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A Viable System View of the Japanese Lean Production System

Gandolfo Dominici[1], *Federica Palumbo*[2]

Abstract

Today, growing complexity and variability of the business environment, calls for more flexible and efficient production systems. Among the most effective and efficient production system, the Japanese lean production is the most known and studied, but still not the most applied with success outside Japan. The reason of the scarce success of lean production outside its native country is the insufficient understanding of the strong interactions among the enterprise system and the business system.

In order to fill this gap of knowledge, it can be useful to investigate the systemic interaction according to the Viable System Model (VSM) and its evolution in business science, the Viable System Approach (VSA).

In this paper we combine these models in an unified framework, integrating the internal analysis of VSM with the analysis of the links with supra-systems developed by VSA. We apply this framework to analyze the peculiar aspects of Japanese lean production systems in Japan.

There are many similarities between the Japanese lean production system and the Viable Systems approach. In particular:

- the strong interactions of the kaisha[3] with the environment;
- the recursivity of the system;
- the importance of relationships ("relational capitalism", Okimoto & Rohlen, 1988).

We first describe the applications of VSM to business, as highlighted by

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[3] Kaisha (会社) is the Japanese firm.

Stafford Beer and the developments of VSA of the Italian school of G.M. Golinelli.

Then we proceed depicting the peculiarities of lean production system, shedding light on its roots with the Japanese business environment (Dominici, 2010).

We conclude drawing a scheme of lean production system as a viable system and we analyze the results and the possibilities for further research.

Keywords: Viable System Model, Viable System Approach, Lean production, Keiretsu, Kaisha, Japanese Business Environment, Just in Time

1. Introduction

Since the last two decades of the 20th century we saw a gradual transformation of the business environment in which firms work and survive. This process, due to fast and continuous changes in the markets, undermined the stability of the business context, causing the boost of all the three factors of complexity: economic, technical and socio-psychological (Merli & Saccani, 1994).

Economic complexity regards the changing of the relations among business players; such as the increase of market size, the low rates of economic growth, the heterogeneity of demand.

Technical complexity considers the technological development paths (which generate a rapid obsolescence of both hardware and software structures) and the request for more flexible technologies.

Socio-psychological complexity deals with social behaviors of the consumer. The role of consumer has evolved from "consumer" to "prosumer"[4]. Consumer has become more demanding, more informed

[4] In 1972 McLuhan & Nevitt in their book "Take Today" pointed out that with the "future" spread of electronic technologies, the consumer would become producer of the goods he wants. Some year later, in 1980, the futurologist Alvin Toffler, in his book "The Third Wave", coined the term "*prosumer*"; he predicted the blurring of the distinction of role between consumer and producer. According to Toffler this has been caused by the market saturation of standardized goods , which would have caused the search for higher level of differentiation and personalization of products.

and, at the same time, more helpful to supply information in order to obtain a more personalized product which better satisfies his desires, needs and expectations. Consumer need have changed also by the point of view of time: product innovation must be fast because consumers' desires change fast. Firms need to adapt their structure considering the strategic relevance of "flexibility" and "time" otherwise they perish.

Mass production system is able to achieve hi level of efficiency and productivity thank to economies of scale; but despite its efficiency it works well only in stable environments and with constant growth rates. This happens because the implementation of mass production needs a rigid hierarchic structure, which is not able to react in an agile and fast way to the changes of the business environment. Hierarchic organization structures entail the consistency of social, economic and technological factors (Montgomery 1980). Moreover mass production can be applied efficiently only to large production volumes of standardized products, not considering the consumer's need of more personalized products.

It is indeed necessary for the firms to adopt a flexible and agile production system, which may be able to assure levels of performances comparable to those of mass production. Such a system must be able to:

- react to the turbulences in the business environment (new products, unexpected fluctuations of demand, etc.);
- survive to the changes of production processes;
- rapidly respond to the failures in production process (defects, timing problems, etc.).

To answer to these problems, the Japanese "lean production" can be the solution. In fact the lean production system (at least when applied in Japan) showed in the past decades its effectiveness in giving agility to industrial production systems by reducing stocks and wastes (in Japanese called "muda").

The problem of lean production is represented by the many failures when trying to implement it outside Japan. Taichi Ohno, the "creator" of Toyota Production System (TPS), which is the first and most

famous lean production model, has never kept a secret about it because he was sure that TPS could never work outside Japan. According to Ohno, the lean production is deeply rooted in the Japanese socio-economical context which is unique and deeply different from those of western countries (Monden, 1998).

Many things have changed in the western world since the time of Ohno. Today all advanced countries are going through a deep transformation in labor markets which are becoming more flexible than in the 1980s. Moreover for western economies, the lean production with its links to a skilled, "educated" and flexible labor force can represent the way to counter the general trend to place production plants abroad where labor is cheaper.

To understand how to effectively export the lean production system outside Japan it's very important to identify the links of this production system with the business environment; an analysis of the system in a viable-systemic perspective can be very useful for this aim. The VSM is able to interpret the lean production system and analyze its features and its relations with external environment thus helping to understand the process underlying it. We have chosen this approach to study a complex phenomenon because it overcomes reductionist and holistic limitations, considering the whole as result of interactions among parts. We integrate the VSM with the VSA which emphasize better the relations with the supra-systems and the environment.

We highlight the main characteristics of lean production and we analyze them using a viable-systemic perspective. Doing so we consider the lean production with its osmotic interactions with the Japanese business system and we create a framework which highlights the key relations which are essential for the viability of the system.

