

Small Business and Industrial Engineering Tools

by

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ABSTRACT

UltraMed, a small distribution company located in the United Arab Emirates, faces high operations cost due to inefficiency in methods and concepts implemented in their business. Through the use of basic Industrial Engineering techniques, UltraMed and other small businesses can succeed in reducing their operational costs through the implementation of three major concepts of Industrial Engineering: Operations Research, Database Management, and Engineering Economic Modeling.

To succeed in implementing the design, it is important to have the right data and a cohesive foundation for the design; else, the results generated by the techniques will be invalid and could cause further complications to the operations of the small business. Therefore, it is essential for the small business manager, and examiners, to first identify what elements in the business needs to be improved, and later, once the needs are identified, implement the concepts that can be beneficial in reducing their costs. The model is configurable and changeable as it provides room for managers to use any platform as long it can support the techniques used, reduce training time, and reduce additional cost derived from purchasing expensive and complicated software.

The outcome of the implementation of the model displayed a significant potential of growth – represented by the profits generated by UltraMed. The factors contributed to the increase in profits were the combination of effective utilization of the model and marketing momentum to sustain an efficient, and growing, business environment.

INTRODUCTION

According to the Small Business Association (2009), there is an estimate of 29.6 million small businesses in the United States. These small businesses employ nearly over half of country's private sector workforce; that include 52% home-based businesses and two percent franchises, and they generate a majority of the innovations that come from the United States companies (U.S. SBA Office of Advocacy, 2009). Despite the positive facts that small businesses provide much impetus to the growth of the nation's economy by creating jobs, and production of goods and services, they are very difficult to sustain and maintain.

Small business owners and managers face variety of problems at different stages of their business development. Some of these include: difficulties in obtaining capital, difficulties in reaching out and attracting customers, difficulties in attracting and maintaining skilled employees, difficulties to grow their resources (financial and human), and challenges faced through competition against the larger companies with similar services. Small business owners, mostly rely on their own wits and motivation, and use extensive networking to find innovative ways to keep their business afloat. Although they seek financial growth and expansion of their business, apparently, many of them oversee the need to improve their operations alongside business expansion and consolidation. Some of the techniques business owners oversee are:

1. Developing an effective forecasting model for their services and products.
2. Determining the best number of products, or employees, needed to maximize profit.

3. Reducing wait time and optimizing operations.

Given the few methodologies mentioned above, small business owners can implement simple Industrial Engineering (IE) techniques to assist them to operate efficiently. Thus, if implemented systematically, these processes would help to increase their revenues, while keeping the costs of operation low. Operations optimization assists businesses to operate at their optimum potential capacity. To examine the effectiveness of IE methods on small business operations, the project will implement the techniques of Industrial Engineering, such as Operations Research and Statistical Analysis through the assistance of database systems, on a small business located in the United Arab Emirates. Although this business operation is located far away from the United States, its function and daily activities are identical to any other similar business in the USA. This particular business model was chosen as the subject of this study, due to the fact that all the financial and operational data are fully accessible to the researcher. Further information about the company can be found in the Background section.

The objective of this project is to determine the effectiveness of Industrial Engineering techniques over intuitive methods of decision making that is commonly used by the owners of small businesses. Transforming operations within the small business into meaningful financial metrics, the report will provide a better perspective to the business owner on how much potential benefit exists when implementing IE techniques to improve the operations of the system.

Three essential IE concepts will be utilized and delivered in form of a report for the small business owner. They include the following:

1. Operations Research Model: The models will provide a better perspective on how much product the manager should purchase given a set of constraint; such as budget, shelf life, demand, and capacity. In addition, implementing Queuing Theory, EOQ model, and AHP model to attain a better, and rational, perspective to a problem.
2. Engineering Economics Forecasting Model: Forecasting model will provide the manager a better perspective and outlook on the growth and progress of their business and examine different avenues of growth and improvement of their operations.
3. Database Management: The database model will provide a stable and reliable infrastructure to analyze the growth and progress of operations within UltraMed, such as inventory management and economic growth.

It is essential to note that the scope of the project will be limited to the concepts mentioned above. In addition, due to the complexity of the matter, the design will focus strictly on the product-based small businesses rather than service-oriented businesses. To maintain the flexibility and ease of configuration of the concepts, design and model used in this report, small businesses are free to use any software that they deem suitable for their operations. The minimum requirements of the software include:

1. Accessibility to internet, with a web host platform.
2. Database Management System.
3. Simulation software.
4. Statistical and Work Sheet Platform (MS Excel is highly recommended)
5. Data fitting platform.

