Proceedings of the 1999 Winter Simulation Conference
P. A. Farrington, H. B. Nembhard, D. T. Sturrock, and G. W. Evans, eds.

SUPPLY CHAIN VS. SUPPLY CHAIN: USING SIMULATION TO COMPETE BEYOND THE FOUR WALLS

George Archibald
Nejat Karabakal
Paul Karlsson

IBM Corporation
140 East Town Street
Columbus, OH 43215, U.S.A.

ABSTRACT

It has been said in this world of virtual corporations that it is no longer companies that compete, but supply chains. When you look at the model of a corporation today, the traditional vertically integrated business seems to be a thing of the past. A prime example of this is Nike. They own no factories, trucks, or stores, yet are one of the world's most successful retail firm. Today's supply chains reflect this trend in that few firms control the entire supply chain from end to end. Most companies rely on a mix of suppliers, transportation resources, assemblers, warehousing firms, and retail outlets to bring their product to the market. As a result of this mix of outside firms, it is often difficult to know the impact of changes or poor performance on the supply chain. What is needed is a tool that can give visibility of the entire supply chain that allows for the testing of numerous "what if" scenarios such as outsourcing, consolidating vendors, collaborative planning, or implementing e-business. Only with this capability will you and all of your supply chain partners be able to effectively compete against your competitors' supply chains.

1 INTRODUCTION

The Supply Chain is the series of activities that an organization uses to deliver value, either in the form of a product, service, or a combination of both, to its customers. Recent trends in the economy have de-emphasized the benefits of vertical integration (economies of scale, access to capital, large physical infrastructure investment, etc.) and instead focused on the benefits of being specialized and focused (speed, agility, rapid growth, deep skills, etc.). These trends have forced even large organizations to rely on hundreds or even thousands of external firms or suppliers to deliver value to the marketplace.

As this shift has taken place, the importance of managing and coordinating the activities between these disparate entities has become paramount. Today that effort is often referred to as Supply Chain Management or SCM for short. SCM can be defined as achieving a sustainable competitive position and maximizing shareholder value by optimizing the relationship of process, information, and physical goods among internal and external trading partners. This optimization process involves the following activities:

1. Customer Demand Planning
2. Customer Order Fulfillment and Customer Service
3. Strategic Sourcing and Procurement
4. Production Logistics
5. Distribution Networks and Warehouse Management
6. Transportation and Shipment Management
7. Integrated Supply and Demand Planning

Successful SCM requires an integration of these activities into a seamless process. This process must include the organizational departments responsible for each activity and the external suppliers and customers who are part of the equation. The goal is speed-to-market, agility, and flexibility to respond more quickly to actual customer demand, while keeping cost at a minimum. Herein lies the potential of an integrated SCM process.

A critical additional component is the information systems required to monitor these activities. Information is the key. It must be bi-directional between the organizational departments and suppliers/partners to truly leverage the supply chain.

Typically, SCM costs represent a majority of the operating expenses of most companies. These costs can range from as low as 30% to as high as 75%. In addition to reducing operating costs, SCM can provide additional

organizational benefits such as improving asset productivity and compressing order cycle time. These benefits can contribute to the long-term profitability of any extended enterprise

2 A CASE STUDY APPROACH

To illustrate how Supply Chain Management practices and policies can have a major impact on a business and its financial performance, the authors have developed the following case study. The case study is designed around a hypothetical organization called Global Food Manufacturing (GFM). This case study is designed to analyze the manufacturing, distribution, transportation, and retail aspects of the supply chain in which GFM operates. A simulation tool (The IBM Supply Chain Analyzer) is then used to quantify the effects of making changes throughout the supply chain and the impact of those changes to their competitive performance in the marketplace.

2.1 Supply Chain Simulation Model Overview

GFM is a notional multinational food manufacturer that operates in three regional supply chains; one in North America, one in Europe and one in Australia. Each regional supply chain contains GFM factories, a wholesaler, and a retail location as well as competitors at each level to satisfy customer demand. A high level representation of the North American supply chain is shown below.

