

Comparative study of the theory of constraints and the philosophy of just-in-time

Vicente Lentini Plantullo

Joshua Onome Imoniana

Jouliana Jordan Nohara

Resumo:

The Objective of this paper is to compare and contrast two philosophies of managerial science namely Just-in-Time and the Theory of Constraints. The research was produced based on literature review using inductive approach towards analytical and interpretative procedures. To execute the research procedures, firstly, we analyze the fundamentals of the mentioned philosophies. Secondly, we emphasize earnings versus the costs behaviors, hitherto highlighting the surrounding concepts and their practical application, thus retrieving the relationship among lung, drum and string, the words used by Eliyahu M. Goldratt, the father of the Theory of Constraints. Finally, the factors that enhance maximization of the throughput period in the manufacturing processes such as production capacity, batch sizes, timings, accuracy, planning & control, flexibility and costs were compared. Results reveal that there is a clear need for a change in the manufacturing methodologies so that firms could be competitive, therefore, in order to attain objectives in a competitive environment one could adopt the convincing JIT or TOC philosophies.

Palavras-chave:

Área temática: *Gestão Estratégica de Custos*

Comparative study of the theory of constraints and the philosophy of just-in-time

ABSTRACT

Vicente Lentini Plantullo

Universidade Metodista de São Paulo

vplentini@uol.com.br

Joshua Onome Imoniana

Universidade Metodista de São Paulo

Jouliana Jordan Nohara

Universidade Metodista de São Paulo

The Objective of this paper is to compare and contrast two philosophies of managerial science namely Just-in-Time and the Theory of Constraints. The research was produced based on literature review using inductive approach towards analytical and interpretative procedures. To execute the research procedures, firstly, we analyze the fundamentals of the mentioned philosophies. Secondly, we emphasize earnings versus the costs behaviors, hitherto highlighting the surrounding concepts and their practical application, thus retrieving the relationship among “lung”, “drum” and “string”, the words used by Eliyahu M. Goldratt, the father of the Theory of Constraints. Finally, the factors that enhance maximization of the throughput period in the manufacturing processes such as production capacity, batch sizes, timings, accuracy, planning & control, flexibility and costs were compared. Results reveal that there is a clear need for a change in the manufacturing methodologies so that firms could be competitive, therefore, in order to attain objectives in a competitive environment one could adopt the convincing JIT or TOC philosophies.

1. BACKGROUND

The Just-in-Time as a management philosophy in one hand arose in the far east and was spread to the manufacturing world during the 1960's through 1980's whereas The Theory of Constraints on the other hand arose from the west in response to the recent industrial advancements which installed in Southeast Asia, embracing countries such as Japan, Thailand, South Korea, Taiwan and Singapore. These happenings characterized them as the tigers of Asia having grown at an average rate of 6.00% per annum maintaining uncommon growth rate as different from the rest of the world on the same standard, considering economic handicap.

Therefore, in order to consolidate our understandings about the aforementioned theories as literatures would have it, and upon examination of the differences between OPT – Optimized Production Technology – and TOC – Theory of Constraints, see table 1 below, we are of the assumptions that, the first arose within a production environment, whereas the latter has a macro character, that is, it

seeks to check and study not just the constraints of machinery and equipment, but also market, political and economic constraints. Meaning that it arose from the analysis of the general business environments.

