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# NAVAL POSTGRADUATE SCHOOL Monterey, California



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A SUPPLY ALLOCATION AND OPTIMIZATION MODEL  
FOR THE U.S. MARINE CORPS  
INTERMEDIATE SUPPLY LEVEL

by

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December 1992

Thesis Advisor

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A Supply Allocation and Optimization Model  
for the U.S. Marine Corps  
Intermediate Supply Level

by

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Submitted in partial fulfillment of the  
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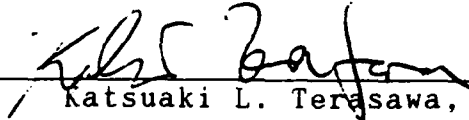
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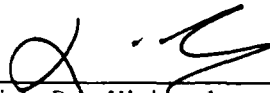
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## ABSTRACT

As spending cuts for defense intensify, the Marine Corps must try to maximize its readiness with a reduced budget. Replenishment supplies and parts stocked at the U.S. Marine Corps intermediate supply level are currently stocked according to historical usage data and Combat Essentiality-Criticality Codes (CECs). However, this system may not result in maximum readiness. Items with the same CEC may differ in the degree to which they contribute to combat readiness, and historical demand is not necessarily an indicator of item importance. This thesis presents a model which demonstrates a theory for allocating funds for supplies and parts at the intermediate supply level subject to a budget constraint, based upon weighted essentiality values for inventory items. Analysis of the model shows that, given a budget reduction, a proportionate allocation policy is the optimal policy to pursue after steady state consumption is reached. The model analysis will also provide a basis for further research into readiness-oriented stockage.

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## I. INTRODUCTION

### A. BACKGROUND

As the 21st century approaches, the armed forces of the United States are facing a future that offers little certainty beyond the fact that there will be less money available for a new, and perhaps more complex, era in defense. With such challenges in mind, the Department of the Navy developed its Strategic Goals, which begin with a vision for the future:

We, the leaders in the Department of the Navy, will optimize the effectiveness of the Navy-Marine Corps team by leading our people and managing our systems as an integrated force within a quality-focused organization. We will work to influence our future by translating our vision, mission, and guiding principles into goals, strategies, and actions so that resources and improvements are aligned with the same intent. [Ref. 1:p. 1]

At each level there is opportunity to "optimize the effectiveness" to get the most out of every defense dollar spent. From the perspective of a Marine Corps infantryman, whose ultimate mission is to achieve victory over the enemy, maximum effectiveness means having the equipment required to complete the mission. The infantryman is the foundation of the Marine Corps; therefore, the ultimate mission of the Marine Corps Supply System is to provide to the infantryman *what* is needed, *when* it is needed, and *where* it is needed [Ref. 2:p. 5].

The Marine Corps operates a supply system that is separate and distinct from the other services [Ref. 3: p. 1-1-2]. Within that system is the intermediate level of supply which supports a defined geographic area and specific organizations or activities [Ref. 4:p. v]. Currently, the replenishment supplies and parts stocked at the intermediate level are stocked according to historical usage data and Combat Essentiality-Criticality Codes (CEC) [Ref 4:p. 1-7]. This thesis examines this system and analyzes how it might be modified to reflect a more readiness-oriented posture.

One drawback in the current system is that although the combat essential items do not require a demand level as high as the non-combat essential items in order to be stocked, they still will not be stocked unless they satisfy the minimum demand level. Therefore, readiness could be adversely affected if an essential item is not on hand when needed. Conversely, stocking a high-demand item which is *not* combat essential may consume a significant portion of scarce funds.

A second area of concern is the difficulty in evaluating how well the intermediate level supply system is performing in relation to readiness. Although there are several performance measures applied to the intermediate level supply points, there is no explicit correlation between performance measures and readiness (or operational availability).

Finally, although the current system is intended to stock items so that they are available when required for use with



minimal delay between the intermediate supply level and the end user, this system is not necessarily designed to maximize readiness.

## B. THESIS OBJECTIVE

This thesis presents a model which demonstrates a theory for allocating funds for supplies and parts at the intermediate supply level, subject to a budget constraint. Analysis of the model will produce a working hypothesis which states that, given a budget reduction, a proportionate allocation policy is the optimal policy to pursue after steady state consumption is reached.

An important element in the model is a weighted value assigned to each stock item, based upon combat essentiality and criticality. The model analysis will provide a basis for further research into readiness-oriented stockage and measures of effectiveness.

## C. SCOPE OF THESIS

This thesis examines the Marine Corps intermediate level supply system and stockage criteria, analyzing it in terms of its orientation towards readiness. The focus is on demand-supported items, stocked at Supported Activities Supply System Management Units (SMUs). This thesis does *not* examine:

- Stocked insurance items;
- Critical low density items;
- Stocked numeric items;

- Stocked provisioning items:
- Stocked prepositioned war reserve materiel.

#### D. THESIS OVERVIEW

This thesis continues with the following chapters.

Chapter II is an overview of the Marine Corps supply system and the intermediate level supply management policy. It discusses combat essentiality-criticality codes and performance measures of effectiveness.

Chapter III presents a myopic supply allocation and optimization model. The results from the model are compared with a simulated steady state to demonstrate how the model functions over time. Chapter III concludes with a discussion of a proportionate supply reduction policy given a budget reduction.

Chapter IV concludes the thesis with a summary of the findings and recommendations regarding further research into how the Marine Corps might use these conclusions.

## II. MARINE CORPS INTERMEDIATE LEVEL SUPPLY MANAGEMENT

This chapter acquaints the reader with the intermediate supply level. The chapter proceeds with the following sections:

- A. Organization and Operations
- B. Combat Essentiality-Criticality Codes
- C. Performance Measures of Effectiveness

### A. ORGANIZATION AND OPERATIONS

The Supported Activities Supply System (SASSY) Management Unit (SMU) is the intermediate supply activity that supports Fleet Marine Force (FMF) units and holds most of the *intermediate-level* of inventory for its geographic area. "The intermediate-level of inventory is an inventory regardless of funding source, that is required between the consumer and wholesale-levels of inventory for support of a defined geographic area." [Ref. 3:p. 2-1-6] The SMU is considered the hub of supply matters within the FMF.

The SMU manages its inventory with a computer-based system known as the Supported Activities Supply System (SASSY). SASSY is used throughout the Fleet Marine Force and selected base units. It is "a centralized record-keeper, stock manager, forecaster...and central data bank or information point for the using units...." [Ref. 3:p. 1-1-6] The

computer-produced documentation facilitates receiving, issuing, and accounting for material throughout the FMF [Ref. 4:p. 1-1-6]. SASSY also generates an extensive range of management reports which provide total "asset visibility on an item quantitative basis for all elements within a MEF [Marine Expeditionary Force]", aiding the FMF Commander in resource allocation [Ref. 3:p. 2-1-17]. These reports are applicable at all levels of management--operational level (battalions and squadrons); intermediate level (Division, Wing and Force Service Support Group), Fleet Marine Force headquarters; and top level (Headquarters Marine Corps (HQMC)).

The SMU is located within the Supply Company of the Force Service Support Group (FSSG) (see Figure 1). The FSSG is responsible for supply support to itself, the air combat element, the ground combat element, and the command element. The SMU within the FSSG links the integrated material managers at the various Inventory Control Points (ICPs) with the supported units of the Fleet Marine Force (FMF). [Ref. 3:p. 2-1-7]

The SMU inventory consists of a wide variety of supplies and parts for issue to using units. To maintain its stock at prescribed inventory levels, the SMU adheres to Headquarters Marine Corps stockage policy and replenishes its stocks from various agencies at the *wholesale inventory level*. The *wholesale inventory level* is defined as an inventory "...regardless of funding source, over which an inventory

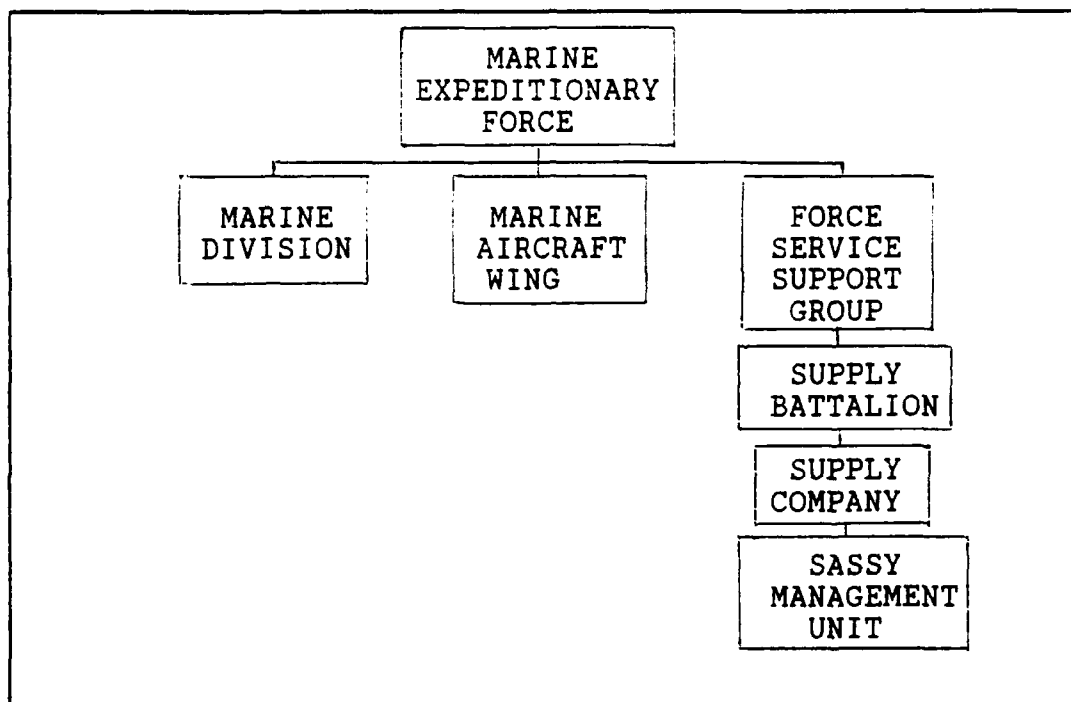


Figure 1. Organization

manager at the inventory control point has asset knowledge and exercises unrestricted asset control to meet worldwide (DOD/Service) inventory management responsibilities." [Ref. 4:p. v] The SMU interacts with several agencies including the Defense Logistics Agency, the General Services Administration, other services, and the Marine Corps Inventory Control Point (ICP) at Albany Georgia [Ref. 3:p. 1-1-8].

The Marine Corps ICP is the central supply processing point for the Marine Corps Supply System. Among other functions, the ICP is responsible for providing the Combat Essentiality/Criticality Codes (CECs) to the SMUs. The ICP is also responsible for updating the various programs used by the SASSY system. The program modifications are sent from Albany

to the SMU. where the SASSY program files are updated. [Ref 3:p. 2-1-13]

The supported units or using units at the *consumer-level* of inventory include the various battalions and squadrons. The consumer-level of inventory is "an inventory, regardless of funding source, usually of limited range and depth, held only by the final element in an established supply distribution system for the purpose of internal consumption" [Ref.4:p. v]. Battalions and squadrons are the end users of the inventory. Located within the Marine Division (ground combat element), the Marine Air Wing (air combat element), or the Force Service Support Group (support element), they are the final element in the supply distribution system [Ref. 3:p. 2-1-19].

The SMU is subject to fiscal constraints based on the annual budget appropriated and allocated for operating the Marine Corps. Therefore, the SMU's budget fluctuates with the annual Marine Corps budget. Funds are allocated to the intermediate-level on a quarterly basis and budgeted for an entire year. The funding for the SMU is allocated from an appropriated account, the Operations and Maintenance Marine Corps (O&M,MC) account [Ref. 3:p. 2-1-20]. The SMU receives Planning Estimate funding that corresponds to the Requisitioning Authority of units supported by the SMU.

## B. COMBAT ESSENTIALITY-CRITICALITY CODES

In July 1991, the Marine Corps converted its stockage policy from historical demand and item cost based to demand and Combat Essentiality-Criticality Codes (CECs) based. By giving stockage priority to items essential to operational readiness, this policy helps decision makers consider readiness in allocating funds. This section will first discuss the assignment of the CECs and then the application of the policies.

### 1. Assignment of USMC Combat Essentiality-Criticality Codes

When a new weapons system is being procured, many aspects of system supportability are considered at the beginning of the procurement cycle, from Mission Requirements Analysis to System Phase out. As the weapon system moves through the various phases of the acquisition process it also undergoes logistic support analysis (LSA), "...an iterative analytical process by which the logistic support necessary for a new system is identified and evaluated." [Ref. 5:p. 14] A code, called Essentiality Code, is derived from the Logistics Support Analysis Record (LSAR). It is defined as "A code to indicate the degree to which the failure of the part affects the ability of the end item to perform its intended operation." [Ref. 6] The contractor provides the various essentiality codes to the Department of Defense during the procurement process. The codes are as follows:

#### CODE DEFINITION

- 1 Failure to this part will render the item inoperable.
- 3 Failure to this part will not render the end item inoperable.
- 5 Item does not qualify for assignment of code 1 but is needed for personnel safety.
- 6 Item does not qualify for assignment of code 1 but is needed for legal, climatic, or other requirements peculiar to the planned operational environment of the end item.
- 7 Item does not qualify for assignment of code 1 but is needed to prevent impairment of or the temporary reduction of operational effectiveness of the end item. [Ref. 6]

The Marine Corps policy is to further define an end item as combat essential or non-combat essential, define the criticality of the repair part to the end item, and assign a combat essentiality-criticality code. Combat essentiality-criticality codes are assigned to all other classes of supply as well. These codes are as follows:

#### CODE DEFINITION

- 0 Noncombat Essential End Item. End items that do not fit the definition code items.
- 1 Combat Essential End Item. End item equipments whose availability in a combat ready condition is essential for execution of the combat and training missions of the command.
- 2 Noncritical Repair Part. Repair parts or major components whose failure in an end item will not render the end item inoperative or reduce its effectiveness below the minimum acceptable level of efficiency, and which do not fit the definition of Code 3 or 4 items.



- 3 Critical for Health and Safety of Personnel. Those parts and components that are required for the health and safety of personnel, and which do not fit the definition of Code 5 or 6 items.
- 4 Critical for State and Local Laws. Those parts and components that are required for conformance to state law or local ordinances, and which do not fit the definition of Code 5 or 6 items.
- 5 Critical Repair Part to a Combat Essential End Item. Those parts or components whose failure in a Combat Essential end items will render the end item inoperative or reduce its effectiveness below the minimum acceptable level of efficiency.
- 6 Critical Repair Part to a Noncombat Essential End Item. Those parts or components whose failure in a noncombat essential end item will render the end item inoperative or reduce its effectiveness below the minimum acceptable level of efficiency. [Ref. 3:p. 4-6-31]

The contractor provides essentiality codes to the Marine Corps on LSAR tape when the item is procured. The Marine Corps loads the tape to a part of its computer system called Subsystem-10 (provisioning). The essentiality codes are converted to the Marine Corps Combat Essentiality-Criticality Codes, then entered into the Supported Activities Supply System (SASSY), for use in demand-based stocking of repair parts at the intermediate level. [Ref. 7]

## 2. Application of Policies

The current stockage policy for demand-supported items for an operations and maintenance Marine Corps (O&MC) funded activity is as follows:

- (1) Three recurring demands (issues) in 12 months are required to stock an item if the combat essentiality code (CEC) is 5 or 6. A minimum stock level (RO = 5, ROP = 3) will be established for items in this category.

(2) Six recurring demands (issues) in 12 months are required to stock an item if the CEC is other than 5 or 6. A minimum stock level (RO = 2, ROP = 1) will be established for items in this category.

(3) Once a demand-supported RO is generated, the RO will not be deleted until it fails to meet stockage criteria for a twelve month period. [Ref. 4:p. 1-7]

This stockage criteria places emphasis on CEC 5 & 6 items. If an item receives three demands in a 12-month period the item will be stocked with a requisitioning objective of five and a reorder point of three. CEC 0, 1, 2, 3, and 4 items must have six demands in a 12-month period in order to be stocked at the intermediate level. Therefore, an item that is CEC 5 or 6 is more likely to be stocked than an item that is CEC 0, 1, 2, 3, or 4.

However, there may be items that are very essential (CEC 5) but have less than three demands in a 12-month period. To prevent an out-of-stock situation on an essential item, it might be better to establish a minimum requisitioning objective (RO) of one for such items, even if it means reducing the RO for an item with a CEC of 2, 3, or 4 that has six demands per year.

In addition, the present system makes no distinction between items in each CEC as to their relative contribution to readiness, or which ones contribute to readiness in the most effective way. For example, a vehicle seat cushion, national stock number (NSN) 2540-01-313-0678, costing \$32.42 and a set of glow plugs, NSN 2920-01-188-3863 costing \$4.89, are combat

essential (coded CEC 5) [Ref. 8]. A marginal stock reduction of one seat cushion would allow a marginal increase of 6.63 sets of glow plugs, a part required for the operation of diesel engines. In a hypothetical combat situation, stocking one less seat cushion could allow stocking enough glow plugs to keep the vehicles running. In other words, some items might be considered "more" combat essential than others. This indicates a need for a more definitive ranking system between various NSNs.

Given the assumptions that battalion commanders and using unit supply officers are making the best possible supply decisions, but that funding will be increasingly inadequate, achieving maximum readiness will depend upon identifying which items contribute most to readiness. The following hypothetical example illustrates the tradeoffs which will be required as budget cuts intensify. It also illustrates the need for a more definitive ranking system for supplies and repair parts.

A unit is scheduled to go to training at the Marine Corps Air Ground Combat Center at Twentynine Palms, California. The unit has several vehicles with broken mirrors. The mirrors are coded CEC 3. If the mirrors are out of stock when the scheduled training date arrives, what is the impact on overall readiness? Although the vehicles are not *combat-deadlined*, they are *safety-deadlined* (they cannot drive on the highway to Twentynine Palms). Therefore, readiness is reduced because of the inability to accomplish the scheduled training

using the vehicles. In a combat situation it is easy to see why glow plugs are CEC 5 and mirrors are CEC 3. Yet, to be *totally* effective--and training is a part of total effectiveness--the mirror and the glowplugs are both important. CEC 5 items *must* be stocked for combat readiness. CEC 3 items *should* be stocked because they are essential for health and safety, but CEC 2 items (a sword and scabbard, for instance) *needn't* be stocked if doing so results in inadequate funding for more essential items.

If funds are reduced to the point where difficult choices must be made, a definitive ranking system will help with these choices. There are many areas competing for funds and many conflicts when discussing what is combat essential. However, the reality of today's military situation is that the budget has been reduced and will be further reduced. Decisions now must be made about what is *absolutely* combat essential. The current problem is that everything coded CEC 5 is considered equally important, with demand being the only discriminator. Furthermore, it is not clear how much more important CEC 5 is over CEC 4, or 3, etc.

### 3. Weighted Value

A weighted value system entailing more detailed divisions among all Combat Essentiality-Criticality Codes could better differentiate between the importance of the NSNs as they relate to readiness. The supply allocation and optimization model requires a value between 0.01 and 0.99, with 0.01

indicating the lowest contribution to combat readiness and 0.99 indicating those items absolutely essential to combat readiness. It is not within the scope of this thesis to determine how these weights should be assigned; rather, the model will demonstrate the application of the weighted value in the allocation of funds.<sup>1</sup> One intent of weighting the various NSNs would be to increase the stock level of those items considered most critical to readiness. The net effect would be a reduction in the probability of a critical item being out of stock, and a corresponding increase in the probability of a non-critical item being out-of-stock, all other things remaining equal. This concept will be illustrated in the model. It also leads to a discussion of measuring readiness based upon the probability of an item being out-of-stock.

### C. PERFORMANCE MEASURES OF EFFECTIVENESS

#### 1. Introduction

Determining appropriate measures of effectiveness (MOEs) for the intermediate level supply points is a complicated task. As MOEs are designed to better represent the ultimate objective (readiness), "...the amount and type of data required to compute the MOEs increases, the mathematics

---

<sup>1</sup>For a further discussion on essentiality weighting and the complexities involved, see *Essentiality Weighting Models For Wholesale Level Inventory Management* by Robert L. Schwaneke, Naval Postgraduate School Masters Thesis S375115, December 1988.

become more complex, and the cost of obtaining the measurement increases." [Ref. 9:p. 43]

In addition, as decision variables change to improve one MOE, another may worsen. The most significant conflicts are "...between the MOE's which represent cost (which we wish to minimize) and the MOE's which represent customer service (which we wish to maximize)." [Ref. 9:p. 43] For instance, to provide the rapid supply support that units want, intermediate supply inventory levels must be increased. The desirable rise in the customer service MOE is accompanied by an undesirable increase in costs (storage costs, ordering costs, etc.).

The Marine Corps Intermediate Supply Policy Manual does not define any specific "measures of effectiveness," but rather provides broad policy guidance for "effective" stockage:

1. Secondary item stockage for the intermediate-level of supply shall provide optimum stockage for each material category by incorporating a balance between performance and economy with consideration of military essentiality.

