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## A Comparative Study of Healthcare Procurement Models

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# A Comparative Study of Healthcare Procurement Models

by

Arka P. Bhattacharya

A thesis submitted in partial fulfillment  
of the requirements for the degree of  
Master of Science in Industrial Engineering  
Department of Industrial and Management Systems Engineering  
College of Engineering  
University of South Florida

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method

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## DEDICATION

To my parents and my lovely wife for their unconditional support and love. To my advisor Dr. Kingsley Reeves for his constant guidance, encouragement and for his excellent mentorship. To Dr. Bob Sullins, Dr. Janet Moore, Ms. Margaret Martinroe and Ms. Mia Fluit from the Dept. of Undergraduate Studies for their unstinted support, encouragement and inspiration.

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## A Comparative Study of Healthcare Procurement Models

Arka P. Bhattacharya

### ABSTRACT

Group Purchasing Organizations (GPOs) play a significant role in the healthcare industry. The presence of GPOs helps the healthcare centers to offload their responsibilities so that they can focus on more critical areas which require attention like providing quality care.

This thesis involves the comparison of three models of procurement operations in terms of cost efficiency. This cost comparison model features a healthcare organization associated with a National GPO, a healthcare organization which procures by Self sourcing (not associated with a GPO), and a Hybrid procurement model involving a National GPO and a regional GPO. The comparison model highlighted the cost effectiveness of these three different ways of procurement, which threw significant light on the purchasing operations of healthcare organizations.

In the second part of this research study, we formulated a method to measure the degree of access to innovative products across the above mentioned procurement models either involving on-contract (from a GPO) purchasing, or off-contract purchasing (from

individual manufacturers not affiliated to GPO) or both. We also identified the metrics for innovation and measure the innovativeness of products. Based on the literature study, it was found that purchasing groups may also be an entry barrier to new suppliers (Zweig 1998), with big National GPOs dominating the market and dictating the pricing of commodities.

The first hypothesis H1 of this research study was stated as “National GPOs (Group Purchasing Organizations) enable the healthcare establishments to lower the cost of medical services and operations.”

The second hypothesis H2 of this research study was acknowledged as “National GPOs a barrier to the entry of innovative product manufacturers in the healthcare industry.”

This thesis will identify the advantages and disadvantages of each type of procurement operation and address the economic issues which affect the relationship between a healthcare center and a GPO. The proposed research would indirectly help to identify whether cost savings are being shared by the links in the downstream supply chain and if savings are being percolated to patients for the added welfare of the society. It will also identify the importance of innovative products in the society and will raise the bar of specialty treatments without compromising on the level of service being offered to the patients. This thesis will also highlight positive aspects of niche manufacturers of innovative products with smaller volumes, currently marginalized in the market by the big National players.

To the best of the author's knowledge, the research objective of measuring innovation of products has not been addressed yet in academic literature and will have the benefit of comparing three different purchasing models used in healthcare industry.

## CHAPTER 1 - INTRODUCTION

Group Purchasing Organizations have become very significant in the healthcare industry. The GPOs (also called purchasing groups) have mostly become popular in healthcare, education and government organizations. The healthcare industry is faced with the constant pressure to cut down costs and stiff competition among healthcare centers which have led to mergers and acquisitions resulting in suppliers of larger size. The most frequent reason given by a healthcare center to be affiliated with a GPO is advantageous contractual conditions. The modern GPOs have changed the conservative method of procurement. The huge pressure of lowering the prices has mostly been beneficial to the end user which in our case is a customer to a healthcare center.

A GPO is a formal and virtual structure that facilitates the consolidation of purchases for many organizations (Nollet 2005). The outsourcing of purchasing to GPOs has facilitated healthcare centers to focus on their critical areas like providing healthcare. This has taken off the burden of purchasing operations which many healthcare centers used to face previously. It has been estimated that more than 70 percent of the healthcare purchases are done through group purchasing (Nollet 2002). These purchasing groups have a stronger negotiating capacity in dealing with their suppliers and have the necessary volume to support, which lowers the cost of commodities (standardized objects). Purchasing groups empower their members in negotiation and create favorable

conditions for their members. However, the price advantages are greater for larger GPOs as they have more negotiating capacity. There is also a general agreement that GPOs generate savings between 10 and 15 percent amounting to \$12.8 billion to \$19.2 billion (Hendrick 1997) and (Schneller 2000). Thus, it is quite evident that in the healthcare industry, the existence of GPOs cannot be ignored.

According to a recent Health Industry Group Purchasing report, goods and purchased services accounted for the second largest dollar expenditure (55% labor and 45% non labor supplies, services and capital equipment) in the hospital organization (Schneller 2000). The main rationale for group purchasing is to achieve lower prices, ensure price protection, implementing improved quality programs, reduced contracting costs and monitoring market conditions (Schneller 2000). Estimates place the GPO market for healthcare organizations and nursing homes at between \$148 and \$165 billion dollars and growing to \$257 and \$287 billion per year by 2009 (Hewitt 1995). It is also noteworthy that 72 to 80 percent of every healthcare (acute care organization) supply dollar is acquired through group purchasing (Schneller 2000).

In addition to purchasing options, GPOs offer information sharing, clinical and operational benchmarking and value assistance benchmarking that could strategically differentiate GPO members in their market (Schneller 2000). Schneller also stated from a report that product standardization and entering into GPO contracts were the most effective cost reduction strategies (Schneller 2000). In choosing to contract with a GPO, a company must evaluate the performance of its suppliers with that of the GPO's performance in terms of purchasing power (Schneller 2000).

The purchasing groups facilitate their members to get more favorable conditions than they would have obtained individually (Rozemeijer 2000). The administrative costs also get lowered due to the fact that a single organization performs the negotiations instead of many. There are two types of structures among GPOs. The first type is cooperative structure where the purchases to be performed by the group are distributed among members. Second type of structure is the third party structure where a distinct organization negotiates and writes contracts according to a mandate given by the members (Hendrick 1997). The healthcare value chain is shown below in figure 1.1.

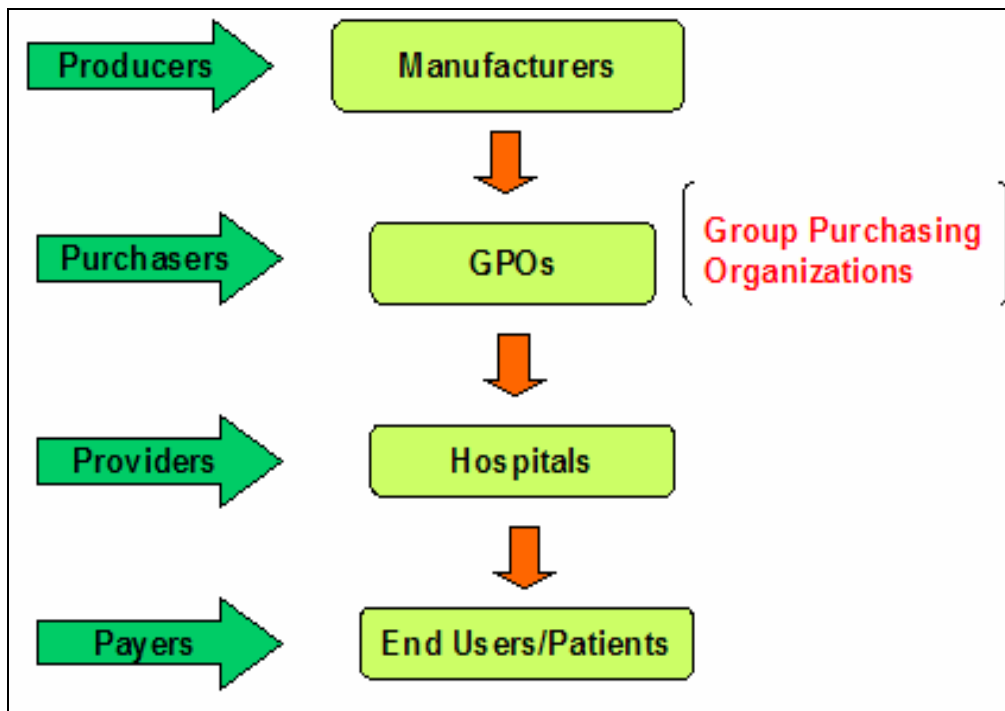


Figure 1.1 Healthcare Value Chain

## CHAPTER 2 - OBJECTIVES AND SIGNIFICANCE

In this thesis our main objective is to compare the three models of procurement operations in terms of cost effectiveness by capturing the purchasing costs per unit of the commodities/items procured by different healthcare organizations. This comparative study focuses on three scenarios featuring a healthcare organization which procured through a National level GPO, a healthcare organization which procured by Self sourcing and a Hybrid procurement model (comprising a National GPO and a regional GPO). In this study, items procured by the healthcare organizations are classified into 2 main categories, medical devices and surgical devices. These items are common items required in daily operations and procured in bulk quantities by the healthcare organizations. The procurement costs of these items are highlighted through this comparative study. Apart from supplying commodities and surgical instruments to healthcare organization, many GPOs are now focusing on diversifying their product range and providing additional support services like maintaining medical records and training hospital employees in new technologies. This has led to an overall growth of technology and made the daily operations more efficient. Our comparison model evaluates and highlights the economic benefits of these three different ways of procurement, which will throw significant light on the purchasing operations of healthcare organizations.

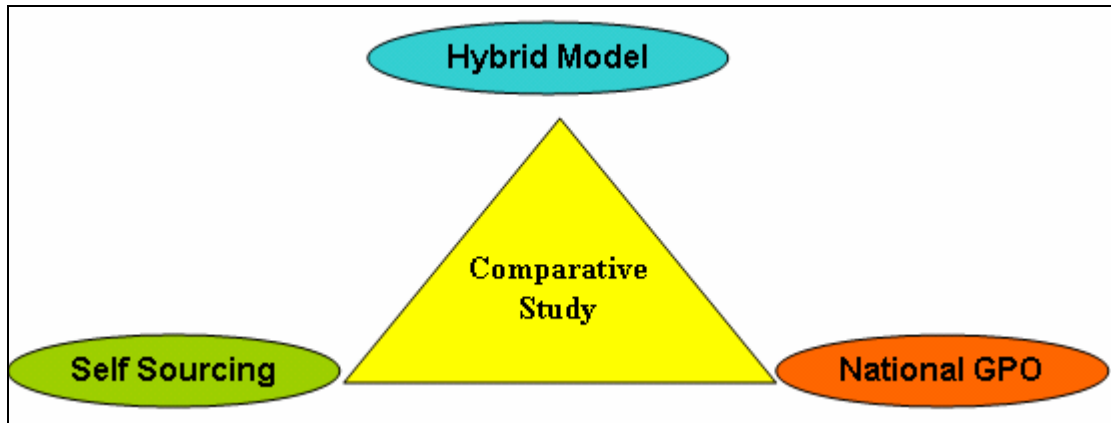


Figure 2.1 Procurement Models Used in the Research

We have also captured the degree of access and compared the cost associated with the procurement of innovative products through a National GPO, a Hybrid model, and Self sourcing. This is done by firstly identifying metrics for innovation and formulating a technique to measure the degree of innovation of products sourced from healthcare organizations involving a National GPO model, a Self sourcing and a Hybrid one either involving on-contract (from a GPO) purchasing, or off-contract purchasing (from individual manufacturers not affiliated to a GPO) or both. The measure of innovation is tied to the cost of the products and both the factors are used in the comparison of models. This may highlight the fact that when it comes to innovative products (for example pacemakers), whether a procurement model is rated higher in terms of innovation and also whether the advantages of low cost outweigh the advantages of innovation.

## 2.1 Hypothesis

Based on our literature review, it was found that purchasing groups may also be an entry barrier to new suppliers (Zweig 1998). Big National GPOs provide commodities at a much lower price due to large volumes, which gives an advantage to existing



suppliers, since suppliers with innovative products do not have sufficient sales volume to allow them to take advantage of economies of scale and to offer competitive prices (Elhauge 2002).

Formally, the hypothesis can be stated as follows:

H1 - National GPOs (Group Purchasing Organizations) enable the healthcare establishments to lower the cost of medical services and operations.

H2 - National GPOs a barrier to entry of Innovative product manufacturers in the healthcare industry.

This proposed thesis will throw light on the pros and cons of each type of procurement operation. There is a strong need to address these economic issues as they will affect the relationship between a healthcare center and a GPO. These factors can affect the consistency of healthcare delivery quality which will have a social impact. Our thesis will highlight positive aspects of niche manufacturers of innovative products with smaller volumes which are currently marginalized in the market by the big National players. Most of the big players in the GPO market are driven by costs and big volumes and they sideline the smaller players which manufacture innovative products (Zweig 1998; Everard 2005). One added advantage of our project will be that it will help the specialty healthcare organizations realize the importance of innovative products and help them choose the procurement model for innovative products which will be most cost effective. This will help to reduce the cost of innovative products in the market and help the patients in accessing high end products at reasonable price. To these healthcare organizations, technology of the products will be of higher priority which will help to raise the quality of specialty healthcare services. To the best of the author's knowledge,

the research objective of measuring innovation of products has not been addressed yet in academic literature and will have the benefit of comparing three different purchasing models used in healthcare industry.

## 2.2 Effects of GPO Sourcing

GPOs have a large effect on the healthcare industry. Based on our study, we have found that there can be positive as well as negative effects when a healthcare organization affiliates with a GPO. However, since the minimization of cost is a top priority for many healthcare organizations, these negative effects are sometimes overshadowed. With affiliation to a GPO, healthcare organizations enjoy lower prices, protected pricing, improved quality control programs, reduced contracting costs and GPOs also monitor market conditions (Schneller 2000). This price protected market gives healthcare organizations some form of security against price fluctuations. However, along with these favorable conditions there are quite a number of cons associated. Affiliation to a GPO, reduces the autonomy of an individual healthcare organization and often it gets bound by a contract and cannot come out of it (Nollet 2005). This may lead to dissatisfaction among some physicians who wish to maintain their autonomy in choosing products, and may sometimes circumvent the contract terms of the GPO to access those products (Burns 2002). This reduces the overall cost savings of the GPO in the long run. GPOs also create an entry barrier to small innovative product suppliers, who cannot compete with large volume existing suppliers due to small volumes (Zweig 1998). This may affect quality of specialized commodities in the long run and result in dissatisfied customers. Thus, the cost associated with loss of business has to be considered. Due to the large size of GPOs

and long term contracts with the suppliers, few big players dominate the market and many small players have complained about the lack of competitive access (Burns 2002). This creates an oligopolistic market scenario, and big players end up dominating the market, while the smaller ones are marginalized.

Close cooperation among healthcare competitors sourcing from the same GPO also gives rise to anti-trust issues(Nollet 2005). Sometimes members do not want to share sensitive information with their rivals.

Sometimes National players are not able to deliver their products on time due to logistic problems and during calamities. This causes unscheduled delays to patients and the service quality of the healthcare organization suffers. In this aspect, local or regional suppliers are sometimes better off as their logistic operations prove to be better. Many local players also share their warehouses with their clients which may help in product delivery and reduce overhead. This is our added research objective and will determine innovation metrics to analyze whether regional sourcing improves quality of products and results in a superior distribution model.

### 2.3 Broader Impact of the Research

The proposed research would indirectly help to identify whether cost savings are being shared by the links in the downstream supply chain and if the savings are being percolated to patients for the added welfare of the society. It will also identify the importance of innovative products in the society and will raise the bar of specialty treatments without compromising on the level of service being offered to the patients.

### CHAPTER 3 - RELATIONSHIP TO CURRENT LITERATURE

One of the most common issues dealt in the past and current literature is about the optimal size of GPOs and the benefits which healthcare organizations gain by affiliating with a GPO. There is an overall consensus that affiliation with a GPO indeed results in cost savings. The past literature has dealt with issues like size of purchasing group and the types of benefits which can be extracted with affiliation to a GPO (Nollet 2005). This study was based mostly on the interviews with health managers. Jean Nollet and Martin Beaulieu identified the different aspects of a relationship with a GPO. The paper evaluated the impacts of a GPO on a supply market. The issue related to the size of a GPO and its effects on the buyers and the suppliers were also discussed. They further went on to discuss the member characteristics and the issues faced by them.

M. Essig described the concept of group purchasing as “Purchasing Consortium” and has introduced it as a supply management concept combining symbiotic horizontal relationships and strategic understanding to gain competitive advantage (Essig 2000). This paper focused on the symbiotic relationship among the members in a similar hierarchy level. This literature further described and classified sourcing options available to a GPO and illustrated the benefits associate with each type.

Member commitment has a huge role to play in the success of a GPO and also the growth of member enrollment depends on it (Nollet 2002). W. R. Doucette pointed out

that the transparency in sharing of information between the members and the trust issues shape the success of GPOs by creating a strong member commitment (Doucette 1997). Member commitment is influenced by other members to a great extent.

The major chunk of literature has dealt with the identification of costs and the cost saving benefits enjoyed by the healthcare organizations (Schneller 2000), (Rozemeijer 2000) and (McFadden 2000). Any healthcare center affiliated to a GPO benefits from three types of cost reductions: price, administrative costs and utilization costs (Anderson 1998). As has been discussed earlier that affiliation to a GPO can generate savings up to 10 to 15 percent which is a direct cost savings (Hendrick 1997) and (Schneller 2000). The healthcare organizations can utilize the savings generated in more vital areas which relate directly to technical quality (quality of healthcare delivery).

Chapman mentioned that the real savings in the healthcare savings come from product standardization (Chapman 1998). However certain types of purchases like commodities are suited for larger savings and standardization may be enforced by certain purchasing groups by forcing healthcare centers to use all the products in the package (Nollet 2005). A significant amount of study has been carried out previously about the role of GPOs and identifying the economic costs and its impact on the entire supply chain (Schneller 2000).

