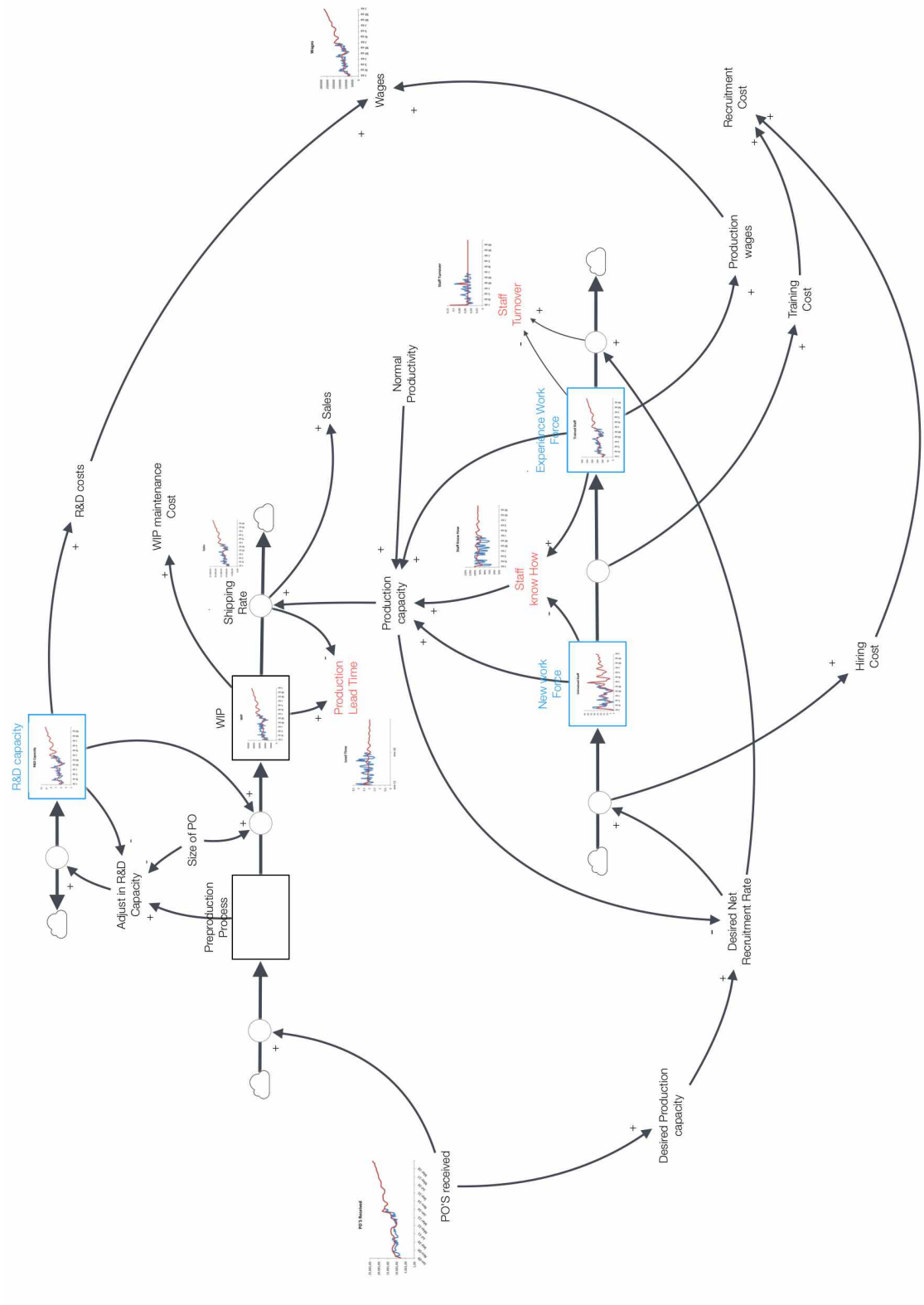


Figure 7. Operation Architecture[2]