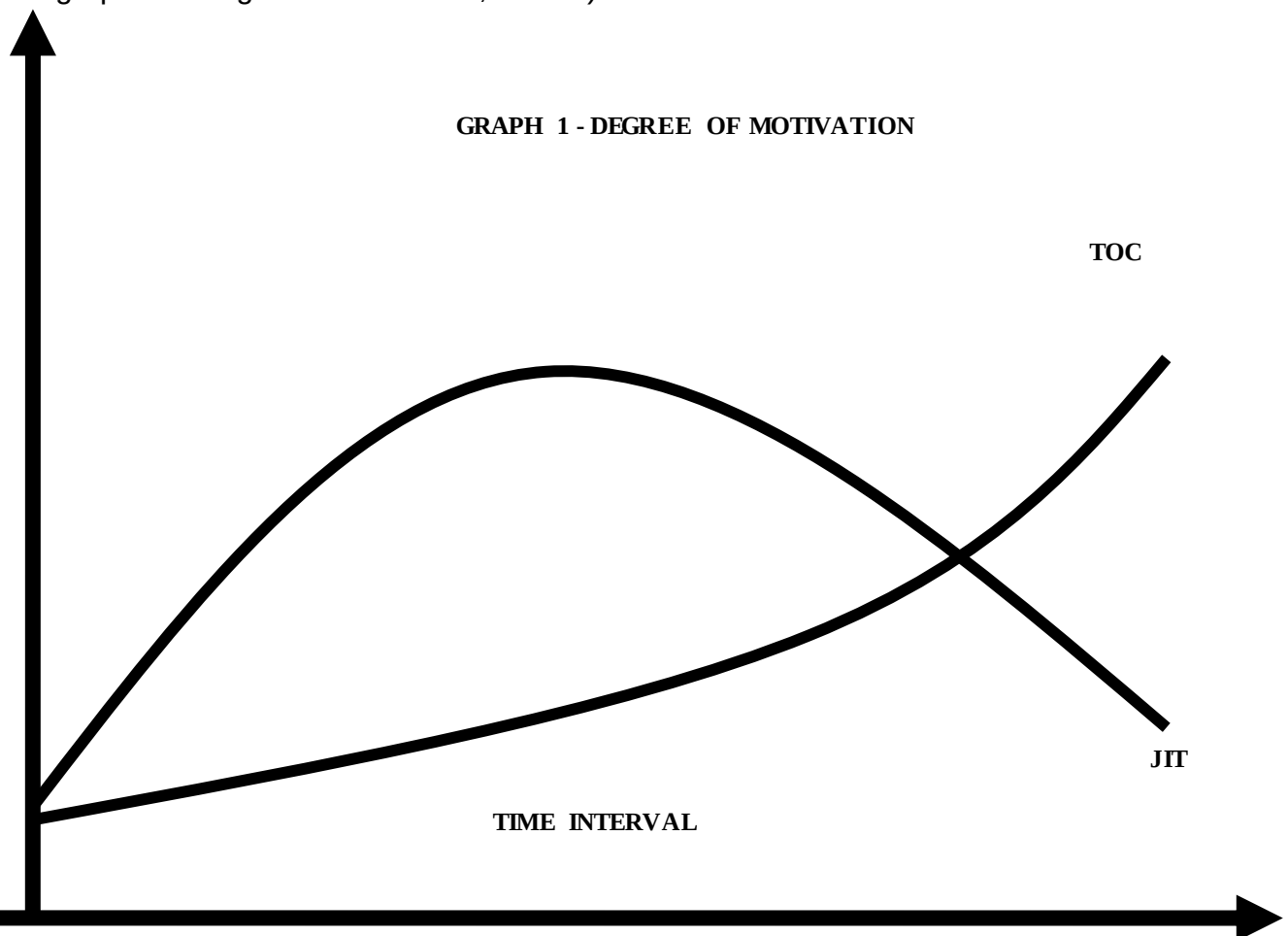
As we can observe in Table 1 – Comparison of JIT and TOC, Just-in-Time management philosophy employs a conducive environment to enhance product optimization, by so doing considers that all the variables involved have the same weight. The Theory of Constraint seeks to treat surrounding environment in a different form and locate bottlenecks when dealing with production. Finances, Marketing, Logistics, as well as political and economic variables are within the scope of the study of the Theory of Constraints. The Theory of Constraints is self-motivating, whereas the Just-in-Time management philosophy is not, always requiring a constant research for a motivation and the involvement of the employees.

TABLE 1: Comparison of JIT and TOC

Variables Analyzed	JIT	TOC
Production Capacity	Limited Control by means of Kanban	Limited Control by means of bottleneck or constraint
Batch sizes	Very low levels	Variable
Production timing	The production sequence must be totally synchronized Use of Kanban to manage fluctuations Seeks production leveling	Fluctuations due to the use of available capacity and stricter production planning Emphasis on a continuous flow of the production process
Accuracy		Vital in areas with capacity constraints
Planning	Less complete Slower response	More complete Faster response
Flexibility	Less flexible	More flexible

	Uses more inventory	Uses less inventory
		Better RRC protection
Cost		No need for computers

Thus, results are presented faster than those arrived at with the Theory of Constraints, but there may be demotivation after a given interval of time “t”. (see graph 1 – Degree of motivation, below).



