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Lean production

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Abstract

"Lean production", or rather "lean management", is an intellectual approach consisting of a system of measures and methods which when taken all together have the potential to bring about a lean and therefore particularly competitive state in a company. The main fields of activity concerned are product development, the chain of supply, shop floor management and to a lesser extent after-sales service. The portability of the concept in the light of changing circumstances can be called into question, but it nevertheless provides food for thought for the restructuring of industries whose production processes are out of date.

As a contrast to this, a brief introduction is given to the fractal approach, which is based on the self-organisation of goal-oriented corporate units and which enables solutions which are ideally suited to each individual area to be integrated into a dynamic structure. This does not mean copying existing solutions but exploiting one's own particular strengths.

Keywords: Lean production; Automotive industry; Plant management; Self-organization; Fractal company

1. Point of departure

When in 1990 a book appeared by the title, *The Machine that Changed the World*, often referred to as the "MIT study", no-one anticipated the repercussions which the ensuing debate would have [1]. Even the authors themselves were surprised by the extent of the controversy.

The causes of such a wide-ranging debate must be sought in a wider context, i.e. in the competition between the most important industrial areas of the world: North America, Japan, Western Europe, the so-called Triad. In this respect, the subject matter is not new, but none the less serious. One thing that has since become irreversible is the disappearance of the once leading German optical industry from the mass markets, and a similar event has taken place in consumer electronics. The debate was rekindled in the 1970s by the entry of Far Eastern competitors into the flagship of Western industrial countries, namely automobile manufacture.

The competitive situation is forcing industrial companies to come to terms with the so-called Japanese or even Japanese–American challenge [2]. The shortfall in productivity ratios which had been evident for some time resulted in industrious if also partly irrational reactions, for example to the

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explicit goal of creating a "Japanese factory" in Germany. Consequently, the MIT study falls on fertile ground since it offers a recipe for meeting this considerable challenge: through lean production.

2. The elements of lean production

But what is lean production? This notion can best be characterized as a system of measures and methods which when taken all together have the potential to bring about a lean and therefore particularly competitive *state*, not only in the manufacturing division, but throughout the entire company.

Four individual aspects can be identified:

- product development
- chain of supply
- shop floor management
- after-sales service

Here it becomes clear that production itself is only *one* field of activity in this new structural approach. Against this background the term itself must be seen as something of a misnomer. "lean management" or "lean industry" would be a much more appropriate description.

Occasionally, the essence of lean production is reduced to the notion that when compared with conventional systems only the half of all resources (time, costs, staff, etc.) are needed. The mere stipulation to restrict these factors in such a dramatic way is of course of little help when it comes to putting the idea into practice. Methods of rationalization have been systematically sought after for quite some time.

The MIT study therefore illustrates how this requirement can be met by drawing a comparison between the model, the "Toyota Manufacturing System", and the "old" structures. In order to appreciate the nature of lean production we must therefore examine more closely the four fields of activity indicated above.

2.1. Product development

The continuous process of product innovation and further development assumes a much greater importance in today's competitive environment than was the case one or two years ago. This can be seen most clearly by reference to what is probably the most short-lived industry of our times, the manufacture and distribution of semi-conductors.

The time window within which acceptable prices can be obtained in the marketplace is often reduced to only a few months. Whoever misses his opportunity here finds himself sidelined in a very short space of time. In this regard we must not lose sight of the high capital investment required. In the 1970s it cost approximately 30 million dollars to set up a production plant for memory chips. Today the costs are 20 times that amount and we can expect this figure to double yet again with the next product generation. Product development costs alone amount to about the same figure (approximately. US $1 billion for the 64 MB DRAM) [2].

The period between product specification and production start-up must therefore be kept as short as possible. Many small- and medium-sized businesses still do not appreciate that the continued existence of their company is largely dependent on this fact.

Not very much remains today of the vision developed in the 1980s of mastering this problem through the increased use of technology. Neither computer integration nor more flexible manufacturing systems are the ultimate answer to this challenge. Experts are increasingly favoring organizational measures to shorten the product development cycle (Fig. 1) [3].

The early involvement of specialist departments reveals possible problem areas in time for the necessary corrective measures to be taken. This is not usually possible after delivery, quite apart from the loss of prestige involved.

If costing, delivery and quality targets are optimized in unison then the spectrum of business activities is extended considerably. It is not just a matter of responding to short-term trends; by minimizing costs in this way, finance becomes available for many more innovations and detailed improvements which would not otherwise be possible. Taken together, these contribute significantly to overall competitiveness.

In addition, there is a further effect: the ability to concentrate on critical value creation stages and to involve suppliers in quite a different way.