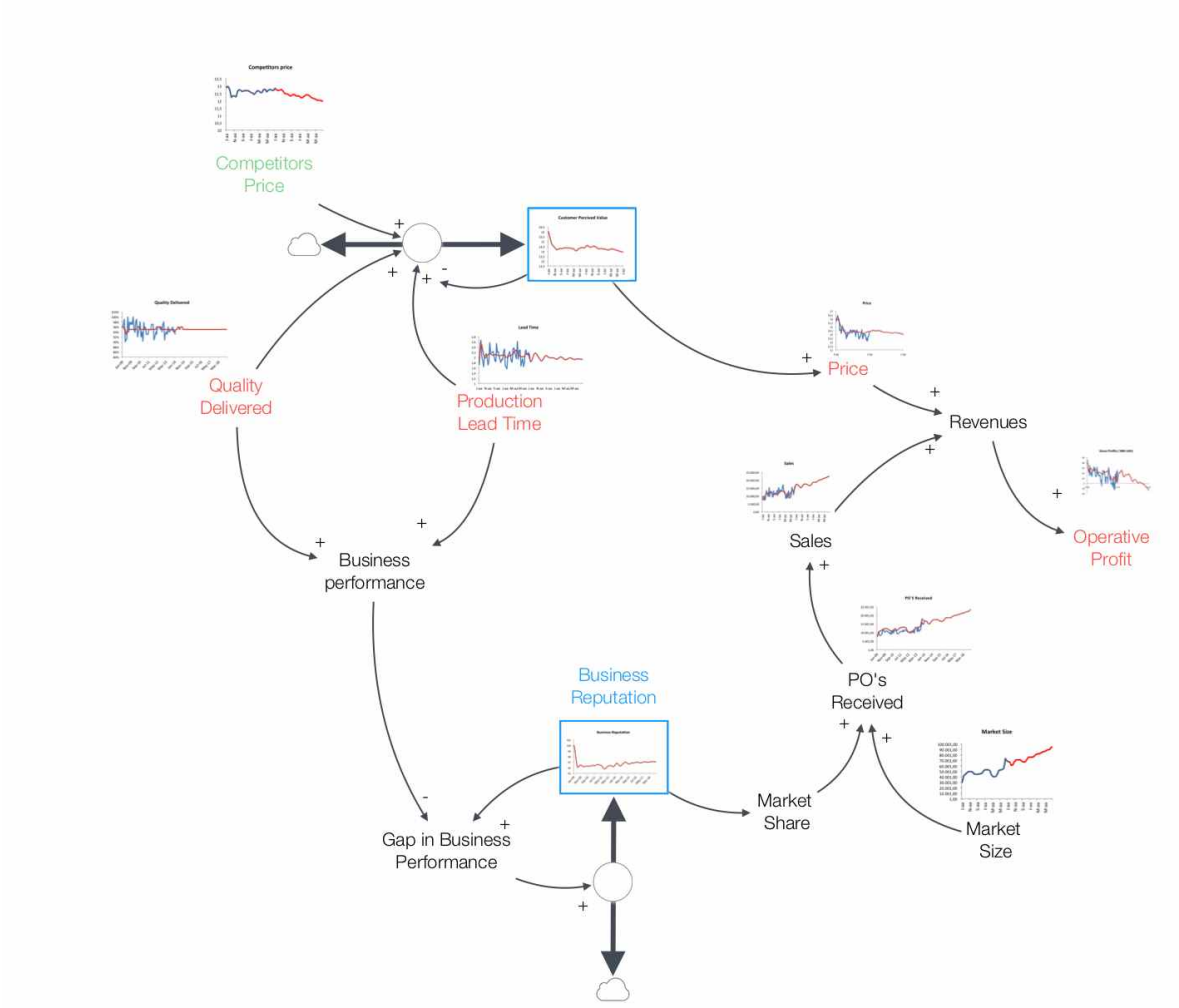


Figure 8. Commercial Architecture[2]

The orders received were understood as result of the market size and the market share the company can capture. In this case the market was considered exogenous and a forecast developed by a professional marketing consultancy firm for JeansFactory[1] was used as input to the model. In contrast, the market share was modeled as an internal factor. According to the brand managers and the commercial director, the size of market they can capture depends on the reputation of the company.

If the company is able to offer better quality and short delivery time than their competitors, customers will find more value in the product than in the product of their competitors and would be willing to pay more for it. However, the team recognized that despite the efforts of the operation team, customers' value perception has been eroded due to their poor performance, like was shown by their marketing research. This has pushed the commercial staff to lower the prices in order to adjust them to the customer expectations.

In addition, the commercial staff also highlighted that the market research they conducted a year before showed how the unfulfilled promises regarding quality and delivery time have decreased the reputation of the company. As the company has been incapable to consistently fulfill the quality and

delivered time offered to the customers, they don´t trust to the company anymore. These make it harder to capture sales and the only way the commercial staff have found to keep the customers was offering “good deals” to the customers. Examples of these “good deals” are some short and cheap orders the company has accepted to “keep the customer happy”.
The complete strategic architecture is shown in the Figure 10. This representation of the model shows how the three “architectures” are actually integrated and work together in order to produce the observed performance of the gross profits. Working with this model, the board of directors had two meetings in order to understand each element of the model and the behavior of the main performance indicators and strategic resources.

4.3 Where? The current trend

The next question, to answer was: “Where JeansFactory[1] is going to be in the future if they continue doing the same?”. Even this is question is normally answer using simple correlation tools; this tools fail when accumulation is involve (Warren, 2008). For example a simple correlation of the past behavior of the past six months gross profits’ behavior can give the wrong impression the gross profits will increase in the future. Only understanding the causes of the current behavior and the current level of the strategic resources we can estimate which will be future behavior of the system.
To do this, the simulation model was used to produce the behavior of the upcoming five years. Like can be observed in the Figure 9, the results were not encouraged at all. The company would grow in the upcoming year pushed by the growth of the markets. However after 2015 even the markets continue growing the weak competitive position of JeansFacotry[1] will inhibit their success and push them to lower prices. This scenario will put the company in a dangerous financial position in the future. Was obvious for the board of directors, actions must be taken to change the current behavior.

