Systemic Assessment Framework of a Learning Organization's Competitive Positioning

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Abstract:

Purpose: The purpose of this paper is to devise an innovative feasible, replicable and comprehensive assessment framework of a learning organization's competitive positioning.

Design/methodology/approach: The three characteristics listed above are approached as follows. Feasible refers to being easy and not in need of much resources (time, personnel,...). This is done through early elimination of non-important variables. Replicable is having a well structured methodology based on scientific proven methods. Following this methodology would result in good results that can be explained if needed and replicated if deemed necessary. Comprehensive translates into a holistic set of indices that measure performance as well as organizational learning.

Findings: The three attributes (feasible, replicable and comprehensive) have become crucial for ensuring any kind of added value for such a methodology that hopes to tackle the modern dynamic business environment and gaining a sustainable competitive advantage.

Research limitations/implications: Such a methodology would require several full contextual applications to be able to set its final design. It entails thorough internal revision of a

company's structure. Therefore a great deal of transparency and self-transcendence from the individual involved is a pre-requisite for any chance of success.

Originality/value: It offers a systematic way to assess a company's performance/competitive positioning while accounting for the crucial attribute of organizational learning in its makeup.

Keywords: organizational learning, competitive advantage, system dynamics, analytic network process, manufacturing sustainability

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1. Introduction

In our fast changing business environment, the need for a company to develop into a learning organization is becoming more and more urgent and crucial for any chance of sustaining competitiveness in the market place. Empirical research has shown that a company's knowledge management practices are all correlated with its performance (Syed & Xiaoyan, 2013). Performance in this paper is synonymous to the degree of which the company is capable of generating and sustaining competitive advantage. Based on these findings as well as numerous others, a company's performance cannot be evaluated without taking into consideration its ability to sustain and manage its knowledge, which can only be done through its development into a learning entity which itself is reliant on management of internal resources within a firm.

This paper proposes a framework that aims to assess a manufacturing company's performance in terms of achieving sustained competitive advantage. The case specific study in section 3 dealt with manufacturing sustainability as its theme. There exist ample literature that deal with topics such as competitive advantage, company's performance and organizational learning. However, according to the knowledge of the authors, there has not yet been proposed a framework that aims at evaluating company's performance, equal to competitive advantage in this paper, with emphasis on organizational learning. This is deemed crucial in modern business environments, because complexity and knowledge have exponentially grown. Hence this paper builds on previous literature, by combining the need for a systematic framework that quantitatively measures performance and competitive advantage while accounting for the crucial yet often underweighed and misconceived organizational learning element.

The question now is how to kick-start and sustain this company wide initiative in the most efficient way. Modeling for many is the solution. Modeling within the organization can help in achieving a common perspective on multi-disciplinary topics that span across departments from HR to R&D and everything in between.

The framework is built on concepts and tools that span across two distinct yet relevant fields, System Dynamics (or SD) and Analytic Network Process (or ANP).

2. Literature Review

In this section, the following questions will be answered: What is organizational learning? Why is Learning so important? How does modeling help a company in becoming a learning entity? What kind of modeling fits well this purpose?

2.1. Organizational learning, Mental Models & Competitive advantage

Organizational learning has been the subject of extensive study for the past decades, and its most recent version is based on the 1990 book "The fifth Discipline" by Peter Senge (Senge, 1990). Not much detail will be given to the topic of organizational learning itself since there is plenty of papers and books, some of them are referred to in this paper, that deal solely on defining and developing this quite complex subject. However, some notions relating this topic to the overall goal of the paper must be briefly explored.

A firm's environment, external as well as internal, is made up of a complex network of variables connected with varying degrees by causality. Through continuous adjustment and learning, managers within these firms are required to understand, control and guide the output of such a system to the best interest of the company (Soderlund & Vilgon, 1993). This is organizational learning.

Organizational learning takes place at different levels with different forms. The adapted table below from (Wang & Ahmed, 2002) summarizes in a brief yet relatable way these concepts:

Focus	The concept of organizational learning	Practices
Individual learning	"when individuals within an organization experience a problematic situation and inquire into it on the organizational behalf"	Staff training & development
Process or system	Is the process whereby organizations understand and manage their experiences	Enhancement of information processing and problem solving capability
Culture or metaphor	"A learning organization should be viewed as a metaphor rather than a distinct type of structure, whose employees learn conscious communal processes for continually generating, retaining and leveraging individual and collective learning"	Creation and maintenance of learning culture through team working, employee empowerment, etc...
Knowledge management	Knowledge acquisition, dissemination, refinement, creation and implementation, and exploit it to develop insights	Facilitation of interaction and strengthening of knowledge base
Continuous improvement	"Continuously transform the entire organization and its context"	TQM practices
Innovation and creativity	Constantly questioning existing processes, identifying strategic positions, adopt various modes of learning, all to achieve sustained competitive advantage	Facilitation of triple-loop learning and knowledge creation

Table 1. Different forms of Organizational Learning (Wang & Ahmed, 2002)

One of the basic elements in such an organization are mental models. Mental models are the major driver of any development that a company goes through. They are basically the strongest and dearest assumptions developed over the years, therefore shaping how an organization thinks and acts. A definition from (Doyle & Ford, 1998) is that a mental model is a dynamic system with "a relatively enduring and accessible, but limited, internal conceptual representation of an external system whose structure is analogous to the perceived structure of the system". Often these mental models are misleading and too simplistic compared to the complex real life settings. (Carter, Kaufmann & Michel, 2007) by investigating behavioural supply management, showcased how decision making violates the assumptions of homo-economicus. These deviations are a result of relying on heuristics when making decisions. These developed heuristics are the manifestations of the mental models of the firms.

They present a major hurdle for the organization to develop into a learning entity. This attachment to our mental models give rise to "espoused theories" which define what we plan to do and to "theories in use" which are what we actually do. So, with a large volume of mental models operating in a silo fashion within and across the company's departments, there will be strong resistance to change and very little progress towards the strategic set of goals. A general policy adopted by the top management that guarantees open conversation and feedback from the people, would endogenize the learning process making it part of the mental models. This endogenization facilitates the success in transitioning into a learning organization (Magzan, 2012).

The endogenous shift in the learning process makes it integrated inside the company, in other words it is integrated learning. It is this integrated learning that sustains the shift towards a

learning organization because it is a combination of cognitively and behaviourally driven change, and this combination is the recipe for long term change (Nemeth, 1997).