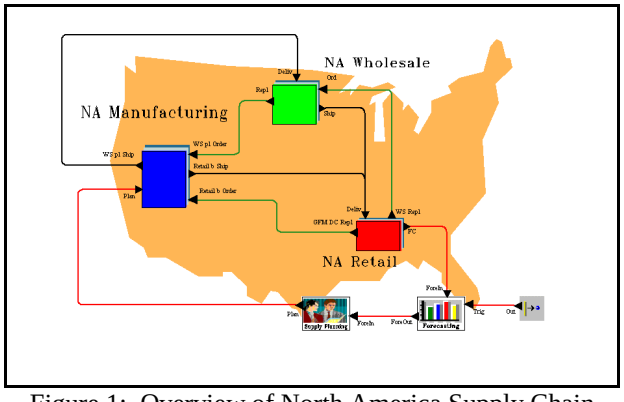

Figure 1: Overview of North America Supply Chain

GFM manufactures both branded and private label processed food items. GFM operates its own distribution center to facilitate the shipment of its branded items directly to retailers. Private label products are shipped to a wholesaler.

GFM transports private label goods from the factory to the wholesaler's warehouse where they are held in inventory until needed to fill an order from a retailer. Once allocated for an order, the wholesaler attaches the appropriate label and ships the products to the retailer. The retailer receives both the branded items (from GFM) and the private label items (from the wholesaler) and makes them available to the customers at each store. The model contains alternative manufacturers, wholesalers, and retailers with unlimited capacity to represent competitive supply chains to be used whenever demand cannot be met by GFM's supply chain.

2.2 Detailed Model Description

The manufacturers are grouped in a model sub-process entitled "NA Manufacturing" (Figure 2).

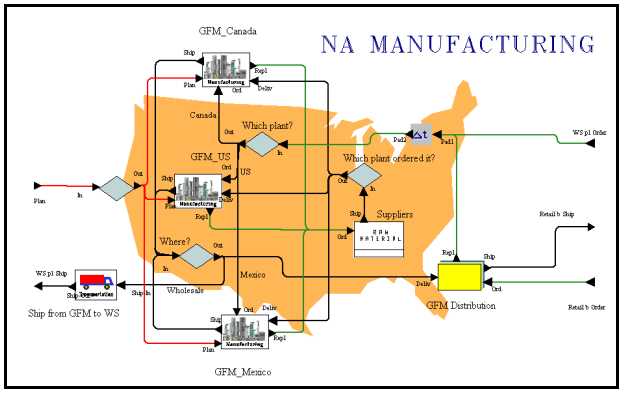

Figure 2: North America Manufacturing Process

GFM operated factories are located in Canada, the United States, and Mexico. The Canadian factory manufactures frozen private label and branded products. The U.S. factory manufactures refrigerated private label and branded products. The Mexican factory manufactures dry private label and branded products. GFM transports all its branded products from these three factories to its own distribution center where they are held in inventory until needed to fill an order from North American Retailers. GFM's distribution is contained in a sub-process within NA Manufacturing.

A wholesaler is used to distribute all GFM's private label products. The wholesaler's process is grouped in the sub-process entitled "NA Wholesale" (Figure 3).

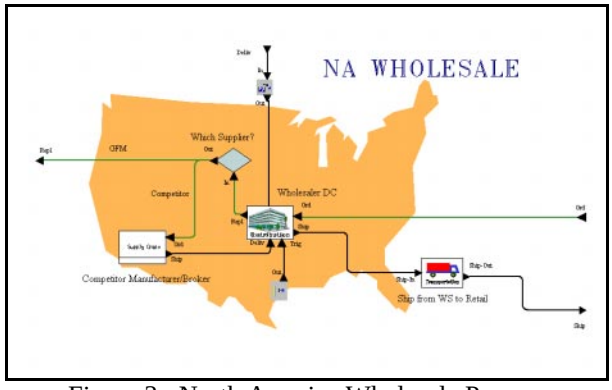

Figure 3: North America Wholesale Process

The wholesaler transports the private label products to its distribution center and holds them in inventory until they are needed for an order from a retailer. Once an order is received from the retailer, the products are allocated, labeled and shipped to the retailer. The wholesaler's primary supplier is GFM. However, if the products needed to fill an order is not available from GFM, the wholesaler uses the "Competitor Manufacturer/Broker" to fill the order. All orders filled by the Competitor Manufacturer/Broker are counted as a lost sale for GFM, which is tallied for post simulation analysis. The retailer is contained the sub-process entitled "NA Retail" (Figure 4).