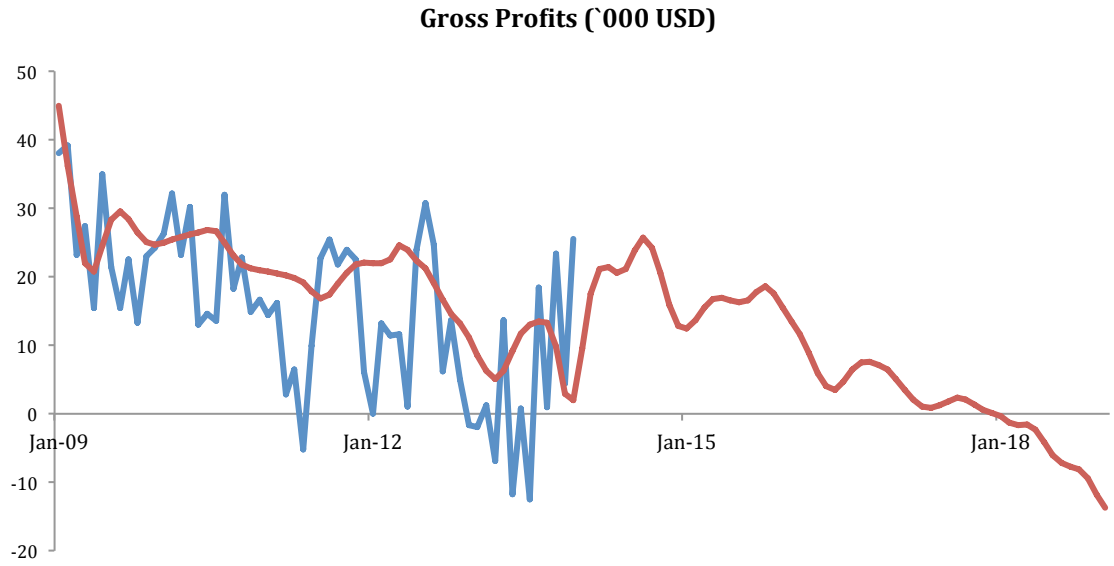


Figure 9. Gross Profits[2] behavior trend

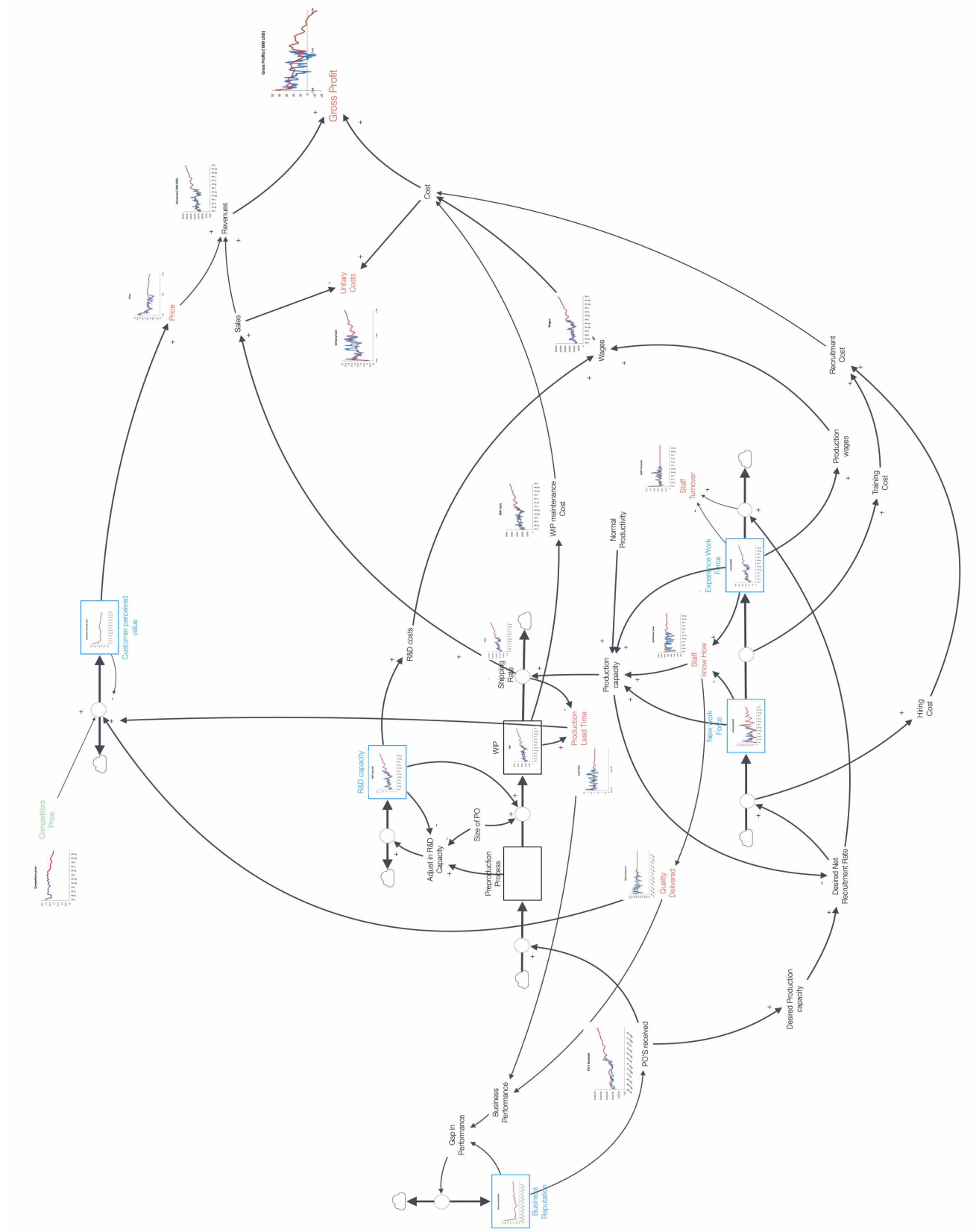


Figure 10. JeansFactory[1] Strategic Architecture[2]

4.3 How? Defining policies and strategies

After calibrating the model and analyzing the model, it was possible to define the initiatives the board of directors wanted to explore in order to improve company's' performance. In order to answer the question: *How we can manage the strategic resources in order to improve the performance?*, the team tested some ideas about what can be done in the model. After discussing the perspectives shown by the model, the board of directors decided to focus on one main strategy: Serve complex and highly profit brands.

To back up that strategy, focused on the increase of the "customers' perceived value" resource, five initiatives were choose in between a set of 9 initially proposed ones. Those initiatives are briefly presented in the Table 3. The board of directors fixed the objectives of each initiative in terms of the performance indicators and strategic resources analyzed previously.

The portfolios of initiatives were given to the tactical analysis teams for the next step. In this step they developed business cases combining the insights of the System Dynamics model built and other daily tools in the organization.

Initiative[3]	**Objective**[3]	**Brief Explanation**[3]
Marketing campaign based on differentiation	Increase customers value perception Increase company reputation	After the commercial staff exposed their concerns about how the value perceptions of the customers and the company reputation have decreased the team decided to put special attention to increase these resources.
Redesign Human Resource process	Reduce Staff Turn-over and Increase Staff Know-How.	Recognizing the relevance of the trained staff as important strategic resources, a specific initiative was devoted to redesign HR process, reducing the staff turnover, the training time and cost of new staff.
New production planning process	Reduce WIP and reduce the Production Lead Time	During the analysis of the model the company realized that even they have made considerable effort to be more agile and flexible, they have not included the WIP adjustment in their estimations to recruit personal. The planning process was focus on satisfies their shipping demand; and the WIP was understood as consequence of the process design. New production-planning tool was entrusted to the planning team.
