

Management by the market constraint in the Hi-Tech industry

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This paper presents a systematic approach to managing by the market constraint in the Hi-Tech industry. In line with the Theory of Constraints methodology, it is argued that in a market-constrained environment, the marketing and sales department together with the research and development department are Permanent Bottlenecks and need to be managed as such. The paper modifies the Theory of Constraint's five focusing steps to accommodate the market constraint. It describes the Strategic Gating and Tactical Gating that enable the firm to increase shareholder value, emphasizing that even though the company has to seek profitable orders in the competitive market, management can control the situation by the focusing methods presented. The paper also suggests a way to reduce costs in non-critical areas and stresses the need for lead-time protective buffers.

1. Introduction

The globalization trend of the last few decades is clearly a threat to many firms, but it also offers them the opportunity to penetrate markets around the globe. Most firms have excess capacity in production, services and logistics, and conduct their business under a market constraint. If a firm does not conform to lead-time, price, quality and performance requirements, it may not survive in the global buyers' market.

This paper addresses the issue of managing a market-constrained Hi-Tech firm, from the vantage point of the Theory of Constraints (TOC). First introduced to describe a resource-constrained environment (Goldratt and Cox 1992), the five focusing steps and most definitions of the TOC relate to the system's bottlenecks. Acknowledging the market as the more severe and more common of all the constraints facing the organization, TOC-based methods and techniques such as the current reality tree (CRT) and conflict resolution diagram (CRD) that are helpful in coping with this environment have begun to emerge (Goldratt 1994). Research and practice have produced methods to build better decision-making processes for costing and pricing (Goldratt 1990), but no comprehensive method has yet emerged for addressing the issue of management in a market-constrained environment.

This paper presents an integrative and consistent method to cope with the market constraint for a Hi-Tech firm, defined as one that uses technology as a key strategic component (Levy and Ronen 1989). Key characteristics of the Hi-Tech industry are the highly qualified people it employs and the high research and development (R&D) content of its activities. Its competitive edge lies in the ability to apply innovation and technology in a way that will better satisfy customer needs. In this industry, time to market (TTM) is a key success factor.

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It is usually easier to cope with an internal resource constraint rather than with an external market constraint: in dealing with an internal resource constraint, management has more control over its activities. As will be shown below, the Hi-Tech firm always has two Permanent Bottlenecks: marketing and sales (M&S) and R&D. Though these Permanent Bottlenecks exist whether or not a market constraint exists, the firm can control and improve its position in the market by properly managing them.

Section 2 presents the generic resource model of the firm by the cost-utilization (CUT) diagram, presenting the M&S and R&D departments as the Permanent Bottlenecks Hi-Tech firms face. Section 3 prescribes the seven-step model for managing the market constraint. Section 4 deals with the issue of cost management and cost reduction. Section 5 discusses the importance of lead-time protective capacity as a means to build a competitive customer service level. Section 6 concludes the paper.

2. Generic resource model

A market constraint is defined as a situation in which the production/operations resource capacity exceeds market demand, and lack of profitable orders prevents the system from achieving higher value to its shareholders. However, although the capacity of production/operations and logistics resources in a Hi-Tech firm may be higher than the pertinent market demand, it always has two internal Permanent Bottlenecks: the R&D and the M&S departments.

The R&D department is necessarily a bottleneck since the demand for development always exceeds its capacity. There are more internal and external requests for development than resources to execute them. Whatever the size of the R&D work force, the potential demand will always be infinite with respect to the available resources. The M&S personnel are also an inevitable bottleneck since they could all bring in more sales if they had more hours available. The load on M&S includes processing ongoing orders, pursuing leads on potential customers, increasing sales to existing customers, participation in exhibitions and conventions, and tracking down all potential customers. Clearly, in such a situation the demand exceeds the supply, no matter how many new salespersons are recruited. In the case of M&S as in the