2. DEVELOPMENT

Based on computer programs with linear programming models, Eliyahu M. Goldrat created in the 1980,s the Theory of Constraints. A multidisciplinary nature of its application enables it to be used in various environments, be it in

manufacturing, commerce or services, ANTUNES (1989:58). It shows that the objective of any organization is an increase in throughput, rate at which the systems generates cash by means of its net sales GOLDRATT & COX (1990). For Goldratt, throughput may be defined as the “earning”, or, the simple arithmetical difference between total invoicing and the raw materials consumed. Thus, earning becomes a global operation measurement as well as an extremely simplified concept for performance measurement. Another concept used is that of net profit, understood to be the difference between the earning and the sum of all the operating expenses. Finally, return on investment. This is a quotient between net profit and the invested capital.

In defining throughput, which may be understood as an aggregate value GOLDRATT & COX (1990) is an index that indicates the generation of cash through sales. Operating expenses are all the funds that the system utilizes to transform inventory into aggregate value, and by inventory it means that all cash that the system invests in the purchase of raw materials that enters into transformation process that in turn being marketed.

Mathematically we have:

Throughput = earnings = sales - raw materials consumed;
Net Profit = earnings - operating expenses; and
Return on Inventory = net profit/inventory.

3.THE GOAL

According to Eliyahu M. Goldratt, the objective of any industrial, commercial or service organization is to “*make money now, and guarantee its continuity in the future*”. The maximization of manufactured products; the maximization of the shareholders wealth are resulting elements. The actions taken are the result of effect-cause-effect decisions. A basic problem that always exists immersed in this process will provide concern with the current culture, forming a general concept based on the equity of funds and products, always following the idea of both local and general optimization. From here on the final results are consequences of results by product, obtained via systems generating information by product. The final results are difficult to obtain, since the participation and adherence of people is very small, resulting in

decisions that are unrelated to the final objectives and in the taking of intuitive, unreliable decisions CSILLAG (1990). What are actions for? To create a link through which it is possible to act directly upon the net profit (absolute measure), the return on inventory (relative measure) – and on the company's cash flow (survival measure) GOLDRATT & FOX (1989:31).

4.THE THEORY OF CONSTRAINTS APPROACH

The Theory of Constraints seeks to enter into the world of earnings rather than into the world of costs. This last is consecrated by the generally accepted accounting principles, IUDICIBUS (1987:42) notably: the principles of entity (where companies are separate entities from their shareholders, whether people or firms); the principles of continuity (the principle of the going concern where the continuity of the company's business is emphasized until strong evidence such as judicial or extra-judicial solvency, or persistent losses render the business unfeasible); the principle of historical cost as a base of value (where assets should be incorporated to other company assets with the purchase value. Also, costs should be incorporated to place the assets in working condition. Here we should point out that, in a highly inflationary economy, this principle no longer hold; the principle of income realization (accepted when there is a real profit or loss in the industrial, commercial or services transaction); the principle of the confrontation of income and expenses (when income and expenses are treated solely and exclusively as a function of their respective "generating facts"; the principle of the common monetary unit (a principle that requires the establishment of a standard monetary yard-stick for the measurement and comparison of results).

Regarding this last principle, in Brazil the common monetary unit for determining results is the Real (R\$), observing the following conventions: the convention of objectivity (a principle that seeks to distinguish between relevant and irrelevant procedures and always selects the most objective); the convention of conservatism (where the most conservative evaluation of the assets, liabilities and net worth of the entities should predominate). The objective is: "*Never anticipate income and appropriate all possible expenses and losses*"; the convention of materiality (where, to avoid waste of time and money, only events worthy of attention are recorded, for their materiality, on a timely manner); and the convention of

consistency (where accounting principles should not be periodically altered, in an irresponsible manner, compromising the successful application of other principles).

In addition to these principles, there is the principle of the allocation of indirect manufacturing costs, which are usually appropriated because of direct costs. Even great specialists in the area of industrial costs have contested the allocation as a function of costing by absorption or standard costing. This is an issue that has involved both academics and the executives of great organizations, in addition to scholars on the subject.

4.1.STEPS IN THE THEORY OF CONSTRAINTS

With the Theory of Constraints, bottlenecks are shown up. A bottleneck is “*every resource having a capacity smaller than its demand*”. If in a factory there is a machine X, capable of processing no more than 600 tons of material per hour and two machines Y and Z downstream in the production process that can process 700 and 800 tons per hour respectively, it will be impossible to process more than 600 tons per hour with machine X. We have, therefore, a restriction or constraint in capacity, or a bottleneck.