For the purpose of this project, MINITAB and Microsoft Excel will be used to satisfy the areas of Operations Research and Engineering Economic Analysis, whereas integration of available online software and platforms were used for database management; such as Google Docs, PHP/MySQL platforms, and XHTML. An E-R diagram will be used to explain the database platform needed for small businesses to utilize the flow of information effectively.

BACKGROUND

Since its inception in United Arab Emirates in 1996, UltraMed has been able to establish its services on mutual trust, quality and promptness. UltraMed's partners are two German pharmaceutical companies, DHU and Hevert, which rely on UltraMed's services for marketing and distribution of their products in the UAE. There is mutual trust between each of these companies and UltraMed and they have provided exclusive dealership and distributorship rights to UltraMed. UltraMed, on the other hand, has been able to gain trust of their customers by providing them highest quality natural products available on most competitive prices. UltraMed is committed in providing their suppliers with professional marketing, distribution services and proficient customer care to ensure maximum customer satisfaction and loyalty. In addition, UltraMed's operations covers both private and government healthcare sectors by promoting homeopathic products through direct purchase orders, participation in public tenders and daily inquiries.

Other activities that UltraMed partake include: after sales support, consumer education through direct and indirect methods, reporting and follow-up with the suppliers, and product launching strategies.

While researching UltraMed's financial and operational documents and after conducting several interviews with the owner, I have identified several flaws in the system that I believe, if not checked and rectified would lead to considerable losses to the business. In addition, given the obligation of the company to buy fixed batch sizes of the products, some of which have short shelf life, have caused havoc for the owner, as he is put under pressure to order the products and then to sell them in short span of time, before they get expired. Consequently, many of these pharmaceutical products remain on the shelves and cannot be sold to the potential pool of customers. Thus, UltraMed is suffering from high holding costs. In addition, there is a lack of effective communication between the manager of the business and the employees as there are no metrics to show the progress, or the needed effort, for the employees to be motivated to work.

Given such conditions, I believe that UltraMed is the best business to implement IE models upon.

LITERATURE REVIEW

In 2009, there were over 595,600 small businesses that closed, and 43,546 businesses that filed for bankruptcy in the United States (Small Business Administration - Office of Advocacy, 2009). Based on researches and studies conducted by individuals in the

field of Economics and Business, several elements were identified to be correlated with the rate of closure and bankruptcies of small businesses. Some examples include, lack of experience and knowledge in decision making, poor capital structure or insufficient capital, poor inventory management, competition and unexpected growth (Berle, 1990; Ames, 1994). In the present paper, the following factors will be investigated and will be connected to the solutions present to reduce the risk of closure and bankruptcy. The following literature reviews attempt to demonstrate and support such claim while connecting them to suggested practices.

According to different Economic and Business institutions and journals, the fundamental factor connected to all of the factors above is the ineffective methods and practices used in decision making by small business owners. Based on a research conducted by Armacost, Hosseini and Javalgi, (1990) state that small businesses encounter similar decisions as the largest corporations do; however, they do not have the resources and knowledge necessary to develop the information required to make the same quality decisions. Currently, managers of small businesses have identified a need to use various market research analysis tools in order to assess their internal and external environments (McDaniel, 1985). According to Thomas L. Saaty, Chair of University Professor at the University of Pittsburgh and a Member of the National Academy of Engineering, states that not all information, in this case from the various market research tools, are useful for improving our understanding and judgments (Saaty, 2008). When business owners decide intuitively, they are inclined to believe that all kinds of information are useful and the larger the quantity, the better the decision process. However, such practice is false. In the field of business and entrepreneurship, majority of the factors, such as demand of products

or service to be sold, are intangible. The measurement of intangible factors in decisions has defied human understanding. Therefore, Saaty stated that there are two possible ways to learn about anything (in terms of business, it could be the product, service or an idea). The first method focuses on examining the properties, implementing the product or service, and measuring the feedback or response of customers. The latter method focuses on comparing the product and services with other similar entities and relates it to them by making comparisons. Returning to Armacost, Hosseini and Javalgi, multiple criteria can be used to evaluate several alternatives (for example, products, strategies). In addition, it can provide the capacity for small business owners to accommodate some of the economic factors (such as customer trend/behavior and politics) that manipulate the decision process. In terms of small businesses, they do not require an extensive analysis. Therefore, the use of these intangible, or subjective, factors may play an essential role in decision making than for larger business organizations.