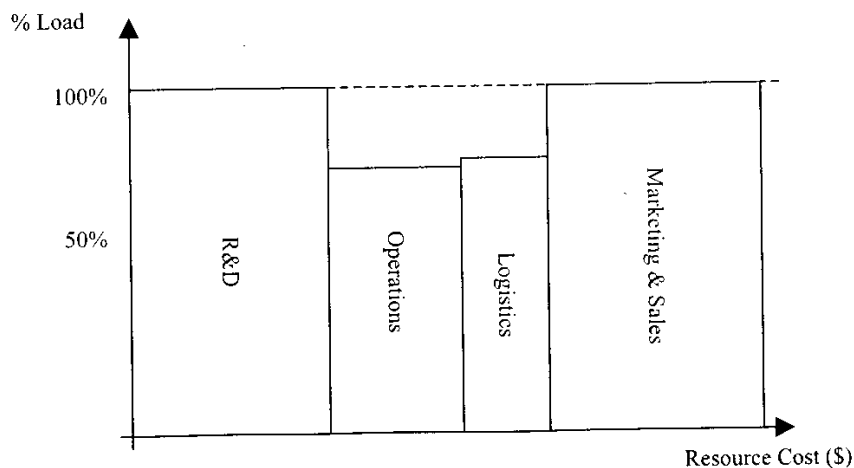


Figure 1. CUT diagram for the typical market-constrained Hi-Tech firm.

case of R&D, adding more resources will probably add some throughput to the firm at a substantial cost, but it will not change the fact that these departments will still remain bottlenecks, and should be managed as such.

A generic market-constrained Hi-Tech firm is presented in figure 1 using a CUT diagram (Ronen and Spector 1992) depicting the various resources in the system as bars. The height of the bar represents the load on the resource (department, in our case) while the width represents the relative cost of this resource (department). As can be seen, Operations are under-loaded and can take an extra load of at least 20% without adding extra resources. The same holds for Logistics. Figure 1 shows that even in a market-constraint environment we have two internal Permanent Bottlenecks, which should be treated accordingly. As the Permanent Bottlenecks can be controlled, management can influence and improve the firm's shareholder value.

3. Seven steps of management by the market constraint

The seven focusing steps (Ronen and Spector 1992, Ronen *et al.* 2001) are a modification of the five focusing steps of the TOC (Goldratt and Cox 1992).

- (1) State the *goal* of the organization.
- (2) Define *global performance measures*.
- (3) *Identify* the system constraints.
- (4) Decide how to *exploit* the system constraints.
- (5) *Subordinate* everything else to the constraints, and to the above decisions.
- (6) *Elevate* the system's constraints.
- (7) If a constraint has been broken, go back to Step 3. Warning: do not let inertia become the system's constraint.

3.1. Step 1: State the goal of the system.

The goal of a business organization is to increase shareholder value.

3.2. Step 2: Define global performance measures

A reasonable and versatile set of performance measures for a firm (Eden and Ronen 1991, Goldratt and Cox 1992) is comprised of the following items.

- Throughput.
- Operating expenses.
- Inventory.
- Lead-time.
- Quality.
- Due-date performance.

3.3. Step 3: Identify the system constraints

For business firms, constraints are divided into four categories (Ronen and Spector 1992) (figure 2).

The traditional definitions of TOC relate mainly to the production/operations department. Thus, a resource constraint (Cox and Spencer 1998) is apparent when demand for production is higher than its capacity, and a market constraint occurs when there is excess capacity in production/operations. A deeper analysis reveals that we need to be more specific.

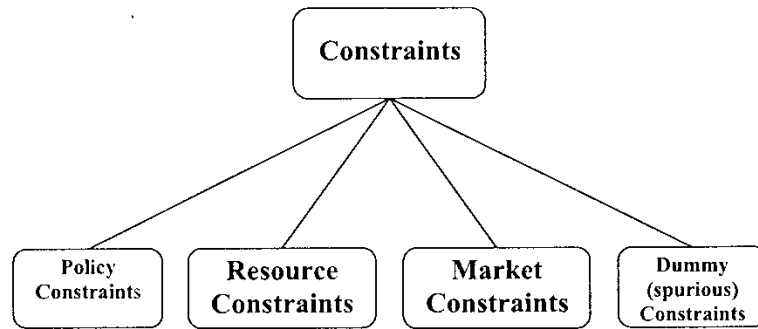


Figure 2. Types of constraints.