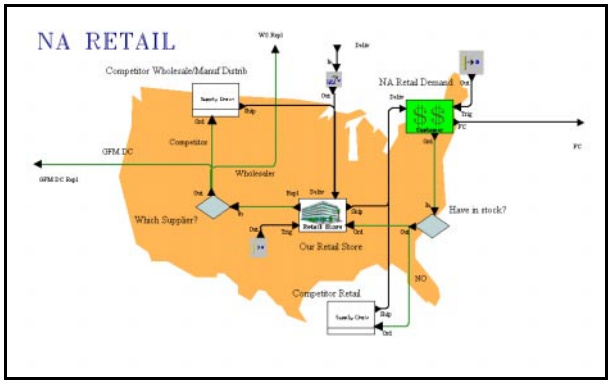

Figure 4: North America Retail Process

Orders for private label products first go to the wholesaler, and then, if the private label products are not available at the wholesaler, the order is placed at the Competitor Wholesale/Manufacturer Distributor. Orders for branded products first go to GFM's distribution center and then, if the branded products are not available at GFM's distribution center, the order goes to the Competitor Wholesale/Manufacturer Distributor. Orders for branded products that are filled by the Competitor Wholesaler/Manufacturer Distributor are counted as lost sales for GFM, which are tallied and reported with GFM's manufacturing lost sales. Likewise, orders filled for private label products by the Competitor Wholesale/Manufacturer Distributor are reported as Lost Sales for the wholesaler. The Competitor Wholesale/Manufacturer Distributor maintains unlimited inventory of all products, so once an order is lost to a competitor, the order does not return. However, since primary and alternate suppliers do not change, each order follows the same sequence regardless of past availability performance.

The Customer at each retailer can also be found in the sub-process entitled "NA Retailer" (Figure 4). This node is labeled " NA Retail Demand." Customers place orders for both private label and branded products at their retailer as dictated by the demand schedule. If the retailer is unable to meet this demand, the customer then goes to the "Competitor Retail" that fills the order with its limitless stock. Each order filled at the Competitor Retail is counted as a lost sale for the Retailer and is tallied for post simulation analysis. The European and Australian regions operates in a similar manner as the North American region.

2.3 Scenarios

Five different scenarios of GFM's Supply Chain have been developed to measure and quantify the effects of making changes to GFM's supply chain. These five scenarios are as follows:

1. Base Case - GFM's current supply chain practices with an internal emphasis
2. Transportation - A change from a Full TruckLoad to a Less Than Truckload approach to reduce transportation lead times
3. Continuous Replenishment - A shifting of inventory management to the manufacturer or wholesaler
4. Collaborative Planning - A sharing of information among all participants of the supply chain
5. Combined Supply Chain Management - A combination of the above three scenarios applied to the base case

2.3.1 Base Case Scenario

Demand: Typical demand at the retailer is generated from a uniform distribution for each product in each period. The exception to this demand schedule is the periodic demand spikes occurring infrequently to individual product groups. Customer demand remains the same among the different scenarios of the model.

Forecast: The GFM manufacturers in this scenario schedule their operations according to their forecast. Historically, this forecast has been higher than actual demand, which has created inventory inefficiencies and periodic product unavailability. The lost sales resulting from the stock-out situations throughout the model represents the potential improvements in market share. Inventory inefficiencies create the potential for improvements in inventory holding and handling costs.

Replenishment: The retailer starts with an initial inventory of each product group. The periodic replenishment policy dictates that they maintain inventory on-hand that will cover the projected demand over a number of days. This "Days of Supply" level is reviewed periodically to determine if a replenishment order is needed to maintain inventory targets. When a replenishment order is initiated by a retailer, it is first sent to its primary supplier. For branded products, the primary supplier is GFM and for private label products the primary supplier is the wholesaler. If the product is unavailable at

the primary supplier the order goes to a secondary supplier. This secondary supplier for all products is a location with unlimited stock that represents the rest of the market.

The wholesaler starts with an initial inventory of private label products. GFM's distribution centers start with an initial inventory of branded product group. Both the wholesalers and GFM's distribution centers have a periodic replenishment policy for maintaining enough stock. Replenishment orders from the wholesaler for private label products go first to primary supplier (GFM) but are forwarded to the secondary supplier if the GFM manufacturer is out of stock. Since GFM supplies branded items directly to the retailer via its distribution center, if the GFM factory is unable to supply the GFM distribution center, the distribution center remains out-of-stock until the product becomes available again from the factory.

GFM factories build their raw material inventory to plan based on customer forecasts and lead times. Local suppliers with unlimited supply satisfy raw materials used in manufacturing.