Mental models are developed over the years based on acquired experience. So, in order to be able to control organizational learning driven by the evolution of mental models, a framework that encompasses a tangible set of indicators must be in turn developed and adopted.

Learning and Knowledge are empirically proven to have a direct impact on the performance of a company (Syed & Xiaoyan, 2013). However, it is misleading to state that more learning or more knowledge is always better in achieving the desired performance. The learning must be aligned with the organization's strategic goals. Therefore its impact, taken in context with the company's goals, paves the way for an accurate assessment of its actual nature of influence in improving organizational performance (Vera & Crossan, 2010).

Organizational learning, a key asset, is difficult to mimic, to substitute, and to transfer. Knowledge catalyses the acquisition of more knowledge. If an organization develops its ability to learn, the potentially dangerous exploding circle of knowledge would be controlled and aligned with the company's goals. So, organizational learning can be said to be essential for a sustained competitive advantage (Martin-de-Castro, Navas-Lopez, Lopez-Saez & Alama-Salazar, 2005).

Simulation is a great tool for setting strategic goals and working efficiently towards their implementation. It allows modelers to benefit from constant feedback about the gap between actual results and simulated ones (Ford, 1999).

Building models is building a framework that translates the mental models of the concerned entities into a computer model. This computer model is controllable and modifiable faster than our mental models. "learning takes place when people discover for themselves contradictions between observed behaviour and their perceptions of how the 'world' should operate" (Morecroft, 1994). So, when errors are extremely expensive and time consuming to repair, by testing and changing computer models in order to detect the difference between observed behaviours and simulated behaviours, decision makers can benefit by adapting faster to the constantly changing reality (Alcantara & Nobrega, 2005).

2.2. System Dynamics & Analytic Network Process

2.2.1. System Dynamics

System Dynamics is a computer simulation methodology that investigates complex dynamic problems. In most cases, there are feedback, delays and non-linearity rendering pure analytical analysis and decision making next to impossible. SD practitioners identify a dynamic problematic behaviour, formulate a hypothesis of what is potentially the root cause of it, develop a basic structure of the causal relationships of relevant components, and then augment this initial simplified structure into a formal holistic model using SD software packages such as Vensim, iThink and Powersim. There exist plenty of accessible sources, for interested readers, that deal with System dynamics philosophy, methodology and applications, however for the scope of this paper, it will not be developed more.

Causal Loop Diagrams (or CLD) or Stocks & Flows (or S & F), which comes first? Among SD practitioners, there are those of the opinion that the initial causal structure should be a simple stock and flow model versus others that argue that it should be a Causal Loop Diagram. For the purpose of evaluating sustainability initiatives within a company, CLD is believed to be the answer. From this initial CLD, a more formal and structurally correct stock and flow model will be developed.

Causal Loop Diagrams are a great tool to track in an easy fashion causal relationships, and specifically those that exhibit feedback with delays through closed loops. However, if not analysed properly, CLD's can be misleading since they do not portray an exact image of the structure of the system under investigation. There are loops that are dominant at certain times, before being dominated by dormant loops at later stages, mainly caused by non-linearity. As a result, methods were developed to quantitatively study the effects of loops. Among these methods are eigenvalue elasticity analysis, eigenvectors and dynamic decomposition weights, pathway participation metrics and traditional control theory which would all require advanced prior mathematical knowledge. Despite their complexity, they still only manage to give a partial analysis of the behaviour, deterring the willingness to apply these rigorous methods in everyday applications (Hayward, 2012).

Also, all of these methods are still very much dependant on the modeler and his/her judgment on how to proceed with the model analysis, making replication difficult and most often not even possible to do (Ford, 1998). So, in order to simplify as much as possible the investigation process, there may be the need to explore possible methods that might shed useful insights into early stage analysis and variable selection rendering models more compact and by principle preserving only the important loops.

2.2.2. ANP

A common problem when trying to investigate a problematic behaviour of a system, is that more often than not, a wide pool of variables is selected making the selection of the most important ones a complex task. There exist numerous variable reduction, causality testing and prioritization techniques that might help in initial variable selection. Among them, Principal Component analysis (or PCA), Numerical Taxonomy (or NT), Friedman's test, Analytic Hierarchy Process (or AHP) and Analytic Network Process (or ANP). Three among them, PCA, AHP and ANP are the closest to fitting the goal of the paper.

PCA is a variable reduction technique, which fits under multivariate statistics, and that studies the possible correlation relationships among the variables in question. So, it tries to reduce the variables into the principal ones which are able to portray most of the variance, and in the process revealing the otherwise hidden information (O'Rourke & Hatcher, 2013). After reducing the pool of variables into independent ones, i.e. uncorrelated, it can be used to rank and analyze decision making units (DMUs). PCA would fit perfectly the description of the method needed except that it has to satisfy one key assumption, the relationship between variables has to be linear (static over time), which would automatically rule it out for the purposes of this paper (O'Rourke, Hatcher & Stepanksi, 2005).

AHP and ANP are decision making methodologies developed by Professor Thomas Saaty. They are built with the purpose of deciding between a set of alternatives based on a set of evaluation criteria. The best decision is in most cases not the optimal one for each criterion rather than the best fit between them. Complex decisions are reduced to a series of pairwise comparisons, generated from experts judgments, which are then synthesized into a weight for each criterion. Based on the weights of the criteria, a score is assigned to each alternative with respect to a given criteria, and the higher the score the better is that option to that criteria. Each alternative, after evaluating its importance for each criteria, is assigned a global score which is then compared to the other alternatives global scores, and consequently they can be ranked from highest score to lowest. There exist ample applications in Literature, among these, (Luthra, Garg & Haleem, 2013) explores how AHP can rank different strategies to implement green supply chain management (or GSCM).

The key difference between the two methods is that ANP has a network structure, meaning it incorporates feedback within and across sectors, versus the hierarchical structure of the AHP which assumes no interdependency between different criteria. Both of these methods have their preferred field of application. The purpose of their use has to be carefully thought of prior to deciding if they are conceptually suitable techniques? and if yes, which is the best for the given case? According to the authors, AHP would prove better when comparing alternatives on a large scale, for example companies across an entire industry, since some if not most of the feedback between the criteria is already captured by the expert judgments in the pairwise

comparisons. However, when analyzing on a smaller scale, for example evaluating a certain initiative or policy within a company, where the smallest feedback could have a larger impact on the final outcome, it is important to include all the relationships and study their dependency. In this case, one seemingly simple interdependency could be the root cause behind a problematic behaviour through nonlinearity and delays.