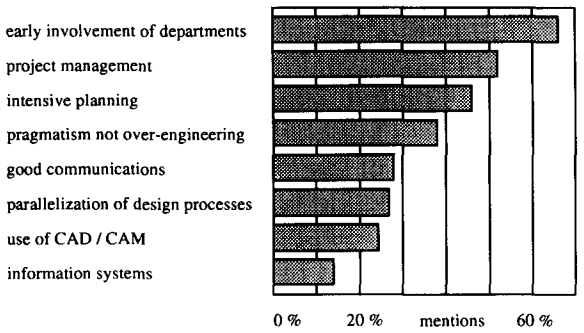

Fig. 1 Methods of reducing the product development cycle – survey of experts. (Source: Fraunhofer-Institute for Industrial Engineering, Stuttgart).

2.2. Chain of supply

The message of the statistics is unmistakable, at least at first sight. Whilst a Japanese assembly plant obtains parts from 170 suppliers, European firms deal with 442, and American ones with as many as 509. This highlights a structural difference in the respective supply markets: in the West this market has a flat structure, i.e. a large number of manufacturers supply direct to the assembly plant. This makes it possible for General Motors to purchase the 25 components for a seat from the same number of suppliers prior to assembling it in-house, with all the related technical and logistical problems which this involves. The situation is quite different in the Far East. A single supplier is made responsible for supplying flawless components exactly in accordance with requirements. He in turn purchases a large number of parts from subcontractors, resulting in a supply pyramid.

The authors of the MIT study are open to the criticism that in their analysis of business connections, they regularly ignore the second and all subsequent levels. This results in a distorted picture of the true relationships.

Neither working conditions nor labor contracts have anything in common with the image which is so often propounded of modern manufacturing plants and cooperative relationships. A considerable amount of the success of Japanese exporters was achieved on the backs of small businesses and their staff. These facts are only reluctantly revealed to visitors. "One does not parade one's wounds", commented an official from the Economics Ministry [4]. However, the problems of this two-tier system have now been recognized in Japan and the first steps have been taken to deal with them. This cannot fail to have an effect on the whole chain of supply.

It is important to remember that system suppliers have a long-standing tradition in Europe. The main difference between this and lean production is, however, much more deeply seated; it is to be found in the trading relationships between an assembly plant and its suppliers.

A great deal of effort continues to be expended on maintaining a base of suppliers who can be played off against each other. Profits of suppliers are becoming virtually non-existent and a process of concentrating on viable units is already well under way. However, the conviction still widely held in purchasing departments that such business practices have the result of getting the best deals for their companies is proving more and more debatable.

Out of fear of initiating a new round of price increases, suppliers carefully conceal their circumstances and processes from their customers and this applies even more to their dealings with competitors. This consequently precludes any multilateral exchange of information and experience, robbing all concerned of a variety of opportunities to exploit structural reserves. It is only recently that dialog on this subject has started in earnest. However, partnerships of this nature do not seem to be very strong as yet, as recent experience has shown. When business takes a serious turn for the worse, pressure is exerted primarily in an external direction, even if this tends to be destructive in the long term.

So let us summarize: a reduction in the vertical range of manufacture opens much greater potentials than is often supposed, provided that partners collaborate from the design stage right through to delivery instead of eyeing each other distrustfully.

2.3. Shop floor management

The characteristics and effects of lean production can best be studied in the factory itself. First it is

apparent that only very few people are to be seen going from workplace to workplace. When compared to the hordes of fitters, stand-ins and quality inspectors who dominate the image we have of such manufacturing plants, the difference is self-evident. A conscious effort is made to concentrate all activities on the actual business of creating value. This means dispensing with a large number of overhead operations.

These operations become redundant because their causes have been removed. Faults are not detected by an inspector specially engaged for that task and subsequently corrected in a repair shop staffed by specially trained staff. Rather, defects are identified at their point of origin and systematically eradicated. Depending on the situation, this can be achieved by a variety of means, e.g. by altering the part, the device or the production process. This prevents the same fault from occurring again. In contrast to this, many conventional manufacturing systems are not in a position to respond adequately to such situations. In order to avoid halting the production flow, which is taken to be the ultimate yardstick, faulty parts are even consciously included, only to be repaired or exchanged at great expense later. This repair work accounts for a considerable portion of the overall assembly time.

Furthermore, in a lean factory the practised eye notices how clearly arranged the whole manufacturing system is. Members of staff maintain regular eye contact with each other and can react quickly and flexibly to irregularities. It is interesting that the production line only rarely stands still although each worker is able to call it to a halt, in contrast to traditional mass-production systems. The reason for this lies in the systematic implementation of a familiar insight: the vast majority of all defects are evident from their first occurrence, at least to an experienced member of staff. It is therefore mainly a question of encouraging intervention at the appropriate time.