2. The VSM and the VSA in Business Sciences

The Viable System Theory is a scientific approach which incorporates Bertalanffy's system theory and cybernetics. The first

who has led the development of cybernetics in the study of organizations was Anthony Stafford Beer, who is considered the father of the "*Management or Organizational Cybernetics*". From the publication of his first book "*Cybernetics and Management"* in 1959, he focused on the enforcement of systems thinking to the management organization, in search for an universally valid approach to model and design organizations. Accordingly Stafford Beer conceived the Viable System Model (VSM) as one set-theoretical model based on systems approach and cybernetics systems viability. Cybernetic systems main feature is their viability which is the ability to successfully face the problems of complex environment, to self regulate and settle down. Whereby we can say that only if an organization survives in a particular sort of context, it is viable.

Stafford Beer's VSM, even though of general applicability, is based upon insights derived from the study of the human nervous system. Human brain is an open system in continuous interaction with the environment, when it receives an external stimulus, it is able to activate a decision-making process and to transform perceptions into actions. Its task is to control and coordinate all the organism's functions and to be adaptive and proactive with the social and physical surrounding world.

Stafford Beer recognized a parallelism between capabilities and basic structural patterns of the human brain of a viable human organism and those of management systems of a viable organization.

He started by considering that the human organism is composed by three main interacting parts: muscles and organs, nervous system and external environment; and he brings back these features in Viable Systems as follows:

- *the Operation (muscles and organs):* it is made up of several operational units which do all the basic work (production, distribution, make profits,…);
- *the Meta-system (nervous system):* has the task to ensure that all the operations units work together in an integrated way (scheduling, accounts, strategic planning, etc.);

- *the Environment (external environment):* all the environment elements, which are in contact and interact with Operation and Meta-system.

The following diagram illustrates the basic VSM:

"Figure 1(The basic VSM) around here"

This basic model considers a viable system as a collection of *operational* elements which are held together by the *meta-system*. These three parts must be in balance. When the environment changes the enterprise must respond accordingly.

A further elaboration of VSM is based on the concept that an autonomous organization needs to have five key interactive systems to maintain its identity and operate effectively in its environment (Stafford Beer, 1989).

In order to be viable, a system must incorporate the following five inter-connected sub-systems:

1. *Operations:* it is placed at the lowest level of the system; inside it we find the "primary units" which are composed by basic units that achieve operations like production or services. The basic units are supervised by their own management, which locally controls them to optimize the daily business.
2. *Coordination:* it is the *"internal eye"* that coordinates different operations carried out in primary units and ensures that they interact through information and communication to serve the whole organization avoiding conflicts.
3. *Control:* it is the command control function which interprets the system's policy according to its internal data. In this sub-system the operations and the processes of the other sub-systems are optimized, harmonized and enhanced through an internal guidance that allocates resources, creates synergies and competes to reach the overall performance optimization of primary units.
   - Complementary to the sub-system 3 we find the sub-system 3* *Auditing/Monitoring*. It is an internal monitoring sub-

system as the sub-system 3; it aims to investigate and validate the information flowing through channels 1-3 and 1-2-3, by means of auditing and monitoring activities which imply a direct access to the basic units. In other words it is an alternative channel that gives to the sub-system 3 the opportunity to get immediate information rather than counting on the intermediation of localized management of primary units.

The management functions of sub-systems 1, 2, 3 and 3* deal with the inside and the present of the viable system ("Inside and Now"), while sub-systems 4 and 5 operate with regard to the future ("Future and Then").

4. *Intelligence:* it is the strategic sub-system; it gathers external data and information (about technologies, markets, competition, society, etc.) and, after evaluating their relevance for the organization, it translates them into strategies and action plans for future activities. The focus here is on the anticipation of the future with a long term orientation and to the capability to harmoniously adapt to future events.
5. *Policy:* it defines the policy of the organization according to the objectives planned according to the basic principles of the enterprise-system formulated by the owners, the shareholders and/or the stakeholders. The action plans developed by sub-system 4 are translated into operations for sub-system 3. This sub-system keeps the identity and coherence of the whole enterprise-system.

The VSM supports management to optimize effectively the production system and to deal with the variety because it represents a new way of looking at an organizational structure. In this approach the decision making process is not hierarchical, but command and control mechanisms are present in all sub-systems and not only in the top management. Hence, vertical management (all the management functions from sub-system 1 to 5) balances the horizontal between the sub-system 1 and the environment.

Moreover VSM is a recursive model in which any viable system has to contain these five sub-systems and, because of its recursive structure, any larger viable system has to be a combination of many viable sub-systems, each one replicating exactly the same structure and the same mechanisms.

In figure 2, we illustrate the whole framework with three levels of recursivity. Each line represents a two ways channel.

"Figure 2 (The Viable System and its sub-systems) around here"

Figure 2 shows two kinds of direct connection between the firm and the environment:

- between sub-system 4 and "future environment" because the main responsibility of sub-system 4 is to carry on the adaptation mechanisms of the production systems with its future environment (composed by the interests of all the stakeholders);
- between primary units of sub-system 1 and the current environment (served market segments) because primary units role isn't only to execute the instructions coming from upper level management, but also to have a certain degree of autonomy in recognizing market segments needs and taking their own decisions in order to be viable.

The Viable System Model has been the starting point for further elaborations by Gaetano Golinelli.