Since PCA assumes that relationships are linear, and AHP assumes no feedback, these two methods despite being close to fitting the goal of the paper, they differ on crucial conceptual points. ANP would prove to be the best fit for analyzing and reducing the initial pool of variables considered in the investigation of a dynamic situation, where feedback, delays and nonlinearity are the norm rather than the exception.

One additional simple yet essential concept to be clarified about ANP, is the necessity to have a consistent judgment based view which would preserve the integrity of the pairwise comparison approach. In this paper, the influence of the criteria on the parent element is the perspective adopted throughout the different sectors. If we are comparing criteria 1 and 2 under parent element A, the question would be: given the parent element and the two criteria in question, which one influences more the parent element's performance?

2.2.3. Hybrid SD & ANP

ANP can be a very useful technique if the critical factors and the scope of the system dynamics model are vague, which is the scenario in the vast majority of cases. Modular approach to system dynamics modelling is a common technique that builds and investigates in stages different parts, or building blocks, of the model. ANP would be a perfect fit for helping in conceptualizing and building these blocks. In this paper's case study, the blocks would be the three sectors of manufacturing, economical and social, and the system would be the sustainability initiatives (Keij & Ashayeri, 2008).

ANP and SD would complement each other when building a framework that relies on computer simulation of complex dynamic systems. Here are a few points that justify this combination:

1. In ANP, The different elements (or variables) can be evaluated by relying on the Delphi method which entails participation of the company or entity being investigated in the investigation/modelling process from the beginning, as often deemed necessary by SD practitioners also. The eventual weights of the alternatives are derived based on pair-wise comparison of the experts judgments.

2. The general structure of the ANP model comprising of a goal, criteria, sub-criteria and their alternatives is also very similar to SD models which investigate a problematic behaviour by looking at different sectors of the problem and their respective variables.

3. Rough CLD sketches of all possible relevant variables can prove extremely useful when building the ANP and when eliciting expert judgments by providing an easy visual reference for them.

Initial SD model building could rely on the findings of the ANP, i.e. which are the most influential variables contributing to the generation of the problematic behaviour, so as to make sure to include them, as well knowing which are the less important variables and try to remove them from the model. Also, when an SD model is built, and there is the need to scale it for better understanding, ANP results could be very useful in the variable elimination selection. ANP and SD model building can be used in an iterative process influencing one another as the investigation progresses.

3. Framework

This entire framework has the purpose of setting or re-setting of company's strategic goals to ameliorate their competitive positioning. It is expected that there will be quantifiable as well as non-quantifiable variables in such a study. Both SD and ANP are built to cope with soft as well as hard defined variables. Also, as the investigation progresses, some variables will be discovered that have very little historical data (whether qualitative or quantitative). SD would prove particularly useful in such situations, because it can rely on rough, yet plausible, relationships without significantly losing any of the accuracy of its findings. This property renders SD an ideal approach to investigate fluffy topics, such as company's strategies and possibly update them.

Here are the steps to be followed in the proposed framework:

1. Define the performance indicators

2. Categorize them under sectors

3. Compile an initial list of variables

4. Build a rough CLD that depicts the relationships between these variables

5. Build an ANP model based on the rough CLD

6. Identify vital variables (the ANP model would weigh the different variables in a systematic fashion while taking into account their respective strategic goals. The result would be a justifiable quantitative one that translates the management's insights into concrete distinction between vital and non-vital processes in need of investigating)

7. Build SD model (in order to investigate the dynamic relationships between these vital processes from a systems thinking perspective)

8. Identify trends of development of performance (based on the SD results, performance scores will be calculated. These scores would help the company in forming a better understanding of the dynamic nature of the company's processes and of the trends of development, and accordingly set or adjust its long-term strategic goals)

9. Design or re-design policies to ameliorate Competitive positioning (based on these new insights, new performance indicators might be discovered or existing ones might be given a different weight. Accordingly, either a complete reiteration of the methodology is necessitated or just updating of the ANP model and what follows)

Complexity of modern companies renders such a framework essential, since it can cope with the large number of operational details, i.e. vast number of multidisciplinary variables, as well as capture the dynamic relationships, i.e. feedback and delays. This methodology would guarantee a higher chance that performance will be improved in a sustainable manner ensuring competitive advantage.
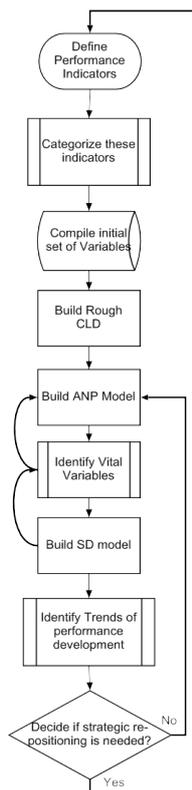

Figure 1. Hybrid SD-ANP Methodology

3.1. Hypothetical Scenario

Competitive advantage is achieved when a company has gained some knowledge that is unique and that allows it to perform at a higher level than other competing firms. Based on a survey conducted for Massachusetts Institute of Technology, that encompasses global thought and business leaders, sustainability initiatives can be said to be important for achieving competitive advantage. This is so, because there is growing media coverage and legislative pressures on companies to adopt sustainable strategies. By doing so, a company would keep up with the public trend ensuring customer satisfaction as well as acquiring intrinsic values that arise from such policies (Berns, Townend, Khayat, Balagopal, Reeves, Hopkins et al., 2009).

Superior performance of a manufacturing company would ensure competitiveness in the market place. To have a sustained edge over competitors, performance must be routinely evaluated, and by doing so future strategic goals can be set based on historical performance (Amrina & Yusof, 2011). In this application scenario, sustainable manufacturing will be the topic of investigation and will serve as the benchmark for performance. The proposed framework, highlights that competitiveness, sustainability performance and organizational learning are linked in their success or failure, and that they need to be addressed together.

The scenario is fully developed till step 6, and steps 7 to 9 are limited to explanation and clarification.

