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PROTOTYPING IN ORGANIZATIONAL PROCESS ENGINEERING

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ABSTRACT
Organizations are increasingly developing new forms of integration. With the support of Organizational Design and Engineering - a new perspective on pursuing organizational effectiveness - it is now possible to attain new forms of competitive advantage through organizational changes whose outcomes are more easily predictable than in the past. To enable these changes we propose to intervene on organizational processes, considered by many scholars a convenient level of analysis. This paper aims to suggest which are the appropriate techniques to prototype the different components of a process. To this intent, we classify processes according to three analytical dimensions and then we propose the use of Discrete Event Simulation for Operational processes, of System Dynamics for Behavioral processes and of Agent Based Modeling for Change processes. This analytical classification favors the comparison of the different techniques and their uses We argue that, in complex situations, several techniques should be simultaneously employed.

Keywords:Prototyping; Organizational Process Design; Modeling, Simulation, Integration

1 INTRODUCTION

The attention towards design as a lever to favor organizational change is growing among organizations and managers. Nonetheless, many scholars recognize that the current approach to organizational change is sometimes “handcrafted” [1-3]. This interest is now channeled in an emerging discipline, called Organizational Design and Engineering (ODE) that aims at bridging the gap between the theory knowledge base of organizational sciences on one side and actual design problems in organizations on the other [1]. In order to fill this gap, the organizational designer, which we label organizational process engineer for reasons that we will explain later, needs a proper design methodology and sound prototyping tools.

The topic of organizational design has become extremely important for every type of organization and, along with business and academic interests, has resulted in a multitude of approaches, methodologies, and techniques to support organizational change management and implementation [4]. The conceptual relationships between the topics of integration, organizational design and organizational processes are significant.

The attainment of an organizational goal avails itself, in a more general case, of the contribution of activities and competences characterized by different nature. Since activities and competences are usually grouped on the basis of similarities within single organizational units, a core characteristic of processes is their need to integrate several different units (responsibility centers within a single organization, business units, independent organizations as within a goal oriented network).

To study organizational processes is considered a convenient intermediate level of analysis to understand organizations and their management. Some researchers have suggested that an entire organization is too aggregate level of analysis for a meaningful comparison of forms and they look on how particular outcomes are realized using the process as the focus of analysis [5].

However considering organizations as a group of processes, basically independent, is quite limited because some processes share resources, information and sometimes goals. However, the perspective of Process-focused Organizations prompts, more than a hierarchical perspective, the awareness of the logical connections between activities and the organization’s end-results. In addition to that, because a process may represents a significant portion of the organization that employs resources to generate output, to design a single process is a way to improve organizational performance without facing the entire organizational complexity.

Extant literature proposes many organizational design methodologies like Business Engineering [6], Enterprise Engineering [7] and Business Process (Re)Engineering [8, 9] but, even if the design community gives great importance to the ability of prototyping, we still don’t know well which are the proper prototyping techniques for organizational change [1, 2].

It is not surprising that, in recent years, techniques to improve business processes have received much attention [10, 11]. Improving or re-thinking processes with the goal of enhancing the firms’ competitive position requires models able to support management to map and analyze processes, to interpret the causes of processes’ performance, and to prototype how potential changes in the modalities of integration or “make or buy” decisions could improve the same performance. Without a proper prototyping methodology able to show the future effects of decisions, the only change that can be properly evaluated is the one already introduced, which, at this point, is difficult and costly to modify.

Hence, organizations necessitate of tools that enable the evaluation of the consequences on performance of hypothesized, but not yet enacted, changes. Prototyping can help to detect in advance weaknesses and inefficiencies of the process at a stage where it is possible to introduce changes and modifications fairly easy and at limited costs.

Because with the generic term ‘process’ we can refer to portions of the organization characterized by a very different nature (for instance, the assembly process and the budget process), technical and modeling tools have to be consistent with the prevalent characteristics of the process.

This notwithstanding, most process improvement initiatives have focused on operations and/or on the use of technical tools (such as BPMN Business Process Modeling Notation) [12] specifically suitable for process that can be described as predetermined sequence of activities. Extant literature, however, offers few suggestions to management on how to prototype organizational processes where the change of the very nature of the organization or the decision making dimensions are relevant [2]. As we will explain later, techniques originally developed to solve different problems can be also useful to the goal of prototyping organizational processes.

2 SCOPE

Based on an analysis and classification of different approaches to process design of Organization Theory and Organizational Behavior, this paper aims at identifying the proper characteristics a prototyping technique must have. These characteristics will change depending on the analytical lens the organizational process engineer will use, therefore we expect to identify more than one prototyping need the engineer could have.

