The dynamics of the JIT/Lean system and its sustained successes

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Any system can be judged by its goals and its results. The results are dependent on the goals and reflect the goals’ ambitions. Wonderful results based on improvement activities aimed at “reasonably attainable” objectives can hardly be sustained over a long period of time. Such improvement programs are here referred to as simple or time-framed improvement programs.
Continuous improvement (kaizen) implies the idea of endless efforts aimed at goals that are seemingly beyond the system’s means or reach. The paper sustains thus that kaizen is a dynamic process directed toward unrealistically reachable goals. In fact, the paper shows that asymptotic goals are the dynamic engine that sustains lean systems like TPS. The paper tries to identify and classify those goals without which the TPS/JIT system dynamics could have lost its steam. Besides, the presentation offers the framework within which sustained results and a system’s kaizen can be measured.

Key words
JIT system, Lean system, TPS, Kanban, QCC (quality control circles), SS (suggestion system), improvement, time-framed improvement, simple improvement, continuous improvement, kaizen, system’s dynamics, system’s goals, z-goals, s-goal, asymptotic goals, achievable goals

1. Approaches to improvement activities
Theoretical approaches to improvement activities feature a number of patterns that can easily be identified (Kupanhy, 2005). Descriptive and empirical studies seem to focus on the benefits of kaizen activities (Imai, 1991; Nemoto, 1983; Monden, 1983 & 1998; Kupanhy, 1994; Brunet & New, 2003). Kaizen has also been studied from the viewpoint of knowledge and cost management (Delbrigde & Barton, 2002; Modarress, Ansari, Lockwood, 2005 ). Researchers have not only dealt with the transfer of Japanese kaizen techniques and their implementation in different managerial and cultural settings (Recht & Wilderom, 1988; Cole, 1983; Abdul-Azia, Chan, Metcalfe, 2003); but they have also examined the role kaizen can or should play (Sverker, 1992; Imai, 1991; Lillrandk, 1991, Webb 1993)
Monden’s approach to kaizen seems the most interesting in the sense that it
deals with kaizen within the framework of the QCC and SS structures. Kupanhy (2005) has not only shown the importance and merits of Monden’s descriptive framework; but he has also gone beyond it to tentatively establish a strong relationship between QCC, SS, and successful kaizen activity programs. Yet, he has recognized the probability for a company to have improvements even though it does not feature any QCC and SS. In other words, improvements can take place outside the framework of those two structures; but he contends however that such improvements can not be sustained over a long period of time:

“Improvement can be made without setting up QCC and SS programs. However, QCC and SS being by their nature and purpose permanents instances for improvement, without them it seem almost impossible to sustain improvements. And for me, sustained improvement is the same as continuous improvement. In fact, the analysis of the data findings has strongly suggested that companies sporting both QCC and SS are the most likely to make not only improvements but substantial improvements.”

Although the different approaches to kaizen mentioned so far have each the merit of shedding the light on specific aspects of the Japanese concept of kaizen, they seem however to be static and have so far failed to point to the dynamics of improvement processes of the JIT/lean production system. Furthermore, they do not seem to clearly distinguish between “improvements” and “continuous improvements or kaizen”.

2. Results of kaizen structure activities at Toyota

In fact, kaizen by its essence and nature is a dynamic process of continuous or endless improvements. Just for the sake of illustration, let’s get a quick look at the number of suggestions for improvements at Toyota. Toyota set up the kaizen structures (QCC & SS) in 1951. On the 50th anniversary in 2001, the total cumulative number of suggestions for improvements was 34,690,000. That means an average of 693,800 suggestions per year during 50 years. In the 1980s, a period with peaks of over two millions, more than 95% of those suggestions were turned into actual improvements. In 2002, 651,000 suggestions were collected and the company did turn 99.5% of those suggestions for improvement into actual improvements.1 How can a company

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1 See Toyota Jidoshaino teianseido (Toyota’s Creative Suggestion System), unpublished. This document was given to me by Toyota in June 2003 during a study tour with my Japanese students of Wakayama University, in Japan. It is worth noting that while the number of suggestions have significantly shrunk, the cost saving has not. In fact, improvement’s main areas have shift from production lines to engineering design rooms.
sustain improvement activities and their successes over half a century? Can other companies do the same?