Automation of the process	Reduce WIP Increase quality delivered. Reduce Production Lead Time and Reduce Staff turnover	Expecting to reduce its dependency on labor force, the initiative will explore alternatives to automate some operations. Reduced dependency of the labor force was expected to improve in quality delivered and increase productivity. In addition, with automation of processes in some particular activities, the organization aims to reduce the fluctuations on their staff, reducing the staff turnover.
Re-launch Six-Sigma project.	Increase Quality delivered. Reduce Re-work	With more training and better controls, this initiative aims to have high and quick impact on the quality performance of the company. With good quality the company wanted to reduce their operational costs but also support their marketing efforts to regain the customers trust.

Table 3. Prospect Initiatives[3]

5. Tactic Analysis: Combining tools

Once the team defined the initiatives they wanted to test, the next stage of the intervention started. During this stage, five interdisciplinary teams were working to build detailed study cases of the selected initiatives. The resulting projects were presented to a selection committee, which evaluated and analyzed them in order to provide a portfolio with the best initiatives.

5.1 Stage 1: Projects Design

The System Dynamics model built in the first stage was shared with medium and low levels of the organization to explain the current ideas of the board of directors and to validate the relationships and decision rules included in it. Detailed results are not available due to confidentiality reasons, but the main description is provided.

Teams were integrated with the participation of almost all the departments of JeansFactory[1]. In total five teams, one per initiative, worked for one and a half week on building a detailed business case of each initiative.

The work was intense as the time was short. The teams used analytical and simulation models developed previously by the company in this task. The production model, see Figure 10, developed in ExtendSim is one example of the models used. The model includes Monte Carlo simulations and analytic equations to produce a “discreet “simulation. The model represents the production chain process as a series of queues interconnected receiving orders in a Poisson distribution. The model was used to assess the possible pathways of new planning tools, developed to reduce levels of work in progress and assess the opportunities of automation in the process.