In fact, on the basis of a classification of organizational processes, we will suggest what are the most suitable techniques to prototype and analyze processes by matching the needs with the techniques’ features and the current use in management and engineering, according to the process characteristics. In order to select the techniques we will consider the modeling and simulation approaches currently available [13, 14].

We will also evaluate advantages and disadvantages of the different techniques with an example based on a very well know process. We will retrace the design process to clearly understand where the prototyping tools are useful and how the different analytical lenses come into play.

We also argue that, in complex situations, several techniques should be simultaneously employed.

3 PROTOTYPING NEEDS IN ORGANIZATIONAL PROCESS DESIGN

In order to understand the needs in organizational process design, we will use a well known organizational process extrapolated from the beer game as presented in Senge [15]. This process represents a typical industrial production and distribution system, firstly developed in the sixties by the Sloan School of Management at Management Institute of Technology [16]. The process, as presented in Senge [15], counts on three actors (the retailer, the dealer and the factory) which constitute a supply chain. They communicate with each other only through the beer orders that each player sends to the next one down the chain. The retailer sells to the end customer and he is the only player that knows the actual market demand. The dealer is the beer distributor, while the Factory produces the beer. Figure 1 represents a simplified model of the beer game process.

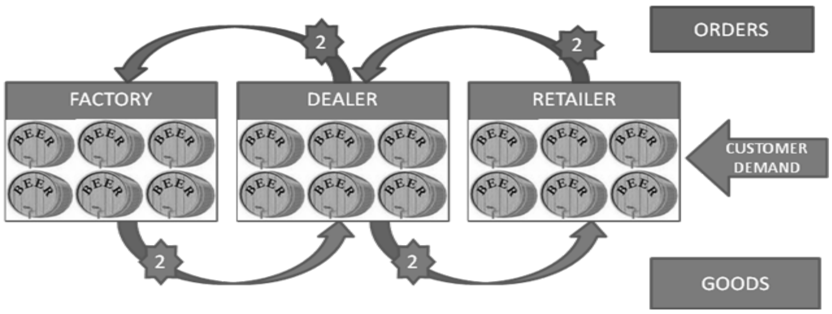

Figure 1 - Model of the beer game

In the beer supply chain there are two kinds of flows: orders' flow (above) and goods' flow (below). Orders are issued weekly by each player, and there is a two weeks delay from the issue to the actual receiving and processing by the next player down the chain (Information delay). Once orders are processed, the beer is shipped and other two weeks are needed from the shipment date to the consignment date (materials delay). As it will be shown later, these delays play a crucial role in determining the game dynamics. The beer game develops in 52 weeks and at the beginning each player has a stock of 12 beer cases while orders and consignments are 4 cases per week. The game assumes that the demand is of 4 cases during the first two weeks and of 8 cases in all the following weeks. This change in the demand introduces a variation which is not simply handled with the current supply chain process. All the actors go out-of stock for several weeks, and then, around week 20th, the stocks start to build up going out of control. It is interesting that this huge stock grow depends only on the feedback internal to the systems, since the demand doesn't change after the third week. In the following figure (Figure 2) we see the performance of system. The graph reports three stocks trends: the retailer (1), the dealer (2) and the factory stocks (3).

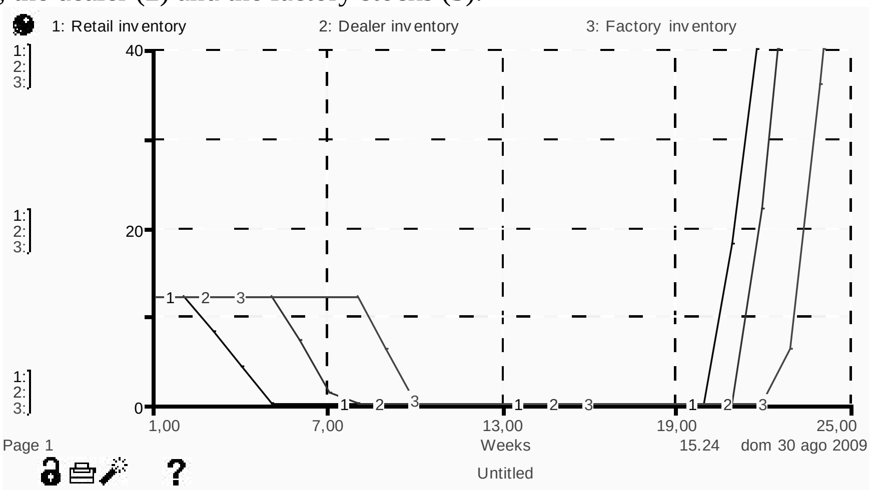

Figure 2 – Beer Supply Chain Performance

This poor performance gives us the opportunity to consider the prototyping needs of an hypothetical organizational process engineer whose task is to fix the situation. In order to discover the needs, we briefly summarize the different analytical lenses that this professional could use to understand this (inter)organizational process's problem.