While Stafford Beer focused on understanding organizations' inner functioning (the 5 sub-systems) in order to support the external adaptation (Stafford Beer, 1972; Espejo & Harnden, 1989; Espejo, 1999; Christopher, 2007), Golinelli's VSA (Viable Systems Approach) is more *externally oriented* and analyzes the influence coming from other overlying systemic entities in the environment (the supra-systems).

According to Golinelli a viable system is characterized by the following features:

- *openness:* the firm is conceived as an open system, whose boundaries are blurred. The system-firm needs to exchange

flows of energy, resources, raw materials and information with the environment in order to survive and be "viable";

- *self regulation and homeostasis:* it is the principle of self-regulation of living organisms. Every viable system comprises an adaptive mechanism that keeps the system in condition of equilibrium within the limits of its structure and the constraints of the outside world (Beer, 1975).
- *equifinality:* refers to the capability of different systems, in different starting conditions (that is, from different structures), to reach the same end state by taking different evolutionary paths. In other words, various systems can emerge from one structure, and one system can be based on different structures.
- *equilibrium:* represents the ability to provide an appropriate contribution to the needs of supra-systems within the overall systemic framework (Beer, 1975);
- *autopoiesis:* is self-organizing and aims to stimulates a selective mechanism to ally the systems' internal complexity with the complex environment (Maturana and Varela, 1975);

Golinelli postulates also the following four assumptions which are the basis of VSA:

1. *"A system is viable if it can survive in a particular sort of environment"*(Golinelli 2010:55). The firm is not independent from the environment but it is an open system which can survive only if able to contextualize its activity and to create exchange processes with the external environment.
2. *"Viable systems have the isotropic property"* (Golinelli 2010:55). Each viable system has the attribute of identity or invariance of its shape (in the meaning of the ancient Greek eidos - ειδος[5)] independently from the perspective (tropos) we look at it. This identity of shape is made of two areas: the area of decision making (Firm Government) and the area of action

[5] (ειδος) means "idea", "image", "shape". Was used by the Greek philosopher Plato to refer to the ideal Forms or Ideas in his Theory of Forms.

(Operative Structure), which may have continual interactions and not be separated or isolated.

3. *"The viable system is projected toward pursuing purposes and attaining objectives and can be connected to supra-systems and subsystems from which and to which expectations, guidelines and rules can be received and allocated"* (Golinelli 2010:56). This principle implies that the "Firm Government" (organo di governo, OdG) must try to interpret and satisfy the expectations of supra-systems also by mediating the interests of its sub-systems.
4. *"A viable system, as an autonomous entity, may be dissolved within the supra-system it refers to in a specific time-frame due to resonance processes which may follow conditions of consonance"* (Golinelli 2010:58). This postulate refers to the possibility that a viable system could annihilate its borders and its identity to dissolve itself in a supra-system with which it shares values and aims (condition of resonance[6]). To do so the condition of consonance[7] must be achieved.

The VSA is an useful tool for the observation of complex phenomena, and can help to shed the light on the complex mechanisms of the relations among socio-economic entities looking for viable interacting conditions (Golinelli, 2000; Barile, 2000; Golinelli et al., 2001).

It underscores the role of collaborative connections with the supra-systems as well as supplier, consumer, distribution, financial and institutional systems that, according to a porterian vision, are considered competitive forces which can affect viability.

[6] The situation of resonance is when a system improves its own performance producing a harmony of purpose within the supra-system (Golinelli, 2010).

[7] The condition of consonance is when a viable system defines its own structure in order to be perfectly integrated into the extended structure of the supra-system it refers to (Golinelli, 2010).

3. The Japanese Lean Production System

Japanese manufacturers' re-building after the Second World War faced big problems of material and financial resources. These problems were very different from those of their Western counterparts. Lacking the vast market volume which American automakers enjoyed in early post world war days, Toyota and other Japanese automakers had to innovate in order to be cost competitive at the same time accommodating limited but diversified consumer needs. These circumstances led to the development of new, lower cost, manufacturing practices. A disciplined, process-focused production system first known as the "*Toyota Production System*" and then as "*Lean Production*" was created to adapt to those conditions.

The term "lean" was created later, in the mid 1980s, by John Krafcik, a MIT master's student of the IMVP (International Motor Vehicle Program) who worked at NUMMI, the Toyota-GM manufacturing joint venture. This term was introduced in the management terminology in 1990 by Womack, Jones and Roos in the book *"The Machine that Changed the World"*, which collected the results of the 5 years analysis and benchmarking of IMVP and outlined the main feature of the Japanese "lean" approach in contrast with the Western mass production.

Lean production is a modern management philosophy inspired by the Japanese concept of *kaizen* (the strategy of continuous improvement). The word "lean" reflects the aim to employ "less" resources in all aspects of business operations. The objective of this system is to minimize the consumption of resources that add no value to a product and to seek both differentiation and low cost.

Lean Production, as defined by Monden (1998), embraces several management and operative approaches, which are necessary for its implementation:

- *Kaizen:* the Japanese word "kaizen" means continuous improvement. Kaizen philosophy explains the way innovation is introduced in the *kaisha.* With kaizen every innovation comes up gradually with small continuous steps generating continuous

small changes, rather than with one single big, sudden, and radical innovation.