The concept presented is ample. The constraints, as positioned here may be located in the environment. We may have constraints in the final consumer market when it is not willing to consume the goods and services offered on the market and direct constraints when a product or service competes with a company's same product or service (margarine A and margarine B made by the same company, for example). A market constraint is indirect when demand for a product increases and, due to capacity constraints, there is a reduction in the probability of the system providing another equivalent product or service.

Another constraint peculiar to the external environment is a political constraint. It is the strongest of constraints: many projects are abandoned for lack of political support. A correct understanding of these constraints is vital for the economic development of the country due to the enormous volume of money involved.

There are constraints generated by a supplier, when supply sources are held back to increase prices or create better advantages for bargaining with the buyer.

Therefore, the concept of constraints backs up the Theory of Constraints, a macro-concept, whereas the concept of OPT – Optimized Production Technology is closely linked to the manufacturing field.

The steps in the Theory of Constraints are the following: identification of the constraints, specially when there is a surplus of stocks; a decision on how to exploit the constraint; subordination of the non-constrained elements to the constrained element; improvement of the constraining element; should the constraining element cease to be a constraint, identify the next constraint so as to repeat the previous steps. Take care however, that the new inertia does not become the next constraint.

ADVANTAGES

- a) -a simplified technique for production planning, where:
 - planning does not require a great deal of preparation time;
 - planning does not require a large amount of data;
 - data does not need to be highly accurate;
 - few people are needed to analyze production planning.
- b) - a complex interactive process where previous knowledge is not required.
- c) - a rapid projection or change in planning where:
 - in the manufacturing process there is a maximization of production outputs, and the simultaneous minimization of stocks of products-in-process occurs through techniques, based on mathematical interactions;
 - an increase of roughly 10% in the production rate is possible, using the same available resources;
 - it is possible to reduce the stock of products in process by 20%;
 - the size of small batches is calculated on a profitability basis and not through purchasing and production economic lots;
 - a more precise control of short term resources is permissible;
 - existing finite resources are taken into account;
 - there is no space for any type of error.
- d) -it is more complex than JIT:
 - rapid planning and extremely rapid changes call for more flexibility;
 - planning changes should be done in hours rather than in days;
 - since planning is extremely rapid it should be possible to conduct several simulations.

e) - it permits an accurate analysis of the industrial plant:

- constraints in the production process become clearly defined;
- improvements may be easily made in the industrial plant, due to a clear definition of the constraints;
- through a simulation process, several mixes of products may be experimented with implications for the industrial plant from a viewpoint of the capacity of machines and finances .

DISADVANTAGES

a) -the necessity to reorganize the industrial plant. This is a conceptual reorganization within the industrial plant and within the company, although it is less than that required by the JIT philosophy:

- changes in the management style for handling problems;
- creation of a new culture;
- finally, displacement and changes in equipment so that the theory may be applied more efficiently.

b) -a break with traditional systems of accountancy and costing;

- efficiency can no longer be calculated in this system;
- performance evaluations are no longer issued.

c) -a breakdown in the users concept;

- users of the system need to be trained: new types of reports should be developed to support the new type of data processing and the accountancy systems must be adapted to the new information base.

4.2.THE WORLD OF COST X THE WORLD OF “EARNINGS”

Under current perception, where a vision of the world of costs, HOPP & LEITE (1988:63) predominates, expenses have a direct relationship with net profit and with return on investment. Expenses are the first object of concern. Operational expenses become, in the world of costs, a convenient point of reference to attribute values to actions and to their impact on final results. The investment, or more precisely, the available inventory, is relegated to a third plane. In the world of costs the priorities are: operating expenses, general manufacturing expenses and inventory.

Under the perception where the world of earnings predominates, an earning variable is defined, and it is intimately associated to net sales, in turn dependent

upon customers and suppliers. To a certain extent the benefits of earnings are an intangible: the quality of the product, the time needed to develop new products, delivery performance, the quality of services rendered, industrial automation and the return obtained on advertising.

Therefore, priorities in the world of earnings become useless, when compared to those in the world of costs: earnings or net sales, inventory, operating expenses.

It should be pointed out here that many mistakes are made at this point. The business must have difficulty in perceiving the world of earnings where common sense predominates, to sell products cheaper with a better quality, seeking to reduce inventories and, lastly, reducing operating expenses. The vision of the world of costs recommends, in a crisis, a cut in operating costs, a cut in investments and finally the attempt to maintain profit margins through an increase in prices, generating “stagflation”.