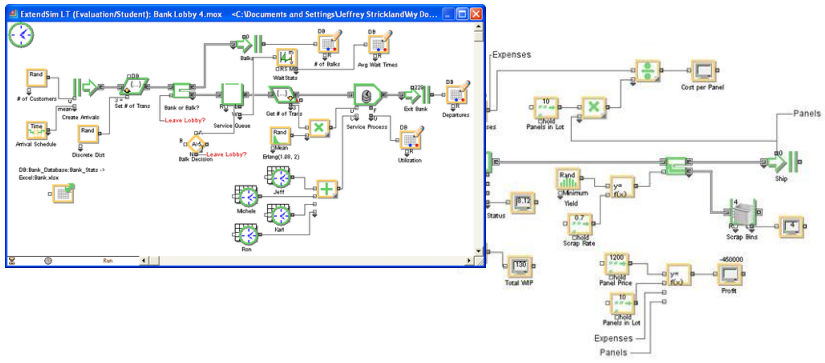


Figure 10. View[2] of the ExtendSim production model used for the initiative “New production planning process”

Another example of the models used in this stage is the Monte Carlo simulation developed with @Risk palisade software by the Human Resource team. This simulation was used to evaluate the changes in the labor force demand and the changes in the labor market. The use of these simulations to deal with the uncertainty allows the team to built a robust system to maintain high levels of know how and recue the time needed for training.

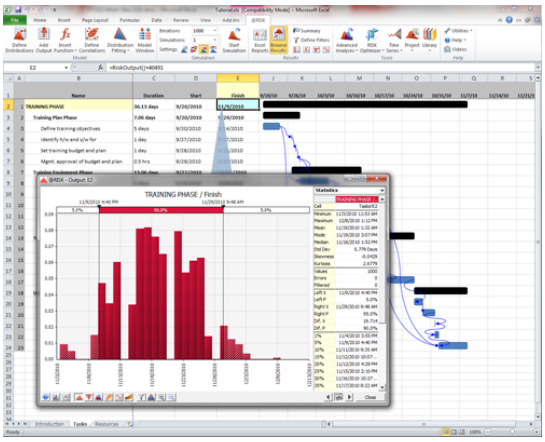


Figure 11. View[2] of the @RiskPalisade simulation for the initiative: "Redesign Human Resource Process[3]"

Besides that, the team devoted to re-launch the Six Sigma project used another Monte Carlo simulation based on the production control graphs. Even the project has been running for three years, it has never had completely achieved its goals. With the aim of improving its performance and devoting more effort to it, the team was expecting to increase the quality of the orders in a short time.

The team devoted to the initiative: "Marketing campaign based on differentiation" worked with a focus group in order to get quick feedback from the real customers and potential ones about the reputation of JeansFactory[1] and assess where they should increase the brand awareness of the organization. At the end, they were able to focus their efforts on couple of apparel events where they would be able to rich a bigger amount of customers and show their products.

Despite the effort of the team working on the initiative "Automation of the process", the time was to short to present the complete investment portfolio needed to increase the flexibility of the company. However, they could present potential equipment and new process that could be used with this purpose. The board of directors considered this initiative highly relevant and decided to give this team three more months to work on it and continue developing the initiative with more details.

5.2 Stage 2 Projects Evaluation

An evaluation process was conducted with the purpose of assess which would be the best initiative or combination of initiatives and their potential impact in the organization. The process was divided in two: first the results of each initiative were introduced in the simulation model built previously and then the results were evaluated in terms of Uncertainty, Direct Costs, Time and NPV.

Despite the fact that each initiative was focused in a specific area of the organization (Planning, Human Resources, Marketing, etc.) the board of directors understood they would have effects in other areas as well. To capture all system, the initiatives were incorporated into the System Dynamics model built previously. Some initiatives were introduced as a change in the structure of the model (See Figure 13 New Human Resources structure) and other just as management decisions (for example the initiative to invest on Marketing).