- Every firm faces a market constraint. As noted by Schragenheim and Dettmer (2001), the market constraint always exists even in firms with shortages of production/operations resources. This means, for instance, that all firms should subordinate their decisions to market requirements and tastes, regardless of their capacity.
- As noted, the M&S and the R&D departments are always resource constraints (Permanent Bottlenecks).
- Policy constraints occur when some wrong or outdated policy limits the throughput of the firm.
- Dummy (spurious) constraints (Ronen and Spector 1992) occur if some very inexpensive resource is the bottleneck of the system.

Once management has identified the system constraints, it should look for ways to improve the situation in order to achieve its goal better.

3.4. Step 4: Decide how to exploit the system constraints

This step introduces short-term actions for system improvement. It aims at making more with the same resources. At this stage, no substantial investment is required and improvements are usually realized in a short time. The action items fall into three categories: efficiency improvements, effectiveness improvements, and elimination of policy and dummy constraints (figure 3). More than one of these actions can be applied concurrently.

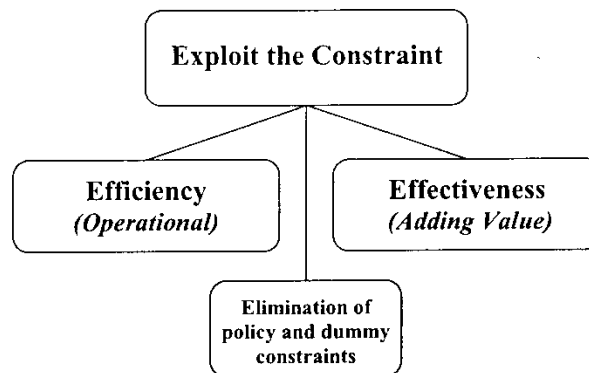


Figure 3. Aspects of constraint exploitation.

3.4.1. *Exploitation of the Permanent Bottlenecks*

3.4.1.1. *Constructing a focused strategy to exploit Permanent Bottlenecks.* A typical reaction to a market constraint situation is an attempt to bring in more sales orders for all and every product or service, which may mean spreading efforts over too many customers. The firm should do just the opposite: management should construct a focused strategy based on its core competence that exploits the scarce M&S and R&D resources.

3.4.1.2. *Gating and the Permanent Bottlenecks.* Effectiveness of the Permanent Bottlenecks is achieved by using the gating mechanism, defined as screening, prioritizing and scheduling the release of jobs, orders and entities to the system. One should differentiate between Strategic Gating and Tactical Gating.

3.4.1.2.1. *Strategic Gating.* Strategic Gating is the strategic screening and prioritizing of products, services, projects, clients and markets on which the firm wishes to focus. It guides management in the selection of long-term activities—focusing on the valuable activities and refraining from engaging in activities that are low in value and high on resource consumption. The leading tool used in Strategic Gating is Specific Throughput (or specific contribution). The Specific Throughput of a certain entity (job, activity, customer, project, market, service or order) is the expected present value of the throughput gained, divided by the number of time units of constraint that are required to process this particular entity. In other words, for a given entity:

$$\text{Specific Throughput} = \text{Throughput} / \text{Time units of constraint.}$$

Also known as the criterion for the Product Mix algorithm (or rule), this equation means that the higher the expected throughput of a given entity and the less constraint time it consumes, the higher its Specific Throughput score (for related references, see Mabin and Balderstone 2000). The Specific Throughput can be used to rank jobs (Goldratt 1990) in a similar way as they are ranked by mathematical programming (Luebbe and Finch 1992). Since M&S and R&D are the Permanent Bottlenecks, the system is unable to process all the demanded jobs. Management has to take the difficult decision of *what should be processed* by these bottlenecks *and what should be rejected*, using the Specific Throughput as a leading argument. Naturally, decision-makers also have to take into account other strategic considerations, though it is important to translate these strategic considerations into expected throughput terms to enable the use of the Specific Throughput criterion.

3.4.1.2.2. *Tactical Gating.* While Strategic Gating directs the firm to the most valuable directions, one has to take account of the day-to-day screening and scheduling decisions that need to be made. These decisions include accepting or rejecting a certain order, project or customer and prioritizing them. These tactical decisions should be delegated to the specific Vice Presidents and their subordinates. The leading tool for these decisions is also the Specific Throughput.

Thus, the highest Specific Throughput jobs are selected, one by one, until the capacity of the Permanent Bottleneck is fully used. The lowest priority jobs are either rejected or delayed for further consideration.

