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# Observable outcomes and performance effects of the application of theory of constraints to organizational management

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**OBSERVABLE OUTCOMES AND PERFORMANCE EFFECTS  
OF THE APPLICATION OF THEORY OF CONSTRAINTS  
TO ORGANIZATIONAL MANAGEMENT**

**By**

**Martha Lair Sale, A.S., B.S., M.P.A.**

**A Dissertation Presented in Partial Fulfillment  
of the Requirements for the Degree of  
Doctor of Business Administration**

**COLLEGE OF ADMINISTRATION AND BUSINESS  
LOUISIANA TECH UNIVERSITY**

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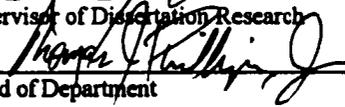
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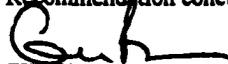
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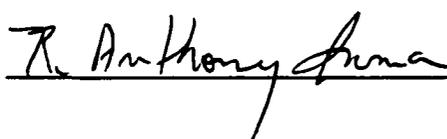
  
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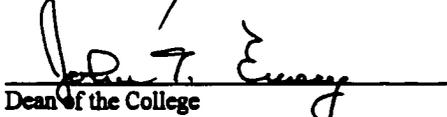
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## ABSTRACT

The objectives of the study were to empirically examine the relationships among the three elements of the Theory of Constraints (TOC), a number of observable outcomes expected to be associated with application of TOC, and business unit performance. Measures were developed for each of the elements of TOC and a number of observable outcomes (OUTCOMES) expected to be associated with practice of TOC. TOC is defined as consisting of scheduling logistics (LOGISTICS), the Thinking Process (THINKING), and non-traditional performance measures (MEASURES). A previously developed and widely used measure of business unit performance (PERFORMANCE) was employed.

The sampling frame for this research consisted of business unit employees who had some knowledge of TOC. Discussion groups and web sites devoted to TOC were monitored to identify these individuals. The questionnaire was sent via email and posted on a web site. A total of 180 usable responses were received. A response rate could not be accurately calculated because it could not be determined how many individuals had access to the survey. Responses collected from the different sources were compared and no significant differences were found.

The statistical analysis revealed that adoption of the individual elements of TOC independently had varying relationships to business unit performance. When used

alone, LOGISTICS was negatively related to PERFORMANCE. THINKING did not have a significant relationship to PERFORMANCE. Use of MEASURES was positively related to PERFORMANCE, and the presence of OUTCOMES had a positive relationship with PERFORMANCE. The complete model of all four factors (LOGISTICS, THINKING, MEASURES, and OUTCOMES) was positively related to PERFORMANCE. Interacting effects of these four factors were found to be complex. OUTCOMES were found to have a moderating effect on the relationship between two of the elements of TOC and PERFORMANCE.

From these results, the data suggests use of TOC is effective as an aid to improving business unit performance. However, the negative relationship between some individual elements of TOC and the complex interaction relationships suggest managers should be cautious in adopting TOC in a piecemeal fashion. Failure to adopt all three elements of TOC could result in unwanted consequences.

## DEDICATION

This dissertation is dedicated to the memory of my father, L. D. Lair, my mother-in-law, Gloria Thorley Sale, and my Uncle, Gordon McCormick Sale. Their belief in my abilities meant so much to me. Without their legacy of encouragement and support, I doubt I would have had the confidence to try.

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Above all, I want to offer a prayerful thanks to the Almighty.

## CHAPTER 1

### INTRODUCTION

The decrease in competitiveness of United States manufacturing during the seventies and early eighties led to examination of how management practices of companies in other countries, especially Japan, differ from domestic practices. Japanese manufacturers stressed continuous quality improvement and low inventories, perhaps without really understanding how these factors interacted with the rest of the manufacturing environment or why they might translate into an improved competitive advantage. Researchers initially attributed many of the differences in management practices to difference in culture—attitude, relationships with the employer, and work ethic. Dr. Taichi Ohno, Executive Vice President of Production at Toyota, discovered the correlations or theories called the Toyota Production System and the Kanban approach, which in the U. S. were combined under the name of Just-In-Time (JIT). Dr. Ohno knew his method worked but never asked the question "WHY?" He is reputed to have said, "My system does not make sense at all but, by God, it's working" (Sytsma, 1997).

Managers made some attempts to emulate the Japanese style of management and encourage changes in the work culture. American managers could not expect to readily accomplish dramatic changes in corporate culture simply by changing company policies. However, American managers could easily adapt Japanese management philosophies in some areas.

Fearing that Eastern competitors knew something about management that Americans had not learned, hundreds of American manufacturers adopted Advanced Management Practices (AMP) as a panacea for the ills of American manufacturing (Goldratt, 1990, pp. 52-57). Advanced Management Practices are those techniques developed since World War II, initially associated with Japanese management philosophies, but more recently characterized by a wide range of practices developed to improve manufacturing quality and productivity (Perera, *et al.*, 1997). These practices focus on quality improvement processes and include Just-in-Time (JIT), Total Quality Management (TQM), and the more recently developed Theory of Constraints (TOC) (Noreen, *et al.*, 1995, p. xii).

### Relevance of Cost Accounting

Since the 1950's, financial accounting standards and income tax regulations in the United States require the use of absorption, or full, costing for external financial reporting and tax purposes. Absorption costing is based on the allocation of all production costs (full costs) to inventory. Although the requirement applies to external financial reporting only, many companies use the same information for internal

management decision-making (Garrison & Noreen, 1997, p. 84; Morse & Zimmerman, 1997, p. 290). Under absorption costing, managers must allocate the cost of all direct materials, direct labor, variable factory overhead, and fixed factory overhead to the cost of finished goods (Dominiak & Louderback, 1997, p. 608). Companies most often choose direct labor hours as the base for allocating fixed factory overhead (Garrison & Noreen, 1997, p. 180). When cost accounting developed, direct labor represented the most significant manufacturing cost of most manufactured goods. Managers believed there was a high correlation between direct labor and the rate at which fixed factory overhead cost was incurred (Garrison & Noreen, 1997, p. 181).

Direct labor now represents a much less significant component of product cost, as increased automation makes manufacturing less labor intensive. Product diversity continues to increase with plants making a wider variety of products that require varying amounts of direct labor (Garrison & Noreen, 1997, p. 181). As a result of these changes, fixed overhead makes up a dramatically higher percentage of costs and the advisability of basing fixed overhead allocation on direct labor is seriously questioned (Kaplan, 1986).

In an attempt to accurately reflect fixed overhead cost in the production of a variety of products using different mixes of inputs, companies may adopt Activity Based Costing (ABC). ABC attempts to provide greater accuracy by associating fixed overhead cost with the input activity or "cost driver" which necessitates the incurring of the cost. To use ABC, management identifies, measures, and records the type and amount of activities associated with a particular product or class of products.

Management then allocates fixed overhead based on this measure (Dominiak & Louderback, 1997, p. 95). Often managers identify fixed overhead costs and cost drivers for individual factors of production. They may then assign fixed overhead to products based on the activities of individual departments or even the output of individual machines. When managers allocate fixed overhead for an individual machine, efficiency ratings depend on the production capabilities of the machine without regard to whether all the output of that machine can be processed or sold by the company. This leads to dysfunctional local optimization of that machine rather than optimization of the process.

If the capacity of some elements of production is consistently greater than the overall capacity of the plant, or greater than the demand in the market, management may be encouraged to produce excess amounts of inventory. This occurs because fixed cost can be divided up over larger numbers of units resulting in lower cost per unit. This results in higher reported net income and greater reported current assets.

In addition to encouraging the buildup of inventories, the practice of fixed cost allocation may contribute to other poor management decisions. The decision of whether or not to take on certain jobs in a job-shop environment or whether to make or buy certain components often depends on cost. Calculation of product cost is dependent on accurate reflection of which costs are truly fixed and which vary with levels of production over the range under consideration. As long as a facility has excess capacity, additional jobs should be produced if the sales price of the job is sufficient to cover the variable cost associated with the job and contribute to the fixed cost of the facility. The

quality of management decisions depends, therefore, on the quality of cost information.

Companies often cannot change labor cost in the short run, yet labor continues to be considered a variable cost. Depreciation is a method of allocating a “sunk” cost. The asset is already purchased. Any difference in the way this past cost is allocated to current production will not affect current cash flows. Economic principles mandate that these sunk costs should not affect the choice of alternatives, but these costs are often included in fixed overhead. Significant evidence suggests managers routinely make decisions using absorption costing. Use of these inappropriate traditional cost accounting measures to make business decisions led Johnson and Kaplan to question the relevance of cost accounting (Johnson & Kaplan, 1987) and Eliyahu Goldratt to refer to cost accounting as the number one enemy of productivity (Goldratt, 1983).

### Theory of Constraints

Theory of Constraints (TOC) is defined in the American Production and Inventory Control Society Dictionary as, “A management philosophy developed by Dr. Eliyahu M. Goldratt that can be viewed as three separate but interrelated areas—logistics, performance measurement, and logical thinking” (*APICS dictionary: The official dictionary of production and inventory management terminology and phrases*, 1998). The purpose of TOC is to provide a focus for continuous improvement resulting in improved business unit performance. Proponents of TOC advocate certain TOC practices consisting of three elements—logistics, thinking process, and performance measures—they consider necessary for implementation of TOC (Ballew & Schlesinger,

1989; Maskell, 1986; Goldratt, 1986; Goldratt, 1983, pp. 28-31). These three elements of TOC are believed to result in certain observable outcomes and improved business unit performance. The relationship between the adoption of TOC, these observable outcomes, and business unit performance is uncertain.

Publication of *The Goal* by Eliyahu Goldratt in 1984 marks the beginning of an important new concept of business management. In *The Goal*, Goldratt stresses understanding the logic of what happens in the manufacturing environment and implementing changes only after carefully considering and understanding the desired results, as well as any other implications of the proposed change. In the guise of a novel about the life of plant manager Alex Rogo, *The Goal* presents a typical job-shop manufacturing company facing closure because of lack of profit. In an effort to improve profitability, Alex initially concentrates his efforts on attempts to cut cost. This results in a continued deterioration of the ability of the plant to meet customer orders. As the result of several consultations with Jonah, a physics professor, he begins to concentrate on efforts to increase activities that would improve operations and increase profit. This tactic proves successful. After discovering the error of his ways, Alex is able to save his plant by completely disregarding the accepted cost-cutting policies that are creating devastating problems. Alex's friend Jonah continues to help and inspire him in his quest for a better management philosophy.

## Logistics

*The Goal* questions the accepted wisdom of striving to attain the balanced system advocated by JIT. *The Goal* introduces what Goldratt calls a drum-buffer-rope (DBR) scheduling system and a five-step continuous improvement process (LOGISTICS).

The DBR approach to synchronized manufacturing assures that the inventory buffer in front of a capacity constrained resource remains at adequate levels without being too large (Goldratt, 1984, pp. 112-134). The constrained resource becomes the drum that determines the timing for the system. The buffer is the time related supply of inventory before the constrained resource that assures the constrained resource will not be idled by fluctuations in the system leading up to it. The rope is "tied" between the constrained resource and the lead operation in the system assuring that too much inventory does not develop in front of the constraint. In *The Goal*, Goldratt develops an illustration for the idea from a group of scouts. The scouts are marching single-file along a trail and are unable to pass one another. The slowest scout, located somewhere in the middle of the group, represents the drummer determining the pace for the group. The buffer is the natural spacing that spreads between the faster marching scouts in front and the slowest scout. The rope determines the maximum physical distance allowed to develop between the first scout and the slowest scout. The spacing between all scouts following the slowest scout varies somewhat as they change their pace or are detained temporarily, but, being faster, they naturally catch back up to the slowest scout without

intervention. In this analogy the trail traversed represents product moving through the system.

The five-step continuous improvement process is based on exploiting the constraints in the system (Goldratt, 1984, p. 297).

1. Identify the system's bottlenecks.
2. Decide how to exploit (get the most from) the bottlenecks.
3. Subordinate everything else to the above decision (make the bottleneck the drummer).
4. Elevate the systems bottlenecks (find a way around the bottlenecks).
5. If, in a previous step, a bottleneck has been broken go back to step 1.

Goldratt emphasizes that the completion of all five steps will lead to continuous process of improvement and, as it does, the nature of the bottlenecks will change. In a manufacturing environment, for instance, the constraint may change from being a physical constraint within the plant to insufficient market demand or a company policy that must be changed (Goldratt, 1984, p. 297).

### Thinking Process

In addition to the drum-buffer-rope scheduling principles, *The Goal* introduces a Thinking Process designed to produce optimum solutions to conflict resolution. The Thinking Process (THINKING) is based on the concept that compromise solutions are not optimal. Compromises are, by nature, the result of each party to a conflict agreeing to a course of action that is less desirable than the course desired for optimum. The Thinking Process is a method of examining the current situation to determine the underlying causes of the conflict. A course of action is then chosen that will change the

current situation and relieve the conflict by producing a different situation that is optimal for both parties.

### Performance Measures

In *The Goal* the cost accounting system, with its measurements of efficiency and product cost, is a casualty of Alex's improved management philosophy. He finds it necessary to completely redesign the company's accounting system. Like most cost accounting systems in place in American companies today (Garrison & Noreen, 1997, p. 84), the allocation of costs to products encouraged local optimization without consideration for the global good of the company.

According to Goldratt (1986, pp. 28-31) a relatively simple accounting approach is required by TOC in place of current costing systems. He claims that this new approach termed throughput accounting (TA) is consistent with the common goal of all profit-seeking organizations to make money. In throughput accounting Goldratt advocates three "global operational measurements (MEASURES)."

**Throughput**—the rate at which the system generates money through sales. (This is essentially sales less raw material and any other cost, such as commissions, that actually vary directly with sales volume.)

**Inventory**—all the money the system invests in purchasing things the system intends to sell. (This would include what traditional accounting systems consider investments in plant and equipment. Intuitive justifications for including plant and equipment in inventory include the concept that these resources will be used up or worn out as productive assets and then will be sold to recoup any residual value.)

**Operating Expense**—All the money the system spends in turning inventory into throughput.

Companies can generate more money by increasing throughput, decreasing inventory, or reducing operating expenses (including direct labor). Increasing throughput has the greatest potential for generating more money, followed by reducing inventory, then by decreasing operating expenses (Goldratt, 1986, pp. 39-51).

After publication, *The Goal* captured the imagination of working managers in industries across the United States and around the world. It became required reading in some companies and has sold over 8 million copies. Managers seemed almost compelled to share the book with others. It was reviewed in *The Smart CEO's Reading List* (Brokaw, 1991) and appeared on numerous other "must read" list for executives.

Because *The Goal* focuses on the management of constraints in a job shop environment, it rapidly became thought of as a how to book for managers of manufacturing plants. Unfortunately, this perceived limitation has hindered the dissemination of the ideas into other areas that might benefit from application of the theory (Noreen, *et al.*, 1995). Shortly after the book gained popularity, recession and excess capacity made the reduction of production constraints or bottlenecks seem even less important, so even companies which had successfully implemented ideas from *The Goal* found the constraint shifted outside the factory. At that point, managers often failed to see the relevance of TOC to non-production problems and improvements ceased. As improvements stopped, morale dropped and regression often followed. Noreen, *et al.* (1995, p. xxi) see this as a hazard of focusing on TOC as only a job-shop, or even manufacturing, technique instead of properly implementing it as an overall management philosophy.

In 1986 Goldratt established the Avraham Y. Goldratt Institute (AGI) as an educational and training organization. The AGI conducts classes that vary in length from a few hours to several weeks to promote TOC (Noreen, *et al.*, 1995, p. 4). The institute offers a two-week premier course called the "Jonah course" designed to teach the graduates to function like the character Jonah in *The Goal*, spreading the philosophy throughout industry.

### Observable Outcomes

Managers adopt the Theory of Constraints to improve business unit performance. Practice of the Theory of Constraints includes activities designed to control production flow (LOGISTICS), direct management decision-making (THINKING), and provide information appropriate for management decisions (MEASURES). The activities associated with TOC stress inventory management, production flow management, and product choice management. Management of these activities include specific goals such as eliminating unnecessary inventory, decreasing throughput time, decreasing the size of production runs, improving due date performance, increasing pricing flexibility, increasing product diversity, and improving manufacturing flexibility. These outcomes of TOC (OUTCOMES) are measurable goals associated with TOC adoption.

### Business Unit Performance

Business unit performance (PERFORMANCE) can be measured in myriad ways. Changes in the business environment have necessitated examination of the way

performance is measured. Emphasis on quality issues and human capital as business assets has led to the development of non-financial measures of business unit performance. Because different standards of performance are expected for different industries, the performance of a particular firm is best defined in the context of the industry in which it operates (Swamidass & Newell, 1987). Moreover, it has been shown that differences in the acceptability of performance due to industry differences is taken into account by managers' satisfaction with their firm's performance.

#### Statement of the Problem

Although businesses adopted TOC and other Advanced Management Practices at an increasing rate over the past decade, research indicates these initiatives failed to result in significant economic benefits (Ittner & Larcker, 1995). Many researchers and practitioners claim these new techniques perform poorly because of continued use of traditional management accounting systems. They charge that traditional systems do not provide appropriate data for management decisions or performance evaluation and rewards (Kaplan, 1990; Ballew & Schlesinger, 1989; Maskell, 1986; Goldratt, 1983).

Proponents of TOC consider management accounting, as it is practiced, to be ineffective at providing the information necessary for decision making in a progressive manufacturing environment. Several accounting practices help contribute to the type of waste that Advanced Management Practices are designed to eliminate. Some of these accounting practices are: 1) tracking and reporting direct labor for purposes of overhead allocation; 2) tracking and reporting machine utilization efficiencies; and 3) using full-

absorption costing to value work-in-process inventory or cost of goods sold; and 4) using absorption costing to determine cost variances. Such accounting practices contribute to the type of waste that Advanced Management Practices are designed to eliminate (Maskell, 1986).

Of all practitioners of AMP, users of TOC have been particularly critical of cost accounting and its effect on manufacturing. This is especially true of Dr. Eliyahu Goldratt, the originator of TOC. Dr. Goldratt drew attention in the management accounting profession when he delivered a paper entitled, "Cost Accounting: The Number One Enemy of Productivity" (Goldratt, 1983) to the American Production and Inventory Control Society. On the strength of the criticism of cost accounting delivered in that paper, Dr. Goldratt was invited to be a keynote speaker at the annual conference of the National Association of Accountants (now the Institute of Management Accountants) in 1995 (Noreen, *et al.*, 1995, p. iii).

The Institute of Management Accountants recognized the importance of Dr. Goldratt's contribution and with Price Waterhouse sponsored an investigation into the implementation of TOC. The investigation was begun in 1992 and culminated with publication of the report *The Theory of Constraints And Its Implications For Management Accounting* (Noreen, *et al.*, 1995). The three investigators are management accounting professors. Dr. Noreen's background is in research centered on fundamental issues in management accounting addressing the underlying cost accounting models and the actual behavior of costs in organizations. Debra Smith worked in public accounting and spent nine years as division controller and vice

president of finance in manufacturing before becoming a professor. She is involved in offering workshops explaining the necessary changes in accounting systems and measures needed to support quality improvement processes such as just-in-time, total quality management, and TOC. Dr. Mackey is a frequent contributor to *Management Accounting* as well as other accounting journals and is author of *Cases from Management Accounting Practice*, Volume 8. His research interests center on the use of accounting systems in manufacturing settings and he consults on changes to accounting systems made necessary by new technologies (Noreen, *et al.*, 1995, p. xi).

Over the course of several years, Noreen, *et al.* investigated the application of TOC in a variety of settings in the United States and Europe. They note that their sample was not random and companies with a pro-TOC bias were more likely to be chosen. In concluding their report they wrote:

The accounting in TOC should be familiar territory to management accountants. While the terms used in TOC are different from those we commonly use, variable costing, use of scarce resources, and responsibility accounting have been topics in management accounting textbooks for decades. From a theoretical viewpoint, little in TOC is new to accounting. The difference is that some topics—particularly the use of scarce resources—are far more important than we thought and are given more prominence in TOC. The companies involved in TOC are different in that they actually put into practice much of the advice found in textbooks. Surveys over the last several decades have revealed consistently that most companies do not follow many of the practices advocated in management accounting textbooks. Absorption costing routinely is used for internal decision making, corporate headquarters expenses are allocated to divisions in performance reports, product profitability calculations ignore constraints, and so forth. For those of us who teach management accounting, it is reassuring that an identifiable collection of companies practice what we preach (Noreen, *et al.*, 1995, p. 149).

Despite the statement above, little empirical work has been done to assess the degree to which companies practice these concepts taught in management accounting and advocated by TOC.