2. Stockage computations shall employ actual demand history as the primary basis for stockage. The construction of stockage levels will be based on a combination of operating level (OL), actual order/ship time (OST) or procurement lead time (PLT), when available, and defined safety levels. This method of computing stockage levels should minimize total variable costs for any given supply performance or investment objectives." [Ref. 4: p. 1-3]

At the intermediate supply level in the Marine Corps, "measures of effectiveness" can be derived from the reports

produced by the Supported Activities Supply System (SASSY). Some of these measures are oriented toward performance effectiveness and can be applied to the operation of the SASSY Management Unit. A key issue to examine is what information these performance measures actually provide to the decision maker. Selected measures of effectiveness from the United States Navy Supply System will be used as a basis for analyzing the measures derived at the SMUs. To accomplish this, the remainder of this section will proceed as follows:

2. Current Measures of Effectiveness (Navy)
3. Measures of Effectiveness for the Future (Navy)
4. Current Measures of Effectiveness Used by the Intermediate Supply Level (Marine Corps)
5. Readiness Measurement

2. Current Measures of Effectiveness (Navy)

Some of the MOEs currently used at different levels in the Navy supply system are:

**System Material Availability (SMA)** SMA, a customer service measure for the wholesale level, is defined as the percent of requisitions which are satisfied on the first pass against system assets.... It is computed as follows:

$$SMA(\%) = 100 \times \left[ 1.0 - \frac{\text{Backorders Established} + \text{DVDs Established}}{\text{Demand}} \right]$$

or, alternatively as:

$$SMA(\%) = 100 \times \left[ 1.0 - \frac{MOE}{\text{Demand}} \right]$$

The current Navy goal for wholesale SMA is 85%.  
[Ref. 9:p. 44]

**Gross Effectiveness** - The percent of total requisitions, for both stocked and non-stocked items, received and satisfied from stock on hand at any given echelon of inventory. Gross effectiveness is mainly used by the stock points and the retail consumer level supply departments as a measure of customer service. [Ref. 9:p. 44]

**Net Effectiveness** - The percent of total requisitions, for stocked items, received and satisfied from stock on hand. Again, the stock points and retail consumer levels use this as a measure of customer service. [Ref. 9:pp. 44]

**Miscellaneous Measures of Effectiveness** - Some miscellaneous MOEs used by supply system decision makers include the following:

- Average days to stow receipts at a stock point.
- Warehouse refusal rate at a stock point.
- Inventory accuracy audit results. [Ref. 9:p. 45]

What information do these various measures of effectiveness provide? They tell the decision maker how well the Navy's inventory system is working, but not necessarily how well it is helping to improve readiness. The inventory system may be working according to these measures but not maximizing readiness.

### 3. Future Measures of Effectiveness (Navy)

This section describes some MOEs that will be applied to evaluate the supply system in the future, according to NAVSUP Publication 553 - Inventory Management [Ref. 9:p. 45]. These MOE's are directed towards readiness by focusing on the expeditious delivery of supplies to the end user. The following MOEs are being developed or used by the supply system:

a. **Operational Availability (A<sub>o</sub>)** A<sub>o</sub> is the official Navy measure of weapon system performance. It is a measure of readiness and as such provides an indicator of hardware.



fleet and total supply system performance.... $A_0$  is the probability that a system or equipment called upon under stated conditions in an actual environment, will operate satisfactorily....In concept the formula for  $A_0$  is:

$$A_0 = \frac{UPTIME}{UPTIME + DOWNTIME}$$

In Navy use the formula for  $A_0$  is:

$$A_0 = \frac{MTBF}{MTBF + MTTR + MSRT}$$

where:

MTBF = Mean time between failures  
MTTR = Mean time to repair  
MSRT = Mean supply response time.

Operational availability is used to assist in the weapon system and major end item design process. It is also used in the creation of some shipboard allowance lists. Eventually,  $A_0$  may be incorporated in some inventory requirements determination models. [Ref. 9:pp. 45-46]

b. Mean Supply Response Time (MSRT) From the operational availability formula it is simple to observe that any reduction in the MSRT will increase  $A_0$ . MSRT will be used very soon for wholesale level provisioning and may be used in the more distant future for wholesale requirements determination. [Ref 9:p. 46]

c. Average Customer Wait Time (ACWT) A primary performance measure linking supply responsiveness to operational requirements....ACWT represents the average time required in the supply system to satisfy maintenance related demands, regardless of whether the demand was for a stocked or non-stocked item....ACWT is ultimately expressed in hours. It depends on other performance measures (i.e., requisition processing times, gross availability at retail and wholesale levels and required transportation times). Shortfalls in availability at one echelon of supply may be compensated for by higher availability in another echelon. [Ref. 9:p. 46]

#### 4. Intermediate Level Measures of Effectiveness (USMC)

Although there are no *specific* MOEs defined as such in the SASSY Management Unit Procedures Manual (UM-4400-123),

some data items from the SASSY reports are considered and used as performance measures by the SMUs. This section will explain some of these items, as taken from two daily reports: the Balance Analysis GABF and the General Account Performance Report.

**Balance Analysis GABF** - provides the supply officer/commanding officer and general account manager with a report of the stock status of the using unit/general account to include the total number of line items and their dollar value, total assets on hand, due in, and excess. A separate report is provided for SAC 1, 2, and 3. [Ref. 3:p. 4-4-23]

**General Account Performance Report** - provides the general account manager with a daily summary to date for the month of statistical data and dollar values. The data is oriented toward performance measurement. The report is provided daily and cumulatively. [Ref 3:p. 4-4-71]

The following are just a few of the many data items from these reports which are monitored at the SMUs:

**% Complete Fills:** Total number of issues divided by total demands times 100 (Gross Effectiveness in the Navy)

**% Complete RO Fills:** Total complete RO fills divided by total RO demands times 100 (Net Effectiveness in the NAVY)

**Warehouse Denials:** Number of items that are listed on the balance file that a material release order was cut for and the item could not be located in the warehouse. (Warehouse Refusal Rate in the Navy)

**Number of Days to Stow Receipts:** Number of days required to stow receipts from date received to date processed (Date processed - item is added to the balance file). (Average days to stow receipts in the Navy)

**Value Inventory Gains:** The total dollar value of inventory gains since the last update.

**Value Inventory Losses:** The total dollar value of inventory losses since the last update.

Examining these data items raises an important question: how is the effectiveness of the various SMUs measured? Are the SMUs evaluated on the basis of fill rate? By inventory accuracy? By fewest warehouse denials? The list of possibilities is as long as the list of data items in the management reports. They are all measures of how the SMU performs its internal operations. They are all factors that effect the SMU and are all eminently important to the "efficient" operation of the SMU. However there is no *direct* correlation between these measures and readiness or the "effectiveness" of the SMU. For example, if inventory accuracy is poor, a much-needed part may be lost in the warehouse; an inefficient operation. However, inventory accuracy may be very good but the supplies and parts that are stocked may not reflect the *best* use of funds as far as overall readiness is concerned. The SMU may be operating very *efficiently* but its *effectiveness* as it contributes to readiness might be improved.

SASSY does not furnish any systematic report providing information on which items are combat deadlined, and what repair parts are causing items to be deadlined. When a using unit has deadlined principal end items because a part is out of stock, the unit orders the item at the highest priority level. If the part is not received within specified time frames, the unit supply officer usually reconciles the status of outstanding orders with the Customer Service Section of the

SMU. This is often the first indicator for the SMU that items which are backordered, or not stocked, are adversely affecting readiness.

The reconciliation process initiates further action to expedite the receipt of the NSNs in question. The Customer Service section notifies the General Account of deadlined principal end items and the NSN's affecting those end items. The General Account section researches the problem and upgrades the priority of the replenishment requisition (if this has not already been done) in order to expedite the process, or takes alternative action as deemed appropriate, i.e., sending a message directly to the Integrated Materiel Manager.

A method which aids this process is to write a computer program which reviews the Marine Corps Integrated Maintenance Management System (MIMMS) files to check for deadlined items and to determine which NSNs are the cause. This procedure is set up internally within the SMU. It reveals whether an NSN is backordered and the status of the requisition for the part. The NSN might be backordered because of delays in receiving the item or because the item was not stocked due to minimal demand. As stated before, the parts and supplies stocked by the intermediate level supply points are those items that are used by the FMF units for their required missions based on a prescribed policy of historical demand and combat essentiality-criticality codes.

One performance measure of effectiveness (MOE) that is commonly used to evaluate performance at the intermediate level supply points is "fill rate." This is similar to the Gross Effectiveness measure in the Navy. Fill rate is the number of requisitions filled divided by the number requisitions received on a daily basis, multiplied by 100. However, this performance measure does not directly correspond to operational readiness, (i.e., availability of weapon systems located in units supported by the intermediate level supply points). It is simply a percentage that tells the intermediate level supply manager that at a particular time a certain percent of supplies and repair parts were available and issued. The intermediate level supply points may have a high "fill rate" but the using units may not have an acceptable operational readiness due to less than optimal supply support. The opposite may also be true: units may have high operational readiness but the fill rate at the intermediate level may be low. The ideal condition may exist as well: a high "fill rate" and high operational readiness. There is a clear need for a measure that is more indicative of how supply support performance actually relates to readiness and how the Marine Corps can best allocate its scarce resources to insure the infantryman can complete his mission.<sup>1</sup>

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<sup>1</sup>For a thorough analysis of measures relating to readiness, see *United States Marines Corps Provisioning Measures of Effectiveness* by Joseph D. Cassel, Jr., Naval Postgraduate School Thesis C27727, December 1987.

The Rand Corporation conducted a research project sponsored by the Department of the Navy. One of the resulting documents, "Enhancing Integration and Responsiveness in Naval Aviation Logistics: Spares Stockage Issues," summarizes the implications of using fill rate as a performance measure.

Fill rates...are used as goals; and they are used as measures of system performance. The fill rate measure is typical of functionally oriented measures. It is only indirectly related to readiness and sustainability. Although it is a simple measure and easily understood, it is not especially meaningful outside the supply system. More important, it is not *operationally* meaningful. . . . *Weapon system availability* [readiness], on the other hand, . . . does measure very directly the end product of the logistics system: mission capable aircraft. Thus, it is a more ultimate measure of system performance.... Moreover, it accounts explicitly for weapon system complexity.... To the extent that the relationships between fiscal resources and military readiness are important at the budget table, fill rates may fail and weapon system availability rates succeed in motivating the appropriate investment decision...weapon system availability rate ...focus management attention on a more ultimate output of the system than simply its efficiency in filling requisitions. Thus we argue in favor of the use of weapon system availability rates as objective functions...and as goals and performance measures.... [Ref 10:p. 9]

#### 5. Readiness Measurement

Supply support is related to readiness as follows:

$$\text{READINESS} = 1 - \text{PROBABILITY}(\text{NOT-IN-STOCK})$$

This is, of course, a much simpler readiness measure than the Navy measure of weapon system performance ( $A_0$ ). It is intended to measure supply system performance only, without regard to maintenance support, administrative support, etc. Therefore, throughout the remainder of this discussion, the

term readiness refers to readiness in terms of supply support only.

One can see that in order to have 100% readiness there must be a 0% probability of a stockout for a critical item.

$$PROBABILITY(NOT-IN-STOCK) = 1.0 - 1.0 = 0$$

Because it is not within the scope of this thesis to calculate the probabilities of an item being out of stock (based on quantities on hand, order ship time, expected receipts, failure rates, etc.,) this discussion will be limited to the probabilities at the two extremes: 0% and 100%.

If a part on a weapon system fails, readiness is directly related to the probability that either the repair part is on hand or can be instantaneously obtained from the supply support agency. This formula only measures availability for one specific item. Readiness must consider the impact a specific item has on an entire unit. For example, if a tank company had 14 tanks and one tank was deadlined because a gun tube was NIS, then the percent of assets deadlined would be:

$$\% ASSETSDEADLINED = \frac{PROBABILITY(NIS)}{\# ASSETS} = \frac{1}{14}$$

Then:

$$READINESS = 1 - \% ASSETSDEADLINED \rightarrow$$

$$1 - .0714 = .9286$$

Therefore, the company would have 92.86% readiness level. In order to increase a readiness level, the stock level must be increased such that the corresponding decrease in the probability of NIS would yield the desired readiness level. As discussed in the preceding section on combat essentiality-criticality codes, this may involve a decrease in the stock levels of items considered less essential. This concept will be illustrated in the supply allocation and optimization model.

The lead time necessary to obtain the gun tube is a factor in valuing the cost of the deadlined tank as repair-in-process (i.e., if in repair-in-process, then it is not ready). If the cost of the deadlined tank is  $\$R$  a day in readiness and lead time is 30 days, the cost of not having the tank (the cost of decreased readiness) is  $30 \times \$R$ .<sup>3</sup> By reducing the lead time to 10 days the inventory of repair-in-process would decrease by  $20 \times \$R$  while supply support cost would increase by the actual holding cost of the gun tube. Therefore an increase in stock level decreases repair-in-process. To summarize, throughput is increased by decreasing the inventory of repair-in-process, although the inventory of spare parts is

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<sup>3</sup>A key issue at this point is determining the dollar value of a tank, or any other weapon system, that is not ready. In a market economy, the cost of not having enough supplies on hand can be determined easily, i.e. lost customers, lost sales, etc. In defense matters, however, the dollar value of readiness is very difficult to quantify.



increased. The ultimate goal of this concept is to decrease the lead time at all levels of supply.

From intermediate level supply to using unit tank battalion, lead time is usually about 2 days, assuming the part is in stock at the intermediate level. If the lead time is reduced at any supply level then operational readiness will increase by reducing of the repair-in-process and the aggregate inventory of deadlined tanks.

As already stated, to have 100% readiness based on supply support there must be 0% probability of NIS for all repair parts. One can assume, however, that *all* the required parts cannot be stocked because it would be cost prohibitive.

Too much inventory may ideally respond to the demand for spares. However, this may be costly, with a great deal of capital tied up in the inventory. In addition, much waste could occur, particularly if system changes are implemented and certain components become obsolete. On the other hand, providing too little support results in the probability of causing the system to be inoperative due to stock-out, which also can be costly. [Ref. 5:p. 61]

Therefore, the problem is: what is the most effective way to stock repair parts at the intermediate level to maximize readiness (minimize probability of NIS), given a budget constraint?

### III. SUPPLY ALLOCATION AND OPTIMIZATION MODEL

#### A. DESCRIPTION AND DEMONSTRATION

The supply allocation and optimization model<sup>4</sup> is designed to allocate 100% of the available resources to purchase supplies and parts in a manner which maximizes what economists refer to as "utility." Utility is a measure of the level of satisfaction received by consuming a particular combination of goods and services [Ref. 11:p. 131].

In the Marine Corps, the battalion commanders have a variety of assets at their disposal which, when combined, provide the "capability" to accomplish a mission. The effectiveness of the Marine Corps is a function of its capability. An infantry battalion commander has some men armed with rifles, some with mortars, some with machine guns, some with radios, etc. A tank battalion commander, on the other hand, has tanks and sufficient men and support equipment to maintain a given capability. Whatever the form, this capability is the commander's most important asset. Resources should be allocated to attain the highest possible capability within the given budget constraint.

In this model, utility represents capability. The model works under the assumption that a weighted value between 0.01

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<sup>4</sup>Model developed by Professor Katsuaki Terasawa, Adjunct Professor of Economics and Policy Analysis, Naval Postgraduate School, 1992.

and 0.99 is assigned to each NSN in the supply system as previously discussed. To demonstrate the model so that it may be graphically illustrated, only two NSNs are used; however, the concept remains the same for any number of NSNs.

The concept behind maximizing utility is that there exists a combination of NSNs which provides the greatest possible utility within a specific budget constraint. To determine the utility of any combination of NSNs, the model uses the Cobb-Douglas production function as follows:

$$U=U(NSN_a, NSN_b) = (NSN_a^{E_a}) (NSN_b^{E_b})$$

where

U = utility (capability)

NSN<sub>a</sub> = quantity of NSNa

NSN<sub>b</sub> = quantity of NSN<sub>b</sub>

E<sub>a</sub> = essentiality or weighted value of NSN<sub>a</sub>

E<sub>b</sub> = essentiality or weighted value of NSN<sub>b</sub>

For example, if

NSN<sub>a</sub> = 10

NSN<sub>b</sub> = 14

E<sub>a</sub> = .9

E<sub>b</sub> = .8

then:

$$U = 10^{.9} \times 14^{.8} = 65.59$$

The measure of the utility received from the combination of 10 NSN<sub>a</sub> and 14 NSN<sub>b</sub> is 65.59. There is more than one combi-

nation of  $NSN_1$  and  $NSN_2$ , which will provide the same utility of 65.59. By increasing or decreasing  $NSN_1$  and solving for the resulting  $NSN_2$ , or vice versa, the combinations of  $NSN_1$  and  $NSN_2$  yielding a constant level of utility can be graphed as indifference curve I in Figure 2.

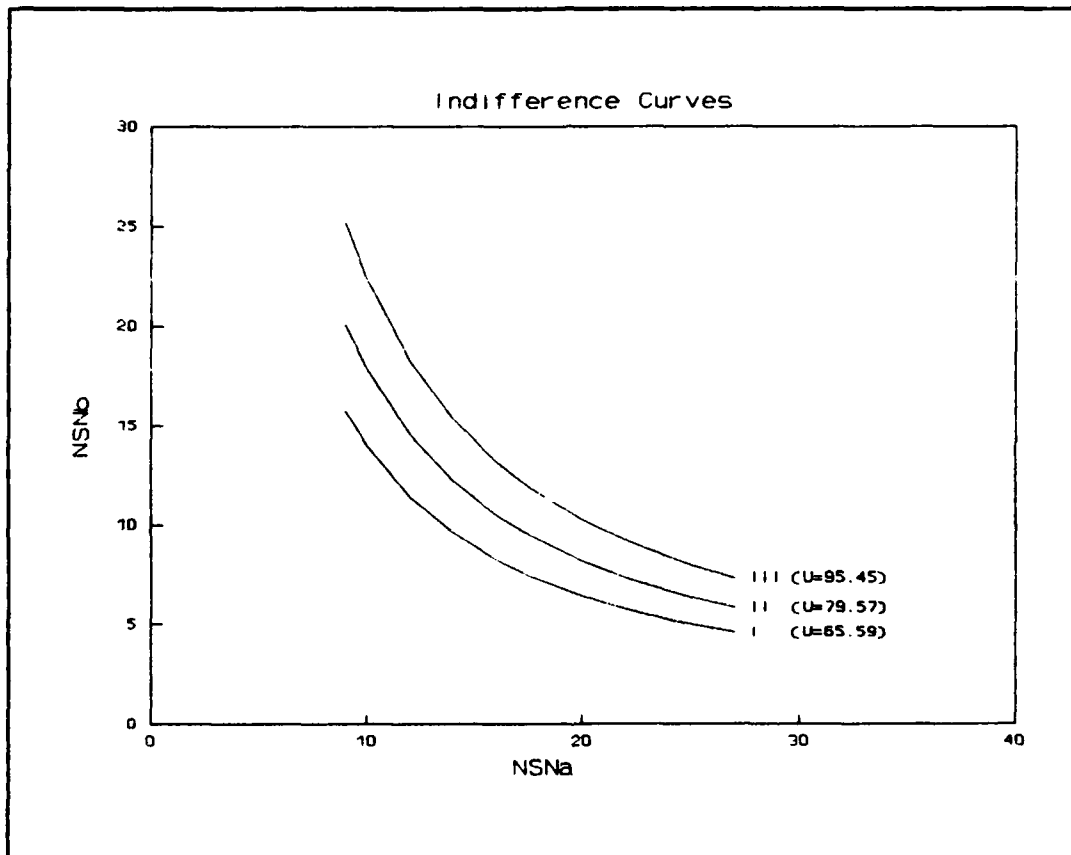


Figure 2. Indifference Map

By increasing the quantities of  $NSN_1$  and/or  $NSN_2$ , a higher level of utility can be obtained. Using the quantities from column two of Table 1 (p. 40),  $NSN_1 = 17.64$  and  $NSN_2 = 9.411$ , the utility is as follows:  $U = 17.64 \cdot 9.411 = 79.57$ . The

graph of all combinations of  $NSN_1$  and  $NSN_2$  which give this utility is shown as indifference curve II in Figure 2.

Continuing this process shows that there are an infinite number of indifference curves. The combination of  $NSNs$  on a higher indifference curve (above and to the right) give a higher utility. These combinations are all preferred to one on a lower curve.

The *marginal rate of substitution* of  $NSN_1$  and  $NSN_2$  measures the quantity of  $NSN_2$  that must be given up when adding a unit of  $NSN_1$  so as to maintain a constant level of utility. For small movements along either axis, ( $NSN_1$  and/or  $NSN_2$ ), it is given by the negative of the slope of an indifference curve at a point:

$$MRS = \frac{\Delta NSN_2}{\Delta NSN_1}$$

The marginal rate of substitution will vary from one point to another on the indifference curve, according to the degree to which one is willing to substitute one good for another. For instance, if one has a large quantity of  $NSN_1$  relative to  $NSN_2$ , one will be willing to give up a lot of  $NSN_1$  to gain another unit of  $NSN_2$  (assuming all other variables are equal).  
[Ref.11:p. 134]

Another important concept that will be observed in the model is *marginal utility*, "the addition to total utility that is attributable to the addition of one unit of a good to the

current rate of consumption, holding constant the amounts of all other goods consumed." [Ref. 11:p.137-138] The marginal utilities of  $NSN_a$  and  $NSN_b$  are related to the marginal rate of substitution as follows:

$$\frac{MU(NSN_a)}{MU(NSN_b)} = \frac{\Delta NSN_b}{\Delta NSN_a} = MRS$$

The model will demonstrate that maximum utility is achieved when the marginal utilities per dollar spent on the last unit of each  $NSN$  are equal.