According to Tactical Gating, M&S employees have to weigh the expected throughput of each marketing or sales activity against the expected time required to accomplish it. They have to focus on the highest priority activities, until their time is exhausted. Similarly, the R&D personnel have to prioritize all the jobs to be performed by their Specific Throughput and select those activities that are at the top of the priority list. Thus, the Tactical Gating mechanism will increase shareholder value by picking the most valuable jobs and preventing the bottlenecks from wasting their time on non-productive work.

Tactical Gating also involves the day-to-day scheduling and the controlled release of jobs and entities to the system, with its Permanent Bottleneck departments, ensuring that the selected jobs and entities enter the system in an efficient way.

A partial form of Tactical Gating is incorporated in the Drum-Buffer-Rope (DBR) mechanism (Goldratt and Fox 1986, Cox and Spencer 1998) in which jobs are released to the system according to the pace of the bottleneck (*drum*), and in synchronization (*rope*) with the level of the jobs in the *buffer* in front of the bottleneck. The Tactical Gating mechanism presented here is an augmentation of the DBR mechanism, entities being released to the M&S and R&D departments according to the following additional guidelines.

- Jobs are released only if they contain a Complete Kit (Ronen 1992) of materials, components, information, tools, required operators, etc.
- Jobs and entities are not released earlier than planned.
- To avoid bad multitasking (Goldratt 1997), release is stopped whenever the work-in-process (WIP) is high.
- Jobs, work orders and work packages released to the system should be appropriately small.

Specific Throughput is the main screening criterion for both Strategic Gating and Tactical Gating. Additionally, one can use the focusing matrix shown in figure 4, a graphical tool that is an approximation for the Specific Throughput, especially in cases where quantitative measures are difficult to assess. When using this tool, each

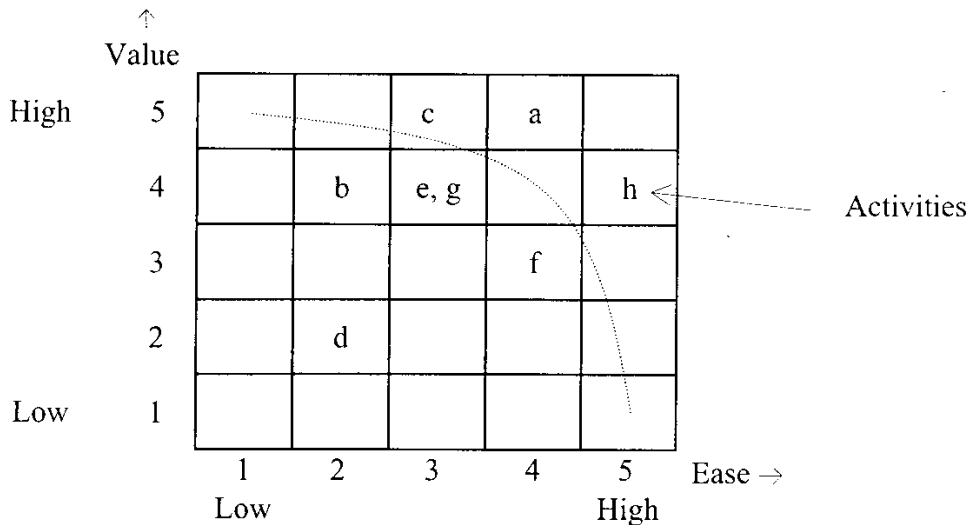


Figure 4. Focusing matrix.

candidate activity is ranked from one to five on its contribution to shareholder value. It is also ranked from one to five according to the ease with which it can be carried out, in terms of the bottleneck resources required. The various activities are mapped in the focusing matrix. The preferred activities are those on the right-hand side and the top of the matrix.

The focusing matrix can be used by R&D and M&S managers in Hi-Tech firms to analyse all current and potential projects, assessing the long-term value of each against the effort required. The M&S department estimates the expected value of each entity, while R&D managers estimate the expected effort. Thus, it also serves as a communication tool between the departments. The method can also be used by M&S people to evaluate clients, markets and projects. This *global decision aid* enables a view of *all* projects in a single snapshot, allowing better decision-making in a global perspective, rather than project by project.