3. Production goals: Toyota vs. Nissan

In June 2002, I visited a Nissan plant in Tochigi with graduate and undergraduate students from Wakayama University, Japan. This was done in the framework of my course of Japanese Production System. So we were interested in the kanban production system. We were told that kanban was not used at Nissan any more. It was abandoned 20 years ago since it brought only problems, disturbing the production due to drivers often confusing for instance the number of parts with the number of kanban. We learned also that at Nissan Tochigi Plant, the make-to-order and make–to-stock production represents 60% and 40% respectively. On the other hand, it is well known that Toyota aims at zero make-to-stock production. I then realized that the two companies should have different production strategies. I therefore thought the (kaizen or improvement) structures set up to support their respective different strategies should not be similar.

It is clear that Toyota knows it will never reach its objectives although it really struggles to; that is why its deployed efforts to get at the goals will have no limits. Nissan can realize its goals. What would happen if/when it does so? In all probabilities, the improvement efforts can be relaxed, unless the company comes up with new targets. By not having the kanban system, the constraint of zero inventories of finished goods ceases being a priority.

We can see that reachable goals set limits to improvement range and human creativity since it confines improvements within a defined framework. Besides, I have visited a number of companies in France where I was given the results of improvement activities carried out years ago. Ideas have since then dried up in the cases where management have set clearly reachable objectives. In some companies, kaizen programs have been initiated, then abandoned or not given any priority any more because of turnover of top management people

2 The case of Caterpillar Plant in Grenoble is very instructive. Years ago, when the plant felt that it was under the threat of being closed, management set clear objectives, switched to the JIT system. At the time I visited that plant in 2000 in the framework of INSEAD’s Industrial Excellence Award, the plant’s life was not in danger anymore. Interestingly, QCC/SS and cost reduction methods (TPM, 5S, etc) adopted during the crisis period were clearly things of the past. We could find some vestiges of improvements made years before, but no sign of such activities going on at the time of the visit.

3 It reminds me of a presentation made by two NASA engineers at the Annual Conference of Industrial Engineering in May 2005 in Atlanta. When I asked them why NASA waited so long before implementing the 5S, the answer was that they had just had a new dynamic and young manager who initiated the program.
come (and go) with different strategies.

In the Japanese context where managers are promoted from within, if there are no ambitious programs to aim at, it may be difficult to overcome the routinely negative effects of the corporate cultural inertia. The risk of not making improvements any more, i.e., becoming less performing, increases highly.

4. Improvement structures and production system goals

We remember that QCC and SS are structures within which improvements can be made and sustained. On the other hand, Chandler (1962) has clearly showed through an empirical historical research that structures never come first. He has somewhat proved that the cart can not be put before the horse. Structures are set up to support specific strategies. Strategies come first. Kaizen or improvement can be viewed as strategies aimed at increasing product quality, process efficiency, workplace safety, etc. And it is well supported by QCC and SS structures.

QCC and SS play also the role of supporting structures for the lean system of which they are at the same time integral part. Therefore, their activities are aimed at the realization of the overall goals of the Toyota/JIT lean production system.

Our earlier studies of the JIT system have emphasized the fact the Japanese JIT/lean production system being made up of elements drawn from the industrial engineering field, from the Japanese management environment and from the structure of operations of the line workers (multi-process handling or multi-manning operation), an implementation of the system outside Japan based mainly on its engineering components would definitely result in limited or partial successes (Kupanhy 1995).

We have contended that most companies that switch to JIT production experience short-lived successes not only because they focus on implementing its operational/technical aspects but also because they fail to pay attention to the supply chain system as its strategic framework of success (Kupanhy, 2005).

The present paper tries to shed a new light on the important role of continuous improvement as a supporting structure for a sustained success of JIT/lean production methods. At the same time, it tries to clarify the difference between simple improvement and continuous improvement, and on the other hand, it examines the impact of their respective activities.
We have rightly pointed to the crucial contribution of structures like QCC and SS to a real sustainable success of kaizen activities within the framework of a successful JIT system. Toyota has been singled out as a model example. But does it mean that setting up formal structures of QCC and SS will automatically and necessarily lead to continuous improvements and sustained successes for ever?