4 DIFFERENT PERSPECTIVES ON ORGANIZATIONAL PROCESSES

An organizational process is indeed: a set of logically related tasks performed to achieve a defined business outcome [8]; any activity or group of activities that takes an input, adds value to it, and provides an output to an internal or external customer [17]; an organized group of activities that uses resources to produce an outcome valued by the customer [9]; a collection of tasks and activities that together – and only together – transform inputs into outputs [18].

The essence of these definitions is that most authors agree on saying that processes have internal or external customers, that a process is a time ordered sequence of interrelated activities, and that a process needs the integration of the activities performed by a variety of actors: realizing a complex task requires a variety of competences and activities which are grouped in different organizational units.

Integration reflects how harmoniously the different parts, departments, organizational units or actors of a network work together and how tightly coordinated their activities are [19]. In essence, integration defines the extent to which distinct and interdependent organizational components constitute a unified whole.

A process, both intra or inter-organizational, is also a unit of analysis sufficiently wide to allow interventions that can improve the overall firm performance without facing the overall organizational complexity. Garvin [18 p. 34] says that *"processes open up the black box of the organization without exposing analysts to the "part-whole" problems that have plagued earlier research. Past studies have tended to focus on either the trees (individual tasks or activities) or the forest (the organization as a whole): they have not combined the two. A process perspective gives the needed integration, ensuring that the realities of work practice are linked explicitly to the firm overall functioning"*.

Extant literature usually refers to operational processes. Operational processes are quite often inefficient and firms sustain the majority of costs to perform such activities. The incidence of the value-added time (the time in which a product has value added to it, as opposed to waiting in a queue or being reworked for earlier problems) is often less than 5% of total processing time [18].

Innovation in operative processes therefore leads to potentially important improvements in terms of costs, prices and time. All this increases the customers' trust, favors the increase of new market shares, improves the strategy's implementation and makes easier entering in new markets. Hammer [20] argued that operations can often be the foundation of strategy and the basis for superior performance.

If this is true, therefore, an important practical problem for managers is that of finding alternative processes for performing a desired task, for example one that is more efficient, cheaper, or that is automated or enhanced by the use of Information and Communication Technology [5]. In other terms, evaluating the effects of proposed changes before implementation [4]. The field of business process simulation received much attention in the past two decades [14, 21, 22] and a fair growth in the organizational design (OD) area demonstrates a rising interest of the simulation community in the abilities of simulation to address organizational topics [13].

As above said, in general terms, a process is a set of organized decisions and actions that transform resources (input) into results (output), where resources are of several types (i.e. information, work, materials), tasks and activities are interdependent, and several actors participate to the process [18]. Because the term process is very broad, it is used to refer to very different types of processes.

Because of the wide meaning of the term process, the academic and managerial literature developed different theories on processes in organizations. In particular, we can distinguish at least three approaches that focus on particular characteristics of processes, delving into their specificities and suggesting modalities to analyze them[1]. To our knowledge no proposal to integrate the different perspectives into a unitary framework has been made.

The three approaches belong respectively to the following fields: (1) industrial engineering and operational research; (2) organizational theory and organizational behavior and (3) organizational change. They respectively pose emphasis on the execution of work (what gets done); on why things are done in certain ways (or, in other words, what decisions systems drive the modalities through which activities are performed) and on the change of the nature of organizations.

These aspects, although they all get to the core of the idea of process, acquire often in concrete situations a different relative importance. In certain cases, attention can be directed toward the execution of programmed activities. This is the case of the already cited operative processes or work processes, for which the representation of the process as a set of connected activities that transform resources into output is meaningful.

In other circumstances, conversely, the main emphasis of the analysis is not on what is done but on the reasons why things are done that way. To this regard, at the core of the analysis, we find the behavioral schema and the relationships among actors who determine the modalities for doing things. These types of processes (where the study of behaviors and of interpersonal relationships is critical) are labeled by Garvin (1998) behavioral processes.