3.4.1.3. *Exploitation of the Permanent Bottlenecks: the efficiency aspects.* A bottleneck resource should work full time on the matters that contribute most to the firm's value. The authors' observations of over 500 firms world-wide reveal that salespersons waste over 50% of their time on irrelevant and non-value added jobs. Thus, for example, only too often have they seen salespersons trying to expedite a certain order on the production/operations floor or in the logistics department when the problem could have been taken care of by non-bottleneck resources. Ineffective sales meetings are also included in this category. Salespersons should use their precious time on sales activities, resulting in increased value.

The same argument applies to R&D people. In one organization the authors actually observed a senior system engineer (a major bottleneck within a Permanent Bottleneck department) wasting hours of his precious time on upgrading the Windows software at workstations.

Hence, the Tactical Gating is an effective mechanism for increasing the throughput of the Permanent Bottlenecks.

3.4.1.4. *Elimination of policy and dummy (spurious) constraints that affect the Permanent Bottlenecks.* The following policy constraints prevent the system from achieving higher M&S value to its shareholders.

- Improper measures of performance. As the goal is to increase shareholder value, performance measures should follow this line: common measures like market share, number of units sold and value per customer should be thoroughly and carefully examined and discarded if not in line with the overall goal.
- Use of traditional cost accounting. The use of full allocated costing, especially in a market-constraint environment, undermines throughput and may lead to the firm missing business opportunities (Goldratt 1990, Eden and Ronen 1991, Noreen *et al.* 1995).
- Minimum order size. Small orders are sometimes rejected automatically. However, small orders from existing customers for ongoing products should be considered a blessing, since production/operations and logistics are not constraints and these sales contribute to the firm's throughput.
- Sales force compensation. Salespersons usually work on a commission basis, according to their sales volume, which encourages them to sell at any price.

Breaking the policy constraint and using throughput as a basis for the compensation scheme may motivate the sales force to strive for more profitable orders.

- Incomplete kit. Salespersons often waste their valuable time by coming unprepared to meetings and bidding with an incomplete kit. The effectiveness of the sales force can be easily increased by applying the Complete Kit Concept (Ronen 1992) to all their activities.

The following dummy constraints have been observed in M&S departments.

- Shortage of low-cost administrative assistance.
- Lack of computers, communication or other IT tools.

Obviously, such constraints should be resolved immediately.

Similarly, the following policy constraints exist in R&D.

- Misunderstanding the goal and improper measures of performance. It should be clear to all R&D people that the goal is to increase shareholder value. R&D should develop products and services that fit the market needs and create cash throughout the product/service life cycle. The authors have witnessed instances of the behaviour of R&D people being dictated by the desire to develop state-of-the-art products or the desire to become a technology leader. The performance measures should be defined according to the goal.
- Over-specification and over-design. R&D people tend to challenge the state-of-the-art technology and develop systems that are over-specified and over-designed. Marketing people do not always know the exact needs of the market and tend to define products that are too versatile. Sometimes, especially in the defence industry, a third player is added to the over-specification and over-design conspiracy: the clients' engineers. When facing market constraints, eliminating over-specification and over-design can increase R&D throughput enormously. The authors' experience shows an improvement of at least 25% in firms that control this harmful tendency.
- Incomplete kit. The compulsion to start working before the product specifications and characteristics are properly defined is one of the sources of wasted R&D Permanent Bottleneck time (Ronen 1992).
- Reluctance to reuse existing solutions or incorporate off-the-shelf subsystems. NIH (not invented here) is a policy constraint that prevents R&D people from using existing modules and subsystems or commercially available solutions.

Dummy constraints found in R&D departments are as follows.

- Shortage of low-cost components and accessories.
- Shortage of low-cost administrative assistance.
- Lack of computers, communication and IT tools.

3.4.1.5. *More about exploiting the market constraint.* Exploitation of the market means being able, in the short-term, to do more using the same resources. This means getting more orders from existing satisfied customers, increasing the firm's share of customers for its products or services and launching long-term relationships with the customers. In R&D, exploitation means exhausting the current products and maximizing their value. The core of exploiting the market constraint is segmentation and differentiation of markets and products, the idea (Goldratt

1994) being to sell nearly the same product to different markets. By differentiating price, image, features and other attributes of perceived value, the firm can satisfy the diverse requirements of the different market segments and is able to exhaust the market potential.

