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Design and Simulation of an Integrated Model for Organisational Sustainability applying the Viable System Model and System Dynamics

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Abstract. The current global situation increases the exposure of organisations to their environment. As a consequence, companies have to consider a variety of topics that they had managed to a limited extent before. An organisation should now go beyond its limits in order to maintain its viability over time, this means being sustainable and making its related environment better by enabling collaborative working. In addition, there are not only challenges in the management of external relationships but in the management of internal ones. These are a consequence of the pressure for decision-making in short periods of time and a lack of coordination between different parts of organisations, effectively operating as silos with divergent goals. Even with common goals, due to a lack of adaptability or flexibility, some areas do not see the benefits of coordinating work for securing a long-term USP (Unique Selling Proposition) of an organisation. In this context, for both external and internal challenges, researchers often fail to holistically consider an organisation as being an agent, interacting and creating ecosystems of cooperation. Thus, the aim of this study is to propose a holistic approach as to how organisations can interact with their environment, as well as internally. Hereby, the Viable System Model and System Dynamics were applied. In conclusion this proposed approach enables companies to interact within its area of influence with an efficient approach. In order to prove the conceptual model, a simulation for a manufacturing supply chain and its area of influence was performed.

Keywords: Sustainability, Organisational Management, Supply Chain, Key Performance Indicators, Viable System Model, Simulation, System Dynamics

1 Introduction

Many companies have “separate kingdoms” in their business operations, with employees being more loyal to their specific business area than to the company itself and the challenge goes beyond the supply chain. As a result, for a company to be successful, a climate of trust, respect and dedication has to be developed by allowing other entities to have their fair share of mutual activities, enabling win-win situations [1].

Nowadays, our society requires the collaboration of all entities to support its commitment to the community. This means fulfilling human needs by creating a sustaina-

ble environment for all human beings. In this context, a company should contribute in its area of influence. However, the company will only support these purposes if there is a benefit for its actions. Within a company and the society individuals play a significant role. Moreover these individuals needs have needs are classified according to Maslow's Hierarchy of needs and own interests.

For these reasons, the purpose of this article is to develop a conceptual model for organisational sustainability at three levels: the company itself (with its functional areas as entities), its supply chain and the society in the area of influence of the company.

The initial hypothesis is that an organisation that is built on the basis of sustainable principles and collaborative working using the structure of the VSM will have a positive impact on the achievement of short, medium and long-term goals of all entities; society, supply chain and company goals.

Based on the conceptual model, a case study for an organisation was chosen. The case study was performed for an automotive plant with different suppliers and customers and also including the interaction with society.

2 Fundamental Definitions and State of Research

2.1 Sustainability

The meaning of sustainability depends on the perspective (social, economic or ecological) and the development of appropriate indicators provides a useful framework for policy making [2].

The concept of sustainability assumes that humans and their economic systems are linked [3]. The World Commission on Environment and Development defines 'Sustainable Development' as being the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". As a consequence, sustainability has to not only meet our needs but, also, it has to provide a benefit to society and external systems [4].

To sum up, the study uses a concept of sustainability that is based on the cybernetic concept of viability. If a company wants to be organised to be able to maintain sustainability, then it needs to be organised with a view to viability [5].

2.2 The Company and its Organisational Management

The organisational structure of many companies is highly function-driven. This approach to process improvement aims to minimise costs for all of the individual processes and this is a significant mistake because the optimisation of individual processes does not give the optimum for the entire process [6], this has a consequence for the organisation structure.

As an example, the logistical corporate conflict of goals comprises three conflicts of interest [7]; the conflict between costs and delivery, the conflict between costs and throughput as well as the conflict between throughput and delivery.

2.3 The Company and its Supply Chain (SC): from the Bullwhip Effect to a Collaborative SC

The supply chain components involve all parties, either directly or indirectly, when fulfilling a customer's request and include the manufacturer, suppliers, transporters, warehouses, retailers, and even the customers themselves [8]. A challenge in the supply chain arises from the fact that every stage in the supply chain wants to reach the same goals such as low stocks, high capacity utilisation, high delivery service, etc. creating an unavoidable conflict of interest between the entities.

Moreover, another challenge is created by the lack of transparency between stages, named the 'bullwhip effect'. As a result, demand along the supply chain is difficult to forecast [9] and it causes an extreme fluctuation of stock [10]. Concepts for a collaborative supply chain strive to mitigate the bullwhip effect through close cooperation between chain members to effectively match the demand and supply that contributes to the increase of the overall chain profitability. Although collaboration is based on a mutual objective, collaboration is a self-interested process in which firms only participate if it contributes to their own survival [11].