Finally, different from the first two representations, relatively static, the analysis can focus on organizational change and on the different phases through which it unfolds. In this case the third

[1] Garvin (1998) proposes such classification.

perspective comes into play and the corresponding processes are labeled change processes. It goes without saying that, for many of the processes, none of the above characteristics prevails. These are, obviously, the most complex cases and it is reasonable to argue that the simultaneous use of several techniques would be appropriate. As a matter of fact, hybrid modeling and prototyping is a satisfactory approach to cope with complex enterprise-wide systems.

We will now focus on our example in order to clarify the above perspectives. In particular we will describe the beer process with every perspective, operational, decisional and change, using the organizational process engineer's point of view.

The first perspective, that originates from industrial engineering and operational research, and that more recently found a new vigor in the process re-engineering movement, focuses on the way activities are developed and the underlying connections. In the beer supply chain, this focus is on how the activities are done, by clearly identifying the actors, the resources and the costs involved. Here, the main need is to be able to clearly represent the activities that we can identify, their output, relations, time and costs involved.

At an extreme we have that: activities can be traced and they end with an outcome or a result that can be traced; input and output are known a priori; the connections among variables are stable; relationships among individuals are of scant importance; decisions are incorporated within programmed work activities. In the case of an operative process, the action dimension (programmed action) is more relevant than the decisional dimension. The awareness of the goals to achieve, and of the cause-effect relationships that allow to achieve them, generates a low level of uncertainty and determines a situation basically deterministic and characterized by a high technical rationality.

On the other side, to interpret a process characterized by a strong decision-making dimension as a sequence of predetermined activities could be ineffective because, in this case, complex phenomena, such as the way individuals and groups take decisions, prevail. To endorse this perspective, the organizational process engineer, in our example, needs to focus on how the decisions are taken, on the hypothesis under which the orders are made, and on what is the information flow that determines the angle each actor assumes from his standpoint. To understand this type of process it is not enough to know the goals or to verify ex post the activities performed; it is important to understand the way goals are set, how decisions about resources allocation are taken, what are the means of communication among actors, how meetings are organized, how managers relate to their collaborators, what incentives -both implicit and explicit- come into play, how managers lead [23]. Such a process can be analyzed through the second perspective of analysis: processes as internalized patterns of actions and behaviors among organizational actors. The main outcome of these processes is not the execution of activities but the shared understanding of the criteria through which decisions have to be taken and work activities have to be performed. The ability to influence the actors' behaviors and their relationships is the main goal of the intervention.

For what we just said, a behavioral processes is not visible and cannot be represented through a mapping of activities that assumes linearity, sequentially, low level of ambiguity. The behavioral dimension of processes influences usually the contents and the characteristics of the process, contributing to the definition of the modalities through which work is done.

Processes of different firms, even though similar in terms of sequence and types of activities performed (for instance, the new product development process), can reach dissimilar outcomes when they avail themselves of different decisional and communication processes [24].

Finally, other processes can be adequately represented as a sequence of events that describes how the nature of the organization changes overtime: for instance, the process through which a firm evolves from a start-up, with a flat structure and few formalized roles, to a hierarchical structure (autonomous change) or the change determined by a radical technological innovation. In our case the organizational process engineer needs to focus on how the actors react to the environment change in beer demand, adapting their behaviors to different input, for example studying what influences the actors' myopia on the system that leads, in return, to the problematic behaviors previously described.

In such circumstances, it is fundamental to understand how individuals, groups and organizations adapt to external environment, evolve and grow following trajectories and structures unknown a priori and that need to be simulated and investigated. In the change processes, the focus shifts from the execution of activities or the reasons why activities are done in a certain way, to the change in organizational identity and size. Differently from the static representations of operational and behavioral processes, the change processes aim to catch "*reality in flight*" [25 p. 270].

In sum, these perspectives highlight very different needs the organizational process engineer has regarding the prototyping techniques.

5 AN INTEGRATED FRAMEWORK

In order to understand which simulation methodology is suitable for the prototyping of organizational processes characterized by the three analytical components above described, we match the needs identified above with the characteristics of the modeling and simulation techniques found in recent literature [13, 14]. We also show the use of the proper simulation techniques in three different design problems, matching the most suitable technique with the specific characteristic of the process. As said, the problem that the organizational process engineer is facing refers to an increase in demand that is not handled properly by the current process, driving inventories out of control.