.Allocating buffers at the appropriate locations can increase the firm's throughput.

- Internal buffers in front of the Permanent Bottlenecks.
- Finished goods buffer is required in cases where the customer expected lead-time for a given product is shorter than the process overall lead-time. Naturally, a well-planned finished goods buffer reduces the amount of lost sales.

Turning operational excellence into strategic leverage can also be used to exploit the market constraint. Low-cost, high-quality and short-quoted and actual lead-times enable the firm to sell its products and services better.

3.5. *Step 5: Subordinate the system to the constraint*

In a market-constrained environment, all decisions should be subordinated to market needs and market demand. Actions to be taken are as follows.

- Persuading managers and workers that meeting customer needs, demand and requests is the key to survival.
- Actively listening to customers' needs. When the Hi-Tech firm sells through OEM (original equipment makers), distributors or VAR (value added resellers), management should make every effort to maintain close contact with the end users and understand their preferences and needs.
- Changing the business/organizational structure to meet market and customer needs.
- Shortening the TTM for new services and products.
- Responding quickly to the customers: information, quotations, confirmations, etc.

An important inference from the foregoing is the need for subordination of all parts of the organization to M&S, which represents 'the voice of the customer'. In case of a conflict between operations/production, logistics, R&D or finance and M&S, M&S should lead the way. A major obstacle in many Hi-Tech companies is the dominance of R&D over M&S. In many of them, the core problem is that they are technology-driven rather than market-driven.

Subordination is a mid-term improvement activity that is carried out with the same resources and achieves quick results. However, field experience shows that subordination is difficult to apply. Managers with seniority and years of experience in other departments do not take kindly to subordinating themselves to M&S. It takes strong leadership to cope with resistance to change and delicate interpersonal and interdepartmental relations.

3.6. *Step 6: Elevate the constraint*

Elevation is a long-term improvement step. A reasonable direction is to add more resources to the Permanent Bottleneck: increasing the sales force, enlarging the R&D department, investing in marketing channels, etc. Elevating the system constraint is

also achieved by offloading (Cox and Blackstone 1998) the Permanent Bottlenecks. Usually this does not require large investments and is very effective.

- Offloading M&S for small accounts by creating partnerships with distributors.
- Adding good low-cost administrative assistance to senior M&S persons.
- Selling through alternative channels that do not consume much of M&S resources, like Web sales.

Similarly, the R&D department can find ways to offload internal bottlenecks such as project managers, team leaders and technical experts.

Elevation also means taking actions that add throughput to the system by doing the following.

- Offering added value to existing customers: adding complementary new products or services; managing customers' facilities; keeping and managing customers' inventories; creating loyal customer clubs, etc.
- Applying customer relationship management (CRM) systems. Tracking and managing past and current contacts with customers can generate more sales orders.
- Entering new markets and products. Following the focused strategy model, management may try to enter new markets and develop new products for current and the new markets. A related and proven route for increasing the firm's value is 'brand extension', whereby the firm develops additional products and services under the umbrella of a known and successful brand.

3.7. *Step 7: When a constraint is broken, return to Step 3*

According to TOC, whenever a constraint is broken one should identify the new constraint and manage the system accordingly. The constraint may shift from the market to a resource. The outcome of such an iterative improvement process is a continuous increase in the throughput of the system, resulting in increase in shareholders' value.

4. **Cost management and cost reduction**

TOC advocates a throughput world (Goldratt 1990), which means that management should focus first on the firm's throughput, then on its inventory and finally on its operating expenses. According to TOC, the throughput world is the opposite of the cost world. In the cost world, management puts operating expenses first.

Management should indeed take actions aimed at reducing operating expenses, such as trimming out excess capacity, outsourcing non-strategic high-cost activities and offshoring expensive production. Implementing these measures has an immediate positive effect on shareholder value.

As will be shown below, capacity trimming is justifiable only if it removes truly excess capacity and does not damage the useful lead-time protecting capacity.

5. **Competitiveness and lead-time protecting capacity**

In a *resource-constrained environment*, the company protects its throughput by doing the following.

- Building a time buffer in front of the bottleneck.
- Adding protective capacity to the non-bottleneck resources to cope with external and internal fluctuations (Schragenheim and Ronen 1990).