2.4 Individual and Society Needs in the Area of Influence of an Organisation

Social structures are the result of man's actions in society and these structures enable him to satisfy his needs [4]. In this study, the definition of human needs by Maslow is used. Maslow studied the motivation of individuals without considering rewards or unconscious desires [12]. Maslow stated that people are motivated to achieve certain needs. When one need is fulfilled a person seeks to fulfil the next one, and so on [13]. The analysis of Maslow's hierarchy within organisational studies remains "extremely rare" and therefore it has a high potential [14]. The hierarchy of needs can be divided into 3 types of needs: basic needs, psychological needs and self-fulfilment needs [15]. There are 5 categories: physiological needs, safety and security needs, love and belonging needs, self-esteem needs and self-actualisation needs [16].

2.5 Concurrent and Collaborative Work Applied to an Organisation and its Related Environment

Organisational behaviour is described as being the result of concurrent actions of the "intelligent adaptive agents", i.e. the individuals within an organisation. Therefore, organisational performance is a function of both individual actions and the context or environment in which they act [17]. As a consequence, the principles of concurrent and collaborative work are used as the basis for the conceptual model development. Therefore, a model in which coordination mechanisms and tools for sharing information are given is compared with a model in which those tools do not exist.

3 Methodology and Concept Development

The method used to reach this goal was the following:

1. Methodological approach: the VSM was selected due to its structure for viability and SD due its capability to analyse the behaviour of complex systems over time
2. Literature review
3. Conceptual model design: logical inter-relationships and casual loop diagrams
4. Simulation and analysis of results: simulation models, assumptions and scenario definitions, extraction and analysis of results
5. Critical reflection and outlook

Beer deduced the VSM by taking the central nervous system of the human being and cybernetics as basis in order to deal with complex systems. The VSM is built on three main principles: viability, recursivity and autonomy [18]. The cybernetic model of every viable system consist always in a structure with five necessary and sufficient subsystems that are in relation in any organism or organization that is able to conserve its identity with independency of its environment [19]. As described in the literature the VSM is a conceptual and methodological tool for the modelling and design of organisations and its areas with the goal of being viable [20]. Moreover, SD is a computer-guided approach for studying, managing and solving complex feedback problems with a focus on policy analysis and design [21]. It is increasingly used to design successful policies in companies and public policy settings [22]. For this reason, Vensim (an SD software) was used to program the conceptual model for the case study.

4 Design and simulation of an Integrated Model for Organisational Sustainability: Applying the Viable System Model and System Dynamics

4.1 Design of an Integrated Model for Organisational Sustainability: Applying the Viable System Model

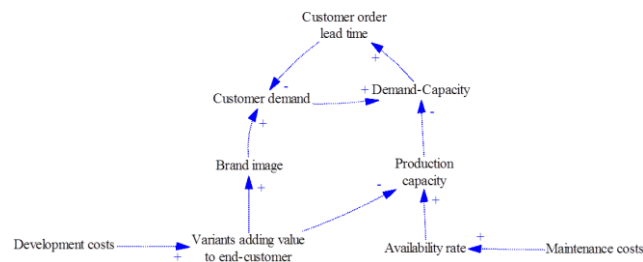
The three levels under study are: society, the supply chain and the company itself. As applying the VSM all levels consist of an invariant structure of 5 subsystems: normative (system 5), strategic (system 4), tactical (system 3), coordination (system 2) and operative units (system 1). In this research study the supply chain is the network level (recursion level n), the company is the plant level (recursion level $n+1$) and society is the related environment for the company.

For the company, the key indicators for every functional area should be described in order to understand the motivation of each entity inside the organisation, systems 1, i.e. the operative units within the recursion level $n+1$.

Table 1. Key Indicators for functional areas of an organisation

Functional area	Indicators
Production	Production volume, performance rate, production costs, production lead time, OEE, capacity utilisation rate
Quality	Quality or rejection rate, control and rework costs
Maintenance	Availability, maintenance costs
Logistics	Service level, customer order lead time, logistics costs
Design & development	Time-to-concept, number of variants, variants adding value to end-customer
Sales & Marketing	Customer demand, brand image, employer image, price, margin
Purchase	Number of suppliers, material costs, time to negotiate
Finance & IT	Product development costs, investments, logistics, production, maintenance, quality & general costs, cost per unit, margin per unit
Human resources	Number of employees, training, motivation, conditions
Other staff areas	Legal, compliance, strategy, etc.