The budget constrains the otherwise unlimited consumption of goods. The Marine Corps would *like* to purchase unlimited quantities of supplies and parts to guarantee 100% readiness. Because of the budget constraint, it must instead spend its resources to produce the *maximum possible* readiness with the available funds. To illustrate the budget line, assume the budget is \$100<sup>5</sup> and the unit prices ( $P$ ) of  $NSN_a$  and  $NSN_b$  are  $P_a = \$3$  and  $P_b = \$5$ , respectively. Expenditure on  $NSN_a$  ( $\$3 \times NSN_a$ ) plus expenditure on  $NSN_b$  ( $\$5 \times NSN_b$ ) must equal the \$100 budget constraint:

$$\$3 \times NSN_a + \$5 \times NSN_b = \$100$$

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<sup>5</sup>The budget constraint is represented by the cost to replace the quantities represented by  $D_a$  and  $D_b$  without optimization (i.e.,  $B = (P_a D_a) + (P_b D_b)$ ). -

Solving for  $NSN_b$  in terms of  $NSN_a$ :

$$NSN_b = \$ \frac{100}{\$5} - \frac{\$3 \times NSN_a}{\$5} = 20 - \frac{3}{5} NSN_a$$

The graph of this equation is budget line I shown in Figure 3. Every point on the line represents a combination of  $NSN_a$  and  $NSN_b$  which can be purchased for exactly \$100. The parallel budget line II in Figure 3 represents all combinations which can be purchased if the budget is decreased to \$80. Constrained utility maximization can be graphically illustrated by combining an indifference curve map with a budget line (Figure 4). The following example is taken from *Managerial Economics* (p. 143-145), modified for use with this model description. As can be seen in Figure 4, the highest possible level of utility is reached when  $NSN_a = 17.64$ ,  $NSN_b = 9.411$ <sup>6</sup>, and  $U = 79.57$ . This occurs at point C on the graph, where the budget line is tangent to indifference curve II. There are other combinations which are preferable because they produce a higher utility, such as point B on indifference curve III ( $NSN_a = 15$ ,  $NSN_b = 14.18$  and  $U = 95.45$ ), but this utility is unattainable since that combination of NSNs cannot be purchased with the specified budget.

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<sup>6</sup>This example works with the assumption that the beginning on-hand quantity is zero. This is because the model maximizes utility of the new on-hand quantity after order quantity is added to the beginning on-hand quantity. Therefore, the new on-hand quantities must equal the order quantities for this illustration to be applicable.

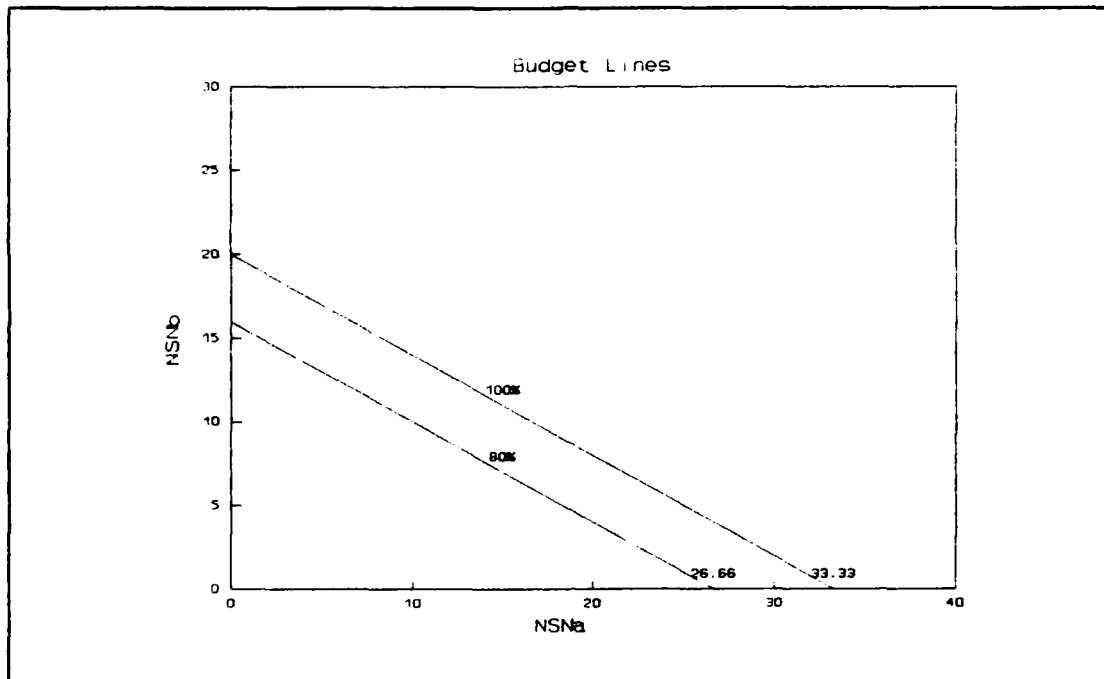


Figure 3. Budget Lines

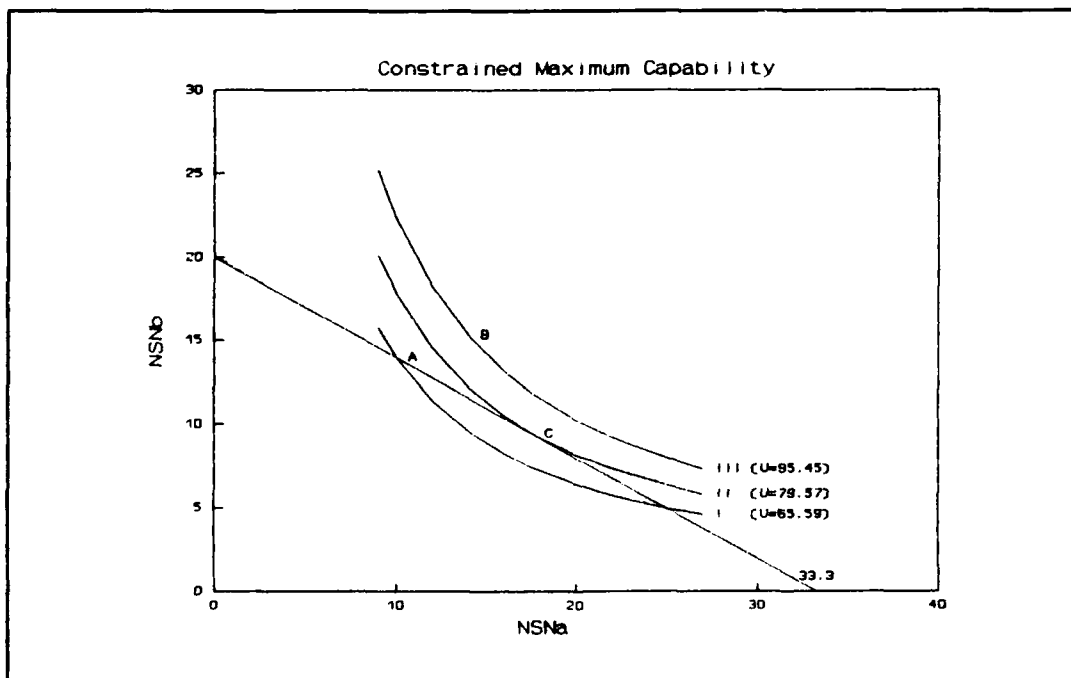


Figure 4. Constrained Maximum Utility



Likewise, there are many combinations along the budget line which can be purchased for \$100. But all of these combinations lie on a lower indifference curve. Therefore, they produce less utility. For example, the combination at point A, where  $NSN_1 = 10$  and  $NSN_2 = 14$ , can be purchased with the \$100 budget. Because it is on indifference curve I, however, it provides less utility ( $U = 65.59$  as opposed to 79.57 at point C). The highest attainable utility is realized at the point where the indifference curve is just tangent to the budget line. At this point, the marginal rate of substitution is equal to the price ratio of  $NSN_1$  and  $NSN_2$ :

$$MRS = \frac{P_a}{P_b}$$

Recall that  $U_1/U_2 = MRS$ ; substituting into the previous equation:

$$\frac{U_a}{U_b} = \frac{P_a}{P_b}$$

or

$$\frac{U_a}{P_a} = \frac{U_b}{P_b}$$

This means that the marginal utility per dollar spent on the *last* unit of  $NSN_1$  equals the marginal utility per dollar spent on the last unit of  $NSN_2$ . Utility is not maximized unless this equality holds.

For example, if

$$\frac{10}{1} > \frac{5}{1}$$

then one can increase total utility by buying more of  $a$  (gain ten per dollar) and less of  $b$  (lose five per dollar). This gives a net gain of five by spending one dollar. This process can be continued until the equilibrium point is reached.

This is the marginal utility interpretation of equilibrium. To maximize utility given a budget constraint, the budget should be allocated so that the marginal utility per dollar for the last dollar spent on each NSN is the same for all NSNs purchased, and the entire budget is spent. [Ref. 11:p. 149]

Figure 5 graphically illustrates the maximization of utility, given a previous on-hand quantity (inventory). Suppose that 1.3 of NSN<sub>1</sub> and 7.2 of NSN<sub>2</sub> are used in one period. At the beginning of the following period, on-hand quantities for NSN<sub>1</sub> and NSN<sub>2</sub> are 8.7 and 6.8, respectively. This point becomes the new origin on the graph. Assume that the budget constraint is equal to the cost of replacing the items used. ( $P_1D_1 + P_2D_2$ ). In this case the budget is 39.9. The objective now is to maximize utility given the budget constraint and the on-hand quantities of NSN<sub>1</sub> and NSN<sub>2</sub>. The optimization process yields an optimal order quantity of 8.95

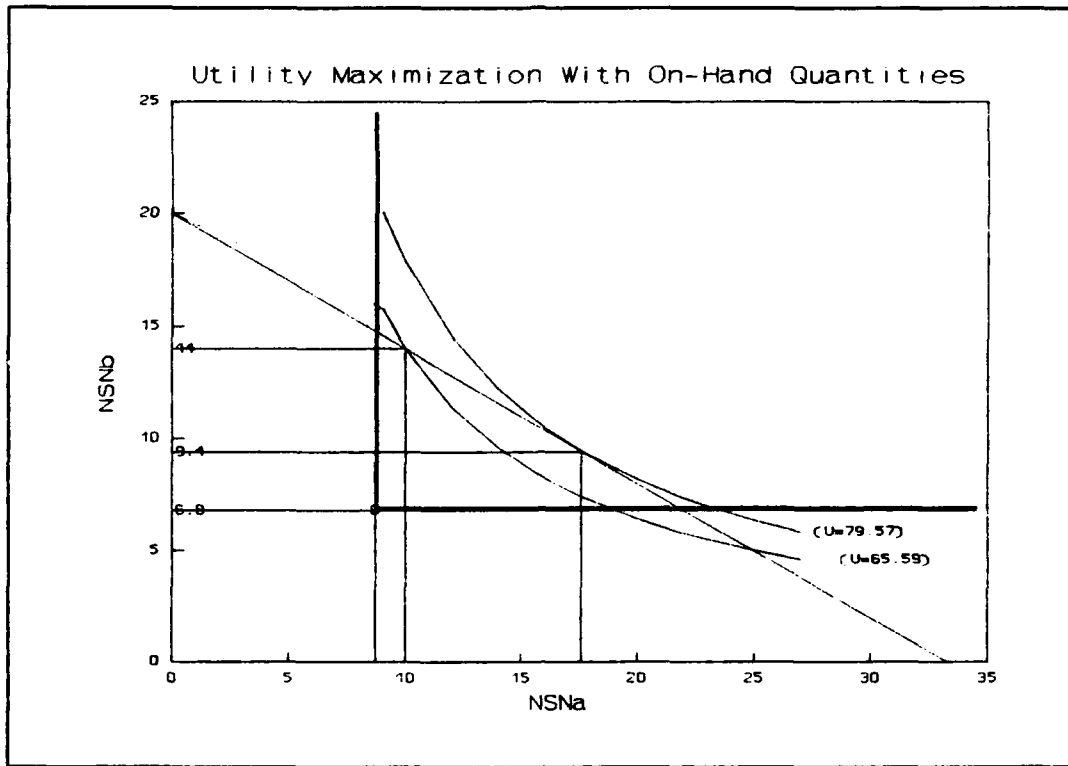


Figure 5

for  $NSN_a$ , and 2.61 for  $NSN_b$ .<sup>7</sup> Substituting these quantities into the utility equation yields:

$$U = (8.70 + 8.95) \cdot^9 (6.80 + 2.61) \cdot^8$$

$$U = 13.24 \times 6.01 = 79.57$$

Figure 5 shows that adding the optimal order quantities ( $O_a$  and  $O_b$ ) to the previous on-hand quantities gives new-on hand

<sup>7</sup>The equations for the derivation of the optimal order quantity are found in Appendix C. The final equation in the derivation for  $O_b$  is

$$O_b = \frac{\frac{E_b}{E_a + E_b} \left( B - \frac{E_a}{E_b} NSN_b P_b + NSN_a P_a \right)}{P_b}$$

quantities of  $NSN_1 = 17.6$  and  $NSN_2 = 9.4$ , the point at which the 79.57 utility curve is just tangent to the budget line.

Recall that when utility is maximized:

$$\frac{U_a}{U_b} = \frac{P_a}{P_b}$$

Utility at the beginning of the period can be rewritten as:

$$U = (NSN_a^- + O_a)^{E_a} (NSN_b^- + O_b)^{E_b}$$

where  $NSN_1^-$  and  $NSN_2^-$  are the on-hand quantities at the beginning of the period and  $O_1$  and  $O_2$  are the optimal order quantities for  $NSN_1$  and  $NSN_2$ , respectively. Similarly, the condition for utility maximization can be rewritten as:

$$\frac{E_a}{E_b} (NSN_b^- + O_b) (NSN_a^- + O_a) = \frac{P_a}{P_b} \rightarrow$$

$$\frac{E_a}{E_b} (NSN_b^- P_b + O_b P_b) = P_a NSN_a^- + P_a O_a$$

This shows that if the weighted value of  $NSN_2$  ( $E_2$ ) goes up, then the optimal amount of  $NSN_2$  increases and order quantity  $O_2$  will increase.  $O_1$  will decrease to maintain the same marginal rate of substitution. For example, if  $E_2$  changes from .8 to .85, and  $E_1$  remains at .9, the optimal order quantity for  $NSN_1$  decreases from 8.95 to 8.44, while the optimal order quantity for  $NSN_2$  increases from 2.61 to 2.91. The reverse, of course, is also true.

Substituting the expanded condition for utility maximization into the budget expression shows that increasing the price of NSN<sub>1</sub> (P<sub>1</sub>) decreases both the optimal order quantities O<sub>1</sub> and O<sub>2</sub> to maintain the budget level. Table 1 is a sample of the model output for this demonstration.

The variables used in the model are defined as follows:

M=Movement	given as:	Ma = 0.1	Mb = 0.5
E=Essentiality	given as:	Ea = 0.9	Eb = 0.8
P=Price	given as:	Pa = 3	Pb = 5
RV=Random Variable			
O=Optimal Order Quantity			
B=Budget			
D=Demand			
NSN=quantity of NSNs			
RO=Requisitioning Objective			
* = after optimizing			
"-" = before ordering			
"+" = after ordering			

The stock of NSN is depleted by D (demand):

$$D = NSN \times M + RV$$

where M simulates a rate by which the NSN is depleted. The higher the value, the more frequently the item is requisitioned in each time period. RV is a random variable to simulate fluctuations in demand.

The initial on-hand quantities for NSN<sub>1</sub> and NSN<sub>2</sub> are:

NSN<sub>1</sub> = 10  
NSN<sub>2</sub> = 14

If M<sub>1</sub> = .1, and RV<sub>1</sub> = .3, then NSN<sub>1</sub> is depleted in one time period (column 2, Table 1) by:

$$D_a = 10 \times .1 + .3 = 1.3 \text{ units}$$

TABLE 1.

	1	2	3	4	5	6	7	8	9	10	11	12
RVa		0.3	0.6	0.4	0.1	0.3	0.9	0.5	0.7	0.2		
Da @ NSNa=10		1.3	1.6	1.4	1.1	1.3	1.9	1.5	1.7	1.2	13	39
NSNa	10	6.7	3.4	3.6	6.9	3.7	3.1	3.5	3.3	3.8		
ROa		10	10	10	10	10	10	10	10	10		
Da		2.364	1.928	1.516	1.814	2.334	1.897	2.136	1.612			
NSNa-		3.7	15.28	14.16	15.14	14.34	13.97	14.36	14.12	14.61		
NSNa+		17.64	16.08	16.65	16.15	16.30	16.26	16.25	16.22	16.26		
Da		6.947	0.807	2.495	1.016	1.964	2.287	1.894	2.106	1.650	23.17	69.51
Da*		7.157	0.646	1.996	0.813	1.571	1.830	1.515	1.685	1.320		18.53
Da**		7.538	0.020	1.332	0.118	0.964	1.229	0.876	1.086	0.655		13.82
NSNa*		15.85	15.92	16.15	15.95	15.91	15.80	15.87	15.80	15.93		
NSNa**		16.23	15.30	15.49	15.25	15.30	15.20	15.23	15.20	15.27		
RVb		0.2	0.1	0.5	0.3	0.1	0.3	0.3	0.2	0.3		
Db @ NSNb=14		7.2	3.5	5.75	4.425	4.887	4.856	4.871	4.764	4.917	45.17	225.8
NSNb	14	5.8	10.5	8.25	9.575	9.112	9.143	9.128	9.235	9.082		264.8
ROb		14	14	14	14	14	14	14	14	14		264.8
Db		4.805	4.790	4.741	4.408	4.648	4.636	4.636	4.535	4.627		
NSNb-		6.8	4.605	3.790	4.141	4.208	4.048	4.036	4.135	4.027		
NSNb+		9.411	8.581	8.883	8.617	8.697	8.672	8.671	8.635	8.675		
Db		2.611	3.925	5.092	4.475	4.488	4.623	4.634	4.519	4.647	39.07	195.3
Db*		2.089	3.180	4.074	3.580	3.591	3.698	3.707	3.615	3.718		31.25
Db**		1.860	3.555	4.472	3.996	3.955	4.059	4.091	3.975	4.117		34.08
NSNb*		8.889	7.786	7.865	7.721	7.799	7.747	7.744	7.751	7.746		
NSNb**		8.660	8.161	8.263	8.138	8.163	8.108	8.127	8.111	8.145		
B	100	39.9	22.3	32.95	25.42	28.33	29.98	28.85	28.92	28.18		264.8
NewB	0.8	31.92	17.84	26.36	20.34	22.67	23.98	23.08	23.13	22.55		211.8
U	65.59	65.59	65.59	65.59	65.59	65.59	65.59	65.59	65.59	65.59		590.3
U*	65.59	79.60	68.03	72.16	68.51	69.60	69.26	69.25	69.03	69.31		634.7
U1		69.07	62.37	63.69	62.05	62.41	61.68	61.93	61.72	62.14		567.1
U**		69.11	62.47	63.80	62.17	62.50	61.78	62.03	61.82	62.26		567.9

Note: The budget is given as the dollar value of what it would cost to replace the quantities issued for the period.

\* indicates quantities obtained by proportionally reducing Da and Db to 80% of their previous value.

\*\* indicates quantities obtained by optimizing at the new budget (80% of previous budget).

then:

$$NSN_a - D = NSN_a^- = 10 - 1.3 = 8.7$$

After maximizing  $U$  subject to the budget constraint of \$39.9, the optimal order quantity for  $NSN_1 (O_1)$  is 8.95, and the optimal order quantity for  $NSN_2 (O_2)$  is 2.61. This combination gives the maximum utility attainable  $U = 79.57$ .  $O_1$  and  $O_2$  are added to  $NSN_1^-$  and  $NSN_2^-$ , respectively to attain the new on-hand quantities  $NSN_1' = 17.6$  and  $NSN_2' = 9.4$ .

If the budget were reduced to 80%, maximizing utility at the new budget level would produce approximately the same result as multiplying the optimal order quantity at the 100% budget level by 80%. This is demonstrated by calculating  $U_1$ .  $U_1$  represents the utility obtained by simply reducing  $O_1$  and  $O_2$  to 80% of their previous value (a method referred to as Proportional Allocation Policy in the remainder of this thesis). Plugging these values into the utility function yields  $U_1 = 69.07$ .

In contrast,  $U^{**}$  represents a utility derived by maximizing utility subject to the new budget constraint, where  $B = .8(39.9) = 31.92$ . This calculation yields new optimal order quantities  $O_1$  and  $O_2$ . In period 1, there is a 0.05% increase from  $U_1$  to  $U^{**}$ . For this particular example, the changes in utility between the two methods for calculating a budget reduction range from 0.05% to 0.20%. Therefore, the

Proportional Allocation Policy seems to be a reasonable approximation for the optimal strategy.<sup>1</sup>

Thus far, utility has been maximized for one time period (myopic optimization). The perceived limitation of myopic optimization suggests contrasting successive myopic optimizations with a multi-period (sustained) optimization.

## B. MYOPIC VS. SUSTAINED OPTIMIZATION RESULTS

To compare myopic optimization with sustained (non-myopic) optimization, the model was revised<sup>2</sup>. The new model calculates optimal order quantities in an infinite time steady state optimization. These values can then be compared with the quantities obtained from myopic optimization over a period of time (meaning myopic optimization is performed in each time period). The model is contained in Appendix D. Note that the essentiality weights of each NSN have changed from those in the previous model:  $E_a$  and  $E_b$  are .5 and .9, respectively.

The derivation of the optimal order quantities for the infinite time steady state case are:

$$O_a = \frac{E_a}{E_a + E_b} \times \frac{B(t)}{P_a} = \frac{.5}{1.4} \times \frac{24}{3} = 2.86$$

---

<sup>1</sup>This result holds for a wide range of parameter values. In fact, the Proportional Allocation Policy becomes the optimal policy when the optimal order quantities in each period converge to a steady state equilibrium.

<sup>2</sup>Professor Katsuaki Terasawa, Adjunct Professor of Economics and Policy Analysis, Naval Postgraduate School, Monterey, CA.



$$O_b = \frac{E_b}{E_a + E_b} \times \frac{B(t)}{P_b} = \frac{.9}{1.4} \times \frac{24}{5} = 3.09$$

Derivations for the myopic steady state are:

$$O_a = \frac{E_a \times B(t) (1-m)}{P_a (E_a + E_b - E_a \times m - E_b \times n)} = \frac{0.5 \times 24 \times (1-0.6)}{3 \times (1.4 - 0.5 \times 0.6 - 0.9 \times 0.8)} = 4.21$$

$$O_b = \frac{E_b \times B(t) (1-n)}{P_b (E_a + E_b - E_a \times m - E_b \times n)} = \frac{0.9 \times 24 \times (1-0.8)}{5 \times (1.4 - 0.5 \times 0.6 - 0.9 \times 0.8)} = 2.27$$

where  $m$  and  $n$  represent  $1-M_a$  and  $1-M_b$ ,<sup>10</sup> respectively (see Appendix D and E, cells C4 and D4).