However, based on our literature research, it is found that there has been a dearth of work related to the comparison of procurement models through Self sourcing, National GPO sourcing and regional GPO sourcing. Most of the earlier or present literatures have identified economic and non economic costs associated with a GPO (Dobler 1996; Anderson 1998; Chapman 1998; Schneller 2000), but there has been no direct

comparison between three different procurement models. Also most of the earlier literatures have just mentioned non economic costs like loss of autonomy of physicians and barrier to entry of innovative products (Zweig 1998) and (Elhauge 2002). Our current research focus will be to address this issue of access to innovative products while sourcing from a GPO. This thesis will identify innovation metrics to evaluate the degree of innovation in products and will also illustrate which procurement method gives access to the highest level of innovative products and at the same time keeping the cost to a reasonable level.

Based on our literature research, it can be said that this proposed research topic is unique because it identifies innovation metrics to analyze the degree of innovation in a particular item which again reflects the procurement model. To the best of our knowledge there has been no scholarly work which deals with the comparison of procurement processes associated with a GPO and measures a product's innovativeness by analyzing particular metrics.

### 3.1 Evolution of GPOs

The concept of GPO took birth way back in 1910 in New York with the formation of Hospital Bureau of Standard Supplies of New York (Barlow 2005).

However, with the advent of 1970s, the formation and growth of GPOs really took shape and the regional groups gave in to National level organizations. Almost close to 37% of the purchasing groups were set up during this period (Nollet 2002). This sudden surge in the number of purchasing groups was due to the increased government pressure on cost reduction.

This augmentation in the number of GPOs resulted in stiff competition among the members in a price sensitive market. GPOs could not enlarge by adding members as most of the healthcare organizations were already serviced by one of them (Nollet 2002). To stay afloat with the competition, GPOs started extending additional services which facilitate the operational efficiency of a healthcare organization. These services include consulting, contact management, human resource management, computing services, etc.

The consolidation of purchasing groups began in the 1990's. This age was the age of mergers and acquisitions. For example, Novation resulted from the merger of VHA and HealthSystem Consortium (Doucette 1997).

## CHAPTER 4 - INSIGHT INTO GPOS

### 4.1 Functions and Services of GPOs

A GPO is a group of organizations which consolidate their resources to have more leverage on their suppliers. Based on past literature, it is seen that a GPO's procurement strategy creates better operational links with the suppliers, shorter lead times, and creates more competition in the market. This favors the end user in terms of lower costs and has a socio economic benefit too. GPOs also provide joint purchasing programs to clinicians, and other healthcare entities.

The areas where GPOs use their influence in negotiating the prices are pharmacy, laboratory, diagnostic imaging, office facilities, dietary, maintenance, IT, and insurance (Burns, 2002). Apart from negotiating prices, a GPO serves as an instrument for price protection for its members as it functions like a link between the large number of vendors and the healthcare organization.

In past, GPOs offered their members the same standardized pricing irrespective of the volume they purchased. This proved to be advantageous to the smaller members and the bigger players felt that they had to bear the burden of subsidizing the smaller ones (Burns 2002). However, the concept of "tiered pricing" (Burns 2002) has come into effect recently which relates the pricing of products to the volumes members purchase.

Affiliation to a GPO is a "win-win" situation for both the healthcare organization as well as the GPO. The healthcare organization gets the benefit of cash incentives, cost savings and outsourcing of purchasing function to a third party which in turn helps them



to streamline their operations. GPOs gain by the added negotiating capacity in controlling the price of the products and also the contract administration fees paid by the vendors.

Apart from controlling and lowering of costs, GPOs offer additional services to their members like materials management, contract management, operations consulting, programs to improve product standardization, insurance services, technology management programs, disease management, human resource management, education, and marketing (Burns 2002). Figure 4.1 briefly summarizes the justifications as mentioned in the past literature for a healthcare organization to be affiliated to a GPO.

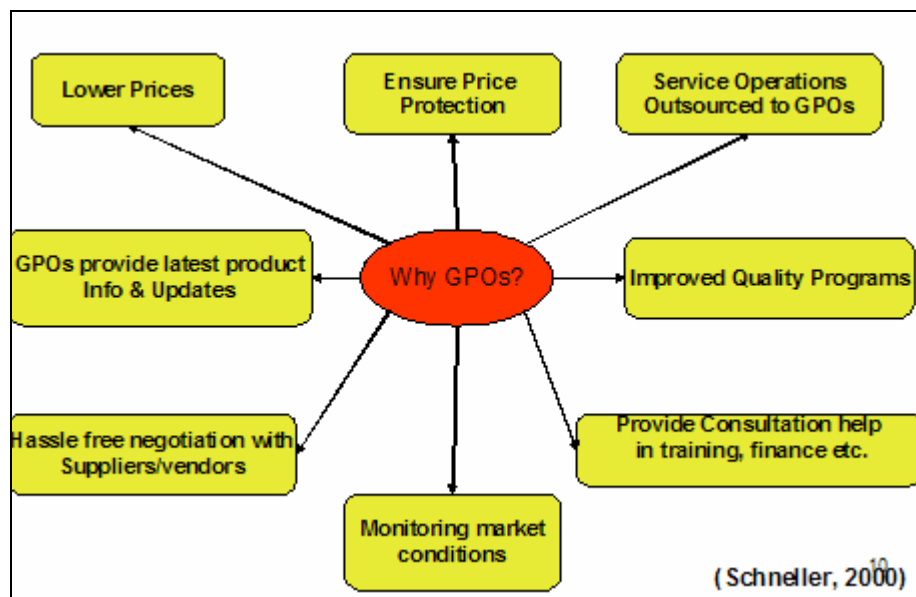


Figure 4.1 Rationale for Group Purchasing

#### 4.2 Importance of GPOs in Healthcare Industry

The process of sourcing through GPO in healthcare industry is mostly seen for non critical items where the level of customization is almost non existent. Most commonly, commodities which are required in bulk quantities and other pharmaceutical

products along with office supplies are sourced through GPOs. Over the years it's been seen that this model of procurement through GPO has seemed to be more cost effective and more and more healthcare organizations are getting affiliated to big National GPOs. The most distinctive factors which have contributed to the rise of GPOs are high volume of commodities being sourced which has helped to lower the price of commodities and the standardization of products being sourced. The levels of customization of products sourced through GPOs have been minimal. According to Dobler and Burt (Dobler 1996), evidence is plentiful that simplification or standardization can result in big savings. Standardization and simplification is also the focus of major efforts in healthcare providers as a tactic for reducing costs (McFadden 2000). This is where the GPOs have a substantial advantage over smaller players in the industry. This leads them to dominate the market.

In healthcare industries, since GPOs are mostly concerned with non critical items, issues like loss of confidentiality are not important. Innovation and technology are not given high importance in the business of non critical items.

Unlike other verticals, healthcare industry has socio-economic obligations. Providing quality healthcare at a low cost has been one of the challenges of the modern healthcare industry. Since it affects the medical services to the common man, controlling the cost becomes a crucial factor. GPOs have played a big role in this by providing commodities at very low costs. This has enabled the healthcare organizations to offer medical services to the common man at reasonable prices and has raised the standards of healthcare quality in the country. Moreover, GPOs also offer other services like data warehousing, information technology services, and training of staff in the latest

technologies to the healthcare establishments and healthcare organization, which have taken off the workload out of these healthcare organizations and helped them focus on more critical issues like operational issues.

#### 4.3 Importance of Innovation/Innovative Products

Based on our research, it can be said that most of the items procured through a GPO are commodities which are pretty simple items and require little or no innovation. These items are sourced in bulk quantities and are supplied at a very low cost. However, it is also seen that healthcare organizations source few type of items like pacemakers and other surgical quantities which are sophisticated and require a high degree of innovation. Though the volumes of these advanced items are quite low compared to the bulk quantities, they have a huge impact on the quality of specialty care. These specialized items require sustained innovation in their lifecycle which is essential for their existence. Many of these state of the art items are manufactured and supplied by niche manufacturers who do not have a strong influence on the National GPOs and cannot deliver at a rock bottom price to the market because of their low volumes. Sometimes these manufacturers are sidelined and the market dominated by the big National GPOs creates a barrier for their entry in the business. According to Muller, “companies must exploit their innovative capabilities to develop new businesses if they are to successfully confront the disruptive effects of emerging technologies, empowered customers, new market entrants, shorter product life cycles, geopolitical instability, and market globalization” (Muller 2005).

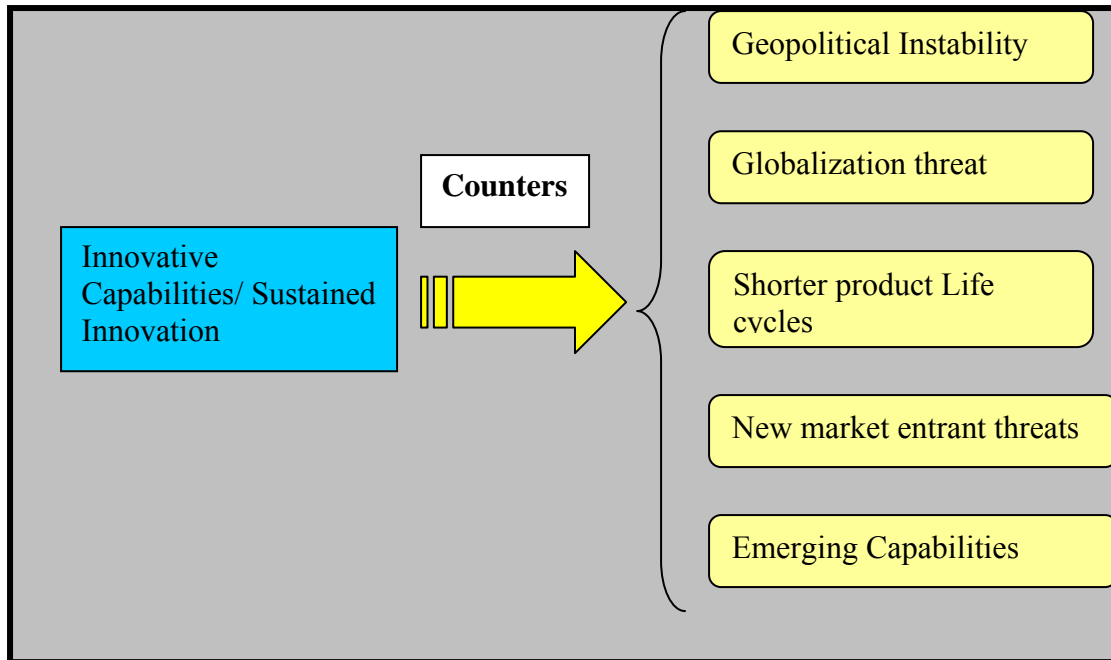


Figure 4.2 Importance of Innovative Capabilities

*Source: Adapted from Strategos et (Muller 2005)*

Innovation management can be also defined as coping with rapidly changing environment or in turbulent environments. Calantone, Garcia and Droge define turbulent environments as those in which market needs or technology are uncertain and have impact on new product development processes (Buganza 2006). Further this paper discusses that to manage turbulent environments, companies have to reduce the development time and increase the ability to react to changes. That is, a product must have high degree of “Life Cycle Flexibility”. Life Cycle Flexibility of a product is the ability to introduce innovations during life cycle processes at a low cost and shortest time.

This allows the product to adapt and be redesigned according to contextual changes and opportunities, i.e., flexibility after the product has been released. Such examples are quite common in the industry and can be clearly seen in the automotive industry. In the automotive industry, cosmetic changes to a product happen often within a

product life cycle based on changing customer views and perceptions. Some cars even undergo major changes in the form of engine capacity and technology to cater to the customer demands.

According to Tommaso Buganza and Roberto Verganti, the metrics for LCF (Life Cycle Flexibility) are (Buganza 2006) :

1. Frequency of adaptation: Number of new features per unit time.
2. Rapidity of adaptation: Inverse of the time needed to adapt to the service/product as a reaction to the launch of the new feature by the competitor =  $(1/\text{Time needed for reaction})$ .
3. Quality of adaptation: Ability to be consistent with quality through different service package adaptations such as robustness as a dimension of quality.

In our proposed thesis we have identified certain metrics for innovation which were proposed in a more generic way by Amy Muller, Liisa Valikangas and Paul Merlyn (Muller 2005) to cater closely to the healthcare industry and which will make it more feasible for data collection. These innovation metrics are essentially product based and the ones which are the most appropriate and will make data collection feasible will be considered. The innovation metrics we have identified for data collection are (adapted from (Muller 2005)) :

1. Measure R&D budget as a % of annual sales of a particular product.
2. No. of patents/new ideas filed by the company in the last year/last month.
3. Measure % of capital that is invested in radical projects.
4. Average time required from idea generation to product/service launch.
5. Ratio of revenue from innovative/new products to commodities.

6. Measure % of employees that are involved in developing an innovative product.
7. Measure innovation revenue per employee from the new product/service developed.
8. % of management that is accountable to development of a new product in terms of time (man hour).
9. No. of incentive schemes to support innovation.

Out of these metrics only few will be considered based on accessibility of data from the three different sources.

#### 4.4 Impact of Purchasing Groups

The purchasing groups play a very important role in manipulation of the commodity prices. The bigger players in the market exploit their leverage with the supplier resulting in the wiping out of the smaller players who lack the negotiating capability. Due to the concentrated market share by the big dominant players, entry of small players in the market becomes very difficult (Sethi 2006). It is prohibitively expensive for a new entrant to gain significant market share because most current and potential customers are already locked in to existing GPOs through various contractual arrangements (Sethi 2006). The extermination of smaller players from the market creates an oligopolistic market scenario where the bigger ones sometimes dictate terms to the buyers as well as the suppliers. This sometimes results in poor service quality by the healthcare organizations. The growth of bigger purchasing groups may result as an advantage to the existing suppliers as smaller volume suppliers may lose out in a price

conscious market even though their product may be technologically superior. This affects the quality of products in the long run.

#### 4.5 Classifications of GPOs

GPOs can be classified based on their ownership, membership, geographical scope, and size (Burns 2002). When GPOs are classified based on ownership, they are distinguished as for-profit, non-profit and public GPOs (Burns 2002). The two largest for-profit GPOs are divisions of the two largest investor owned hospital systems: HCA (Health Trust Purchasing Group) and Tenet (BuyPower) (Burns 2002). The three largest non profit GPOs are hospital cooperatives like Novation, which is a group purchasing arm for VHA/UHC (Burns 2002). The largest public GPO is the VA. Healthcare organizations which are a part of for-profit and the VA systems are more committed to their group purchasing contracts. Healthcare organizations within the non profit alliances join their GPOs voluntarily (Burns 2002).

GPOs also differ in the type of membership. Some GPOs are committed to the larger healthcare organizations where as some of them focus on smaller buyers like ambulatory centers and physicians offices. Many GPOs try to focus on two types of market in order to have a stronger presence (Burns 2002).

Many GPOs differ in their reach to cater to different markets. Some or rather smaller players focus on regional healthcare organizations. This helps them to consolidate their resources and sometimes perform better in logistical operations than National players. Large GPOs generally focus on a National level. They have better reach which is facilitated by their financial muscle and volumes of purchases. These GPOs sometimes

result in extermination of regional players which has been discussed earlier. Figure 4.3 briefly summarizes the classification of GPOs.