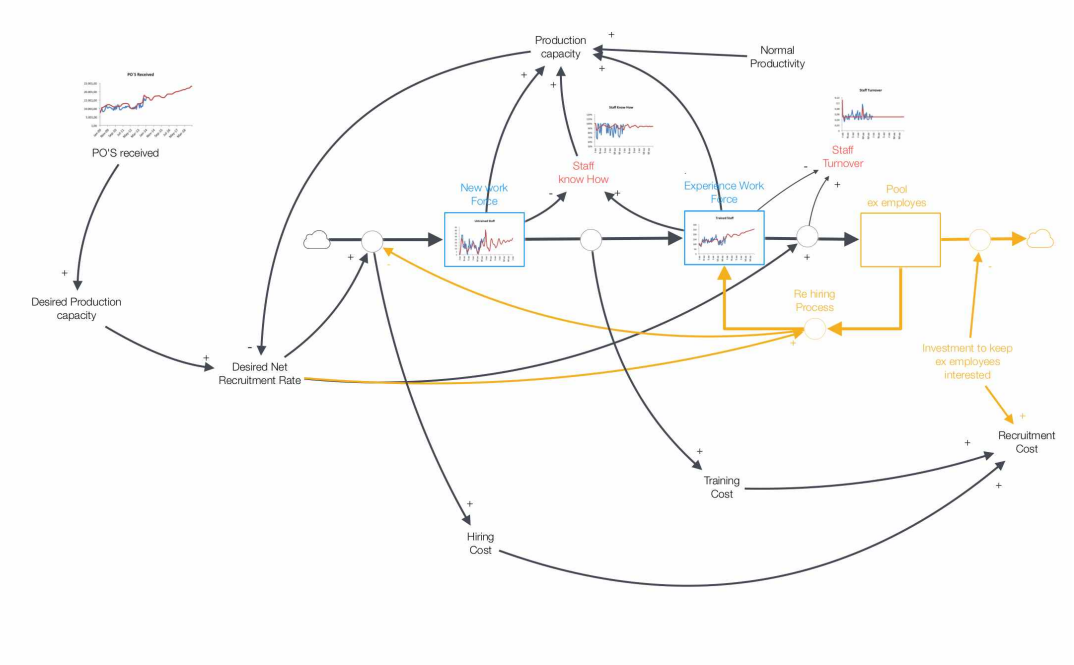


Figure 13. Structure changes to represent the New Human Resources Process initiative.

This management decisions were represented as exogenous input to the model to keep it simple and comprehensive, but also due to time limitations.

After introducing all the initiatives in the model, the team taste all of them separately and combining them in feasible ways to observe the impact of the initiatives on the performance objective ("Gross Profits"). The results of the simulations with the single initiatives are shown in the Figure 14.

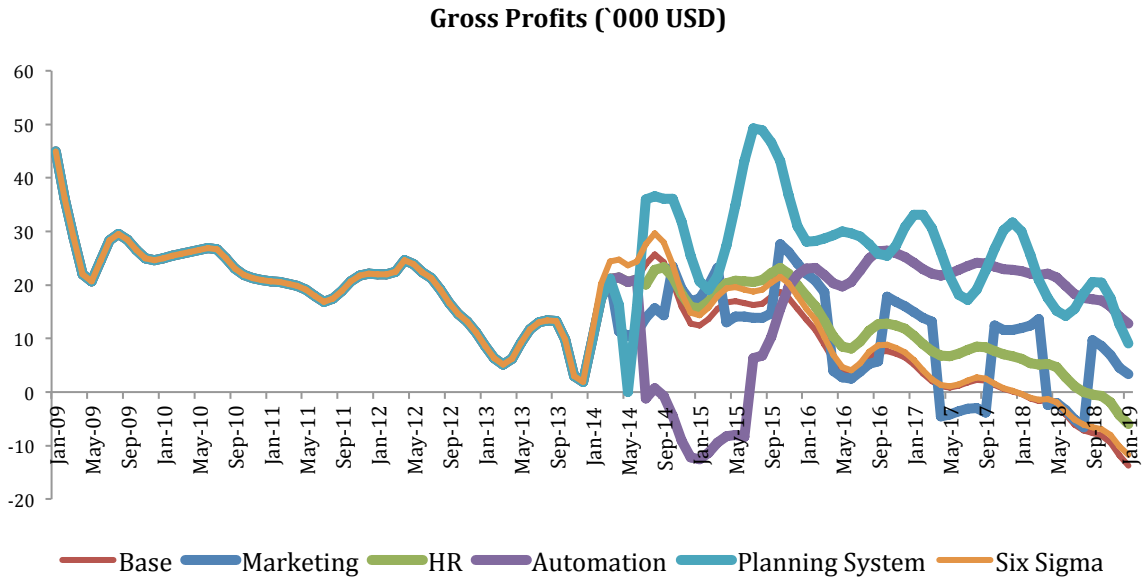


Figure 14. Initiatives effects on Gross Profits.

To select in between each initiative and the possible portfolios the organization can make with them, the company developed an impact/effort grid. The impact was measured as the NPV multiplied by one minus the estimated uncertainty. In this particular situation the uncertainty was defined by the directors as "what are the probabilities that the results would be less than we are expecting"[3]. The board of directors estimated these probabilities based on their experience. Besides, the effort was calculated as the weighted product of the direct costs of each initiative by the time needed for the implementation. The final grid is presented in the Figure 15.