3.1.1. Step one & two: Performance Indicators and Categorizing

Manufacturing sustainability is the bottom line for this scenario. The following performance indicators were selected and categorized:

	Category		
	Manufacturing	*Economical*	*Social*
Performance indicators	• Supply chain • Atmosphere • Production • Policy • Technology & Lean Manufacturing • R&D • Supplier	• Relational Capital • Financial • Marketing	• Workforce • Knowledge Management • Human Capital

Table 2. Performance Indicators and Categories

3.1.2. Step three: Category and Variable Selection

For this framework to be comprehensive, it deals with indicators ranging across distinct fields. Sustainability has commonly in literature three sectors, environmental, economical and social (Global Reporting Initiative, 2002; RobecoSam, 2013) and when it is placed in a manufacturing setting a fourth sector, manufacturing is added (Jain & Kibira, 2010) However, since the objective of this paper is studying manufacturing sustainability within a learning organization, a manufacturing sector is added into which the environmental sector is collapsed. It is judged efficient to collapse the environment sector inside the manufacturing one to be more concise since the bulk of its indicators are related to manufacturing. So, three sectors emerge: Manufacturing, economical and social.

It is important to stay focused on the task at hand and not be distracted by the over-whelming list of indicators that compose each of the categories and sub-categories. What is important for the purposes of this paper, is developing the methodology of compiling different indicators with different properties, and quantitatively judging otherwise qualitatively defined ones. In addition, the merit of the comprehensiveness of such frameworks is not the number of indicators, rather than the inclusion of as much indicators that represent the causal roots of the dynamics of organizational learning.

The first two need no further elaboration since they are straightforward and tangible in nature and dealt with heavily in literature. The third sector, social, which only its human and knowledge aspects are dealt with in this paper, will be very briefly discussed, clarified and justified as to why it is an essential component for such a framework, in manufacturing or any other kind of company. It is the sector where the organizational learning aspect will be dealt with.

The indicators within the social sector were compiled with the purpose of covering "Man" and "Methods". These are the M's of production (out of the total of 4) that tackle the topic of organizational learning.

How firms manage their internal resources is the most critical part in assessing their sustained competitive advantage. Internal resources are mostly confined within knowledge defined boundaries making them for the most part intangible. Under the ongoing fast pace of globalization, definitions and standards are constantly changing, making knowledge and more specifically knowledge creation and retention one of the most, if not the most valuable asset a company can hope to have. This knowledge, is commonly referred to in literature as Intellectual Capital or IC.

This accumulation of knowledge, when synergized with physical assets, generates added value and with it competitive advantage in the market. It is important to recognize, that the

intellectual capital is the pre-requisite, and not the physical assets, behind any sustainable aptitude of a company in generating profits.

Given this large weight of IC, processes that help to internalize, propagate and maintain that knowledge within the company are becoming more and more relevant to overcome possible shifting and renewal of human capital (Bishwas & Sushil, 2012).

The social sector, confined in this paper to intellectual capital IC, is less tangible than the other two categories of Manufacturing and Economy. However, the purpose of this paper is to develop a framework that is able to transform intangible ideas into quantitatively measured ones through the use of hybrid SD-ANP simulation. Pablos (2003) define thouroughly the idea of Intellectual Capital IC and its sub-categories.

In this paper, we will refrain from extensively developing this sector, and limit the indicators to three sub-categories. The sub-categories were modified for the purposes of this paper. The sub-category of "relational capital" is transferred to the Economical category since its indicators are mostly tangible and possess an economic related definition. The sub-category of "human capital" is split into two sub-categories, "human capital" and "workforce". In this paper, the "workforce" sub-category is separeted from the "human capital" since its indicators are simple and easily observable, hence important to stress since they are most often the first ones cited by external observers and judges. The "knowledge management" category with indicators focused on knowledge defined notions, represents a small fraction of the all important organizational capital, yet recognized as the most crucial.

Hence, The social category, limited to intellectual capital in this paper is briefly explored under three sub-criteria: workforce, knowledge management (more commonly referred to in literature as organizational capital) and human capital.

The indices selected across the three sectors are kept on purpose general, so as to serve in as wide pool of cases as possible. However, an actual implementation of such a framework would require more operational, i.e. low level and detailed, indices specific to the company.

Most of the indices below would require the support of suitable information systems (Enterprise resource planning, Supply Chain Management,…),either to collect information from outside of the organization or from within. These information systems would support an efficient continuous quest of adaptation to the changing environment, which in turn preserves the competitive advantage (Arias & Solona, 2013).

Here are tables that briefly define and reference the initial selected indices under the three categories:

Supply Chain	
Distribution (Keij & Ashayeri, 2008)	Overseeing the movement of goods from supplier or manufacturer to point of sale.
Sub-contracting (Keij & Ashayeri, 2008)	Portion of the manufacturing process is assigned to an external company
Average Inventory Levels (Beamon, 1998)	Levels of stock at the different components of the supply chain
Backlog (Kamath & Roy, 2007)	It refers to any order for a product or service that is accumulating as a result of being delayed and not being able to be met on time
Order (Kamath & Roy, 2007)	It involves two components of the supply chain, and it is the act of requesting goods for a return
Delivery delay (Kamath & Roy, 2007)	It is the cause of backlogs and sales, and it can be thought of as a variable versus a stock (backlog is a stock of goods)
Process requirement of network partners (Haag & Tilebein, 2012)	Recognize the difference between desired and actual capabilities of the different components of the supply chain in order to save large % in costs
Demand variance (Beamon, 1998)	It is referred to also as Bullwhip effect, and it is the amplification of small variances in demand upstream to significantly larger ones downstream because of lack communication, ordering strategies, price fluctuations…
Atmosphere	
Environmental costs in sales (Azadeh, Ghaderi, Partovi Miran, Ebrahimipour & Suzuki, 2007)	Cost of considering environmental principals to total sales
GHG emissions (Global Reporting Initiative, 2002)	Defined by the total emissions (through production, overhead and transport used for business travel). Measured by the average GHGs released per ton of product.
Water consumption (Global Reporting Initiative, 2002)	Defined by the water used for the complete direct and indirect life cycle. Measured by the average water intake per ton of product
Land use (Global Reporting Initiative, 2002)	Defined by the used surface land. Measured by the natural cover area percentage of the total land area.
Harmful substances content (Global Reporting Initiative, 2002)	Defined by the proportionality between the regular substances and the harmful classified ones. Measured by the percentage of restricted substances weight in products.
Production	
Quality Control (Keij & Ashayeri, 2008)	Quality control (QC) is a procedure or set of procedures intended to ensure that a manufactured product or performed service adheres to a defined set of quality criteria or meets the requirements of the client or customer
Process improvement (Keij & Ashayeri, 2008)	Checks for the validity of the process approach, planning, control, authority and responsibility (ISO 9004 2009)
Information management (Keij & Ashayeri, 2008)	Computerized management information systems designed to collect and present the data which managers need in order to plan and direct operations within the company.
Capacity Management (Keij & Ashayeri, 2008)	Managing the on-hand capacity and augmentation as per management decision
Process innovation (Azadeh et al. 2007)	Technological innovation in new products, and supply of new products compared to that of competitors
Percent defect & scrap & rework (Azadeh et al., 2007)	Typical production process indicators that gives a good base for assessing process efficiency
Productivity (Hosseini-Nasab, Dehghani & Hosseini-Nasab, 2013)	It is simply the ratio of output to input in production that represents a certain level of efficiency
Training and process experimentation (Dyk & Pretorius, 2012)	It is determined by the amount of worker efforts and resources provided, and in turn it increases problem correction and consequently process throughput
Policy	