In a *market-constrained environment* the firm should protect its lead-time in order to be more competitive. A Hi-Tech firm has to reduce its quoted and actual lead-time by keeping extra capacity for the non-bottleneck resources of operations and logistics. The appropriate level of this added *lead-time protecting capacity* depends on the expected fluctuations, the targeted lead-time and the cost of the extra protective capacity. The typical Hi-Tech firm should adjust the capacity of operations in a way that it will be sufficient to supply the market demand *at the required lead-times*, in at least 95% of the time. In a Hi-Tech firm, operations should be transparent to the decision-makers, i.e. they may assume that all products ordered will be shipped on time, at a given quality level and at targeted expenses. This can be achieved by adding internal resources or external ones (subcontractors or outsourcers). Hence, in any cost-reduction exercises, care needs to be taken not to reduce capacity below lead-time protecting capacity.

6. Conclusions

This paper presented a method to cope with a market-constrained environment in the Hi-Tech industry. The claim was made that the M&S and R&D departments are always the system's Permanent Bottlenecks and that the system can be improved by managing them as such.

The five focusing steps, originally defined for resource constraints, were modified to manage the market constraint. The method presented here suggests that the M&S people can actually increase the expected throughput by focusing on fewer markets and clients rather than on spreading their efforts, hoping to glean more orders. Treating R&D as a constraint enables managers to focus on projects that provide high Specific Throughput and thus increase shareholder value.

Strategic and Tactical Gating in R&D and M&S were presented as effective tools to control and manage the facilities. Finally, though cost reduction is very important for increasing shareholder value in a market-constrained environment, only capacity that exceeds the lead-time protective capacity should be considered excessive and subjected to cost reduction.

This paper calls for a further research to generalize the methods presented for industries other than Hi-Tech.

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References

- COX, J. F. III and BLACKSTONE, J. H., JR (eds). 1998, *APICS Dictionary*. 9th edn (Falls Church, VA: APICS).
- COX, J. F. III and SPENCER, M. S., 1998, *The Constraints Management Handbook*. APICS Series on Constraints Management (Boca Raton, FL: St Lucie).
- EDEN, Y. and RONEN, B., 1991, The hourly rate: myth and reality. *Industrial Management*, **33**, 28–30.
- GOLDRATT, E., 1990, *The Haystack Syndrome: Sifting Information Out of the Data Ocean* (Croton-on-Hudson, NY: North River).
- GOLDRATT, E., 1994, *It's Not Luck* (Great Barrington, MA: North River).
- GOLDRATT, E., 1997, *Critical Chain* (Great Barrington, MA: North River).

- GOLDRATT, E. M. and COX, J., 1992, *Theory of Constraints*, 2nd revd edn (Croton-on-Hudson, NY: North River).
- GOLDRATT, E. and FOX, R. E., 1986, *The Race* (Croton-on-Hudson, NY: North River).
- LEVY, N. S. and RONEN, B., 1989, Purchasing and raw materials management in science based industries. *International Journal of Materials and Product Technology*, **4**, 1–9.
- LUEBBE, R. and FINCH, B., 1992, TOC and linear programming: a comparison. *International Journal of Production Research*, **30**, 1471–1478.
- MABIN, V. J. and BALDERSTONE, S. J., 2000, *The World of the Theory of Constraints* (Boca Raton, FL: St Lucie).
- NOREEN, E., SMITH, D. A. and MACKAY, J. T., 1995, *The Theory of Constraints and its Implications for Management Accounting* (Great Barrington, MA: North River).
- RONEN, B., 1992, The complete kit concept. *International Journal of Production Research*, **30**, 2457–2466.
- RONEN, B., COMAN, A. and SCHRAGENHEIM, E., 2001, Peak management. *International Journal of Production Research*, **39**, 3183–3193.
- RONEN, B. and SPECTOR, Y., 1992, Managing system constraints: a cost/utilization approach. *International Journal of Production Research*, **30**, 2045–2061.
- SCHRAGENHEIM, E. and DETTMER, H. W., 2001, *Manufacturing at Warp Speed*. APICS Series on Constraints Management (Boca Raton, FL: St Lucie).
- SCHRAGENHEIM, E. and RONEN, B., 1990, The Drum–Buffer–Rope shop floor control, *Production and Inventory Management*, **31**, 18–23.