Additionally, there is little evidence in support of economic advantages accruing to companies, which use TOC. To determine whether these TOC principles are effective, it will be necessary to examine whether companies which use TOC principles, actually embrace the accounting concepts advocated or adhere to traditional management information systems.

#### Purpose of the Study

Research suggests that use of TOC, like use of other Advanced Management Practices should be associated the observable outcomes of TOC and with organizational performance. Empirical examination of possible relationships among the individual elements of TOC practice (LOGISTICS, THINKING, and MEASURES), the observable outcomes of TOC, (OUTCOMES), and business unit performance (PERFORMANCE) is lacking. The purpose of this study is to empirically examine these relationships.

## CHAPTER 2

### REVIEW OF RELATED LITERATURE

In this chapter Dr. Goldratt's writings on TOC and major research on TOC published since publication of *The Goal* (Goldratt, 1984) will be examined. Although Goldratt and TOC have been discussed widely in the popular and practitioner oriented press, the ideas have received less attention in academic circles. A survey of current literature reveals that much of what has been written about TOC, by academics and practitioners alike, is published in the practitioner press. Most previously published academic works on TOC are conceptual in nature. Some writers have offered case studies, but empirical work is severely limited.

#### Theory of Constraints Theoretical Development

In addition to establishing the Avraham Y. Goldratt Institute (AGI) in 1986, Eliyahu Goldratt, corroborating with Robert Fox, authored *The Race*. *The Race* addresses the declining competitiveness of United States manufacturers in the global market and the threat this poses to the standard of living in the United States. A companion book to *The Goal*, *The Race* graphically describes the concepts of drum-buffer-rope (DBR) and discusses the implications of excess inventory (Goldratt, 1986).

In 1988 and 1989 the Avraham Y. Goldratt Institute published a series of six booklets by Eliyahu Goldratt that are collectively referred to as *The Theory of Constraints Journal, Volume 1*. Each booklet presents two articles that represent chapters in two different books. The first chapter in each booklet, when combined, becomes a six-chapter volume on the theoretical aspects of TOC entitled *The Theory of Constraints*. The second chapters of each booklet, as a set, present applications of TOC to various industries as described by the fictional character Jonah.

The first set of articles restate many of the problems in the fictional plant of Alex Rogo from *The Goal*. In addition, they specifically address the choice of organizational performance measurements. Although he does not use the term “goal congruence” in his discussion of appropriate performance measures, Goldratt (1988, pp. n. 3, 1) discusses the problem of goal congruence. He begins the discussion with, “Tell me how you will measure me and I’ll tell you how I’ll behave.” From this he develops his argument that localized performance measures foster localized optima incongruent with system-wide goals. He discusses the fact that the goal of for-profit organizations is to make money now, as well as in the future, and contends that viewing a company as a single money-making machine makes it difficult to justify much of the current practice of product costing, efficiency reporting, and variance reporting. He suggests that these currently used measures view the organization as a series of independent activities that are each judged by individual efficiency measures and/or variance reports. He develops the definitions of throughput, inventory, and operating expense discussed earlier and considers the damage caused by current widely used inventory valuation systems. He

suggests dealing with the problem by simply eliminating all value added computations from inventory and preparing reports for internal decision-making using this extreme version of variable costing in which inventory is valued at materials cost only (Goldratt, 1988, pp. 3, 11). He suggests we eliminate the term "cost" from our vocabulary because of the ambiguity associated with its many meanings.

To assess the operations of subsystems within the system, he suggests the use of three control measures to replace the cost variance reports currently in wide use. The three measurements are Throughput-Dollar-Days, Inventory-Dollar-Days and Local-Operating-Expense. Subsystems are assigned all the expenses controlled solely by that subsystem (Goldratt, 1988, pp. 3, 16). This Local-Operating-Expense is consistent with the idea of controllable and non-controllable expenses in responsibility accounting (Dominiak & Louderback, 1997, p. 438). The summed value of each late shipment times the number of days it is late comprise Throughput-Dollar-Days. This measure reflects management effectiveness. It is the amount of potential throughput that remains unrealized. Similarly, Inventory-Dollar-Days reflects the value of the inventory held times the number of days it is held. When compared to the optimum inventory levels that should remain in the buffers, it provides a measure of the effective application of DBR. Use of these non-traditional measures fosters the goal of reducing costs, late orders, and excess inventory (Goldratt, 1988, pp. 3, 18).

In 1990, *The Haystack Syndrome* by Goldratt followed his other two books. It stresses the difference between raw data and usable information and what type of information is actually needed to make sound management decisions. Goldratt claims

that many of the problems associated with inappropriate measures and the continued use of cost accounting is the fault of managers who refuse to give up traditional computations. Goldratt, once again, exhorts managers to give up the familiar nomenclature of cost accounting and abandon cost calculations for more appropriate measures (Goldratt, 1990, p. 42). Goldratt gives an excellent example of what happens when absorption costing is used to determine if a product should be dropped. First the materials cost is determined. To that amount is added the direct labor. Next the overhead rate is calculated and added to the sum of direct materials and direct labor. These last two factors are calculated based on historical figures, not what the changed reality will dictate. Even when the fixed overhead allocation base and fixed overhead per unit is revised this process does not allow for possible changes in variable overhead and direct labor rates. Managers and management accountants are too accustomed to viewing these numbers as truly variable. So, without consideration of how the proposed change will affect the variable overhead or the total direct labor, they establish the "cost" of the product. A comparison of this cost with the sales price determines if the product is to be dropped or retained. Goldratt claims that often managers fail to ask the pertinent questions of, "How much impact will this change actually have on total operating expense?" This habit of using absorption product cost, whether is allocated by conventional means or based on activity based costing (ABC), leads to the error of trying to save parts of machines or percentages of workers (Goldratt, 1990, p. 46). Goldratt advocates consideration of the familiar concept of marginal cost.

Goldratt reiterates again and again that, "Local optima do not add up to the optimum of the total." He stresses the fact that, although total quality management (TQM) and just-in-time (JIT) philosophies help managers focus on what is important, they have done little to help managers change to a new management style that will make coping with this new view of importance possible. He states the opinion that both JIT and TQM have abandoned cost accounting without instituting other more appropriate financial measures. He contends that this is dangerous, given the goal of making money (Goldratt, 1990, p. 55). In *The Haystack Syndrome* Goldratt elaborates on the measures of Throughput-Dollar-Days, Inventory-Dollar-Days and Local-Operating-Expense introduced in *The Theory of Constraints Journal* and devotes considerable time to the details of scheduling.

For twelve monthly issues beginning in June of 1991, Eliyahu Goldratt wrote a series of columns collectively titled *Late Night Discussions for Industry Week*. They highlight various aspects of TOC. They are presented as discussions between the fictional characters Alex Rogo and Jonah. In the first article, the author (Goldratt, 1991a) discusses the buildup of inventory in the American automobile industry. Goldratt claims the presence of as much as three months of finished goods in the system at one time has caused the American automobile manufacturers to be much more removed from, and less responsive to, the needs of the customer than Japanese automobile manufacturers. Since automobiles are offered with limited options, there is no practical reason to have such a vast inventory. Manufacturers cannot reduce inventory, however, since absorption costing recognizes profit on products

manufactured for inventory. The manufacturers would show reduced profits in the period of inventory reduction (Goldratt, 1991a). This would happen because, under absorption costing, fixed costs are allocated based on the number of units produced. Inventory reduction would require a temporary reduction in production providing fewer units over which to allocate fixed costs. The units produced during this period would bear a higher cost and thus provide a lower profit than units produced under stable or increased production.

Another aspect of cost accounting attacked in the series is transfer pricing (Goldratt, 1991b). Goldratt contends that determining transfer pricing through cost calculations encourages inefficiencies. Freedom to contract externally for goods and services available within the company does not encourage the parts of the company to do what is good for the whole. If transfer prices are set too low, companies may actually produce things internally that are outside their core efficiencies and should be obtained externally. On the other hand, if transfer prices are set too high, companies may contract outside and provide profits to competitors for products that, if purchased internally, even at a lower than average profit, would provide a net income to the company (Goldratt, 1991b).

Another topic examined in the *Late Night Discussions* is whether or not the Japanese tendency of holding inventory to extremely low levels and regarding it as a liability is the key to their competitiveness (Goldratt, 1991c). If inventory were truly a liability, nothing would prevent companies from just discarding it. On the contrary, no inventory means nothing to work on and nothing to sell. However, excess inventory

does reduce the ability to compete in the market and therefore reduces future throughput. The purpose of inventory is to protect throughput—to protect the company's ability to have product to sell. Inventory is an asset to the extent that it accomplishes that purpose. It is a liability to the extent that it encumbers the company. Goldratt suggests that, rather than the competitive advantage of the Japanese being grounded in a simplistic maxim like "eliminate waste," or "zero defects," or even "inventory is a liability," it is more far reaching. He hypothesizes that the Japanese are more competitive because they realize product price is a concept derived from product cost plus margin. They understand that, since the notion of product cost no longer applies to current reality, the notion of a fixed product price is erroneous (Goldratt, 1991c).

In *Late Night Discussions: VIII* Goldratt (1992a) examines the paradigm shift necessary to view production from a TOC perspective. Conventional cost accounting defines efficiency as the percentage of time resources (both human and mechanical) are devoted to production and how rapidly they turn out product. In an attempt to meet these definitions of efficiency, to keep resources busy, and to satisfy "economic" order quantities or minimum runs, products are put into process for distant orders or projected needs. In the meantime, any customers with urgent orders or order changes are left unsatisfied. The paradigm shift requires efficiency to be viewed as the extent to which resources are able to satisfy customer needs and the speed with which they can be mobilized to react to customer demands.

In the final article of the series, Goldratt (1992b) addresses how cost accounting gets in the way of the needed paradigm shift. In the words of the character Alex, Goldratt puts forth the thought provoking statement:

To me, the cost of running the operation is real money. We pay money to the workers. We pay money to engineers. We pay money to vendors. We never pay money to a product. Thus, 'product cost' exists only as the result of some calculations. Nevertheless, my peers sometimes behave as if 'product cost' were more real than the actual money we pay.

Goldratt continues by observing that people continue to accept the damaging concepts of 'product price' and 'product cost' and allow these concepts to obliterate information needed for sound business decisions. He suggests they probably do this because these concepts were once valid. Early in the industrial revolution, because labor was usually paid by piecework and there was no automation, the vast majority of costs were totally variable, that is they varied directly with the production of one more or one less unit. Under these conditions, allocating company expense to product cost was a reasonable approximation of the cost of doing business. In the past decade, variable costs per unit have remained stable, while fixed cost (those which do not vary as production varies) have doubled. As automation and fixed cost have increased, product costing has become meaningless as an approximation of the cost of doing business. Because profit is based on these cost calculations, product profit or margin is also meaningless (Goldratt, 1992b).

In 1994 Goldratt published a sequel to *The Goal* called *It's Not Luck*. In it, he continues with the story of the fictional Alex as he progresses from saving his one

manufacturing plant to using the techniques of TOC to save his entire division. In *It's Not Luck* Alex's division consists of all the facilities of the fictional corporation that are not core business. By highlighting several disparate companies, Goldratt shows TOC management techniques applied to various industries from cosmetics, to printing, to industrial capital goods.

In *It's Not Luck*, Goldratt also introduces the Thinking Process central to the Jonah courses offered by AGI. With The Thinking Process, Goldratt contends that a solution to any problem is almost always available without compromise. Those involved must identify the assumptions underlying the conflict, then examine the assumptions until they are able to break the deadlock. This process is called "evaporating clouds." Users examine assumptions by constructing "Current Reality Trees" listing all the current assumptions underlying the conflict. They can then identify a point that can be changed to form the basis of a solution (the "injection" that alters the assumptions). A "Future Reality Tree" is then constructed to determine if implementation of the injection will eliminate the problems (called Undesirable Effects or UDE's) and be sure it does not create other Undesirable Effects (Goldratt, 1994). This extension of TOC has not been as widely practiced as the basic TOC philosophy. Noreen *et al.* attribute this to difficulty of learning the process and its abstract nature (Noreen, *et al.*, 1995, p. 57).

As is true for other management philosophies, successful implementation of TOC depends on the support and involvement of top management. It is possible that the unconventional way TOC was introduced hampered its acceptance by some potential

supporters of innovative management thought. It was written by a physicist as a novel and touted by the popular business press. Many saw it as another self-help, "how to" book for manufacturing managers. Attempts to avoid the use of terms already in use and burdened with ambiguous meanings led to development of a specialized language. This language is based on situations and people in Goldratt's novels. Those who have gone through the process to become expert at the system are dubbed "Jonah" after a fictional character. Constraints are called "Herbies" and the scheduling process is dubbed drum-buffer-rope. Practitioners consider this jargon necessary to distinguish the exact meanings they wish to convey, but this may have prevented TOC being taken as seriously as a tool for the revolution of management thought as it might have been. (Noreen, *et al.*, 1995, p. 4).

Despite these factors, the growth of TOC led managers and management accountants to question the value of measures that focus on any function as a separate, isolated entity, without consideration of the processes of the function, or the way those processes are woven through the fabric of the organization. Cost reduction efforts usually depend on measures of effectiveness and efficiency that focus on individual functions. Management emphasis on these concepts encourages local optimization without consideration of the goals of the organization as a whole. Despite the unconventional presentation, many practicing managers and academics alike recognize TOC as being congruent with these insights.

### Other Descriptive Literature

In an attempt to remain competitive worldwide, the three-part mantra of management has been cost reduction, quality production, and elimination of competition. Salafatinos (1995) contrasts JIT and TOC in their response to these three goals. In contrast to JIT, with a goal of a "balanced" manufacturing system and the reduction of all inventories to zero, Goldratt recognizes that adverse interactions occur between these three potential ways of increasing a company's profit. For example, reducing the inventory of certain parts may reduce throughput by delaying the completion of units that could have been profitably sold. A reduction in inventory could increase operating expenses by increasing overtime paid to expedite the manufacture of parts needed to avoid reductions in throughput. Goldratt contends that a "balanced" system is *not* ideal because then delays at any point in the system causes immediate delays throughout the rest of the system. In such a balanced system, it would be counterproductive for any part of the system to continue to operate when one element is disrupted because, by definition, all parts of the system have the same capacity. If an element were disrupted, continuation of production in processes upstream of the disruption would just cause a permanent buildup of inventory in front of the disrupted element. Goldratt recommends identifying the elements in the system with the least capacity, the constraints, and maintaining an adequate inventory in front of these elements to ensure that they are never idled by disruption of a non-constraint element. Under this system continuing to operate the constraint would not cause a permanent

buildup of inventory down stream because, by definition, the constraint has less capacity than other elements in the system (Salafatinos, 1995).

Attempts of several authors to define TOC requirements in terms of the currently held views of product costing characterizes the current ambiguity about the demands TOC places on accounting. Several researchers including Macarthur (1993), Dugdale and Jones (1996), Fritzsche, (1997), and Salafatinos (1995) advocate both TOC and ABC (Activity Based Costing) as alternate sources of information about the "true" cost of manufacturing. Macarthur states, "Both TOC and ABC provide information that can be useful to decision makers if they interpret and use the information properly. Managers must understand the strengths and weaknesses of both methodologies before they use TOC or ABC information to make decisions." Macarthur stresses the complementary nature of the two accounting methods. He goes on to characterize TOC accounting information as useful only for decisions requiring short-run information (Macarthur, 1993). He stresses the usefulness of TOC for these short-run decisions such as choosing which product to emphasize given certain capacity restraints. However, Macarthur suggests using ABC costing to provide estimates of the long-run cost of organizational activities and cost objects for long-term decisions concerning pricing, profit planning, capacity management, and the cost management of non-value-added and value-added activities. Macarthur does not address the issue of localized optimization encouraged by what Goldratt refers to throughout his writings as this "cost world" focus. ABC, because of the use of different, perhaps more appropriate, allocation bases would provide different cost numbers for individual products. It does

not address the question of whether these costs should attach to inventory and be reflected in inventory valuation or whether they should be expensed as period costs. Whether fixed overhead is allocated to inventory based on direct labor or some other activity base suggested by ABC does not alter the central issue of dysfunction encouraged by allocation costing in general and denounced by Goldratt. Macarthur characterizes ABC as, "an accounting model that measures the long-run cost of the resources consumed to perform activities, then assigns the costs of the activities to cost objects based on their consumption of the activities." The central question raised by Goldratt in accounting for TOC is not how the "consumption" of these activities should be assigned to various products, but whether these activities should be considered as "consumed" in the production of a particular product. He contends, they will be "consumed" whether or not the product is produced. Despite Macarthur's characterization of TOC as appropriate only for short-run decisions, later in the same article he (1993) states TOC is, "a management philosophy that seeks to maximize long-run profit through proper management of organizational bottlenecks or constrained resources, such as machine capacity limitations and management policy restrictions."

King (1993), in an explanation of why across-the-board cost reduction programs and Total Quality Management programs often fail, recognizes some of the same problems addressed by TOC.

Across-the-board cost reduction programs often fail because, unless processes are redesigned, the same work has to be performed by someone. If total required work effort does not change, costs ultimately return to their previous level. Similarly, TQM programs often fail because, unless people come off the payroll, the same dollars are spent.

This article explains that not all "savings" are equal. King (1993) refers to "green-dollar" savings which represent cash, and "blue-dollar" savings which represent a mere reduction in the use of some resource. Green-dollar savings come only when cash outflows are reduced, such as fewer people on the payroll or less spent for purchases. He describes blue-dollar savings as beneficial reductions which should ultimately affect productivity, but which, unless resources are redeployed to activities that affect net income, only increase the capacity to handle additional work. King (1993) describes companies that calculate their cost of quality and learn that they spend too much on, so-called, non-value-added activities. Then they institute a total quality management (TQM) program that gives everyone a sense of accomplishment until it becomes evident that the bottom line has not improved. King states that TQM programs often fail because, people are not removed from the payroll and the same dollars are spent. Additional resources may become available that can be used for growth in volume, but unless more goods are sold with the same number of people, no cash savings will occur. Across-the-board cuts bring a reduction in people with no change in process. TQM often brings a change in process with no reduction in people. Neither change, alone, suffices. To achieve real cash savings that show up on the bottom line, both changes must occur. King gives the example of saving a few minutes of an employee's time versus buying the same quality of a supply at a lower cost. Both are worthwhile, but they have a different effect. Saving the time of the employee may create a savings that can be "spent" on some other activity within the organization, but the way costs are normally calculated, savings of this kind often result in enhanced budget reports using

absorption accounting, but no actual dollar savings to the company. King makes a similar argument about switching to a just in time (JIT) production system. He points out that many of the advantages of JIT, including a reduction in the number of vendors and the number of purchase orders required, may save effort but are unlikely to produce a cash savings (King, 1993).

Bear, *et al.* (1994) write that the intense competition of modern business has reduced the margin of error for businesses causing an increased focus on costing. Companies wishing to remain competitive know it is vital that the information they use for decision-making reflects their environment as accurately as possible. The authors contend that one of the most significant effects companies' experience upon adopting advanced technologies is the move from predominantly variable costs in the production era, to an environment where the vast majority of costs should be considered fixed. The authors point out two historical justifications for traditional standard costing: the concept of standard runs derived from the time and motion studies originating with Frederick Taylor, and the concept of the "economic batch size." Both result in very distorted product costs. They also contend that standard costing produces performance measures that contradict the objectives of management philosophies and advanced technology (Bear, *et al.*, 1994).

Bear, *et al.* (1994) see throughput accounting as compatible with modern technologies and reflecting much of the modern philosophies which enable the reduction of work-in-process inventories and the management of bottlenecks. They state that throughput accounting emphasizes the importance of timing and throughput,

but that there is very little empirical evidence to suggest that the technique provides managers better support than do other approaches.

Westcott (1995) calls on internal auditors and business managers to develop a better view of their business as a system. He cautions that accountants and managers who see the business as an integrated interaction of distinct components fail to recognize and correct for weaknesses that destroy the business. This view is consistent with the call to abandon current accounting practices, that encourage local optimization, in favor of a system such as throughput accounting, which recognizes that only completed transactions increase the wealth of the company. Other activities may be important, but, at best, they increase the potential future wealth of the company, not its current position.

TOC has been suggested as a management philosophy with the potential to provide a definitive answer to the problem of maximizing profitability now and in the future (Salafatinos, 1995). TOC emphasizes identifying and managing constraining elements in the system to increase throughput, reduce inventory, and increase profits. A core idea of TOC is that each system has at least one constraint that limits the system from producing more profit. Salafatinos (1995) contends that throughput accounting is a technical approach to solving production flow problems by focusing on the dynamics of the movement of production, while ABC is generally concerned with focusing on and analyzing fixed overhead. He suggests some of the techniques of the two systems, especially the activity mapping done for ABC, are complementary. Under throughput accounting, the importance of inventory is based on the recognition that a company is

profitable only if the rate at which it generates money exceeds the rate at which it spends money.