Quality projects (Keij & Ashayeri, 2008)	Following the principle of gaining knowledge from every project done
Forecasting (Keij & Ashayeri, 2008)	Estimate the future demand and resources needed (human resources, financial, material) for goods and services
Resource allocation (Dyk & Pretorius, 2012)	It is the decision to provide the needed resources for process improvement and innovation, and it is often influenced by the throughput gap
Raw material selection (Vachon, 2007)	Defined by the raw material selection strategy. Measured by the percentage of renewable resources used.
Recycling policy (Vachon, 2007)	Defined by the recycling ability of a specified industry. Measured by the total weight of recycled material.
Source reduction adoption (Nyikos & Thal, 2012)	Checks for measures taken in order to reduce resources use, such as operations management, product redesign, energy conservation, source elimination, etc...
waste treatment (Yoshida, Takahashi & Takeda, 2009)	Checks for the use of waste treatment methods such as incineration, evaporation, precipitation, correct disposal, etc...
Green building initiatives (Yu, Chu & Yang, 2012)	Checks for Green Building initiatives such as natural ventilation systems that coincide with ISO regulations, high thermal mass buildings, etc...
Technology and Lean Manufacturing	
Technology amortization rate (Hosseini-Nasab et al., 2013)	It is determined by the level of complexity of the industry and consequently the lifetime of a technology
New technology (Hosseini-Nasab et al., 2013)	It is directly determined by the technology amortization rate as well as the need for new programs (process innovation)
Cost to adopt new technology (Hosseini-Nasab et al., 2013)	It is determined by the efficiency of the company's information and process management, as well as its R&D department
Lean Manufacturing (Hosseini-Nasab et al., 2013)	It is the mindset of cutting every excess waste across the production stages. It is influenced by availability of finances, new technology as well as the productivity and level of customer satisfaction
Reliability (Cho & Lee, 2013)	Technology's ability to perform its required functions under stated conditions
R&D	
R&D culture cultivation (Cho & Lee, 2013)	It is the acquirement of relevant experience, educational, and research background through R&D experts
R&D efficiency (Cho & Lee, 2013)	Well defined plan to develop new technology
Top management support (Cho & Lee, 2013)	rewards, granting of needed resources
Originality (Cho & Lee, 2013)	Creates new products that take advantage of new technology
Applicability (Cho & Lee, 2013)	Ability to apply to other products making it expandable and versatile
Patentability (Cho & Lee, 2013)	It is necessary to protect intellectual properties from attempts of imitation
Supplier	
Delivery performance (Cho & Lee, 2013)	Measured by delivery time and the ability to quickly respond to orders changed
Flexibility (Petroni & Braglia, 2000)	Ability to meet customer demands for different types of product with different volumes
Long-term relationship (Petroni & Braglia, 2000)	Relationship built on a basis of sharing and transparency that delivers long term value to all parties involved
Operational efficiency (Cho & Lee, 2013)	It is a combination of the suppliers delivery compliance, price, ease of communication, location of facilities and technological capabilities
Environmental portfolio (Tahriri, Rasid Osman, Ali, Yusuff & Esfandiary, 2008)	Checks if the company is actively auditing its supplier's environmental policies and selecting accordingly critical suppliers (Human rights, OSHA, corruption, ISO, etc.).

Table 3. Manufacturing Indicators

Workforce	
Recruitments/Quits (Keij & Ashayeri, 2008)	The process of hiring and firing, how transparent and efficient is it?
Production value per employee (Azadeh et al., 2007)	It is the output per worker, which is a function of the ratio of capital to labour
Percent of key workforce who quit (Azadeh et al., 2007)	It represents the attractiveness of the company to its most essential members, and its ability to maintain the intellectual capital
Human Capital	
Training and development (Azadeh et al., 2007)	How much does the company invest in its workforce advancement?
Appraisal and rewarding (Dreyer, Hauschild & Schierbeck, 2010)	Checks for management objectives, peer comparison, multi-dimensional performance measures, etc...
Leadership ability (Bozbura & Beskese, 2007)	It is the inherent as well as the developed ability of decision making with a goal of getting closer to the company's strategic ends
Risk taking and problem solving capabilities (Bozbura & Beskese, 2007)	It is the rare yet crucial capability of functioning well under pressure and high uncertainty. This is through proactive problem forecasting, detection and solving.
Experience (Bozbura & Beskese, 2007)	It is the availability of experienced individuals in the right position
Education (Bozbura & Beskese, 2007)	It is the recognition of the need for specific type of education for specific tasks. It is having qualified individuals with little to no need for training.
Knowledge Management	
Accessibility (Bishwas & Sushil, 2012)	It is the ease of accessing previous findings within and across departments
Knowledge creation (Kleindorfer, Singhal & Van Wassenhove, 2005)	It is the active drive for learning to meet company's goals through certifications, external education, etc...
Knowledge transfer (Saaty & Vargas, 2006)	It is the process of continuous sharing of information to maximize the firms knowledge capital through active participation of the individuals involved
Collaboration and trust (Bishwas & Sushil, 2012)	It is the general requirement for a successful knowledge management & dissipation environment.
Conversation (Seligman, 2005)	Despite seeming trivial, it is often the most neglected tool when attempting to convey information. It is the cornerstone on which feedback, reflection and even implementation would be successfully built.
Feedback (Lizeo, 2000)	It is the result of the closed loop structure of any kind of learning initiative. The iterative process of learning is what makes it so valuable because it is by nature adaptive and flexible.
Psychological safety (Lizeo, 2000)	It is, besides conversation, another crucial requirement for any knowledge sharing environment. Individuals have to be at ease at expressing their ideas, questions and contributions, and for this to happen, employee rights, such as whistle blowing, unionize, incentives, etc... have to be protected.