Shipping and Handling: Except for the customer, the cost of transporting goods throughout the supply chain is borne by the company owning the location from which the goods are shipped. In this scenario, transportation policy moves goods by Full Truckloads (FTL). The replenishment order lead time includes travel to destinations plus inbound handling at the destination.

2.3.2 The Transportation Scenario

The Transportation Scenario is designed to quantify the effects that smaller, more frequent, Less-Than-Truckload (LTL) deliveries have on GFM's supply chain participants.

Forecast, Demand, and Replenishment: These are unchanged from the base case scenario.

Shipping and Handling: LTL transportation policy was adopted to reduce the cycle times among the supply chain participants. This reduces the risk of stock-outs without increasing inventory levels. The resulting transportation costs should be higher than the base case scenario, which uses an FTL policy.

2.3.3 Continuous Replenishment

GFM manages the inventory for the wholesaler and retailer for branded products. Wholesaler manages the retail inventory for the private label products.

Forecast and Demand: These remain unchanged from the Base Case Scenario.

Replenishment: Wholesale and retail buffers are converted into continuous type, and their reorder points are periodically optimized through the use of the Inventory Optimizer that is imbedded to the IBM Supply Chain Analyzer.

Shipping and Handling: These are unchanged from the Base Case Scenario.

2.3.4 Collaborative Planning

The Collaborative Planning Scenario shows the result of supply chain participants sharing information on forecasts, product movement, inventory and demand.

Forecast: Due to information sharing between the retailers and the other supply chain participants, forecasts that were 20 percent high in the Base Case have become accurate.

Replenishment: Periodic replenishment buffers are now continuous.

Demand, Shipping and Handling: These remain unchanged from the Base Case Scenario.

2.3.5 Combined Supply Chain Management

The initiatives described by the previous three scenarios are combined into a single scenario.

Forecast: The forecast is the same as the Collaborative Planning Scenario.

Demand: Demand is unchanged from the Base Case Scenario.

Replenishment: Replenishment is the same as the Continuos Replenishment Scenario.

Shipping and Handling: Shipping and Handling are the same as the Transportation Policy Scenario.

3 SIMULATION DISCUSSION

Five models for the above scenarios were developed and outcomes were generated using the IBM Supply Chain Analyzer, a software tool that can help a company or group of companies make strategic business decisions about the design and operation of its supply chain [Bagchi et. al.] Multiple replications, each with a simulation run length of two years, were run to reduce sampling errors. The Analyzer's financial reporting feature generates a detailed transactions file that includes the following:

- cost of raw material,
- revenue from goods sold,
- activity based costing such as material handling and manufacturing,
- inventory holding costs, and
- transportation costs.

A spreadsheet processing of the transactional data yielded the required financial performance metrics that are described in the following section.

4 RESULTS DISCUSSION

4.1 Financial Measures

The following are explanations of the financial measures used to evaluate scenario results:

Inventory Turns: Inventory Turns = Cost of goods sold/Average Inventory on hand. It is the number of times that the average amount of inventory that is on hand is sold within a given period. Average inventory is calculated by averaging the beginning inventory and ending inventory.

Gross Margin Return on Investment (GMROI): GMROI= Gross Profit Margin Percent * (Inventory Turnover Rate/1 – Gross Profit Margin Percent). Common food industry values for GMROI range from 3.0 to 8.6 for manufacturers , 7.7 to 23.1 for wholesalers and 13.2 to 24.5 for retailers. GMROI is the amount that each company earns in Gross Profit for every Dollar it invests in inventory.

Profit Margin: Profit Margin = Net Income After Tax/Sales. This is Net Profit Margin which shows the percentage of net income generated by each sales dollar.

Return on Assets (ROA): ROA = Net Income After Taxes/Average Total Assets. The ROA show how much the company has earned on the investment of all the funds committed to the company.

Stockout Delays: This is a computation of the average delay incurred when a customer or replenishment order is forced to find an alternate supplier in the event of a stockout.

4.1.1 Comparative Scenario Analysis

The model results illustrate the benefits of implementing key supply chain strategies and how they can be further leveraged when these strategies are extended outside the four walls of the company to include supply chain partners.

Base Case vs. New Transportation Policy: Since the forecast, demand and replenishment policies were unchanged in this scenario, the Transportation Scenario isolates the effects that smaller, more frequent LTL deliveries have on GFM's supply chain participants (see Figure 5). The rationale behind this scenario is to reduce the cycle time of supplying finish goods to the customer so that the supply chain could be more responsive to customer demand. As seen in the charts below, this proved beneficial in every metric. The success of this policy is dependent on the benefits of increases sales, increased inventory turns, and the resulting decrease in inventory carrying charges to overcome the increase in transportation costs that accompany frequent LTL deliveries.