Salafatinos (1995) expresses the relationship between production flow and traditional cost accounting techniques:

Improving the flow of product through a factory increases throughput and causes inventory and operating expenses to go down. The conventional idea that each resource needs to be used to capacity ignores the interrelationship of all the resources in a system and leads to an incorrect view of the organization. Traditional management accounting control techniques like standard costing have fostered this view, because standard costing treats a company as if it were a collection of separate and independent investments rather than a single organism designed to make money.

Thus, the focus of TOC is that every minute of operating time should be devoted to producing something that can be sold (Salafatinos, 1995). Using Goldratt's definitions of accounting terms for throughput accounting listed earlier, the primary measure of profitability is the ratio of throughput (sales margin) to operating expenses. The numerator is calculated by deducting total material costs from sales revenue. All other costs of operations go into the denominator. Use of this measure of profitability focuses management's attention concurrently on the three basic objectives: (1) increasing throughput, (2) reducing inventory, and (3) reducing costs. All other things held equal, increasing the speed with which a product moves through production reduces inventory. Therefore it is evident that reducing the effects of constraints increases throughput. If a constraint is pressed beyond its capacity, work in process will begin to build in front of the constraint from the non-constrained resources that precede it. This buildup leads to increases in work-in-process inventory to which is a portion of

fixed cost is allocated. Allocating fixed cost to this inventory allows allocation of less fixed cost to completed units. This leads to recognition of profits that are unattained, and perhaps unattainable. Managers are lead to focus attention on individual resources rather than the performance of the system as a whole because of the faulty underlying logic that, if all resources are utilized to their individual efficiency the system will operate at maximum efficiency and produce maximum profits. The tendency to reward localized efficiency has long been supported by two staples of traditional cost accounting--cost variance analysis and standard costing (Salafatinos, 1995).

Salafatinos (1995) supports Goldratt's view that a balanced system is unattainable because of fluctuations and disruptions in the flow of work in process (Goldratt, 1984, pp. 106-111). It is not important to maximize each individual resource, but to maximize the flow of product through the system as a whole. So, from a TOC perspective, the whole company is perceived as one single, large resource for making money. Since the slowest process governs throughput, these constraints deserve management attention.

In a review of topics that appeared under modern management philosophies Mock (1995) notes that throughput accounting or accounting for TOC is not a completely new concept. He relates the concept of throughput, defined as sales revenue less direct material cost, and constrained resources to the elementary costing concept of contribution per key factor. In examining the texts prepared by the two professional bodies, Canadian Institute of Management Accountants and Chartered Association of Certified Accountants, and used by them for professional certification, he concludes

there is coverage of the concepts required by throughput accounting. These concepts are presented under different terminology.

Dugdale and Jones (1996) trace the origins of the term "throughput accounting" and relate it to what is currently practiced under that name. They found that throughput accounting was derived from Goldratt's original work and traced it through the work of Galloway and Waldron. They compare the works of Goldratt with those of Galloway and Waldron and conclude that Goldratt is more convincing and coherent. Galloway and Waldron prefer a way to measure departmental performance thus departing from Goldratt's ideas of a system view. Galloway and Waldron propose a system for using throughput accounting to cost products, but when they were questioned by the authors in a subsequent interview aimed at clarifying their statements, they recanted using throughput accounting for costing and promoted ABC as a costing procedure. Another point upon which they depart from Goldratt is an insistence, consistent with JIT, that all inventory is bad and that buffers encourage laxity (Dugdale & Jones, 1996). In addition to providing evidence of the attention that throughput accounting is receiving, this article illustrates how the terminology is already beginning to evolve. This may be interpreted as an attempt to incorporate throughput accounting and TOC concepts into a traditional system.

Dugdale and Jones (1996) conclude that Goldratt's ideas, whether entirely new or not, make an important contribution. Coupling the accounting concepts required for throughput accounting with the scheduling innovations of TOC might serve to show how these concepts could and should be used to further management decision-making.

Perhaps adopting a new set of terms for management accounting can encourage the use of under-applied concepts. Despite the fact that the techniques for maximizing throughput (or contribution, if you prefer) are not new, there is little evidence that they have been widely embraced or systematically applied. Dugdale and Jones (1996) cite evidence of the dominance of financial accounting even for managerial decision-making (Dugdale & Jones, 1996).

### Case Studies in Theory of Constraints

The Institute of Management Accountants (IMA) Foundation for Applied Research recognized that Goldratt's TOC is discussed widely in the literature. To determine the extent to which it influences practice, the IMA commissioned the first in-depth evaluation of TOC based on examination of companies practicing it (Noreen, *et al.*, 1995). To find suitable sites for interviewing, the authors attended two conferences sponsored by the Avraham Y. Goldratt Institute. They recognized that choice of subjects from these conferences introduced bias into the study. Only those who found value in the Jonah course are likely to have attended and only a fraction of the attendees volunteered to cooperate. Twenty companies were eventually visited, five in Belgium and the Netherlands and the rest in the United States. The authors report on the extent to which the companies actually practice the concepts of TOC (Noreen, *et al.*, 1995).

About half of the companies visited operated using only the TOC concepts outlined in *The Goal*. The other companies used some TOC principles and incorporated other, often philosophically inconsistent, elements. The authors found that the

companies that used TOC exclusively tended to have fewer problems and be much more satisfied with their operations. At sites where top management did not proscribe to a TOC view, there were usually problems. The worst difficulty was with top managers who continued to evaluate operations managers based on measures of efficiency rather than profit. This illustrates the inability to disentangle TOC from accounting for TOC or throughput accounting. Despite its applicability to the management of constraints, the authors did not find traditional management accounting data, or more specifically, contribution margin per unit of constrained resource, being used to manage constraints (Noreen, *et al.*, 1995, p. xxv).

The authors (Noreen, *et al.*, 1995, p. 38) found companies were forced to deal with the idleness of workers on non-constrained resources. Some managers expressed concern that workers, accustomed to layoffs and the philosophy that one must always be busy, would slow the work pace and be unable to resume a quicker pace if it became necessary. Companies attacked this problem by attempting to find meaningful alternatives to idleness, such as contract work or cross training. The attitude toward efficiency reports reflected this necessary shift in the thinking of managers. One manager of a plant, where the top management still evaluated production based on standard cost variances, successfully implemented TOC because higher management agreed to evaluate the plant based on an overall plant variance rather than a detailed variance report (Noreen, *et al.*, 1995, p. 62). This allowed the manager to take an action that created an unfavorable variance as long as an offset existed elsewhere. Thus, the

plant operated as a profit center striving to maximize its profit (throughput) rather than a cost center concentrating on minimizing cost.

Another company used throughput accounting internally, but a majority of the board of directors still required reports based on Generally Accepted Accounting Procedures (GAAP) for financial reporting. They imposed this requirement even though the company was privately held. GAAP and throughput accounting were often at odds. In the month prior to the visit, a piece of equipment broke down hurting the measure of throughput without any compensating decrease in operating expense as calculated by throughput accounting. However, work-in-process inventories were allowed to increase in front of the constraint so net income was actually higher on a GAAP basis than on the throughput accounting basis (Noreen, *et al.*, 1995, p. 79).

One of the things TOC, and the view of the business unit as a single organism, attempts to avoid is use of erroneous cost figures. Misuse of cost to make decisions on dropping a segment, or dropping a product, or to make decisions between making and buying a product are an important focus of TOC. Noreen, *et al.* (1995) illustrate several examples of companies, which, under past practices, had used product cost for such decisions. Two of the companies concluded that, if they had continued to use these methods to make management decisions, they would no longer be in business. Generally, the authors found that the companies in their sample were drawn to TOC because of problems they could not address by conventional methods. Overall, TOC provided very satisfactory solutions.

Noreen, *et al.* (1995) concluded that TOC made three important contributions: (1) It forced the perspective to change to often neglected management accounting tools such as variable costing and relevant costing. (2) It provided a coherent and focused management theory with clear requirements and no need to second-guess what information managers need and want. (3) For teachers of management accounting, it provided the reward of seeing companies routinely using many of the management decision-making techniques taught, but often found to be at odds with, traditional practice.

In an attempt to examine the ability of TOC to transform companies Dugdale and Jones (Dugdale & Jones, 1996) noted that accountants in a number of UK firms had devised ways of accounting for throughput. They suggested these case studies might provide a useful guide to the impact of TOC thinking on accounting practice. This issue was explored through a detailed study of one company where TOC had a significant impact on accounting practice and led to a number of changes to the accounting systems. The authors discussed changes in production, the influence of these on accountants and the accounting changes that followed. The impact of the new throughput accounting system on production and marketing managers was presented.

Darlington (1995) provided an empirical example of the effects of a change to throughput accounting on one company. In 1990 Allied Signal, Skelmersdale, UK, was using conventional full absorption costing. Darlington was financial controller of Allied Signal. The managers recognized that the scheduling system allowed higher capacity machinery to build up unneeded inventory. Because they adhered to large economic

batch quantities, machinery was often unavailable for current production needs. They decided that if they were to effectively institute a program to reduce inventories and schedule production as needed, it would be necessary to devise a measuring system that complimented the planning system and rewarded adherence to it. Management recognized that conventional local measurement techniques were encouraging the build-up of unwanted inventory. Darlington realized that this situation was hidden from the Finance Department in the short-run because of a desire for the accounting credits associated with the value-added principle of costing inventory. Historically, profits are credited from the allocation of fixed overhead costs to products that require further processing and are not ready for sale (Piggott, 1995),

The management of Allied Signal (Darlington, 1995) developed a system that was throughput driven and essentially identical to what later became referred to as throughput accounting or accounting for TOC. They used a measure called 'schedule adherence' that monitored how closely each unit adhered to the original optimized production technology (OPT) schedule. They valued inventory at raw material cost only. The objective was to reduce inventory and gain shorter lead times for a better response to their market. They recognized that capacity represents utilization potential, while the level of output that can be turned into throughput should determine activation level. Conventional measures of efficiency are based on utilization potential. They successfully carried this logic beyond machine capacity into other manufacturing and administrative areas. They even examined what is categorized by activity based costing as non-value-added activities from a utilization vs. an activation perspective.

Darlington admitted that his reaction to value-added might be prejudiced because his area of expertise (finance), like set-up, and other indirect administrative and production activities, is considered non-value-added. ABC calls for the elimination of such non-value-added activities to the extent possible. In discussing the concept of whether or not an activity adds value, Darlington used the example of machine set-up for production runs. Under ABC, the non-value-added cost associated with set-up is the driving force behind long production runs. Darlington considers that the resources necessary for doing set-ups are available at the *utilization* level; long production runs limit the *activation* of this resource. He questioned this line of thinking and pointed out that set-ups are absolutely essential for production. Since timely production increases customer satisfaction and often product value, he considered it arbitrary to categorize set-up as non-value-added (Darlington, 1995). Darlington pointed out that often the personnel necessary for additional setups are available whether used or not. This utilization potential was available, whether or not it was activated. This is analogous to Goldratt's characterization of set-up as a non-constrained resource.

Smith and Lockamy (1996) discussed throughput as one of the four areas of focus Cummins Engine Company used to assure that the continuous improvement efforts of management would not result in waste of resources. Another case study of United Technologies Automotive (UTA) outlined the successes of applying TOC to a supplier of molded foam parts to the automotive industry. UTA was able to increase the number of parts completed by some of the operations by over 100% and to significantly improve quality in the process. The plant, which often operated over six days a week,

was able to go back on a five-day-a-week schedule. The Ford Q1 Approved Supplier rating, which was very important to UTA, had been previously lost, but was re-awarded.

Murphy and Saxena (1997) wrote of the experience of Harris Semiconductor in conversion to an alternative management strategy involving TOC and synchronous flow manufacturing. Within six months Harris had reduced inventory by 42%, increased throughput by 28% and better defined yield, staffing, and investment strategies. Lead times had also been significantly reduced.

Other researchers examined the use of TOC in conjunction with Materials Requirements Planning. In one case management identified the constraint, subordinated all other manufacturing activities to the constraint, and measured performance of these subordinate functions on how well they kept the buffer before the constraint supplied. As a result work-in-process inventory was reduced dramatically, scrap dropped from 15% to 2%, overtime was reduced significantly, due date performance went from less than 80% to mid 90%, and unit earnings went from .04% to 2.4% of sales (Reimer, 1991). An earlier case described how John Deere managers used information capabilities of MRP to schedule around a constraint. John Deere management saw no real conflict between JIT and TOC and interprets the two management philosophies to have similar goals. They were able to achieve the advantages of synchronous manufacturing in an existing MRP environment, but institution of a drum-buffer-rope system required modification of the system (Spencer, 1991). Weaver (1996) reported on the successes of a specialty steel company's use of Master Production Planner and Scheduler software developed by i2 Technologies and based on TOC principles. The

mill described had a vast flow of material through over a thousand work centers located in about one hundred buildings. A typical product went through as many as forty work centers and often as many as eighteen thousand orders were in process at one time. The new system allowed review of open orders and mill conditions daily, rather than weekly. It continuously reprioritized the scheduling of orders to bypass constrained work centers and assigned alternate paths through the processing line until it achieved the best product flow possible. Inspiration for the scheduling software came directly from "The Goal" by Goldratt.

In another case study ("Manufacturer improves scheduling system", 1995) Riverhead Circuits of Long Island was faced with the inability to accurately project workloads and react to customer demands. Management was faced with rapidly escalating work-in-process inventories, poor on-time delivery, and long cycle times. Daily expedite lists led to a search for a solution. Management chose the PROVISA finite capacity scheduling system from AT&T, and chose Istel to develop a pull inventory system based on TOC. Constraint buffers were developed where needed eliminating extra work-in-process inventory. This freed up 3,000 square feet of floor space, decreased work-in-process inventory by 44%, improved performance to schedule by eighty percent, and decreased cycle time from 18.1 to 7.8 days.

Other case studies have been recorded that highlight one aspect of TOC, often in combination with elements of other management philosophies. Giaouque and Sawaya (1992) discussed the successes of a company that instituted inventory control practices incorporating elements of TOC. Baxendale and Gupta (1998) described a hybrid system

of TOC and Activity Based Costing (ABC) for a screen printing business, but many of their decisions appeared to be based on ABC rather than TOC. They did not employ throughput accounting and the major contribution of TOC to the process appears to have been the application of the five focusing steps of TOC to an activity-based costing system. They used this information to suggest strategic marketing considerations to the business, but provided no indication if these suggestions were followed or the results obtained. Mabin and Gibson (1998) discussed a case relating to improvement of management decisions in a food processing plant. The methods used to address the problems included spreadsheets combined with TOC, both of which were accessible to managers. They demonstrated how standard spreadsheet optimization tools can be used in combination with a TOC framework to provide effective decision aids. Results indicated real productivity improvements are possible from even small models. They went on to explore the interrelationships and complementary points between linear programming and TOC.

Macarthur (1996) described how a cabinet manufacturer improved operations and financial performance by abandoning the ABC system of costing they had attempted to adopt. They moved to synchronous manufacturing and a hybrid system incorporating elements of throughput accounting. The manufacturer stressed the measurement of throughput, but continued to allocate seventy percent of manufacturing labor to inventory in calculating inventory cost for internal reporting purposes.

Aldred (1998) reported on the success of Toyo Tanso USA, of Troutdale, Oregon. Managers of Toyo Tanso, a fully integrated manufacturer of isostatically

molded products, decided to implement a new manufacturing scheduling system using the theory of constraints (TOC) and drum-buffer-robe (DBR) approaches. They purchased ThruPut Technologies' Resonance scheduling software which released orders based upon customer demand. Under the new system machinists worked on jobs based upon a set demand-driven schedule providing smoother, faster product flow. Overall backlog dropped from \$2.4 million to \$1 million, lead times decreased 50 percent from 14-16 weeks to 4-8 weeks for most products, and on-time delivery approached 90 percent for all customers.

Hobbs (1997) described the effects of initial JIT implementation and the subsequent use of JIT, TOC, and focused factories at Amadas Industries, a manufacturer of agricultural and industrial machinery. Late in 1992 members of a focus group charged with problem-solving activities for the JIT implementation were exposed to TOC. The initial improvements provided by JIT had slowed, and managers were quick to recognize TOC as another way to improve performance. As problems were being considered for solution, members of the group began to apply the five focusing steps of TOC. Using these techniques, constraints were identified. This process led to significant production and supply chain improvements.

Another empirical study (Rezaee, *et al.*, 1995) examined the extent to which Asian manufacturers were adopting non-traditional cost accounting measures. They were moving very rapidly from a labor-intensive to a mechanized manufacturing environment. Unlike companies during the industrial revolution in Europe and the United States, they were exposed to alternative cost accounting measures before this shift in production. The authors found the move to modern manufacturing techniques in Asia was accompanied by a shift in managerial accounting emphasis. Modern manufacturers tended to consider inventory control techniques, activity based costing (ABC), the concept of added value, and quality control, while more traditional

managerial accounting measures were retained by more labor intensive manufacturers. This seems to reinforce recognition that traditional costing and measurement techniques may be inappropriate for advanced manufacturing environments.

### Evidence of Legitimization of Theory of Constraints

With the publication of the independent report *Accounting for the Theory of Constraints* (Noreen, *et al.*, 1995), TOC has been legitimized as a new paradigm for management accounting. Recent editions of management accounting texts cover TOC. Applying TOC thinking requires a major paradigm shift from the traditional management and accounting focus of cost control to one of eliminating barriers to throughput. Throughput takes on prime importance as the measure of success of a business--the rate at which it produces money through sales (Sytsma, 1997). With this change in measurement focus, management requires different information for decision making and places new informational demands on accounting systems.

Academic management accountants find the accounting required for TOC familiar territory. Throughput Accounting (TA) uses different terminology, but the theoretical concepts of responsibility accounting, variable costing, and planning for the use of scarce resources are familiar topics from the most basic managerial accounting text (Dominiak & Louderback, 1997) and are equivalent to accounting concepts required in throughput accounting. The difference—throughput accounting affords these topics the important role they deserve in management decision-making. The major difference found in companies that practice TOC is that they are actually putting

into practice unused or under used concepts found in textbooks (Noreen, *et al.*, 1995, p. 149). They do so after consideration of the economic principles involved.

Central to TOC is the assumption that all systems must contain at least one constraint. If they did not, they would produce infinite amounts. Because the constraint is the limiting factor, managers must manage this constraint. Management can use accounting data to help manage a production constraint. Two important decisions—prioritizing the use of the constrained resource, and deciding whether or not to elevate the constrained resource by obtaining more of it—depend on the contribution margin per unit of the constrained resource. TOC recognizes the importance of these concepts and the use of them in management decision-making.

The managerial accounting reports considered normal for American production facilities include detailed cost reports, efficiency reports, and variance reports. These cost reports routinely include fixed overhead and often "transfer prices" for services rendered by other divisions of the same company. Efficiency reports or ratings are based on standard capacity and standard costs for the division. Poor ratings result if the division operates at less than standard capacity or at higher than standard cost. Budget variance reports often provide even more detail. They compare the usage and cost of labor, materials, and overhead to the standard. These standards are inconsistent with application of TOC. To successfully implement TOC, companies must overcome the dominance of financial accounting and costing concepts over the relevance concepts necessary for sound decision making. Information necessary for this type of decision is routinely available to managers, but because of the proliferation of costing and

efficiency reports its use may not be emphasized. It seems that the first hurdle to overcome in adopting a TOC accounting system is to train practitioners, academics, and managers to recognize the information necessary for making these decisions from the context of a TOC paradigm and relate them to informational needs.

The information needs unique to TA (throughput accounting) include the uniquely defined measures of throughput, inventory, and operating expense as outlined earlier. Throughput, as defined by TA, equals sales less direct materials and any other costs such as commissions that actually vary directly with sales volume. This data should be readily available in any adequate accounting system. All are necessary for calculating the income statement by Generally Accepted Accounting Procedures (GAAP).

The TA definition of inventory is completely different from the familiar definition of inventory associated with cost-of-goods-sold. By GAAP definitions, inventory includes the cost of raw materials, direct labor, and allocated fixed overhead used to manufacture products that have not been sold. Of these costs, the TA definition of inventory includes only raw materials. The TA definition of inventory also includes all investment necessary to produce throughput. This includes investments in plant and equipment. The accounting figures necessary to develop this inventory amount should be readily available. Raw material is recorded in the traditional accounting system so is the original price of other elements of production such as equipment, fixtures, and buildings.