As can be seen in Figures 6 and 7, the order quantities and resulting on-hand quantities from myopic optimization approach a steady state over time. This assumes that demand remains relatively constant *over time*.

Recall the discussion of budget reductions under myopic optimization. Optimizing at a reduced budget level produced slightly higher utility than a proportionate reduction in order quantity. As can be seen in Figures 8 and 9, over time the optimal order quantities derived from both myopic and non-myopic optimization actually converge with the proportionate reduction order quantities.

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<sup>10</sup>Recall that  $M$  = movement.  $1-M_a$  and  $1-M_b$  are used in the calculation of on-hand quantity after demand.

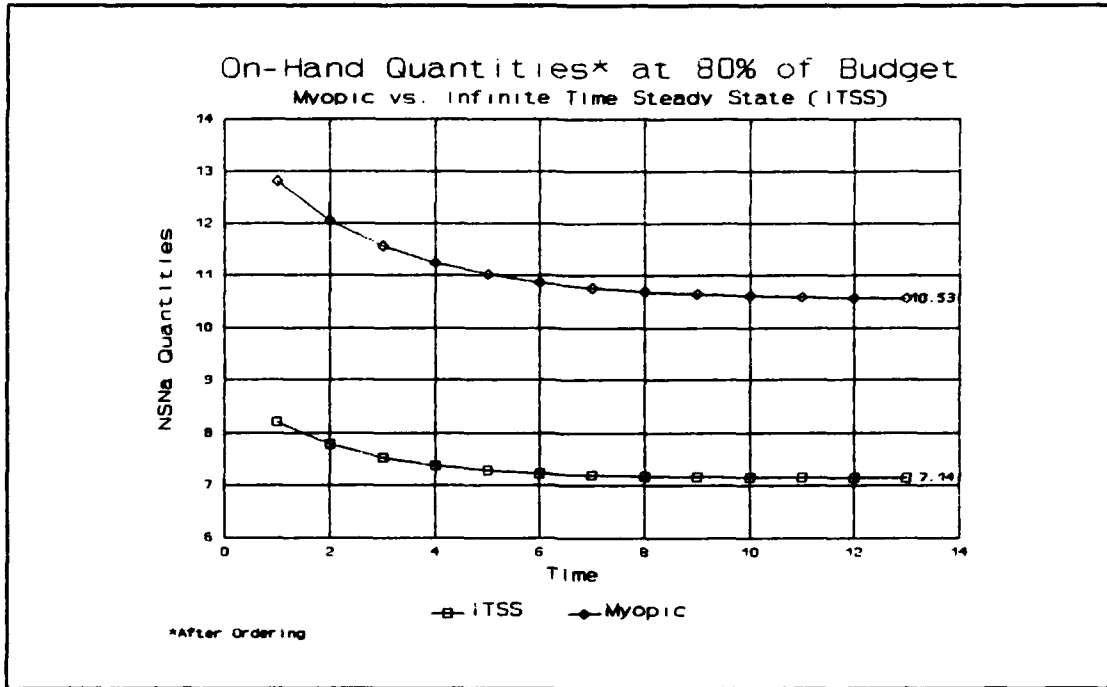


Figure 6 On-Hand Quantities Approaching Steady State

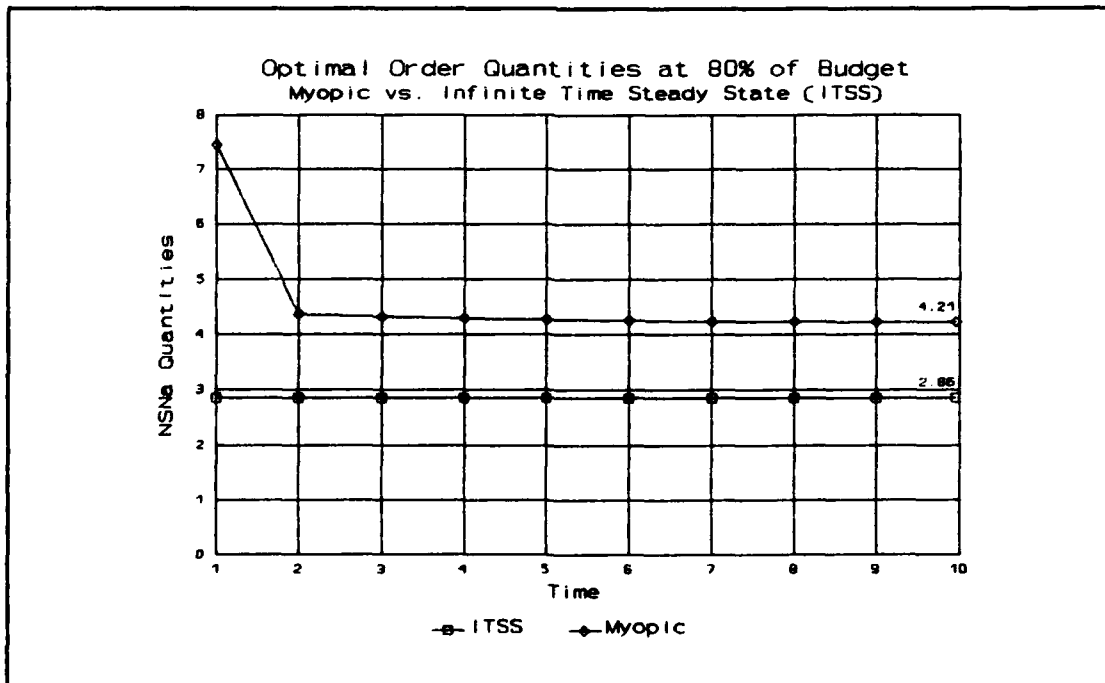


Figure 7 Order Quantities Approaching Steady State

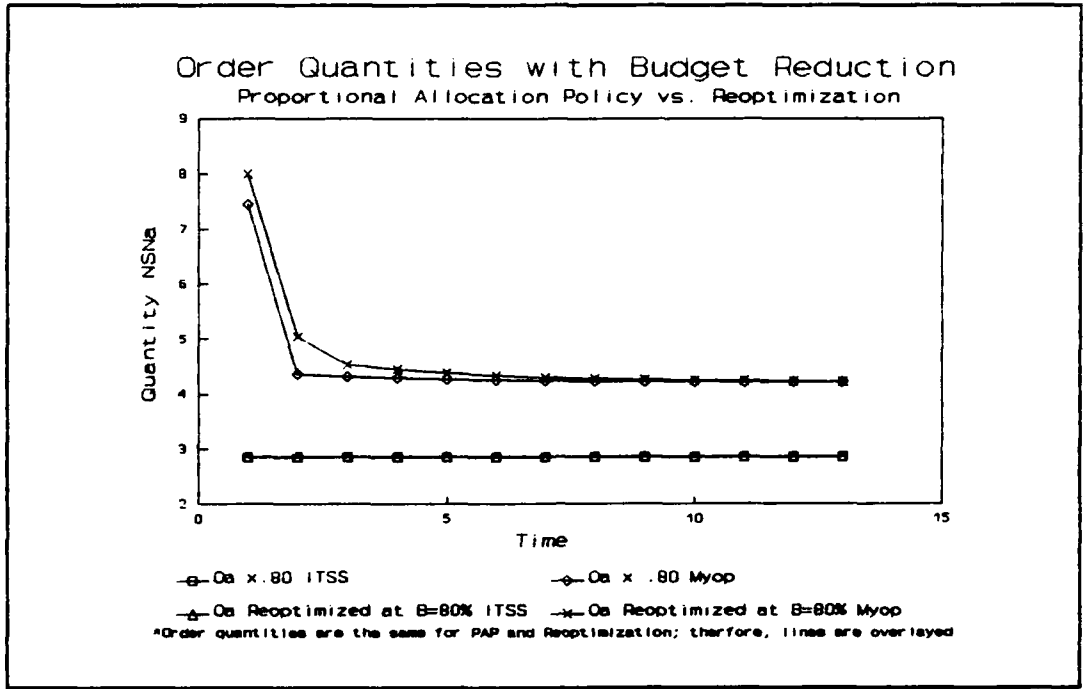


Figure 8 Convergence of Order Quantities Over Time

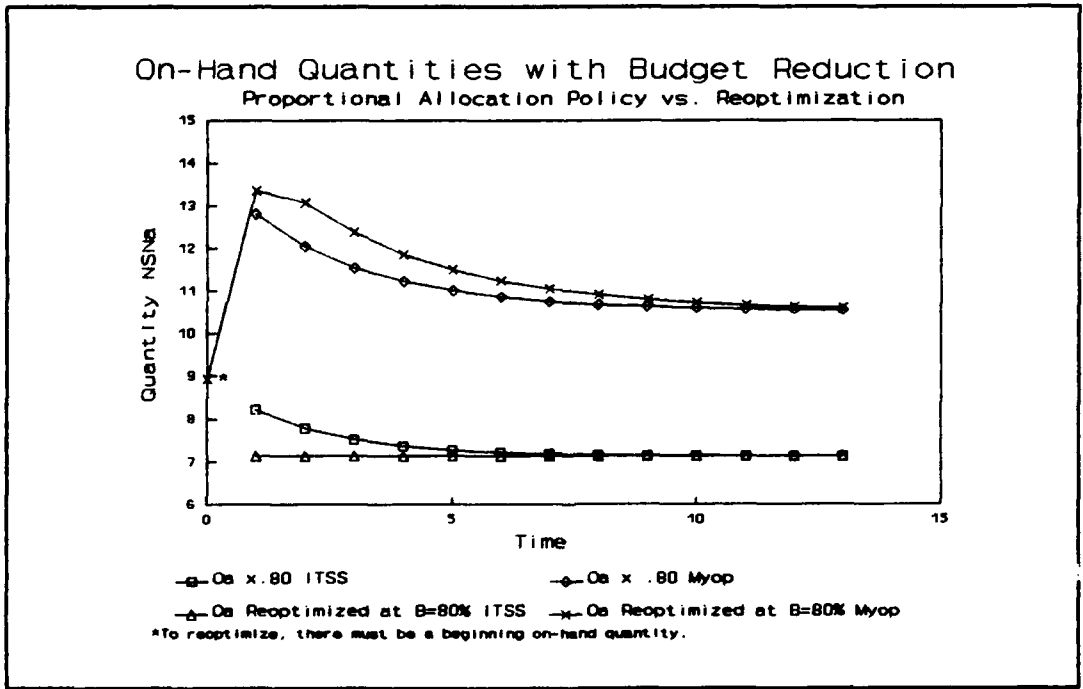


Figure 9 Convergence of On-Hand Quantities Over Time

As this occurs, utilities converge as well (Figure 10). Therefore, a proportionate allocation policy will maximize utility for a given budget reduction if order quantities have reached their steady state values.<sup>11</sup>

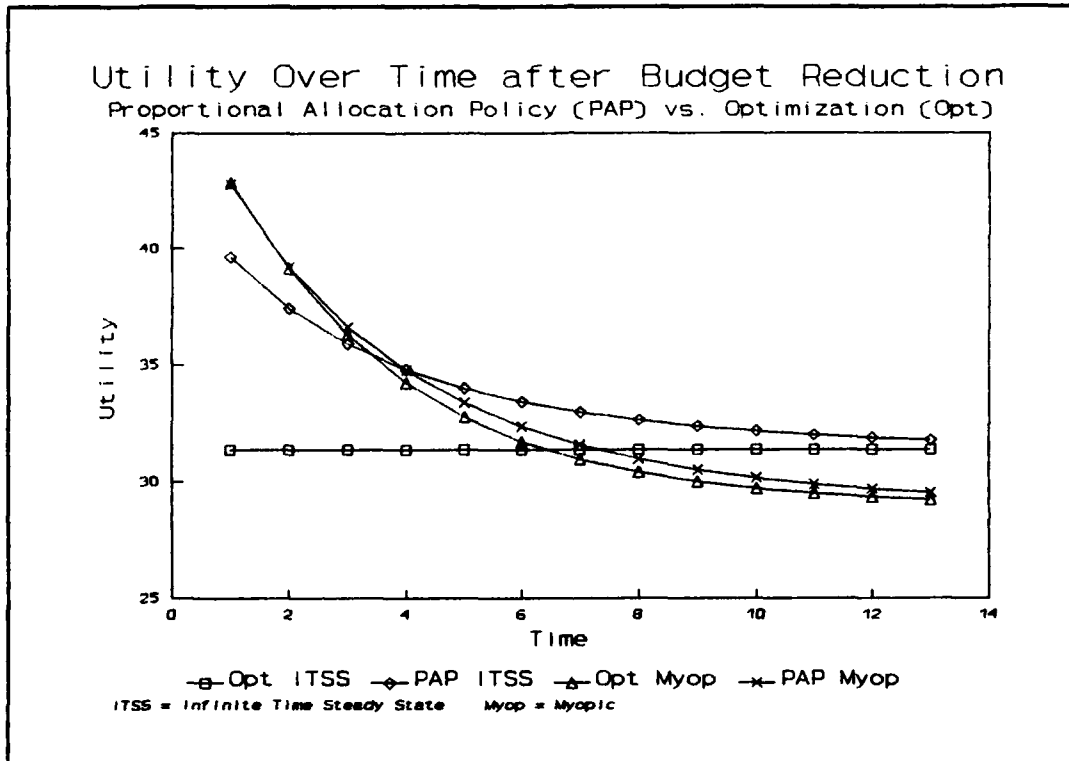


Figure 10 Convergence of Utilities Over Time

<sup>11</sup>Low-demand, slow-moving critical items would be excluded from proportionate reduction to preclude an out-of-stock situation.

#### IV. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

##### A. SUMMARY

To face the defense cuts of the post Cold War era, the Marine Corps will be focusing on readiness-oriented operations in supply support. This thesis discussed combat essentiality-criticality codes and performance measures of effectiveness as critical elements in readiness-oriented supply management. The thesis then presented a supply allocation and optimization model to demonstrate the theory of allocating funds to maximize utility subject to a budget constraint. The model examined the impact of a budget reduction and the proportional allocation and reoptimization alternatives.

##### B. CONCLUSIONS

Combat essentiality-criticality codes should be further classified by weighted values to reflect a more precise measure of the NSNs contribution to readiness.

The intermediate supply level should have a performance measure of effectiveness which indicates how well the supply system is contributing to readiness.

The supply allocation and optimization model demonstrates how a given budget can be allocated to produce the maximum possible utility. After optimization, order quantities and on-hand quantities will reach a steady state over time, given

a stable demand pattern as discussed. Given a budget reduction, reoptimization and proportionate allocation alternatives will yield the same utility over time. Therefore, proportionate allocation of funds is a reasonable procedure to follow given a budget reduction.

### C. RECOMMENDATIONS

Further research is suggested in the following areas:

1. Modifying Combat Essentiality-Criticality Codes so that they are more definitive of the NSNs' contribution to readiness.
2. Determining the probability of a stockout on combat-essential items, in order to formulate a readiness measure based on that probability.
3. Making the supply allocation and optimization model more representative of actual supply operations.
4. Examining the optimal supply budget with respect to marginal benefits and marginal costs, to include the opportunity cost of foregone alternatives, given that the budget will be limited.

APPENDIX A  
 Lotus 1-2-3 Release 3.1+ Spreadsheet  
 Supply Allocation and Optimization Model

A	B	C	D	E	F	G	H	I	J	K	L	M	
1	M=Movement		OH=On Hand quantity before (-) ordering							Ma	Mb		
2	B=Essentiality		OH+a=On Hand quantity after (+) ordering							0.1	0.5		
3	P=Price		O=Optimal Order Quantity							NSWa	NSWb		
4	RV=Random Variable									20	50		
5	D=Demand	B=Budget								Ba	Bb		
6	NSW=A quantity of NSWs	* = after optimizing								0.9	0.8		
7	RO=Requisitioning Objective									Pa	Pb		
8	"" = before ordering, "" = after ordering									3	5		
9		1	2	3	4	5	6	7	8	9	10		
10	RVa	0.3	0.6	0.4	0.1	0.3	0.9	0.5	0.7	0.2			
11	Da	1.3	1.6	1.4	1.1	1.3	1.9	1.5	1.7	1.2	13	39	
12	NSWa	10	8.7	8.4	8.6	8.9	8.7	8.1	8.5	8.3	8.8		
13	ROa		10	10	10	10	10	10	10	10	10		
14	Da*		2.365	1.928	1.516	1.814	2.334	1.897	2.136	1.612			
15	NSWa-		8.7	15.28	14.16	15.14	14.34	13.97	14.36	14.12	14.62		
16	NSWa+		17.65	16.09	16.66	16.16	16.31	16.26	16.26	16.23	16.27		
17	Oa		8.947	0.808	2.495	1.016	1.965	2.288	1.895	2.107	1.65	23.17	69.51
18													
19	sra*		7.158	0.646	1.996	0.813	1.572	1.83	1.516	1.686	1.32		18.54
20	ra**		7.539	0.021	1.332	0.119	0.964	1.229	0.876	1.086	0.655		13.82
21	Ia:s		15.86	15.93	16.16	15.95	15.91	15.8	15.88	15.81	15.94		
22	Ia**		16.24	15.3	15.49	15.26	15.31	15.2	15.24	15.21	15.27		
23			0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	
24			0.843	0.025	0.534	0.117	0.491	0.537	0.462	0.516	0.397	0.436	
25													
26	RVb		0.2	0.1	0.5	0.3	0.1	0.3	0.3	0.2	0.3		
27	Db		7.2	3.5	5.75	4.425	4.888	4.856	4.872	4.764	4.918	45.17	225.9
28	NSWb	14	6.8	10.5	8.25	9.575	9.113	9.144	9.128	9.236	9.082		264.9
29	ROb		14	14	14	14	14	14	14	14	14		264.9
30	Db*		4.806	4.791	4.742	4.409	4.649	4.636	4.536	4.628			
31	NSWb-		6.8	4.606	3.791	4.142	4.209	4.049	4.036	4.136	4.028		
32	NSWb+		9.412	8.581	8.884	8.617	8.697	8.672	8.671	8.655	8.676		
33	Ob		2.612	3.975	5.093	4.475	4.489	4.624	4.635	4.52	4.648	39.07	195.4
34													
35	srb*		2.089	3.18	4.074	3.58	3.591	3.699	3.708	3.616	3.718		31.26
36	rb**		1.861	3.556	4.473	3.997	3.955	4.059	4.092	3.976	4.117		34.08
37	Ib:s		8.889	7.786	7.865	7.722	7.8	7.748	7.744	7.751	7.746		
38	Ib**		8.661	8.162	8.263	8.138	8.164	8.108	8.128	8.111	8.145		
39			0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	
40			0.712	0.894	0.878	0.893	0.881	0.878	0.883	0.88	0.886	0.865	0.77
41													
42	check		-0.00	-0.00	-0.00	-0.00	0.000	0.000	-0.00	-0.00	0.000		
43			39.9	22.3	32.95	25.43	28.34	29.98	28.86	28.92	28.19		264.9
44	B	100	39.9	22.3	32.95	25.43	28.34	29.98	28.86	28.92	28.19		264.9
45	NewB(t	0.8	31.92	17.84	26.36	20.34	22.67	23.99	23.09	23.14	22.55		211.9
46	U	65.6	65.6	65.6	65.6	65.6	65.6	65.6	65.6	65.6	65.6		590.4
47	U*	65.6	79.61	68.04	72.16	68.52	69.61	69.27	69.25	69.04	69.31		634.8
48													
49	U1		69.07	62.38	63.69	62.05	62.41	61.69	61.93	61.73	62.15		567.1
50	U**		69.11	62.48	63.81	62.18	62.51	61.78	62.04	61.82	62.26		568
51	U** - U1		-1	-1	-1	-1	-1	-1	-1	-1	-1		-1
52			0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.002		0.002

APPENDIX B  
Lotus 1-2-3 Release 3.1+ Cell Formulas  
Supply Allocation and Optimization Model

A:A1: [W6] 'M=Movement  
A:D1: [W6] 'OH=On Hand quantity before (-) ordering  
A:K1: (G) [W6] 'Ma  
A:L1: (G) [W6] 'Mb  
A:A2: [W6] 'E=Essentiality  
A:D2: [W6] 'OH+a=On Hand quantity after (+) ordering  
A:K2: (G) [W6] 0.1  
A:L2: (G) [W6] 0.5  
A:A3: [W6] 'P=Price  
A:D3: [W6] 'O=Optimal Order Quantity  
A:K3: (G) [W6] 'NSNa  
A:L3: (G) [W6] 'NSNb  
A:A4: [W6] 'RV=Random Variable  
A:K4: (G) [W6] 20  
A:L4: (G) [W6] 50  
A:A5: [W6] 'D=Demand  
A:D5: [W6] 'B=Budget  
A:K5: (G) [W6] 'Ea  
A:L5: (G) [W6] 'Eb  
A:A6: [W6] 'NSN=A quantity of NSNs  
A:E6: [W6] '\* = after optimizing  
A:K6: (G) [W6] 0.9  
A:L6: (G) [W6] 0.8  
A:A7: [W6] 'RO=Requisitioning Objective  
A:K7: (G) [W6] 'Pa  
A:L7: (G) [W6] 'Pb  
A:A8: [W6] "'-' = before ordering, '+' = after ordering  
A:K8: (G) [W6] 3  
A:L8: (G) [W6] 5  
A:B9: (G) [W6] 1  
A:C9: (G) [W6] +B9+1  
A:D9: (G) [W6] +C9+1  
A:E9: (G) [W6] +D9+1  
A:F9: (G) [W6] +E9+1  
A:G9: (G) [W6] +F9+1  
A:H9: (G) [W6] +G9+1  
A:I9: (G) [W6] +H9+1  
A:J9: (G) [W6] +I9+1  
A:K9: (G) [W6] +J9+1  
A:A10: (G) [W6] 'RVa  
A:C10: (G) [W6] 0.3  
A:D10: (G) [W6] 0.6  
A:E10: (G) [W6] 0.4  
A:F10: (G) [W6] 0.1