5.FEATURES OF THE JUST-IN-CASE, JUST-IN-TIME PHILOSOPHIES AND THE THEORY OF CONSTRAINTS

To give a brief, simple and objective view of these three management philosophies it is important to remember that they are the corner-stones of the development of manufacturing. They have been involved with theories and philosophies since 1900, when the manufacturing system underwent and unprecedented organization, through Taylorism, Fayolism, Fordism, Ohnoism and “Goldrattism” (a word created in honour of the Father of the Theory of Constraints, Mr. Eliyahu M. Goldratt).

5.1.THE WESTERN METHOD – THE JUST-IN-CASE PHILOSOPHY

The conventional Western approach can be characterized by a Just-in-Case system. The production rate will determine when raw materials shall be delivered to the plant. This rhythm will be determined by the excessive capacity of the first operation. Even when the worker has nothing to do, he has raw material to process.

The result is a stock considerably higher than in the Just-in-Time system. The overall value of current sales is protected. But, although we have a manufactured product, our competitive advantage on the market is drastically reduced.

5.2.THE EASTERN METHOD – THE JUST-IN-TIME PHILOSOPHY

In the Just-in-Time approach ANTUNES (1989:100), the production rate is determined by the market demand. It is a “pull” system. The release of raw materials to the plant is the result of a chain reaction initiated by the final consumer. As the products are sold, they are manufactured. It is the concept of supplying and re-supplying a lung. A “lung” in this sense, means a “working stock”. Obviously the lung in the Just-in-Time system is substantially smaller than that of the Just-in-Case system. As the stock protection is smaller, any lack of materials is vital for the manufacturing process in the JIT system. The production line will soon come to a halt. Therefore, current sales are in danger. However, as the stock is smaller, the capacity for diversifying the product line is greater. Therefore, future sales will increase, due to a better degree of market competition. The system works like the links in a chain. Diversification in the production line means flexibility.

5.3.THE THEORY OF CONSTRAINTS

The Theory of Constraints (GOLDRATT & FOX (1990:100) is based on the fact that there are Resources with Restricted Capacity – RRC. The theory recognizes that RRC will impose the production rate for the entire plant. It will be necessary to create a “working stock” for RRC. By seeking to ensure that the stock will not grow beyond the level imposed by the “working stock”, you can limit the rate at which raw materials are released for production.

In other words, the rate at which the initial operation will be permitted to release material to production will be determined by the rate at which RRC is producing.

In GOLDRATT & FOX (1990:99) language, “lung” is understood to mean a protection for the constraining item, a “drum” is the programming of the constraining item and the “rope” is the connection between the first machine and the constraining item, ensuring input to the first machine at the production rate of the constraining item.

The ten commandments of production ANTUNES (1989:60) dimensions are the following:

- the rate of utilization of the production resources not connected to the production bottleneck should not be determined by their own potentials for generating work, but by some other system constraint;
- to activate a resource is not a synonym of using it effectively;
- one hour lost by the bottleneck operation is one hour lost for the entire system;
- saving time in operations other than the bottleneck operation is pointless;
- transfer batches may not be the same as batches in process and often are not;
- the sizes of batches in process should be variable, not fixed;
- capacity constraints and other priorities should be considered simultaneously and not sequentially;
- Murphy's principles become less incisive, that is, their impacts become more easily administered;
- the factory's capacity should not be balance;
- the sum of local optimums is not equal to the overall optimum of the system.

5.4.CONSIDERATION ON THE THEORY OF CONSTRAINTS

The Theory of Constraints arose in response to the continuous advances of the Japanese and generally the Tigers of Asia. It seeks to consider important only the bottleneck points and not all the points in a particular system.

The Theory of Constraints places a new light on previously accepted concepts. The change from a world of costs to a world of earnings is extraordinary. It also helps Western companies to reduce the technological gap in relation to Eastern companies. It is a 1-99 type of ABC curve, and is extremely revolutionary. The theory is powerful. Strong. A motivation. Pungent. It allows structural changes in Western economies and therefore merits the attention of scholars and those in charge of company management practices.

6. CONTRASTS AND COMPARISONS BETWEEN THE JUST-IN-TIME PHILOSOPHIES AND THE THEORY OF CONSTRAINTS

In a brilliant article published in the Production and Inventory Management magazine, PLENERT & BEST (1986:23) who completed his doctorate thesis in the Colorado School of Mines, and Thomas D. Best, Ph.D. and professor of Production and Operation Management at California State University, debates on the question of which would be the best MRP (Material Requirement Planning) technique: JIT or OPT? The research conducted by the authors was solely concerned with these two items and it should be remembered that this article is only concerned with JIT and TOC.