5.1 The operational dimension of a process

To examine the operational dimension of a process we need a technique that allows to map a set of connected activities, with clear identification of the actors (who does what), the resources (what goes through the system) and the costs (how much it is).
The Discrete Event Simulation (DES) technique is based on chronological sequences of events (with no feedback) where each event changes the system state in discrete time [26]. A recent review of literature shows that DES has been used in over 40% of the papers on simulation and is the most widely used technique in manufacturing and business for a wide scope of operational management applications including scheduling, production planning, inventory control, supply chain management, project management and process engineering [13]. This approach is proper to describe the execution of programmed activities and tasks, and to analyze detailed processes, resource utilization and queuing [13, 27]. This implies that DES has been appropriate for operational activities and detailed process analysis where processes are characterized by a low level of uncertainty, and interpretable in a satisfactory manner as a series of intertwined programmed activities whose outcomes are reasonably certain and activities and linkages are a satisfactory perspective of analysis. This confirms earlier research carried out by Kellner et al [27].
To analyze this perspective we developed a prototype of the actual situation using the Discrete Event Simulator included in Oracle Studio 10.1.3 with BPMN (Business Process Modeling Notation). The model is reported in Figure 3. Actors are reported in the swim lanes, and there is an analytical description of all the activities, the costs and the resources associated with them (costs and resources are not visible in the figure). Links between activities are indicated by flow objects (e.g. arrows in the diagram), while gateways (e.g. rhombus in the diagram) describe which direction the process should take.

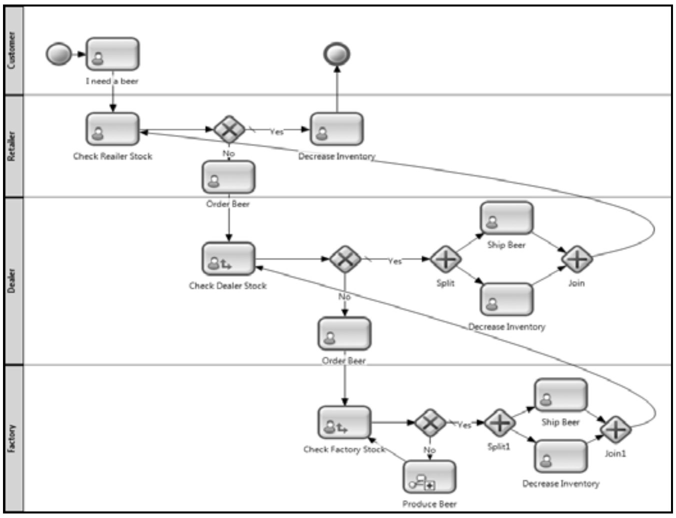

Figure 3 - DES Model

As we said, in the first two weeks the market demand is stable at 4 cases per week. The DES model is a useful instrument to communicate to all the actors involved the structure of the process, the resources and costs associated with each activity. The map is a good starting point to analyze and improve the process and it is also a structured source of information for IT analysts. In fact, in a more

advanced use of these tools, the design of the map produces automatically usable code for IT developers.
When, in the third week, the demand increases to eight cases per week, the resources are insufficient to cope with this new situation, and we can observe a huge increase of queues and stocks and the associated costs and time.
To the sake of this example we consider here two design alternatives to solve this problem. The first one is to calculate and then allocate more resources to the activities (i.e. increase clerks, trucks, hardware) and to look at the consequences until the results are acceptable. This solution is compatible with the existing model, since it does not require to change the structure of the activities. The second solution is to think a new way of sharing information (i.e. sharing the market demand information among all the players). DES techniques are not suitable to treat automatically this second solution, since a new map has to be designed to this end. In other words, this kind of decisions, and their associated activities, are not directly coupled in this modeling tool.

5.2 The decision making dimension of a process

To account for the decision making dimension of the process, we need a technique that describes how decisions are taken, the hypothesized cause-effect relations between different decisions and different outcomes and how information availability influences the process outcome.
System Dynamic (SD) focuses on how casual relationships among constructs can influence the behavior of a system [27-30]. The approach models an organization as a series of simple processes with circular causality that intersect in circular causal loops. SD has been focused on such domains as policy and strategy development, as well as knowledge management and it is the second most widely applied simulation technique in manufacturing and business [13]. One of the main characteristic of this approach is the capability of representing a high and synthetic level of “reality” as well as its intrinsic dynamic. For these reasons this methodology can be applied to the second perspective, where the behavioral dimension is more relevant and can be captured by the feedback loops among stock and flow variables.
To investigate the decision making analytical component of the process we developed a System Dynamic model in iThink (see Figure 4). The model shows the physical material flow (at the centre of the diagram), with the relative delays. Below the material flow we represented the backlogs, or rather the pending demand. Above the material flow we account for the order, or rather the information flow. To mimic the human behavior of ordering it is used a formula developed by Sterman [31].