A:G10: (G) [W6] 0.3  
A:H10: (G) [W6] 0.9  
A:I10: (G) [W6] 0.5  
A:J10: (G) [W6] 0.7  
A:K10: (G) [W6] 0.2  
A:A11: (G) [W6] 'Da  
A:C11: (G) [W6] +C10+B12\*\$KS2  
A:D11: (G) [W6] +D10+C13\*\$KS2  
A:E11: (G) [W6] +E10+D13\*\$KS2  
A:F11: (G) [W6] +F10+E13\*\$KS2  
A:G11: (G) [W6] +G10+F13\*\$KS2  
A:H11: (G) [W6] +H10+G13\*\$KS2  
A:I11: (G) [W6] +I10+H13\*\$KS2  
A:J11: (G) [W6] +J10+I13\*\$KS2  
A:K11: (G) [W6] +K10+J13\*\$KS2  
A:L11: (G) [W6] @SUM(C11..K11)  
A:M11: (G) [W6] +L11\*\$KS8  
A:A12: (G) [W6] 'NSNa  
A:B12: (G) [W6] 10  
A:C12: (G) [W6] +B12-C11  
A:D12: (G) [W6] +C13-D11  
A:E12: (G) [W6] +D13-E11  
A:F12: (G) [W6] +E13-F11  
A:G12: (G) [W6] +F13-G11  
A:H12: (G) [W6] +G13-H11  
A:I12: (G) [W6] +H13-I11  
A:J12: (G) [W6] +I13-J11  
A:K12: (G) [W6] +J13-K11  
A:A13: (G) [W6] 'ROa  
A:C13: (G) [W6] +C12+C11  
A:D13: (G) [W6] +D12+D11  
A:E13: (G) [W6] +E12+E11  
A:F13: (G) [W6] +F12+F11  
A:G13: (G) [W6] +G12+G11  
A:H13: (G) [W6] +H12+H11  
A:I13: (G) [W6] +I12+I11  
A:J13: (G) [W6] +J12+J11  
A:K13: (G) [W6] +K12+K11  
A:A14: (G) [W6] 'Da\*  
A:D14: (G) [W6] +C16\*\$KS2+D10  
A:E14: (G) [W6] +D15\*\$KS2+E10  
A:F14: (G) [W6] +E15\*\$KS2+F10  
A:G14: (G) [W6] +F15\*\$KS2+G10  
A:H14: (G) [W6] +G15\*\$KS2+H10  
A:I14: (G) [W6] +H15\*\$KS2+I10  
A:J14: (G) [W6] +I15\*\$KS2+J10  
A:K14: (G) [W6] +J15\*\$KS2+K10  
A:A15: (G) [W6] 'NSNa-  
A:C15: (G) [W6] +C12  
A:D15: (G) [W6] +C16-D14  
A:E15: (G) [W6] +D16-E14

A:F15: (G) [W6] +E16-F14  
A:G15: (G) [W6] +F16-G14  
A:H15: (G) [W6] +G16-H14  
A:I15: (G) [W6] +H16-I14  
A:J15: (G) [W6] +I16-J14  
A:K15: (G) [W6] +J16-K14  
A:A16: (G) [W6] 'NSNa+  
A:C16: (G) [W6] +C12+C17  
A:D16: (G) [W6] +D15+D17  
A:E16: (G) [W6] +E15+E17  
A:F16: (G) [W6] +F15+F17  
A:G16: (G) [W6] +G15+G17  
A:H16: (G) [W6] +H15+H17  
A:I16: (G) [W6] +I15+I17  
A:J16: (G) [W6] +J15+J17  
A:K16: (G) [W6] +K15+K17  
A:A17: (G) [W6] 'OaA:C17: (G) [W6] @IF(C33>0,\$K\$6/(\$K\$6+\$L\$6)\*(C44-\$L\$6/\$-  
K\$6\*\$K\$8\*C15+\$L\$8\*C31)/\$K\$8,C44/\$K\$8)  
A:D17: (G) [W6] @IF(D33>0,\$K\$6/(\$K\$6+\$L\$6)\*(D44-\$L\$6/\$K\$6\*\$K\$8\*D15+\$L\$8\*D-  
31)/\$K\$8,D44/\$K\$8)  
A:E17: (G) [W6] @IF(E33>0,\$K\$6/(\$K\$6+\$L\$6)\*(E44-\$L\$6/\$K\$6\*\$K\$8\*E15+\$L\$8\*E-  
31)/\$K\$8,E44/\$K\$8)  
A:F17: (G) [W6] @IF(F33>0,\$K\$6/(\$K\$6+\$L\$6)\*(F44-\$L\$6/\$K\$6\*\$K\$8\*F15+\$L\$8\*F-  
31)/\$K\$8,F44/\$K\$8)  
A:G17: (G) [W6] @IF(G33>0,\$K\$6/(\$K\$6+\$L\$6)\*(G44-\$L\$6/\$K\$6\*\$K\$8\*G15+\$L\$8\*G-  
31)/\$K\$8,G44/\$K\$8)  
A:H17: (G) [W6] @IF(H33>0,\$K\$6/(\$K\$6+\$L\$6)\*(H44-\$L\$6/\$K\$6\*\$K\$8\*H15+\$L\$8\*H-  
31)/\$K\$8,H44/\$K\$8)  
A:I17: (G) [W6] @IF(I33>0,\$K\$6/(\$K\$6+\$L\$6)\*(I44-\$L\$6/\$K\$6\*\$K\$8\*I15+\$L\$8\*I-  
31)/\$K\$8,I44/\$K\$8)  
A:J17: (G) [W6] @IF(J33>0,\$K\$6/(\$K\$6+\$L\$6)\*(J44-\$L\$6/\$K\$6\*\$K\$8\*J15+\$L\$8\*J-  
31)/\$K\$8,J44/\$K\$8)  
A:K17: (G) [W6] @IF(K33>0,\$K\$6/(\$K\$6+\$L\$6)\*(K44-\$L\$6/\$K\$6\*\$K\$8\*K15+\$L\$8\*K-  
31)/\$K\$8,K44/\$K\$8)  
A:L17: (G) [W6] @SUM(C17..K17)  
A:M17: (G) [W6] +L17\*\$K\$8  
A:A19: (G) [W6] 'sxa\*  
A:C19: (G) [W6] +C17\*\$B\$45  
A:D19: (G) [W6] +D17\*\$B\$45  
A:E19: (G) [W6] +E17\*\$B\$45  
A:F19: (G) [W6] +F17\*\$B\$45  
A:G19: (G) [W6] +G17\*\$B\$45  
A:H19: (G) [W6] +H17\*\$B\$45  
A:I19: (G) [W6] +I17\*\$B\$45  
A:J19: (G) [W6] +J17\*\$B\$45  
A:K19: (G) [W6] +K17\*\$B\$45  
A:M19: (G) [W6] @SUM(C19..K19)  
A:A20: (G) [W6] 'xa\*\*  
A:C20: (G) [W6] @IF(C36>0,\$K\$6/(\$K\$6+\$L\$6)\*(C45-\$L\$6/\$K\$6\*\$K\$8\*C15+\$L\$8\*C-  
31)/\$K\$8,C45/\$K\$8)  
A:D20: (G) [W6] @IF(D36>0,\$K\$6/(\$K\$6+\$L\$6)\*(D45-\$L\$6/\$K\$6\*\$K\$8\*D15+\$L\$8\*D-

31)/\$KS8,D45/\$KS8)  
 A:E20: (G) [W6] @IF(E36>0,\$KS6/(\$KS6+\$LS6)\*(E45-\$LS6/\$KS6\*\$KS8\*E15+\$LS8\*E-31)/\$KS8,E45/\$KS8)  
 A:F20: (G) [W6] @IF(F36>0,\$KS6/(\$KS6+\$LS6)\*(F45-\$LS6/\$KS6\*\$KS8\*F15+\$LS8\*F-31)/\$KS8,F45/\$KS8)  
 A:G20: (G) [W6] @IF(G36>0,\$KS6/(\$KS6+\$LS6)\*(G45-\$LS6/\$KS6\*\$KS8\*G15+\$LS8\*G-31)/\$KS8,G45/\$KS8)  
 A:H20: (G) [W6] @IF(H36>0,\$KS6/(\$KS6+\$LS6)\*(H45-\$LS6/\$KS6\*\$KS8\*H15+\$LS8\*H-31)/\$KS8,H45/\$KS8)  
 A:I20: (G) [W6] @IF(I36>0,\$KS6/(\$KS6+\$LS6)\*(I45-\$LS6/\$KS6\*\$KS8\*I15+\$LS8\*I-31)/\$KS8,I45/\$KS8)  
 A:J20: (G) [W6] @IF(J36>0,\$KS6/(\$KS6+\$LS6)\*(J45-\$LS6/\$KS6\*\$KS8\*J15+\$LS8\*J-31)/\$KS8,J45/\$KS8)  
 A:K20: (G) [W6] @IF(K36>0,\$KS6/(\$KS6+\$LS6)\*(K45-\$LS6/\$KS6\*\$KS8\*K15+\$LS8\*K-31)/\$KS8,K45/\$KS8)  
 A:M20: (G) [W6] @SUM(C20..K20)  
 A:A21: (G) [W6] 'Xa:s  
 A:C21: (G) [W6] +C15+C19  
 A:D21: (G) [W6] +D15+D19  
 A:E21: (G) [W6] +E15+E19  
 A:F21: (G) [W6] +F15+F19  
 A:G21: (G) [W6] +G15+G19  
 A:H21: (G) [W6] +H15+H19  
 A:I21: (G) [W6] +I15+I19  
 /A:J21: (G) [W6] +J15+J19  
 A:K21: (G) [W6] +K15+K19  
 A:A22: (G) [W6] 'Xa\*\*  
 A:C22: (G) [W6] +C15+C20  
 A:D22: (G) [W6] +D15+D20  
 A:E22: (G) [W6] +E15+E20  
 A:F22: (G) [W6] +F15+F20  
 A:G22: (G) [W6] +G15+G20  
 A:H22: (G) [W6] +H15+H20  
 A:I22: (G) [W6] +I15+I20  
 A:J22: (G) [W6] +J15+J20  
 A:K22: (G) [W6] +K15+K20  
 A:C23: (G) [W6] +C19/C17  
 A:D23: (G) [W6] +D19/D17  
 A:E23: (G) [W6] +E19/E17  
 A:F23: (G) [W6] +F19/F17  
 A:G23: (G) [W6] +G19/G17  
 A:H23: (G) [W6] +H19/H17  
 A:I23: (G) [W6] +I19/I17  
 A:J23: (G) [W6] +J19/J17  
 A:K23: (G) [W6] +K19/K17  
 A:L23: (G) [W6] @AVG(C23..K23)  
 A:C24: (G) [W6] +C20/C17  
 A:D24: (G) [W6] +D20/D17  
 A:E24: (G) [W6] +E20/E17  
 A:F24: (G) [W6] +F20/F17  
 A:G24: (G) [W6] +G20/G17

A:H24: (G) [W6] +H20/H17  
A:I24: (G) [W6] +I20/I17  
A:J24: (G) [W6] +J20/J17  
A:K24: (G) [W6] +K20/K17  
A:L24: (G) [W6] @AVG(C24..K24)  
A:A26: (G) [W6] 'RVb  
A:C26: (G) [W6] 0.2  
A:D26: (G) [W6] 0.1  
A:E26: (G) [W6] 0.5  
A:F26: (G) [W6] 0.3  
A:G26: (G) [W6] 0.1  
A:H26: (G) [W6] 0.3  
A:I26: (G) [W6] 0.3  
A:J26: (G) [W6] 0.2  
A:K26: (G) [W6] 0.3  
A:A27: (G) [W6] 'Db  
A:C27: (G) [W6] +C26+B26\* $\$$ I. $\$$ 2  
A:D27: (G) [W6] +D26+C28\* $\$$ LS2  
A:E27: (G) [W6] +E26+D28\* $\$$ LS2  
A:F27: (G) [W6] +F26+E28\* $\$$ LS2  
A:G27: (G) [W6] +G26+F28\* $\$$ LS2  
A:H27: (G) [W6] +H26+G28\* $\$$ LS2  
A:I27: (G) [W6] +I26+H28\* $\$$ LS2  
A:J27: (G) [W6] +J26+I28\* $\$$ LS2  
A:K27: (G) [W6] +K26+J28\* $\$$ LS2  
A:L27: (G) [W6] @SUM(C27..K27)  
A:M27: (G) [W6] +L27\* $\$$ LS8  
A:A28: (G) [W6] 'NSNb  
A:B28: (G) [W6] (B44-B12\* $\$$ K $\$$ 8)/ $\$$ LS8  
A:C28: (G) [W6] +B28-C27  
A:D28: (G) [W6] +C29-D27  
A:E28: (G) [W6] +D29-E27  
A:F28: (G) [W6] +E29-F27  
A:G28: (G) [W6] +F29-G27  
A:H28: (G) [W6] +G29-H27  
A:I28: (G) [W6] +H29-I27  
A:J28: (G) [W6] +I29-J27  
A:K28: (G) [W6] +J29-K27  
A:M28: (G) [W6] +M11+M27  
A:A29: (G) [W6] 'ROb  
A:C29: (G) [W6] +C28+C27  
A:D29: (G) [W6] +D28+D27  
A:E29: (G) [W6] +E28+E27  
A:F29: (G) [W6] +F28+F27  
A:G29: (G) [W6] +G28+G27  
A:H29: (G) [W6] +H28+H27  
A:I29: (G) [W6] +I28+I27  
A:J29: (G) [W6] +J28+J27  
A:K29: (G) [W6] +K28+K27  
A:M29: (G) [W6] +M17+M33  
A:A30: (G) [W6] 'Db\*

A:D30: (G) [W6] +C32\*\$LS2+D26  
A:E30: (G) [W6] +D32\*\$LS2+E26  
A:F30: (G) [W6] +E32\*\$LS2+F26  
A:G30: (G) [W6] +F32\*\$LS2+G26  
A:H30: (G) [W6] +G32\*\$LS2+H26  
A:I30: (G) [W6] +H32\*\$LS2+I26  
A:J30: (G) [W6] +I32\*\$LS2+J26  
A:K30: (G) [W6] +J32\*\$LS2+K26  
A:A31: (G) [W6] 'NSNb-  
A:C31: (G) [W6] +C28  
A:D31: (G) [W6] +C32-D30  
A:E31: (G) [W6] +D32-E30  
A:F31: (G) [W6] +E32-F30  
A:G31: (G) [W6] +F32-G30  
A:H31: (G) [W6] +G32-H30  
A:I31: (G) [W6] +H32-I30  
A:J31: (G) [W6] +I32-J30  
A:K31: (G) [W6] +J32-K30  
A:A32: (G) [W6] 'NSNb+  
A:C32: (G) [W6] +C31+C33  
A:D32: (G) [W6] +D31+D33  
A:E32: (G) [W6] +E31+E33  
A:F32: (G) [W6] +F31+F33  
A:G32: (G) [W6] +G31+G33  
A:H32: (G) [W6] +H31+H33  
A:I32: (G) [W6] +I31+I33  
A:J32: (G) [W6] +J31+J33  
A:K32: (G) [W6] +K31+K33  
A:A33: (G) [W6] 'Ob  
A:C33: (G) [W6] @MAX(0,\$LS6/(\$KS6+\$LS6)\*(C44-\$KS6/\$LS6\*\$LS8\*C31+\$KS8\*C15)-  
/\$LS8)  
A:D33: (G) [W6] @MAX(0,\$LS6/(\$KS6+\$LS6)\*(D44-\$KS6/\$LS6\*\$LS8\*D31+\$KS8\*D15)-  
/\$LS8)  
A:E33: (G) [W6] @MAX(0,\$LS6/(\$KS6+\$LS6)\*(E44-\$KS6/\$LS6\*\$LS8\*E31+\$KS8\*E15)-  
/\$LS8)  
A:F33: (G) [W6] @MAX(0,\$LS6/(\$KS6+\$LS6)\*(F44-\$KS6/\$LS6\*\$LS8\*F31+\$KS8\*F15)-  
/\$LS8)  
A:G33: (G) [W6] @MAX(0,\$LS6/(\$KS6+\$LS6)\*(G44-\$KS6/\$LS6\*\$LS8\*G31+\$KS8\*G15)-  
/\$LS8)  
A:H33: (G) [W6] @MAX(0,\$LS6/(\$KS6+\$LS6)\*(H44-\$KS6/\$LS6\*\$LS8\*H31+\$KS8\*H15)-  
/\$LS8)  
A:I33: (G) [W6] @MAX(0,\$LS6/(\$KS6+\$LS6)\*(I44-\$KS6/\$LS6\*\$LS8\*I31+\$KS8\*I15)-  
/\$LS8)  
A:J33: (G) [W6] @MAX(0,\$LS6/(\$KS6+\$LS6)\*(J44-\$KS6/\$LS6\*\$LS8\*J31+\$KS8\*J15)-  
/\$LS8)  
A:K33: (G) [W6] @MAX(0,\$LS6/(\$KS6+\$LS6)\*(K44-\$KS6/\$LS6\*\$LS8\*K31+\$KS8\*K15)-  
/\$LS8)  
A:L33: (G) [W6] @SUM(C33..K33)  
A:M33: (G) [W6] +L33\*\$LS8  
A:A35: (G) [W6] 'sxb\*  
A:C35: (G) [W6] +C33\*\$B\$45

A:D35: (G) [W6] +D33\*\$BS45  
A:E35: (G) [W6] +E33\*\$BS45  
A:F35: (G) [W6] +F33\*\$BS45  
A:G35: (G) [W6] +G33\*\$BS45  
A:H35: (G) [W6] +H33\*\$BS45  
A:I35: (G) [W6] +I33\*\$BS45  
A:J35: (G) [W6] +J33\*\$BS45A:K35: (G) [W6] +K33\*\$BS45  
A:M35: (G) [W6] @SUM(C35..K35)  
A:A36: (G) [W6] 'xb\*\*  
A:C36: (G) [W6] @MAX(0, SLS6/(SKS6+SLS6)\*(C45-SKS6/SLS6\*SLS8\*C31+SKS8\*C15)-  
/SLS8)  
A:D36: (G) [W6] @MAX(0, SLS6/(SKS6+SLS6)\*(D45-SKS6/SLS6\*SLS8\*D31+SKS8\*D15)-  
/SLS8)  
A:E36: (G) [W6] @MAX(0, SLS6/(SKS6+SLS6)\*(E45-SKS6/SLS6\*SLS8\*E31+SKS8\*E15)-  
/SLS8)  
A:F36: (G) [W6] @MAX(0, SLS6/(SKS6+SLS6)\*(F45-SKS6/SLS6\*SLS8\*F31+SKS8\*F15)-  
/SLS8)  
A:G36: (G) [W6] @MAX(0, SLS6/(SKS6+SLS6)\*(G45-SKS6/SLS6\*SLS8\*G31+SKS8\*G15)-  
/SLS8)  
A:H36: (G) [W6] @MAX(0, SLS6/(SKS6+SLS6)\*(H45-SKS6/SLS6\*SLS8\*H31+SKS8\*H15)-  
/SLS8)  
A:I36: (G) [W6] @MAX(0, SLS6/(SKS6+SLS6)\*(I45-SKS6/SLS6\*SLS8\*I31+SKS8\*I15)-  
/SLS8)  
A:J36: (G) [W6] @MAX(0, SLS6/(SKS6+SLS6)\*(J45-SKS6/SLS6\*SLS8\*J31+SKS8\*J15)-  
/SLS8)  
A:K36: (G) [W6] @MAX(0, SLS6/(SKS6+SLS6)\*(K45-SKS6/SLS6\*SLS8\*K31+SKS8\*K15)-  
/SLS8)  
A:M36: (G) [W6] @SUM(C36..K36)  
A:A37: (G) [W6] 'Xb:s  
A:C37: (G) [W6] +C31+C35  
A:D37: (G) [W6] +D31+D35  
A:E37: (G) [W6] +E31+E35  
A:F37: (G) [W6] +F31+F35  
A:G37: (G) [W6] +G31+G35  
A:H37: (G) [W6] +H31+H35  
A:I37: (G) [W6] +I31+I35  
A:J37: (G) [W6] +J31+J35  
A:K37: (G) [W6] +K31+K35  
A:A38: (G) [W6] 'Xb\*\*  
A:C38: (G) [W6] +C31+C36  
A:D38: (G) [W6] +D31+D36  
A:E38: (G) [W6] +E31+E36  
A:F38: (G) [W6] +F31+F36  
A:G38: (G) [W6] +G31+G36  
A:H38: (G) [W6] +H31+H36  
A:I38: (G) [W6] +I31+I36  
A:J38: (G) [W6] +J31+J36  
A:K38: (G) [W6] +K31+K36  
A:C39: (G) [W6] +C35/C33  
A:D39: (G) [W6] +D35/D33  
A:E39: (G) [W6] +E35/E33