Table 4. Social Indicators

Relational Capital	
Shareholders (Bozbura & Beskese, 2007)	Individuals who own part of a company through stock ownership
Suppliers (Bozbura & Beskese, 2007)	It is the component upstream delivering goods to the entity downstream in a supply chain
Market share (Azadeh et al., 2007)	It is the measure of how well a company is doing through the size of its controlled share of its relevant market
Fraction of new customers (Azadeh et al., 2007)	It is a sign of the company's success in retaining its innovation and products appeal
Customer service level (Azadeh et al., 2007)	It is a direct measure of the company's efforts to sustain its profits through building a loyal customer base
Synergy with existing businesses (Cho & Lee, 2013)	It is the goal of building fruitful relationships with other companies, most probably along the supply chain as well as potential competitors, to maximize the efficiency of the company's operations and profits
Financial	
Investment in sales (Kamath & Roy, 2007)	It is the conscious decision to increase sales capacity through more investments in staff and branding
Sales growth of each product (Azadeh et al., 2007)	It is the measure of the success of maintaining the momentum of every product launch
Revenue to total number of employees (Azadeh et al., 2007)	It is a measure of the company's ability to accumulate revenue with its stock of human capital
Salaries and wages to production value (Azadeh et al., 2007)	It is a rough measure of the return on investment when it comes to production output value
Raw material cost to production value (Azadeh et al., 2007)	It is a measure of the efficiency of the company when designing its production process and selecting the relevant raw material in terms of monetary value
Finished goods inventory to production (Azadeh et al., 2007)	It is a measure of the company's success in transforming and increasing value in the process of producing products
Value of WIP to production (Azadeh et al., 2007)	It is a measure of the how good the production line in itself is in terms preserving resources
Investment (Kamath & Roy, 2007)	It is the general decision to invest in an ongoing or new activity to improve the current status. It represents the company's awareness of the ever present room for improvement
Marketing	
Market potential (Cho & Lee, 2013)	It is a relative measure to assess the limiting capacity in terms of how the market would react to a certain offer of product
Customer needs (Cho & Lee, 2013)	It is the main indicator that should drive any kind of initiative in a company and it is through marketing that it can be discovered and communicated with the company
Legalities (Cho & Lee, 2013)	It is simply the limitations, mostly time and copywrights, that delimit the extent of marketing activities
Expected time to commercialize (Cho & Lee, 2013)	It is a very important delay that must be taken into consideration whenever planning production, hiring & firing, order placing and marketing campaign themselves
Commercialize cost (Bishwas & Sushil, 2012)	It is the available funds to implement planned marketing campaigns and surveys
Attractiveness of product (Haag & Tilebein, 2012)	Even though not being a direct indicator of quality, it is often the main driver of customer adoption, especially of new and non basic commodity products
Attractiveness of competitors (Haag & Tilebein, 2012)	It is the benchmark on which to base any kind of self assessment and consequently adjustment of branding and status of product market share

Table 5. Economical Indicators

3.1.3. Step Four: Rough CLD

Given this set of indices, a rough CLD is developed with the purpose of visualizing the relationships between them. Some of the connections might be removed, others might be added. It is a process highly dependent on the context in which it is being executed. For instance, an automotive manufacturing company would have different relationships than an airline one would. Different assembly lines with different policies would engender different performance indicators with different distribution of weights.
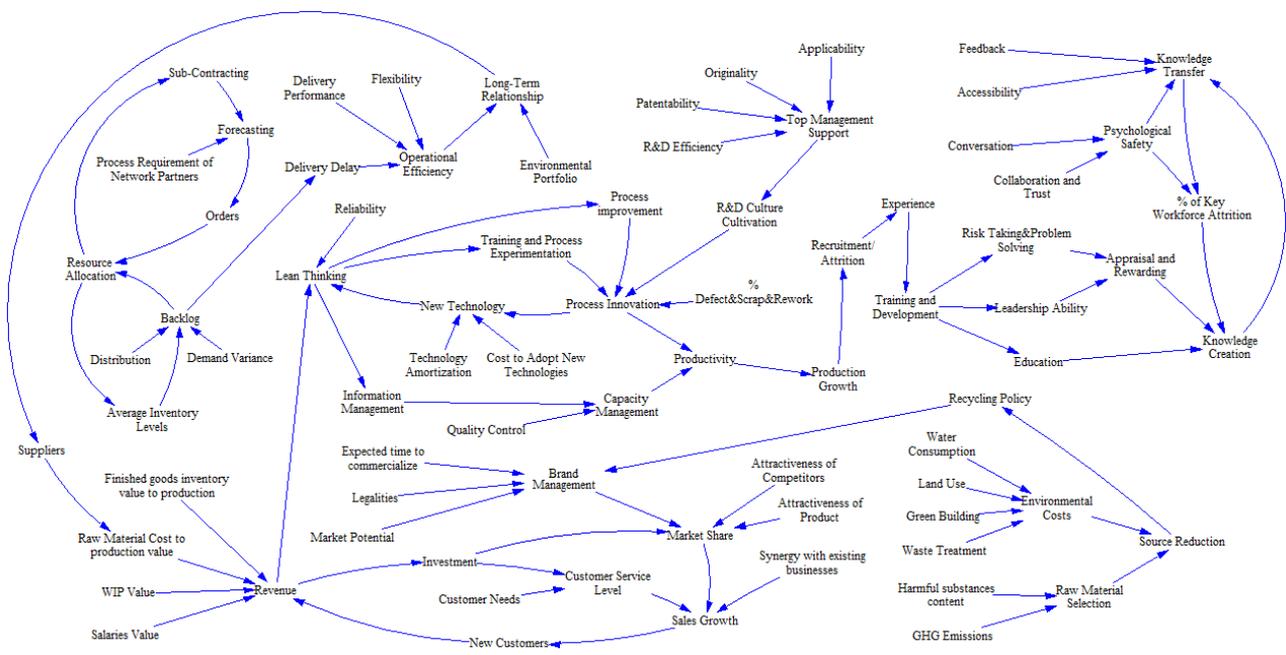