Operating expense is the other accounting measure necessary for TA. It consists of all the money spent turning inventory into throughput. This is analogous to the traditional GAAP designation of a period cost. In TA all overhead would be included in this category as well as the administrative costs normally considered period cost and direct labor as long as the labor was not provided on a piece rate and was not directly variable with production levels. In other words, if it isn't Throughput (money coming in) or Inventory (money tied up within the system), it is Operating Expense (money going out) (Dettmer, 1996). Managers probably find the TA concept of operating expense most difficult to accept. Traditional managerial accounting measurements encourage the transfer of any possible expense out of operating expense into overhead, direct labor, or direct materials where it becomes part of product cost and may be valued as an asset in inventory rather than decrease income for the current period.

These three measures, as defined--throughput, inventory, and operating expense--are used to develop all the accounting data required by TA. They lead easily to familiar relationships:

$$\text{Net profit} = \text{Throughput} - \text{Operating expense}$$

$$\text{ROI} = \frac{\text{Throughput} - \text{Operating expense}}{\text{Inventory}}$$

The managerial accountant will find nothing revolutionary here. Throughput and operating expense are variations on the traditional partitioning of income into the portion that covers fixed cost and the portion that provides contribution. The definition of "inventory" is more familiar as a definition of "investment," "assets," or "capital

employed." Goldratt does not call for a costly sweeping change of informational needs; he argues convincingly for a crucial change in managerial emphasis (Dugdale & Jones, 1996).

In addition to these changes, TA advocates a very conservative stance in recognizing revenues. No sales are recorded when the sale is to a member of the distribution chain that has the right to reverse the sale. Goldratt contends that excess products in the distribution channels, like excess finished goods inventory, increase the distance between the producer and the consumer and provides a recipe for loss of future throughput (Goldratt, 1990, pp. 20, 22).

Again Goldratt's ideas are not revolutionary. Conservatism is an underlying concept of accounting. Noreen *et al.* (1995, p. 15) sum up their impression of TA this way:

In the context of the history of management accounting thought, Goldratt has simply updated variable costing and is conservative with respect to revenue recognition. He advocates variable costing for the same reasons it always has been advocated--it is closer to cash flows, can be used more easily than absorption costing to estimate relevant costs and benefits, and, most important, does not contain incentives to build inventories.... Any system such as absorption costing that rewards managers for building inventories to manipulate profits can be far more dysfunctional than even the critics of the 1950s imagined.

Goldratt wants managers to concentrate on increasing throughput, not on controlling and reducing operating expense. Goldratt claims that traditional cost accounting is obsessed with what he calls, "cost world thinking." He describes this as a process which can lead to a headlong plunge into cost-cutting, declining output, and more cost-cutting. JIT concentrates on reducing inventory. This may be more effective

than cost cutting and, by reducing inventory, JIT reduces production lead-times. This can improve responsiveness to customer demand. According to Goldratt, the key theoretical deficiency with both cost cutting and inventory reduction (JIT) is their limited nature. Companies need some inventory for production to take place at all. In Goldratt's opinion, the successful management philosophies of the late 20th century, TOC, JIT and TQM work because they all encourage throughput. However, only TOC is specifically designed to accomplish this goal (Dugdale & Jones, 1996).

## CHAPTER 3

### METHODOLOGY

In this chapter, theoretical justification for the methodological procedures employed in the research will be presented. A model describing TOC as consisting of the three factors of production principles (LOGISTICS), thinking process (THINKING), and performance measures (MEASURES), and the impact of the use of these practices on business unit performance (PERFORMANCE) will be presented. Presentation of the research questions and an examination of the method used to select the variables follow the model. In the final section of the chapter, the measures of business unit performance and the tests to be employed will be introduced.

#### Elements of Theory of Constraints

TOC was first recognized as a scheduling technique. It was seen as a way to identify constrained resources and determine the ideal level of buffer inventories before these constrained resources. Despite the evolution of TOC into a complete management philosophy including throughput accounting and the thinking process, this drum-buffer-rope (DBR) scheduling is the first element associated with TOC and remains an essential factor in TOC adoption. A survey of the literature on TOC reveals that certain production scheduling principles have become firmly associated with TOC

adoption. As presented earlier, there is much anecdotal evidence to suggest that these production principles are associated with improved business unit performance. These production principles (LOGISTICS) include identification of constraints, use of buffer inventories, elevation of constraints, and subordination of other activities to the constrained resource.

In addition to the scheduling principles developed for TOC, practice of this management philosophy has come to include use of a specialized Thinking Process for problem solving. The Thinking Process (THINKING) is designed to provide a detailed analysis of the current situation called a current reality tree. From this analysis underlying assumptions are identified. These assumptions are the reasons for the current situation and therefore are the reasons the problem exists. Once the assumptions are listed the participants can select alternative courses of action, termed injections, that change the current assumptions and break the deadlock through a process called “evaporating clouds.” Once this is accomplished a future reality tree is constructed and analyzed to determine if other problems have been created.

The third recognized element of TOC is performance measurement (MEASURES). Ittner and Larcker (1995) found that production oriented quality improvement practices are related to information and reward systems that place greater emphasis on non-financial performance, more frequent dissemination of quality information to all organizational levels, and use of bottom-up data-gathering techniques such as statistical process control. Strategic information is communicated more broadly throughout the organization including more frequent review by the board of directors

reflecting integration of the quality program into the organization's overall business strategy. They also found that in companies without extensive formal quality programs, greater reliance on these nontraditional information and reward systems is associated with higher performance levels. Normative prescriptions offered by theorist and consultants suggest that the highest performance should be achieved by companies with the greatest use of formal quality programs and nontraditional information and reward systems (Johnson, 1992; Santori & Anderson, 1987; Ballew & Schlesinger, 1989). However, this relationship was not supported by Ittner and Larcker's findings (1995). This raises questions about the relationship between organizational performance and these particular management innovations. As pointed out by Maher in his discussion of Ittner and Larcker's 1995 work, it is not clear whether it is the management practices that are innovative or whether they have merely been assigned innovative names (Maher, 1995). This ambiguity is consistent with the observation by Noreen, *et al.* that the major difference between companies that do and do not practice TOC is that practicing companies actually do those things advocated by management accounting texts. (Noreen, *et al.*, 1995, p. 149).

Advanced Management Practices call for a continuous flow of process information for monitoring improvement activities (Ittner & Larcker, 1995; Johnson, 1992; Hayes, *et al.*, 1988). In addition, information on strategic priorities must be communicated widely throughout the organization (Ittner & Larcker, 1995). Critics of traditional accounting information point out that innovative management programs demand more timely, more highly detailed, and differently focused information than the

traditional cost and efficiency reports. TOC is predicated on the concept of variable costing for process decisions and maximizing the contribution margin on constrained resources. These concepts are consistent with the teachings of management accounting, but are not reflected in the full absorption costing and full capacity utilization concepts of the traditional cost and efficiency reports. This suggests that one factor of TOC adoption should be use of non-traditional information and reward system measures (Ittner & Larcker, 1995).

Figure 1 models the proposed relationship between TOC, the observable outcomes of TOC, and organizational performance.

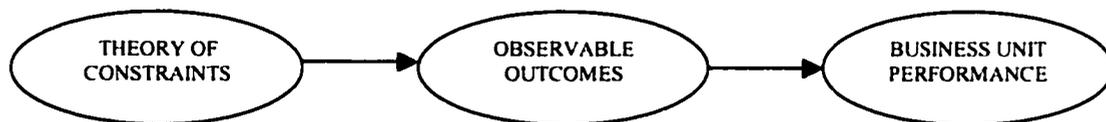


Figure 1: MODEL

### Research Questions

As discussed earlier, TOC practices consists of multiple elements. Theory suggests the presence of three elements—LOGISTICS, THINKING and MEASURES.

This research will address the following research questions.

**Do business units employing a high level of LOGISTICS perform better than those business units that do not employ a high level LOGISTICS?**

In the presence of a positive relationship between the use of LOGISTICS and business unit PERFORMANCE, business units employing higher levels of LOGISTICS should perform better than those business units employing lower levels of LOGISTICS.

Do business units employing a high level of the THINKING perform better than those business units that do not employ a high level of THINKING?

In the presence of a positive relationship between employment of THINKING and business unit performance, business units employing higher levels of THINKING should achieve higher performance than business units employing lower levels of THINKING.

Do business units employing a high level of MEASURES perform better than those business units that do not employ a high level of MEASURES?

In the presence of a positive relationship between the employment of MEASURES and business unit performance, business units employing higher levels of MEASURES should achieve higher performance than business units employing lower levels of MEASURES.

Do business units exhibiting high levels of OUTCOMES perform better than those business units that do not exhibit high levels of OUTCOMES?

In the presence of a positive relationship between the presence of OUTCOMES and business unit performance, business units exhibiting higher levels of OUTCOMES should achieve higher performance than business units exhibiting lower levels of OUTCOMES.

These four questions examine whether there is a direct relationship between each of these phenomena and organizational performance. Recognizing the presence of multiple factors, it is possible that these factors interact. Therefore, it will be necessary to test for interaction of the four factors. The following research questions express consideration of this interaction.

Do business units employing a high level of LOGISTICS perform better than those business units that do not employ a high level LOGISTICS independent of the level of the other three factors in the model?

Do business units employing a high level of THINKING perform better than those business units that do not employ a high level THINKING independent of the level of the other three factors in the model?

Do business units employing a high level of MEASURES perform better than those business units that do not employ a high level MEASURES independent of the level of the other three factors in the model?

Do business units exhibiting high levels of OUTCOMES perform better than those business units that do not exhibit high levels of OUTCOMES independent of the level of the other three factors in the model?

In addition to these questions, it is unclear whether or not the observable OUTCOMES of TOC have an effect on the relationship between TOC and business unit performance.

Is the relationship between the elements of TOC (LOGISTICS, THINKING, AND MEASURES) and PERFORMANCE different for business units exhibiting high levels of OUTCOMES than for those business units exhibiting low levels of OUTCOMES?

These research questions will be examined through consideration of several hypotheses. Stated in the null they are presented in Table 3.1.

**Table 3.1 HYPOTHESES**

**Hypothesis I**

**H<sub>0</sub>: There is no association between the individual factors (LOGISTICS, THINKING, MEASURES, and OUTCOME) and PERFORMANCE.**

**Hypothesis II**

**H<sub>0</sub>: There is no association between all four factors (LOGISTICS, THINKING, MEASURES, and OUTCOMES) and PERFORMANCE.**

**Hypothesis III**

**H<sub>0</sub>: There is no interaction between the level of the four factors (LOGISTICS, THINKING, MEASURES, and OUTCOMES) in their relationship to PERFORMANCE.**

**Hypothesis IV**

**H<sub>0</sub>: The relationship between the elements of TOC (LOGISTICS, THINKING, and MEASURES) and PERFORMANCE is unaffected by the presence of different levels of OUTCOMES.**

**Selection of Measures**

In selection of measures to operationalize the elements of the Theory of Constraints (LOGISTICS, THINKING, and MEASURES) the first step was identification of the constructs associated with these phenomena. Since this area of research has not previously benefited from systematic analysis, no established measures of these specific constructs are available. However, TOC shares many characteristics with other Advanced Management Practices and guidance on selection of measures was obtained from literature addressing other Advanced Management Practices such as TQM (Black & Porter, 1996). The identification of LOGISTICS characteristic of Theory of Constraints, the identification of MEASURES associated with Theory of

Constraints, the identification of the Thinking Process (THINKING) associated with Theory of Constraints, and the identification of observable outcomes (OUTCOMES) of adoption of Theory of Constraints was necessary. These were identified by an extensive search of the relevant literature. Chenhall (1993) developed a measure of Advanced Management Practices consisting of eight statements to which the subject responded on a Likert-type scale. The statements were designed to indicate the degree to which the company had stressed management philosophies that respond to three dimensions: 1) reduction or elimination of inventories, 2) quality improvement, and 3) dependability of supply. Similarly designed items representing practices identified as being associated specifically with Theory of Constraints are included in the questionnaire.

Business unit PERFORMANCE has been systematically studied and operationalized in any of a large number of ways. Gupta and Govindarajan's (1984) multidimensional measure of organizational performance was chosen to be used in its original form.

### Logistics

It was important to the research questions of interest to identify those principles that characterize implementation of Theory of Constraints. Chenhall's method of identification and measurement of Advanced Management Practices (AMP) provided guidance for the identification and measurement of TOC practices (Chenhall, 1993). Since introduction of a new practice may be an incremental process, the degree of implementation may not be the same for all adopters of the process. Thus, simply asking

if the business unit had adopted TOC would not have provided sufficient information on whether or not the unit adhered to all three practices associated with implementation of TOC. Question 1 on the instrument asked if managers of the business unit employ TOC and Question 16 asked them to name the system constraint. These questions were intended to verify formal adoption of TOC. In addition, other questions were formed to measure degree of implementation of all three elements of TOC .

Production principles that characterize implementation of Theory of Constraints LOGISTICS as identified in the literature were:

1. identification of system constraints;
2. establishment of appropriate buffer inventories;
3. use of the five-step continuous improvement process
4. identification of production flow patterns using VAT analysis

The degree of implementation of LOGISTICS was thus captured in three items as dichotomous responses. The items, which addressed these production logistics, are reproduced in Table 3.2 below.

**Table 3.2 LOGISTICS**

Do managers in your unit use drum-buffer-rope scheduling?	YES	NO
Do managers in your unit employ the five-step continuous improvement process?	YES	NO
Do managers in your unit classify your production structure according to VAT analysis?	YES	NO

### Thinking Process

Several activities were been identified as being associated with practice of THINKING as related to TOC. These items were:

1. The identification of Undesirable Effects
2. The creation of Current Reality Trees to identify underlying assumptions
3. The search for Injections that would change these assumptions
4. The creation of Evaporating Clouds to alter the Current Reality Tree
5. The Creation of a Future Reality Tree

The use of this process was examined through a four-item dichotomous scale as reproduced in Table 3.3.

<u>Table 3.3 THINKING PROCESS</u>		
Do managers in your unit employ the Thinking Process associated with TOC?	YES	NO
Do managers in your unit construct Reality Trees?	YES	NO
Do managers in your unit solve problems by use of Evaporating Clouds?	YES	NO
Do managers in your unit solve problems by use of Injections?	YES	NO

### Performance Measures

The performance MEASURES identified in the literature as being associated with Theory of Constraints were:

1. measurement of throughput using Throughput Dollar Days
2. measurement of inventory using Inventory Dollar Days
3. abandonment of traditional measures of operating expense
4. abandonment of standard cost variance reporting
5. abandonment of efficiency reporting
6. use of variable costing for internal reporting
7. evaluation of managers based only on results under their control
8. use of marginal analysis (variable costing) information to determine acceptability of special orders;

9. use of marginal analysis (disregarding sunk cost) in asset replacement decisions;
10. use of contribution margin per time unit of constrained resource to maximize return on constrained resources;
11. disregarding fixed overhead as irrelevant to (using variable cost for) outsourcing decisions;
12. disregarding allocated cost as irrelevant to (using variable cost for) decisions on discontinuing divisions or lines of products;
13. abandonment of standard costing;
14. abandonment of transfer pricing.

As with LOGISTICS, Chenhall was followed in designing a series of questions to specifically address these attributes (Chenhall, 1993). Use of MEASURES was assessed by use of three items requiring a dichotomous response and a nine-item, 10-point Likert-type scale. These items are reproduced in Table 3.4.



OUTCOMES were assessed by use of an eight-item, 10-point Likert-type scale. These items are reproduced in Table 3.5.

<u>Table 3.5 OUTCOMES</u>	Increased Dramatically					Decreased Dramatically				
	1	2	3	4	5	6	7	8	9	10
Throughput time (product cycle time) has	1	2	3	4	5	6	7	8	9	10
Value of work-in-process inventory has	1	2	3	4	5	6	7	8	9	10
Size of production runs has	1	2	3	4	5	6	7	8	9	10
Due date performance (orders shipped on time) has	1	2	3	4	5	6	7	8	9	10
Necessity to expedite orders has	1	2	3	4	5	6	7	8	9	10
Product diversity (number of different products) has	1	2	3	4	5	6	7	8	9	10
Pricing flexibility has	1	2	3	4	5	6	7	8	9	10
Manufacturing flexibility has	1	2	3	4	5	6	7	8	9	10

To In order to conduct analysis of variance, as was indicated in Chapter 2, responses were categorized as being from business units that characterized either high or low users of each of the elements of TOC (LOGISTICS, THINKING, and MEASURES). They were also categorized as displaying either high or low incidence of the OUTCOMES of TOC.

### Business Unit Performance

Business Unit PERFORMANCE was evaluated using both financial and non-financial criteria. Multiple measures of performance help to avoid misleading interpretations resulting from use a single dimension or a narrow definition of the performance construct. Because, even within the same industry, different performance criteria are appropriate for evaluating the effectiveness of different management strategies it is important to use a performance measure that is not strategy specific. Following Covin, *et al.* (1997), Gupta and Govindarajan's (1984) performance scale was chosen.

Financial performance was measured using a self-rating instrument. Because different standards of performance are expected for each industry, the performance of a particular firm is best defined in the context of the industry in which it operates (Swamidass & Newell, 1987). Moreover, it has been shown that differences in the acceptability of performance due to industry differences is taken into account by manager's satisfaction with their firm's performance. Respondents first were asked to indicate on a 5-point Likert-type scale, ranging from 1 = of little importance to 5 = extremely important, the degree of importance the upper management of their business unit attaches to each of thirteen different financial and non-financial performance criteria. The respondent was then asked to indicate the extent to which the upper management of the business unit was satisfied with the unit performance on each of these performance criteria. This response was also captured on a 5-point Likert-type scale where 1 = not at all satisfied and 5 = highly satisfied. As in Gupta and

Govindarajan (1984) the importance scores were mathematically adjusted to 1.0 to minimize the impact of response bias on the performance scores. This adjustment prevented the performance score of a respondent from being upwardly biased because the respondent marked all the performance measures as “extremely important.” Individual satisfaction scores were multiplied by the standardized importance score for that criterion and the products summed to create a weighted average performance index for each firm (Covin, *et al.*, 1997).

The weighted average performance score equation is:

$$\text{Performance} = \frac{\sum (\text{Criterion Satisfaction Score} \times \text{Criterion Importance Score})}{\sum (\text{All Criteria Importance Scores})}$$

If the raw satisfaction data were used in this equation the resulting performance score for respondents who indicated the managers were “not at all satisfied” with unit performance on a criteria they considered “extremely important” would equal 5 (1 x 5). This would be higher than the performance score for respondents who indicated managers were “not at all satisfied” with unit performance on a performance criteria they considered “of little importance” which would equal 1 (1 x 1). To avoid this problem the raw satisfaction scores are re-coded to a -2.0, -1.0, 0, 1.0, 2.0 scale prior to development of the above index. This transformation procedure has no adverse effect on the measurement properties of the scale (Covin, *et al.*, 1997).

Self-rating scales are criticized for potential bias, but this is less a concern where such a bias is generic and where the ratings are used in a relative rather than absolute measure as in the proposed study. Following Chenhall (1993) and Perera, *et al.* (1997)

performance is measured as the mean of the responses. The items to measure business unit performance are reproduced in 3.6.

	Extremely Important			Of Little Importance	
Sales level	1	2	3	4	5
Sales growth rate	1	2	3	4	5
Market share	1	2	3	4	5
Operating profits	1	2	3	4	5
Profit to sales ratio	1	2	3	4	5
Cash flow from operations	1	2	3	4	5
Return on investment	1	2	3	4	5
New product development	1	2	3	4	5
Market development	1	2	3	4	5
R & D activities	1	2	3	4	5
Cost reduction programs	1	2	3	4	5
Personnel development	1	2	3	4	5
Political/public affairs	1	2	3	4	5

### Research Instrument

The complete research instrument is included in Appendix A. The instrument was designed and tested over several stages. An initial questionnaire was developed based on the above criteria. It was then pilot tested and modified as necessary for clarity. Item 1 was intended to measure formal adoption of TOC. Three items (16, 27, and 40) were designed to provide a way to verify that response. Items 2, 10, 11 and 17 were intended to measure LOGISTICS. Item 12 provides a check to verify Item 11. Four items (3 through 6) were intended to measure use of THINKING. Eleven items (7, 8, 9, 26, 27, 28, 29, 31, 32, 33, and 34) were intended to measure MEASURES. Several other items (13, 14, 15, 17, and 30) were deigned to support the measure of

**MEASURES.** Items 18 through 25 measure the **OUTCOMES** of adopting **TOC**, and Items 42 through 67 measure business unit **PERFORMANCE**. The balance of the instrument is devoted to demographic information.