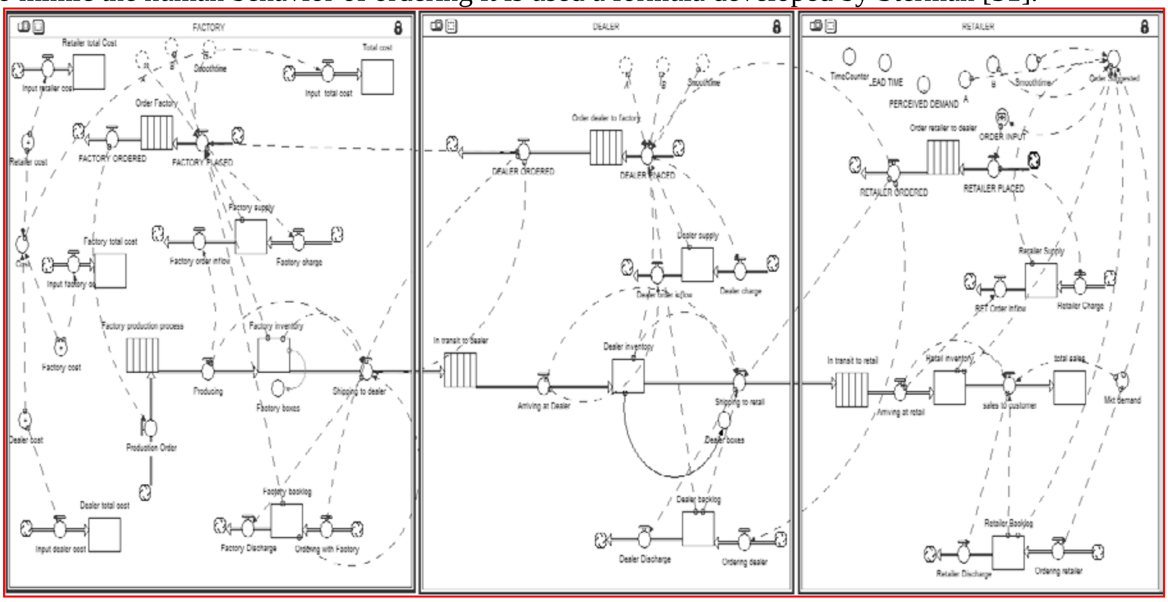

Figure 4 - SD Model

As previously said, to solve the supply chain problem, we can at least imagine two options: the first is to allocate more resources to the activities, while the second is to change the way information is shared. It is important to recognize that changing the way information is shared is one of the principal way of changing coordination among actors, and therefore their level of integration. Therefore we will prototype the collaborative scenario, where all the players share the market demand and the backlog

information, by testing a shared policy among the players to minimize cumulative stock costs. This second option, which, as we said, is difficult to analyze with DES techniques, is conversely well suited for a system dynamic approach. To obtain this effect, we have not changed the map, but simply how the information is shared and the decisions are made. It is noticeable that in this scenario there is not out-of-stock for any of the player and the behavior of the supply chain is very efficient. It's also interesting to note that if the three players share information about market demand, backlogs and stocks, they integrate themselves in a "collaboration network", becoming, as a matter of fact, a goal oriented network.
This technique has a good fit with the decision making characteristic of the process but it is not appropriate to account for the operational characteristic of the process. In fact, this technique does not describe how the actual work is done. The modeling system is composed by black boxes and related input-output transformation functions, but not activities.

5.3 The change dimension of a process

Sometimes, when we analyze and model a process, it is possible to forget that this process is embedded in a network of organizations and that tasks and activities are accomplished by people that have the freedom of changing their behavior when something occurs. These changes, that involve the behavior of individuals, are difficult to model with tools that have a predetermined structure of relations among activities or variables. In this sense, the organizational process engineer needs a way to model actors and their relationships, and to cope with changes in their behaviors based on the situations they are involved with.
Agent Based Simulation (ABS) models comprise a number of autonomous, responsive and proactive agents which interact with each other in order to maximize their utility function. Differently from the SD and DES approaches, the ABS does not require to know the structure of the process, rather the structure is the result of the interactions among agents. The agent based modeling and simulation focuses on organizational development, addressing the modeling of human agents' behaviors as well as the communications among them [13]. Therefore with this methodology is it possible to prototype how processes evolve over time not by changing the relations among activities but by changing the environment.
In this scenario we are interested in the behavior of individuals that face an out-of-stock of their favorite beer. These customers could instead decide to buy another product, for example a coke. We are then presenting the integrated behavior of these two supply chains studying what agents would do if the beer supply chain were inefficient and would not serve them their favorite beer.
This third prototype was developed in NetLogo 4.1[32] to illustrate a possible change component of the beer game. Accounting for this, we represented the three actors of the systems as agents, modeling their behavior and their interaction with the flow of orders and goods. The actors form together a supply chain which delivers beer to customers through a system of orders and deliveries.