Figure 2. Rough CLD

3.1.4. Step Five & Six: Build ANP Model and Weigh Indices

An ANP model was built based on this rough CLD, taking inspiration from the existing relationships. The model has three control criteria, Social, Manufacturing and Economic. The sub-sectors and indices for each of these dimensions are already discussed and defined in previous sections. The social criteria, part of the ANP model, is shown below to illustrate how it looks like using the Super Decision software offered by Creative Decision Foundation.
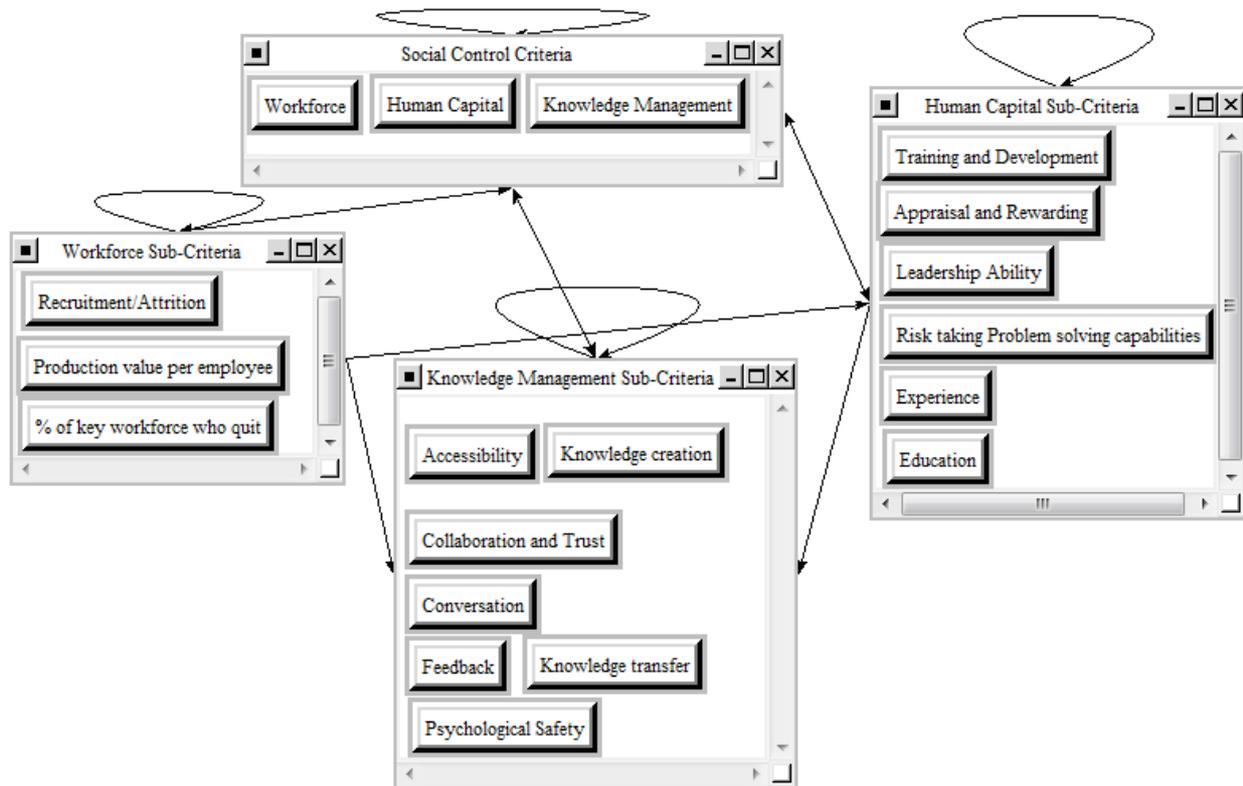

Figure 3. Social Sector of the ANP model

In the proposed framework, the subsequent step is to build an SD model to assess the level of sustainability of a manufacturing company based on a CLD refined from the findings of the analytic network process. With this goal in mind, the cluster of alternatives in the ANP is different than if the purpose was solely to build an ANP model. Usually there is one cluster for the alternatives, however now the alternatives are the variables that will partly constitute the CLD and S&F. So they do not match the traditional definition of "alternatives" in ANP, instead they can be grouped and assigned as nodes under the different clusters of sub-criteria (ex: Relational Capital, Financial and Marketing corresponding to the Economic control criteria) under each of the control criteria (Economic, social and Manufacturing). Also, the goal of the study cannot be conceptually placed as a cluster in the ANP. So, the ANP model will be without

an endogenously defined goal and without an explicit cluster of alternatives, instead it will have multiple sets of sub-criteria that will serve as the alternatives in the overall goal.

Since the set of indices was kept general, it was possible to perform the pair wise comparisons by interviewing three industry experts. However, specific individuals inside the company in question would be the ideal source of information in a full application of this methodology. As mentioned earlier, a key point to remember when conducting the pairwise comparison, is having a consistent judgment based view. In this case study, the influence of the criteria on the parent element is the perspective adopted throughout the different sectors. For example, If we are comparing "Originality" and "Applicability" under "R&D", the question would be: given the parent element of "R&D", which one of the two criteria in question "Originality" or "Applicability", influences more the parent element's performance?

From the pair wise comparisons, the ANP simulation was run and weights (or priorities) were deduced for the individual indices as well as the performance indicators. After running the simulation, the resulting priorities of the performance indicators are listed below:

Name	Weights
Financial	0.32172
Marketing	0.29909
Relational Capital	0.3792

Table 6. Economic Performance Indicators Priorities

Name	Weights
Human Capital	0.45362
Knowledge Management	0.33716
Workforce	0.20921

Table 7. Social Performance Indicators Priorities

Name	Weights
Production	0.24141
Policies	0.17842
Supply Chain	0.15821
R&D	0.14208
Supplier	0.14193
Technology and Lean Manufacturing	0.08439
Atmosphere	0.05355

Table 8. Manufacturing Performance Indicators Priorities

In this study, there were no problems in remaining within acceptable levels of consistency, so it was no problem incorporating some of the known links between the different control criteria. However, based on (Saaty & Vargas, 2006), and from reflections on possible pitfalls that could be encountered, the following can be said; since, there are individual supermatrices for the different control criteria, in case there were difficulties in having a consistent set of judgments, it can be argued that there is no need to create a structure to link the different supermatrices and get the overall priorities. The goal can be reduced to be selection of indicators with highest priorities within each sector, which would utilize ANP as a great tool in building an SD model in modular approach sector by sector. In that case, it would be up to the modeler to judge if this decision to omit possible relationships does not compromise the entire process of deriving scores of the variables in a dynamic environment, versus risking having to artificially fix the consistency through multiple rounds of expert weight elicitation.