### Research Design

An email questionnaire was developed for the survey. A sampling frame was adopted consisting of business units identified as being actively involved in **TOC**. The **TOC** Special Interest Group of **APICS** Educational Society for Resource Management and special discussion groups devoted to the topic were chosen as a source of the targeted business units. The questionnaire and a cover letter explaining the nature of the study were made available to the potential participants.

### Statistical Techniques Used

The primary statistical technique used for analyzing the data was Analysis of Variance (**ANOVA**). The interval-scaled indices obtained from compilation of these results were converted to categorical measures, each at the mean. The conversion to categorical measure enabled the use of **ANOVA** to test for performance differences. The existence of possible measurement error in the interval scales prevents a more powerful test for the existence of interaction between **LOGISTICS**, **THINKING**, and **MEASURES**. The basic model will then consist of performance as a function of two treatment levels for **LOGISTICS**, two treatment levels for **THINKING**, and two treatment levels for **MEASURES**.

By using contemporaneous measures of the constructs and the performance measure, this model assumes the use of Theory of Constraints and relative to performance is stable over time. A second model was designed to control for firm-specific factors such as location, industry, and capitalization, which affect performance but are unrelated to current Theory of Constraints practices. This was accomplished by asking respondents to evaluate the performance of the company three years prior to the current date in the same manner they evaluated current company performance. The two performance measures were then be compared to determine whether performance had improved. If, as one might expect, organizations adopt innovative techniques in response to poor performance, and if the widely accepted positive autocorrelation exists in performance measures, it would be expected that any positive results of innovative management techniques would not be immediately evident in performance. The performance score for three years ago was subtracted from the current performance score. This measure was designated as change (CHANGE) in performance and was used to evaluate business unit PERFORMANCE.

## CHAPTER 4

### RESULTS

The results of the statistical analysis of the data are presented in this chapter. The steps taken to obtain a data sample of sufficient size are outlined and the results of the initial survey are explained. The first section contains characteristics of the sample, followed by a discussion of the issues of non-response error and potential sample bias. In the next section descriptive statistics and correlation matrices are presented for the variables in the study. Results of the ANOVA analyses performed to test the hypotheses developed in Chapter 3 are presented in a separate section.

#### Characteristics of the Sample

A potential pool 923 of participants was identified by collecting email addresses from two sources: the APICS (American Production and Inventory Control Society) Special Interest Group discussion board devoted to Theory of Constraints, and guest books posted on TOC web sites. Forty of these addresses were at academic institutions and were eliminated. Of the remaining 883 addresses, 178 could be identified by suffix as international. The remaining 705 were assumed to be domestic addresses. The initial mailing to this group of 883 addresses disclosed that 41 were no longer valid. This left a potential sample of 742 respondents. An email consisting of a cover letter and the

research instrument was sent to each of these addresses. The research instrument was sent as an HTML (Hypertext Markup Language) document. In the cover letter accompanying the instrument, respondents were asked to either complete the attached form or follow a live link that would automatically take them to a web site where the form was posted. It was explained that this procedure was followed to assure anonymity. Rather than communicate directly via email, each response was independently captured by the form-filler capability of the mainframe server and forwarded via email from the university server. In this way, all correspondence went through the server and was untraceable. The link to the web site where the instrument was posted was provided for potential participants who, because of concerns about virus infection, might be reluctant to open attachments containing live macros. These responses were also routed through the form-filler of the university server and were indistinguishable from the responses using direct reply. Fifty-eight responses were received from this initial mailing. A copy of the cover letter is provided in Appendix B.

In response to these activities, several emails were received indicating that the potential participant did not have access to rich text email or could not access the World Wide Web. The instrument sent in the original email was coded in HTML (Hypertext Markup Language) so the response could be automatically coded and returned via the form filler capabilities of the server where the instrument was posted. Because both media were directed through form filler, this method of response assured the anonymity of the respondent and made it impossible to distinguish between responses received directly from email and responses entered at the web site.

Potential participants, without access to rich text email, could not read the instrument nor submit it in this manner. If they did not have access to the World Wide Web, they could not link to the web site where the instrument was posted. An additional mailing was sent to accommodate those individuals who wished to participate, but did not have the technological capabilities to respond in the proscribed manner.

The second mailing was sent to the same list as the original mailing. It also served as a reminder to individuals who had not responded to the original instrument. The second mailing included a copy of the instrument in plain text format that could be returned directly by reply email. The second mailing also directed respondents to the web site. In the cover letter for the second mailing, potential respondents were informed that responding by reply email would allow them to be identified. They were assured that their identities would be held in strictest confidence and that no information identifying them with the survey would be disseminated. A copy of this second communication is available in Appendix C. After the second mailing an additional 23 responses were returned directly via email. This resulted in a total of 81 solicited responses. Of these responses 75 were usable. This represents a response rate of approximately nine percent.

In addition to the directly solicited responses, a message was posted on four listserves devoted to discussions of TOC, manufacturing quality, and other manufacturing issues. This message consisted of the original cover letter and link to the web site where the instrument could be accessed. Another 110 responses were obtained using this

approach. A grand total of 191 responses were received. Of these responses ten were largely incomplete. One response, received directly via return email, was unusable because the respondent had not confined the response to the range indicated on the Likert scale. This left 180 usable responses.

One difficulty with collecting data in this manner is the inability to determine a response rate. Since the instrument was posted on list-serves where there was no way to assess the frequency of participants monitoring of the lists, and where no information is available about the membership of the lists, traditional tests for non-response bias would be meaningless. In addition, there was no definitive way to determine which responses were returned as a result of the emails and which were returned as a result of the postings. The responses did, however, arrive in three waves corresponding with the two emails and the subsequent posting to the discussion groups. Since data was collected using two separate email mailings and by postings to discussing group list-serves, it is possible the three different segments of the sample were not homogenous. To test the data from these separate activities to determine if there were significant differences in the samples, three different tests of sample differences were conducted. These statistics test the null hypothesis of no difference in sample means and deviation. The null hypothesis could not be rejected using any of these tests. This indicates there was no significant difference in the three segments of the sample. The results of these tests are presented in the Table 4.1 below.

<b>Test</b>	<b>Statistic Value</b>	<b>F-statistic</b>	<b>Significance</b>
<b>Pillai's Trace</b>	<b>Trace = 0.52</b>	<b>1.18</b>	<b>0.16</b>
<b>Wilks' Lambda</b>	<b>L = 0.55</b>	<b>1.18</b>	<b>0.16</b>
<b>Hotelling's Trace</b>	<b>Trace = 0.71</b>	<b>1.18</b>	<b>0.16</b>

Similarly, because of the way the instrument was administered, it is impossible to draw firm conclusions about the sample. The target population consisted of business units in which there is a familiarity with the concepts of TOC. The effort was made to contact members of this population, but there is no assurance that the sample drawn is representative of the population. The test of bias between different segments of the sample showed no statistical differences between these groups supporting the assumption that the sample was drawn from the one population.

Selected characteristics of the respondents are presented in Table 4.2.

<b>Table 4.2 CHARACTERISTICS OF THE RESPONDENTS</b>			
<b>Demographic Characteristic</b>	<b>Category</b>	<b>Number</b>	<b>Percentage</b>
<b>Primary business activity</b>	<b>Manufacturing</b>	121	67
	<b>Assembly</b>	3	2
	<b>Distribution</b>	6	3
	<b>Service</b>	32	18
	<b>Other</b>	18	10
<b>Job function of respondent</b>	<b>Engineering/technical</b>	34	19
	<b>Production/service manager</b>	51	28
	<b>Financial manager</b>	21	12
	<b>Other manager</b>	62	34
	<b>Other</b>	12	7
<b>Years in current position</b>	<b>Less than 1</b>	36	20
	<b>1-3</b>	57	32
	<b>3-5</b>	40	22
	<b>5-10</b>	27	15
	<b>over 10</b>	20	11
<b>Years with current employer</b>	<b>Less than 1</b>	21	12
	<b>1-3</b>	46	26
	<b>3-5</b>	24	13
	<b>5-10</b>	48	27
	<b>over 10</b>	41	13
<b>Years in current line of work</b>	<b>Less than 1</b>	0	0
	<b>1-3</b>	36	20
	<b>3-5</b>	43	24
	<b>5-10</b>	39	22
	<b>over 10</b>	62	34
<b>Educational Level</b>	<b>no college</b>	0	0
	<b>0-2 years of college</b>	3	2
	<b>2 years - 4 years (no degree)</b>	9	5
	<b>4-year degree</b>	89	49
	<b>Advanced degree</b>	79	44

Question 1 on the instrument asked if managers of the business unit employ TOC. It was intended to identify business units as users of TOC. Other questions were included to measure degree of implementation of each of the elements of TOC, measure the OUTCOMES of TOC, and measure business unit PERFORMANCE. These issues are examined in this dissertation. The balance of the questions provides qualitative information about the types of measures used and demographic information. (Qualitative questions are 12, 13, 14, 15, 16, 17 and 30. Demographic questions are 36, 37, 38, 39, 40, 41, 68, 69, 70, 71, 72, 73, 74, and 75.)

### Logistics

The degree of implementation of TOC LOGISTICS was captured in three items as dichotomous responses. Question 2 asked respondents to characterize managers of their business unit as users of Drum-buffer-rope scheduling, Question 10 asked if managers of the business unit employed the five-step continuous improvement process, and Question 11 asked if managers of the business unit employ VAT analysis. It was expected that users of TOC would answer positively to Question 2, Question 10, and Question 11.

### Thinking Process

The use of THINKING was examined through the use of four items requiring a dichotomous response. Question 3 asked if managers employed the Thinking Process. The other three items asked if managers employed each of the major elements of the Thinking Process: Reality Trees, Evaporating Clouds, and Injections (Question 4,

Question 5, and Question 6 respectively). It was expected that high adopters of TOC would answer positively to all these questions as well.

### Performance Measures

Use of non-traditional performance MEASURES was assessed by use of three items requiring a dichotomous response and a nine-item, 10-point Likert-type scale. The three items requiring a dichotomous response were Question 7, Question 8, and Question 9 asking the respondent to characterize the business unit as using Throughput Dollar Days, Inventory Dollar Days, and a measure of local operating expense respectively. In the nine scalar items (Question 26 through Question 29 and Question 31 through Question 35), the respondent was asked to indicate the level of use various accounting measures. The questions addressed each of the following: standard cost variance reports, labor efficiency reports, efficiency reports for individual machines, departmental efficiency reports, variable costing, absorption costing, standard costing, transfer pricing, and marginal analysis.

It was expected that users of TOC would answer positively of Question 7 and Question 8 and negatively for Question 9. Throughput Dollar Days and Inventory Dollar Days are the operating measures invented for use with TOC and advocated in the TOC literature. Proponents of TOC are opposed to use of any type of localized operating expense. Because of the wording of this question it was necessary to reverse score Question 9. It was expected that users of TOC would answer with a relatively low number for Question 26, Question 27, Question 28, and Question 29. Variance reports

and efficiency reports of all kinds are localized measures eschewed by TOC proponents. Absorption costing, standard costing, and transfer pricing (represented by Question 32, Question 33, and Question 34) are considered to contribute to poor management decisions by those advocating use of TOC so a low number on these questions would signify a high degree of adoption of TOC. All seven of these questions (26, 27, 28, 29, 32, 33, 34) represent traditional cost accounting measures. Advocates of TOC consider these to be poor measures of performance leading to dysfunctional decisions, but a review of the relevant literature revealed no consistent measures in use by adopters of TOC to replace these. Adopters of TOC appeared to be using a wide array of individually developed measures. Therefore, the use of non-traditional accounting and reward system measures is equated with non-use of these traditional measures. This necessitated reverse scoring for these seven variables. Variable costing and marginal analysis are techniques used in traditional management accounting and are effectively the same as techniques advocated by TOC. The terms “variable cost” and “marginal analysis” are not used in TOC literature, however. When these questions were chosen it was unclear whether the respondents would be sufficiently familiar with traditional accounting to recognize these terms and to identify the concepts correctly. It was expected that high adopters of TOC principles would respond with a relatively high number on these questions.

### Observable Outcomes

Evidence of the observable outcomes (OUTCOMES) associated with TOC was assessed by use of an eight-item, 10-point Likert-type scale. The items designed to measure these observed outcomes were presented in Question 18 through Question 25. The respondents were asked indicate to what degree an increase or decrease had been experienced in each of the following: throughput time, value of work-in-process inventory, size of production runs, due date performance, necessity to expedite orders, product diversity, pricing flexibility, and manufacturing flexibility. Pricing flexibility was defined in the instrument as sale of the same product at more than one price, and manufacturing flexibility was defined as the ability to produce multiple products. One of the major points of TOC is an emphasis on increasing throughput. This emphasis on increased throughput should decrease throughput time which would cause a decrease in product cycle time, so it was expected high adopters of TOC would experience a decrease in throughput time and would thus answer with a relatively low number for Question 18. Drum-buffer-rope scheduling would cause a decrease in inventories for companies not having previously adopted some other inventory reduction strategy such as JIT (Just-in-time), so it was expected that high adopters would answer with a relatively low number on Question 19. Since, the responses to Question 18 and Question 19 were expected to be relatively low for high adopters of TOC, these questions were reverse scored.

Proponents of TOC consider the allocation of fixed costs to be dysfunctional in decision making. Proponents also advocate production for current orders only. For

these reasons, they do not advocate adhering to economic order quantities. This should cause a decrease in size of production runs. Therefore, high adopters of TOC were expected to answer with a relatively high number to Question 20. One of the purposes of drum-buffer-rope scheduling is to improve due date performance (Question 21) and reduce the need to expedite orders (Question 22). It was expected that high adopters would answer with a relatively high number to Question 21 and a relatively low number to Question 22. It was necessary to reverse score Question 22. Application of TOC practices should allow a manufacturer to increase product diversity (Question 23), pricing flexibility (Question 24), and manufacturing flexibility (Question 24). It was expected that high adopters would answer with a relatively high number to each of these questions.

A correlation matrix for each of the items designed to measure the elements of the model is included in Appendix D. These elements are designated as MEASURES, OUTCOMES, LOGISTICS, THINKING, AGO3 (performance 3 years ago), and CURRENT (current performance). A summed correlation matrix for these elements is presented below in Table 4.3.

	MEASURES	OUTCOMES	LOGISTICS	THINKING	AGO3	CURRENT
MEASURES	1.00	0.26	-0.36	-0.42	0.09	-0.12
OUTCOMES	0.26	1.00	-0.26	-0.26	0.12	-0.46
LOGISTICS	-0.36	-0.26	1.00	0.79	-0.03	0.11
THINKING	-0.42	-0.26	0.79	1.00	-0.05	0.09
AGO3	0.09	0.12	-0.03	-0.05	1.00	-0.11
CURRENT	-0.12	-0.46	0.11	0.09	-0.11	1.00

Cronbach's alpha, perhaps the most widely used measure of reliability, was calculated for each measure. They ranged from .67 on LOGISTICS to .97 on THINKING. This is within the range of at least .60 recommended by Nunnally (1978).

In order to conduct analysis of variance, as was indicated in Chapter 2, responses were categorized as being from either high or low users of each of the elements of TOC: LOGISTICS, THINKING, and MEASURES. They were also categorized as displaying either high or low incidence of the OUTCOMES of TOC.

Business units were categorized as high users of LOGISTICS if the response was yes to all three of the LOGISTICS questions. They were categorized as low users of LOGISTICS if they were not users of the three production principles associated with TOC.

Business units were categorized as high users of THINKING if the response was positive to all four of the THINKING questions. They were categorized as low users of THINKING if the response was negative to all four Thinking Process questions. Of the

180 respondents, 167 answered either all yes or all no and were categorized according to the above criteria. The mixed responses were examined and assigned to groups by judgment. Of these seventeen responses, one didn't answer the questions in this category and another answered the first question negatively and skipped the next three. These responses were assigned to the group of low users of THINKING. The remainder (fifteen) answered positively to the direct question about use of the Thinking Process and indicated high usage of at least one of the elements of the thinking process as represented by Question 4, Question 5, and Question 6. These responses were assigned to the group of high users of THINKING.

MEASURES consisted of three YES/NO questions and nine questions requiring a response on a Likert-type scale. Responses for the nine scalar questions were summed. The mean response was calculated and found to fall between 49 and 50. Business units were considered to be high users of MEASURES if the total on the nine items was greater than 49 and low users of MEASURES if the total on the nine was less than 50. Only thirteen respondents answered positively to two or more of the three YES/NO questions. Twelve of these responses had an average of more than 50 on the nine scalar questions. This was considered to be support of the coding schema that had been chosen and no further adjustments were deemed necessary.

The measure of OUTCOMES consisted of nine questions requiring a response on a Likert-type scale. Responses for the nine scalar questions were summed. The mean response was calculated and found to fall between 53 and 54. Business units were considered high users of OUTCOMES if the total on the nine was greater than 53. They

were considered low users of OUTCOMES if the total on the nine questions was less than 54.

### Business Unit Performance

Business unit PERFORMANCE was evaluated using both financial and non-financial criteria. Multiple measures of performance help to avoid misleading interpretations resulting from use of a single dimension or a narrow definition of the performance construct. Because, even within the same industry, different performance criteria are appropriate for evaluating the effectiveness of different management strategies it is important to use a performance measure that is not strategy specific. Following Covin, *et al.* (1997), Gupta and Govindarajan's (1984) scale was chosen. Questions 42 through 67 comprise this measure in its entirety. Question 42 through Question 54 asked the respondent to indicate the importance of thirteen financial and non-financial measures to the business unit's managers. These responses are used to weight the responses to Question 55 through Question 67. In Question 55 through Question 67 respondents are asked to indicate the level of satisfaction of the business unit's managers with these same measures. Each question measures the level of satisfaction at the time of the survey and three years ago allowing a measure of change in performance (CHANGE). CHANGE was calculated as the mathematical difference between CURRENT and AGO3.

### Qualitative and Demographic Items

Question 1 was designed to categorize business units as users of TOC. Question 16, Question 37, and Question 40 were designed to support Question 1. Question 16 asked respondents to name the system constraint for their business unit. It was expected that all users of TOC should be able to identify a system constraint. If respondents had been unable to name a constraint it would have been considered unlikely that they were actually users of TOC. However, all respondents who answered positively to Question 1 identified a constraint in Question 16. This supported the validity of Question 1. Question 37 asked respondents to identify the degree to which TOC was used in the business unit. All respondents who answered positively to Question 1 answered five or higher on Question 37 (1 = Not Used at All, 10 = Used to a Large Extent). The overall average response on Question 37 was 4.39. Question 37 supported the validity of Question 1. Question 40 asked respondents to identify the degree to which synchronous manufacturing was used in the business unit. Since the term synchronous manufacturing is often used to identify the production scheduling logistics of TOC, a high correlation should exist between positive answers to Question 1 and high answers to Question 40. However, fifteen of the respondents who answered positively on Question 1 chose one (Not Used at All) on Question 40. Despite this fact, the average for all responses on Question 41 was 2.86. This is contrasted to an average of 6.91 for responses where Question 1 was also positive.

Question 11 asked the respondent to indicate if managers of the business unit use VAT analysis. Question 12 asks the respondent to use VAT analysis to identify the structure of the business unit or to indicate that the respondent is unsure of the structure. Question 12 could help determine if respondents who answered positively to Question 11, indicating the business unit used VAT analysis, were able to identify production structure of the business unit by VAT analysis. All of the forty-three respondents who answered Question 11 positively indicated knowledge of the production structure of their organization. Thus, Question 11 supported Question 12.

Question 13 (How do you measure throughput?), Question 14 (How do you measure inventory?), and Question 15 (How do you measure operating expense?) were designed to gather information about non-traditional accounting measures. If patterns of use of certain measures could be identified, it might indicate development of a consistent measure for users of TOC. The most predominant answers were developed into a coding schema including the categories of variable cost, full or absorption cost, physical count, sales or revenue, using TOC measures, no measure, some other measure, and no response. Analysis revealed no pattern that could be categorized consistently with theoretical expectations. Throughput was measured using the measures suggested in the TOC literature for only six (3.2%) of the business units. Variable cost and absorption cost were each listed by 7.9% of the respondents. A physical count of some type was listed by 24.6%. Twenty percent of the respondents indicated some measure based on sales or revenue. Some other measure was listed by 13.8% and the remainder left the question blank. It was expected that some form of throughput accounting

measure or variable cost would be used by business units which had adopted TOC, and that some measure of absorption cost would be employed by non-adopters. Responses including physical count, sales, or revenue were outside the range of expected answers and the percentage of responses indicating use of TOC measures, variable cost, and absorption cost were not consistent with the number of respondents which had adopted TOC. No pattern of measure use could be identified.