- *TQM:* is a managerial philosophy for continuously improving the overall business performance, in accordance with customer's desires and expectations. It can be defined as *"All activities of the overall management function that determine the quality policy, objectives and responsibilities, and implement them by means such as quality planning, quality control, quality assurance and quality improvement within the quality system"* (ISO 8402, 1994).
- TQM embraces all control activities, including "*Quality control*" of which it is the extension outside the shop floor. Total Quality implies the total involvement of every employee of the organization. Every worker at any level is responsible and focused on reducing the cost of quality while controlling the standard of process and helping to continuously improve the system. To achieve TQM, "Quality circles" are useful to spread the TQM culture inside the organization. Quality circles are sets of scheduled meetings where all the employees discuss with management and find solutions to various problems.
- *Just in time*: the main purpose of JIT systems is to produce and supply the quantity needed, at the time and in the place needed. The elimination of waste of all kinds (excessive production resources, overproduction, excessive inventory and unnecessary capital investment) is the way Just in Time systems plan to achieve these goals. One of the main achievements of JIT systems is the reduction of work in process inventory (WIP), because it creates several problem of flexibility in the production line. JIT system needs to be supported by all the other features of lean production.
- *Kanban:* It is a Japanese term meaning "signal card". A kanban is a paper (or sometimes a metal tag) attached to every box of materials or components signaling the exact quantity required by the subsequent process to every process along the production line. The kanban is sent through the processes in the line, and to

suppliers connecting them to each other and regulating production, supply and conveyance process. Kanban system is also an information and control system. At the beginning Toyota used the kanban to cut costs and control machine utilization. Later Toyota became able to use this system not simply to manage costs and flows but also to recognize constraints along the production line and implement continuous improvement (*kaizen*).

- *Jidoka*: "autonomation" (or *Jidoka* in Japanese) is one of the pillars of the Toyota Production System. *Jidoka* is the concept of adding an element of human judgment to automated equipment. With Autonomation, the workers inside the production process become able to discriminate against improper quality, and the automated process becomes more reliable.
- *Smoothing of production:* is the adaptation of production to the variability of demand in order to minimize the quantity variance in the production line and it could regard both the total production and each model's quantity production smoothing. Total production quantity smoothing aims to reduce variance between two following time periods by forecasting peaks and valleys in the demand in order to avoid waste in the entire production system.
- *Reduction of lead time and batch size:* a short lead-time is essential to obtain the flexibility needed to quickly respond to the requests of the market and to benefit of the stability of smoothed production. As pointed out by Monden: *"The Japanese JIT production system is aimed at flexible adaptation to fluctuations in demand quantity and variety in the market. Here the term flexible means with short production lead time"* (Monden, 1998:116). Single-unit production is not possible in all processes. Nonetheless it is always possible to make efforts in order to reduce the batch size. To achieve the single-unit production (*ikko nagashi*), or the small lot production, it is necessary for suppliers to adopt the same production system. This allows suppliers to be synchronized with the main factory

and avoids the burden of accumulation of inventory otherwise necessary to satisfy the supply requirements of the main factory.

- *Modular cell manufacturing:* One of the parts of the lead-time where Toyota achieved considerable improvements is the "conveyance time". Conveyance time can be reduced with *Quick Conveyance* and *Machine Layout*. Both the above objectives can be better implemented with *modular cell manufacturing*, which organizes machinery so that products can be manufactured in a continuous flow. In the typical production system machines are grouped by function and parts move from a function to another and from one part of the factory to another, resulting in long waiting times between procedures. Modular cell manufacturing re-engineers the production line so that products can flow smoothly through all the line, parts do not idle waiting to be worked on, and forklift trucks do not need to travel kilometers to move parts and materials from one part to another of the plant. Modular cell manufacturing can be realized by implementing U-shaped processing lines, which integrate the manufacturing process into a continuous flow and increase supply accessibility to the lines[8].
- *Standardization of tasks and multifunctional workers:* The human element in the organization is one of the most important factors for the successful implementation of lean production. Employing *multi-functional workers* is one of the key elements of Human Resource Management in order to enhance quality and to make the operating process more flexible. Each worker needs to be able to manage more than one machine at a time and he needs to move continuously to other machining centers or assembly lines, participate actively to teamwork and other support activities. Flexibility of tasks gives workers the chance to accept more job responsibility while increasing their feelings

[8] For a better analysis of the U-Turn layout see: Monden Yausuhiro, *"Toyota Production System: An Integrated Approach to Just-IN-Time"* 3rd edition, EMP, 1998.

of value for the whole company. This makes it possible to achieve the goals of reduction of lead time and smoothing of production. To implement the multifunctional worker, it is important to *standardize all the tasks*. Thanks to the standardization of jobs it is possible to switch worker among the various tasks after a proper training.

It is important to point out that all these elements are interconnected with the business environment to create the lean production system.

4. The Lean Production System as a Viable System

Japanese lean production can be considered as a viable system inside a specific business environment. In other words it can be analyzed as a system of networks of formal and informal relations, comprising the institutional, the managerial and the social systems.

The *managerial system* is the particular method of organizing, managing and controlling the *kaisha*, which is established in a particular context.

The *institutional system* comprehends formal laws, regulations, procedures, informal conventions, customs and norms, that broaden, mould and restrain the socio-economic activities and behaviors.

The s*ocial system* is the system of social, cultural and educational conventions that constitute the external environment. The Japanese lean production system refers to a more specific *"Social production system"* as the social system supporting the production system (Monden, 1998).