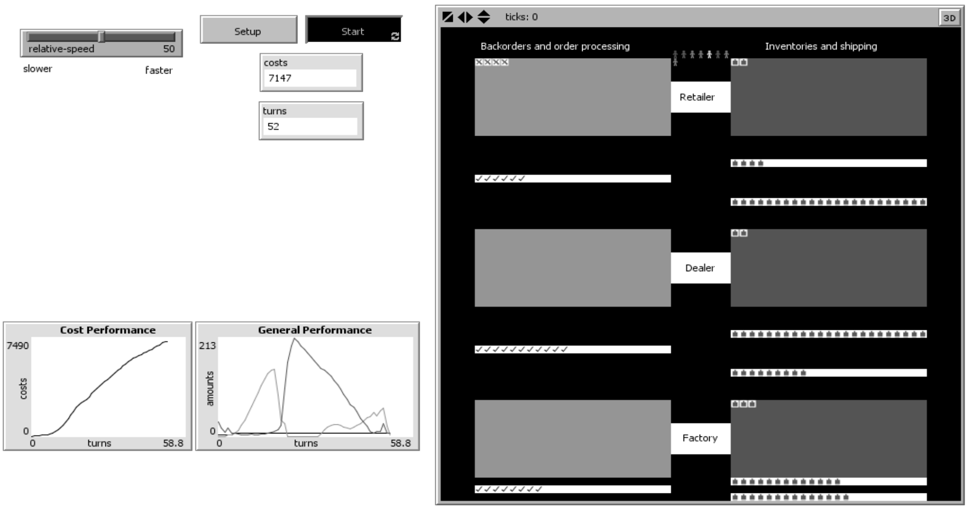

Figure 5 - ABM Model

In Figure 5 we present the beer game, adapted from an existing simulation (HubNet Root Beer Game, Wilenski, 2003). On the right of Figure 5 we see the agent space, with the customers and the beer

players represented. In dark grey are the Inventories and Shipping, with the two weeks delay for shipping in white, while in light grey are the backorders and order processing with the delay for orders in white.
This modeling technique, as SD, does not allow to represent activities. The focus is on agents and their behavior. As we said, a specific characteristic of this technique is that we can simulate the change component of a process, i.e. to explore the changing structure of the process. As an example, we prototyped an expansion of the possibilities of actions of the customers (agents) adding another competitive supply chain (coke).
We ran the analysis with two supply chains, beer and coke, and we observed the turn away phenomenon. In fact when a customer does not find beer he would go and buy a coke. It is also interesting to note that after some time the whole system composed by the two supply chains is in equilibrium, lowering the total costs. To do this, we simply replicate the beer supply chain in the coke supply chain and modified the customer behavior. This kind of simulation would have meant a significant complication and a complete change of the structure of the problem if faced with SD or DES techniques.

6 CONCLUDING REMARKS

The three perspectives do not claim the existence of ‘pure’ processes. The operational, behavioral and change dimensions are, rather, conceptual tools for analysis and prototyping. Every process implies, as a matter of fact, the performance of certain activities, certain behaviors and patterns of interactions among actors, and it pursues some type of change or adaptation.
However, as explained above, the attention to pose to these distinct dimensions can vary significantly during organizational design interventions according to the dominant nature of the process. From an applicative point of view, this implies that processes where the operational dimension is dominant require technical tools for process modeling different from circumstances where the analysis has to focus on organizational change or the criteria for taking decisions.
As illustrated in the example we presented, in general it is possible to associate to each of the previously described process’s analytic dimensions specific techniques for simulating and analyzing processes. Table 1 synthesizes this idea.

Table 1 - prototyping techniques

Operational Dimension	Discrete Event Simulation and Modeling (i.e. BPMN) Focus: performance of activities and their connections
Decisional Dimension	System Dynamics Focus: why activities are done in a certain way
Change Dimension	Agents Based Simulation Focus: change overtime of the nature of the organization

The example we presented certainly doesn’t exhaust the possibilities of how change can tear the fabric of an organization, or the ways in which managers can respond. But, in our opinion, it offers insights on how and when modeling and simulation techniques should be used, to enable the organizational process engineer to prototype process design changes.
There is, actually, a growing attention on the field of Organizational Design and Engineering defined as: “*the application of social science, design science and computer science research and practice to the study and implementation of new organizational designs, including the integrated structuring, modelling, development and deployment of IS/IT and social processes*”. Professional education, in general, is about learning to deal with problems that require diagnosis and treatment. All the engineers and all the designers have their tools to prototype reality and therefore to simulate the impact that their design will make before the actual implementation. Applying the same concept to the field of Organizational Design and Engineering requires to define a new category of engineers who can design organizations and IT/IS tools able to support them: organizational process engineers.
No question, modeling and simulation are only a partial reflection of the real complexity involved in real-world change. Anyhow, these engineers will use the tools and methods illustrated above in order to have better organizational processes design that pursue specific requirements. Design, indeed, refers to the process of creating and developing a plan for an artifact (product, structure, system, or component) with a specific intent.