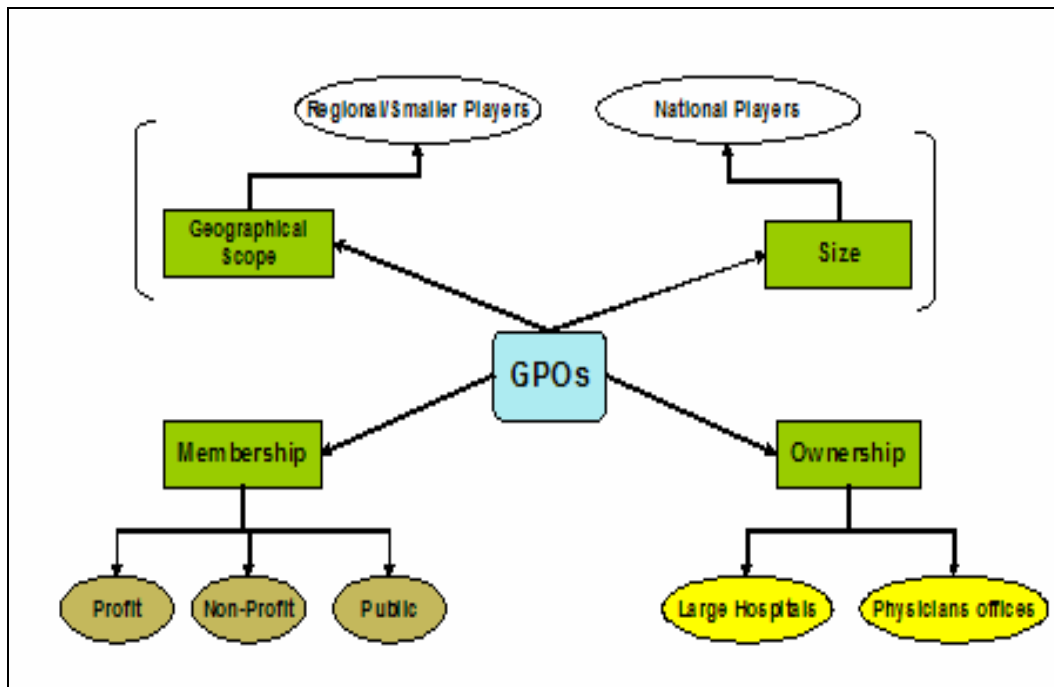


Figure 4.3 Classification of GPOs



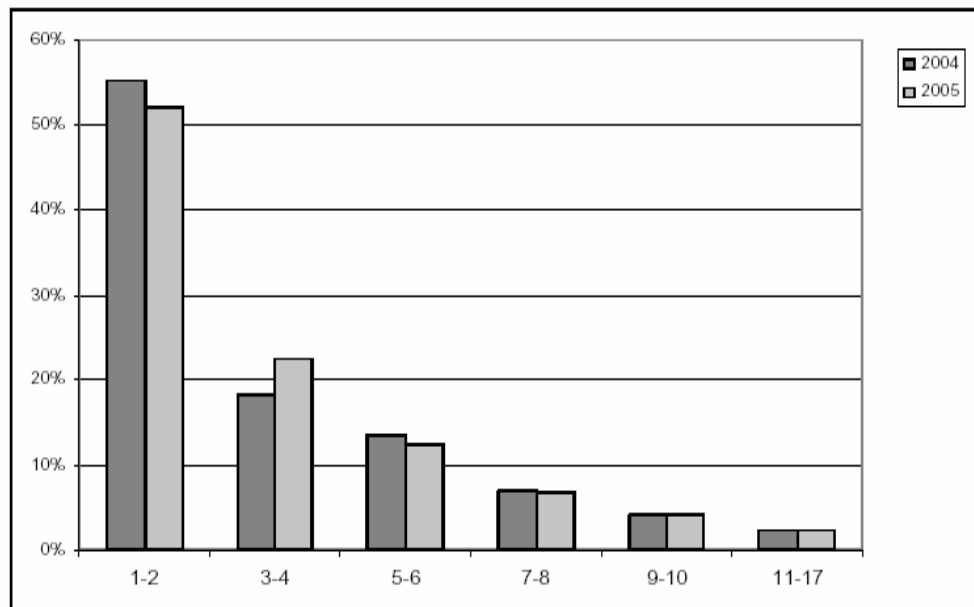
	Value of Contracts (\$ millions)			Member Hospitals (# of hospitals)		Alternate Sites		Total Members	
GPO*	2003	2004	2005 (Proj.)	2004	2005	2004	2005	2004	2005
Premier	\$24,157	\$25,264	\$27,031	1,433	1,478	30,731	33,952	32,164	35,430
Novation	\$20,700	\$23,700	\$24,700	1,545	1,671	12,925	15,090	14,470	16,761
Med Assets	\$7,000	\$10,000	\$15,000	2,200	2,400	18,000	21,028	20,200	23,428
Broadlane	\$5,000	\$6,100	\$7,400	856	935	13,169	20,935	14,025	21,870
Amerinet	\$6,000	\$6,150	\$6,350	1,856	1,890	18,703	22,227	20,559	24,117
Health Trust**	N/A	\$5,700	\$6,000	N/A	N/A	N/A	N/A	900	1,200
Consorta	\$2,980	\$3,700	\$4,200	338	363	1,171	1,550	1,509	1,913
GNVHA									
(Premier)	\$1,900	\$2,000	\$2,100	110	132	N/A	N/A	110	132
CHCA	\$149	\$191	\$195	35	35	3,600	N/A	3,635	35
<b>Total</b>	<b>\$67,886</b>	<b>\$82,805</b>	<b>\$92,976</b>	<b>8,373</b>	<b>8,904</b>	<b>98,299</b>	<b>114,782</b>	<b>107,572</b>	<b>124,886</b>
<b>Total (17 GPOs)</b>	<b>\$71,249</b> ***	<b>\$88,631</b>	<b>\$99,433</b>	<b>13,161</b>	<b>13,886</b>	<b>127,450</b>	<b>156,228</b>	<b>141,511</b>	<b>171,314</b>

\* Becker, C. (2005) "Of Two Minds," *Modern Healthcare*, Vol. 35, Issue 33, pp. S1-S5, 08/15/2005. .

\*\* Information for Health Trust: "Group Purchasing Organizations," BusIntell Reports, May 2005. 2005 data is retrieved from the company's website.

\*\*\* Data for year 2003 is available for 16 GPOs only.

Figure 4.4 Ranking of GPOs by Contract Purchases and Memberships



- |  |   |
|--|---|
| 1 Premier                                      | 9 GNYHA (Premier)                               |
| 2 Novation                                     | 10 Innovatix                                    |
| 3 MedAssets                                    | 11 AllHealth                                    |
| 4 Broadlane                                    | 12 Hospital Purchasing Service                  |
| 5 Amerinet                                     | 13 Yankee Alliance                              |
| 6 Health Trust                                 | 14 Resource Optimization & Innovation           |
| 7 Consorta                                     | 15 Child Health Corporation of America          |
| 8 HealthCare Purchasing Partners International | 16 National Capital Area Shared Services Shared |
|  | 17 Services Healthcare                          |

\* Companies-signatories of HGPII

Sources: Group Purchasing Organizations Report, Knowledge Source Inc. (May 2005); Cinda Becker, "Of Two Minds," Modern Health Care, August 15, 2005, pp. S1-S5.

Figure 4.5 Market-share of GPOs

## CHAPTER 5 - COST COMPARISON ANALYSIS

In this project, we would like to focus on two aspects of healthcare industry. The first aspect would be comparing the prices of the bulk items across three different procurement models. The second aspect would be to compare the degree of access to innovative items across different procurement model using a technique called data envelopment analysis (DEA). The second part of the research is explained in chapter 6.

### 5.1 Cost Comparison Methodology

Firstly, we would like to capture the total cost of procuring items through three different procurement models. This involves comparison of procurement models of commodities through a Self sourcing unit, a National GPO and a Hybrid model. A Self sourcing healthcare organization procures items through individual contracts with vendors and manufacturers. A healthcare organization affiliated to a National GPO procures most of its items through the GPO and is bounded by GPO contracts. These organizations also have to take into account the mandatory compliance rate sometimes being enforced by some GPOs. It is important to note here that during the course of interaction with the staff of healthcare organizations under consideration in this study, the compliance rate was found to vary among GPOs ranging from 60 percent to 90 percent. The Hybrid model in the study features healthcare organizations which are affiliated to a National GPO as well as to a regional GPO. In this model, the healthcare organization

procures items from a National GPO as well as a regional GPO and has the flexibility to choose products from either of them depending on the lower prices. This chapter will include a comparison of the costs associated with these procurement models. In order to achieve this, a clear understanding of the series of processes and operations undertaken in each of these procurement models is required. This involved mapping out the entire process/operation in the form of a flow diagram (Process Map) with each operation described briefly and the resources associated with it for each of the procurement model (Please refer appendix A, B and C).

#### 5.1.1 Building the Cost Model

The cost model was designed to capture an estimated overall price/cost of the items which includes the overhead. Please refer figure 5.1 on page 29 which displays the screenshot of the MS Excel based model.

Primary Overhead includes the human resource cost only which means the salary of individuals involved in the purchasing operation or part of their function relates to purchasing. Secondary overhead comprises of the administrative fees paid by the healthcare organization to the GPO (applicable only for GPO members) and the rebates gained by the hospital from the GPO due to various reasons like compliance/loyalty etc.

Primary Overhead has been classified into seven types:

1. Legal staff - negotiates the contracts with the supplier.
2. Follow up staff - checks the price and the quality of the suppliers (gets the price quotes) and chooses the suppliers.

3. Administration staff - works on the purchase orders and sends the orders to the suppliers.
4. Inventory staff - maintains the inventory and works on them and notifies when there is some short fall of some items.
5. Finance staff - processes the funding associated with funding and releases the money.
6. Stocking staff - manages the stocking of the products in the warehouse after they are obtained from the suppliers.
7. Transportation Staff - manages the transportation of products/items within the campus.

This is a general classification and only those teams/buckets which are applicable to a particular hospital or healthcare organization are taken into consideration. For example: There may be legal staff involved in the procurement of items for hospital A whereas it might be absent for hospital B. In calculating the overhead, the average annual salaries of the individuals or the titles they represent are taken. Once the final annual overhead is calculated (sum of the annual average salaries of all the individuals involved), it is then calculated per day by taking the number of work days in a year as 260.

Also, it should be noted here that the proportionate salary of the average annual salary should be taken into comparison. If a staff has a fraction of the responsibility involved in procuring operations, then that fraction should be multiplied with the annual average salary and then that amount should be filled in as the annual average salary. For

example, if staff A earns \$50,000 per year and 50% of his job responsibilities fall in the procurement operations, then  $.50 * 50,000 = 25,000$  will be his annual average salary.

Secondary Overhead has been classified into:

1. Administrative fees - The fee paid by the GPO members to the GPO on an annual basis. This fee is only applicable to the healthcare organization associated with the GPO. This amount calculated on a yearly basis is added to the Total Overhead in a year.
2. Rebates - The money paid to the GPO members by the GPO for a variety of reasons. This could be loyalty of the member to the GPO or for maintaining good compliance rates or sometimes to clinch deals with the members in a very competitive market. This amount taken annually is subtracted from the Total Overhead calculated annually.

Spending per category is defined as the total amount spent on each category like drugs, office supplies, medical devices, etc. We have coined a term “ICV” which is the “Total average cash value of the items in the inventory per day (ICV)”. The ICV of the four categories in consideration are finally added to get the total amount spent or total ICV per day.

The cost model is then built on the “average daily inventory” of the items (for example: 1, 3, 6, 10, 200, etc.) which are procured and their “standard price” in the next column in the spreadsheet. The product of these two will give the “Total \$\$ amount/day” of products in the column next to the standard price in the spreadsheet.

“Spending % Value” is the percentage of “Total \$\$ amount/day” spent on each item to the total amount spent or “total ICV per day”.

“% Overhead” is the product of the “Spending % Value” with “total overhead/day” to get the % of overhead added in every product's cost.

The sum of “% Overhead” and the “Total \$\$ amount/day” will give an estimated “Overall Cost” of each item. This “Overall Cost” is then divided by the “average daily inventory” to finally calculate the estimated “Unit Overall Cost” for each of the items. The estimated “Unit Overall Cost” for each item will be taken for comparative study. It is this cost which will be used for the comparison of each item across the different healthcare organizations.

Maintaining the confidentiality of data has been given the utmost importance in this thesis. This cost model based on the MS Excel was created to get an estimated pricing of the products/items, since information regarding actual pricing of the products could not be accessed by us. The Excel sheet has been designed in a way that the items which are commonly procured are divided into two categories (Please refer figure 5.1 on page 29). They are medical devices and surgical supplies. The excel model would be populated with 50 to 100 items for each of the above mentioned categories for the procurement models (with the help of information accessed from each of these three healthcare centers respectively) being in operation in the healthcare organizations considered in the study. The items in each of those two categories must be common to all the three healthcare centers having different procurement models.

To maintain the confidentiality, the data concerning overhead, spending per category, standard price and daily inventory are entered by the staff from the hospital. After the data was filled in these shaded cells (refer to the screenshot), the spreadsheet would automatically calculate the overhead, overhead% and finally the “unit overall

cost”. Also, to maintain error proofing, the cells other than those shaded ones (where the data is entered by the hospital staff) were formulated and locked. This is the column we were interested in and this column “unit overall cost” and the “products/items” column were then copied and pasted in a different excel sheet and sent to us. We had no access to the actual pricing information and actual salary figures which are confidential.

A	B	C	D	E	F	G	H	I	J	K	L	M	N
Drugs													
Overhead							Appendix						
Annual Average Salaries													
Staff Team	No. of Per	Per 1	Per 2	Per 3	Per 4	Total Avg	Salaries						
		in US(\$)	in US(\$)	in US(\$)	in US(\$)								
Legal						0							
Follow Up						0							
Admin						0							
Inventory						0							
Finance						0							
Stocking						0							
Transportation						0							
			Total Overhead for a year			0	in US(\$)						
Total number of working days			260 per year										
Overhead per day			0										



this research, we were assisted by the staff from the materials management department of all the three healthcare organizations. Also, there was no data available for the procurement of office supply equipment. Among the inventory of bulk items which were procured by the three healthcare organizations, we could get 222 items which were common across all the three healthcare organizations. This number could be further broken down into 156 medical device items and 66 surgical devices items. Utmost effort was made to match the products having similar generic names and features. The data obtained from the three healthcare organizations were non-parametric in nature which is shown in the figure 5.2 below.

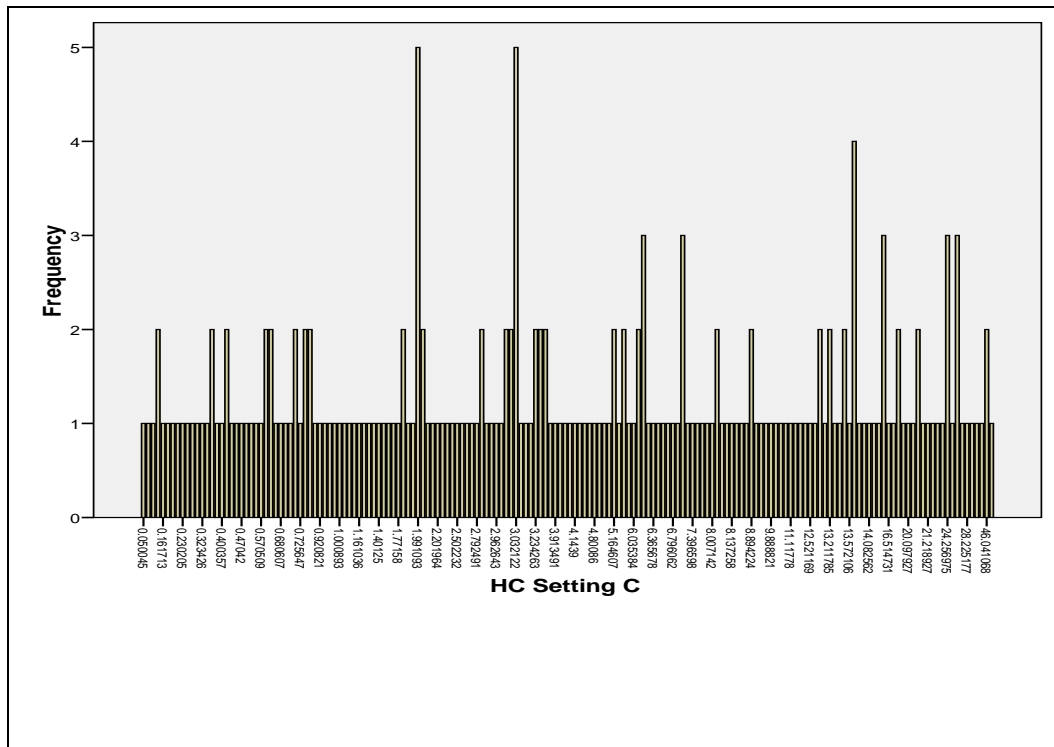


Figure 5.2 Distribution of Data Obtained from Healthcare Organization C

Since prices obtained from the three healthcare organizations do not follow a normal distribution, we considered implementing Wilcoxon signed-rank test.

Wilcoxon signed-rank test is a non parametric alternative to the paired Student's t-test for comparison of two related samples of data. In this study, we are comparing the prices of same bulk items (paired) across two healthcare organizations at a time, i.e., first we will be comparing the prices of bulk items between healthcare organization A and healthcare organization B, followed by comparison between healthcare organizations A and C, and between B and C. Wilcoxon test is used to compare differences between measurements at interval levels. This enables to compare differences between arbitrary pairs of data.

1. Wilcoxon test assumes that the difference between two samples of data,

i.e.  $d_i = A_i - B_i$  for  $i = 1$  to  $\dots n$ . are simulated to be independent.

Where A and B are two related samples of data and d is the difference between these two samples at each measurement.

2. Each difference  $d_i$  is drawn from a continuous population.

Testing the null hypothesis (for a paired t-test):

$$H_0: \mu_d = 0$$

$$H_1: \mu_d \neq 0$$

Where  $\mu_d$  is the mean difference between the measurements. In a paired t-test, the null hypothesis  $H_0: \mu_d = 0$  will be rejected if the mean difference between the sample measurements is not equal to zero. However, the null hypothesis in Wilcoxon test is that the median difference between pairs of observations is zero. By testing and rejecting the null hypothesis, it can be shown that the data samples do not have the same median and are drawn from different populations. This is done by ranking the absolute value of the differences between observations from the smallest to the largest, with the smallest

difference getting a rank of 1, followed by the next larger difference getting the 2<sup>nd</sup> rank, etc. Ties are given average ranks. The ranks of all differences in the (positive) direction are summed, and the ranks of all differences in the negative direction are summed. In this study, only after the null hypothesis in the Wilcoxon test has been rejected, the cost efficiency of one procurement model can be compared with the other by measuring the mean difference of prices and the mean percentage differences of prices (difference between the prices of commodities and expressed as a percentage of the price of the commodity from which it is subtracted). If the null hypothesis is not rejected, then the mean difference of the prices and the mean percentage difference between the samples will be zero and the cost efficiency of one procurement model versus the other cannot be determined.

For example: If we compare procurement models of healthcare (now onwards we would call healthcare as HC) organization A versus HC organization B, then the mean difference of prices of all the bulk items is calculated, i.e., we are subtracting the prices of the bulk items of HC organization B from HC organization A. If the mean difference is a positive value, then we can conclude that HC organization B is more cost efficient than HC organization A or vice versa. This will enable us to rank the different procurement models in terms of cost efficiency. In this study, comparison model will comprise of HC organization A versus HC organization B, HC organization A versus HC organization C and HC organization B versus HC organization C, with the latter models' procurement prices subtracted from the former ones.

Similarly, the percentage difference between the prices of all the commodities are calculated, and if the mean percentage difference of all the commodities in comparison is

zero, then the two procurement models cannot be compared. If it's not zero but a positive or a negative value then there exists a difference and it can be determined which procurement model is more cost efficient. When HC organization A and B are compared the percentage difference is calculated by

$$\% \text{ difference} = ((\text{Cost A} - \text{Cost B})/\text{Cost A}) * 100.$$

The mean percentage difference is given by  $(\sum_i^n \% \text{ difference})/n$  (where  $n = 222$ ).

The null hypothesis is tested by the relations below.

(Adapted from <http://www.nist.gov/speech/tests/sigtests/wilcoxon.htm>):

The mean is given by

$$\mu = \frac{n(n+1)}{4} \quad \text{Eq. 5.1}$$

The variance is given by  $\sigma^2 = \frac{n(n+1)(2n+1)}{24}$  Eq. 5.2

Sum of the positive and negative ranks  $Z_+ + Z_- = \frac{n(n+1)}{2}$  Eq. 5.3

Where  $Z_+$  and  $Z_-$  are sum of positive and negative ranks respectively.

The test statistic  $W$  is

$$W = \frac{Z_+ - \mu}{\sigma} \quad \text{Eq. 5.4}$$

The null hypothesis in the Wilcoxon test will be rejected if

$$P(W) \leq \alpha \text{ value} \quad \text{Eq. 5.5}$$

Where  $\alpha = P(\text{type I error}) = P(\text{reject } H_0 | H_0 \text{ is true})$ , is the significance level.