6.1.DIFFERENCES BETWEEN COUNTRIES – SPECIFIC FACTORS

It is interesting to commence the analysis by looking at three different realities: The United States, Israel and Japan. In the United States land is not a constraining factor and factories may be installed anywhere in the continental-sized country. In Israel land is an element of constraint while in Japan this is a critical factor and is without any doubt a factor and point of strangulation.

In the United States the manufactured production is absorbed internally. In Japan and Israel consumer markets are thousands of miles away. Therefore repairs to a defective product become extremely expensive. In the United States repairs are not expensive, and usually generate profit for the manufactures. The same applies to Brazil.

In Brazil as in the United States there is a great variety of products offered on the final consumer market. In Japan exactly the opposite occurs, that is, few options are on the market, thereby making changes to finished products difficult. In Israel, there is a combination of these two points, permitting a certain degree of flexibility in products offered on the consumer market. They are three different realities.

Due to these structural differences, factories in North American and in Brazilian territories tend to become enormous, with much wasted space where products are stored to provide for different preferences.

Both the North American and the Brazilian industries have emphasized the workers' individual productivity, in contrast with the ruling philosophy in Japan and Israel, which is team productivity (the word has been used so as to identify the real productivity that a formal and informal groups of employees who work together as a

family would arrive at). The difference is clearly noted in the methods for determining costs; in the United States and in Brazil the focus is on the number of standard parts produced by the worker. This leads the operator or worker towards a production process where the products may not even be necessary. Quality is relegated to a second plane.

In the Japanese and Israeli production systems, the quality of the product becomes the responsibility of the worker. The worker is not evaluated by the amount produced but by this production without taste. The production system is dependent upon market demand. This is the “pull” system.

In the Japanese system production environment, materials are fed to the production line, as the consumer market requires the final products. This is a system of “links” in a chain. A break in any link results in shutting down the production line. In Japan, the lead time for manufacturing a motorcycle is one or two days, whereas in the United States it is one or two months. The difference is visible: as in the United States or in Brazil production department programming is dependent upon a sales forecast, usually large quantities of unsold products are accumulated in stores, to satisfy forecasted requirements.

With the TOC, production or the elements connected to it are not based upon a “pull” or a “push” system, but rather upon a system that looks for bottleneck or constraints, whether in manufacturing or pertaining to the structural macro-environment. Production is planned according to the bottleneck of constraint in capacity. As the entire factory is subject to the constraint, its utilization at maximum levels will optimize the use of the rest of the factory at a certain production level.

7.CONCLUSION

The experts sensed the need for a change in manufacturing methods as a way to face international competition. This requirement is to a certain extent defined with the use of the JIT or TOC philosophies. We have found that although both philosophies are highly productive, the TOC is more embracing, more localized and also includes all the JIT principles at these localized points. In other words, the TOC

gives importance that which is important while JIT gives the same importance to everything. Thus, the TOC results in a smaller total inventory and better protection against production line shutdowns. One system is as simple to apply as the other.

It is a philosophy that should be spread to other fields such as commerce and services. This is a challenge for further research to be conducted in this fertile and promising field: the Administrative science.

8. References

ANTUNES, J. A V. J. *et alli*. Considerações críticas sobre a evolução das filosofias de administração da produção do Just-in-Case ao Just-in-time. *Revista da Administração de Empresas. EAESP/FGVSP*. Volume 29, numero 3, p. 58 –100, 1989.

CSILLAG, João Mário. *Introduction to the Theory of Constraints*. Paper presented on 11/06/1990 at EAESP/FGVSP, Brazil

GOLDRATT, E. M.; FOX, R.E. *A corrida pela vantagem competitiva*. São Paulo: IMAM, 1989. p.31.

GOLDRATT, E. M. FOX, J. *A meta*. An introduction by Claudiney Fullman to the Brazilian edition. São Paulo: IMAM, 1990.

HOPP, João Carlos, LEITE, Hélio de Paula. O crepúsculo do lucro contábil. *Revista de Administração de Empresas. EAESP/FGVSP*. Brazil, volume 28, no. 4, 1988 p. 55-63.

IUDÍCIBUS, Sérgio de. *Análise de Balanços*. 4.ed. São Paulo: Atlas, 1987. p.27-42

PLENERT, G., BEST, T. D. MRP. JIT and OPT: What's the best? *Production and Inventory Management Journal*, second quarter, 1986. p. 22-23.