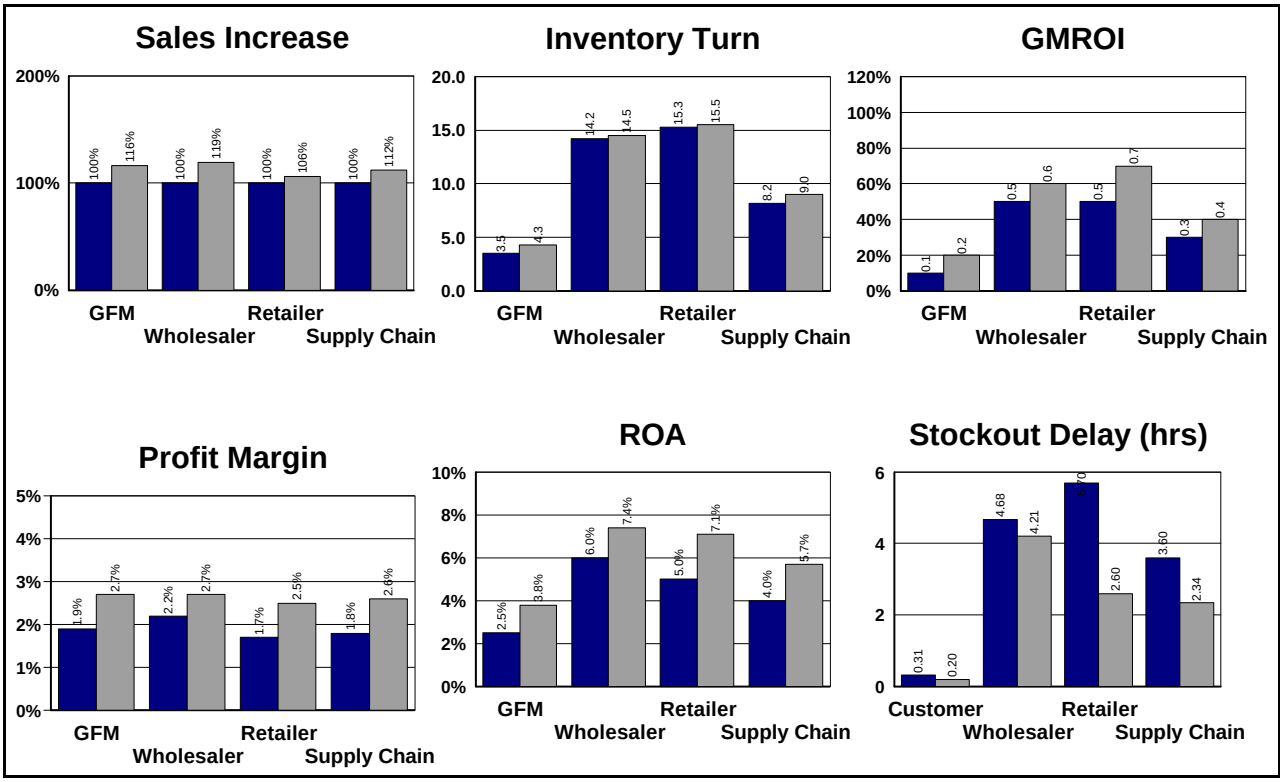

Figure 5: Base Case vs. New Transportation Policy
Solid = Base Case; Hatched = New Transportation Policy

Base Case vs. Continuous Replenishment: In this scenario, forecast and demand remained unchanged from the Base Case. However, the replenishment policy was changed to continuous with the reorder points periodically optimized by the SCA's Inventory Optimizer. As with the Transportation Scenario, this policy was instituted to make the supply chain more responsive to customer demand. Here, GFM manages the inventory for the wholesaler and retailer for branded products and the wholesaler manages the retail inventory for the private label products. In this scenario, GFM is able to anticipate demand from the wholesaler and the retailer earlier in the manufacturing cycle. This enables GFM to reduce operational costs by aligning set-up, work-in-process quantities, batch sizes, etc. more closely with actual demand. Thus resulting in improvements in operational flexibility and product availability to the end customer. The end result is improved performance over the Base Case in each measure (see Figure 6).