Any system can be judged by its goals and its performance or results. The results are themselves dependent on the goals and may reflect at the same time the ambitions of those goals. Many companies take pride in the fact that their performance results are within the range of, and/or even beyond their fixed objectives. The conventional interpretation would be that management has set for the company realistic goals. But can realistic goals play the role of a dynamic engine for sustaining continuous improvements? We are inclined to answer,” No”.

4.1. System goals: simple vs. continuous improvement

We contend that, wonderful results based on improvement activities aimed at realistic, i.e. reasonably attainable, objectives can hardly be sustained over a long period of time. The paper tentatively refers to improvement programs designed in order to attain realistic goals as *simple improvement* programs. In order to sustain such programs' activities, one will in fact have to look continuously for new targets without which continuous improvements cannot be made. Not finding new targets anymore might result in the loss of interest in improvement activities. Therefore, improvement programs designed in order to attain realistic goals can not qualify as continuous improvement or kaizen programs. *Simple improvements refer to one-time, fixed-term, short-term or time-framed improvements, well confined within a specified time range during which stated goals will/should be accomplished.* Once the defined objectives are achieved, improvement activities lose their raison d’être and usually stop going on unless new objectives are set. In other words, the results of such simple improvements can not be sustained over a very long period of time, less last for ever. In fact, the sustainability of such results would require continuously setting new targets without which endless or sustained improvements cannot be made (See Exhibit 1). In the West where a high turnover of top management is a common feature, new top management people usually bring not only new blood and ideas, but also new strategies and objectives for the companies. Unfortunately this will not lead to continuous improvement programs but to *successive and/or intermittent sets of different types of improvement programs* (See Table 1). Nissan having set for itself reachable goals ended up feeling the
need, in the long run, for an outsider from the West to bring in new ideas and save it from going bankrupt\textsuperscript{4}.

The Toyota system constrains and challenges Toyota people to continuously come out with new ideas since its clearly stated objectives are placed at a level that can not reasonably be reached, but to which (level) the company can, through endless efforts, get closer and closer. And Toyota relies on these ideas in order to improve its products\textsuperscript{5}. The objectives of the JIT require the company either to continuously break its own records; or to sustain the effort so that it can not fall down at the lower level.

True continuous improvements imply thus the idea of an endless effort aimed at a goal that is seemingly out of the range of the means at one’s disposal. In other words, the characteristics of a company’s goals determine or define the nature of its improvement activities. With realistically achievable goals, improvements will definitely have limits. \textit{We sustain thus that the continuous improvement is a dynamic process directed toward reasonable unreachable goals} (See Exhibit 2 & Table 1).

Exhibit 1: Achievable goals lead to time-framed or simple improvements

\begin{center}
\begin{tikzpicture}
\begin{scope}[node distance=2cm, auto]
    \node (achievable) {Achievable new goals};
    \node (system) [right of=achievable] {System’s time-framed QCC & SS or improvement structures};
    \node (time-framed) [below of=system] {Time-framed and/or successive improvement activities};
    \node (simple) [below of=time-framed] {Simple or time-framed improvements (non-sustainable results or performance)};

    \draw[->] (achievable) -- (system);
    \draw[->] (system) -- (time-framed);
    \draw[->] (time-framed) -- (simple);
\end{scope}
\end{tikzpicture}
\end{center}

\textsuperscript{4} When problems Nissan was experiencing started being made public in the Japanese press, I asked a young Japanese colleague of mine, why Nissan was performing badly while Toyota and Honda were doing so well in the same Japanese car market. This can not be due to the price since for similar models there is almost no difference in price between the three manufacturers. He replied that the general perception in Japan is that the defective rate for Nissan is higher. And then he added, “Look at the prices of used cars, and you will understand that Nissan cars depreciate very quickly in the mind of the car users. That is why for similar used cars, Nissan models are usually cheaper”.