In addition to decision making, raising capital and identifying cash flow within the small business structure is a challenge many small business owners face. D. J. Storey, author of *Small Business: Critical Perspectives on Business and Management*, states that it is initially significant to categorize the problems and growth patterns of the small business in a systematic way that can be considered useful to the business owner when viewing the problem. Based on the framework designed, it can aid accountants and consultants in finding the remedy and solutions for the problems within the organization. Therefore, for such outcome to initiate, the need of a cash-flow planning is “paramount” (2000). However, it is essential to note the correct, or reasonable, definitions of the elements within the framework. Jim Blasingame, president and founder of Small Business Network Inc.,

explains that many business owners, even of those with college degrees, do not have the necessary knowledge of accounting; especially viewing the problem beyond the scope of debits and credits. Blasingame states that the most essential concept that business owners need to understand is the relationship between cash flow and accounting. On his website, Jim provides the following insight of the financial terms used in determining the cash flow:

- **Cash flow and accounting are not the same thing:** Profit is accounting, not cash. Cash flow is cash, not profit.
- **You can be profitable but not have positive cash flow:** Understanding the difference between Account Receivable and the current cash available in the business.
- **You can have positive cash flow and not be profitable:** According to Blasingame, it is the major reason why many point-of-sale businesses fail. Therefore, it is essential to understand the concept of Account Payable.
- **Balancing Accounts Payable and Account Receivable to avoid financial pressure.**
- **Profit is essential. However, Cash is necessary:** The need to be liquid while in the small business phase is essential to remain flexible during difficult economic environment.

For majority of product-based industries, finance is connected to the items the businesses sell to their customers. Therefore, to grasp a better understanding of the financial condition of the business, the owner must identify the demand, and the available supply, of the product they wish to provide.

Inventory management is one of the biggest concerns for every business owner. The aim of every business owner, in an ideal condition, is to have zero inventories (or no units) in their stock. According to Longenecker, Moore, Petty and Palich, the difference between a successful and failing small business is inventory management. The objective of every business owner is to determine the right number of goods at the right time and place. Small business owners, using intuitive purchasing methods and ineffective forecasting methods, face difficult financial situation as they face the condition of losing their customers due to them not be well-stocked, or incurring high costs due to over-stocking (Longenecker, Moore, Petty, & Palich, 2005). Therefore, to narrow any possibility of facing either of the conditions mentioned above, Dale Sauers, professor of management at York College of Pennsylvania, suggests integrating MRP computing method and system to the operations of small businesses (1984).

In addition to inventory control, it is essential for the products, or services, to be of high quality to sustain in the competitive business environment. Research states that small business owners and managers tend to view human resource management strategies as being less important than finance, marketing, and planning (McEvoy, 1984). Furthermore, small business managers do not perceive incentives to be critical to improving productivity (Amba-Roa & Pendse, 1985). Based on these findings, it is evident why many small businesses fail to last in the economic environment they are operating in. However, it is important to note that Quality Control methods can be implemented within small businesses. A review of the relative strengths and weaknesses of small firms reveals that the TQM principles such as employee participation and flexibility could, in fact, be more successfully applied in small firms than in large ones (Manoochchri 1988; Sonfield 1984).

Therefore, the use of Statistical Process Control tools, Control Charts, and other Lean methods of operation could curb the risks of failure of the small business.

Given the statements mentioned above, the project will implement the methods mentioned above on few product-based small firms. Following the order of the problems stated above, the project will use the references from the sources found to attain a better insight and focus in identifying a general procedure for small businesses to follow, provided the tool and methods, to operate effectively.

DESIGN

To test the effectiveness of the model, we will use UltraMed's current operations as a platform to test the methods stated previously, which were Operations Research, Economic Analysis and Database Management. As there are different types and fields of small businesses across the globe, the methods and design mentioned below will serve as a backbone to the development of models that are more suitable for the needs of small businesses.

Prior to implementing the methods, several steps are needed to be completed to aggregate the needed information to successfully implement the design. Once the necessary information is captured and the needs are identified, the designer will then base their methods of implementation based on the results gained from the survey and data collected. Finally, depending on the time frame needed, the designer will revise the new operation through data analysis and compare the values with the data collected prior to the

implementation of the design. The following steps below will guide the method of implementing the tools:

SURVEYING AND RESEARCH

Identifying the needs of the small business is the first essential step in order to effectively capture the issues and problems revolving around a firm. In relation to UltraMed, the basis of the decisions needed to implement the design was based on the qualitative and quantitative observations experienced during the period I have worked at UltraMed. However, after re-evaluating the observation into a more analytical procedure, a decision chart (Fig.1) can be used to assess the needs of the small business.