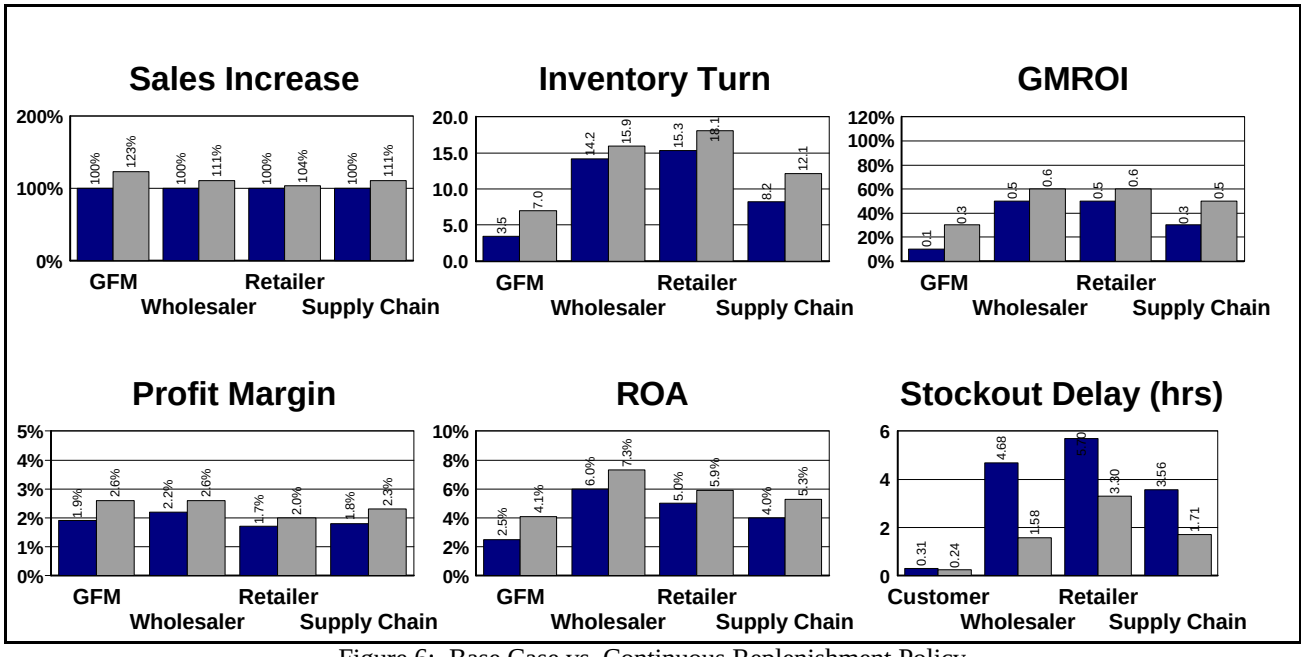

Figure 6: Base Case vs. Continuous Replenishment Policy
Solid = Base Case; Hatched = Continuous Replenishment Policy

Base Case vs. Collaborative Planning: The Collaborative Planning scenario dramatizes the effects of sharing the best possible demand forecast information among supply chain partners. The resulting improvement in demand forecast information enables a dramatic reduction in the amount of safety stock required to cover the uncertainty of inaccurate forecasting (see Figure 7). As a result, the inventory turnover rate increases and total inventory carrying charges decrease while the supply chain is able to increase the availability of goods to the customer**.**

Base Case vs. All Initiatives: The most dramatic improvement of all the scenarios over the Base Case is when all the aforementioned supply chain initiatives are applied simultaneously. This scenario combines the benefits of more frequent deliveries, GFM's aligning manufacturing with demand, and the sharing of better demand forecasts. The net result is an overall reduction in costs and improvement in customer service. These benefits are highlighted in the accompanying graphs (Figure 8).

Summary and Conclusions: As stated at the beginning of this paper, in today's world of competitive business it is no longer companies that compete, but supply chains. To compete effectively in this environment, the ability to measure the impact of policies and strategies across the entire supply chain becomes critical. Through the use of a specialized simulation tool, the IBM Supply Chain Analyzer, the authors demonstrate the financial impact of several supply chain policy alternatives using a case study approach. The net result is a significant improvement in operational and financial performance for all participants in the supply chain, including the end customer. Clearly this approach demonstrates the value of looking beyond the four walls of the corporation and how cooperation across the supply chain can result in a win-win situation for all parties.