\textsuperscript{5} In Takaoka plant, the statement “Good Thinking, Good Products” is well displayed in order to show the importance of ideas from employees. According to an un-published document I was handed, the motto was adopted in 1953!
Monden (1997, p. 1) has rightly pointed to the fact that “The primary goal of the Toyota production system is cost reduction”. In fact, cost reduction to the lowest level, to the minimum i.e., to zero might be considered the ultimate and legitimate target. That goal can be reached only as results of attaining various other concrete goals TPS has assigned itself. The goals of that lean system are by their very nature asymptotic. They constrain thus the TPS/JIT system to continuously look for ways to improve the tools and means it uses in order to get closer and closer to those unreachable goals.

4.2. JIT/Lean system’s goals as its internal dynamics for kaizen

Monden (1997, p.1) has rightly pointed to the fact that “The primary goal of the Toyota production system is cost reduction”. In fact, cost reduction to the lowest level, to the minimum i.e., to zero might be considered the ultimate and legitimate target. That goal can be reached only as results of attaining various other concrete goals TPS has assigned itself. The goals of that lean system are by their very nature asymptotic. They constrain thus the TPS/JIT system to continuously look for ways to improve the tools and means it uses in order to get closer and closer to those unreachable goals.

4.2.1. z-goals and s-goals

The goals of the JIT/lean system can be classified into two main groups. The first category is made up of those that aim at reducing operations costs to zero, i.e. a
100% thorough elimination of each kind of targeted wastes:\(^6\):

- zero inventories (of finished goods),
- zero defective items,
- zero defective work/operations or zero wasteful processing,
- zero transportations (within the production system),
- zero delivery lead times (within the production system),
- zero setup times,
- zero time on hands
- zero wasteful motions,
- zero overproduced items,
- zero delivery time (reaction time),
- zero accidents,
- zero physical and/or administrative barriers,
- zero design-in defects, and so on.

Of course the realization of those goals would lead to the likelihood of reducing costs to zero. Such objectives are referred to here as “zero-object” goals or z-goals.

Are tentatively considered to pertain to the second group the lean system’s goals consisting each of a single unit or single object:

- single-unit production and conveyance, i.e., one-at-a-time production flow of material,
- single unit of wip at each process (i.e. the item mounted on the machine and being processed),
- single integrated processing line,
- single reduced shop floor,
- single virtual company that includes suppliers and manufacturer and customers, and so on.

We term the elements of this second group as “single-object” goals or s-goals.

In the framework of kaizen-supported JIT system with its unreachable goals, we will never say, when evaluating the results, that we have reached our objectives, but we can just say how far we have moved toward the goals or not.

*These z-goals and s-goals are what makes up the dynamics of the JIT/Lean production system.* The JIT/Lean system is a set of many techniques and methods (Kupanhy, 1995). QCC and SS are for sure part of the JIT system.

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\(^6\) Hiroyuki Hirano (1997) mentioned well 5 of the z-objectives as a background setting of the JIT system. He does not look at them as the engine that makes up the dynamics of the JIT system. Chiba et al. (1998) also are interested in the production processes to which they assign z-goals but once again they don’t find or establish any relationship with the production system’s continuous improvement process.
Furthermore, they provide support to each of the remaining JIT techniques. Without QCC and SS structures, it would be impossible to implement JIT, i.e., to attain its goals.

4.2.2. System’s strategic and operational goals

A close look reveals that the objective of zero inventories is not of the sphere of production operations. This objective is fixed at a higher level, at which level it should be situated. It is in fact a strategic goal. The other goals can be categorized as operational targets. Their accomplishment at the production operations level makes it possible to attain the production department’s strategic objective of zero inventories.

We do remember that the primary goal of the TPS is thorough cost reduction. This is a corporate strategic goal that shapes and impacts strategies of each functional department. In fact, it is translated differently in the different functional departments which will set their respective goals that will contribute to the accomplishment of that global goal of the corporation, i.e., the cost reduction to zero. In the manufacturing or production organization, that step may consist in the reduction of inventories to zero, which, as stated earlier, is a strategic objective of the production department.

Pursuing the objective of zero inventories can be attained through the
accomplishment of operational targets (see Exhibit 3). If the corporate objective were not asymptotic (cost reduction to zero), the production department’s goal would not be fixed at a reasonably un-reachable level (zero inventories), and there would be no necessity of setting asymptotic operational goals. By the same token, there would be no reason for improvement structures to be permanent. And without permanent improvement structures, it would not be possible to have continuous improvements.