Following the steps mentioned in Fig.1, the first step identifies whether the firm is a small business or not. The purpose behind this evaluation is to reduce the level of complexity, in addition, feasibility of using B2C software, such as Microsoft Excel. The following table will provide a window to differentiate between a small and large business. Due to the advancement of technology, computers and further research into the field of Small Business Management, the information presented in the table is valid for a limited period of time.

Elements of a Firm	Maximum Value
Number of Employees (W-2 and 1099 Employees)	60
Number of Dependent Products (Products that are of the same range. For example, tooth pastes of different brands are direct competitors to one another).	45
Number of Ranges	10

UltraMed's Case: UltraMed holds three ranges of products, with each range having a set of 12 – 30 products. There are 8 employees working full-time. The model focuses on the flow of products in UltraMed. Therefore, the number of products and ranges are sufficient to implement the model effectively.

The next step in the process is accessibility to the internet. The use of the internet in the current model is highly significant. It will be used as a medium to provide information to buyers, suppliers, and managers of the small firm to operate effectively. To establish a more dynamic database infrastructure, the internet will be used to capture, view, and update data flowing into the firm. In the current stage, developed nations satisfy the requirement. However, for areas that do not have the infrastructure to access the internet, a wireless device, such as cell phones, can assist in providing a constant flow of information when needed.

UltraMed's Case: UltraMed has access to the internet. In addition, they have their own website and a host; both of which are beneficial for DBMS phase and will provide freedom to further expand the use of the internet in their operations.

The third step notes the availability of data needed to conduct statistical analysis. Historical data can help in forecasting the demand of a product on the shelves, identifying products that are fast moving versus slow moving, and if there is a shelf-life for the products in question, it will establish a criterion for the movement of the products and implementation of market strategies and inventory management to assess the movement of the product. In a product-based firm, the types of data can be broken down into two categories; Sales Data and Demand Data. Sales data is a common data that is normally acquired through the transactions made by the firm with their buyer and supplier. Through Sales Data, the business attains information of their accounting profit and losses. However, the Sales Data does not account for economic profit or losses. In other words, the opportunity cost of having one type of product over the other, or the actual demand in the market regardless of the transaction made (Quantity needed versus Quantity sold). In this scenario, only few firms have Demand Data; data that reflects the need of the market. The advantage of the Demand Data is that it accounts for the demand needed during periods when the company is out-of-stock for the product the consumer needs. The use of Sales Data and Demand Data will be discussed in further detail during the implementation phase of the Database Management System.

UltraMed's Case: UltraMed collected only transaction data. In addition, data relevant to stock and products are written first on inventory cards and later inputted into the worksheet on Excel. Some data has been lost due to such practice. In addition, when items were out-of-stock, UltraMed employees have not taken into account sales lost due to lack of available stock. Therefore, UltraMed only possess Sales Data; which are recorded on PeachTree software.

The data in question is attained from a database or worksheet in the firm; whether it is MS Excel, MS Access, Peachtree, worksheets notebook or other available software or medium used by small businesses. Surveying the database or worksheet is the next step in the research phase of the design. Through examination, it is essential to note the data and information captured by the business. The question that must be answered is whether the database is sufficient for the current, and future, operations of the small business. In this step, the designer decides how to implement the Database Management System to better assess the operations of the small business.

UltraMed's Case: Currently, UltraMed does not have a database other than a worksheet which records the number of items in the inventory. There are no relations between the different worksheets in UltraMed. Therefore, if one of the fields is changed in the worksheet; other worksheets must be manually manipulated to account for the change.

After identifying the current database infrastructure and data available in the small business, the next step is to evaluate the method the small business uses to forecast the demand of their operations. Due to limited capacity of human resources available in small businesses, most managers follow a qualitative method of forecasting. Despite the fact that some businesses use available software to assist them in identifying trends and data, the methods used for forecasting may be ineffective and inappropriate. The cause can be insufficient knowledge of what forecasting methods are available, and the validity of the data being forecasted. Through statistical analysis, the designer will identify the best alternative to forecasting methods.

UltraMed's Case: Using Sales Data, UltraMed's manager forecasts the demand through qualitative analysis. Through intuitive and experience, the manager decides, based on the data he derives from PeachTree and other worksheets, how many units to purchase for the future.