A:F39: (G) [W6] +F35/F33  
A:G39: (G) [W6] +G35/G33  
A:H39: (G) [W6] +H35/H33  
A:I39: (G) [W6] +I35/I33  
A:J39: (G) [W6] +J35/J33  
A:K39: (G) [W6] +K35/K33  
A:L39: (G) [W6] @AVG(C39..K39)  
A:C40: (G) [W6] @IF(C36/C33>0,C36/C33,1)  
A:D40: (G) [W6] @IF(D36/D33>0,D36/D33,0)  
A:E40: (G) [W6] @IF(E36/E33>0,E36/E33,0)  
A:F40: (G) [W6] @IF(F36/F33>0,F36/F33,0)  
A:G40: (G) [W6] @IF(G36/G33>0,G36/G33,0)  
A:H40: (G) [W6] @IF(H36/H33>0,H36/H33,0)  
A:I40: (G) [W6] @IF(I36/I33>0,I36/I33,0)  
A:J40: (G) [W6] @IF(J36/J33>0,J36/J33,0)  
A:K40: (G) [W6] @IF(K36/K33>0,K36/K33,0)  
A:L40: (G) [W6] @AVG(C40..K40)  
A:M40: (G) [W6] (M20+M36)/(L17+L33)  
A:A42: (G) [W6] 'check  
A:C42: (G) [W6] (C19-C20)\*\$K\$8+(C35-C36)\*\$L\$8  
A:D42: (G) [W6] (D19-D20)\*\$K\$8+(D35-D36)\*\$L\$8  
A:E42: (G) [W6] (E19-E20)\*\$K\$8+(E35-E36)\*\$L\$8  
A:F42: (G) [W6] (F19-F20)\*\$K\$8+(F35-F36)\*\$L\$8  
A:G42: (G) [W6] (G19-G20)\*\$K\$8+(G35-G36)\*\$L\$8  
A:H42: (G) [W6] (H19-H20)\*\$K\$8+(H35-H36)\*\$L\$8  
A:I42: (G) [W6] (I19-I20)\*\$K\$8+(I35-I36)\*\$L\$8  
A:J42: (G) [W6] (J19-J20)\*\$K\$8+(J35-J36)\*\$L\$8  
A:K42: (G) [W6] (K19-K20)\*\$K\$8+(K35-K36)\*\$L\$8  
A:C43: (G) [W6] +C11\*\$K\$8+C27\*\$L\$8  
A:D43: (G) [W6] +D11\*\$K\$8+D27\*\$L\$8  
A:E43: (G) [W6] +E11\*\$K\$8+E27\*\$L\$8  
A:F43: (G) [W6] +F11\*\$K\$8+F27\*\$L\$8  
A:G43: (G) [W6] +G11\*\$K\$8+G27\*\$L\$8  
A:H43: (G) [W6] +H11\*\$K\$8+H27\*\$L\$8  
A:I43: (G) [W6] +I11\*\$K\$8+I27\*\$L\$8  
A:J43: (G) [W6] +J11\*\$K\$8+J27\*\$L\$8  
A:K43: (G) [W6] +K11\*\$K\$8+K27\*\$L\$8  
A:M43: (G) [W6] @SUM(C43..K43)  
A:A44: (G) [W6] 'B  
A:B44: (G) [W6] 100  
A:C44: (G) [W6] +C43  
A:D44: (G) [W6] +D43  
A:E44: (G) [W6] +E43  
A:F44: (G) [W6] +F43  
A:G44: (G) [W6] +G43  
A:H44: (G) [W6] +H43  
A:I44: (G) [W6] +I43  
A:J44: (G) [W6] +J43  
A:K44: (G) [W6] +K43  
A:M44: (G) [W6] @SUM(C44..K44)  
A:A45: (G) [W6] 'NewB(t)

A:B45: (G) [W6] 0.8  
A:C45: (G) [W6] +C44\*\$BS45  
A:D45: (G) [W6] +D44\*\$BS45  
A:E45: (G) [W6] +E44\*\$BS45  
A:F45: (G) [W6] +F44\*\$BS45  
A:G45: (G) [W6] +G44\*\$BS45  
A:H45: (G) [W6] +H44\*\$BS45  
A:I45: (G) [W6] +I44\*\$BS45  
A:J45: (G) [W6] +J44\*\$BS45  
A:K45: (G) [W6] +K44\*\$BS45  
A:M45: (G) [W6] @SUM(C45..K45)  
A:A46: (G) [W6] 'U  
A:B46: (G) [W6] +B12^\$KS6\*B28^\$LS6  
A:C46: (G) [W6] +C13^\$KS6\*C29^\$LS6  
A:D46: (G) [W6] +D13^\$KS6\*D29^\$LS6  
A:E46: (G) [W6] +E13^\$KS6\*E29^\$LS6  
A:F46: (G) [W6] +F13^\$KS6\*F29^\$LS6  
A:G46: (G) [W6] +G13^\$KS6\*G29^\$LS6  
A:H46: (G) [W6] +H13^\$KS6\*H29^\$LS6  
A:I46: (G) [W6] +I13^\$KS6\*I29^\$LS6  
A:J46: (G) [W6] +J13^\$KS6\*J29^\$LS6  
A:K46: (G) [W6] +K13^\$KS6\*K29^\$LS6  
A:M46: (G) [W6] @SUM(C46..K46)  
A:A47: (G) [W6] 'U\*  
A:B47: (G) [W6] +B12^\$KS6\*B28^\$LS6  
A:C47: (G) [W6] +C16^\$KS6\*C32^\$LS6  
A:D47: (G) [W6] +D16^\$KS6\*D32^\$LS6  
A:E47: (G) [W6] +E16^\$KS6\*E32^\$LS6  
A:F47: (G) [W6] +F16^\$KS6\*F32^\$LS6  
A:G47: (G) [W6] +G16^\$KS6\*G32^\$LS6  
A:H47: (G) [W6] +H16^\$KS6\*H32^\$LS6  
A:I47: (G) [W6] +I16^\$KS6\*I32^\$LS6  
A:J47: (G) [W6] +J16^\$KS6\*J32^\$LS6  
A:K47: (G) [W6] +K16^\$KS6\*K32^\$LS6  
A:M47: (G) [W6] @SUM(C47..K47)  
A:A49: (G) [W6] 'U1  
A:C49: (G) [W6] +C21^\$KS6\*C37^\$LS6  
A:D49: (G) [W6] +D21^\$KS6\*D37^\$LS6  
A:E49: (G) [W6] +E21^\$KS6\*E37^\$LS6  
A:F49: (G) [W6] +F21^\$KS6\*F37^\$LS6  
A:G49: (G) [W6] +G21^\$KS6\*G37^\$LS6  
A:H49: (G) [W6] +H21^\$KS6\*H37^\$LS6  
A:I49: (G) [W6] +I21^\$KS6\*I37^\$LS6  
A:J49: (G) [W6] +J21^\$KS6\*J37^\$LS6  
A:K49: (G) [W6] +K21^\$KS6\*K37^\$LS6  
A:M49: (G) [W6] @SUM(C49..K49)  
A:A50: (G) [W6] 'U\*\*  
A:C50: (G) [W6] +C22^\$KS6\*C38^\$LS6  
A:D50: (G) [W6] +D22^\$KS6\*D38^\$LS6  
A:E50: (G) [W6] +E22^\$KS6\*E38^\$LS6  
A:F50: (G) [W6] +F22^\$KS6\*F38^\$LS6



A:G50: (G) [W6] +G22^\$KS6\*G38^SLS6  
A:H50: (G) [W6] +H22^\$KS6\*H38^SLS6  
A:I50: (G) [W6] +I22^\$KS6\*I38^SLS6  
A:J50: (G) [W6] +J22^\$KS6\*J38^SLS6  
A:K50: (G) [W6] +K22^\$KS6\*K38^SLS6  
A:M50: (G) [W6] @SUM(C50..K50)  
A:A51: (G) [W6] 'U\*\*~U1  
A:C51: (G) [W6] @IF(C50-C49=0,1,-1)  
A:D51: (G) [W6] @IF(D50-D49=0,1,-1)  
A:E51: (G) [W6] @IF(E50-E49=0,1,-1)  
A:F51: (G) [W6] @IF(F50-F49=0,1,-1)  
A:G51: (G) [W6] @IF(G50-G49=0,1,-1)  
A:H51: (G) [W6] @IF(H50-H49=0,1,-1)  
A:I51: (G) [W6] @IF(I50-I49=0,1,-1)  
A:J51: (G) [W6] @IF(J50-J49=0,1,-1)  
A:K51: (G) [W6] @IF(K50-K49=0,1,-1)  
A:M51: (G) [W6] @IF(M50-M49=0,1,-1)  
A:C52: (G) [W6] (C50-C49)/C49  
A:D52: (G) [W6] (D50-D49)/D49  
A:E52: (G) [W6] (E50-E49)/E49  
A:F52: (G) [W6] (F50-F49)/F49  
A:G52: (G) [W6] (G50-G49)/G49  
A:H52: (G) [W6] (H50-H49)/H49  
A:I52: (G) [W6] (I50-I49)/I49  
A:J52: (G) [W6] (J50-J49)/J49  
A:K52: (G) [W6] (K50-K49)/K49  
A:M52: (G) [W6] (M50-M49)/M49

APPENDIX C  
Derivation of Optimal Order Quantity

The following is the process for deriving the optimal order quantities. Given the utility measure

$$U = U(NSN_a, NSN_b) = (NSN_a^{Ea}) (NSN_b^{Eb})$$

$O_a$  (optimal order quantity) is substituted into  $D_a$  (quantity issued)<sup>12</sup> in the utility function so that the utility will reflect on hand-quantity with the *optimal* order quantity, rather than with the *replacement* order quantity. The process is as follows:

$$U_a = \frac{E_a U}{NSN_a + D_a}$$

$$U_b = \frac{E_b U}{NSN_b + D_b}$$

The first order condition (the marginal utility interpretation of equilibrium) is:

---

<sup>12</sup>The utility function is based on on-hand quantities. If the order quantity is the same as the quantity issued, then the utility does not change. To reflect a change in on-hand quantity resulting from optimization (and thus an optimal order quantity) the optimal order quantity ( $O_a$ ) must be used in place of the quantity issued ( $D_a$ ).

$$\frac{U_a}{P_a} = \frac{U_b}{P_b}$$

Substituting the previously defined expressions for  $U_a$  and  $U_b$ :

$$\frac{\frac{E_a U}{NSN_a + D_a}}{P_a} = \frac{\frac{E_b U}{NSN_b + D_b}}{P_b} \rightarrow$$

$$\frac{E_a}{E_b} \times \frac{NSN_b + D_b}{NSN_a + D_a} = \frac{P_a}{P_b} \rightarrow$$

$$\frac{E_a}{E_b} (NSN_b P_b + D_b P_b) = P_a NSN_a + P_a D_a$$

Substitute the expression into the budget equation  $B = (D_b P_b) + (D_a P_a)$ :

$$B = D_b P_b + \frac{E_a}{E_b} (NSN_b P_b + D_b P_b) - P_a NSN_a \rightarrow$$

$$B = D_b P_b \frac{E_a + E_b}{E_b} + \frac{E_a}{E_b} (NSN_b P_b) - P_a NSN_a \rightarrow$$

Solve for  $O_b$ :

$$O_b^* = \frac{\frac{E_b}{E_a + E_b} \left( B - \frac{E_a}{E_b} NSN_b P_b + P_a NSN_a \right)}{P_b}$$

$O_b$  is the optimal order quantity for  $NSN_b$ , which will maximize readiness (utility) given a budget constraint.

APPENDIX D

Lotus 1-2-3 Release 3.1+ Myopic vs. Non-myopic Optimization

A	B	C	D	E	F	G	H	I
1 Myopic vs Non-Myopic								
2 Q = Order Quantity	NSN = Stock Quantity(I) = Infinite			(M) = Myopic		(F) = Finite		
3 Ea	Eb	I-Ma	I-Mb	NSNa(t0)	NSNb(t0)	B(t0)	B(t1)	Pa
4 0.500	0.900	0.600	0.800	7.143	15.429	24.000	24.000	3.000
5 Ea-I	Eb-I	Ea+Eb	G13	G23	G33	H13	H23	H33
6 -0.500	-0.100	1.400	0.119	-0.643	0.595	0.129	-0.357	0.386
7 (I-Ma)(NSNa(t0))	(I-Mb)(NSNb(t0))	B/Pa	Pb/Pa	Y2-	Y3-	Y3-	NSNa(I)/(M)	NSNa(I)
8 4.286	12.343	8.000	1.667	12.286	9.653	10.425	0.679	7.143
9								
10 Ob(t1)(F)	Oa(t1)(F)	NSNb(t1)(F)	NSNa(t1)(F)	Ob(t2)(F)	Oa(t2)(F)	NSNb(t2)(F)	NSNa(t2)(F)	Oa(I)
11 1.180	6.033	13.523	10.319	1.610	5.316	12.428	11.508	2.857
12 U1	U1	U2	U1+U2	a/(PxY2)	b/(PyY2)	Check3	B@t=0	B@t=1
13 31.364	33.480	32.770	66.249	0.014	0.014	0.000	24.000	24.000
14								
15 (m,n)=	0.600	0.800	(Y1,Y1)=	7.143	15.429	8.930	19.290	
16 Myop vs Infinite		Bt	24.000	24.000	24.000	24.000	24.000	24.000
17 s=>	0.800	0.000	1.000	2.000	3.000	4.000	5.000	6.000
18 Consumption			3.572	5.343	5.227	4.951	4.750	4.604
19 NSNa-(Stock pre-order)			5.358	8.015	7.841	7.427	7.125	6.906
20 Oa Inf(t)StySt			2.857	2.857	2.857	2.857	2.857	2.857
21 Oa Myopic			8.000	5.053	4.537	4.449	4.384	4.337
22 NSNa Inf(t)StySt			7.143	7.143	7.143	7.143	7.143	7.143
23 NSNa Myopic		8.930	13.358	13.068	12.378	11.876	11.509	11.243
24								
25 Consumption			3.858	3.086	2.823	2.674	2.565	2.486
26 NSNb-(Stock pre-order)			15.432	12.346	11.291	10.695	10.260	9.944
27 Ob Inf(t)StySt			3.086	3.086	3.086	3.086	3.086	3.086
28 Ob Myopic			0.000	1.768	2.078	2.131	2.170	2.198
29 NSNb Inf(t)StySt			15.429	15.429	15.429	15.429	15.429	15.429
30 NSNb Myopic		19.290	15.432	14.114	13.368	12.826	12.430	12.142
31								
32 Ut2	Inf(t)		31.364	31.364	31.364	31.364	31.364	31.364
33 Ut	Myopic	42.877	42.899	39.154	36.291	34.245	32.776	31.717
34 CumU(t) Inf			31.364	62.728	94.091	125.455	156.819	188.183
35 CumU(t) Myo			42.899	82.054	118.345	152.590	185.366	217.083
36		Myo - Inf	0.000	0.000	0.000	0.000	0.000	0.000
37	Bt Check		0.000	0.000	0.000	0.000	0.000	0.000
38		Bt	0.000	24.000				
39 Finite (2)			1.000	2.000				
40 Consumption			2.857	4.128			U1	U1+U2
41 NSNa-(Stock pre-order)			4.286	6.191		Infinite	31.364	62.728
42 Oa (Fin)			6.033	5.316		Myopic	42.899	82.054

A	A	B	C	D	E	F	G	H	I
43	NSNa (Fin)		7.143	10.319	11.508		Finite(2)	33.480	66.249
44									
45	Consumption			3.086	2.705				
46	NSNb-(Stock pre-order)			12.343	10.818				
47	Ob (Fin)			1.180	1.610				
48	NSNb (Fin)		15.429	13.523	12.428				
49		Ut	31.364	33.480	32.770	66.249			
50		Bt Check		0.000	0.000				

	J	K	L	M	N	O	P	Q	R	S
1										
2										
3	Pb (1-Ma)(1+G23)	(G13)(B@t=1)	(G33)(1-Db)							
4	5.000	0.214	2.857	0.476						
5	NSNb(I)/(M)	n(1+H23)	H13B1	H33m						
6	1.357	0.514	3.086	0.231						
7	NSNb(I)	NSNa/NSNb(I)	(Eb)(1-Mb)(Pa)	(Ea)(1-Ma)(Pb)						
8	15.429	0.463	2.160	1.500						
9										
10	Ob(I)	NSNa(M)	Oa(M)	Oa/Ob(I)		NSNa/b(M)				
11	3.086	10.526	4.211	0.926	0.926	0.926	0.926			
12	Check2	NSNb(M)	Ob(M)	Oa/Ob(M)						
13	0.003	11.368	2.274	1.852	1.852					
14										
15	8.000									
16	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000
17	7.000	8.000	9.000	10.000	11.000	12.000	13.000	14.000	15.000	16.000
18	4.497	4.419	4.363	4.321	4.291	4.269	4.253	4.242	4.233	4.227
19	6.746	6.629	6.544	6.482	6.437	6.404	6.380	6.363	6.350	6.341
20	2.857	2.857	2.857	2.857	2.857	2.857	2.857	2.857	2.857	2.857
21	4.303	4.278	4.259	4.246	4.236	4.229	4.224	4.221	4.218	4.216
22	7.143	7.143	7.143	7.143	7.143	7.143	7.143	7.143	7.140	7.140
23	11.048	10.906	10.803	10.728	10.673	10.633	10.604	10.583	10.568	10.556
24										
25	2.428	2.386	2.356	2.334	2.317	2.305	2.297	2.291	2.286	2.283
26	9.714	9.546	9.423	9.334	9.269	9.222	9.187	9.162	9.144	9.131
27	3.086	3.086	3.086	3.086	3.086	3.086	3.086	3.086	3.086	3.086
28	2.218	2.233	2.244	2.252	2.258	2.262	2.265	2.268	2.269	2.270
29	15.429	15.429	15.429	15.429	15.429	15.429	15.429	15.429	15.430	15.430
30	11.932	11.779	11.668	11.586	11.527	11.484	11.453	11.430	11.413	11.401
31										
32	31.364	31.364	31.364	31.364	31.364	31.364	31.364	31.364	31.360	31.360
33	30.952	30.398	29.996	29.704	29.492	29.338	29.225	29.144	29.084	29.041
34	219.547	250.911	282.274	313.638	345.002	376.366	407.730	439.094	470.454	501.814
35	248.034	278.432	308.428	338.132	367.624	396.961	426.187	455.330	484.414	513.455
36	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
37	0.000	0.000	0.000	0.000	0.000	0.000	0.000			

	J	K	L	M	N	O	P	Q	R	S
38										
39										
40		07	026							
41	219.547	501.814								
42	248.034	513.455								
43										
44										
45										
46										
47										
48										
49										
50										

APPENDIX E  
Cell Formulas - Myopic vs. Non-myopic

A:A1: (F3) [W16] "Myopic vs Non-Myopic  
 A:A2: [W16] '0 = Order Quantity      NSN = Stock Quantity  
 A:D2: [W13] "(I) = Infinite      (M) = Myopic      (F) = Finite  
 A:A3: (F3) [W16] "Ea  
 A:B3: (F3) [W17] "Eb  
 A:C3: (F3) [W13] "1-Ma  
 A:D3: (F3) [W13] "1-Mb  
 A:E3: (F3) [W11] "NSNa(t0)  
 A:F3: (F3) [W11] "NSNb(t0)  
 A:G3: (F3) [W13] "B(t0)  
 A:H3: (F3) [W13] "B(t1)  
 A:I3: (F3) [W9] "Pa  
 A:J3: (F3) [W13] "Pb  
 A:K3: (F3) [W14] "(1-Ma)(1+G23)  
 A:L3: (F3) [W15] "(G13)(B@t=1)  
 A:M3: (F3) [W15] "(G33)(1-Db)  
 A:A4: (F3) [W16] 0.5  
 A:B4: (F3) [W17] 0.9  
 A:C4: (F3) [W13] 0.6  
 A:D4: (F3) [W13] 0.8  
 A:E4: (F3) [W11] +I8  
 A:F4: (F3) [W11] +J8  
 A:G4: (F3) [W13] 30\*\$B\$17  
 A:H4: (F3) [W13] 30\*\$B\$17  
 A:I4: (F3) [W9] 3  
 A:J4: (F3) [W13] 5  
 A:K4: (F3) [W14] +SC\$4\*(1+E6)  
 A:L4: (F3) [W15] +D6\*H4  
 A:M4: (F3) [W15] +F6\*\$D\$4  
 A:A5: (F3) [W16] "Ea-1  
 A:B5: (F3) [W17] "Eb-1  
 A:C5: (F3) [W13] "Ea+Eb  
 A:D5: (F3) [W13] "G13  
 A:E5: (F3) [W11] "G23  
 A:F5: (F3) [W11] "G33  
 A:G5: (F3) [W13] "H13  
 A:H5: (F3) [W13] "H23  
 A:I5: (F3) [W9] "H33  
 A:J5: (F3) [W13] "NSNb(I)/(M)  
 A:K5: (F3) [W14] "n(1+H23)  
 A:L5: (F3) [W15] "H13B1  
 A:M5: (F3) [W15] "H33m  
 A:A6: (F3) [W16] +SA\$4-1