Inventory was measured at full cost in the business units of 34.9% of the respondents. A physical count of some type was listed by 26.2% of the respondents. Eighteen of the respondents (9.7%) indicated the business unit measured inventory using variable costing as is suggested for TOC. The question was left blank or "none" was listed in 27.7% of the responses. The remainder of the respondents indicated some other system or measure was in use. It was expected that the response to this question could be categorized into variable cost measures and full or absorption cost measures. The inclusion of such a wide array of responses indicated no consistent measures were in use by the respondents.

The same situation occurred with operating expense. It was measured using full absorption costing by the business units of 53.8% of the respondents. Eighteen of the respondents (9.7%) indicated the business unit measured operating expense using everything except variable cost or materials cost as is advocated by TOC. Of the other respondents 14.3% listed some other method of measure and the balance left the question blank.

Questions 36 through Question 41 are designed to gather additional information about the business unit. They address use of other advanced management practices and are not directly related to this research. Questions 68 through Question 75 are designed to gather additional information about the respondent and are not addressed in the current research. A list of each question on the instrument and its purpose is included in Table 4.4. The asterisks indicate questions for which reverse scoring was necessary.

1	identify users	39	DEMOGRAPHIC information about company
2	use of LOGISTICS	40	DEMOGRAPHIC information about company
3	use of THINKING Process	41	DEMOGRAPHIC information about company
4	use of THINKING Process	42	Measure of PERFORMANCE
5	use of THINKING Process	43	Measure of PERFORMANCE
6	use of THINKING Process	44	Measure of PERFORMANCE
7	use of MEASURES	45	Measure of PERFORMANCE
8	use of MEASURES	46	Measure of PERFORMANCE
*9	use of MEASURES	47	Measure of PERFORMANCE
10	use of LOGISTICS	48	Measure of PERFORMANCE
11	use of LOGISTICS	49	Measure of PERFORMANCE
12	QUALITATIVE information	50	measure of PERFORMANCE
13	QUALITATIVE information	51	measure of PERFORMANCE
14	QUALITATIVE information	52	measure of PERFORMANCE
15	QUALITATIVE information	53	measure of PERFORMANCE
16	QUALITATIVE information	54	measure of PERFORMANCE
17	QUALITATIVE information	55	measure of PERFORMANCE
*18	Measure of OUTCOMES	56	measure of PERFORMANCE
*19	Measure of OUTCOMES	57	measure of PERFORMANCE
20	Measure of OUTCOMES	58	measure of PERFORMANCE
21	Measure of OUTCOMES	59	measure of PERFORMANCE
*22	Measure of OUTCOMES	60	measure of PERFORMANCE
23	Measure of OUTCOMES	61	measure of PERFORMANCE
24	Measure of OUTCOMES	62	measure of PERFORMANCE
25	Measure of OUTCOMES	63	Measure of PERFORMANCE
*26	use of MEASURES	64	Measure of PERFORMANCE
*27	use of MEASURES	65	Measure of PERFORMANCE
*28	use of MEASURES	66	Measure of PERFORMANCE
*29	use of MEASURES	67	Measure of PERFORMANCE
30	QUALITATIVE information	68	DEMOGRAPHIC information about respondent
31	use of MEASURES	69	DEMOGRAPHIC information about respondent
*32	use of MEASURES	70	DEMOGRAPHIC information about respondent
*33	use of MEASURES	71	DEMOGRAPHIC information about respondent
*34	use of MEASURES	72	DEMOGRAPHIC information about respondent
35	use of MEASURES	73	DEMOGRAPHIC information about respondent
36	DEMOGRAPHIC information about company	74	DEMOGRAPHIC information about respondent
37	DEMOGRAPHIC information about company	75	DEMOGRAPHIC information about respondent
38	DEMOGRAPHIC information about company	*Items for which reverse scoring was necessary.	

### Descriptive Statistics

This section provides descriptive statistics of the variables of this study. Table 4.5 presents descriptive statistics for each of the dimensions under consideration. Change in performance (CHANGE) is the difference between the performance score as reported currently (CURRENT) and the performance score reported for three years ago (AGO3).

<u>Table 4.5 DESCRIPTIVE STATISTICS</u>					
	N	Minimum	Maximum	Mean	Standard Deviation
AGO3	180	-1.75	2.00	.14	.80
CHANGE	180	-2.00	2.43	-.14	1.02
CURRENT	180	-1.07	1.20	-.003	.55
LOGISTICS	180	1	2	1.70	.46
THINKING	180	1	2	1.67	.47
MEASURES	180	1	2	1.50	.50
OUTCOMES	180	1	2	1.52	.50

### Analysis of Variance Approach

Analysis of Variance was used to test the hypothesis that differences in performance are related to the three elements of TOC (LOGISTICS, THINKING, and MEASURES) and to OUTCOMES. The results are shown in Table 4.6.

<b>Table 4.6 TESTS OF BETWEEN-SUBJECTS EFFECTS</b>					
<b>Source</b>	<b>Dependent</b>	<b>Type III SS</b>	<b>Mean Sq.</b>	<b>F</b>	<b>Sig.</b>
<b>Corrected Model</b>	AGO3	28.99	1.93	3.75	.000
	CHANGE	63.98	4.27	5.68	.000
	CURRENT	16.95	1.13	4.86	.000
<b>Intercept</b>	AGO3	3.736	3.74	7.25	.008
	CHANGE	5.49	5.49	7.30	.008
	CURRENT	0.17	0.17	0.72	.397
<b>LOGISTICS</b>	AGO3	0.43	0.43	0.84	.361
	CHANGE	2.28	2.28	3.04	.083**
	CURRENT	0.73	0.73	3.14	.078**
<b>THINKING</b>	AGO3	0.29	0.29	0.56	.457
	CHANGE	0.03	0.03	0.03	.852
	CURRENT	0.48	0.49	2.09	.150
<b>MEASURES</b>	AGO3	5.74	5.73	11.13	.001*
	CHANGE	7.93	7.93	10.56	.001*
	CURRENT	0.18	0.18	0.76	.383
<b>OUTCOMES</b>	AGO3	0.04	0.04	0.08	.779
	CHANGE	2.26	2.26	3.01	.084**
	CURRENT	2.91	2.91	12.52	.001*
<b>LOGISTICS * THINKING</b>	AGO3	0.007	0.00	0.01	.906
	CHANGE	0.176	0.18	0.23	.629
	CURRENT	0.255	0.26	1.11	.296
<b>LOGISTICS * MEASURES</b>	AGO3	1.284	1.28	2.49	.116
	CHANGE	1.571	1.57	2.09	.150
	CURRENT	0.014	0.01	0.06	.804
<b>LOGISTICS * OUTCOME</b>	AGO3	1.255	1.26	2.44	.120
	CHANGE	7.369	7.37	9.81	.002*
	CURRENT	2.541	2.54	10.94	.001*
<b>THINKING * MEASURES</b>	AGO3	0.716	0.72	1.39	.240
	CHANGE	1.55	1.55	2.06	.153
	CURRENT	0.159	0.16	0.68	.410
<b>THINKING * OUTCOMES</b>	AGO3	0.128	0.13	0.25	.619
	CHANGE	1.339	1.34	1.78	.184
	CURRENT	0.64	0.64	2.75	.099**
<b>MEASURES * OUTCOMES</b>	AGO3	0.085	0.08	0.16	.685
	CHANGE	2.213	2.21	2.95	.088**
	CURRENT	1.431	1.43	6.16	.014*

Source	Dependent	Type III SS	Mean Sq.	F	Sig.
LOGISTICS * THINKING * MEASURES	AGO3	0.778	0.78	1.51	.221
	CHANGE	0.555	0.55	0.74	.391
	CURRENT	0.019	0.02	0.08	.776
LOGISTICS * THINKING * OUTCOMES	AGO3	1.052	1.05	2.04	.155
	CHANGE	0.869	0.87	1.16	.284
	CURRENT	0.009	0.01	0.04	.847
LOGISTICS * MEASURES * OUTCOMES	AGO3	0.779	0.78	1.51	.221
	CHANGE	0.517	0.52	0.69	.408
	CURRENT	0.027	0.03	0.11	.735
THINKING * MEASURES * OUTCOMES	AGO3	0.000	0.00	0.00	.981
	CHANGE	0.636	0.63	0.85	.359
	CURRENT	0.608	0.61	2.62	.11
LOGISTICS * THINKING * MEASURES * OUTCOMES	AGO3	1.946	1.95	3.78	.053*
	CHANGE	3.527	3.53	4.69	.032*
	CURRENT	0.233	0.23	1.00	.32

\*statistically significant at a level of .05  
\*\*statistically significant at a level of .10

As can be seen from the results in Table 4.6, the main effect of LOGISTICS is marginally significant for both CHANGE and CURRENT. The main effect of MEASURES is significant for both AGO3 and CHANGE. The main effect OUTCOMES is marginally significant for CHANGE and is significant for CURRENT. The main effect of THINKING was not found to be significant for any of the three measures of performance.

The two-way interaction of LOGISTICS and OUTCOMES was significant for both CHANGE and CURRENT. Similarly, for MEASURES and OUTCOMES, CHANGE was found to be marginally significant and CURRENT was found to be

significant. The two-way interaction of THINKING and OUTCOMES was marginally significant for CURRENT.

No three-way interactions were found to be significant. However, the four-way interaction of LOGISTICS, THINKING, MEASURES, and OUTCOMES was found to be marginally significant for AGO3 and significant for CHANGE.

### Test of Hypothesis I

An important step in examining a two-way ANOVA is the construction of a table of cell means. This allows an overview of the results of interest. The cell means for the ANOVA model using mean change in performance as the response variable are presented in Table 4.7 below.

<u>Table 4.7 CELL MEANS</u>					
Factor Level (Group)	Factor				
	LOGISTICS	THINKING	MEASURES	OUTCOMES	Row Avg.
High	-.35	-.07	.08	.15	-.18
Low	-.05	-.17	-.45	-.41	-.59

Hypothesis I as it was stated in the null was:

$H_0$ : There is no association between the individual factors (LOGISTICS, THINKING, MEASURES, and OUTCOME) and PERFORMANCE.

Each of the four related sub-hypotheses must be examined independently.

Stated in the null the sub-hypothesis related to LOGISTICS would be:

$H_0$ : There is no association between LOGISTICS and PERFORMANCE.

From the cell means, there appears to be a difference in CHANGE in performance based on the level of LOGISTICS. This effect is negative, however, with high users of LOGISTICS exhibiting a more highly negative change in performance than low users LOGISTICS. An examination of the results for the main effect of LOGISTICS on CHANGE in Table 4.6 indicates marginal statistical significance at a level of .083. Thus with some caution the null hypothesis can be rejected. From the results obtained, some support can be found for the alternate hypothesis that LOGISTICS, when considered independently of the other elements of the model, has a statistically significant effect on PERFORMANCE. This difference is in the opposite direction than expected. There is support for the conclusion that the adoption of TOC LOGISTICS independent of the other elements of TOC (THINKING and MEASURES) and in the absence of the OUTCOMES associated with TOC has a negative effect on business unit PERFORMANCE.

Stated in the null the sub-hypothesis related to THINKING would be:

H<sub>0</sub>: There is no association between THINKING and PERFORMANCE.

From the cell means it is apparent that the difference in CHANGE in performance when considering adoption of the THINKING independent of the other elements of TOC (LOGISTICS and PRACTICES) is more favorable for high adopters of THINKING. This difference is small, however. An examination of the results for the main effect of THINKING on CHANGE in Table 4.6 indicates no statistically significant effect of THINKING on business unit PERFORMANCE. Thus the null hypothesis cannot be rejected. The results obtained cannot support the alternate hypothesis that THINKING

independent of the other elements of TOC and in the absence of OUTCOMES associated with TOC has a statistically significant effect on business unit performance.

Stated in the null the sub-hypothesis related to MEASURES would be:

$H_0$ : There is no association between MEASURES and PERFORMANCE.

From the cell means it appears that there is a relatively large difference in CHANGE in performance between high and low users of MEASURES. This difference indicates a positive change in performance for high users of MEASURES and a negative change for low users MEASURES. An examination of the results for the main effect of MEASURES on CHANGE in Table 4.6 indicates statistical significance at a level of .001. Thus the null hypothesis can be rejected. From the results obtained, support is shown for the alternate hypothesis that the use of the non-traditional performance MEASURES associated with TOC has a statistically significant effect on business unit PERFORMANCE. This supports the conclusion that the adoption of the non-traditional measures associated with TOC has a positive effect on PERFORMANCE independent of the other elements of TOC (LOGISTICS and THINKING) and in the absence of the observable OUTCOMES associated with TOC.

Stated in the null the sub-hypothesis related to OUTCOMES would be:

$H_0$ : There is no association between the OUTCOMES and PERFORMANCE.

From the cell means it appears that there is a relatively large difference in CHANGE performance between business units exhibiting high and low levels of the observable OUTCOMES associated with TOC. This difference indicates a positive CHANGE for

high incidences of the OUTCOMES and a negative CHANGE for low incidences of OUTCOMES. An examination of the results for the main effect of OUTCOMES on CHANGE in Table 4.6 indicates a marginal statistical significance at a level of .084. Thus the null hypothesis can be rejected with some caution. From the results obtained, some support is shown for the alternate hypothesis that OUTCOMES is associated with PERFORMANCE independent of the level of adoption of the elements of TOC. This supports the conclusion that the presence OUTCOMES associated with TOC independent of the elements of TOC has a positive effect on business unit PERFORMANCE.

#### Test of Hypothesis II

Hypothesis II as it was stated in the null was:

Hypothesis II

H<sub>0</sub>: There is no association between all four factors (LOGISTICS, THINKING, MEASURES, and OUTCOMES) and PERFORMANCE

From the cell means it appears that there is a relatively large difference in CHANGE in performance between those exhibiting high and low levels of all four of the elements of the model (LOGISTICS, THINKING, MEASURES and OUTCOMES). This difference indicates a positive change in performance for high users of LOGISTICS, THINKING, and MEASURES, which also exhibit high levels of the OUTCOMES. It indicates a negative change in performance for low users of LOGISTICS, THINKING, and MEASURES, which also exhibit low levels of the OUTCOMES. An examination of the results for the overall effect of LOGISTICS,

THINKING, MEASURES and OUTCOMES on CHANGE in Table 4.6 indicates statistical significance at a level of .000. Thus the null hypothesis can be rejected. From the results obtained, support is shown for the alternate hypothesis that the use of high levels of the elements of TOC and the observable outcomes expected to be associated with TOC has a significant effect on business unit performance. This supports the conclusion that these four elements have a positive effect on business unit performance.

### Test of Hypothesis III

Again, examining the table of cell means allows an overview of the results of interest.

#### Hypothesis III

H<sub>0</sub>: There is no interaction between the four factors (LOGISTICS, THINKING, MEASURES and OUTCOMES).

From examination of the cell means, differences in the level of each of the factors do not appear to have the same effect on CHANGE in business unit performance. CHANGE, for the different levels of LOGISTICS, was in the opposite direction than CHANGE for the different levels of both THINKING and MEASURES, and for the different levels of OUTCOMES. An examination of the results for the interaction effects shows statistical significance at a level of .002 for interaction between LOGISTICS and OUTCOMES. It shows a statistical significance at a marginal level of .088 for interaction between MEASURES and OUTCOMES. In addition, statistical significance at the level of .032 is shown for the interaction between all four elements of the model. Thus the null hypothesis can be rejected. From the results

obtained, support can be found for the alternate hypothesis that interaction exists between the four elements of the model. This supports the conclusion that business unit performance is not consistent between the elements of the model when there are differences in the level of the other elements.

Considering the purpose of TOC and the mixed results, it was of practical interest to examine sub-sets of responses with various combinations of high and low levels on each of the four elements of the model. Statistically significant differences in these sub-sets offer some evidence as to possible interacting elements that affect business unit performance. Means of the sub-groups are presented in Table 4.8, Table 4.9 and Table 4.10.

<b>Table 4.8 MEANS FOR TWO-WAY INTERACTION</b>				
<b>LOGISTICS</b>	<b>THINKING</b>	<b>MEASURES</b>	<b>OUTCOME</b>	<b>Change</b>
L	L	-	-	-0.14
L	H	-	-	0.38
H	L	-	-	-0.40
H	H	-	-	-0.34
L	-	L	-	-0.39
L	-	H	-	0.41
H	-	L	-	-0.69
H	-	H	-	-0.18
L	-	-	L	-0.47*
L	-	-	H	0.38*
H	-	-	L	-0.28*
H	-	-	H	-0.44*
-	L	L	-	-0.38
-	L	H	-	0.17
-	H	L	-	-0.79
-	H	H	-	0.19
-	L	-	L	-0.49
-	L	-	H	0.19
-	H	-	L	-0.24
-	H	-	H	0.09
-	-	L	L	-0.70**
-	-	L	H	-0.13**
-	-	H	L	-0.07**
-	-	H	H	0.40**

\*Designates means for which the difference was found to be statistically different at a level of .05.

\*\*Designates means for which the difference was found to be statistically different at a level of .10.

Table 4.9 MEANS FOR THREE-WAY INTERACTION				
LOGISTICS	THINKING	MEASURES	OUTCOME	Change
L	L	L	-	-0.35
L	L	H	-	0.29
L	H	L	-	-1.23
L	H	H	-	0.63
H	L	L	-	-0.69
H	L	H	-	-0.26
H	H	L	-	-0.69
H	H	H	-	-0.15
L	L	-	L	-0.58
L	L	-	H	0.31
L	H	-	L	0.06
L	H	-	H	0.69
H	L	-	L	-0.03
H	L	-	H	-1.14
H	H	-	L	-0.42
H	H	-	H	-0.26
L	-	L	L	-0.66
L	-	L	H	-0.07
L	-	H	L	-0.16
L	-	H	H	0.87
H	-	L	L	-0.84
H	-	L	H	-0.46
H	-	H	L	0.05
H	-	H	H	-0.43
-	L	L	L	-0.60
-	L	L	H	-0.09
-	L	H	L	-0.28
-	L	H	H	0.57
-	H	L	L	-1.13
-	H	L	H	-0.34
-	H	H	L	0.14
-	H	H	H	0.22

\*Designates means for which the difference was found to be statistically different at a level of .05.

\*\*Designates means for which the difference was found to be statistically different at a level of .10.

<b>Table 4.10 MEANS FOR FOUR-WAY INTERACTION</b>				
<b>LOGISTICS</b>	<b>THINKING</b>	<b>MEASURES</b>	<b>OUTCOME</b>	<b>Change</b>
L	L	L	L	-0.59
L	L	L	H	-0.07
L	L	H	L	-0.55
L	L	H	H	0.93
L	H	L	L	-1.88
L	H	L	H	0.09
L	H	H	L	0.50
L	H	H	H	0.75
H	L	L	L	-0.69
H	L	L	H	-0.69
H	H	L	L	-0.92
H	H	L	H	-0.42
H	L	H	L	0.40
H	L	H	H	-1.25
H	H	H	L	-0.12
H	H	H	H	-0.18

\*Designates means for which the difference was found to be statistically different at a level of .05.

\*\*Designates means for which the difference was found to be statistically different at a level of .10

T-tests were conducted for sub-groups exhibiting high levels of all elements under consideration for interaction and those exhibiting low levels of all the elements under consideration for interaction. The results of this analysis are presented in Table 4.11.

<b>Table 4.11 T-TESTS FOR DIFFERENCES IN SELECTED MEANS</b>				
<b>LOGISTICS</b>	<b>THINKING</b>	<b>MEASURES</b>	<b>OUTCOME</b>	<b>Change</b>
L	L	-	-	-0.14
H	H	-	-	-0.34
L	-	L	-	-0.39
H	-	H	-	-0.18
L	-	-	L	-0.47
H	-	-	H	-0.44
-	L	L	-	-0.38*
-	H	H	-	0.19*
-	L	-	L	-0.49*
-	H	-	H	0.09*
-	-	L	L	-0.70*
-	-	H	H	0.40*
L	L	L	-	-0.35
H	H	H	-	-0.15
H	H	-	H	-0.26
L	L	-	L	-0.58
L	-	L	L	-0.66
H	-	H	H	-0.43
-	L	L	L	-0.60*
-	H	H	H	0.22*
L	L	L	L	-0.59
H	H	H	H	-0.18

\*Designates means for which the difference was found to be statistically different at a level of .05.

\*\*Designates means for which the difference was found to be statistically different at a level of .10

Examination was first made of the results of t-tests for difference in cell means for two-way interaction between LOGISTICS and THINKING. This showed that there was no statistically significant difference between the mean CHANGE in performance of respondents exhibiting high levels of both LOGISTICS and THINKING and those exhibiting low levels of these two elements (See Table 4.11). Examination of the cell means of all combinations of LOGISTICS and THINKING show that the greatest CHANGE in mean performance is shown in the group exhibiting low LOGISTICS and high THINKING (.38). Further t-tests revealed that there is a statistically significant difference between the change in mean performance of this group at a level of alpha equal to .05 and all other groups compared on these two attributes alone. See Table 4:12.