Finally, the last step includes the firm's management of their inventory. The final step identifies the macro-level of operation in a firm; how different areas of the firm define the operation the firm is engaged in. This includes the design of the facility base on the number of inventory the firm has, or the flow of material within a company.

UltraMed's Case: Currently, UltraMed did not translate the data they have analyzed into form of action. It is unknown whether UltraMed follows the FIFO system. In addition, there exists a lack of documentation of important activities; which leads to miscommunication and implementation of wrong strategies. UltraMed's manager also recounts that when employees leave, the operations that was first implemented gets discontinued as the new employees were not trained to continue the practice.

After evaluation the result of the survey thoroughly, the designer can determine which of the three Industrial Engineering tools can be implemented in the operations of the small business. In the case of UltraMed, all three tools were necessary based on the difficulties they have faced in their operations: Lack of an effective database to manage their inventory and qualitative approach to forecasting data. After attaining all the necessary data, we begin with the first step of implementation; which is statistical analysis.

STATISTICAL ANALYSIS

After attaining the necessary data from the business entity, it is essential to note whether the data is usable for the Operations Research model, which will include a simulation system. In retrospect, the larger the amount of data obtained, the better it can assist in reducing the chance of error and variability; providing a better perspective on the demand of the market when designing a forecasting model. The minimum amount of data depends on the method used by the business to collect data and the period in which they have recorded their data. To gain a more accurate representation of the pattern of the data, a minimum of 20 units of data can suffice.

After acquiring the optimum amount of data, the data can be fitted using either MINITAB or R-Project statistical software. The data-fitting program will provide a better function for forecasting by identifying the trend of the data and linking it to the distribution that is relevant to the data inputted.

UltraMed's Case: UltraMed recorded their data monthly, collecting sales record since 2006; providing around 48 months of data per product. For the purpose of the analysis, the amount of data obtained is sufficient to find the data pattern of each product and minimizing error.

To organize the data effectively for ease of read and analysis, the worksheet on excel was designed in a manner that accommodates all the necessary information needed for simulation purposes. Figure 3 provides an example of a set of information used for UltraMed to analyze the data effectively.

After inputting the data into MINITAB, the next step is to identify the pattern through MINITAB's Individual Distribution Identification function¹. Referring to Fig.2, the data in this case was arranged under Column C1. Under "Options," the default Confidence Level was selected (95%) as a measure to analyze the data. Once the necessary settings are selected, the function is run. MINITAB will generate a set of Windows; comparing the set of data with different distribution sets. A given distribution is a good fit if:

- The data points roughly follow a straight line
- The p-value is greater than 0.05

To simplify the method of analysis, the first window provides a reasonable set of solution that can be feasible for the operations of a small business. Especially, the feasibility in implementing the function in a worksheet software, such as using MS Excel. Figure 4 demonstrate the result generated by MINITAB; focused on the functions that are deemed feasible for use in commercial worksheet packages. Based on the P-Values, it is evident that the lognormal model can be used for the current data used in MINITAB. With the statistical analysis portion of the design now complete. The next step needed is the implementation of Operations Research model using simulation techniques and MS Excel's "Solver" Add-In.

OPERATIONS RESEARCH MODEL

Operations Research uses mathematical modeling, statistical analysis, and mathematical optimization to arrive at optimal or near-optimal solutions to complex decision-making problems. The most common goal in which small businesses are planning to achieve is to maximize their profit while maintaining low costs. In this phase, the designer must take into account all constraints

¹ <http://www.minitab.com/en-US/training/tutorials/accessing-the-power.aspx?id=1706&langType=1033>

and factors involved in decision making to best determine the optimal solution of the firm. In a product-based industry, among the factors include shelf space, budget, demand for each product, and dependency factors between products. Depending on the case, operations research aims to either maximize a given objective (such as profit), or minimize it (such as cost). To conduct an operations research function, it is essential to formulate the problem by identifying:

- The entities, and factors, in the model.
- The objective of the operations research model.
- The constraints that influence the objective of the model.