The *institutional system* and the *social system* are interconnected and constitute the business system in a comprising system which is the basis for the development of the network of inter-corporate alliances. Using Stafford Beer's VSM, we can draw a basic representation of Japanese lean production viable system as described in figure 3:

"Figure 3 (The basic Lean Production VS scheme) around here"

In figure 3 the "kaisha" (the Japanese firm) is identified with the managerial system. The meta-system and the operations inside the managerial system are both connected with the environment.

Starting from the basic scheme in figure 3 we develop our analysis of Lean Production as a viable system.

First we look "inside the kaisha" and we identify the five VSM sub-systems.

Then we look "outside the kaisha" to detect the relevant supra-systems in the social and institutional Japanese environment. To complete the framework we proceed examining the links among these supra-systems and the kaisha and analyzing the interactions between sub-systems and supra-systems shifting the focus from structure to system, following the VSA.

4.1 The Viable Systemic Structure of the Kaisha

We can identify two main areas in every *kaisha*: the *Meta-system* as a decision making area (sub-systems 2-3-3*-4-5) and the Operative structure (sub-system 1).

It's important to note that, because of the recursive structure of a viable system, the meta-system is present at every level of the organization (including the management of primary units).

4.1.1. Sub-System 1 – Lean production Operations

In Sub-system 1 there is the "Operative Structure" where we find the primary units which adopt the main techniques and practices for the implementation of *lean production* (*kanban*, *jidoka*, smoothing of production, reduction of lead time and batch size, modular cell manufacturing, standardization of tasks and multifunctional workers).

This kind of production can help to achieve the elimination of waste and the ideal one-piece production and conveyance (*ikko nagashi*).

4.1.2. Sub-system 2 – Kanban Coordination System

As we noted before, the kanban is a coordination and information system that "pulls" the flow of materials along the production process. It is an effective tool to coordinate primary units (sub-system 1) and to signal to the upper management the occurrence of problems in the production line. In figure 4 this is indicated by the arrow going from sub-system 1 to sub-system 3, which is the sub-system 2 of Coordination.

4.1.3. Sub-system 3 – TQM as a Control System

This sub-system has the task to harmonize through an internal guidance the allocation of resources and to create synergies in order to augment the performance of primary units. In the lean production these functions are strictly connected to the concept of quality. The sub-system of control in this framework has to put into practice all the actions required to control the quality standards defined by the top management. In order to achieve the goal of an effective implementation of TQM the whole firm-system has to follow a PDCA cycle.

While the "Plan" of PDCA is merely a task of sub-system 5 and 4 and the "Do" of sub-system 4, sub-system 3 manages the "Check" and sub-system 1 the "Act".

To Check the quality standards it is also (but not only) used the statistical methodology through the Statistical Quality Control (SQC). It is important to point out that SQC is a part of the set of TQM elements. SQC alone is not sufficient to implement TQM and achieve and keep quality standards.

4.1.3.1. Sub-system 3 - The Internal Monitoring System: "Jidoka"*

The idea of cooperation and multifunctional workers imply giving more responsibility to the worker. For this reason, in lean production system, the worker controls volume, quality and, in some cases,

financial performance (Heiko, 1991).

Jidoka (or autonomation) is the core of internal monitoring sub-system 3*. Even if we considered Jidoka also as a component of sub-system 1, we included it also as the core of sub-system 3. Infact Jidoka is, as the same Japanese term says, an internal and human control system. Moreover Jidoka makes it possible to obtain information directly from the worker also without the intermediation of management localized in primary units. As described in figure 4, sub- system 3* is represented by the links between sub-system 3 and basic units of sub-system 1.

4.1.4. Sub-system 4 – Business Intelligence through ERP and Kanban

The Intelligence, sub-system 4, is the only part of meta-system which is directly linked with the environment. It collects data from the external environment to transform them into plans. The outputs of the activity of this sub-system are: financial plans, human resource plan, production and operations plans.

In the lean production the planning alone is not considered sufficient to achieve the reduction of WIP inventory and to obtain JIT deliveries.

For this reason the production process has to be efficient but also based on customer demand. To achieve this goal the lean production system is pull and push at the same time. While in the *push production* the speed of production is determined by the availability of raw material or, if using a ERP[9] planning, by the expected demand, in the *pull production* the quantity produced by each process is established by the consumption of materials of the subsequent process and at the end by the real demand. The Toyota lean production system combines the ERP for forecasting (looking forward - push) and the Kanban (pull) for the fine-tuning of daily production within the forecasted period.

In this way it is possible to produce and supply the quantity needed,

[9] Enterprise Resource Planning (ERP) is an integrated information system that serves all departments within an enterprise.

at the time and in the place needed, which is the most important purpose of JIT deliveries of lean production.

4.1.5. Sub-system 5 - The Management Style and Kaizen

Sub-system 5 (Policy) is where top strategic decisions are taken to ensure the survival of the whole viable system. It is the sub-system where the Firm Government operates.
Kaizen and management style have a strong influence on the way to establish objectives and policies of the *kaisha*.

The *"kaizen"* can be considered the force on which is based the viability of the lean production system. Kaizen influences the definition of policy and objectives of the *kaisha*.

With regard to management style, top down decision are not usually appreciated in Japan, because they could break the harmony of the group and create conflicts. The leadership inside the kaisha is based on seeking the consensus through "*nemawashi*" (agreement in advance). To achieve the *nemawashi* the decision is usually preceded by several informal meetings also with middle management. Quality circles are the most effective tool of TQM to promote consensus in the kaisha because the formal and informal participatory management plays an important role in the company's capacity to accomplish the aims of lean production.