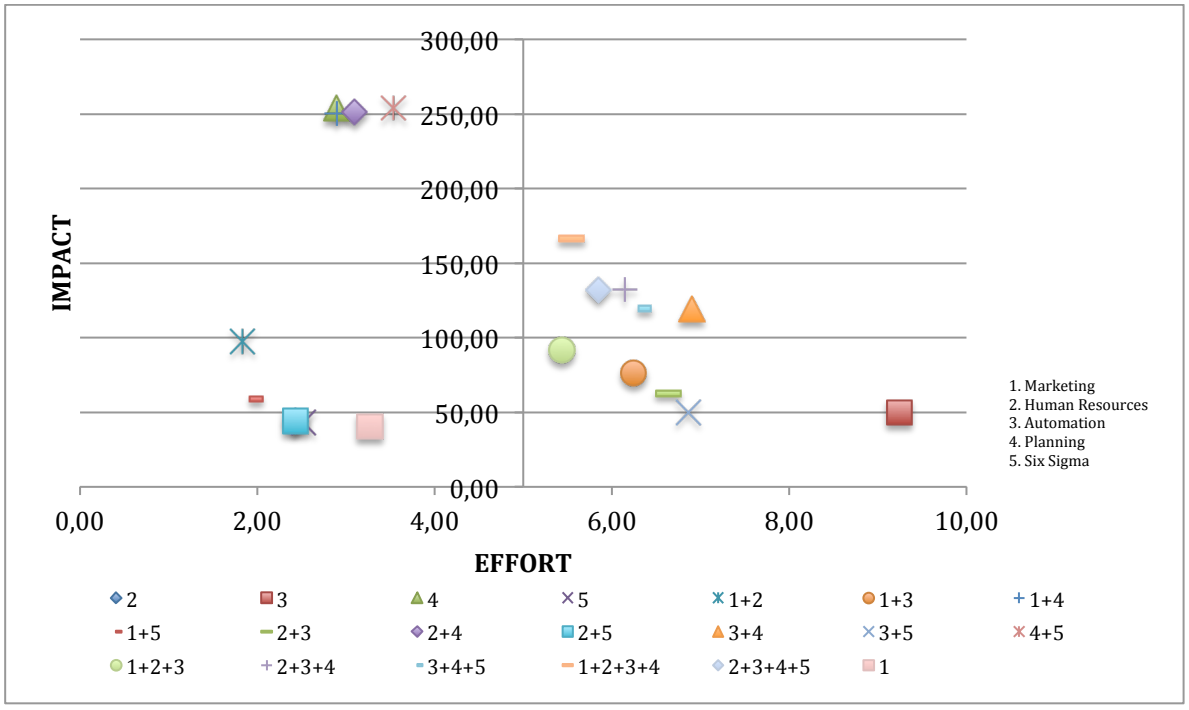


Figure 15. Impact vs. Effort Gird

Based on this grid JeansFactory[1] decided to start with the initiatives that show more impact and need less effort. The initiatives selected were: New production planning process and Redesign Human Resource Process. Both initiatives did not require high investments and provide high benefits in different areas to the organization. For example, the Redesign of Human Resource Process not only reduces the training costs, but also improves the moral of the team, increases the staff knowledge and reduces the percentage of re-work.

The automation initiative provides high benefits to the gross profits but at the moment of evaluation of the project the information regarding it was incomplete. In that sense the board of directors estimated that the benefits currently show in the model were highly uncertain. For this reason, the team agreed to work on this initiative and evaluate it again in the nearest future in order to have more certainty about the results.

6. Discussion

The current study case represents an example of how a successful intervention using System Dynamics can help the organization to redraw their strategy and provide valuable dynamic insights in a short period of time. In this sense, two important aspects can be remark of the case: a) the suitability of System Dynamics integration with other management tool in a natural way and b) the short time needed to achieve a high valued model.

The integration path followed during this intervention is shown in the Figure 16. As it can be appreciated, the intervention started with the organization control panel (BSC) and translate it to performance indicators overtime Using the BSC as a starting point, first of all, made the intervention more friendly, but, second of all, it kept the modeling process within organizations' attention area, which was highly important for a successful implementation. Currently, the two initiatives the company decides to focus on have been already implemented. Beside, the shareholders are already evaluating the investment in automation of the process after the initiative was finally presented.

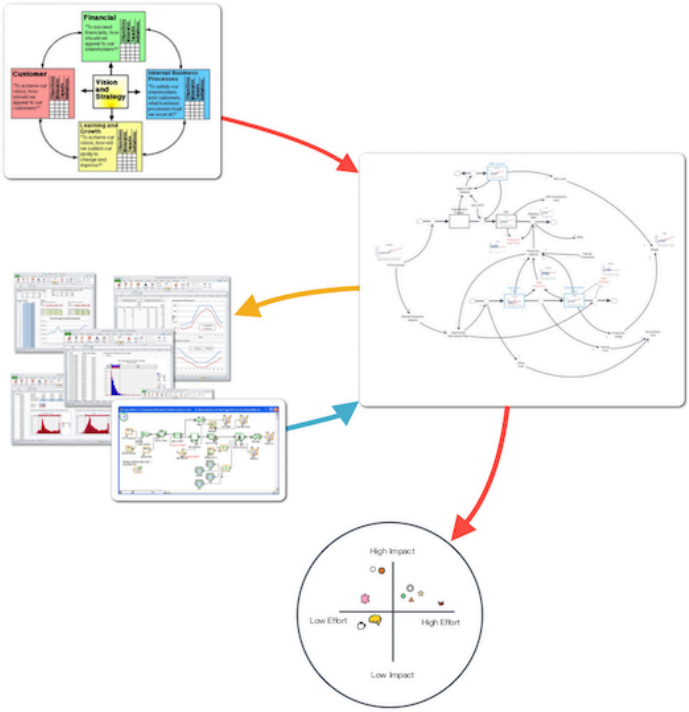


Figure 16: Integrative model scheme during the intervention

Other models and tools, the organization was familiar with, supported the next stage of the process. Using discrete simulations or well-known Monte Carlo simulations linked to their databases the other levels of the organization could get engaged in building grounded business cases to support the System Dynamics model built previously.