A:B6: (F3) [W17] +SBS4-1  
A:C6: (F3) [W13] +SAS4+SBS4  
A:D6: (F3) [W13] +SAS4/(\$CS6\*SIS4)  
A:E6: (F3) [W11] -SBS4/\$CS6  
A:F6: (F3) [W11] +D6\*\$JS4  
A:G6: (F3) [W13] +SBS4/(\$CS6\*SJS4)  
A:H6: (F3) [W13] -SAS4/\$CS6  
A:I6: (F3) [W9] +G6\*\$IS4  
A:J6: (F3) [W13] +J8/K13  
A:K6: (F3) [W14] +SDS4\*(1+H6)  
A:L6: (F3) [W15] +G6\*H4  
A:M6: (F3) [W15] +I6\*\$CS4  
A:A7: (F3) [W16] "(1-Ma) (NSNa(t0))  
A:B7: (F3) [W17] "(1-Mb) (NSNb(t0))  
A:C7: (F3) [W13] "B/Pa  
A:D7: (F3) [W13] "Pb/Pa  
A:E7: (F3) [W11] "X2-  
A:F7: (F3) [W11] "X3-  
A:G7: (F3) [W13] "Y3-  
A:H7: (F3) [W13] "NSNa(I)/(M)  
A:I7: (F3) [W9] "NSNa(I)  
A:J7: (F3) [W13] "NSNb(I)  
A:K7: (F3) [W14] "NSNa/NSNb(I)  
A:L7: (F3) [W15] "(Eb) (1-Mb) (Pa)  
A:M7: (F3) [W15] "(Ea) (1-Ma) (Pb)  
A:A8: (F3) [W16] +\$CS4\*E4  
A:B8: (F3) [W17] +\$DS4\*F4  
A:C8: (F3) [W13] +G4/\$IS4  
A:D8: (F3) [W13] +\$JS4/\$IS4  
A:E8: (F3) [W11] +\$CS4\*\$SES4+\$GS4/\$IS4  
A:F8: (F3) [W11] +K4\*\$CS4\*\$SES4+L4+M4\*\$DS4\*\$FS4  
A:G8: (F3) [W13] +K6\*\$DS4\*\$FS4+L6+I6\*\$CS4\*\$CS4\*\$SES4  
A:H8: (F3) [W13] +I8/K11  
A:I8: (F3) [W9] +I11/(1-\$CS4)  
A:J8: (F3) [W13] +J11/(1-\$DS4)  
A:K8: (F3) [W14] +I8/J8  
A:L8: (F3) [W15] +SBS4\*\$DS4\*\$IS4  
A:M8: (F3) [W15] +SAS4\*\$CS4\*\$JS4  
A:A10: (F3) [W16] "Ob(t1) (F)  
A:B10: (F3) [W17] "Oa(t1) (F)  
A:C10: (F3) [W13] "NSNb(t1) (F)  
A:D10: (F3) [W13] "NSNa(t1) (F)  
A:E10: (F3) [W11] "Ob(t2) (F)  
A:F10: (F3) [W11] "Oa(t2) (F)  
A:G10: (F3) [W13] "NSNb(t2) (F)  
A:H10: (F3) [W13] "NSNa(t2) (F)  
A:I10: (F3) [W9] "Oa(I)  
A:J10: (F3) [W13] "Ob(I)  
A:K10: (F3) [W14] "NSNa(M)  
A:L10: (F3) [W15] "Oa(M)  
A:M10: (F3) [W15] "Oa/Ob(I)



A:O10: (F3) [W12] "NSNa/b(M)  
A:A11: (F3) [W16] 1.18 (Derived)  
A:B11: (F3) [W17] +C8-D8\*A11  
A:C11: (F3) [W13] +F4\*SDS4+A11  
A:D11: (F3) [W13] +E4\*SCS4+B11  
A:E11: (F3) [W11] @IF(F11>0,L6+H6\*C11\*SDS4+I6\*D11\*SCS4,SHS4/\$JS4)  
A:F11: (F3) [W11] @MAX(0,L4+E6\*D11\*SCS4+F6\*C11\*SDS4)  
A:G11: (F3) [W13] +E11+C11\*SDS4  
A:H11: (F3) [W13] +F11+D11\*SCS4  
A:I11: (F3) [W9] +SAS4/SCS6\*(SGS4/\$IS4)  
A:J11: (F3) [W13] +SBS4/SCS6\*(SGS4/\$JS4)  
A:K11: (F3) [W14] (\$AS4\*SGS4)/((SCS6-\$AS4\*SCS4-SBS4\*SDS4)\*\$IS4)  
A:L11: (F3) [W15] +SAS4\*SGS4\*(1-SCS4)/(\$IS4\*(SCS6-SAS4\*SCS4-SBS4\*SDS4))  
A:M11: (F3) [W15] +I11/J11  
A:N11: (F3) [W8] +SAS4\*\$JS4/(\$BS4\*\$IS4)  
A:O11: (F3) [W12] +K11/K13  
A:P11: (F3) [W9] +SAS4\*\$JS4/(\$BS4\*\$IS4)  
A:A12: (F3) [W16] "U1  
A:B12: (F3) [W17] "U1  
A:C12: (F3) [W13] "U2  
A:D12: (F3) [W13] "U1+U2  
A:E12: (F3) [W11] "a/(PxX2)  
A:F12: (F3) [W11] "b/(PyY2)  
A:G12: (F3) [W13] "Check3  
A:H12: (F3) [W13] "B@t=0  
A:I12: (F3) [W9] "B@t=1  
A:J12: (F3) [W13] "Check2  
A:K12: (F3) [W14] "NSNb(M)  
A:L12: (F3) [W15] "Ob(M)  
A:M12: (F3) [W15] "Oa/Ob(M)  
A:A13: (F3) [W16] +E4^SAS4\*F4^SBS4  
A:B13: (F3) [W17] +D11^SAS4\*C11^SBS4  
A:C13: (F3) [W13] +H11^SAS4\*G11^SBS4  
A:D13: (F3) [W13] +B13+C13  
A:E13: (F3) [W11] +SAS4/(\$IS4\*H11)  
A:F13: (F3) [W11] +SBS4/(\$JS4\*G11)  
A:G13: (F3) [W13] +E13-F13  
A:H13: (F3) [W13] +\$IS4\*B11+\$JS4\*A11  
A:I13: (F3) [W9] +\$IS4\*F11+\$JS4\*E11  
A:J13: (F3) [W13] +D11^A6\*C11^B6\*(\$AS4\*C11\*\$JS4-SBS4\*D11\*\$IS4)-H11^A6\*G11-  
^B6\*(L8\*H11-M8\*G11)  
A:K13: (F3) [W14] (\$BS4\*SGS4)/((SCS6-\$AS4\*SCS4-SBS4\*SDS4)\*\$JS4)  
A:L13: (F3) [W15] +\$BS4\*SGS4\*(1-SDS4)/(\$JS4\*(SCS6-\$AS4\*SCS4-SBS4\*SDS4))  
A:M13: (F3) [W15] +L11/L13  
A:N13: (F3) [W8] +SAS4\*(1-SCS4)\*\$JS4/(\$BS4\*(1-SDS4)\*\$IS4)  
A:A15: (F3) [W16] "(m,n)=  
A:B15: (F3) [W17] +C4  
A:C15: (F3) [W13] +D4  
A:D15: (F3) [W13] "(X1,Y1)=  
A:E15: (F3) [W11] +E4  
A:F15: (F3) [W11] +F4

A:G15: (F3) [W13] 8.93  
A:H15: (F3) [W13] 19.29  
A:J15: (F3) [W13] +D16/SIS4  
A:A16: (F3) [W16] 'Myop vs Infinite  
A:C16: (F3) [W13] "Bt  
A:D16: (F3) [W13] +SGS4  
A:E16: (F3) [W11] +SHS4  
A:F16: (F3) [W11] +SHS4  
A:G16: (F3) [W13] +SHS4  
A:H16: (F3) [W13] +SHS4  
A:I16: (F3) [W9] +SHS4  
A:J16: (F3) [W13] +SHS4  
A:K16: (F3) [W14] +SHS4  
A:L16: (F3) [W15] +SHS4  
A:M16: (F3) [W15] +SHS4  
A:N16: (F3) [W8] +SHS4  
A:O16: (F3) [W12] +SHS4  
A:P16: (F3) [W9] +SHS4  
A:Q16: (F3) +SHS4  
A:R16: (F3) +SHS4  
A:S16: (F3) +SHS4  
A:A17: (F3) [W16] 's=>  
A:B17: (F3) [W17] 0.8  
A:C17: (F3) [W13] 0  
A:D17: (F3) [W13] +C17+1  
A:E17: (F3) [W11] +D17+1  
A:F17: (F3) [W11] +E17+1  
A:G17: (F3) [W13] +F17+1  
A:H17: (F3) [W13] +G17+1  
A:I17: (F3) [W9] +H17+1  
A:J17: (F3) [W13] +I17+1  
A:K17: (F3) [W14] +J17+1  
A:L17: (F3) [W15] +K17+1  
A:M17: (F3) [W15] +L17+1  
A:N17: (F3) [W8] +M17+1  
A:O17: (F3) [W12] +N17+1  
A:P17: (F3) [W9] +O17+1  
A:Q17: (F3) +P17+1  
A:R17: (F3) +Q17+1  
A:S17: (F3) +R17+1  
A:A18: (F3) [W16] 'Consumption  
A:D18: (F3) [W13] +C23\*(1-SCS4)  
A:E18: (F3) [W11] +D23\*(1-SCS4)  
A:F18: (F3) [W11] +E23\*(1-SCS4)  
A:G18: (F3) [W13] +F23\*(1-SCS4)  
A:H18: (F3) [W13] +G23\*(1-SCS4)  
A:I18: (F3) [W9] +H23\*(1-SCS4)  
A:J18: (F3) [W13] +I23\*(1-SCS4)  
A:K18: (F3) [W14] +J23\*(1-SCS4)  
A:L18: (F3) [W15] +K23\*(1-SCS4)  
A:M18: (F3) [W15] +L23\*(1-SCS4)

A:N18: (F3) [W8] +M23\*(1-SCS4)  
A:O18: (F3) [W12] +N23\*(1-SCS4)  
A:P18: (F3) [W9] +O23\*(1-SCS4)  
A:Q18: (F3) +P23\*(1-SCS4)  
A:R18: (F3) +Q23\*(1-SCS4)  
A:S18: (F3) +R23\*(1-SCS4)  
A:A19: (F3) [W16] 'NSNa-(Stock pre-order)  
A:D19: (F3) [W13] +C23-D18  
A:E19: (F3) [W11] +D23-E18  
A:F19: (F3) [W11] +E23-F18  
A:G19: (F3) [W13] +F23-G18  
A:H19: (F3) [W13] +G23-H18  
A:I19: (F3) [W9] +H23-I18  
A:J19: (F3) [W13] +I23-J18  
A:K19: (F3) [W14] +J23-K18  
A:L19: (F3) [W15] +K23-L18  
A:M19: (F3) [W15] +L23-M18  
A:N19: (F3) [W8] +M23-N18  
A:O19: (F3) [W12] +N23-O18  
A:P19: (F3) [W9] +O23-P18  
A:Q19: (F3) +P23-Q18  
A:R19: (F3) +Q23-R18  
A:S19: (F3) +R23-S18  
A:A20: (F3) [W16] ' Oa Inf(t)StySt  
A:D20: (F3) [W13] +SAS4/SCS6\*(SGS4/SIS4)  
A:E20: (F3) [W11] +SAS4/SCS6\*(SGS4/SIS4)  
A:F20: (F3) [W11] +SAS4/SCS6\*(SGS4/SIS4)  
A:G20: (F3) [W13] +SAS4/SCS6\*(SGS4/SIS4)  
A:H20: (F3) [W13] +SAS4/SCS6\*(SGS4/SIS4)  
A:I20: (F3) [W9] +SAS4/SCS6\*(SGS4/SIS4)  
A:J20: (F3) [W13] +SAS4/SCS6\*(SGS4/SIS4)  
A:K20: (F3) [W14] +SAS4/SCS6\*(SGS4/SIS4)  
A:L20: (F3) [W15] +SAS4/SCS6\*(SGS4/SIS4)  
A:M20: (F3) [W15] +SAS4/SCS6\*(SGS4/SIS4)  
A:N20: (F3) [W8] +SAS4/SCS6\*(SGS4/SIS4)  
A:O20: (F3) [W12] +SAS4/SCS6\*(SGS4/SIS4)  
A:P20: (F3) [W9] +SAS4/SCS6\*(SGS4/SIS4)  
A:Q20: (F3) +SAS4/SCS6\*(SGS4/SIS4)  
A:R20: (F3) +SAS4/SCS6\*(SGS4/SIS4)  
A:S20: (F3) +SAS4/SCS6\*(SGS4/SIS4)  
A:A21: (F3) [W16] ' Oa Myopic  
A:D21: (F3) [W13] @MAX(0,@MIN(SAS4/SCS6\*(D16-SBS4/SAS4\*SIS4\*D19+SJS4\*D26)-  
/SIS4,D16/SIS4))  
A:E21: (F3) [W11] @MAX(0,SAS4/SCS6\*(E16-SBS4/SAS4\*SIS4\*E19+SJS4\*E26)/SIS4)  
A:F21: (F3) [W11] @MAX(0,SAS4/SCS6\*(F16-SBS4/SAS4\*SIS4\*F19+SJS4\*F26)/SIS4)  
A:G21: (F3) [W13] @MAX(0,SAS4/SCS6\*(G16-SBS4/SAS4\*SIS4\*G19+SJS4\*G26)/SIS4)  
A:H21: (F3) [W13] @MAX(0,SAS4/SCS6\*(H16-SBS4/SAS4\*SIS4\*H19+SJS4\*H26)/SIS4)  
A:I21: (F3) [W9] @MAX(0,SAS4/SCS6\*(I16-SBS4/SAS4\*SIS4\*I19+SJS4\*I26)/SIS4)  
A:J21: (F3) [W13] @MAX(0,SAS4/SCS6\*(J16-SBS4/SAS4\*SIS4\*J19+SJS4\*J26)/SIS4)  
A:K21: (F3) [W14] @MAX(0,SAS4/SCS6\*(K16-SBS4/SAS4\*SIS4\*K19+SJS4\*K26)/SIS4)  
A:L21: (F3) [W15] @MAX(0,SAS4/SCS6\*(L16-SBS4/SAS4\*SIS4\*L19+SJS4\*L26)/SIS4)

A:M21: (F3) [W15] @MAX(0,SAS4/SCS6\*(M16-SBS4/SAS4\*SIS4\*M19+SJS4\*M26)/SIS4)  
A:N21: (F3) [W8] @MAX(0,SAS4/SCS6\*(N16-SBS4/SAS4\*SIS4\*N19+SJS4\*N26)/SIS4)  
A:O21: (F3) [W12] @MAX(0,SAS4/SCS6\*(O16-SBS4/SAS4\*SIS4\*O19+SJS4\*O26)/SIS4)  
A:P21: (F3) [W9] @MAX(0,SAS4/SCS6\*(P16-SBS4/SAS4\*SIS4\*P19+SJS4\*P26)/SIS4)  
A:Q21: (F3) @MAX(0,SAS4/SCS6\*(Q16-SBS4/SAS4\*SIS4\*Q19+SJS4\*Q26)/SIS4)  
A:R21: (F3) @MAX(0,SAS4/SCS6\*(R16-SBS4/SAS4\*SIS4\*R19+SJS4\*R26)/SIS4)  
A:S21: (F3) @MAX(0,SAS4/SCS6\*(S16-SBS4/SAS4\*SIS4\*S19+SJS4\*S26)/SIS4)  
A:A22: (F3) [W16] ' NSNa Inf(t)StySt  
A:D22: (F3) [W13] +SES4  
A:E22: (F3) [W11] +SES4  
A:F22: (F3) [W11] +SES4  
A:G22: (F3) [W13] +SES4  
A:H22: (F3) [W13] +SES4  
A:I22: (F3) [W9] +SES4  
A:J22: (F3) [W13] +SES4  
A:K22: (F3) [W14] +SES4  
A:L22: (F3) [W15] +SES4  
A:M22: (F3) [W15] +SES4  
A:N22: (F3) [W8] +SES4  
A:O22: (F3) [W12] +SES4  
A:P22: (F3) [W9] +SES4  
A:Q22: (F3) +SES4  
A:R22: (F3) 7.14  
A:S22: (F3) 7.14  
A:A23: (F3) [W16] ' NSNa Myopic  
A:C23: (F3) [W13] +G15  
A:D23: (F3) [W13] +D19+D21  
A:E23: (F3) [W11] +E19+E21  
A:F23: (F3) [W11] +F19+F21  
A:G23: (F3) [W13] +G19+G21  
A:H23: (F3) [W13] +H19+H21  
A:I23: (F3) [W9] +I19+I21  
A:J23: (F3) [W13] +J19+J21  
A:K23: (F3) [W14] +K19+K21  
A:L23: (F3) [W15] +L19+L21  
A:M23: (F3) [W15] +M19+M21  
A:N23: (F3) [W8] +N19+N21  
A:O23: (F3) [W12] +O19+O21  
A:P23: (F3) [W9] +P19+P21  
A:Q23: (F3) +Q19+Q21  
A:R23: (F3) +R19+R21  
A:S23: (F3) +S19+S21  
A:A25: (F3) [W16] 'Consumption  
A:D25: (F3) [W13] +C30\*(1-SDS4)  
A:E25: (F3) [W11] +D30\*(1-SDS4)  
A:F25: (F3) [W11] +E30\*(1-SDS4)  
A:G25: (F3) [W13] +F30\*(1-SDS4)  
A:H25: (F3) [W13] +G30\*(1-SDS4)  
A:I25: (F3) [W9] +H30\*(1-SDS4)  
A:J25: (F3) [W13] +I30\*(1-SDS4)  
A:K25: (F3) [W14] +J30\*(1-SDS4)

A:L25: (F3) [W15] +K30\*(1-\$DS4)  
A:M25: (F3) [W15] +L30\*(1-\$DS4)  
A:N25: (F3) [W8] +M30\*(1-\$DS4)  
A:O25: (F3) [W12] +N30\*(1-\$DS4)  
A:P25: (F3) [W9] +O30\*(1-\$DS4)  
A:Q25: (F3) +P30\*(1-\$DS4)  
A:R25: (F3) +Q30\*(1-\$DS4)  
A:S25: (F3) +R30\*(1-\$DS4)  
A:A26: (F3) [W16] 'NSNb-(Stock pre-order)  
A:D26: (F3) [W13] +C30-D25  
A:E26: (F3) [W11] +D30-E25  
A:F26: (F3) [W11] +E30-F25  
A:G26: (F3) [W13] +F30-G25  
A:H26: (F3) [W13] +G30-H25  
A:I26: (F3) [W9] +H30-I25  
A:J26: (F3) [W13] +I30-J25  
A:K26: (F3) [W14] +J30-K25  
A:L26: (F3) [W15] +K30-L25  
A:M26: (F3) [W15] +L30-M25  
A:N26: (F3) [W8] +M30-N25  
A:O26: (F3) [W12] +N30-O25  
A:P26: (F3) [W9] +O30-P25  
A:Q26: (F3) +P30-Q25  
A:R26: (F3) +Q30-R25  
A:S26: (F3) +R30-S25  
A:A27: (F3) [W16] ' Ob Inf(t)StySt  
A:D27: (F3) [W13] +\$BS4/\$CS6\*(SG\$4/\$JS4)  
A:E27: (F3) [W11] +\$BS4/\$CS6\*(SG\$4/\$JS4)  
A:F27: (F3) [W11] +\$BS4/\$CS6\*(SG\$4/\$JS4)  
A:G27: (F3) [W13] +\$BS4/\$CS6\*(SG\$4/\$JS4)  
A:H27: (F3) [W13] +\$BS4/\$CS6\*(SG\$4/\$JS4)  
A:I27: (F3) [W9] +\$BS4/\$CS6\*(SG\$4/\$JS4)  
A:J27: (F3) [W13] +\$BS4/\$CS6\*(SG\$4/\$JS4)  
A:K27: (F3) [W14] +\$BS4/\$CS6\*(SG\$4/\$JS4)  
A:L27: (F3) [W15] +\$BS4/\$CS6\*(SG\$4/\$JS4)  
A:M27: (F3) [W15] +\$BS4/\$CS6\*(SG\$4/\$JS4)  
A:N27: (F3) [W8] +\$BS4/\$CS6\*(SG\$4/\$JS4)  
A:O27: (F3) [W12] +\$BS4/\$CS6\*(SG\$4/\$JS4)  
A:P27: (F3) [W9] +\$BS4/\$CS6\*(SG\$4/\$JS4)  
A:Q27: (F3) +\$BS4/\$CS6\*(SG\$4/\$JS4)  
A:R27: (F3) +\$BS4/\$CS6\*(SG\$4/\$JS4)  
A:S27: (F3) +\$BS4/\$CS6\*(SG\$4/\$JS4)  
A:A28: (F3) [W16] ' Ob Myopic  
A:D28: (F3) [W13] @MAX(0,@IF(D21>0,\$BS4/\$CS6\*(D16-\$AS4/\$BS4\*\$JS4\*D26+SIS4-\*D19)/\$JS4,D16/\$JS4))  
A:E28: (F3) [W11] @MAX(0,@IF(E21>0,\$BS4/\$CS6\*(E16-\$AS4/\$BS4\*\$JS4\*E26+SIS4-\*E19)/\$JS4,E16/\$JS4))  
A:F28: (F3) [W11] @MAX(0,@IF(F21>0,\$BS4/\$CS6\*(F16-\$AS4/\$BS4\*\$JS4\*F26+SIS4-\*F19)/\$JS4,F16/\$JS4))  
A:G28: (F3) [W13] @MAX(0,@IF(G21>0,\$BS4/\$CS6\*(G16-\$AS4/\$BS4\*\$JS4\*G26+SIS4-\*G19)/\$JS4,G16/\$JS4))