LOGISTICS	THINKING	Mean	t-value	Significance	Mean Difference
L	H	0.38	2.29	0.03	0.78
H	L	-0.4			
L	H	0.38	2.35	0.03	0.71
H	H	-0.34			
L	H	0.38	2.04	0.04	0.52
L	L	-0.14			

It appears from this analysis that the performance of groups exhibiting low LOGISTICS and high THINKING significantly out perform groups exhibiting other combinations of levels of LOGISTICS and THINKING. This is particularly interesting in light of the finding that groups exhibiting high levels of LOGISTICS performed significantly more poorly than those exhibiting low levels of LOGISTICS and that there was no difference in those exhibiting high and low levels of THINKING. It seems to suggest that higher levels of THINKING ameliorate the effect of high levels of LOGISTICS.

Examination was then made of the results of t-tests for difference in cell means for two-way interaction between LOGISTICS and MEASURES. A similar pattern is evident when considering only LOGISTICS and MEASURES. This showed that there was no statistically significant difference between the mean change in performance of respondents exhibiting high levels of both LOGISTICS and MEASURES and those exhibiting low levels of these two elements (See Table 4.11). Examination of the cell means of all combinations of LOGISTICS and MEASURES show that the highest change in mean performance is shown in the group exhibiting low LOGISTICS and high MEASURES (.41). Further t-tests revealed that there is a statistically significant difference between the change in mean performance of this group at a level of alpha equal to .05 and all other groups compared on these two attributes alone. See Table 4:13.

<b>LOGISTICS</b>	<b>MEASURES</b>	<b>Mean</b>	<b>t-value</b>	<b>Significance</b>	<b>Mean Difference</b>
L	H	0.41	5.03	0	1.1
H	L	-0.69			
L	H	0.41	2.66	0.01	0.6
H	H	0.18			
L	H	0.41	4.12	0	0.8
L	L	-0.39			

The same conclusion might be drawn about the interaction between LOGISTICS and MEASURES. It appears that the high use of MEASURES may ameliorate the effect of high LOGISTICS.

Next an examination of the results of t-tests for difference in cell means for two-way interaction between LOGISTICS and OUTCOMES revealed the same pattern as the results discussed above. This showed that there was no statistically significant difference between the mean CHANGE in performance of respondents exhibiting high levels of both LOGISTICS and OUTCOMES and those exhibiting low levels of these two elements (See Table 4.11). Examination of the cell means of all combinations of LOGISTICS and OUTCOMES show that the highest change in mean performance is shown in the group exhibiting low LOGISTICS and high OUTCOMES (.38). Further t-tests revealed that there is a statistically significant difference between the CHANGE in mean performance of this group at a level of alpha equal to .05 and all other groups compared on these two attributes alone. See Table 4:14.

LOGISTICS	OUTCOMES	Mean	t-value	Significance	Mean Difference
L	H	0.38	3.18	.002	.66
H	L	-0.28			
L	H	0.38	3.43	.001	.82
H	H	-0.44			
L	H	0.38	4.7	.000	.85
L	L	-0.47			

Again, the same conclusion might be drawn about the interaction between LOGISTICS and OUTCOMES. It appears that the high presence of OUTCOMES may ameliorate the effect of high LOGISTICS.

Table 4.11 shows that in all other interactions between two elements there is a significant difference between groups exhibiting high levels of both elements and those exhibiting low levels of both elements. In all cases the groups exhibiting high levels outperform those exhibiting low levels.

Next an examination was made of the t-tests for three-way interaction of subgroups exhibiting high levels of all three elements under consideration for interaction and those exhibiting low levels of all the elements under consideration for interaction (see Table 4:11). It was noted that in all cases those groups exhibiting high levels of all three elements outperformed those groups exhibiting low levels of all three elements. However, this difference was statistically significant only in the case of interaction between THINKING, MEASURES, and OUTCOMES.

Next the sub-group for four-way interaction which displayed high levels of all four elements was compared to the sub-group that displayed low levels for all four elements. Although the group displaying high levels showed a considerably less negative mean change performance, the difference was not statistically significant.

#### Test of Hypothesis IV

Hypothesis IV as stated in the null was:

**H<sub>0</sub>:** The relationship between the elements of TOC (LOGISTICS, THINKING, and MEASURES) and PERFORMANCE is unaffected by the presence of different levels of OUTCOMES.

The typology developed by Sharma, *et al.* (1981) is followed in the examination of whether or not OUTCOMES either modifies the form or the strength of the relationship between the predictor variables (LOGISTICS, THINKING, and MEASURES) and the dependent variable CHANGE. Table 4.15 presents this typology.

Table 4.15 TYPOLOGY OF SPECIFICATION VARIABLES		
	Related to Criterion and/or Predictor	Not Related to Either Criterion or Predictor
No Interaction With Predictor Variable	Intervening Exogenous Antecedent Suppressor Predictor	Moderator (Homologizer)
Interaction with Predictor Variable	Moderator (Quasi Moderator)	Moderator (Pure Moderator)

To test the effect of OUTCOMES as a moderator three regressions were performed. Assuming Y is the dependent or criterion variable and X is the predictor or independent

variable and Z is the moderator the following regression performed for each of the elements of TOC:

$$(1) Y = b_0 + b_1X + b_2Z + b_3XZ$$

The variables are entered in the exact order indicated above. According to Sharma, *et al.* (1981), the significance of the partial regression coefficients of equation (1) provide a test of the moderating effect of the variable Z. If  $b_3$  and  $b_2$  are statistically significant Z is a quasi moderator. If, however,  $b_3$  is significant, but  $b_2$  is not, Z is a pure moderator.

If  $b_3$  is not significant the following regressions should be performed:

$$(2) X = b_0 + b_1Z$$

$$(3) Y = b_0 + b_1Z$$

If  $b_1$  is significant in either (3) or (4), Z is an antecedent, exogenous, intervening, or suppressor variable. In the current study, X is LOGISTICS, THINGING or MEASURES, Y is CHANGE, and Z is OUTCOMES. The results of the hypothesis tests are presented in Table 4.16 below.

<b>Table 4.16 STANDARDIZED COEFFICIENTS FOR HYPOTHESIZED RELATIONSHIPS</b>				
<b>(Absolute t Statistics and their Significance are shown in parentheses.)</b>				
<b>H<sub>4a</sub>: OUTCOMES moderates the relationship between LOGISTICS AND CHANGE.</b>				
(1) CHANGE =	.719	+ .13 LOGISTICS	- .57 OUTCOMES	+ .08 LOGISTICS*OUTCOMES
t	(3.07)	(1.75)	(-3.85)	(.69)
sig.	(.00)	(.08)	(.00)	(.49)
<b>R<sup>2</sup> = .08</b>				
<b>H<sub>4b</sub>: OUTCOMES moderates the relationship between THINKING and CHANGE.</b>				
(1) CHANGE =	.719	- .04 THINKING	- .57 OUTCOMES	- .04 THINKING*OUTCOMES
t	(3.07)	(-.52)	(-3.85)	(-.86)
sig.	(.00)	(.60)	(.00)	(.39)
<b>R<sup>2</sup> = .08</b>				
<b>H<sub>4c</sub>: OUTCOMES moderates the relationship between MEASURES and CHANGE.</b>				
(1) CHANGE =	.669	- .05 MEASURES	+ .01 OUTCOMES	- .35 MEASURES*OUTCOMES
t	(4.22)	(-.51)	(.09)	(-.57)
sig.	(.00)	(.61)	(.93)	(.00)
<b>R<sup>2</sup> = .15</b>				

As can be seen above,  $b_3$  is not significant for either LOGISTICS or THINKING. This necessitates further testing using equation (2) and equation (3). However,  $b_3$  is significant and  $b_2$  is not for MEASURES. This indicates that OUTCOMES is a pure moderator with respect to MEASURES. Therefore the sub hypothesis related to MEASURES which would be stated in the null as:

$H_0$ : The relationship between MEASURES and CHANGE is unaffected by the presence of different levels of OUTCOMES.

can be rejected.

The results of the additional hypothesis tests for LOGISTICS and THINKING are presented in Table 4.17 below:

<u>Table 4.17 ADDITIONAL STANDARDIZED COEFFICIENTS FOR HYPOTHESIZED RELATIONSHIPS</u>		
(Absolute t Statistics and their Significance are shown in parentheses.)		
<b>H<sub>4d</sub>: OUTCOMES is an antecedent, exogenous, intervening or suppressor in the relationship between LOGISTICS and CHANGE.</b>		
(2) LOGISTICS =	.176	- .04 OUTCOMES
t	(16.14)	(-.53)
sig.	(.00)	(.60)
R <sup>2</sup> = .02		
(3) CHANGE =	.72	+ .57 OUTCOMES
t	(3.06)	(-3.85)
sig.	(.00)	(.00)
R <sup>2</sup> = .08		
<b>H<sub>4e</sub>: OUTCOMES is an antecedent, exogenous, intervening or suppressor in the relationship between THINKING and CHANGE.</b>		
(2) THINKING =	1.63	- .02 OUTCOMES
t	(14.47)	(.36)
sig.	(.00)	(.75)
R <sup>2</sup> = .01		
(3) CHANGE =	.72	+ .57 OUTCOMES
t	(3.06)	(-3.85)
sig.	(.00)	(.00)
R <sup>2</sup> = .08		

As can be seen from the table  $b_1$  is not significant for LOGISTICS in either equation, therefore OUTCOMES is neither an antecedent, exogenous, intervening, nor

suppressor variable with respect to LOGISTICS. To determine if it is a homologizer variable it is necessary to perform subgroup analysis. If the subgroups are different in respect to R, then OUTCOMES is a homologizer variable with respect to LOGISTICS. For THINKING  $b_3$  is significant in equation (3) indicating OUTCOMES is an antecedent, exogenous, intervening, or suppressor variable with respect to THINKING. Therefore the sub-hypothesis related to THINKING, stated in the null is:

$H_0$ : The relationship between THINKING and CHANGE is unaffected by the presence of different levels of OUTCOMES.

cannot be rejected.

Results of tests for differences with respect to R are given in Table 4.18 below.

<b>Table 4.18 HYPOTHESIS TEST FOR HOMOLOGIZER EFFECT</b>		
CHANGE = -.08 + .07 High LOGISTICS		
t	(-.74)	(.61)
sig.	(.46)	(.54)
R = .05		
CHANGE = .72 + .53 Low LOGISTICS		
t	(-6.91)	(5.65)
sig.	(.00)	(.00)
R = .62		

The groups are different with respect to R indicating OUTCOMES is a homologizer variable with respect to LOGISTICS. The sub-hypothesis related to LOGISTICS stated in the null as:

$H_0$ : LOGISTICS and CHANGE is unaffected by the presence of different levels of OUTCOMES.

can be rejected.

## CHAPTER 5

### CONCLUSIONS

This chapter provides a discussion and interpretation of the empirical results presented in Chapter 4. The chapter begins with a discussion of the research conducted and the conclusions drawn from the tests of hypothesis. Possible implications of this area of research to business managers are considered in the next section. The third section of the chapter discusses potential directions for future research. Finally the contributions of the study are presented.

#### Research Findings and Conclusions

Findings of this research investigating relationships between the elements of the practice of Theory of Constraints (TOC), the observable outcomes associated with the practice of TOC, and change in business unit performance are discussed in this section. Conclusions drawn from the research are presented.

No conclusions can be drawn for this sample about the relationship between the use of the THINKING and changes in business unit performance. This relationship was not statistically significant using this data set. Although there was no statistically significant difference in the change in performance for groups using high and low levels of THINKING, those groups using low levels failed to perform as well, on average as

groups using high levels of THINKING. Further research with a larger data set and perhaps a more highly refined measure of the thinking process associated with the use of TOC might be useful in further investigation of this possible relationship.

A statistically significant relationship does exist between the use of the LOGISTICS associated with TOC and CHANGES in business unit performance. Use of LOGISTICS is associated with a more negative change in business unit performance. This finding implies that LOGISTICS, when adopted alone, lead to poorer business unit performance.

A statistically significant relationship exists between MEASURES and CHANGES in business unit performance. Use of performance MEASURES associated with TOC is related to a positive CHANGE in business unit performance. This finding implies that MEASURES, when adopted alone, lead to improvement in business unit performance.

A marginal statistically significant relationship exists between the observable OUTCOMES associated with TOC and CHANGE in business unit performance. The existence of the OUTCOMES is related to a positive CHANGE in business unit performance. This finding implies that existence of the OUTCOMES, in the absence of the elements of TOC, leads to improvement in business unit performance.

The statistical significance of the model indicates there is a relationship between the use of the three elements of TOC (LOGISTICS, THINKING, and MEASURES), the existence of the observable OUTCOMES associated with TOC, and business unit performance. The existence of all four of these factors together is associated with a

positive CHANGE in business unit performance. This finding implies that use of all the elements TOC together with presence of the observable OUTCOMES associated with TOC leads to improvement in business unit performance.

A statistically significant interaction effect is present between LOGISTICS and OUTCOMES. Although, LOGISTICS when used alone appear to have a detrimental effect on CHANGE in performance, the use of MEASURES, and the presence of the observable OUTCOMES associated with TOC, both appear to mitigate this effect. There was no significant three-way interaction between any of the elements of the model.

In summary, for this data, there was a relationship between the use of TOC and change in business unit performance. This relationship appears to be quite complex with various degrees of interaction between the three elements of TOC. In addition, presence of the observable outcomes associated with TOC was significantly related to change in business unit performance and interacted with the three elements of TOC.

The moderating effect of the observable OUTCOMES on the relationships between two of the individual elements of TOC and CHANGE in business unit PERFORMANCE was supported. The evidence of the observable OUTCOMES of TOC as a pure moderator of the relationship between MEASURES and CHANGE indicates that the presence of these observable outcomes is necessary for the MEASURES to have maximum effect. Evidence of OUTCOMES having a homologizer effect on the relationship between LOGISTICS and CHANGE indicates that the strength of the effect of the use of LOGISTICS on CHANGE is affected by the

presence of OUTCOMES, despite the fact that OUTCOMES is not significantly related to either LOGISTICS or CHANGE. This may be due to the fact that these same observable OUTCOMES could be the result of other management philosophies such as JIT (just in time). To test this possibility the mean level of OUTCOMES and the mean CHANGE in performance was compared between high users of LOGISTICS and respondents who had indicated adoption of JIT. The results of these tests are illustrated in the following table.

LOGISTICS	JIT	Mean CHANGE	t-value	Significance	Mean Difference
H	H	-0.48	.71	.48	.16
L	L	-0.32			
LOGISTICS	JIT	Mean OUTCOME	t-value	Significance	Mean Difference
H	H	1.58	-1.38	.17	-.18
L	L	1.40			

From the results of these tests there is no support for the presence of differences between the group designated as high adopters of LOGISTICS associated with TOC and the group indicating usage of JIT. This might explain why presence of the observable OUTCOMES associated with TOC appeared to mitigate the effect of adoption of the LOGISTICS associated with TOC.

The evidence of the observable OUTCOMES of TOC as either an antecedent, exogenous, intervening, or suppressor of the relationship between THINKING and CHANGE can be examined in light of the two-way interaction between THINKING and

OUTCOMES. Due to the hypothesized relationship of OUTCOMES as the result of management philosophy, and the relationship noted in the Table 5.2 below, it is expected that further examination would reveal OUTCOMES as an intervening variable to the relationship between THINKING and CHANGE.

THINKING	OUTCOMES	Mean CHANGE
L	L	-0.49
L	H	0.19
H	L	-0.24
H	H	0.09

### Implications

A number of implications for business firms can be drawn from the findings of this study. One such implication is that TOC may be an effective management philosophy that can lead to improved business performance. However, TOC can be adopted in a piecemeal fashion, and the results of the study show mixed results for different elements of TOC. Since these mixed results include the possibility of a negative effect on business unit performance for users of only the LOGISTICS associated with TOC, business firms should be aware that different elements might have varying effects if adopted in different combinations.

### Directions for Future Research

The research conducted in this study is exploratory in that it identified and tested a set of measures not previously tested. Consistent with this exploratory design, these measures should be verified by further testing, and the possibility of other, better measures should be examined. Further exploration of the complex relationships between the elements of the design should be undertaken. It is possible that with the availability of additional data, more sophisticated statistical methods might be employed to test these relationships.

Also, the relationship between LOGISTICS and the observable OUTCOMES should be examined in light of use of other Advanced Management Practices that might result in some of the same outcomes. Possible relationships between TOC and other Advanced Management Practices should be explored

### Contributions of the Study

The purpose of this exploratory study was to examine the relationships between the three elements of TOC (LOGISTICS, THINKING, and MEASURES) and the observable OUTCOMES associated with TOC. The investigation made a number of important contributions to the research literature regarding the effectiveness of TOC as a management philosophy.

First, it showed that TOC might be effective as a management philosophy when adopted to improve business unit performance. Second, it suggest that managers

adopting TOC should be cautious about adopting only some of the practices associated with TOC.

## APPENDICES

## APPENDIX A

### SURVEY QUESTIONNAIRE

**CONFIDENTIAL QUESTIONNAIRE** Any information you provide will be held in strictest confidence. There is no way for anyone to determine the address of the respondent from the response. Only aggregate information will be published or released to those who request it. Your carefully considered response is extremely important to the completion and accuracy of the study. **If you cannot answer all questions with certainty, please provide your best estimate. If you are unable to provide the type of information requested, please forward this address to someone within your business unit who has access to the necessary information.**

1. Do managers of your unit employ TOC?	Yes	No		
2. Do managers in your unit use drum-buffer-rope scheduling?	Yes	No		
3. Do managers in your unit employ the Thinking Process associated with TOC?	Yes	No		
4. Do managers in your unit construct Reality Trees?	Yes	No		
5. Do managers in your unit solve problems by use of Evaporating Clouds?	Yes	No		
6. Do managers in your unit solve problems by use of Injections?	Yes	No		
7. Is Throughput Dollar Days measured for your business unit?	Yes	No		
8. Is inventory Dollar Days measured for your business unit?	Yes	No		
9. Does your business unit use a measure of local operating expense?	Yes	No		
10. Do managers in your unit employ the five-step continuous improvement process?	Yes	No		
11. Do managers of your unit classify your production structure according to VAT analysis?	Yes	No		
12. Which term best describes your production structure?	V	A	T	I am unsure of our production structure.
13. How do you measure throughput?				
14. How do you measure inventory?				
15. How do you measure operating expense?				
16. What is your current system constraint?				

**Please indicate how each of the following has changed for your business unit in the past ten years by choosing the appropriate number.**

	Decreased Dramatically					Increased Dramatically				
	1	2	3	4	5	6	7	8	9	10
17. Emphasis on increasing throughput rather than reducing cost	1	2	3	4	5	6	7	8	9	10
18. Throughput time (product cycle time)	1	2	3	4	5	6	7	8	9	10
19. Value of work-in-process-inventory	1	2	3	4	5	6	7	8	9	10
20. Size of production runs	1	2	3	4	5	6	7	8	9	10
21. Due date performance (orders shipped on time)	1	2	3	4	5	6	7	8	9	10
22. Necessity to expedite orders	1	2	3	4	5	6	7	8	9	10
23. Product diversity (number of different products)	1	2	3	4	5	6	7	8	9	10
24. Pricing flexibility (sales of the same product at different prices)	1	2	3	4	5	6	7	8	9	10
25. Manufacturing flexibility (ability to produce multiple products)	1	2	3	4	5	6	7	8	9	10

Please indicate the degree to which your business unit uses each of the following as a measure of production performance by choosing the appropriate number.

	Not Used at All					Used to a Large Extent				
	1	2	3	4	5	6	7	8	9	10
26. Standard cost variance reports	1	2	3	4	5	6	7	8	9	10
27. Labor efficiency reports	1	2	3	4	5	6	7	8	9	10
28. Efficiency reports for individual machines	1	2	3	4	5	6	7	8	9	10
29. Departmental efficiency reports	1	2	3	4	5	6	7	8	9	10
30. Instead of any of the above, we measure production performance using										

Please indicate the degree to which each of the following is used in your business unit for internal decision making by choosing the appropriate number.

	Not Used at All					Used to a Large Extent				
	1	2	3	4	5	6	7	8	9	10
31. Variable costing	1	2	3	4	5	6	7	8	9	10
32. Absorption (full) costing	1	2	3	4	5	6	7	8	9	10
33. Standard costing	1	2	3	4	5	6	7	8	9	10
34. Transfer pricing	1	2	3	4	5	6	7	8	9	10
35. Marginal analysis	1	2	3	4	5	6	7	8	9	10

Please indicate the degree to which your business unit utilizes the following management practices by choosing the appropriate number.