UltraMed's Case:

As a distribution company, UltraMed's main objective is to maximize profits. This can be broken down into minimizing costs and maximizing sales. To determine how to maximize profits, it is essential to determine if there were any trends in the data. UltraMed must keep an inventory of its products and must determine the products to purchase and hold in the inventory. The data was examined on a quarterly basis to help in determining the best products to have on hand for a certain quarter. It was essential to determine the best product to buy for a given quarter to maximize sales. With finding the best inventory selection to maximize sales, certain limitations, or constraints, were implemented. In conclusion, the combination of all these objectives assisted in determining the best fit model for UltraMed to use to maximize their profits. The objective can be formulated by the following mathematical model:

x_i = Number of units of product i

k_i = Capacity, or size, of product i

c_i = Contribution margin, or profit generated, from product i

Z = Total Profit

$$MAX Z = \sum_i^n x_i * c_i$$

Given the constraint:

$$Total\ Capacity\ on\ Shelf = \sum_i^n x_i * k_i$$

For the present case, the capacity of each unit is constant. Therefore, the constraint factor will not directly affect the objective. However, once the capacity of each unit is recorded, the model will provide an optimal solution to the problem; identifying the best amount of each unit given their profit and capacity.

The first step in creating the Operations Research (OR) model was collecting historical data on a single range of products. For this case, UltraMed's Biochemic Remedies was used. As mentioned before, the data was provided by the UltraMed accounting department and includes sales and price info for 2006 through 2008. The charts show a month by month report of units sold, cost and selling price per unit. Because UltraMed only began keeping inventory of its products using computer memory systems a few years ago, the data range was limited. The limitation was the inaccuracy of the data recorded. The Sales Data only represented the sales made by UltraMed, disregarding the sales lost due to UltraMed being out of stock. In addition, returned items were added back into the inventory data, which leads to fluctuation of inventory level. The issue was later resolved with UltraMed implemented a better policy on inputting data for returned goods.

Because UltraMed places orders for its products on a quarterly basis (every three months), that data is divided each year into quarters, and then combined the pertaining data of the years to their corresponding quarters (see Table1); for example, January through March constituted Quarter 1 (Q₁) so all sales for Q₁ for 2006 were grouped together with sales for Q₁ of 2007 and Q₁ of 2008. Furthermore, April through June constituted Quarter 2 (Q₂), July through September constituted Quarter 3 (Q₃), and October through December constituted Quarter 4 (Q₄). Once all of the respective yearly data was grouped together by quarters, the data was divided into different sections: the 25th percentile, 50th percentile, and 75th percentile of the quantity sold of each drug for each quarter (see Table 3). With this information, a random variable for the quantity demanded (Q_d) was created that

could be simulated for each product for a single month of each quarter. Based on the MINITAB data fitting function, a lognormal distribution function, using Simtools² GENLINV³ function, was created for each product for each quarter (see Table 5). After running a preliminary simulation of the data, it was noted that they had to be limited in its lower and upper bounds in order to make sense. More precisely, its lower bound had to be equal to 0 (since there can't be a negative demand); deciding the upper bound took some subjective analysis. However, after reviewing the data, it was considered reasonable to assume that the quantity demanded of any given product should not exceed its historical average by a significant amount. Therefore, using MS Excel's MAX function to find the maximum amount sold of each unit for a given month of a given quarter (see Table 2) and then added 20 to the Maximum value - an amount that seemed reasonable given the variability of the historical data. In Table 5, the **Conditional Factor**, which represents the probability model, using Excel notation, was limited as follows: $IF(Q_d < 0, 0, IF(Q_d > MAX + 20, MAX + 20, Q_d))$. In summary, if the output of quantity demanded from the simulation model is less than zero then copy the quantity "0," and if the output is greater than the historical maximum demand plus twenty, then copy the quantity "MAX plus twenty" - otherwise keep the outputted quantity.

The variable cost per unit and price per unit were set constant for all of the products that were being evaluated. Therefore, by subtracting cost from the price it was possible to find the contribution margin of each unit. Due to privacy concerns, the value of the price, cost and contribution margin are not here in the report.

² <http://home.uchicago.edu/~rmyerson/addins.htm>

³ GENLINV(probability, quart1, quart2, quart3, *lowest*, *highest*) returns inverse cumulative values for a generalized-lognormal random variable that has 25% probability below the quart1 value (the top of the first quartile), 50% probability below quart2, and 75% probability below quart3. A generalized-lognormal random variable is a constant plus or minus a lognormal random variable. When the first parameter is a RAND(), GENLINV yields a random variable which could be positive or negative, but is bounded on the side of the narrower quartile range. If optional lowest and highest values are specified (satisfying lowest < quart1 < quart2 < quart3 < highest), then values of the generalized-lognormal random variable are adjusted as necessary to keep GENLINV within these bounds (increasing to the lowest value from below it, decreasing to the highest value from above it).