Then, the collaborative and mutual benefits for the functional areas are searched for, thanks to a system dynamics analysis with casual loop diagrams:

**Fig. 1.** Extract of a company casual loop diagram: interrelationships between key indicators

This was repeated between all indicators of the above-listed functional areas. As a second step, the recursion level of the supply chain was considered. For this, the different entities, their objectives and key indicators were considered in order to determine potentials for collaboration across the supply chain.

Table 2. Key Indicators for the supply chain participants

Participants	Indicators
Company	Replenishment time, rejection rate from suppliers, raw material stock levels, capacity utilisation, finished product stock levels, customer order lead time, service level, production costs, level of exchange of real customer demand information, adaptability to change
Suppliers	Stock level or capital employed, capacity utilisation, delivery service, product quality, order lead time, level of exchange of real customer demand information

Retailer	Stock levels, replenishment time, customer order lead time, level of exchange of real customer demand information, distribution costs, new quality problems
End-customer	Service level, order lead time, number & type of claims

In the same way as for the company recursion level, casual loop diagrams were developed for the participants in the supply chain describing the inter-relationships between key indicators. As an example, if the retailer knows the real demand information, then the logistics routes and the utilisation rates of trucks can be optimised, thereby reducing the distribution costs and improving the customer order lead time. By using this approach, benefit-sharing can be achieved.

In the third level, society and its needs in the area of influence of the company are considered. For this, only the basic needs of society are taken into account. The following needs, indicators and measures that are contributed from the company to society were considered in the conceptual model and in the simulation.

Table 3. Key Indicators & potential measures for basic needs in the area of influence

Basic needs	Specific need	Need key indicator	Measure
Physiological needs	Breathing	Pollution rate	Countermeasures for zero-impact
	Food	Malnutrition, obesity	Catering with healthy food, surplus for non-profit organisations
	Shelter	Homeless rate, working years for buying a house	Construction of flats for employees & relatives
Safety and security needs	Health	Sedentary level	Hospital
		Cardiovascular diseases	Health insurance
		Death rate	Gym
		Absenteeism rate	Rehabilitation centre
		Accident rate	Catering with healthy food
		Average time off work	Ergonomics
Employment	Family	Permanent contract	Leasing options
		Motivation rate	Financing options
		Two working parents, single parent, grandparents in the city, distance to work location	Training
			Development options
			Home-office, kindergarten, permissions paid

4.2 Simulation of an Integrated Model for Organisational Sustainability using System Dynamics

The previously described levels were programmed into the Vensim software. For the case study, an automotive plant was selected. Several suppliers and a retailer with end-customers were considered. The assumptions in the simulation were: one car

model, 5 year simulation time with 220 working days, a maximum capacity and demand of 1,000 cars per day:

Table 4. Simulation results for the three levels: company, supply chain and society measures

Simulation level	Key Indicator	No collaborative work Simulation Model	Collaborative work Simulation Model
Company level	Margin per unit	3,680 € / unit	6,750 € / unit
	Production capacity	740 units / day (t=1,100)	910 units / day (t=1,100)
	Customer order lead time	80 days (t=50)	60 days (t=50)
Supply chain level	Margin per unit	6,000 € / unit	6,750 € / unit
	Customer demand	910 units / day	935 units / day
	Customer order lead time	100 days (t=50)	60 days (t=50)
Society measures of the company	Margin per unit	1.600 € / unit	6.750 € / unit
	Absenteeism rate	9%	3%
	Productivity rate	90%	99%

From the results obtained, it can be observed how the collaborative work simulation model presents better results for all three levels.

5 Critical Reflection and Outlook

After completion of the research work, the following points can be successfully concluded:

- Thanks to a new model for organisational management that is able to make decisions in relation to its environment, its supply chain partners and internal set-up, the sustainability of an organization and its related environment can be assured.
- The VSM provides the necessary structure to determine the inter-relationships between areas and parameters that allow them to be optimised in a recursive way.
- The simulation of an organisation using the conceptual model with collaborative mechanisms presents better results for the relevant key parameters for all three levels of all entities: company, supply chain and society impact. As a result, the simulation evolves in a decision-making support tool for managers.

The final goal is to transfer this research method to real organisations, applying it in particular cases as a management guide for sustainable design and development. Moreover, future research would be to study the specific levels in detail before trying to implement it in a real organisation. In summary, all individual needs and society needs can be included as demand factors to complete the model.

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