Shifting our focus from the firm-system *kaisha* to the supra-system *keiretsu*[10] we can see the similarities among them. In the keiretsu as in the kaisha strategic decision are taken in collaborative way and by searching *nemawashi*. In the keiretsu decisions are taken by the *"shocko-kai*", or President's club. The heads of the companies (president and chairman, or in some cases, only presidents) belonging to keiretsu usually meet once a month. These meetings are the core of the strategic decisions of the keiretsu "relational" groups.

[10] The Japanese industrial group. When written in Japanese, *Keiretsu* (系列) comprises two kanji ideograms (kei and retsu), meaning "system" and "row". Thus the term keiretsu is now used more generally to mean an alliance of companies and individuals that work together for mutual benefit.

4.2 The Environment

In order to understand the Japanese business system, where the lean production was born and developed, it is necessary to analyze peculiarities and unique features of its business system[11]. As Monden pointed out: *"The foundation of JIT production system is backed by social and institutional conditions peculiar to Japan."* (Monden, 1998: 336). The Japanese culture created a business ambiance that is deeply different, not only from the western, but also from those of other Asian countries. It was not by chance that the manufacturing and management techniques, later defined as "lean", were born and raised in Japan.

We analyzed the relevant features of the Japanese institutional and social systems, in order to identify which are the supra-systems that have an important influence on the lean production system. To this scope we shifted from Stafford Beer's VSM framework to the Viable System Approach (VSA) developed by Golinelli.

We found that the relevant and peculiar supra-systems of the Japanese business environment are:

1. the Keiretsu
2. the Financial System
3. the Jinmyaku
4. the Government and the *Kanryo*
5. the Educational System
6. the Labor Market

4.2.1. Supra-system 1 - The Keiretsu

The *Keiretsu* is a group of firms linked by a set of relations (of business and social nature) with the common aim to prosper through

[11] See among the others:
- Hamada, 1991
- Melville, 1999
- Morgan J.C. & Morgan J.J., 1991

mutual help and combination of their resources. From the point of view of the kaisha (the Japanese firm), *Keiretsu* is the closest supra-system. The Japanese lean production system needs a strong link with suppliers forming a cohesive and stable supply chain network. The keiretsu can assure long-term stable relations.

Keiretsu can be classified according to their structures and to the nature of the main company:

- *Vertical keiretsu:* it is characterized by a vertical, hierarchical structure. It is composed of several subsidiaries, subcontractors and affiliates and ultimately dominated by a major manufacturing or trading company. Thus vertical keiretsu can be conceived as a typical Japanese structure of integrated supply chain. Long-term relations with suppliers improve cooperation, which is necessary to improve and keep quality standards and assure Just In Time deliveries. Businesses who maintain long term trade relations with a firm are more interested in long term performance and growth.
- *Horizontal keiretsu:* it includes ties with different corporations in a wide range of industries and it is usually centered on a main bank. A distinctive feature of the horizontal keiretsu is the *"Cross-shareholding"*, this entails that the shares are owned by fellow firms rather than by other investors to reduce the risk of external takeovers.

Keiretsu is still a strong reality in Japan but they are now more open than they were in the years of the Japanese miracle. Even if the Japanese system is gradually transforming due to the deregulation process, it will take time before such a cultural aspect will be changed completely.

4.2.2. Supra-system 2 - the Financial System

The Japanese financial system is "bank-centered" and for many aspect similar to those of Italy and Germany. The relations among enterprises and banks in Japan are characterized by strong links with a main bank, and by ties with the main bank of the keiretsu. The main

bank is the bank from which the firm borrows most of the money. Even if the bank has a limit in the possibility of directly holding shares of other companies, other members of the group can hold shares at the request of the bank, representing the bank's interests. The relationship between the firm and the main bank implies that:

- The main bank serves like a form of corporate governance taking the responsibility of monitoring the firm;
- In times of distress the main bank has the power to change the board of directors of the firm.

The Japanese financial system is currently undergoing a major transformation and evolution. In late 1996 the Japanese government inaugurated its *"Big Bang"* of financial deregulation designed to create a "free, fair, and open financial market". The Ministry of Finance (MOF), which dominated the Japanese financial system policy since the post-war period, has been deprived of most of its former regulatory powers.

4.2.3. Supra-system 3 - the Jinmyaku

Jinmyaku can be translated as "personal contacts" that in the *social-oriented* Japanese business system assume a particular relevance. In Japan, each person and company operates an extensive network of relations called *Jinmyaku*. The more contacts a manager has, the stronger his *Jinmyaku* is. Their value to the company is dependent on their *Jinmyaku*. The Japanese practice of moving managerial staff every two or three years gives to the managers the possibility to extend their personal and company networks.

The *Jinmyaku* are often closely linked through cross-share holdings, information networks and history inside the keiretsu; this represents the *"company's Jinmyaku":* a network of contacts and business relations.

As outlined by Okimoto and Rohlen: *"The emphasis on organizational networks and human relationships, based on structural interdependence, is so strong that Japanese capitalism might perhaps be called 'relational capitalism', in contrast to the American model of*

'transactional capitalism' which gives greater weight to the `invisible hand` of the market." (Okimoto&Rohlen, 1988:16).

4.2.4. Supra-system 4 - the Government and the Kanryo

Since the end of World War II the Japanese government had a strong role with its intervention to support the economy in order to achieve the industrial recovery and development.

The high rank bureaucrats who belong to the industrial and economic ministries are called the *"Kanryo"* and represent the elite class among the public bureaucracy in Japan.