The next step was to run many simulations of the model for quantity demanded and matching it with the contribution margin per unit. 2000 simulations were ran for each quarter for each product, totaling an overall 96,000 simulations (see Table 4). Each random simulation represented the monthly-quarterly demand for each product. To get a picture of the overall units sold, the demands of all of the products we summed (see Table 7). With these 2000 scenarios of total quarterly demand, the average, standard deviation, 25th percentile, and 75th percentile were derived. The overall demands was multiplied for each quarterly scenario by the contribution margin, which provided an insight of the expected profits the company generated each quarter. (See Table 8).

The final stage of the procedure was to decide, based on the simulation model, how much total inventory should be purchased each month and how much should be allocated for each product. To answer the former question, it was observed the 25th, 50th, and 75th percentiles of the total quantity demanded for single months in each quarter, and resulted with figures that lied somewhere between the 50th and 75th percentiles. The relatively high figure was used at the request of UltraMed's owner who shared his belief that sales should be higher than usual for 2010. The final total figures can be found at the bottom of Table 10. To answer the question of how much of each product should be included in the quarter inventory; Excel's solver was used along with the simulated demands. The Solver function for determining Q_i , for example, was "Maximize expected profits by changing the quantity distributions of the products with the constraint that the total quantity should equal 660." This was repeated for each product until the optimal quantities were found.

To attain a better perspective of how many units would be demanded in a given quarter the monthly figures were multiplied by 3 – Each quarter represents three months (Table 10). The resulting figures are revealing. It is apparent that certain products should be allocated a larger

proportion of the inventory for some quarters while less for others. In general, Q₂ and Q₄ are the most profitable quarters of the year as the demand for all products is particularly high during those times. This could perhaps be related to the allergy and flu season to which these quarters correspond. However, certain products have specific quarters where they sell much better (and much worse) than other products. For example, drug No. 6 (Kalium Sulfuricum) and No. 9 (Natrium Phosphoricum) are much more sought for during Q₄ than any other quarter. Most of the biggest sellers seem to have their worst quarter at Q₃ but there are some exceptions. No. 10 (Natrium Sulfuricum), for example, sells its best in Q₃. Similarly, most products sell in Q₁ poorly compared to other quarters except for No. 7 (Magnesium Phosphoricum) that sells its best on that quarter. Other products, particularly No. 2 (Calcium Phosphoricum) and No. 4 (Kalium Chloratum) are consistently strong sellers and should be kept in relatively high volumes during all quarters.

While these results do seem to be sensible when related to the expected demand of each product for each quarter, certain cautions should be taken from the analysis. One potential point of weakness in the analysis is the assumed distribution of the data. While the generalized lognormal distribution used, parameterized by the 25th, 50th, and 75th percentiles of the historical data, should be an appropriate model under the given conditions, the lack of substantial historic data could have undermined the accuracy of its outputs. Ideally, one would like to have 30 or more sample years off of which parameters could be acquired. But given the circumstances, this was impossible.

Another potential drawback of the procedure is the limited number of variables analyzed for each product. Certain unmentioned constraints and costs - shelf life, individual shipping costs, distributor's tax, and inventory costs - could influence the supply and demand of each of these products. Furthermore, the simulation of only single months instead of whole quarters, which was necessary given the limited amount of historic data, may ignore certain quarterly trends. In regards to the first issue, it is assumed by the researchers that the major relevant variables for the demand

of these products are external factors (seasonal diseases, allergies, etc.) over which the business has no control. Moreover, it is assumed that the demand for each product follows a particular distribution and that this distribution should become apparent over multiple repetitions and simulations. In regards to the second issue, there was no way to create a workable model off of total quarterly data as this would only give three points for each quarter - not enough to create functional probability model.

Operations Research technique is only to be used as a method to optimize systems. As for UltraMed's case, the aim is to optimize the number of products on the shelf based on the capacity available. It is essential to note that the Operations Research technique is to be used along a forecast model to provide a comprehensive understanding of the flow of products within a business. Depending on the demand of the products, especial forecasting techniques must be used to satisfy the needs of a firm. Among the common forecasting techniques that can be used are Moving Averages Forecasting, Seasonal Adjustment and Exponential Smoothing, and Weighted Average.

Based on the observations gained from the Operations Research model, it was noted that an effective database platform was needed to process orders properly. In addition, implementing a platform to record data effectively and having the information available online for the manager, and sales people, to view wherever they may be. Therefore, the next phase, and final phase, of the design process is the development of an effective database model that will improve the flow of information to, and from, UltraMed.