The assumption here is that  $\alpha$ , the significance level of the test is simulated to be 0.05. Therefore the percent confidence interval of the test is  $100(1 - \alpha) = 95$ .

As discussed earlier, only if the null hypothesis is rejected, we can compare the cost efficiency between the procurements models and rank them accordingly from the most to the least.

The procurement model with the lowest price in the comparison study will emerge as the most economical leader in procurement operations and also help to determine whether GPOs are the most economical ways of procuring items.

## 5.2 Results of Cost Comparison

As mentioned in the previous section, the cost comparison study was performed by matching almost exact bulk items across three different procurement models, i.e., Self sourcing, GPO model and Hybrid model. All in all, 222 bulk items were found common across these three procurement models which can be further classified as 156 medical devices and 66 surgical devices.

### 5.2.1. Procurement Model A versus Procurement Model B

In this cost comparison model we compared the procurement model of HC organization A versus HC organization B, i.e. the comparison of “Self source” model with that of “National GPO” model. The prices of each of the bulk items (totaling 222 items) of the HC organization B are subtracted from those of HC organization A to get the differences at each sample point. Using the assumptions and equations mentioned in section 5.1.2, we get

$$n = 222.$$

The mean is given by Eq 5.1

$$\mu = \frac{n(n+1)}{4} = 12,376.5$$

The variance is given by Eq. 6.2

$$\sigma^2 = \frac{n(n+1)(2n+1)}{24} = 917,923.75$$

After running Wilcoxon test in the MS excel solver for the sum of ranks, the results are displayed in table 5.1

Table 5.1 Wilcoxon Results of Comparison of HC A and HC B

Differences	N	Rank-Sum
Negative	59	6991
Positive	163	17762
Zero	0	
		<b>P</b>
		1.89725E-08

From table 5.1 it can be said the number of positive ranks are higher than negative ranks. Thus, sum of positive ranks and negative ranks  $Z_+ + Z_- = \frac{n(n+1)}{2} = 24,753$ . The

$Z_+$  and  $Z_-$  values are 17762 and 6991 respectively. Thus test statistic given by Eq. 6.4

$$W = \frac{Z_+ - \mu}{\sigma} = 5.621.$$

Now,  $P(5.621)$ , i.e. the significance of the difference from the table 7.1 as given by the solver is 1.89725E-08. Thus using Eq. 5.5, the null hypothesis in the Wilcoxon test will be rejected as:  $P(W) \leq \alpha \text{ value} = 1.89725E-08 < 0.05$ .

Since the null hypothesis is rejected, two procurement models can be compared against each other based on their cost efficiency. The mean difference when the prices of commodities of HC organization B (GPO model) are subtracted from those of HC organization A is \$2.77, which is a positive value. The mean percentage difference of the prices of the commodities is 6.17 percent, again a positive value. Thus, we can say that

the average prices of commodities procured by the Self source model are more than the GPO model as shown by a positive value of mean difference and mean percentage difference. Thus, in this comparison model the GPO procurement model of HC organization B is more cost efficient than that of Self sourcing model of HC organization A.

#### 5.2.2. Procurement Model A versus Procurement Model C

In this cost comparison model we compared the procurement model of HC organization A versus HC organization C, i.e. the comparison of “Self source” model with that of “Hybrid” model which encompasses procurement through a National GPO as well as a regional GPO. The prices of each of the bulk items (totaling 222 items) of the HC organization C are subtracted from those of HC organization A to get the differences at each sample point. Using the assumptions and equations mentioned in section 5.1.2, and the values of mean, variance and  $n = 222$ , the sum of positive ranks is displayed in table 5.2.

Table 5.2 Wilcoxon Results of Comparison of HC A and HC C

Differences	N	Rank-Sum
Negative	51	4967
Positive	171	19786
Zero	0	
		<b>P</b>
		1.04361E-14

From the table 5.2 it can be said the number of positive ranks are higher than the negative ranks. Thus, sum of positive ranks and negative ranks  $Z_+ + Z_- = \frac{n(n+1)}{2} =$

24,753. The  $Z_+$  and  $Z_-$  values are 17762 and 6991 respectively. Thus, test statistic given

$$\text{by Eq. 5.4 } W = \frac{Z_+ - \mu}{\sigma} = 7.73$$

Now,  $P(7.73)$ , i.e. the significance of the difference from the table 5.2 as given by the solver is  $1.04361\text{E-}14$ . Thus, using Eq. 5.5, the null hypothesis in the Wilcoxon test will be rejected as:  $P(W) \leq \alpha \text{ value} = 1.04361\text{E-}14 < 0.05$ .

Since the null hypothesis is rejected, the cost efficiency of one model versus the other can be determined. The mean difference when the prices of commodities of HC organization C (Hybrid model) are subtracted from those of HC organization A is \$3.96, which is a positive value and the mean percentage difference is 14.87 %, again a positive value. Thus, we can say that the average prices of commodities procured by the Self source model are more than the Hybrid model as shown by these positive values. Thus, in this comparison model the Hybrid procurement model of HC organization C is more cost efficient than that of Self sourcing model of HC organization A. One interesting observation can be made here, the mean difference of prices between HC organization A and HC organization C (when subtracted) is more than the mean difference of prices between HC organization A and HC organization B. Thus, we can say that HC organization C is not only more cost efficient than HC organization A but also HC organization B. This can be illustrated further in the following section which shows the comparison between HC organization B and HC organization C.



### 5.2.3. Procurement Model B versus Procurement Model C

In this cost comparison model we compared the procurement model of HC organization B versus HC organization C, i.e. the comparison of “National GPO” model with that of “Hybrid” model. The prices of each of the bulk items (totaling 222 items) of the HC organization C are subtracted from those of HC organization B to get the differences at each sample point. Again repeating the steps mentioned in the preceding sections using the assumptions and equations mentioned in section 5.1.2, and the values of mean, variance and  $n = 222$ , the sum of positive ranks is displayed in table 5.3.

Table 5.3 Wilcoxon Results of Comparison of HC B and HC C

Differences	N	Rank-Sum
Negative	97	10243
Positive	125	14510
Zero	0	
		<b>P</b>
		0.025957856

From the table 5.3 it can be said the number of positive ranks are higher than negative ranks. Thus, sum of positive ranks and negative ranks  $Z_+ + Z_- = \frac{n(n+1)}{2} = 24,753$ . The  $Z_+$  and  $Z_-$  values are 17762 and 6991 respectively. Thus test statistic given by Eq. 5.4  $W = \frac{Z_+ - \mu}{\sigma} = 2.226$ . Now,  $P(7.73)$ , i.e. the significance of the difference from the table 5.3 as given by the solver is 0.025957856. Thus using Eq. 5.5, the null hypothesis in the Wilcoxon test will be rejected as:  $P(W) \leq \alpha$  value = 0.025957856 < 0.05.

Again while comparing the cost efficiency of the GPO model versus the Hybrid model, the mean difference when the prices of commodities of HC organization C

(Hybrid model) are subtracted from those of HC organization B (GPO model) is \$1.18, and the mean percentage difference is 11.61 percent. Thus, we can say that the average prices of commodities procured by the GPO model are more than the Hybrid model. Thus in this comparison model the Hybrid procurement model of HC organization C is more cost efficient than that of GPO model of HC organization B. However, it should be noted that mean difference of prices between these two models is the least, which goes on to show that these two models are quite close in terms of cost efficiency with Hybrid model being the most.

#### 5.2.4. Summarization of Results of Cost Comparison Study

The results obtained by the comparison study shows the comparative cost efficiency of each of the three procurement models in consideration. From the results obtained above, it can be concluded that GPOs overall deliver products to healthcare organizations at a much reduced price, or in other words they are more cost efficient compared to Self sourcing models. This can be attributed to the volume of bulk products the GPOs carry in their inventory and their negotiating skills with the manufacturers. However in this study, two healthcare organizations B and C are affiliated to GPOs with C being further associated with a regional GPO. HC organization C fared the best with being the most cost efficient among the three models due to their flexibility of procurement contracts with a National GPO as well as a regional GPO. During the course of interaction, staff from HC organization C acknowledged that affiliation to both National GPO and regional GPO is important to drive prices low. Moreover, this gives the model more leverage to procure items through two different sources depending on lower prices. Apart from the benefit of choosing the lowest priced products being offered

by the competing National and regional GPO, another factor which might be responsible for the Hybrid model to achieve the highest cost efficiency would probably be larger volume of items. High compliance rate with the National as well as regional GPO contracts may be another reason why the prices of the items in the Hybrid model are low as compared to others. During the course of interaction with the staff from HC organization C, it was brought to our knowledge that the compliance rate is very high and that helps them to drive costs low. The compliance rate varies from one healthcare organization to another and has a significant effect on the pricing of the items being procured. By staying within the contract with the GPOs, the healthcare organizations are making use of the power enjoyed by the GPOs with manufacturers in reducing costs. As suggested in the past literature, GPOs have the capacity to supply the varied items at large volumes as compared to small scale manufacturers. This might be the same reason why HC organization A is the least cost efficient as all the items are Self sourced from individual manufacturers locally. By increasing the volume of items, the cost per item reduces, and this can be exploited by many healthcare organizations which have high volumes of procurement to get affiliated to a GPO and contract for a variety of items.

Thus, in this study we can rank the Hybrid model of HC organization C as the most cost efficient, followed by GPO model of HC organization B and the least being Self source model of HC A. The table 5.4 in the following page would summarize the results.

Table 5.4 Cost Efficiency of Procurement Models

Healthcare Organization	Procurement Model	Ranking based on Cost Efficiency (Most to Least)
C	Hybrid	1
B	GPO	2
A	Self	3

### 5.3 Analysis of Cost Comparison

The analysis of the results for each of the three comparison studies of procurement models has been classified into further three sections, i.e, overall comparison, medical devices comparison and surgical devices comparison.

#### 5.3.1. Overall Comparison

Overall comparison involves the comparison of the total price difference and the mean price difference of all the bulk items (totaling 222 in number) between HC organizations A and B, A and C and B and C.

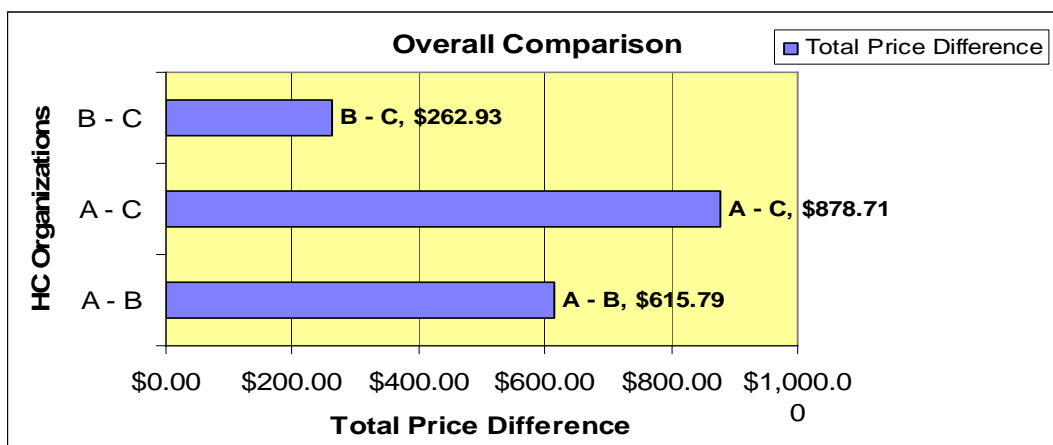


Figure 5.3 (a) Overall Comparison Based on Total Price Difference

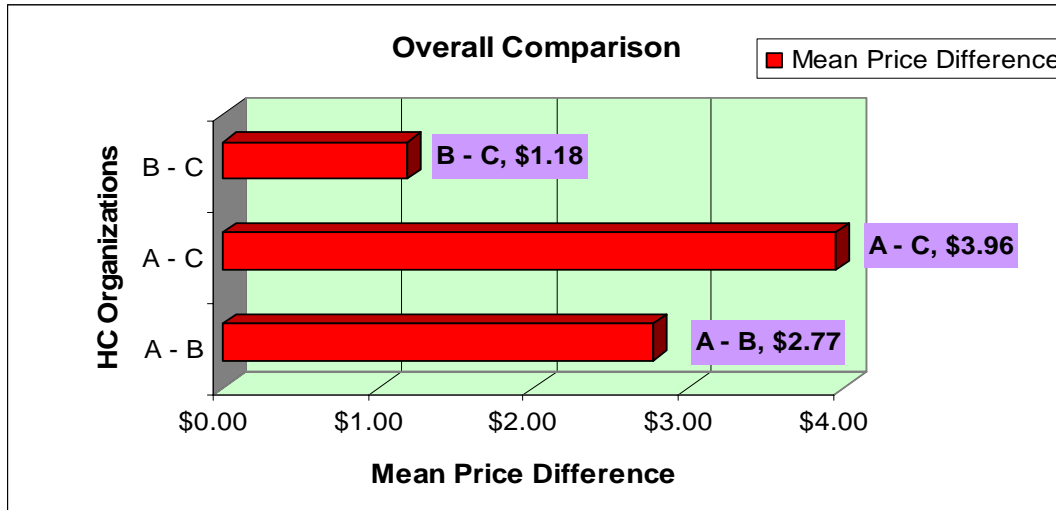


Figure 5.3 (b) Overall Comparison Based on Mean Price Difference

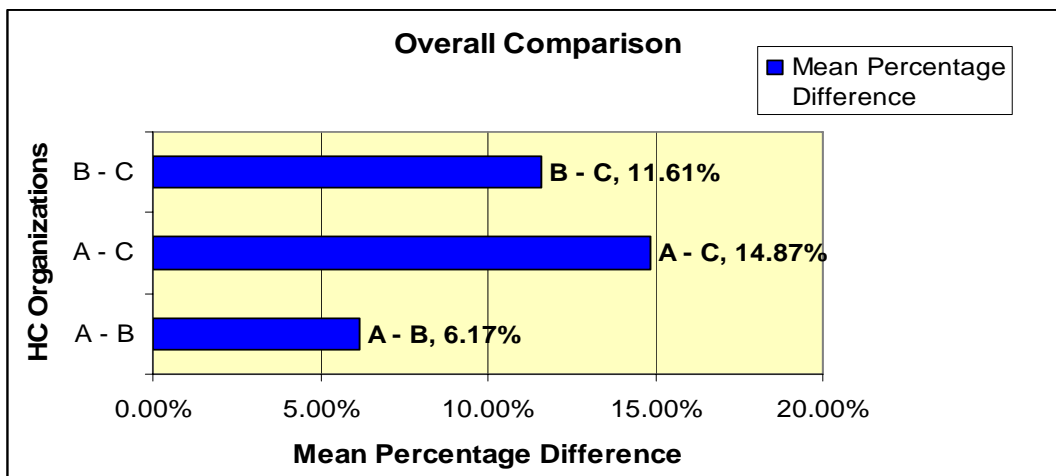


Figure 5.3 (c) Overall Comparison Based on Mean Percentage Difference

From the figures 5.3(a) and 5.3(b), it can be concluded that the Hybrid model of HC organization C is the most cost efficient, followed by the GPO model of HC organization B and the Self sourcing model of HC A being the least efficient. This is because the difference of both the total price as well as the mean price is maximum with a positive value of \$878.71 and \$3.96 respectively when the HC organization C is compared with HC organization A (with prices of HC organization C subtracted from HC

organization A) with respect to other comparison between HC organization B and HC organization A. From figure 5.3 (c), the mean percentage difference between HC organization A and HC organization C (14.87 percent) is also higher than HC organization A and HC organization B (6.17 percent). This again proves that the Hybrid model is the most cost efficient as the percentage difference is the largest when compared with HC organization A as compared to when HC organization B with HC organization A. However, the difference in the total price as well as the mean price of items between HC organization B and HC organization C (with prices of HC organization C subtracted from HC organization B) are smaller positive numbers of \$262.93 and \$1.18 (HC organization C being more cost efficient) with respect to the other two comparisons. This can be due to the fact that both the healthcare organizations are affiliated to a GPO which helps to bring down the cost of procurement. The Hybrid model of HC organization C has more leverage to choose between commodities based on lower prices as it is affiliated to a National GPO as well as a regional GPO. As mentioned earlier and acknowledged during the course of this study by the staff of HC organization C, in a Hybrid model the healthcare organization has more freedom to negotiate the prices of items with the National GPO and many times they procure items from the regional GPO at costs lower than those offered by a National GPO. In fact, as acknowledged by the HC organization C staff, that by negotiating contracts with regional GPOs, the healthcare organization can get rebates on a yearly or quarterly basis which can result in huge savings in the long run. This may not be possible for National GPOs, as they are bounded by much standardized pricing across the country and may have many healthcare organizations affiliated to them. Based on the past literature and recognized by the staff of HC organization C, the

regional GPOs have the added advantages of better knowledge of regional market dynamics and may provide better logistics and warehousing facilities to the regional healthcare organizations as compared to the National GPOs. At the same time, the regional GPOs have fairly large inventory and sufficient number of healthcare organizations in that particular region to keep costs low. Thus, a healthcare organization following a Hybrid model of procurement involving a National GPO and a regional GPO gets the best of both worlds and has more flexibility in choice of products as compared to a healthcare organization following only the GPO model.

### 5.3.2. Medical Devices Comparison

This gives more in depth analysis of the cost comparison of procured medical devices by comparing the total price difference and the mean price difference of only the medical devices (totaling 156 in number) between HC organizations A and B, A and C and B and C.