3.1.5. Step Seven to Nine: SD Model Building, Performance Scores and Company Strategic Evaluation

Building a formal SD model requires full knowledge of a given company's operational details. Also, it involves constant feedback from concerned individuals inside the company. Without these two pre-requisites, it is not possible to build a Stocks & Flows model for the purposes of this framework. As such, it is outside the boundary of this paper to build this model since the aim is to propose and justify a framework.

The building of the SD model is a joint effort between the modelers and the corresponding individuals throughout the company. The very process of conceiving and developing such a model would test the company's mental models and clarify the actual dynamics of processes. Historical data is needed to either formulate mathematically the relationships between variables or to just define them. Such an effort is quite difficult, because variables would pop up that have often little to no historical data. However, SD is not meant to deliver detailed results, rather to paint a picture of the complex web of relationships and their evolution over time. Through sensitivity analysis and validation testing, a model could still be deemed representative without having a full database behind every variable.

The resulting priorities (Table 6, 7 and 8), generated from the ANP simulation would constitute the input in building the SD model. Indicators with relatively important weights are included and their behaviour is analyzed by formulating their causal dynamic structure. Indicators with relatively low weights, are either disregarded or inputed as minor variables, maybe even exogenously driven constants in the SD model.

After building a valid model, the modelers could run the model a certain period into the future, and hypothesize about how the performance indicators will evolve through simulated numerical output.

Some indicators would influence positively and others negatively the sustainability performance of the company. The following two equations would enable to standardize the indicators:

Equations:

$$Y_{ij} = (X_{ij} - \min X_{ij})/(\max X_{ij} - \min X_{ij}) \tag{1}$$

$$Y_{ij} = (\max X_{ij} - X_{ij})/(\max X_{ij} - \min X_{ij}) \tag{2}$$

where:

Y_{ij} = standardized value of the ith indicator in year j and,

X_{ij} = value of the ith indicator in year j and,

1 < i < m: m is the number of indicators under each of the performance indicators (for example, R&D performance indicator has 6 indicators) and,

1 < j < n: n is the interval of time to be simulated (for example, if the simulation runs between 2000 and 2050, then n=50).

After calculating the standardized values of each of the indicators under a performance indicator, the performance score of a company under this indicator would be calculated the following way:

$$Z_j = \sum_{i=1}^{m} W_i * Y_{ij} \tag{3}$$

Where:

Z_j = score of a certain performance indicator in the jth year (for example "Supplier" at year 10) and,

W_i = weight (or priority) of the ith indicator (obtained from the ANP)

Then, the score for each of the categories (for example: Manufacturing, Economical and Social in this case study) is calculated using:

$$Z_{cj} = \sum_{i=1}^{k} W_i * Y_{ij} \tag{4}$$

Where:

Z_{cj} = score of a certain category c in year j (for example, score of Manufacturing in year 10)

W_i = weight of the performance indicator i (obtained from ANP)

Y_{ij} = score of performance indicator i in year j (for example, score of "Supplier" in year 10)

1 < c < L: L is the number of categories in the framework

1 < i < k: k is the number of performance indicators under one category (for example, there are 7 performance indicators under the "Manufacturing" category)

Finally, the performance score of the entire company is calculated using:

$$P_j = \sum_{c=1}^{L} W_c * Y_{cj} \tag{5}$$

Where:

P_j = Performance of the company in year j

W_c = Weight of the category C

Y_{cj} = Performance score of category C in year j

The values of the indicators (X_{ij}) are directly extracted from the numerical simulation output of the SD model. The composite indices would clarify what areas need improvement, what policies have been successful and what have failed. Given this new knowledge, policies would be set or adjusted to guide the company towards its strategic goals. A common strategic goal for a manufacturing company would be sustained innovative products ensuring lead market share. Policies to guide the company towards that goal can focus on developing R&D, knowledge retention, active customer participation...These policies in turn are tested in the SD model, and the entire process starts again following a closed loop of learning.

4. Discussion and Limitations of the model

It is important to discuss briefly the assumptions and potential limitations that underline this framework.

Such a model would not be possible without the company's, and in particular the individuals involved, capability of conducting an objective self-assessment excercise. The exercise is simply following the steps listed earlier. It requires full disclosure of past policies implemented and their tangible results, which more often than not fail to meet the projected expectations.

This exercise which leads to the development of a ANP-SD model would force the company to examine its current status and judge if it is desirable or change is needed.

Another main point which this model is built on, is the one to one relationship which relates mental models to organizational learning, however not much emphasis was placed on discovering and altering these mental models. They are intangible by nature, however their outcomes are very much the opposite. Hence the need to develop an add-on to this framework which specifically tackles the framing of mental models in a quantitative manner. This can be done through the use of SD coupled with psychology models such as the Bruswickian lens model which measures the individuals perception of their environment and its accuracy.

Furthermore, for the purposes of this paper, which are the development of a framework and its operational details, the list of indicators is kept to minimum yet still representative of the most important ideas. It is important to stress that is not the number of indicators that reflect the comprehensiveness of such a framework, rather than the structural importance of the included indicators in generating the current dynamic competitive position of the company. Also, For the specific applications within a company, the list must be altered and fitted to the company in question. The indicators are merely the output of the company's endogenously generated behaviour, therefore each company will need a slightly different list capable of explaning and modifying the behaviour.

5. Conclusion

A hybrid SD-ANP framework that assesses a learning organization's competitive advantage is still a rough idea in development. It does exhibit a great potential to capture in a wholesome manner the organization's performance. Also, it is practical for initial variable selection and reduction whether in a SD or any other modelling context. Nowadays, just like personal learning is a daily necessity for growth, organizational learning has become a pre-requisite for any kind of sustained competitive edge. One cannot evaluate a company's performance, without assessing its capacity for learning, and vice versa. A company, much like a society, is a tangled network of messy relationships that fluctuate and evolve over time in various degrees and shapes. Nothing can be claimed to be irrelevant or not worthy of learning unless properly investigated using causality versus correlation as the main judgment. The top down approach of the ANP which incorporates feedback combined with the continuous-time SD simulation, make for a well rounded methodology with the end goal of forming, testing and updating corporation's strategies based on its performance. Future work would be to fully apply the framework in a real life setting, collect comments about its operational application and if deemed necessary make the necessary adjustments.

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