A further explanation for this clearness can be observed in the practice of delivering parts to the workstation as and when they are required. The space available is inadequate for larger stocks, so unnecessary inventories, which may clearly harbour a variety of problems, can not be established.

For methodological reasons, all of Womack's studies refer to assembly plants, but they can be applied in principle to all areas of manufacturing, e.g. parts manufacture. With regard to the prevention of defects, for example, this could mean changing tools in good time. Another method which could well be employed here would be the constant recording and processing of production parameters.

Far Eastern cultures are conducive to the implementation of the insights derived above. This becomes particularly clear when we look at the quality circle. Attempts to transfer this method directly to the Western world have, however, been rewarded with only modest success; often enough there was no discernible success at all. Now is the time to re-examine this idea.

Group technology concepts are now being strongly advocated once again. But the way they are being introduced here does not bode well. Here, too, models are often taken which are based on quite different requirements. Assembly and process structures can be very easily changed from the top, but this leads us nowhere if management principles remain untouched. This is a recipe for many a disappointment, although the approach itself is justified. In the meantime reports are flooding in that the introduction of group technology has not achieved any visible reduction in absenteeism, which is a reliable indicator of the quality of personnel management. It must be assumed that in all these cases the corporate and management culture has not become leaner. The whole question of lean production is being treated on a much too operative level. The intellectual considerations of the management philosophy behind it are currently being given short shrift.

2.4. After-sales service

If it is true that our current circumstances conform to the model of a service economy, then this should be especially evident in our relationship to the automobile, a product which is so important for so many people. Indeed there are a wide variety of both useful and questionable services in connection with the motor car.

In European countries it is therefore unthinkable to sell a car as a discount product, although it is in fact a quite uniform mass-produced item. The establishment of a relationship of trust with the customer, who expects to be treated courteously and to receive professional advice, is an indispensable pre-requirement for sales success. The anecdote related by Womack of a former shoe salesman who lacked all technical knowledge of the cars he was selling can hardly originate from central Europe. If it is an indication of the state of affairs on the continent of America then this is a sign that there can be no universally valid business strategy. No sector of the business community reacts more quickly and with more imagination to the requirements of the market than the department which confronts it directly, namely the sales department.

It is hard to appreciate why a drastically reduced network of distributors such as that required by a "lean" sales organization should be in a position to do more justice to the customer's requirements. The system of selling through a horde of sales representatives, as is common in Japan, has not been adopted in other countries and making regular contact with potential customers would hardly be acceptable in our highly individualistic culture.

This pulls the ground away from under the advantages of the systematic consumer research to which Womack refers and which is widely practised in Japan. Furthermore, it is inconceivable here for every customer to enter his personal data into a computer upon entering a showroom so that it may be evaluated and passed on for marketing purposes.

Then there remains the problem of product variants. Even lean production can not deflect the increased cost of customer-specific features. The question is whether it is not better to standardize production at a higher level of sophistication and to thereby meet the wishes of a majority of customers whilst at the same time avoiding the extra expense of added logistics work [5]. Observations at several mass-production plants strengthen this suspicion. Japanese suppliers have successfully demonstrated this strategy, albeit enforced through the distance to the target market. Moreover, unlike in America, automobiles leaving the production line in Europe are usually allocated to a specific customer, thereby fulfilling one of the characteristics listed by Womack for a lean relationship between manufacturer and customer.

3. Conclusions

The characteristics of lean production shown below can be derived from an analysis of the fields of activity. Here it becomes evident that the essential aspects of this approach were discussed in Germany as early as 15 years ago, within the framework of the program, "Humanization of Working Life" [6]:

- organization before automation
- efficient channels of communication
- delegation of responsibility
- teamwork
- the company as a community experience
- systematic eradication of the causes of defects
- constant product and process improvements
- close collaboration with suppliers
- short product life cycles
- customer orientation in all divisions of the company

One thing was missing at that time: the ability and the will to pursue this line to its logical conclusion. Opinions may differ as to the reasons, but at the time they were certainly of an ideological nature. Anyone who wishes to put lean production into practice only to stop half-way would be better advised to keep away from it.

The structural notion of lean production is derived via an inductive approach. Rules are extracted from the description of a model identified as successful in order to arrive at guidelines for solving similar problems. The originators of lean production themselves warn against uncritically adopting their approach.

So it can be seen that lean production structures (and lean production can only be described by reference to its elements) do not in themselves contain any previously unknown methods.

Nevertheless, the differences which have been revealed between the production methods of the three most important industrial regions of the world should be an incentive to us to keep on looking for improved solutions. In any case the

repercussions of the debate which this has sparked off are to be welcomed since they bring the problem out into the open. We have seen that the whole subject extends far beyond technical matters and also begs questions of a socio-political nature. Daniel Jones, one of the coauthors of the book, put it in a nutshell: "You need a shock!"