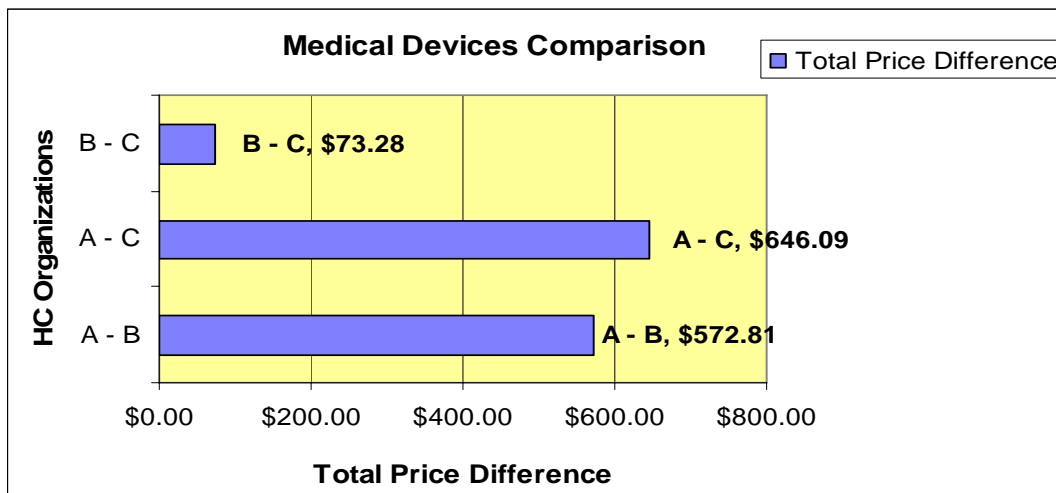


Figure 5.4 (a) Medical Device Comparison Based on Total Price Difference

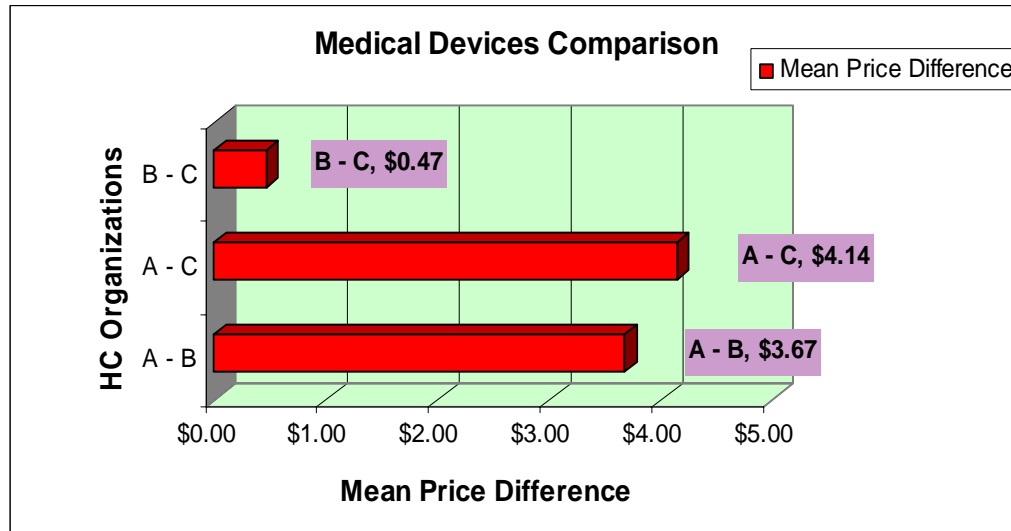


Figure 5.4 (b) Medical Device Comparison Based on Mean Price Difference

From figures 5.4(a) and 5.4(b), it can be again concluded that Hybrid model is the most cost efficient followed by GPO model and the least being Self sourcing model concerning the procurement of medical devices. However, it should be noted here that the differences in total price as well as the mean price of medical devices when healthcare organization B and C (prices of medical devices of HC organization C being subtracted from those of HC organization B) are compared are very small positive values. This suggests that though Hybrid model followed by HC organization C is more efficient than the GPO model followed by HC organization B, but it's by a very narrow margin. With the difference in total price and mean price being small, positive numbers of \$73.28 and \$0.47, respectively, it can be concluded that the cost efficiency of GPO model of HC organization B comes very close to that of Hybrid model of HC organization C (almost as cost efficient as C) when the procurement of medical device items is concerned.



### 5.3.3. Surgical Devices Comparison

This section involves the comparison of the total price difference and the mean price difference of only the procured surgical device items (totaling 66 in number) between HC organizations A and B, A and C and B and C.

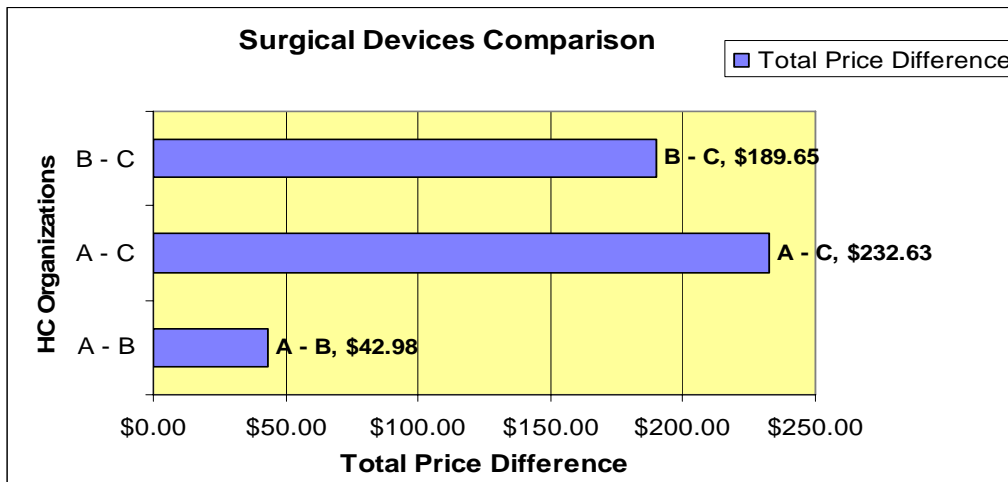


Figure 5.5(a) Surgical Device Comparison Based on Total Price Difference

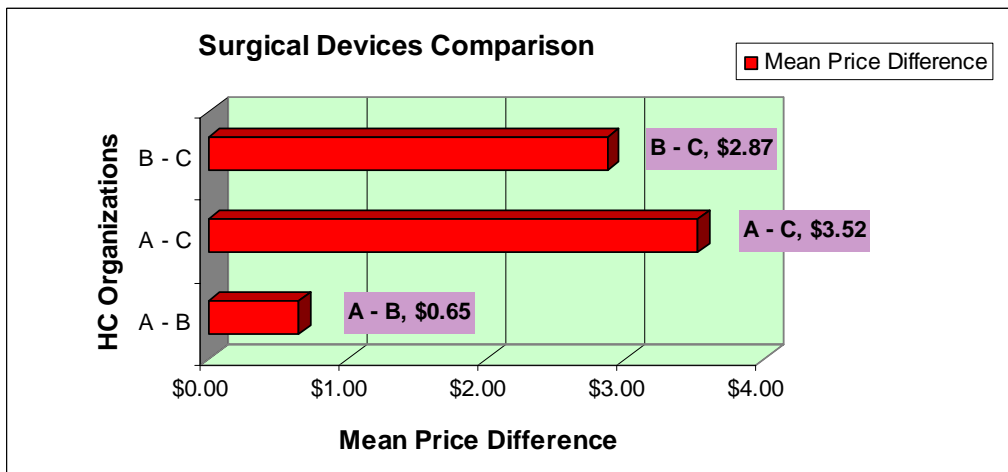


Figure 5.5 (b) Surgical Device Comparison Based on Mean Price Difference

From figures 5.5(a) and 5.5(b), the analysis of the comparative cost efficiency of the procurement models leads to the same inference of Hybrid model being the most cost efficient, followed by the Hybrid model and the Self sourcing one being the least when

surgical devices are concerned. It is important to note that the GPO model fairs poorly in terms of cost efficiency compared to the Hybrid model. It's just the reversal of GPO models performance in the medical devices comparison. In fact, the GPO affiliated HC organization B is slightly better than the Self sourcing model of HC organization A as displayed by the small positive values of differences of total price and mean price when HC organizations A and B are compared. Here, the Hybrid model of HC organization C outperforms the GPO model of HC organization B by a big margin in terms of cost efficiency. The differences in the total price and the mean price of the surgical devices procured by the HC organization B and HC organization C are quite large positive values of \$189.65 and \$2.87 respectively which suggests that the GPO model is trailing behind the Hybrid model in terms of cost efficiency significantly.

## CHAPTER 6 - MEASUREMENT & COMPARISON OF INNOVATION (DEA)

### 6.1 Methodology of Innovation Measurement & Cost Comparison

This is the second aspect of our research. Here we will be identifying certain innovation metrics in measuring the degree of access to innovative products procured through off- contract as well as on-contract negotiations in different procurement models. Innovative products in this study can be classified as those products which have a fairly higher degree of sophistication and advanced technologies as compared to bulk items. Common items which falls under this category are temporary pacemakers, splines, ventilators, beds, etc, which might be procured in very few quantities or in low numbers for specialized medical cases. This aspect of the project would enable us to compare the different procurement models based on the off-contract and on-contract price of innovative products and degree of access to innovative technologies. This is independent of the cost comparison study and would involve more than three healthcare organizations. During the course of the study it was found that there exists lot of variation in the models employed by the healthcare organizations in procurement of innovative items. Many healthcare organizations procure innovative items strictly on an on-contract basis either through a GPO or a regional GPO whereas some healthcare organizations purchase these items through off-contract means and some procure similar type of items through both on-contract as well as off-contract means. This would throw light on the concern as mentioned in the past literature (Zweig 1998) that sometimes National GPOs (mostly on-

contract purchases) are a hindrance to the entry of niche manufacturers of innovative products (mostly off-contract purchases) and as a result the healthcare organizations affiliated to only GPOs may sometime lose out on the more advanced technologies available in the market. The items which are procured through GPOs are termed as “on contract” purchased items and the ones which are procured from local manufacturers or vendor which are not affiliated to any GPO are called “off-contract” items.

In this study three types of models of procurement of innovative items are studied:

1. Healthcare organizations which procure innovative items only through on-contract purchases, i.e. through contracts with GPOs.
2. Healthcare organizations which procure innovative items only through off-contract purchases, i.e. through contracts with individual manufacturers and vendors not affiliated to any National or regional GPO.
3. Healthcare organizations which procure innovative items through on-contract purchases as well as off-contract purchases, i.e., again different models of a particular generic item like pacemaker, purchased through both the sources (dual sourcing).

#### 6.1.1 Identifying Innovation Metric

Based on the literature research, we have identified certain innovation metrics which will help us in measuring access to innovative technologies.

The innovation metrics we have identified for data collection can be classified into two types:

Product Innovative Metrics (metrics specific to the product):

1. Product features and specifications of the product.

2. Life cycle of the product.
3. Warranty details of the product.
4. Support from the manufacturer of the product in terms of training and technical expertise.
5. Ease of operation of the product.
6. Reliability and quality of the product.

Corporate Innovative Metrics (adapted from (Muller 2005)):

These are the metrics applicable at the corporate level for the manufacturers of innovative products which are listed below:

1. Measure R&D budget as a % of annual sales of a particular product manufacturer.
2. No. of patents/new ideas filed by the manufacturing company of that particular item in the last year/last month.
3. Measure % of capital that is invested in radical projects by the company manufacturing the innovative product.
4. Ratio of revenue from innovative/new products to commodities.
5. Measure % of employees that are involved in developing an innovative product.
6. Measure innovation revenue per employee from the new product/service developed.
7. % of management that is accountable to development of a new product in terms of time (man hour).
8. No. of incentive schemes to support innovation.

The most substantial metrics will be considered which is totally dependent on accessibility and feasibility of data from the different sources, i.e., the data obtained from

the healthcare organizations as well as the product manufacturers. Data concerning innovation metrics will be accessed from these sources and analyzed using the Delphi Method.

#### 6.1.2 Analyzing Innovation Metric Using Delphi Method

The data available for the innovative products from different sources will be utilized to measure the degree of access to innovative technologies of the healthcare organizations which procures that particular item. To measure the degree of access of innovation, the Delphi method will be used which will enable us to get an “innovation score” which is discussed in the latter part of this study.

Delphi method is extremely useful in cases where there is lack of scientific knowledge. Delphi method becomes handy in forecasting and making judgments. This involves expert opinion, intuition and experience. Most of the Delphi applications are used for generating information for decision making

Delphi method involves a panel of experts from the related disciplines who are given questionnaires concerning the particular subject. The experts chosen are knowledgeable individuals who can draw from their extensive experience to assist in forecasting results. In this study, the panel of experts will involve physicians who use the products on a daily basis and material management staff who procure these items when they are on-contract. During the initial contact, the nominated persons are told about the Delphi and invited to participate. They are assured of anonymity in the sense that none of their statements will be attributed to them by name (Gordon 1994). Each expert is provided with a feedback on the preceding round of replies before the beginning of the next round of questionnaire. In the first round the participants are asked to provide their

views on the subject in discussion. Then an analysis of the first round will throw light on the range of opinions. In the second round, the range would be presented to the group, and experts holding opinions at the extremes of the range would be asked to reassess their opinions in view of the group's range and provide reasons for their positions (adapted from Theodore (Gordon 1994)). These reasons would be synthesized by the researchers at the end of round two; the synthesized reasons would form the basis for the third questionnaire (Gordon 1994). In the third round, the questionnaire comprises of the new opinions of the panel members. The opinions along with the reasons are then presented to the participants. Each member of the group would be asked to reassess his or her position in view of the reasons presented. They might also be asked to refute, if appropriate, the extreme reasons with facts at their disposal (Gordon 1994).

In a fourth and final round, these arguments would be presented, along with the evolving group consensus, and a reassessment requested (Gordon 1994). In a sense, Delphi method is a controlled debate. The reasons for extreme opinions are made explicit, fed back coolly and without anger or rancor (Gordon 1994).

The idea is that the consensus will lead to the best response. Statistically, the midpoint of responses is identified by the median score. With every round, the range of responses by experts is supposed to reduce which will help the median move closer to the best response. A flowchart of the Delphi method processes is shown in figure 6.1 on the next page.

Some of the advantages of the Delphi method include that the panelists need not be physically present at the same location to give their responses and the process does not require agreement by all the members as consensus is sought to arrive at the median.

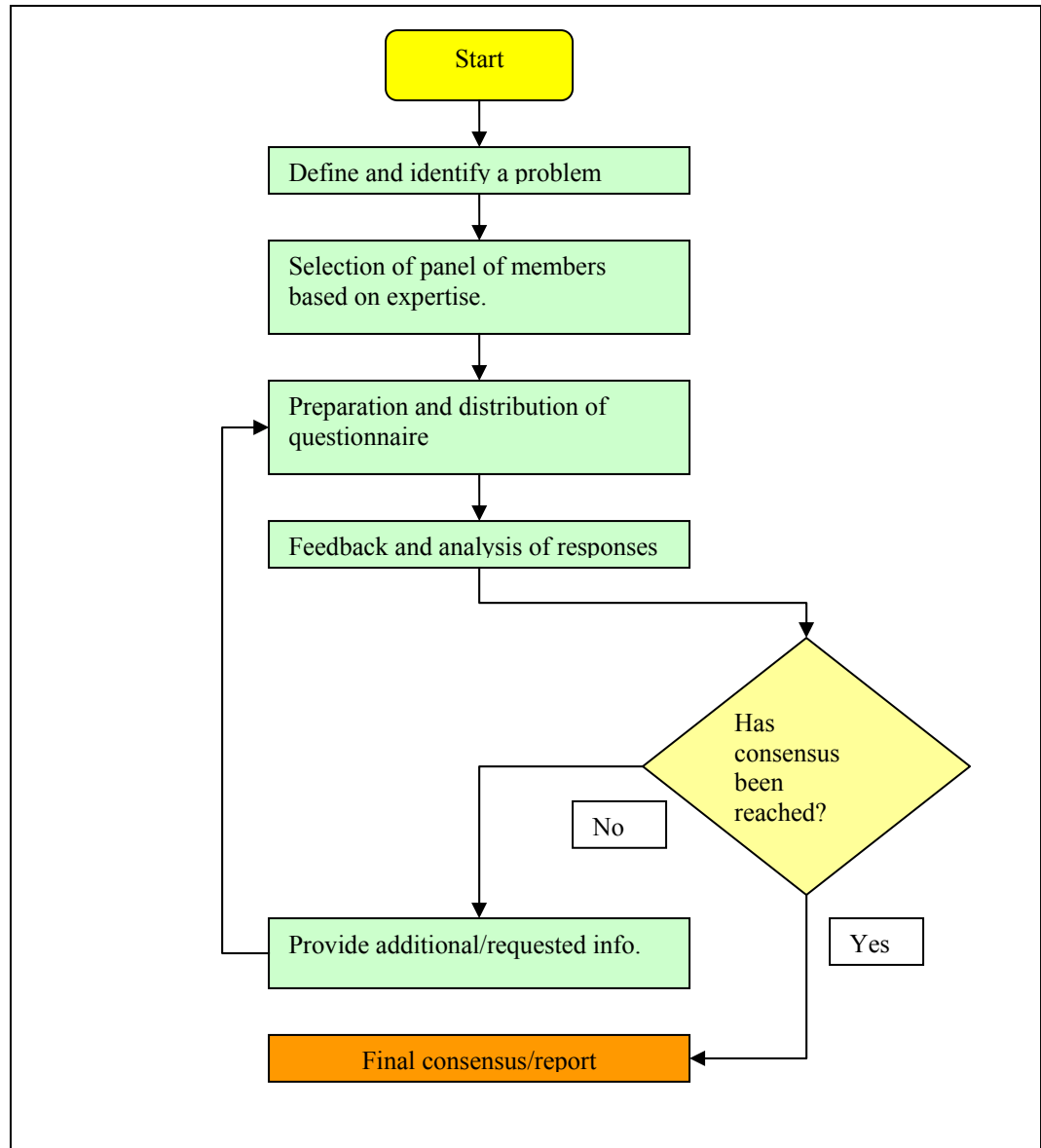


Figure 6.1 Flowchart Showing Processes of Delphi Method

(Adapted from <http://www.ryerson.ca/>)

### 6.1.3 Innovation Metric Scale and Innovation Score

After the opinions and the feedback expressed by the panel of experts, each innovative product is rated on a scale of 1 to 5 by these experts which has been termed as “innovation metric scale” (IMS). The IMS will be used to assign each product a particular rating termed in this study as “innovation score” from 1 to 5 with 1 being the



most innovative and 5 being the least. Thus, every product will have a specific innovation score from a range of 1 to 5 which will be used in the data envelopment analysis (DEA) later.