REFERENCES

Bagchi, S., Buckley S., Ettl M, and Lin G., 1998. Experience Using IBM Supply Chain Simulator. In *Proceedings of the 1998 Winter Simulation Conference,* ed. D.Medeiros, E.F. Watson, J.S. Carson, and M.S. Manivannan. Institute of Electrical and Electronics Engineers, Piscataway, New Jersey.

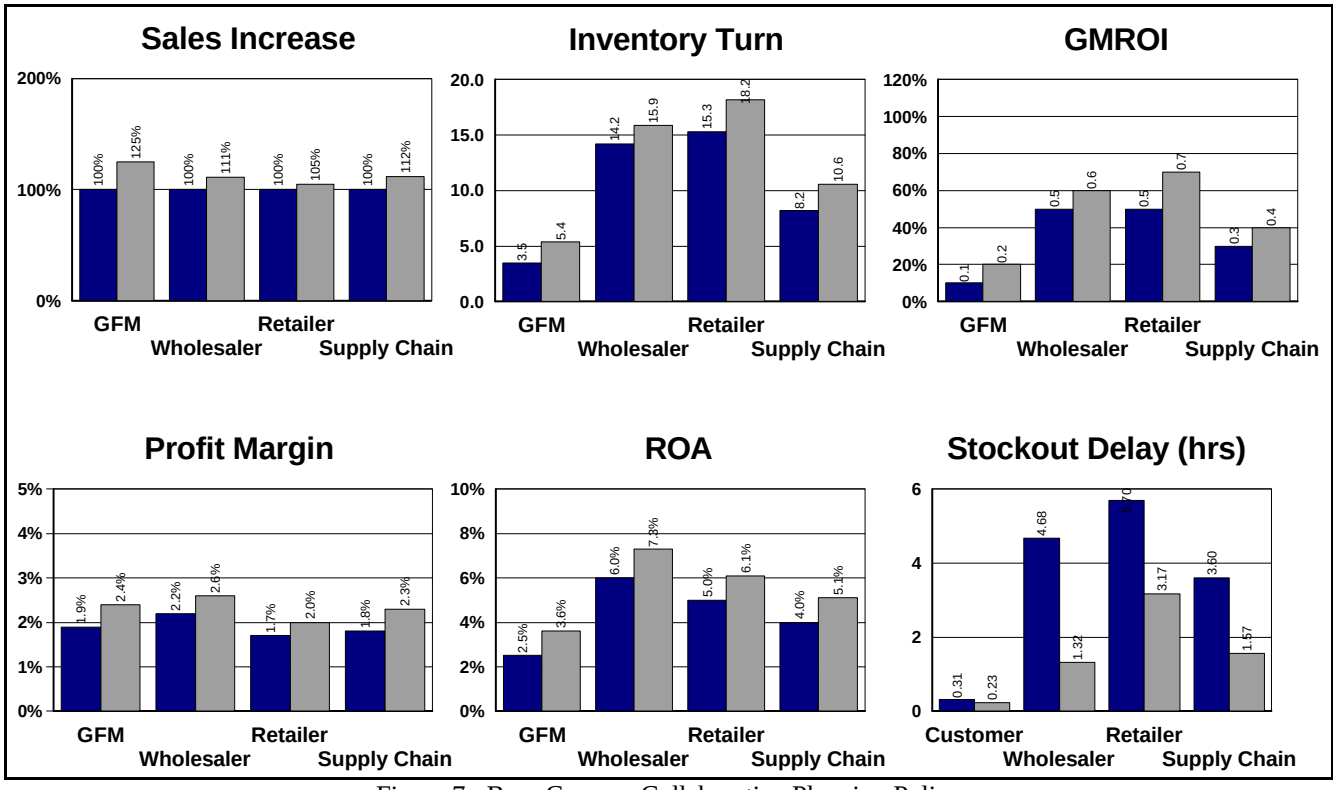

Figure 7: Base Case vs. Collaborative Planning Policy
Solid = Base Case; Hatched = Collaborative Planning Policy