4.2.3. JIT/Lean system’s goals and continuous improvement structures

For the sake of illustration, let’s just examine a few operational goals in order to show a) how lean methods aimed at the system’s operational goals are supported and sustained by QCC and SS; b) how the asymptotic features of those goals imply the setting of permanent but dynamic QCC and SS structures.

- **Zero setup times**

  In fact, the kanban system implementation requires that the set-up time be reduced first. Without ideas for improvement, it would be impossible to reduce the changeover time. And, in the absence of QCC and/or SS structures, it would be very difficult, if not almost impossible, to gather ideas for improvement, and then turn them into actual improvement, i.e., actual set-up time reduction. The likelihood of reaching such a goal of zero set-up time makes it necessary to keep QCC/SS continuously running.

- **Zero defects & wasteful processing operations**

  The JIT aims at zero defects and defective processing (operations). Poka Yoke can help reach those objectives. It is known that Poka Yoke devices are based on the suggestions for improvement and are at the same time results of QCC and SS suggestions for improvement. Because of the practical unlikelihood of reaching that goal on the one hand, and the possibility of getting closer and closer to it through sustained effort on the other hand, it seems necessary to set permanent but dynamic QCC and SS programs.

- **Zero transportations, zero wasteful motions, and one single integrated processing line**

  The JIT/Lean system requires that operations be standardized, the processes be laid close and/ even linked to each others. Ideas for standardization, freeing unnecessary space that is the cause of transportation and laying processes in an efficient way have their sources in QCC and SS activities, etc. Is it possible to have zero transportation? Is it possible to reduce an operator’s motions to ones value-creating only? Unfortunately, one could hardly find a single production site
that could proudly pretend to have realized such a feat. Therefore, keeping QCC and SS permanently would contribute to continuously reducing those wastes.

Besides, one of the underlying principles of the QCC/SS-supported JIT/lean system is that the imagination and creativity of the human being as well as his capabilities to learn has virtually no limits. That may be the reason why the system 1) expects the ideas from employees their career long; 2) trains its operators in developing as many skills as possible; 3) sticks to continuous job rotation and training; 4) requires that an operator be able to man as many machines or processes as possible; 5) aims at using the least number of people of the production line. Such an operator can attend to a whole production line would the latter consist of a limited number of machines. This mean that one would be then ideal number of operation worker. This is another asymptotic goal

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7 Shingo (1981, p. 103) reported that at Toyota “Around 1955, 3500 sets of machines were equipped in the machine plant and only 700 workers were employed. Therefore, an average of 5 sets of machines were managed by one worker”. In a survey conducted in Osaka, two companies stated that the maximum number of machine a worker can supervise was 10 (Kupanhy, 1994, p. 168). And Monden (1983, p. 69-70) reported that at Toyota, “In the gear manufacturing process, (...) each worker attends to 16 machines (...) which perform different types of operations: grinding, cutting, etc”. This aspect having a minimum number of workers handling many processes should not be confused with un-manned processed or computerized processes. Here the worker successively switches on machines, mounted items on them, detached processed items, etc.
that just reminds us that there is no end to improvement activities.

**Conclusion**

The asymptotic goals of the JIT/Lean are the engine that keeps the system running continuously, autonomously and confers to the system its auto-dynamic aspects. Those goals keep the system questioning not only itself, but also the means and methods it uses since it can never be 100% satisfied of its performance even though it breaks many of its own past records. If the too high level at which those goals are set is lowered, one may get the satisfaction of reaching them; but at the same time that sets limits to human creativity and, by same token, to improvement activities. *Improvements that help realize the reasonably fixed goals are what we have called simple or time-framed improvements. Endless improvements are aimed at goals we will never reach. Only such improvements are referred to as kaizen or continuous improvements.*

Therefore, there is no kaizen without unreachable goals. And kaizen is the sign that the system as well as its supporting structures (QCC and SS) remain permanently dynamic (Exhibit 4). This is the main feature that distinguishes JIT/Lean or TPS from other production systems.

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