The model was simple for explaining and understanding and it was a good tool to communicate the feedback structure to other levels of the organization. However, the participants translated those concepts to other tools, where they were modeling small parts of the model, enabling them to provide new insights for the model.

These results are supported by the posterior interviews conducted among the participants:

"I think the model was a fair representation of what we were doing. When we saw the diagram, it was pretty clear that we were not managing our WIP properly, more capacity was needed." [3] (Planning analyst)

"We always focus our efforts on keeping the inflow growing, for this reason we lowered the price forsome customers. Value perception is hard to create among the customers and the production staff doesn´t understand how much impact production delay or bad quality has on the product. Seeing the complete picture clearly showed what we were trying to explain."[3] (Brand Manager)

"Yes the model was understandable, we have similar models already doing just the production part, but being able to include the other departments was illustrative….We can see now how the output of our model (*ExtendSim Production Model*) actually impacts the profits and even the price."[3] (Floor Engineering Manager)

Finally the model was built in short time and with high return value for the board of directors and other levels of the organization. Instead of built a detailed and close to reality model of the organization architecture, the intervention focus their efforts on building a coherent and sustained causal explanation of the performance objective. Backed with data since the beginning, the model was able to reproduce the "main behavior" of the performance indicators. This simple but powerful representation was enough to bring valuable chunks of dynamic information to the managers and help them to understand this particular problem better. The C.E.O of JeansFactory[1] summarized this during the final interview:

"I´m satisfy with the process, we talked all together with the same numbers and in the same language. The model was accurate enough to show the relevant problems. The process was fast and effective. Other process we had before lost the enthusiasm of the team because it was too long, and the premises change so quick that we end with something useless."[3] (C.E.O JeansFactory[1])

Notes

[1] The real name of the company was substituted by "JeansFactory", due to confidentiality
[2] Real values have been substitute to protect the confidentiality of the company data.
[3] Translated from the original quote in Spanish.

References

Andersen, D.F; Rouwette, E.A.J.A; Richardson, G.P; Vennix, J.A.M (2007). Group model building: problem structuring, policy simulation and decision support. The Journal of the Operational Research Society. 58 (5), 691 – 694.

Collis, D. and Montgomery, C. (1995). Competing on resources: strategy in the 1990s. Harvard Business Review, 73 (4), 118–128.

Diehl, E. & Sterman, J. (1995) Effects offeedback complexity on dynamic decision making. Organizational Behavior and Human Decision Processes 62(2), 198-215.

Forrester, Jay Wright (1961). Industrial Dynamics. MIT Press: Cambridge, MA.

Grant, R. (2005) Contemporary Strategy Analysis, Blackwell, Oxford, Chapter 5.

Meadows, D.H. (1976): The Unavoidable A Priori. In Proceedings of the 1976 International Conference of the System Dynamics Society. 166–238

Nielsen, S., & Nielsen, E. H. (2008). System dynamics modelling for a balanced scorecard: Computing the influence of skills, customers, and work in process on the return on capital employed. Management Research News, 31(3), 169–188.

Risch, J. D., Troyano-bermddez, L., & Sterman, J. D. (1995). Designing corporate strategy with system dynamics : a case study in the pulp and paper industry. System Dynamics Review, 11(4), 249–274.

Sterman, J. D. (1994). Learning in and about complex systems. System Dynamics Review,10, 291–330.

Sterman J. D. (2000). Business dynamics: System thinking and modelling in a complex world. Boston: McGraw-Hill.

Sterman, J. D., Henderson, R., Beinhocker, E. D., Newman, L. I., Sterman, J. D., Henderson, R., Newman, L. I. (2007). Getting Big Too Fast: Strategic Dynamics with Increasing Returns and Bounded Rationality. Management Science, 53(4), 683–696.

Thompson, K. R., & Mathys, N. J. (2008). The Aligned Balanced Scorecard: Organizational Dynamics, 37(4), 378–393.

Vennix, J. a. M. (1995). Building consensus in strategic decision making: System dynamics as a group support system. Group Decision and Negotiation, 4(4), 335–355.

Warren, K. (2000). The Dynamics of Strategy. System Dynamics Review, 10(3), 1–16.

Warren, K. (2002). Competitive Strategy Dynamics. NY: John Willey and Sons LT.

Warren, K. (2005). Improving strategic management with the fundamental principles of system dynamics. System Dynamics Review, 21(4), 329–350.

Warren, K. (2008). Strategic Management Dynamics. Chichester: John Willey and Sons LT.