The links among the Japanese government and the private sector are tightened by the practice of *Amakudari*. *Amakudari* literally means "descendent from heaven" and it refers to acquirement of lucrative high-level positions after quitting the government agency. The reason why the *Kanryo* bureaucrats accept the *amakudari* is merely economic, after some years in the private sector they can get golden retirements. This is the way private companies pay back the government officers for the protection received in the past. *Kanryo* bureaucrats, and thus the governmental agencies, traditionally consider the protection and development of the industry under their jurisdiction as their most important task.

This system makes difficult for foreign firms to enter in Japan and to compete on equal basis with Japanese counterparts. Although some authors affirm that the government's industrial policy made the "Japanese Miracle" in the post-World War II period, now the leaders of Japanese multinational corporations believe that Japan's licensing regulation is unacceptable worldwide and they are worried about the consequences abroad (Johansson & Nonaka, 1996; Ohmae, 1982).

Japan is now more open than in the past, thanks to the gradual reduction of the role of *Kanryo*, this in order to favor foreign investment to fight the recession.

4.2.5. Supra-system 5 - the Educational System

Education is considered the cornerstone of success in Japanese society. The Japanese education system is by many aspects similar to the traditional European approach of more than 50 years ago. Its main principles are:

- *Personal discipline* with high levels of tolerance and endurance.
- The *role of the teachers* that are considered with a high degree of respect, being addressed with the honorific title of "*sensei*". They have to prepare students not only academically, but they also have to build up the students' sense of ethics, nurturing their ability to work with others, and making them they stay out of trouble also outside the school.
- The importance of *working as a group*. Pupils since the age of six are taught to live in group and to achieve in group. Teachers educate them to obtain achievements working hard together. The best students must use their skills to help the others. This implies that every accomplishment made individually, outside the group is not awarded.
- The *activities outside of the classroom* are many and frequent. The aim of these activities is to enforce teacher-student relations and the sense of group groups with the commitment to learn and to succed with others transcending individual needs and skills. As stated by Ohmae: *"This cultural upbringing is the mainspring of the workaholic nature of the Japanese"* (Ohmae, 1982).

4.2.6. Supra-system 6 - the Labor Market

The Japanese labor market was (and still is in big companies) traditionally characterized by three elements:

- *Life employment*: the *kaisha* is seen as the "family" of the worker, a community he joins for most of his life as a member and of which he shares success and failures. This labor policy, not imposed by legislation, made it possible to reduce the cost of employment through the benefit and promise of lifetime job.
- *Seniority-plus-merit careers:* career advancements are usually

determined by the years of service in the firm and/or the rank of the university where the employee gained his degree plus, later in the career, the merits of the worker, but not influenced by individual achievements in a specific task.

- *Company unions:* wages and work conditions are negotiated within the company because unions are inside the company and not national like in Western countries. The enterprise unions include all the employees of the company with no differentiation among job category, blue-collars or white-collars. The union is not an entity separated from the *kaisha* or in conflict with it. The "*wa*" (harmony) philosophy shows its dominance in Japanese social and business culture also in the most conflicting issues.

The Japanese labor market is changing. Since the collapse of the economic bubble in the early 1990s, the traditional labor system based on loyalty and relations showed its limit in lack of flexibility in responding adaptively to rapidly changing markets. As stated by Sato (1997), in order to keep the lifetime employment system, large companies are increasingly choosing to transfer their core employees to their affiliates and subsidiaries. As a consequence, the practice of life employment within a single corporation is slowly giving way to the practice of life employment within a group. At the same time the crisis made difficult to keep the seniority based wage system.

In figure 4 we depict the main features of the Lean Production Viable System framework.

"Figure 4 (The Lean Production Viable System) around here"

5. The relations between Japanese environmental supra-systems and the sub-systems of the Kaisha.

In this paragraph we identify the peculiar supra-systems of the Japanese socio-economical environment that impact on the sub-

systems of the kaisha to complete the analysis of the whole structure. When we change perspective from the "structure" to the "system", these relations can be conceived as interactions. According to VSA, a viable system emerges from the structure by the activation of relationships into dynamic interactions among external supra-systems and internal subsystems (Golinelli et al., 2010). This implies a paradigm shift respect of Beer's view from the "static" structure to the "dynamic" system moving the focus of analysis from the individual components of the system and of the relations towards an holistic view of the dynamics of interaction of the observed reality (Barile & Polese, 2010).

5.1 Links with the Educational supra-system

The Educational supra-system is directly linked with sub-system 5 (Policy) because it influences Kaizen philosophy and Management Style. Education in Japan is responsible for teaching children and students the value of kaizen. Concept of kaizen like the 5S of housekeeping are taught in the classrooms being part of the Japanese educational culture as well as orientation towards group work. Management concept like *nemawashi* contribute to creation and maintenance of a non-conflictual work environment, necessary for the implementation of kaizen within the company. Educational system is related also with sub-system 1 (Lean Production Operations) and 3 (Control). The orientation towards the group is indeed a key factor for the effective collaboration in primary units (such as modular cell manufacturing, multifunctional workers, etc.) and to implement TQM.

"Figure 5 (Relations among educational supra-system and kaisha sub-systems) around here"

5.2 Links with the Labor Market supra-system

Labor ethics and corporate unions make possible it to have a flexible work force (multifunctional workers). Multifunctional

workers are necessary both to reduce the batch size and the lead time, seeking to achieve the "*ikko nagashi"* and to implement the modular cell manufacturing. Furthermore, in exchange for flexibility, workers are habitually and significantly involved in the product key manufacture (Jidoka). Most companies use the JIT-Kanban system also to provide life employment. This supra-system is connected to sub-system 1 (Lean Production Operations), 2 (Kanban Coordination System), and 3* (Internal Monitoring system).