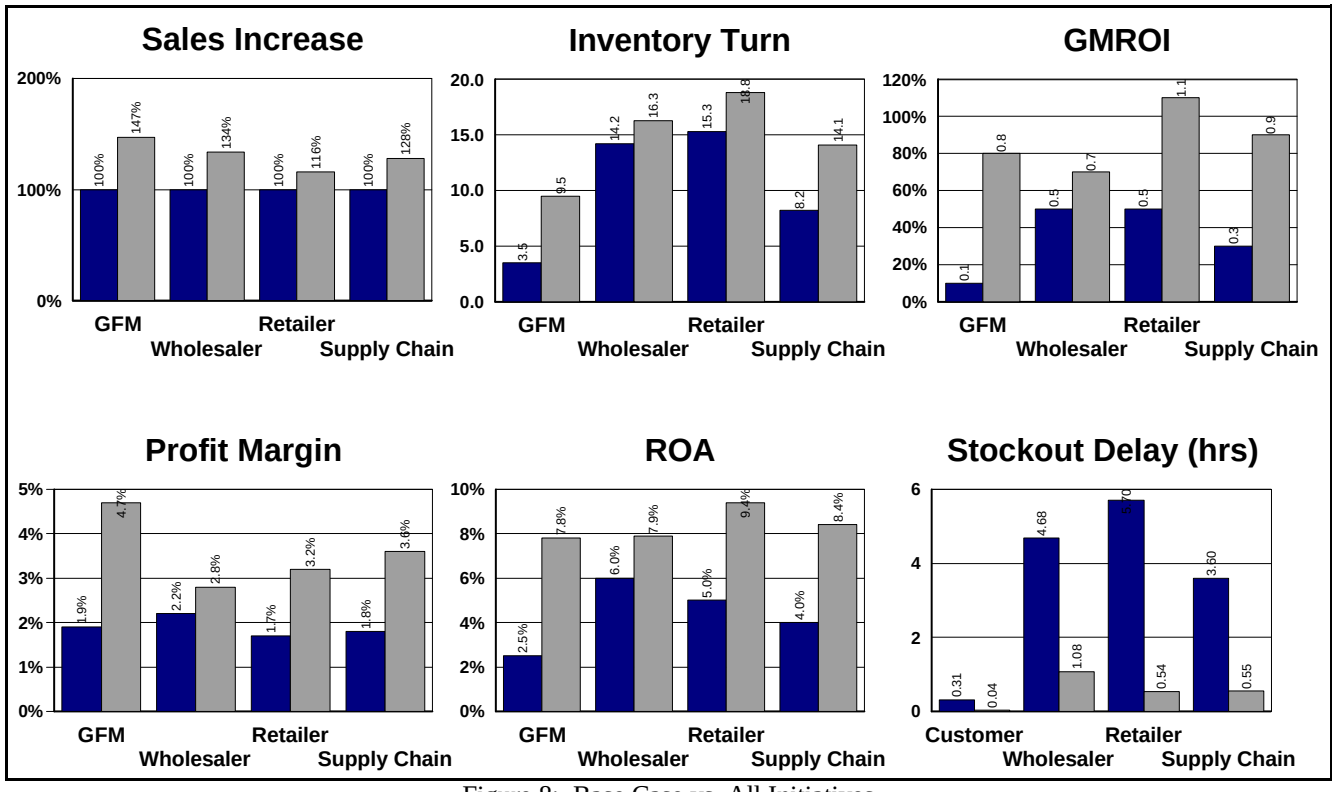

Figure 8: Base Case vs. All Initiatives
Solid = Base Case; Hatched = All Initiatives

AUTHOR BIOGRAPHIES

GEORGE ARCHIBALD is a Consulting Sales Specialist on the IBM Global Supply Chain Management team. His current area of focus is in the application of simulation tools to improve the performance client's supply chains. He has a masters degree in Industrial and Systems Engineering from Ohio University.

NEJAT KARABAKAL is consultant with IBM's Supply Chain Services. His focus is on supply chain simulation and optimization. For the last four years, he has been involved in several supply chain and manufacturing simulation and optimization projects. Major supply chain projects included a reengineering effort to improve the vehicle distribution system of a major automobile manufacturer, where combined optimization and simulation models were used to analyze the company's supply chain operations. Prior to his consulting career, he taught courses at the University of Michigan and Bilkent University in Turkey, including Simulation, Production and Inventory Control, and Operations Management. He received his Ph.D. degree in Industrial and Operations Engineering from the University of Michigan, with concentration in operations research . His M.S. and B.S. degrees, both in Industrial Engineering, are from Middle East Technical University in Turkey.

PAUL KARLSSON is a Supply Chain Consultant for IBM Supply Chain Services. Currently, he primarily works with the IBM Supply Chain Analyzer to develop models for IBM's external clients to quantify the projected impacts of supply chain initiatives. He earned his MBA from The College of William and Mary and BBA from University of Mississippi.