#### 6.1.4 Theoretical Analysis versus Empirical Analysis

During the course of this research, getting access to data from the product manufacturers as well as the healthcare organizations has been a very thorny task since the start. Data concerning the pricing of innovative products, warranty details, product features manufacturer's details and model numbers are crucial to have a realistic analysis. As mentioned earlier in the past literature (Zweig 1998; Everard 2005; Sethi 2006), the big National GPOs quite often create a hindrance to the entry of manufacturers of high technology products in to the market. Due to this reason, as was mentioned in the past literature (Zweig 1998), physicians sometimes circumvent the hospital contracts with a GPO and procure these items through off-contract means, which becomes an added cost to the healthcare organizations. Due to less volume of these items coupled with high level of sophistication, healthcare (HC) organizations may not be in a position to negotiate and reduce costs. Also, the compliance rate of the HC organizations reduces as more and more physicians prefer the off-contract route. However, contrary to the past concerns about the HC organization not maintaining the compliance rate as discussed earlier, we found that based on the interaction and our correspondence with the materials management departments of almost seven HC organizations, that contract compliance is more or less enforced by these healthcare organization managements on the physicians. If a particular product is being preferred by the physicians, the physician has to provide suitable justifications for choosing the particular product. The chances for the physician

preferred items to be approved by the material management department for purchase would depend on strict evaluation of the products capabilities, long term cost savings and relevance. Only after the product has satisfied the entire requirements specific to a particular HC organization, would the products be approved for purchase. Once the product has been approved for purchase it becomes the new standard and would be added in the list of on-contract items. Thus, by ensuring large volumes of purchase, the HC organizations tend to drive costs low. This trend was observed across all the seven HC organizations we had interacted. This made the accessibility of data even more difficult and so the comparison between on-contract items and off-contract ones could not be undertaken as all the HC organizations seem to have products sourced through on-contract means only. Secondly, information regarding product manufacturers and warranty details were considered confidential by both the HC organizations and the manufacturers and could not be accessed by us. In the first aspect of this research project involving the comparison of cost of bulk items, we could get hold of only an estimated price for each of those products using the MS Excel model and thus we could compare the estimated cost of those products. The information regarding manufacturers details, warranty, technical expertise (considered confidential) were not required unlike in this second part. Without specific information of a product like features, model numbers, pricing and warranty details, it is impossible to carry out our research into measuring the degree of access of innovative technologies across different HC organizations following different procurement models. As a result, the main idea about this section is to propose a research methodology which can be implemented if real data from the industry is available. This is more of a theoretical analysis and if empirical data is available, this

methodology can be used to realistically compare the HC organizations. In order to simulate real world scenarios, suitable and realistic data has been taken into consideration, which would give us simulated results. However, this research idea can be replicated not only in healthcare vertical but also other sectors where similar procurement models are followed and GPOs have been known to exist. The fundamental question which has been addressed in this section is to determine whether items classified as innovative have the same levels of innovation (compare the degree of innovation and cost of procurement) when they are procured by different means like on-contracting in the form of a GPO or off-contracting through niche manufacturers. This also underlines the concerns in the past literature that Nationalized GPOs cause a barrier to the entry of niche manufacturers and slow down the entry of new advanced products (Everard 2005) than currently available in the market. Data which is vital for undertaking Delphi method has been simulated and so is the outcome of Delphi method which is the “innovation score”.

#### 6.1.5 Comparison and Ranking Using DEA

In actual scenario with available real data, after the products are assigned a particular innovation score by the panel of experts, a data envelopment analysis (DEA) is carried out to compare and rank every procurement model followed by HC organizations considered in this study for a particular product. For example, say healthcare organization (HC) 1 uses both off-contract and on-contract models to procure an innovative product like pacemaker. Thus it will have two different models of pacemakers with different pricing and different innovation score (every model of a particular generic item will have a unique pricing and innovation score), i.e., on-contract and off-contract pricing. So the pacemaker model procured by HC 1 by on-contract means with a unique pricing and

innovation score will be compared with the pacemaker model procured by HC 1 with off-contract means with a different pricing and innovation score, as well as with other pacemaker models procured by other healthcare organizations using either of the three procurement models like only off-contract, only on-contract and both.

#### 6.1.6 Data Envelopment Analysis (DEA)

Data envelopment analysis is a performance measurement approach used to measure the relative performance of a number of entities called decision making units (DMUs) by evaluating their efficiencies. DMUs can be various entities like departments, HC organization, manufacturers etc. This is mostly used where there are multiple inputs and multiple outputs where the DMUs are rated based on their efficiency as there are limitations when multiple inputs and outputs are involved to evaluate efficiency of units in conventional statistical approaches. The statistical approaches reflect “average” or “central tendency” behavior of the observations while the DEA deals with the best performance and evaluates all performances by deviations from the “efficient frontier line” (Cooper 2006). The “efficient frontier line” connects the most efficient DMUs and all the lesser efficient DMUs are either above or below this line in a output versus input graph. This approach helps to identify the performance leaders which have the most efficiency in a particular group and compares every DMU with these leaders. DEA had been used to benchmark particular organizations as most efficient ones to highlight inherent inefficiencies of the poor performing ones in that industry vertical.

DEA utilizes mathematical programming techniques which can handle large number of variables and relations (constraints) in terms of inputs and outputs and this relaxes the requirements that are often encountered when one is limited to choosing only

a few inputs and outputs because the techniques employed will otherwise encounter difficulties (Cooper 2006). For every DMU a fractional programming problem is formulated where the relative efficiency of the DMU is obtained by maximizing the objective function which is a ratio of output DMU weights to input DMU weights. The Fractional Programming (FP) solution for every DMU produces weights which are most favorable to that particular DMU for maximizing efficiency. Since the objective function is a ratio of the DMU output weights to DMU input weights, the optimal efficiency is at most 1.

The mathematical model is as follows (Cooper 2006)

$$\begin{aligned} \max \theta = & \frac{u_1 y_{1o} + u_2 y_{2o} + \dots + u_s y_{so}}{v_1 x_{1o} + v_2 x_{2o} + \dots + v_m x_{mo}} \quad \text{Eq 6.1} \\ \text{ST} \dots & \frac{u_1 y_{1j} + \dots + u_s y_{sj}}{v_1 x_{1j} + \dots + v_m x_{mj}} \leq 1 (j = 1, \dots, n) \\ & v_1, v_2, \dots, v_m \geq 0 \\ & u_1, u_2, \dots, u_s \geq 0 \end{aligned}$$

The constraints signify that the ratio of the output weights to input weights should not exceed 1, i.e., the optimal objective value can be at most 1.

After replacing the above fractional programming model to linear programming model the basic DEA algebraic model becomes

$$\begin{aligned} \max \theta = & \frac{\sum_{r=1}^s u_r y_{ro}}{\sum_{i=1}^m v_i x_{io}} \\ \text{ST} & \\ & \frac{\sum_{r=1}^s u_r y_{ro}}{\sum_{i=1}^m v_i x_{io}} \leq 1, (o = 1, \dots, n) \quad \text{Eq 6.2} \\ & u_r \geq 0; r = 1, \dots, s \\ & v_i \geq 0; i = 1, \dots, m \end{aligned}$$

Where  $v_i$  is the optimal weight for the input item  $i$  and it's magnitude expresses how highly the item is evaluated. Similarly,  $u_r$  does the same for the output item  $r$ . (Cooper 2006).

#### 6.1.7 Selection of Decision Making Units (DMUs)

As mentioned earlier, non accessibility of real data led us to consider realistic simulated data. In this section, the decision making units will be “model type of product/name of hospital” for a particular generic product. For example, for temporary pacemakers, the different DMUs will be model1/hospital 1 (Hybrid on-contract), followed by other different permutations. Thus, there will be a unique product, i.e., unique model of say pacemaker which will be compared with other models of pacemakers procured through different sources. Even within the same HC organization two different types of pacemakers may be procured if they follow both on-contract as well as off-contract purchasing. The table 6.1 below displays all the DMUs which will be considered in this analysis.

Table 6.1 Simulated DMUs

DMUs	Hospital Type	Procurement model considered by the hospital.
Model 1/Hosp A	General	Self sourcing off-contract
Model 2/Hosp B	General	GPO model with on-contract
Model 3/Hosp C	General	GPO model with off-contract
Model 4/Hosp D (on-contract model of Hosp D)	General	GPO model with both off and on-contract purchasing
Model 5/Hosp D (off-contract model of Hosp D)	General	GPO model with both off and on-contract purchasing

Table 6.1 (continued)

DMUs	Hospital Type	Procurement model considered by the hospital.
Model 6/Hosp E	General	Hybrid model with on-contract
Model 7/Hosp F	General	Hybrid model with off-contract
Model 8/Hosp G (on-contract model of Hosp G)	General	Hybrid model with both off and on-contract purchasing
Model 9/Hosp G (off-contract model of Hosp G)	General	Hybrid model with both off and on-contract purchasing
Model 10/Hosp H	Specialty	Specialty Hospital with Self sourcing (off-contract)
Model 11/Hosp I	Specialty	Specialty Hospital with GPO model (on-contract)
Model 12/Hosp J	Specialty	Specialty Hospital with GPO model (off-contract)
Model 13/Hosp K	Specialty	Specialty Hospital with Hybrid model (on-contract)
Model 14/Hosp L	Specialty	Specialty Hospital with Hybrid model (off-contract)
Model 15/Hosp M (on-contract model of Hosp M)	Specialty	Specialty Hospital-GPO model with both off and on-contract purchasing
Model 16/Hosp M (off-contract model of Hosp M)	Specialty	Specialty Hospital-GPO model with both off and on-contract purchasing
Model 17/Hosp N (on-contract model of Hosp N)	Specialty	Specialty Hospital-Hybrid model with both off and on-contract purchasing
Model 18/Hosp N (off-contract model of Hosp N)	Specialty	Specialty Hospital-Hybrid model with both off and on-contract purchasing

The DMUs under consideration in this research are different models of a particular generic product like pacemakers sourced from diverse healthcare organizations. There are two types of healthcare organizations under consideration (2<sup>nd</sup> column in table 6.2 titled “hospital type”) i.e., general and special. General type represents HC organizations which cater to all sorts of medical cases from orthopedics to pediatrics.

These may have a wide range of departments like cardiology, neurosurgery, orthopedics etc.

The specialty type represents the HC organizations which cater to special treatments and research like cancer, cardiac ailments, geriatric disorders, neuro-surgery etc. These are more focused in treatment of special cases and research and tend to be more advanced over general HC organization. However they cater to a smaller population sample and it is simulated that the features of the items they procure are more sophisticated.

The next sub classification of DMUs is the procurement model they follow like Self sourcing, GPO or Hybrid. Again these procurement models can be followed by either general or specialty HC organization. These HC organizations following a particular procurement model for example Hybrid model can procure innovative items by only on-contract means, or only off-contract means or both (Model 8 and model 9). Sometimes the same hospital can procure two different models of an item with one being procured through on-contract way and the other through off-contract. It should be noted the models of products are unique which are the DMUs in this study. For example: the model 2 is different from model 3 of a particular item as they are procured by two different HC organizations, with model 2 being procured by on-contract means which is being followed by hospital B whereas model 3 is being procured by on-contract means which is being followed by hospital C though hospital B and C are affiliated to a GPO.

Similarly in a more complicated case where the same hospital follows two different sources of contracting, the models of the items procured will be different and unique for that particular source of contracting. For example: model 4 and model 5 are



two different models of an item procured by the same hospital using two different sources of contracting as shown in table 6.1. Same pattern is repeated in specialty HC organizations. However, Self sourcing HC organizations are unique as they do only off-contracting as they are not affiliated with any GPO or bounded by any contract. They procure their bulk items as well as innovative items the same way.

DEA models vary from having single output and single input to multiple inputs and outputs. In this research methodology, all the data concerning outputs and inputs have been realistically simulated due to non accessibility of data from the industry. Two inputs are considered in this study with one output. These two inputs are in the form of:

1. Cost of innovative products.
2. Innovation Score (1 being the most innovative and 5 being the least).

The output considered is the “the number of hospital beds”. This would give an idea about the maximum number of patients a hospital can treat. It is simulated and highlighted in the past literature that there is an underlying link with the cost of the product as larger volume of products will drive costs low. Thus, it is simulated that if a hospital has the capacity to treat a large number of patients, its cost for procuring a particular item will be lower than another hospital which has lesser capacity of treating patients.

#### 6.1.8 Simulated Costs of DMUs (Input)

Cost of innovative products has been adjusted based on the healthcare organizations. That is, the underlying assumption is that the cost of a particular DMU of a general HC organization is lower than a specialty one under both off-contract and on-contract means. Similarly as evident from the first aspect of the thesis, it has been

simulated that the DMUs under the Hybrid models are the most cost efficient, followed by those under GPO models for both general and specialty HC organization only when the items are sourced through on-contract means. Off-contract purchase costs for all HC organizations having different procurement models, are simulated to be quite close but not same as it depends on the negotiating power of the respective HC organization with the vendors when they off-contract. But it differs in a case where a particular HC organization has two sources of contracting as mentioned in this study. For the same HC organization, cost of a DMU by off-contract means is simulated to be higher than an on-contract one for both general and specialty type organizations having dual sources of contracting. Another assumption is that the cost of procurement for Self sourcing will be higher than those of GPO and Hybrid models by on-contract means for both general and specialty HC organizations. Table 6.2 displays the simulated costs of innovative items for the DMUs. The simulated cost of generic item pacemaker is taken into consideration with a price range between \$4000 and \$5000 for a general HC organization and between \$5100 and \$6000 for the specialty ones.

Table 6.2 Simulated Costs of DMUs (Input)

DMUs	Hospital Type	Procurement model considered by the hospital.	Simulated Costs in US Dollars (input)
Model 1/Hosp A	Gen	Self sourcing off-contract	5000
Model 2/Hosp B	Gen	GPO model with on-contract	4400
Model 3/Hosp C	Gen	GPO model with off-contract	4900
Model 4/Hosp D (on-contract model of Hosp D)	Gen	GPO model with both off and on-contract purchasing	4500

Table 6.2 (Continued)

DMUs	Hospital Type	Procurement model considered by the hospital.	Simulated Costs in US Dollars (input)
Model 5/Hosp D (off-contract model of Hosp D)	Gen	GPO model with both off and on-contract purchasing	4850
Model 6/Hosp E	Gen	Hybrid model with on-contract	4200
Model 7/Hosp F	Gen	Hybrid model with off-contract	4900
Model 8/Hosp G (on-contract model of Hosp G)	Gen	Hybrid model with both off and on-contract purchasing	4300
Model 9/Hosp G (off-contract model of Hosp G)	Gen	Hybrid model with both off and on-contract purchasing	4950
Model 10/Hosp H	Sp	Specialty Hospital with Self sourcing (off-contract)	5800
Model 11/Hosp I	Sp	Specialty Hospital with GPO model (on-contract)	5400
Model 12/Hosp J	Sp	Specialty Hospital with GPO model (off-contract)	5900
Model 13/Hosp K	Sp	Specialty Hospital with Hybrid model (on-contract)	5150
Model 14/Hosp L	Sp	Specialty Hospital with Hybrid model (off-contract)	5900
Model 15/Hosp M (on-contract model of Hosp M)	Sp	Specialty Hospital-GPO model with both off and on-contract purchasing	5300
Model 16/Hosp M (off-contract model of Hosp M)	Sp	Specialty Hospital-GPO model with both off and on-contract purchasing	6000
Model 17/Hosp N (on-contract model of Hosp N)	Sp	Specialty Hospital-Hybrid model with both off and on-contract purchasing	5250
Model 18/Hosp N (off-contract model of Hosp N)	Sp	Specialty Hospital-Hybrid model with both off and on-contract purchasing	5850

In the above table “Gen” represents general category of HC organizations and “Sp” represents specialty units.

#### 6.1.9 Simulated Innovation Score (Input)

When assuming innovation scores of DMUs under consideration, similar pattern is seen. As discussed earlier, the innovation score ranges from 1 to 5 with 1 being the highest or most innovative and 5 being the least innovative. For example, when the innovation score of a particular model A is 3 and another model B is 5, it can be said that model A will have higher innovation score than the model B. The innovation score of a particular DMU of a specialty hospital having a certain procurement model and contracting source is simulated to be higher than that of a corresponding DMU of a general hospital. Again the innovation score of the DMUs of Hybrid models is simulated to be higher than those of GPO models only for on-contract means for both general and specialty HC organizations. This is because of the assumption that Hybrid models have more flexibility than just GPO models in the choice of products and have generally wider range. However, for off-contract purchases, innovation score is simulated to be constant for all the three models of procurement for comparisons within general and specialty HC organizations. It is also simulated that the innovation score for DMUs of HC organizations having two sources of contracting for both GPO as well as Hybrid models of procurement under both general and specialty categories will be higher for the ones through off-contracting than those procured through on-contracting. Again, it has been simulated that the innovation score of the Self sourcing DMUs for both general and specialty categories will be higher than their respective Hybrid and GPO on-contract DMUs, whereas remaining the same as that of their respective off-contract DMUs.

It should be noted here that under a category of HC organization like general, certain DMUs will have the same innovation score whereas their cost will vary slightly. For example, models 1, 3, 5, 7, and 9 under general HC organization type are simulated to have same innovation score whereas they may not have same cost prices as cost is dependent on the negotiating power and the volume of the items a HC organization purchases when making off-contract purchases. However, their costs are simulated to be quite close if not the same.