"Figure 6 (Relations among labor market supra-system and kaisha sub-systems) around here"

5.3 Links with the Keiretsu and Jinmyaku supra-systems

Keiretsu and Jinmyaku contribute to establish long-term relations with suppliers. The Keiretsu system nurtured many of the successful Japanese practices thanks to the stability ensured by loyal suppliers and customers. Long term relationships with vendors permit the transfer of technology which enables them to adopt the same lean production system of the main company. Therefore, kanbans can circulate not only inside the company but all along the supply chain. In such an environment stock levels can be kept at a minimum and the kanban system (pull production) works at its optimum. Hence these two supra-systems are connected with sub-system 4 (Intelligence). These relationships with suppliers create the condition of reliability required for the smoothing of production and the reduction of batch size, all of which are imperative factors of JIT (sub-system 1).

"Figure 7 (Relations among keiretsu and Jinmyaku supra-systems with kaisha sub-systems) around here"

6. Lean Production Viable System: from Structure to System

After the analysis of the architecture of our Lean Production Viable

System framework, we demonstrate how the dynamics of lean production can be seen in the viable system approach (VSA).

Considering the characteristics of viable systems according to Golinelli (see paragraph 2) we consider the lean production system according to each of the features indicated in VSA. The lean production system is:

- *Open*. Our scheme in figure 4 describes two kinds of interactions with the environment:
  - between the sub-system 1 and the environment;
  - between sub-system 4 and the environment.

  This links are essential to maintain the viability of the system through the exchange of information, resources and raw materials.
- *Self regulating and homeostatic*. Lean production is also a pull system: the flow of information coming from the environment conducts and continuously redefines the activities and the objectives of the *kaisha*. This is possible by two characteristics of the lean-enterprise:
  - the lean structures of the *kaisha* with its high level of flexibility,
  - the *kaizen*, which makes the *kaisha* able to self regulate according to the changes of the environment by improving standardized activities and processes (*SDCA cycle*).
- *Equifinality.* The strong sense of group and cooperation that prevails on individual performance, creates an awarding system that rewards the result of the team. Thus everyone, from the top management to the blue collar workers, is motivated to contribute to the outcome of the group and pursue a common finality which can permit to the system to maintain its viability. This characteristic of the Japanese social environment has a strong influence also inside the kaisha (with Quality Circles and Cellular layout of shop floor) and the keiretsu (with *Presidents' Club* and long-term relations) and for both determines the *nemawashi* decision process.
- *Well-balanced:* the philosophy of "wa" through the kaizen avoid

revolutionary changes that could disrupt the harmony and the spirit of group inside the *kaisha*.

- *Autopoietic:* many of the features of lean production system and especially *Jidoka* and multifunctional workers allows the system to self organize and regenerate.

If we consider Golinelli's first postulate (*a system is viable if it can survive in a particular sort of environment*) we deem that lean production was born to cope the peculiarities of the Japanese business environment in a continuous evolution to adapt to it, exactly as a viable system would do.

Lean production system has also the *isotropic property*. The internal system of *lean-firm* is divided, indeed, in two areas: decision making and operative structure. These two parts are linked by relations of coordination and control, as every viable system. And this is evident in every *kaisha* and at any level of the *kaisha*, because of recursivity property.

Moreover, Lean production system openness, flexibility, self regulation and pull approach seek legitimacy and consensus, structural consonance and systemic resonance with the environment, as a generic viable system seeks the relations and interactions of the lean-firm with supra-systems.

7. Conclusions

The Japanese lean production still represents the global benchmark in the manufacturing sector. In supply chain and production systems, the Japanese approach is probably the most effective model to attain both effectiveness and efficiency in turbulent environments. Despite of lean production system value, its nature has always been strongly linked with the Japanese business environment, so the implementation of this approach outside Japan has often been problematic.

In this paper we examined the basic principles of lean production system in a viable system view.

The viable system approach is a powerful set of ideas, which serves as a theoretical and practical base to understand and define enterprise architecture and dynamics. VS is a cogent model to describe the firms and their relations with the environment. In the business science academic world, many critics point out that a model based on a metaphor may have some limitations in the practical use, we don't believe so. With this paper we used the VSA to analyze a business system and to represent it in a viable system framework.

This analysis is not a mere academic exercise. Through our interpretation of the lean production system we demonstrated that it is without any doubt a viable system.

We think that this framework can be functional for a better understanding of lean production. Understanding lean production and considering it a viable system can explain many of the failures in exporting it outside Japan and be the basis for the research of ways to implement it effectively in different environments.

This could be not just a way to achieve profit but could also have social relevance, if we consider that the links with a particular environment and the quest for agility and fast adaption to customers (which are typical of the lean production) could be a reason to avoid the allocation of industrial plants in other countries, thus having a great impact on employment levels and fighting the crisis of advanced economies.

With this studied we showed the "Why" lean production is rooted in Japanese culture; the next, and more important, step is to do further research to understand "How" the "lean approach" could be adjusted to succeed in other developed countries, trying to evaluate if it might have the same synergic effects and the same competitive value that the Japanese lean production found in its original environment to cope with the challenges of 21st century.

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