On the basis of a processes' classification, in fact, we proposed what modeling and simulation techniques are more suitable to simulate and analyze processes according to the process characteristics. We designed three models of the Beer Game, considering the operational, decision making and change component of the process. We prototyped these components through modeling and simulating the process in what we considered the most appropriate tool.
The results supported the idea that the Discrete Event Simulation technique is proper for the operational component of the process, while the System Dynamics takes into account properly the decision making component. Finally the Agent Based Modeling and Simulation copes well with the change component of the process.
Our main objective was not to compare the beer game behavior with the three techniques, nor to tackle the bullwhip effect problem [33, 34]. We have shown that different techniques are suitable to understand and deepen our knowledge about the process under study. In complex situations it is arguable that an hybrid use of techniques is necessary.
We can point out that the three different modeling techniques allowed us to perceive the links between activities in the DES Model, the relations among variables (stock and flow) in the System Dynamic model and the relations among agents in the Agent Based model.
As an engineering mindset requires, in order to understand a complex problem, we first decompose it in simplest components and then we synthesize a unitary solution. From our understanding, gathered from the prototyping we did in the example presented above, we can use the three modeling and simulation methodology in one unitary framework where we first start from Discrete Event Simulation to map the visible part of the process and gather simulation data on time and cost. We then use those data to feed the variables of the System Dynamic model and understand the behavior of the system as a whole. Finally we can abstract from the process in order to study how the change we are designing impact on people actions with the Agent Based Model and Simulation. The proposed integrated framework is presented in the figure that follows.

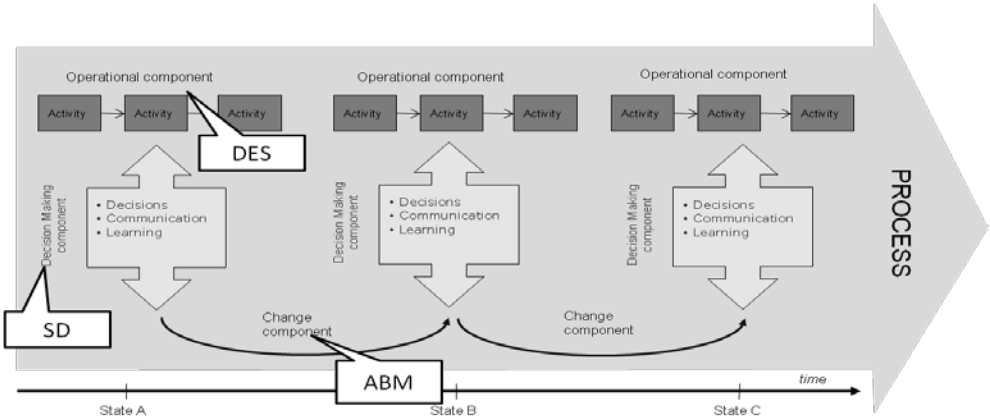

Figure 6 - Organizational Process Engineering Prototyping Framework

This study is not without limitations. First since it's a case study the results are hardly generalizable and we are not sure if other techniques could be used to prototype organizational processes. Secondly these analytical lenses were applied to a very generic process as the beer supply chain, therefore a more broad application is required in order to conclude that those techniques are the most appropriate for prototyping the different analytical dimensions of organizational processes. Finally, our contribution has its roots in organizational theory; a different starting point could have led to different analytical perspectives and therefore to different prototyping tools.
This result, even if in a preliminary version, has important implications for both management and theory. On one side it could be a helpful framework for managers when they face organizational change that needs to modify the extant processes. It could also enlarge the toolset currently available to organizational and IT analysts and designers to better prototype various aspects of reality. On the other side there is a contribution to existing literature on organizational design and engineering expanding the current methods to analyze, study and prototype organizational processes.
Future research should validate these results on a broader set of organizational processes, accounting for different techniques and tools. Introducing other perspective, for example derived from information systems theory, could enrich the analytical lenses the organizational process engineer can use.

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