The DEA will be unique for each kind of generic item, i.e. say for pacemakers, there will be a DEA model with different models of pacemakers numbered from 1 to 18 forming the DMUs. Similarly, other generic items like implants etc. will have their own respective DEA. Thus in this study, innovation score and the output “the number of hospital beds” is simulated to remain constant for a particular DMU under different DEA models. For example, model 3 will have same simulated values for “innovation score” and “no. of beds” constant for all generic item DEA models. Only the cost of innovative items (simulated input) will change across the DEA models because every generic innovative item costs differently. Table 6.3 listed in the following page displays the simulated innovation scores for the DMUs.

Table 6.3 Simulated Innovation Scores of DMUs (Input)

DMUs	Hospital Type	Procurement model considered by the hospital.	Innovation Score (input)
Model 1/Hosp A	Gen	Self sourcing off-contract	3
Model 2/Hosp B	Gen	GPO model with on-contract	5 (same for all general GPO on-contracts)
Model 3/Hosp C	Gen	GPO model with off-contract	3 (same for all general off- contracts)
Model 4/Hosp D (on-contract model of Hosp D)	Gen	GPO model with both off and on-contract purchasing	5

Table 6.3 (Continued)

DMUs	Hospital Type	Procurement model considered by the hospital.	Innovation Score (input)
Model 5/Hosp D (off-contract model of Hosp D)	Gen	GPO model with both off and on-contract purchasing	3
Model 6/Hosp E	Gen	Hybrid model with on-contract	4 (same for all general Hybrid on-contracts)
Model 7/Hosp F	Gen	Hybrid model with off-contract	3
Model 8/Hosp G (on-contract model of Hosp G)	Gen	Hybrid model with both off and on-contract purchasing	4
Model 9/Hosp G (off-contract model of Hosp G)	Gen	Hybrid model with both off and on-contract purchasing	3
Model 10/Hosp H	Sp	Specialty Hospital with Self sourcing (off-contract)	1 (same for all specialty off-contracts)
Model 11/Hosp I	Sp	Specialty Hospital with GPO model (on-contract)	3 (same for all specialty GPO on-contracts)
Model 12/Hosp J	Sp	Specialty Hospital with GPO model (off-contract)	1
Model 13/Hosp K	Sp	Specialty Hospital with Hybrid model (on-contract)	2 (same for all specialty Hybrid on-contracts)
Model 14/Hosp L	Sp	Specialty Hospital with Hybrid model (off-contract)	1
Model 15/Hosp M (on-contract model of Hosp M)	Sp	Specialty Hospital-GPO model with both off and on-contract purchasing	3
Model 16/Hosp M (off-contract model of Hosp M)	Sp	Specialty Hospital-GPO model with both off and on-contract purchasing	1
Model 17/Hosp N (on-contract model of Hosp N)	Sp	Specialty Hospital-Hybrid model with both off and on-contract purchasing	2
Model 18/Hosp N (off-contract model of Hosp N)	Sp	Specialty Hospital-Hybrid model with both off and on-contract purchasing	1

#### 6.1.10 Simulated “No. of Beds” (Output) of DMUs

The simulated values of the output of the DMUs in the DEA the specialty HC organization has will have lesser number of beds compared to general ones as the former ones are more focused to a particular type of treatment whereas the latter ones cater to a wider range of treatments and population. However, the number of beds (output) for DMUs which fall under the category of HC organizations which have dual contract sources is simulated to be same as they are the same HC organization. Table 6.4 listed below shows the simulated values of outputs (No. of beds) for the DMUs

Table 6.4 Simulated Values of Outputs (No. of beds)

DMUs	Hospital Type	Procurement model considered by the hospital.	No. of Beds (output)
Model 1/Hosp A	Gen	Self sourcing off-contract	300
Model 2/Hosp B	Gen	GPO model with on-contract	350
Model 3/Hosp C	Gen	GPO model with off-contract	325
Model 4/Hosp D (on-contract model of Hosp D)	Gen	GPO model with both off and on-contract purchasing	250
Model 5/Hosp D (off-contract model of Hosp D)	Gen	GPO model with both off and on-contract purchasing	250
Model 6/Hosp E	Gen	Hybrid model with on-contract	400
Model 7/Hosp F	Gen	Hybrid model with off-contract	350
Model 8/Hosp G (on-contract model of Hosp G)	Gen	Hybrid model with both off and on-contract purchasing	325
Model 9/Hosp G (off-contract model of Hosp G)	Gen	Hybrid model with both off and on-contract purchasing	325
Model 10/Hosp H	Sp	Specialty Hospital with Self sourcing (off-contract)	150
Model 11/Hosp I	Sp	Specialty Hospital with GPO model (on-contract)	175

Table 6.4 (Continued)

DMUs	Hospital Type	Procurement model considered by the hospital.	No. of Beds (output)
Model 12/Hosp J	Sp	Specialty Hospital with GPO model (off-contract)	160
Model 13/Hosp K	Sp	Specialty Hospital with Hybrid model (on-contract)	180
Model 14/Hosp L	Sp	Specialty Hospital with Hybrid model (off-contract)	145
Model 15/Hosp M (on-contract model of Hosp M)	Sp	Specialty Hospital-GPO model with both off and on-contract purchasing	170
Model 16/Hosp M (off-contract model of Hosp M)	Sp	Specialty Hospital-GPO model with both off and on-contract purchasing	170
Model 17/Hosp N (on-contract model of Hosp N)	Sp	Specialty Hospital-Hybrid model with both off and on-contract purchasing	165
Model 18/Hosp N (off-contract model of Hosp N)	Sp	Specialty Hospital-Hybrid model with both off and on-contract purchasing	165

#### 6.1.11 Selection of (DEA) Model

The DEA model chosen in this study will be “CCR input-oriented bounded” model. The CCR model was proposed by Charnes, Cooper and Rhodes in 1978 (Cooper 2006). The main assumptions of the CCR model are (Cooper 2006)

1. Constant returns to scale which assumes that a proportional change in the inputs also increases the output by the same proportion.
2. Since all the data (inputs and outputs) are simulated to be positive, translation invariant capability is not required. Translation invariance converts negative data to positive values, which are not a concern in this study.



Expressing the linear programming model of DEA (Eq. 6.2) from section 6.2.5 in the form of vector matrix notation (Cooper 2006),

$$\begin{aligned}
 (\text{LP}_o) \quad & \max_{v,u} = uy_o \\
 \text{subject to} \quad & vx_o = 1 \\
 & -vX + uY \leq 0 \\
 & v \geq 0, u \geq 0.
 \end{aligned}
 \tag{Eq. 6.3}$$

Where matrix(X,Y) comprises of row vector  $v$  as input multipliers and  $u$  for as output multipliers.

Input-oriented CCR models minimize inputs to satisfy the desired output levels. In this research study, the main objective would be to minimize the values of inputs, i.e. the cost and innovation score. The DMUs with the relative minimum innovation score and relative minimum cost would be the optimal DMU against which the other DMUs will be measured. It was decided to minimize input because the output which is the number of beds, cannot be varied as that is constant and specific to a hospital. Minimization of input is the sole reason for choosing a inverted innovation scale with 1 being the most innovative and 5 being the least.

The dual problem of the (LP<sub>o</sub>) in equation 6.3 expressed with a real variable  $\theta$  and the transpose of non negative vector  $\lambda = (\lambda_1, \dots, \lambda_n)$  (Cooper 2006)

$$\begin{aligned}
 (\text{DLP}_o) \quad & \min_{\theta, \lambda} \theta \\
 \text{Subject to} \quad & \theta x_o - X\lambda \geq 0 \\
 & Y\lambda \geq y_o \\
 & \lambda \geq 0.
 \end{aligned}
 \tag{Eq. 6.4}$$

Since the innovation score is bounded by an inverted scale of innovation score of a maximum value of 1 and minimum value of 5. The innovation score cannot go out of this range and this is the sole reason why bounded input-oriented CCR model is applied as the solution will try to minimize the innovation score and give optimal efficiency for each DMU.

The bounded equations are:

$$l_o^x \leq X\lambda \leq u_o^x \quad \text{Eq. 6.5}$$

$$l_o^y \leq Y\lambda \leq u_o^y \quad \text{Eq. 6.6}$$

where (  $l_o^x, u_o^x$  ) are lower and upper bound vectors to inputs and (  $l_o^y, u_o^y$  ) to outputs respectively.

## 6.2 Results of Comparison of Access to Innovation with Cost

This section of the study deals with the comparison of degree of access to innovative products across various HC organizations following different procurement models and contract sources. As discussed earlier, accessibility of data for off-contract items has not been possible due to the recent phenomenon of HC organizations to lay stress on on-contract purchasing. Also, information regarding product features, manufacturer's details was not available to us due to confidentiality concerns shared by the hospital staff and the manufacturing units. This comparison model is totally based on simulated data which has been tailored to suit real world scenarios as closely as possible. The conditions and the justifications for the assumptions have been explained in detail in the methodology section. The main idea here is to bind the two factors' cost and innovation score and rate the models of pacemakers which are the DMUs in terms of

efficiency and ultimately rank them. There is a link between the cost and the degree of access of innovation rated by innovation score and based on these two factors, the DEA model tries to find out the optimal efficient DMU which would be rated as the most efficient and all other DMUs will be measured against it in terms of efficiency.

The DEA model is run for the generic item pacemaker using DEA solver and the results are shown below.

Table 6.5 Ranking and Efficiency Scores of DMUs

Rank	DMU	Score	Reference set (lambda)
1	6	1	6
2	8	0.976734	6
3	2	0.954536	6
4	4	0.933324	6
5	5	0.865971	6
6	3	0.857134	6
6	7	0.857134	6
8	9	0.848476	6
9	1	0.839992	6
10	13	0.815526	6
11	17	0.799992	6
12	15	0.792445	6
13	11	0.777777	6
14	10	0.724131	6
15	18	0.717942	6
16	12	0.711857	6
16	14	0.711857	6
18	16	0.699993	6

Table 6.5 above displays the efficiency score of each DMU and the rankings based on efficiency score. The efficiency score is the efficiency of each DMU evaluated against the most efficient DMU which in this study is model 6. The reason for model 6 to be ranked most efficient is due to lower cost as Hybrid model in this study is simulated to have lowest cost for on-contract purchases (assumption is taken from the cost comparison

analysis where the Hybrid model had the lowest cost) as compared to GPO and Self sourcing and at the same time fair better on the innovation scale than the GPO model.

Understandably, the second ranking DMU is model 8 which again is from Hybrid model and has on-contract purchase sources. It can be seen that there is a huge difference in ranking between second ranking model 8 and eighth ranking model 9. Both the models are procured by the same hospital G, however the extremely low prices of on-contract Hybrid models (low even compared to GPO on contract) as compared to off-contract prices which are quite similar across the Hybrid, GPO and Self sourcing model, drive the difference in rankings. Because the difference between the simulated off-contract pricing and on-contract pricing for the GPO model of the same hospital is less as compared to the Hybrid model, model 4 and model 5 trail closely in ranking at 4 and 5, with model 4 being the more efficient one. However, it is closely followed by GPO on-contract DMUs models 2 and 4 at ranks 3 and 4. Since DMU model 6 is the most efficient, it is taken as a reference set against which other DMUs will be rated. Quite expectedly, model 1, which is procured by off-contract Self sourcing is the least efficient among general items as it is generally simulated to have a highest price. From the table it can be said that the general HC organization are more efficient than specialty ones. The major factors behind this might be the fact that the average cost of items in specialty units are much higher than those of general HC organization (higher inputs) and at the same time lower outputs in terms of “number of bed”. When rated on innovation score, specialty ones will outperform the general ones (as they have better innovation score), but when costs are tied with innovation they seem to be less efficient overall. Similar trends as in the general

hospital can also be observed in the specialty HC organization. The figure 6.2 shows the efficiency of DMUs in a graphical form below.

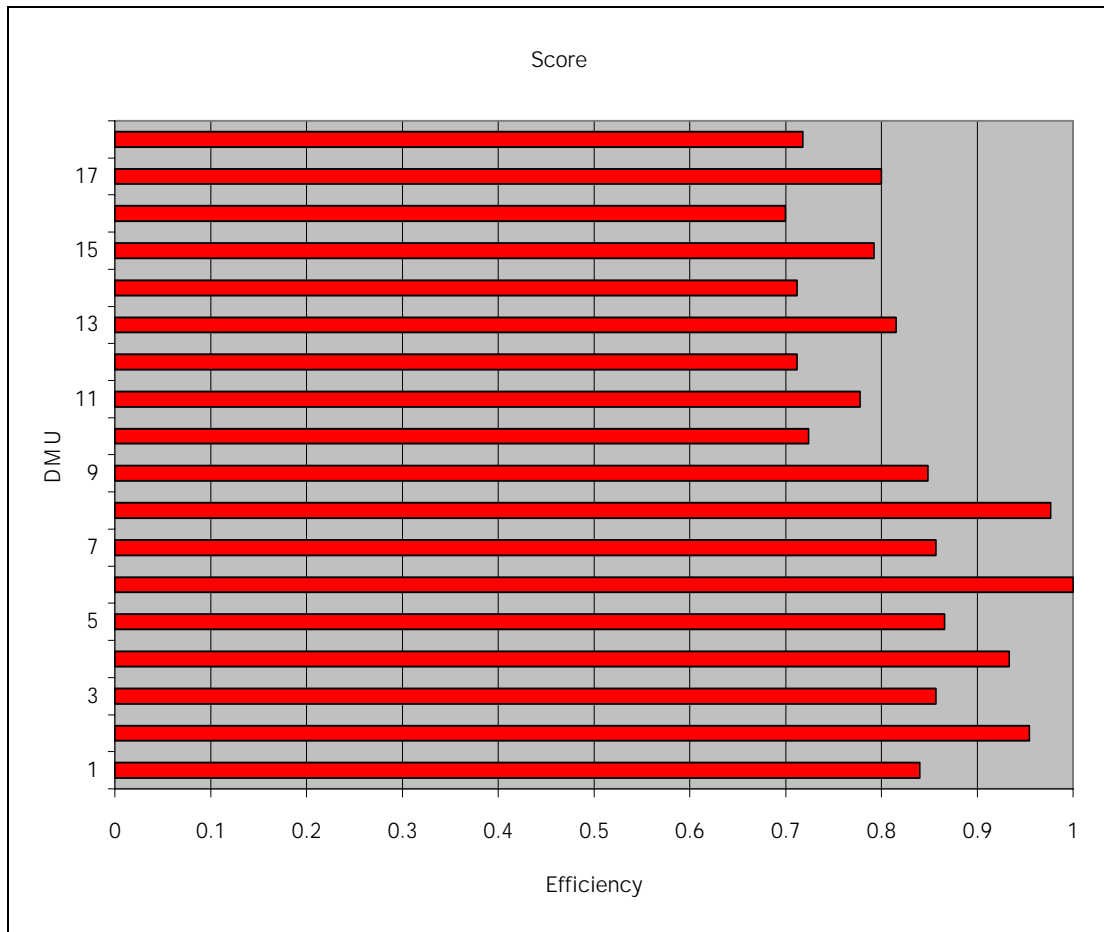


Figure 6.2 Graph Showing Efficiency Scores of DMUs

Table 6.6 Statistics on Input/Output Data

	(IB)InScore	(I)Cost	(O)Beds	
Max	5	6000	400	
Min	1	4200	145	
Average	2.666666667	5141.667	241.9444	
SD	1.290994449	564.764	84.19783	
Correlation				
	(IB)InScore	(I)Cost	(O)Beds	
(IB)InScore	1	-0.92579	0.741941	
(I)Cost	-0.925789863	1	-0.84902	
(O)Beds	0.741940575	-0.84902	1	
DMUs with inappropriate Data with respect to the chosen Model				
No.	DMU			
	None			
No. of DMUs	18			
Average	0.826934118			
SD	0.09234159			
Maximum	1			
Minimum	0.699993			
No. of DMUs in Data =				18
No. of DMUs with inappropriate Data =				0
No. of evaluated DMUs =				18
Average of scores =				0.826934
No. of efficient DMUs =				1
No. of inefficient DMUs =				17

Table 6.6 above shows the statistics like maximum, minimum and average values of outputs and input. It also displays the correlation between the inputs to the outputs, standard deviation, and average efficiency score along with the maximum and minimum values. The correlation is of particular importance here. It describes the strength and the nature of relationship between the inputs and between the inputs and the output. As seen from the table, the bounded input “InScore” (Innovation Score) has inverse correlation with output variable “Cost” and is equal to -0.92579. The relationship between “InScore

and Cost” is however stronger than the relationship between “Cost and Beds” and “InScore and Beds”. The inverse correlation shows that as “InScore” increases the cost would decrease. This is because of the usage of inverted Innovation Scale where the most efficient is rated as 1 and the least 5. The model also has been based on assumptions that on-contract purchases are low on innovation as compared to off-contract ones, i.e. on-contract purchases have an innovation score range between 3 and 5 whereas off-contract ones range between 1 and 3. At the same time on-contract items have a much lower price as compared to off-contract and this would be the reason for inverse correlation. Similarly, the correlation between input “cost” and output “bed” is also shown as inverse with a value of -0.84902, which can be justified as the cost decreases with the increase of capacity of the hospital to treat patients.

Table 6.7 Projection of DMUs

No.	DMU I/O	Score Data	Projection	Difference	%
4	4	0.933324			
	(I)InScore	5	3.99996	-1.00004	20.00%
	(I)Cost	4500	4199.958	-300.042	-6.67%
	(O)Beds	250	399.996	149.996	60.00%
5	5	0.865971			
	(I)InScore	3	3.99996	0.99996	33.33%
	(I)Cost	4850	4199.958	-650.042	13.40%
	(O)Beds	250	399.996	149.996	60.00%
6	6	1			
	(I)InScore	4	4	0	0.00%
	(I)Cost	4200	4200	0	0.00%
	(O)Beds	400	400	0	0.00%
7	7	0.857134			
	(I)InScore	3	3.99996	0.99996	33.33%
	(I)Cost	4900	4199.958	-700.042	14.29%
	(O)Beds	350	399.996	49.996	14.28%

Table 6.7 (Continued)

8	8	0.976734			
	(IB)InScore	4	3.99996	0	0.00%
	(I)Cost	4300	4199.958	100.042	-2.33%
	(O)Beds	325	399.996	74.996	23.08%
9	9	0.848476			
	(IB)InScore	3	3.99996	0.99996	33.33%
	(I)Cost	4950	4199.958	750.042	15.15%
	(O)Beds	325	399.996	74.996	23.08%

The above table 6.7 shows the projection of DMUs to the efficient frontier. The projection of model 4 to model 9 has been chosen to be displayed here. Model 6 is the reference set and is the most efficient DMU. In order to achieve optimal efficiency, the DMUs are projected to the efficient frontier, and their difference and percentage changes are also highlighted. As can be seen, since DMU model 6 is the most efficient, the percentage change and difference in input and output weights for it to be projected to the efficient frontier are both zero. The other DMUs either have positive or negative changes to their input and output values for them to be projected to the efficient frontier, as they are less efficient than model 6.