The argument that lean production represents the ultimate manufacturing system of the 21st century must be strongly resisted. The time for blueprints for successful manufacturing systems is over. We are currently going through a period of transition towards adaptable solutions which can vary greatly even though the problems may be similar in nature. Above all, the cultural background of the workforce in the factories of the 21st century will have a decisive influence on structural design.

When we make our assessment of the present century in seven years' time we will remember lean production. The intellectual debate has thrown up enough dust to ensure this; but it may be that we will smile at today's sense of upheaval. It would not be the first time.

4. The Fractal Company – A company with a future

When we speak of a Fractal Company, the first things that come to mind are the geometrical objects of the same name. These can be used to describe many natural shapes whose coarseness and structure remain basically unchanged when magnification is increased. A significant characteristic of these structures is therefore the fact that each of their parts contains the whole structure. Three characteristics of fractal objects are of particular interest to us: self-organization, self-similarity and dynamics. These represent an attempt to adjust production structures to the requirements of our times [7].

One of the essential requirements which we have stipulated for production structures with a future is the capacity of entrepreneurial ways of thinking and acting in all areas, right down to the individual employee. If the image that this conjures up of independently operating units is valid, then each fractal must itself be a (little) "Fractal Company".

But it is by no means enough to create "factories within a factory" if it cannot be ensured that they are all pulling in the same direction. Unfortunately, hotly defended spheres of influence continue to be the rule rather than the exception in our business organizations. But neither is it sufficient to create corporate models which cannot be converted into daily practice. For this reason we use the term self-similarity to refer primarily to the goals of the company and its fractals. Global goals which have quite sensibly been formulated in general terms must be turned into specific action. In order for this to take place "synchronously" in all fractals, their goals are formulated in much more concrete terms. For a machinist who enjoys a large degree of autonomy, for example, it is not immediately obvious what effects his decisions may have on the customer orientation of the company.

Operative self-organization means the application of suitable methods for controlling processes. Different fractals therefore use different methods. The structuring process which is common today in a factory or manufacturing system always receives its impetus from outside. Such stimulus is often the result of obvious defects and therefore comes too late. We must appreciate that not only procedures but also the processes for forming structures must be highly dynamic in nature in order to do justice to changing requirements. We refer to this process as dynamic structuring.

The CIM systems of the future will have an important task. They will have to provide the flexible and efficient information and navigation systems required by a fractal within a factory [8]. Information systems will have the task of providing the data required for the manufacture of products and the exploitation of materials and facilities within the framework of the relevant manufacturing process. New navigation systems will have to be developed to support the continuous efficiency improvement processes carried out independently by individual fractals. This requirement is of prime importance since future management systems will only set the global goals of a company which must then be implemented at a local level. Instead of the previous system of more and more detailed checks carried out with the aid of CIM systems, in the

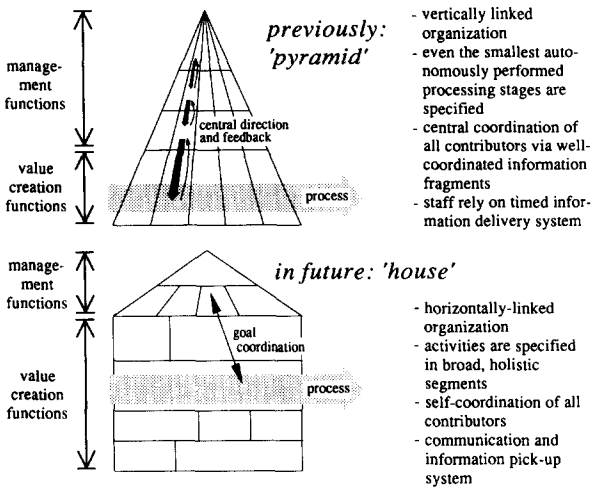

Fig. 2 Interplay of organization, information and value creation.

Fractal Company only a result-oriented assessment of fractals will be performed.

With regard to the corporate structure it comes down to the task of changing from a hierarchical system, symbolized for example by a pyramid, to a house-like structure with a relatively flat roof (Fig. 2). However, this will only be possible with a management culture which is not entirely new to us, but which is not yet very widespread in the business community.

5. Prospects

It should be clear by now that the solutions of the future cannot be "bought off the shelf", but must be pioneered. A process of change in awareness and behavior must be given priority over the use of technical aids. In many cases we are still at square one. Only if corporate management works unequivocally towards this goal will it be possible to mobilize middle management and staff. This requires a reappraisal on the part of all concerned, a process which will be wearisome and in part painful, but which is absolutely essential. History teaches us that structures and organizations which are only concerned with hanging onto power and which no longer offer new ideas and solutions, will sooner or later disappear and be replaced by new ones. This prophesy can surely be made without knowing the precise nature of these new forms.

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