	Not Used at All					Used to a Large Extent				
	1	2	3	4	5	6	7	8	9	10
36. JIT	1	2	3	4	5	6	7	8	9	10
37. TOC	1	2	3	4	5	6	7	8	9	10
38. TQM	1	2	3	4	5	6	7	8	9	10
39. MRP	1	2	3	4	5	6	7	8	9	10
40. Synchronous Manufacturing	1	2	3	4	5	6	7	8	9	10
41. Activity Based Costing	1	2	3	4	5	6	7	8	9	10

Please indicate the importance your business unit's managers attach to each performance criteria by choosing the appropriate number.

	Of Little Importance			Extremely Important	
	1	2	3	4	5
42. Sales level	1	2	3	4	5
43. Sales growth rate	1	2	3	4	5
44. Market share	1	2	3	4	5
45. Operating profits	1	2	3	4	5
46. Profit to sales ratio	1	2	3	4	5
47. Cash flow from operations	1	2	3	4	5

48. Return on investment	1	2	3	4	5
49. New product development	1	2	3	4	5
50. Market development	1	2	3	4	5
51. R & D activities	1	2	3	4	5
52. Cost reduction programs	1	2	3	4	5
53. Personnel development	1	2	3	4	5
54. Political/public affairs	1	2	3	4	5

Please indicate the extent of **your business unit's top managers** satisfaction with your business unit's performance on each of the following criteria both **CURRENTLY** (by making a choice in the left column of numbers) and **THREE YEARS AGO** (by making a choice in the right column of numbers).

	Not at all Satisfied (Current - choose number)						Very Satisfied (Three years ago - choose number)					
	1	2	3	4	5		1	2	3	4	5	
55. Sales level	1	2	3	4	5		Sales level	1	2	3	4	5
43. Sales growth rate	1	2	3	4	5		Sales growth rate	1	2	3	4	5
56. Market share	1	2	3	4	5		Market share	1	2	3	4	5
57. Operating profits	1	2	3	4	5		Operating profits	1	2	3	4	5
58. Profit to sales ratio	1	2	3	4	5		Profit to sales ratio	1	2	3	4	5
59. Cash flow from operations	1	2	3	4	5		Cash flow from operations	1	2	3	4	5
60. Return on investment	1	2	3	4	5		Return on investment	1	2	3	4	5
61. New product development	1	2	3	4	5		New product development	1	2	3	4	5
62. Market development	1	2	3	4	5		Market development	1	2	3	4	5
63. R & D activities	1	2	3	4	5		R & D activities	1	2	3	4	5
64. Cost reduction programs	1	2	3	4	5		Cost reduction programs	1	2	3	4	5
65. Personnel development	1	2	3	4	5		Personnel development	1	2	3	4	5
67. Political/public affairs	1	2	3	4	5		Political/public affairs	1	2	3	4	5

Please choose the response below that best answers the question in the first column.

68. The primary business activity of your business unit is best describes as:	Manufacturing	Assembly.	Distribution or resale.	Service.	Other.
69. Your job function can best be described as	Engineering or technical.	Production or service manager.	Financial or accounting manager.	Other manager.	Other (non-manager).
70. How long have you been employed in your current POSITION?	Less than one year.	One to three years.	Three to five years.	Five to ten years.	Over ten years.
71. How long have you been employed by your current EMPLOYER?	Less than one year.	One to three years.	Three to five years.	Five to ten years.	Over ten years.
72. How long have you been involved in your current LINE OF WORK?	Less than one year.	One to three years.	Three to five years.	Five to ten years.	Over ten years.
73. What phrase best describes your highest level of education?	No college.	Fewer than two years of college.	Two or more years of college.	Four-year degree.	Advanced degree.
74. What best describes your field of study?	Engineering or technical.	Business or management.	Humanities or general studies.	Science, math, or medicine.	Other.
75. What professional certifications do you hold?	PE.	Other engineering certification.	CPM.	CPIM.	Other production certification
	CPA.	CMA/CFM.	Other accounting or financial certification.	Jonah.	Other.

**APPENDIX B**  
**COVER LETTER**

Hello,

My name is Martha Sale and I am a doctoral student doing research in Theory of Constraints (TOC). As part of my dissertation, I hope to show the relationship between certain elements of the practice of TOC and business unit performance.

I need your help in completing this important piece of work. The enclosed questionnaire will require between ten and fifteen minutes to answer completely and thoughtfully. The quality of the resulting research is dependent on the kindness of people like you. Since my purpose is to study the relationship between TOC and business unit performance, it is NOT necessary that participants work in business units employing TOC.

You may either complete the questionnaire, as attached, and submit it, or you may follow the link to my web site at Morehead State University. If you choose to complete the attached questionnaire, it would be possible for me to trace the address where the response originated. I have no interest in this type of identification. No results will be available except in aggregate. However, if you are concerned about confidentiality you may follow the link to my web site. Results from the site are completely anonymous.

In advance, please accept my heartfelt thanks for your participation. I wish I could offer you some tangible reward for your help. I can assure you that I will be eternally grateful and will do my best to add significantly to our knowledge of TOC.

## APPENDIX C

### SECOND MAILING INSTRUMENT

I sent you an email last week asking for your help with my doctoral dissertation research. If you have responded please accept my apologies for bothering you again. This is for those who wanted to participate, but had difficulty due to technical problems. The questionnaire is duplicated below in a simple text format. It isn't as attractive, but it should work with every system. You can reply to this message like you would any other email. For those of you who have your email set to include the original message, you can then just fill in the blanks. If your reply doesn't include the original, this format should copy and paste with no problems. Please respond to:  
m.sale@morehead-st.edu  
or  
sale@kih.net

The questionnaire is still available in its original interactive form at:  
<http://www.morehead-st.edu/people/m.sale/Inst4-6.htm>

Thanks in advance for all your help, and a special thanks to those who sent words of encouragement.

Marty Sale

\*\*\*\*\*

1. Do managers of your unit employ TOC? (Yes or No) \_\_\_\_
2. Do managers in your unit use drum-buffer-rope scheduling? (Yes or No) \_\_\_\_
3. Do managers in your unit employ the Thinking Process associated with TOC? (Yes or No) \_\_\_\_
4. Do managers in your unit solve problems by use of Evaporating Clouds? (Yes or No) \_\_\_\_
5. Do managers in your unit construct Reality Trees? (Yes or No) \_\_\_\_
6. Do managers in your unit solve problems by use of Injections? (Yes or No) \_\_\_\_
7. Is Throughput Dollar Days measured for your business unit? (Yes or No) \_\_\_\_
8. Is Inventory Dollar Days measured for your business unit? (Yes or No) \_\_\_\_

9. Does your business unit use a measure of local operating expense?  
(Yes or No) \_\_\_

10. Do managers in your unit employ the five-step continuous  
improvement process? (Yes or No) \_\_\_

11. Do managers of your unit classify your production structure  
according to VAT analysis? (Yes or No) \_\_\_

12. Which term best describes your production structure? (Choose one.)

V \_\_\_

A \_\_\_

T \_\_\_

I am uncertain of our production structure. \_\_\_

13. How do you measure throughput?

14. How do you measure inventory?

15. How do you measure operating expense?

16. What is your current system constraint?

Please indicate how each of the following has changed for your  
business unit in the past ten years by choosing the appropriate number  
where 1 = Increased Dramatically and 10 = Decreased Dramatically.

17. Emphasis on increasing throughput rather than reducing cost  
(1 to 10) \_\_\_

18. Throughput time (product cycle time) (1 to 10) \_\_\_

19. Value of Work-in-Process inventory (1 to 10) \_\_\_

20. Size of Production Runs (1 to 10) \_\_\_

21. Due date performance (orders shipped on time) (1 to 10) \_\_\_

22. Necessity to expedite orders (1 to 10) \_\_\_

23. Product diversity (number of different products) (1 to 10) \_\_\_

24. Pricing flexibility (sales of the same product at more than one  
price) (1 to 10) \_\_\_

25. Manufacturing Flexibility (ability to produce multiple products)  
(1 to 10) \_\_\_

Please indicate the degree to which your business unit uses each of  
the following as a measure of production performance by choosing the  
appropriate number where 1 = Not Used at All and 10 = Used to Large  
Extent.

26. Standard cost variance reports (1 to 10) \_\_\_

27. Labor efficiency reports (1 to 10) \_\_
28. Efficiency reports for individual machines (1 to 10) \_\_
29. Departmental efficiency reports (1 to 10) \_\_
30. Instead of any of the above, we measure production performance using:

Please indicate the degree to which each of the following is used in your business unit for internal decision making by choosing the appropriate number where 1 = Not Used at All and 10 = Used to a Large Extent.

31. Variable costing (1 to 10) \_\_
32. Absorption (full) costing (1 to 10) \_\_
33. Standard costing (1 to 10) \_\_
34. Transfer pricing (1 to 10) \_\_
35. Marginal analysis (1 to 10) \_\_

Please indicate the degree to which your business unit utilizes the following management practices by choosing the appropriate number where 1 = Not Used at All and 10 = Used to a Large Extent.

36. JIT (1 to 10) \_\_
37. TOC (1 to 10) \_\_
38. TQM (1 to 10) \_\_
39. MRP (1 to 10) \_\_
40. Synchronous Manufacturing (1 to 10) \_\_
41. Activity Based Costing (1 to 10) \_\_

Please indicate the importance your business unit's managers attach to each performance criteria by choosing the appropriate number where 1 = Of Little Importance and 5 = Extremely Important.

42. Sales level (1 to 5) \_\_
43. Sales growth rate (1 to 5) \_\_
44. Market share (1 to 5) \_\_
45. Operating profits (1 to 5) \_\_
46. Profit to sales ratio (1 to 5) \_\_
47. Cash flow from operations (1 to 5) \_\_

48. Return on investment (1 to 5) \_\_
49. New product development (1 to 5) \_\_
50. Market development (1 to 5) \_\_
51. R & D activities (1 to 5) \_\_
52. Cost reduction programs (1 to 5) \_\_
53. Personnel development (1 to 5) \_\_
54. Political/public affairs (1 to 5) \_\_

Please indicate the extent of your business unit's top managers satisfaction with your business unit's performance on each of the following criteria both CURRENTLY and THREE YEARS AGO (by indicating a choice in the appropriate space) where 1 = Not at All Satisfied and 5 = Very Satisfied.

55. Sales level (Current, 1 to 5) \_\_ (Three Years Ago, 1 to 5) \_\_
56. Sales growth rate (Current, 1 to 5) \_\_ (Three Years Ago, 1 to 5) \_\_
57. Market share (Current, 1 to 5) \_\_ (Three Years Ago, 1 to 5) \_\_
58. Operating profits (Current, 1 to 5) \_\_ (Three Years Ago, 1 to 5) \_\_
59. Profit to sales ratio (Current, 1 to 5) \_\_ (Three Years Ago, 1 to 5) \_\_
60. Cash flow from operations (Current, 1 to 5) \_\_ (Three Years Ago, 1 to 5) \_\_
61. Return on investment (Current, 1 to 5) \_\_ (Three Years Ago, 1 to 5) \_\_
62. New product development (Current, 1 to 5) \_\_ (Three Years Ago, 1 to 5) \_\_
63. Market development (Current, 1 to 5) \_\_ (Three Years Ago, 1 to 5) \_\_
64. R & D activities (Current, 1 to 5) \_\_ (Three Years Ago, 1 to 5) \_\_
65. Cost reduction programs (Current, 1 to 5) \_\_ (Three Years Ago, 1 to 5) \_\_
66. Personnel development (Current, 1 to 5) \_\_ (Three Years Ago, 1 to 5) \_\_
67. Political/public affairs (Current, 1 to 5) \_\_ (Three Years Ago, 1 to 5) \_\_

Please choose the response below that best answers the question.

68. The primary business activity of your business unit is best described as:

Manufacturing.   
 Assembly.   
 Distribution or resale.   
 Service.   
 Other.

69. Your job function can best be described as:

Engineering or technical.   
 Production or service manager.   
 Financial or accounting manager.   
 Other manager.   
 Other (non-manger).

70. How long have you been employed in your current POSITION?

Less than one year.   
 One to three years.   
 Three to five years.   
 Five to ten years.   
 Over ten years.

71. How long have you been employed by your CURRENT employer?

Less than one year.   
 One to three years.   
 Three to five years.   
 Five to ten years.   
 Over ten years.

72. How long have you been involved in your current LINE OF WORK?

Less than one year.   
 One to three years.   
 Three to five years.   
 Five to ten years.   
 Over ten years.

73. What phrase best describes your highest educational level?

No college.   
 Fewer than two years of college.   
 Two or more years.   
 Four-year degree.   
 Advanced degree.

74. What best describes your field of study?

Engineering or technical.   
 Business or management.   
 Humanities or general studies.   
 Science, mathematics or medicine.   
 Other.

75. What professional certifications do you hold?

PE.   
 Other engineering certification.   
 CPM.   
 CPIM.   
 Other production certification.   
 CPA.   
 CMA/CFM.

Other accounting or financial certification. \_\_\_  
Jonah. \_\_\_  
Other. \_\_\_

## APPENDIX D

### CORRELATION MATRIX

Question Number (CH is change in performance)

	2	10	11	3	4	5	6	26	27	28	29	31	32	33	34	35	17	18	19	20	21	22	23	24	25	CH
2	1	.5	.3	.5	.6	.5	.5	.3	.2	.2	.2	.0	.6	.5	.3	-.1	-.4	.4	-.1	.0	-.4	.0	.0	.3	.1	.2
10	.5	1	.4	.8	.7	.8	.7	.3	.3	.3	.3	.0	.5	.4	.2	.1	-.3	.4	.0	.0	-.3	-.3	-.1	.2	.3	.0
11	.3	.4	1	.5	.4	.4	.4	.1	.0	.0	.1	.1	.1	.3	.0	.2	-.2	.1	-.2	-.1	-.3	-.1	-.2	.2	-.1	.0
3	.5	.8	.5	1	.9	.9	.9	.4	.4	.4	.4	-.1	.4	.4	.3	.2	-.5	.4	.0	-.1	-.3	-.2	.0	.3	.3	.1
4	.6	.7	.4	.9	1	.9	.9	.4	.4	.4	.4	-.1	.5	.4	.3	.1	-.5	.3	.0	.0	-.2	-.2	.0	.3	.3	.2
5	.5	.8	.4	.9	.9	1	.9	.3	.3	.3	.3	-.1	.4	.4	.2	.2	-.4	.3	.0	.0	-.3	-.3	-.1	.2	.2	.0
6	.5	.7	.4	.9	.9	.9	1	.4	.4	.3	.3	.0	.4	.4	.3	.2	-.4	.3	.0	.0	-.3	-.3	-.1	.2	.2	.1
26	.3	.3	.1	.4	.4	.3	.4	1	.9	.7	.8	-.1	.6	.6	.5	-.1	-.4	.0	.1	.1	-.1	-.1	.2	.2	.2	.2
27	.2	.3	.0	.4	.4	.3	.4	.9	1	.8	.8	-.2	.5	.5	.5	-.1	-.4	-.1	.1	.2	-.1	-.1	.2	.2	.1	.2
28	.2	.3	.0	.4	.4	.3	.3	.7	.8	1	.8	.0	.5	.4	.4	.1	-.4	.0	.2	.0	-.1	.0	.3	.2	.3	.3
29	.2	.3	.1	.4	.4	.3	.3	.8	.8	.8	1	.0	.4	.6	.4	.0	-.3	-.1	.0	.0	-.1	-.1	.2	.2	.1	.0
31	.0	.0	.1	-.1	-.1	-.1	.0	-.1	-.2	.0	.0	1	-.2	-.1	-.4	.6	.1	-.1	.1	-.3	-.1	-.1	.1	.1	-.1	.2
32	.6	.5	.1	.4	.5	.4	.4	.6	.5	.5	.4	-.2	1	.6	.6	-.2	-.5	.5	.0	.2	-.3	.0	.1	.3	.4	.2
33	.5	.4	.3	.4	.4	.4	.4	.6	.5	.4	.6	-.1	.6	1	.4	.1	-.3	.1	-.2	.2	-.3	-.1	.0	.2	.2	-.1
34	.3	.2	.0	.3	.3	.2	.3	.5	.5	.4	.4	-.4	.6	.4	1	-.4	-.4	.2	.1	.2	.1	.1	.1	.4	.2	.1
35	-.1	.1	.2	.2	.1	.2	.2	-.1	-.1	.1	.0	.6	-.2	.1	-.4	1	.1	-.2	-.2	-.1	.0	-.3	-.2	-.2	.1	.0
17	-.4	-.3	-.2	-.5	-.5	-.4	-.4	-.4	-.4	-.4	-.3	.1	-.5	-.3	-.4	.1	1	-.3	-.3	.2	.3	-.2	-.4	-.5	-.6	-.3
18	.4	.4	.1	.4	.3	.3	.3	.0	-.1	.0	-.1	-.1	.5	.1	.2	-.2	-.3	1	.3	-.2	-.4	.2	.3	.4	.3	.1
19	-.1	.0	-.2	.0	.0	.0	.0	.1	.1	.2	.0	.1	.0	-.2	.1	-.2	-.3	.3	1	-.6	.0	.2	.4	.5	.2	.2
20	.0	.0	-.1	-.1	.0	.0	.0	.1	.2	.0	.0	-.3	.2	.2	.2	-.1	.2	-.2	-.6	1	.2	-.2	-.3	-.2	-.2	.0
21	-.4	-.3	-.3	-.3	-.2	-.3	-.3	-.1	-.1	-.1	-.1	-.1	-.3	-.3	.1	.0	.3	-.4	.0	.2	1	-.1	-.1	.0	-.2	-.1
22	.0	-.3	-.1	-.2	-.2	-.3	-.3	-.1	-.1	.0	-.1	-.1	.0	-.1	.1	-.3	-.2	.2	.2	-.2	-.2	1	.5	.2	-.1	.0
23	.0	-.1	-.2	.0	.0	-.1	-.1	.2	.2	.3	.2	.1	.1	.0	.1	-.2	-.4	.3	.4	-.3	-.1	.5	1	.4	.4	.4
24	.3	.2	.2	.3	.3	.2	.2	.2	.2	.2	.2	.1	.3	.2	.4	-.2	-.5	.4	.5	-.2	.0	.2	.4	1	.3	.4
25	.1	.3	-.1	.3	.3	.2	.2	.2	.1	.3	.1	-.1	.4	.2	.2	.1	-.6	.3	.2	-.2	-.2	-.1	.4	.3	1	.4
CH	.2	.0	.0	.1	.2	.0	.1	.2	.2	.3	.0	.2	.2	-.1	.1	.0	-.3	.1	.2	.0	-.1	.0	.4	.4	.4	1

MSU Institutional Review Board for the Protection of Human Subjects in Research	
NOTIFICATION OF PROTOCOL REVIEW	
<b>Principal Investigator/Researcher:</b>	
Name: <u>Martha Lair Sale</u>	Title: <u>Assistant Professor</u>
Campus Address: <u>UPO 737</u>	Campus Phone: <u>2723</u>
Department: <u>Accounting, Economics, and Finance</u>	
<b>Purpose:</b>	
Title of Project/Course: <u>Management Accountant Performance Relationships</u>	
Funding Source/Agency: <u>Research and Creative Productions Committee</u>	
Period of Project/Course:	From: <u>6/99</u> To: <u>8/99</u>
<b>Protocol Review Number:</b> <u>99-02-27</u>	
Initial Review <input checked="" type="checkbox"/> Continuing Review <input type="checkbox"/>	
The human subject use protocol described above has been reviewed by the MSU Institutional Review Board for the Protection of Human Subjects in Research with the following results:	
<input checked="" type="checkbox"/> Approved, may proceed as written	
<input type="checkbox"/> Not Approved, may not proceed	
<input type="checkbox"/> CONTINUED REVIEW, MAY NOT PROCEED. THE IRB REQUESTS THE FOLLOWING INFORMATION IN WRITING FOR CONTINUED REVIEW OF THE PROTOCOL	
Signed: <u>Carole Morello</u>	Date: <u>2/24/99</u>
<small>Chair, Institutional Review Board for the Protection of Human Subjects in Research</small>	
Please refer to the protocol review number in any future references to this protocol. Principal investigators of research projects with durations of more than one year should submit yearly to the IRB completed Form C; if any revisions are made to a project or if any unforeseen risks arise during an investigation, the principal investigator must submit Form C to the IRB, fully explaining all changes or unexpected risks; upon completion or termination of a research project, principal investigators must again submit Form C.	
pc:	Green Miller Protocol File

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