## CHAPTER 7 - CONCLUSION AND DISCUSSIONS

As discussed earlier, this research study has two contributions. In the first section, the goal was to determine whether National GPOs help the healthcare organizations affiliated to them to drive their costs low as compared to the healthcare organization which Self contract. Based on the available data from three healthcare organizations involving a Self sourcing model, a GPO model and a Hybrid model, our results clearly prove that healthcare organizations affiliated to National GPO are indeed more cost efficient than the Self sourcing ones. A Hybrid model was also used in the comparison and it was the clear winner in terms of cost efficiency in the comparison test. The Self sourcing model has significantly higher overall costs compared to the GPO model and the Hybrid model. The Hybrid model achieves the efficiency by having the flexibility of wider range of products and the ability to choose between the best prices offered by a National GPO and a regional GPO. Thus, based on the results of this cost comparison study, the first hypothesis “H1 - National GPOs (Group Purchasing Organizations) enable the healthcare establishments to lower the cost of medical services and an operations” is valid. It should be mentioned that during the course of research, it was found that no two healthcare organizations affiliated to the same GPO have the same price figures. Thus, two different healthcare organizations under the same GPO will have different cost efficiencies. This is dependent on the negotiating capacity of each healthcare organization, volume of purchase, and the compliance rate of the healthcare organization.

For example, a healthcare organization having a high compliance rate and high volume of purchase will have lower prices of products from the GPO as compared to another which has lesser compliance rate and volume under the same GPO. Also, many GPOs have mandatory compliance rates.

The second aspect of this research was to measure and compare the degree of access to innovative products across HC organization with different procurement models and modes of contracting. In this study, since data was not available, realistic data were simulated. The results achieved with the simulated data, models of items procured through contracts by a GPO and Hybrid model driven HC organization fared most efficient as compared to Self sourcing and off-contracted models. In spite of on-contracting models having lesser innovative features as compared to off-contracting ones, the fact that they are more cost efficient, improves their efficiency. Thus, many HC organizations in their attempts to drive costs lower might go for on-contracting source of procurement and might compromise on the quality of products as they are more cost efficient. This might create a barrier to the entry of niche manufacturers of high end items whose products are more advanced than the ones offered by the GPOs, but do not have the necessary volumes to drive the cost low. They might be beaten out in the race and since they are generally not affiliated to GPOs, they may not find the support from the HC organization to sustain in the competitive marker. Thus, if this research study is performed with real world data and if it is quite similar to the simulated data used in this project, the hypothesis “H2 - National GPOs a barrier to entry of innovative product manufacturers in the healthcare industry” can be proved, which again reflects the concerns shared by the past literature.

In this research project, the most common procurement models like Self sourcing, GPO and Hybrid are compared and discussed in terms of cost efficiency. But, during the course of the study, it came to our knowledge that one more type of procurement model is gaining acceptance in the healthcare industry. This model is the recent phenomenon of formation of “regional cooperatives”. In this model, multiple healthcare organizations which are in the close proximity geographically create a purchasing and logistics subsidiary, which is solely responsible for procurement operations to those healthcare organizations. Based on our interaction with the healthcare professionals, we could interpret that regional cooperatives generally drive high compliance rate and have contracts with local manufacturers. Contracting with local vendors and maintaining high compliance rate for the items might result in low costs and better distribution facilities and supply lines. They might also have better access to latest technologies in the industry through contracting with niche manufactures, and since multiple hospitals have shares in a regional cooperative, a large volume would help to drive costs low. It would be interesting to compare this procurement model with the three compared in this study as a future research study.

Future research can also involve actually comparing off-contract pricing with on-contract pricing for innovative items, as there would be several healthcare organizations where the physicians circumvent and procure their preferred products. Unfortunately, in this study, almost four healthcare organizations we worked with, had no way of accounting for off-contract purchasing, as they strictly enforce the compliance rate to drive costs low.

## REFERENCES

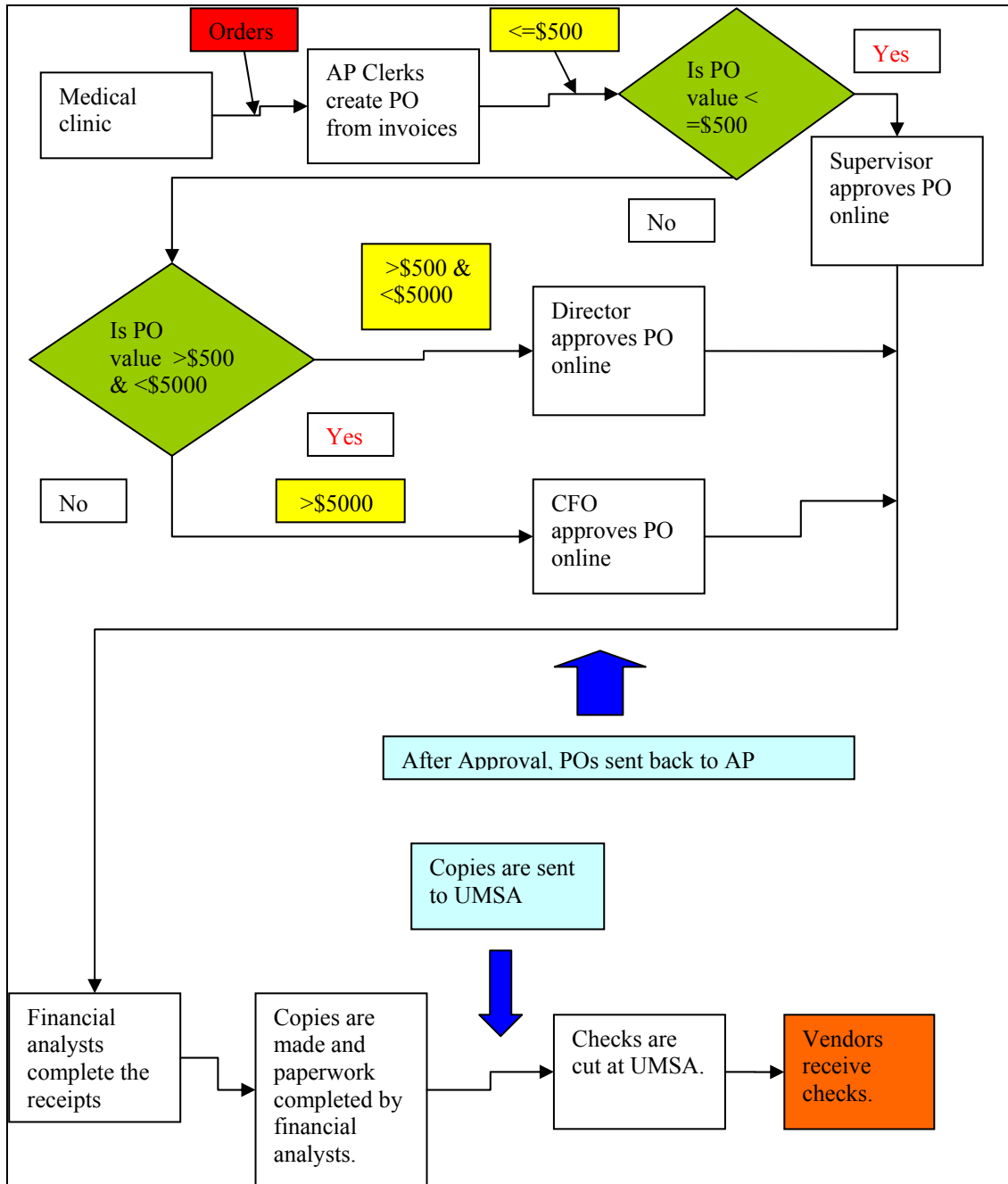
- Anderson, M. G., and Katz, P.B. (1998). "Strategic sourcing." International Journal of Logistics Management **9**(1): 1-13.
- Barlow, R. D. (2005). "Glancing back." Healthcare Purchasing News.
- Buganza, T. a. V., Roberto (2006). "Life-Cycle flexibility: How to measure and improve innovative capability in turbulent environments." The Journal of Product Innovation Management **23**: 393-407.
- Burns, L. R. (2002). "The Health Care Value Chain."
- Chapman, T. L., Gupta, A., Mango, P.D. (1998). "Group Purchasing is not a panacea for US Hospitals." McKinsey Quarterly **1**: 160-165.
- Cooper, W. W., Seiford, Lawrence M., Tone, Kaoru (2006). "Introduction to Data Envelopment Analysis and Its Uses."
- Dobler, D. W., and Burt, David N. (1996). "Test and Cases." Purchasing and Supply Management.
- Doucette, W. R. (1997). "Influences on Member Commitment Group Purchasing Organizations." Journal of Business Research **40**: 183-189.
- Elhauge, E. (2002). "The exclusion of competition for hospital sales through group purchasing organizations." unpublished.
- Essig, M. (2000). "Purchasing consortia as symbiotic relationships: developing the concept of 'consortium sourcing'." European Journal of Purchasing & Supply Management **6**: 13-22.
- Everard, J. L. (2005). "Defining and Measuring Hospital Product-Based Cost Savings."
- Gordon, T. J. (1994). "THE DELPHI METHOD." AC/UNU Millennium Project.
- Hendrick, T. E. (1997). "Purchasing Consortiums: Horizontal Alliances Among Firms Buying Common Goods and Services: What? Who? Why? How?"
- Hewitt, D. (1995). "The Consortium Option." Purchasing and Supply Management: 32.

- McFadden, C. D., and Leahy, Timothy M., (2000). US Healthcare Distribution.
- Muller, A., Liisa Valinkangas, and Merlyn, Paul (2005). "Metrics for Innovation: Guidelines for developing a customized suite of innovation metrics." Strategos, An International Strategic Management Consultancy.
- Nollet, J., and Beaulieu, Martin (2002). "The development of group purchasing: an empirical study in the healthcare sector." Journal of Purchasing & Supply Management.
- Nollet, J., and Beaulieu, Martin (2005). "Should an organization join a purchasing group?" Supply Chain Management: An International Journal **10**(1): 11-17.
- Rozemeijer, F. (2000). "How to manage corporate purchasing synergy in a decentralized company? towards design rules for managing and organizing purchasing synergy in decentralised companies." European Journal of Purchasing & Supply Management **6**(1): 5-12.
- Schneller, E. S. (2000). "The value of group purchasing in Health Care Supply chain."
- Sethi, P. (2006). "Group Purchasing Organizations: An Evaluation of their Effectiveness in Providing Services to Hospitals and Their Patients." HGPII Report, 07-20-06.
- Zweig, P. L., Zellner, W. (1998). "Locked out of the Hospital." Business Week **3569**: 75-76.

## APPENDICES

## APPENDIX A

### Process Map of Self Sourcing Model



## APPENDIX B

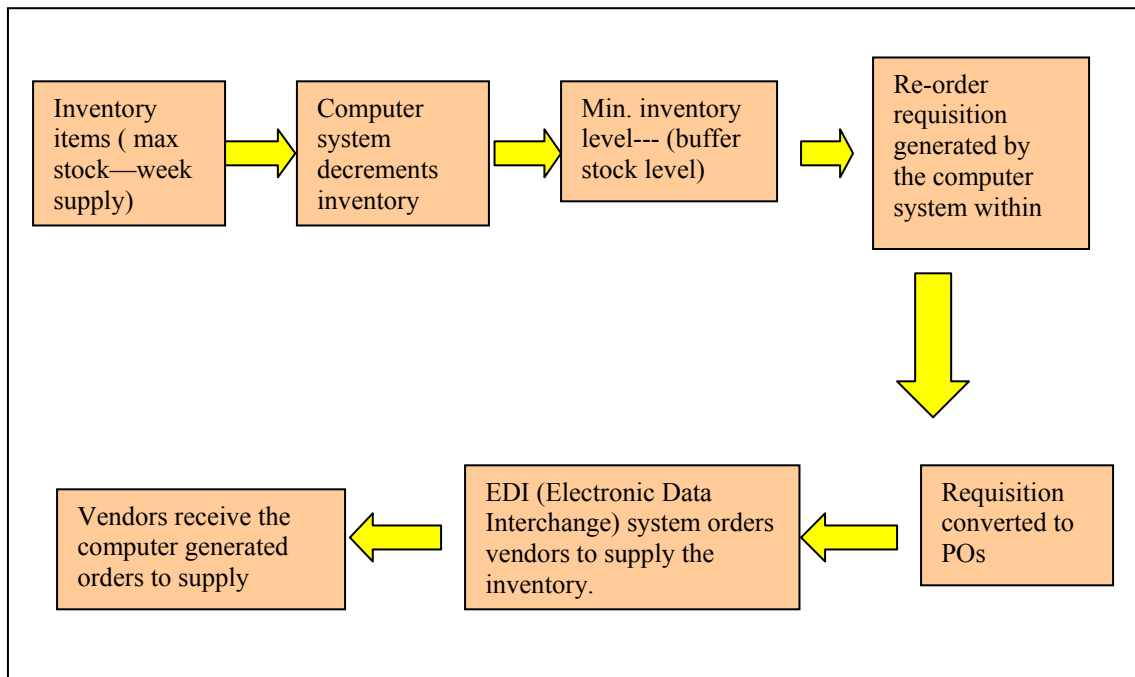
### Process Map of GPO Model

There are 4 kinds of items sourced by this GPO affiliated

1. Inventory Items (Frequently ordered and officially booked inventory)
2. Non-Inventory Items:
  - a. Non Stocks----Not officially booked inventory (Not in the ledger, frequently ordered)
  - b. Special Items----- Not officially booked inventory (infrequently accessed).
3. Services.

### Process- Maps:

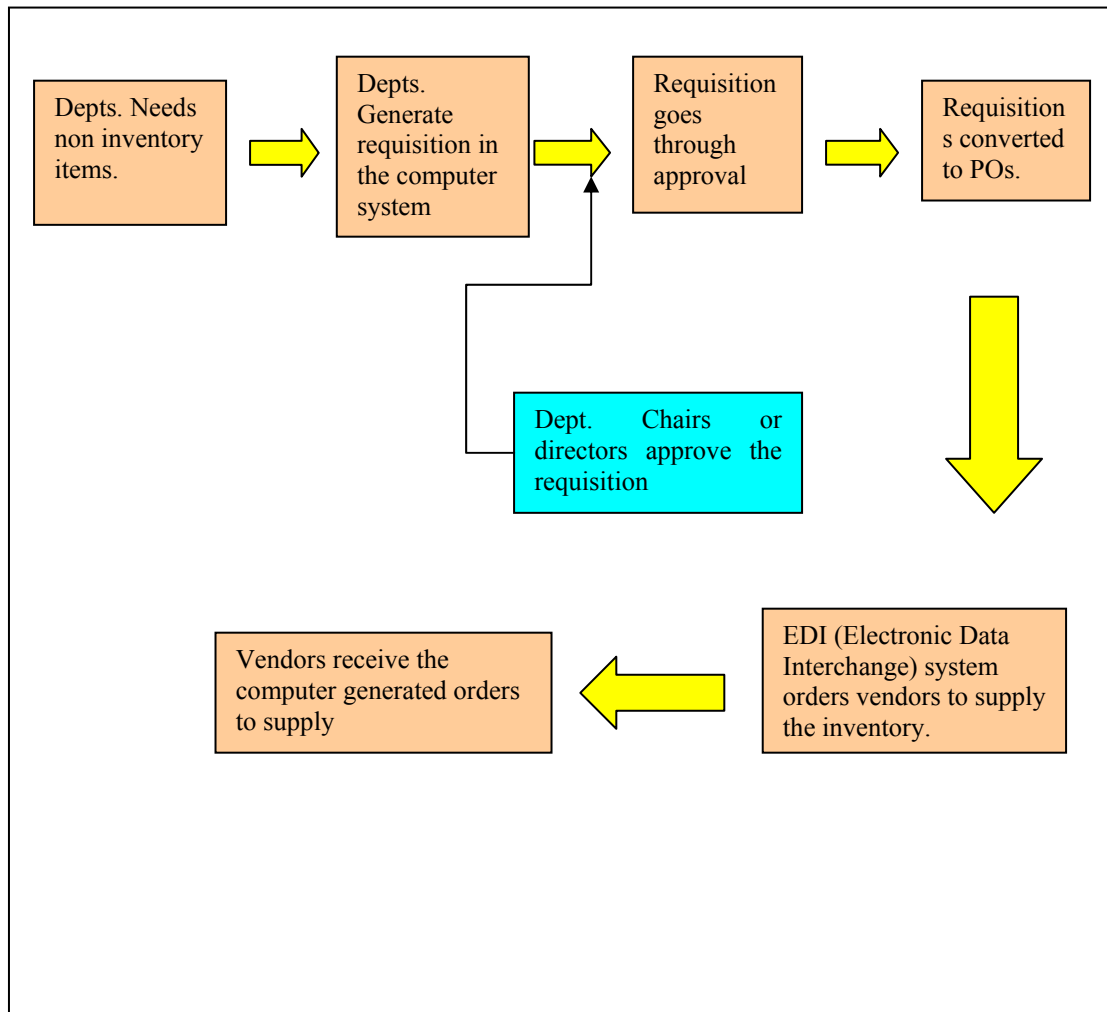
1. Inventory Items





## APPENDIX B (CONTINUED)

### 2. Non Inventory Items



## APPENDIX C

### Process Map of Hybrid Model