A:H28: (F3) [W13] @MAX(O,@IF(H21>O,\$BS4/SCS6\*(H16-SAS4/SBS4\*SJS4\*H26+SIS4-  
\*H19)/\$JS4,H16/\$JS4))  
A:I28: (F3) [W9] @MAX(O,@IF(I21>O,\$BS4/SCS6\*(I16-SAS4/SBS4\*SJS4\*I26+SIS4\*-  
I19)/\$JS4,I16/\$JS4))  
A:J28: (F3) [W13] @MAX(O,@IF(J21>O,\$BS4/SCS6\*(J16-SAS4/SBS4\*SJS4\*J26+SIS4-  
\*J19)/\$JS4,J16/\$JS4))  
A:K28: (F3) [W14] @MAX(O,@IF(K21>O,\$BS4/SCS6\*(K16-SAS4/SBS4\*SJS4\*K26+SIS4-  
\*K19)/\$JS4,K16/\$JS4))  
A:L28: (F3) [W15] @MAX(O,@IF(L21>O,\$BS4/SCS6\*(L16-SAS4/SBS4\*SJS4\*L26+SIS4-  
\*L19)/\$JS4,L16/\$JS4))  
A:M28: (F3) [W15] @MAX(O,@IF(M21>O,\$BS4/SCS6\*(M16-SAS4/SBS4\*SJS4\*M26+SIS4-  
\*M19)/\$JS4,M16/\$JS4))  
A:N28: (F3) [W8] @MAX(O,@IF(N21>O,\$BS4/SCS6\*(N16-SAS4/SBS4\*SJS4\*N26+SIS4\*-  
N19)/\$JS4,N16/\$JS4))  
A:O28: (F3) [W12] @MAX(O,@IF(O21>O,\$BS4/SCS6\*(O16-SAS4/SBS4\*SJS4\*O26+SIS4-  
\*O19)/\$JS4,O16/\$JS4))  
A:P28: (F3) [W9] @MAX(O,@IF(P21>O,\$BS4/SCS6\*(P16-SAS4/SBS4\*SJS4\*P26+SIS4\*-  
P19)/\$JS4,P16/\$JS4))  
A:Q28: (F3) @MAX(O,@IF(Q21>O,\$BS4/SCS6\*(Q16-SAS4/SBS4\*SJS4\*Q26+SIS4\*Q19)/-  
SJS4,Q16/\$JS4))  
A:R28: (F3) @MAX(O,@IF(R21>O,\$BS4/SCS6\*(R16-SAS4/SBS4\*SJS4\*R26+SIS4\*R19)/-  
JS4,R16/\$JS4))  
A:S28: (F3) @MAX(O,@IF(S21>O,\$BS4/SCS6\*(S16-SAS4/SBS4\*SJS4\*S26+SIS4\*S19)/-  
JS4,S16/\$JS4))  
A:A29: (F3) [W16] ' NSNb Inf(t)StySt  
A:D29: (F3) [W13] +FS4  
A:E29: (F3) [W11] +FS4  
A:F29: (F3) [W11] +FS4  
A:G29: (F3) [W13] +FS4  
A:H29: (F3) [W13] +FS4  
A:I29: (F3) [W9] +FS4  
A:J29: (F3) [W13] +FS4  
A:K29: (F3) [W14] +FS4  
A:L29: (F3) [W15] +FS4  
A:M29: (F3) [W15] +FS4  
A:N29: (F3) [W8] +FS4  
A:O29: (F3) [W12] +FS4  
A:P29: (F3) [W9] +FS4  
A:Q29: (F3) +FS4  
A:R29: (F3) 15.43  
A:S29: (F3) 15.43  
A:A30: (F3) [W16] ' NSNb Myopic  
A:C30: (F3) [W13] +H15  
A:D30: (F3) [W13] +D26+D28  
A:E30: (F3) [W11] +E26+E28  
A:F30: (F3) [W11] +F26+F28  
A:G30: (F3) [W13] +G26+G28  
A:H30: (F3) [W13] +H26+H28  
A:I30: (F3) [W9] +I26+I28  
A:J30: (F3) [W13] +J26+J28  
A:K30: (F3) [W14] +K26+K28

A:L30: (F3) [W15] +L26+L28  
A:M30: (F3) [W15] +M26+M28  
A:N30: (F3) [W8] +N26+N28  
A:O30: (F3) [W12] +O26+O28  
A:P30: (F3) [W9] +P26+P28  
A:Q30: (F3) +Q26+Q28  
A:R30: (F3) +R26+R28  
A:S30: (F3) +S26+S28  
A:A32: (F3) [W16] 'Ut2  
A:B32: (F3) [W17] 'Inf(t)  
A:D32: (F3) [W13] +D22^\$A\$4\*D29^\$B\$4  
A:E32: (F3) [W11] +E22^\$A\$4\*E29^\$B\$4  
A:F32: (F3) [W11] +F22^\$A\$4\*F29^\$B\$4  
A:G32: (F3) [W13] +G22^\$A\$4\*G29^\$B\$4  
A:H32: (F3) [W13] +H22^\$A\$4\*H29^\$B\$4  
A:I32: (F3) [W9] +I22^\$A\$4\*I29^\$B\$4  
A:J32: (F3) [W13] +J22^\$A\$4\*J29^\$B\$4  
A:K32: (F3) [W14] +K22^\$A\$4\*K29^\$B\$4  
A:L32: (F3) [W15] +L22^\$A\$4\*L29^\$B\$4  
A:M32: (F3) [W15] +M22^\$A\$4\*M29^\$B\$4  
A:N32: (F3) [W8] +N22^\$A\$4\*N29^\$B\$4  
A:O32: (F3) [W12] +O22^\$A\$4\*O29^\$B\$4  
A:P32: (F3) [W9] +P22^\$A\$4\*P29^\$B\$4  
A:Q32: (F3) +Q22^\$A\$4\*Q29^\$B\$4  
A:R32: (F3) +R22^\$A\$4\*R29^\$B\$4  
A:S32: (F3) +S22^\$A\$4\*S29^\$B\$4  
A:A33: (F3) [W16] 'Ut  
A:B33: (F3) [W17] 'Myopic  
A:C33: (F3) [W13] +C23^\$A\$4\*C30^\$B\$4  
A:D33: (F3) [W13] +D23^\$A\$4\*D30^\$B\$4  
A:E33: (F3) [W11] +E23^\$A\$4\*E30^\$B\$4  
A:F33: (F3) [W11] +F23^\$A\$4\*F30^\$B\$4  
A:G33: (F3) [W13] +G23^\$A\$4\*G30^\$B\$4  
A:H33: (F3) [W13] +H23^\$A\$4\*H30^\$B\$4  
A:I33: (F3) [W9] +I23^\$A\$4\*I30^\$B\$4  
A:J33: (F3) [W13] +J23^\$A\$4\*J30^\$B\$4  
A:K33: (F3) [W14] +K23^\$A\$4\*K30^\$B\$4  
A:L33: (F3) [W15] +L23^\$A\$4\*L30^\$B\$4  
A:M33: (F3) [W15] +M23^\$A\$4\*M30^\$B\$4  
A:N33: (F3) [W8] +N23^\$A\$4\*N30^\$B\$4  
A:O33: (F3) [W12] +O23^\$A\$4\*O30^\$B\$4  
A:P33: (F3) [W9] +P23^\$A\$4\*P30^\$B\$4  
A:Q33: (F3) +Q23^\$A\$4\*Q30^\$B\$4  
A:R33: (F3) +R23^\$A\$4\*R30^\$B\$4  
A:S33: (F3) +S23^\$A\$4\*S30^\$B\$4  
A:A34: (F3) [W16] 'CumU(t) Inf  
A:D34: (F3) [W13] +D32  
A:E34: (F3) [W11] +D34+E32  
A:F34: (F3) [W11] +E34+F32  
A:G34: (F3) [W13] +F34+G32  
A:H34: (F3) [W13] +G34+H32

A:I34: (F3) [W9] +H34+I32  
A:J34: (F3) [W13] +I34+J32  
A:K34: (F3) [W14] +J34+K32  
A:L34: (F3) [W15] +K34+L32  
A:M34: (F3) [W15] +L34+M32  
A:N34: (F3) [W8] +M34+N32  
A:O34: (F3) [W12] +N34+O32  
A:P34: (F3) [W9] +O34+P32  
A:Q34: (F3) +P34+Q32  
A:R34: (F3) +Q34+R32  
A:S34: (F3) +R34+S32  
A:A35: (F3) [W16] 'CumU(t) Myo  
A:D35: (F3) [W13] +D33  
A:E35: (F3) [W11] +D35+E33  
A:F35: (F3) [W11] +E35+F33  
A:G35: (F3) [W13] +F35+G33  
A:H35: (F3) [W13] +G35+H33  
A:I35: (F3) [W9] +H35+I33  
A:J35: (F3) [W13] +I35+J33  
A:K35: (F3) [W14] +J35+K33  
A:L35: (F3) [W15] +K35+L33  
A:M35: (F3) [W15] +L35+M33  
A:N35: (F3) [W8] +M35+N33  
A:O35: (F3) [W12] +N35+O33  
A:P35: (F3) [W9] +O35+P33  
A:Q35: (F3) +P35+Q33  
A:R35: (F3) +Q35+R33  
A:S35: (F3) +R35+S33  
A:C36: (F3) [W13] 'Myo - Inf  
A:D36: (F3) [W13] @IF(D35-D34>0,0,-1)  
A:E36: (F3) [W11] @IF(E35-E34>0,0,-1)  
A:F36: (F3) [W11] @IF(F35-F34>0,0,-1)  
A:G36: (F3) [W13] @IF(G35-G34>0,0,-1)  
A:H36: (F3) [W13] @IF(H35-H34>0,0,-1)  
A:I36: (F3) [W9] @IF(I35-I34>0,0,-1)  
A:J36: (F3) [W13] @IF(J35-J34>0,0,-1)  
A:K36: (F3) [W14] @IF(K35-K34>0,0,-1)  
A:L36: (F3) [W15] @IF(L35-L34>0,0,-1)  
A:M36: (F3) [W15] @IF(M35-M34>0,0,-1)  
A:N36: (F3) [W8] @IF(N35-N34>0,0,-1)  
A:O36: (F3) [W12] @IF(O35-O34>0,0,-1)  
A:P36: (F3) [W9] @IF(P35-P34>0,0,-1)  
A:B37: (F3) [W17] 'Bt Check  
A:D37: (F3) [W13] +\$I\$4\*D21+D28\*\$J\$4-D16  
A:E37: (F3) [W11] +\$I\$4\*E21+E28\*\$J\$4-E16  
A:F37: (F3) [W11] +\$I\$4\*F21+F28\*\$J\$4-F16  
A:G37: (F3) [W13] +\$I\$4\*G21+G28\*\$J\$4-G16  
A:H37: (F3) [W13] +\$I\$4\*H21+H28\*\$J\$4-H16  
A:I37: (F3) [W9] +\$I\$4\*I21+I28\*\$J\$4-I16  
A:J37: (F3) [W13] +\$I\$4\*J21+J28\*\$J\$4-J16  
A:K37: (F3) [W14] +\$I\$4\*K21+K28\*\$J\$4-K16



A:L37: (F3) [W15] +SIS4\*L21+L28\*SJS4-L16  
A:M37: (F3) [W15] +SIS4\*M21+M28\*SJS4-M16  
A:N37: (F3) [W8] +SIS4\*N21+N28\*SJS4-N16  
A:O37: (F3) [W12] +SIS4\*O21+O28\*SJS4-O16  
A:P37: (F3) [W9] +SIS4\*P21+P28\*SJS4-P16  
A:C38: (F3) [W13] 'Bt  
A:D38: (F3) [W13] +P1  
A:E38: (F3) [W11] +SHS4  
A:A39: (F3) [W16] 'Finite (2)  
A:D39: (F3) [W13] +C39+1  
A:E39: (F3) [W11] +D39+1  
A:A40: (F3) [W16] 'Consumption  
A:D40: (F3) [W13] +C43\*(1-SCS4)  
A:E40: (F3) [W11] +D43\*(1-SCS4)  
A:H40: (F3) [W13] "U1  
A:I40: (F3) [W9] "U1+U2  
A:J40: (F3) [W13] "\_U7  
A:K40: (F3) [W14] "\_U26  
A:A41: (F3) [W16] 'NSNa-(Stock pre-order)  
A:D41: (F3) [W13] +C43-D40  
A:E41: (F3) [W11] +D43-E40  
A:G41: (F3) [W13] "Infinite  
A:H41: (F3) [W13] +D32  
A:I41: (F3) [W9] +D32+E32  
A:J41: (F3) [W13] +J34  
A:K41: (F3) [W14] +S34  
A:A42: (F3) [W16] ' Oa (Fin)  
A:D42: (F3) [W13] +B11  
A:E42: (F3) [W11] +F11  
A:G42: (F3) [W13] "Myopic  
A:H42: (F3) [W13] +D33  
A:I42: (F3) [W9] +D33+E33  
A:J42: (F3) [W13] +J35  
A:K42: (F3) [W14] +S35  
A:A43: (F3) [W16] ' NSNa (Fin)  
A:C43: (F3) [W13] +SES4  
A:D43: (F3) [W13] +D41+D42  
A:E43: (F3) [W11] +E41+E42  
A:G43: (F3) [W13] "Finite(2)  
A:H43: (F3) [W13] +D50  
A:I43: (F3) [W9] +F50  
A:A45: (F3) [W16] 'Consumption  
A:D45: (F3) [W13] +C48\*(1-SDS4)  
A:E45: (F3) [W11] +D48\*(1-SDS4)  
A:A46: (F3) [W16] 'NSNb-(Stock pre-order)  
A:D46: (F3) [W13] +C48-D45  
A:E46: (F3) [W11] +D48-E45  
A:A47: (F3) [W16] ' Ob (Fin)  
A:D47: (F3) [W13] +A11  
A:E47: (F3) [W11] +E11  
A:A48: (F3) [W16] ' NSNb (Fin)

A:C48: (F3) [W13] +SFS4  
A:D48: (F3) [W13] +D46+D47  
A:E48: (F3) [W11] +E46+E47  
A:B50: (F3) [W17] 'Ut  
A:C50: (F3) [W13] +C43^\$AS4\*C48^\$BS4  
A:D50: (F3) [W13] +D43^\$AS4\*D48^\$BS4  
A:E50: (F3) [W11] +E43^\$AS4\*E48^\$BS4  
A:F50: (F3) [W11] +D50+E50  
A:B51: (F3) [W17] 'Bt Check  
A:D51: (F3) [W13] +SI\$4\*D42+D47\*\$JS4-D16  
A:E51: (F3) [W11] +SI\$4\*E42+E47\*\$JS4-E16

APPENDIX F  
Proportional Allocation vs. Optimization

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
2	(m,n)= 0.6	0.8	(11,7)	8.93	19.29	0.5	0.9								
3	Nyop vs Inf			30	30	30	30	30	30	30	30	30	30	30	30
4	s=)			1	2	3	4	5	6	7	8	9	10	11	12
5	Demand NSNa 100%			3.57	5.87	5.70	5.58	5.50	5.43	5.39	5.35	5.33	5.31	5.30	5.29
6	Demand 80% ITSS			3.57	5.29	3.11	3.01	2.95	2.91	2.89	2.88	2.87	2.86	2.86	2.86
7	Demand 80% Nyo			3.57	5.12	4.82	4.62	4.49	4.40	4.34	4.30	4.27	4.25	4.24	4.23
8	NSNa- (pre-order)			5.36	8.80	8.56	8.38	8.25	8.15	8.08	8.03	7.99	7.97	7.95	7.92
9	NSNa- 80% ITSS			5.36	4.93	4.67	4.52	4.42	4.37	4.33	4.31	4.30	4.29	4.29	4.29
10	NSNa- 80% Nyo			5.36	7.68	7.23	6.93	6.74	6.60	6.52	6.45	6.41	6.38	6.36	6.34
11	Oa ITSS			3.57	3.57	3.57	3.57	3.57	3.57	3.57	3.57	3.57	3.57	3.57	3.57
12	Oa 80% ITSS			2.86	2.86	2.86	2.86	2.86	2.86	2.86	2.86	2.86	2.86	2.86	2.86
13	Oa Nyopic			9.31	5.46	5.40	5.37	5.34	5.32	5.30	5.29	5.28	5.28	5.27	5.27
14	Oa 80% Nyopic			7.45	4.37	4.32	4.30	4.27	4.26	4.24	4.23	4.22	4.22	4.22	4.22
15	NSNa ITSS			8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93
16	NSNa 80% ITSS			8.22	7.79	7.53	7.37	7.28	7.22	7.19	7.17	7.16	7.15	7.14	7.14
17	NSNa Nyo	8.93		14.67	14.26	13.96	13.74	13.58	13.47	13.38	13.32	13.28	13.25	13.22	13.19
18	NSNa 80% Nyo			12.81	12.05	11.55	11.23	11.01	10.86	10.76	10.69	10.64	10.61	10.58	10.55
19	Demand NSNb 100%			3.86	3.17	3.08	3.02	2.97	2.93	2.91	2.89	2.88	2.87	2.86	2.85
20	Demand 80% ITSS			3.86	3.70	3.58	3.48	3.40	3.34	3.29	3.25	3.22	3.19	3.17	3.14
21	Demand 80% Nyo			3.86	3.15	2.96	2.81	2.69	2.60	2.53	2.48	2.43	2.40	2.37	2.34
22	NSNb- (pre-order)			15.43	12.67	12.32	12.06	11.87	11.74	11.64	11.56	11.51	11.47	11.44	11.41
23	NSNb- 80% ITSS			15.43	14.81	14.32	13.93	13.61	13.36	13.16	13.00	12.87	12.77	12.68	12.56
24	NSNb- 80% Nyo			15.43	12.61	11.83	11.23	10.77	10.40	10.12	9.90	9.73	9.59	9.41	9.34
25	Ob ITSS			3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86
26	Ob 80% ITSS			3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09
27	Ob Nyopic			0.41	2.73	2.76	2.78	2.80	2.81	2.82	2.82	2.83	2.83	2.84	2.84
28	Ob 80% Nyopic			0.33	2.18	2.21	2.22	2.24	2.25	2.26	2.26	2.26	2.26	2.27	2.27
29	NSNb ITSS			19.29	19.29	19.29	19.29	19.29	19.29	19.29	19.29	19.29	19.29	19.29	19.29
30	NSNb 80% ITSS			18.52	17.90	17.41	17.02	16.70	16.45	16.25	16.09	15.96	15.85	15.77	15.65
31	NSNb Nyo	19.29		15.84	15.40	15.08	14.84	14.67	14.55	14.45	14.39	14.34	14.30	14.28	14.25
32	NSNb 80% Nyo			15.76	14.79	14.04	13.46	13.01	12.65	12.38	12.16	11.99	11.86	11.76	11.61
33	U2 Inf Time			43	43	43	43	43	43	43	43	43	43	43	43
34	U Inf 80%			40	37	36	35	34	33	33	33	32	32	32	32
35	U Nyopic	43		46	44	43	42	41	41	40	40	40	40	40	40
36	U Nyo 80%			43	39	37	35	33	32	31	31	31	30	30	30
37	Cum U Inf Time 100%			43	86	129	171	214	257	300	343	386	429	472	514
38	Cum U Nyo 100%			46	90	133	175	217	257	298	338	378	418	458	498
39										-1	-1	-1	-1	-1	-1
40										0	0	0	0	0	0
41	Bt Check			0	0	0	0	0	0	0	0	0	0	0	0
42	Row 44-66 are Optimization Results based on 80% Budget														
43	(m,n)= 0.6	0.8	(11,7)	7.14	15.43	8.93	19.29								
44	Nyo vs Inf			24	24	24	24	24	24	24	24	24	24	24	24
45	s=)			1	2	3	4	5	6	7	8	9	10	11	12
46	Demand NSNa			3.57	5.34	5.23	4.95	4.75	4.6	4.5	4.42	4.36	4.32	4.29	4.27
47	NSNa- (pre-order)			5.36	8.01	7.84	7.43	7.12	6.91	6.75	6.63	6.54	6.48	6.44	6.4
48	Oa ITSS			2.86	2.86	2.86	2.86	2.86	2.86	2.86	2.86	2.86	2.86	2.86	2.86
49	Oa 80% ITSS			8	5.05	4.54	4.45	4.38	4.34	4.3	4.28	4.26	4.25	4.24	4.23
50	Oa Nyopic			7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14
51	NSNa ITSS			13.36	13.07	12.38	11.87	11.51	11.24	11.05	10.91	10.8	10.74	10.67	10.63
52	NSNa Nyo	8.93		3.86	3.09	2.82	2.67	2.56	2.49	2.43	2.39	2.36	2.33	2.32	2.31
53	Demand NSNb			15.43	12.34	11.29	10.69	10.26	9.94	9.71	9.55	9.42	9.33	9.27	9.22
54	NSNb- (pre-order)			3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09
55	Ob ITSS			0	1.77	2.08	2.13	2.17	2.2	2.22	2.23	2.24	2.25	2.26	2.27
56	Ob Nyo			15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43
57	NSNb ITSS			19.29	15.43	14.11	13.37	12.82	12.43	12.14	11.93	11.78	11.67	11.59	11.48
58	NSNb Nyo														
59	U2 Inf Time			31	31	31	31	31	31	31	31	31	31	31	31
60	U Nyopic	43		43	39	36	34	33	32	31	30	30	30	29	29
61	Cum U Inf			43	63	94	125	157	188	220	251	282	314	345	376
62	Cum U Nyo			43	82	118	153	185	217	248	278	308	338	368	397
63															
64															
65	Nyo - Inf														
66	Bt Check			0	0	0	0	0	0	0	0	0	0	0	0
67	Proportionate Allocation Policy/Optimization														
68	Order Oa ITSS			1	1	1	1	1	1	1	1	1	1	1	1
69	Order Ob ITSS			1	1	1	1	1	1	1	1	1	1	1	1
70	Stock NSNa ITSS			0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
71	Stock NSNb ITSS			0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
72	U ITSS			0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
73	Order NSNa Nyo			1.1	1.2	1.1	1	1	1	1	1	1	1	1	1
74	Order NSNb Nyo			0	0.8	0.9	1	1	1	1	1	1	1	1	1
75	Stock NSNa Nyo			1	1.1	1.1	1.1	1	1	1	1	1	1	1	1
76	Stock NSNb Nyo			1	1	1	1	1	1	1	1	1	1	1	1
77	U2 Nyo			1	1	1	1	1	1	1	1	1	1	1	1
78	U Nyo			1	1	1	1	1	1	1	1	1	1	1	1

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