DATABASE MANAGEMENT SYSTEM

Database systems are essential tools to manage the flow of information, data and records in a firm. It provides a stable foundation for the firm by providing managers and employees control over the activities within the firm and maintaining consistency and efficiency. The most common

software used by many small businesses is using worksheet software, such as Microsoft Excel. Other companies use Access, SAP, or Oracle DB depending on their proficiency on how to use the database.

In UltraMed's case, Excel was used significantly to record the information of their sales and inventory. Therefore, to maintain the simplicity and avoiding any additional complexity into the system, Excel was continued for usage while being complemented with Google Forms and a hosting service.

Prior to establishing the form, it was essential to establish what type of information is needed, who can access and provide the data, and how to organize the data. Figure 5 provides a macro-level view of the flow in information within UltraMed. The form, an order form, will be available for buyers to access through special username and password key that can be modified by enhancing the security of the server through the modification of the .htaccess file⁴. Once the user accesses the form, the customer completes the necessary information and later submits their form, which will then be saved on a cloud server hosted by Google. Table 11 provides an insight of the data requested by UltraMed from their buyers. The three main advantages of using Google Form's package are:

1. Security of the information online; with the option of configuring who can access and manipulate the data.
2. The use of timestamps by Google Forms.
3. Accessibility of the information from any computer.

After a month passes by, UltraMed will download the information into their excel sheet, and modify the information based on their configuration of the database. After configuring the data

⁴ Requires direct access to the root account of the host server. Consult with the hosting company for further information on this matter.

from Google to their needs, the modified information can later be shared with different departments for analysis and evaluation of sales, inventory, and identifying potential areas of expansion based on the demand from different areas. After the data has been evaluated, it will later be aggregated in a central worksheet that will be used by the manager, which can also be shared with the supplier to identify how many items are needed to be manufactured for the given region based on the demand of the products in the region.

METHODOLOGY

The implementation phase would require a minimum of one year, or four quarters, to realize its effect and influence upon the system in question. However, the model can be implemented directly through the use of MS Excel software. The model can be examined through analysis of the inventory and gain in contribution margin at the end of the business year.

In regards to the implementation of the database model, references are available online in regards to how to generate a .htaccess file that will help in ensuring their privacy and security of information for the customers. However, it is essential to note that as the businesses operation expands, it is recommended to seek better software and database management system to accommodate the large demand from the market.

RESULTS AND DISCUSSION

As mentioned in the methodology section, the results of the actual design can be best interpreted and examined after a period of one year to compare previous quarter with the results of the given quarter. However, based on the Operations Research model alone, it can be easily

identified that the benefit of this model is significant compared to the previous methods and operations used by the small firm. In relation to UltraMed, the results from the simulation are summarized on Table 10). According to the model, the expected total profits (π) for each quarter for the given range of product are as follows:

- $\pi_1 = \text{€ } 35,754$
- $\pi_2 = \text{€ } 44,421$ AED
- $\pi_3 = \text{€ } 32,503$ AED
- $\pi_4 = \text{€ } 41,713$.
- Total annual profit is equal to $\sum_{n=1}^{n=4} \pi_n = \text{€ } 154,391$. This figure is a 22.7% increase in profits over 2008 and 9.3% increase in profits over 2009.

This demand schedule should be used as a general guideline for how much of each product should be carried for a given quarter, under the assumption that the UltraMed does not face drastic economic changes. Further research and examination could be conducted if a more sophisticated model was desired. As mentioned previously, other information pertaining to other variables in the business operations could be obtained and inputted into the model. However, given the relatively limited accounting records that UltraMed currently has, more research and data collection would be necessary to create the new model.

SUMMARY AND CONCLUSION

Based on the results, it is evident in theory, and in practice, how Industrial Engineering tools are beneficial in resolving complex decisions faced by small businesses using the available tools available around them. The implementation of the methods is not a difficult task to conduct; however, caution is required when conducting the techniques explained above. It is essential to note the simulation and operations research provides the optimal solution based on the

information it is provided. In other words, if the information inputted into the techniques are invalid, then the results generated by the techniques will also be invalid. Therefore, it is evident that one of the fundamental driving factors that lead to effective results is the acquisition of necessary and useful information that are beneficial to the growth of the business.

Systems management will only provide a stronger foundation to a better control of the operations in hand; but it is insufficient when the data are not used for the purpose of improving methods of operation. Total Quality Management (TQM) is the fundamental concept that must revolve around every operation. Despite the term being widely used in manufacturing and service industries, small business can aim in reducing errors generated by their operations, increase customer satisfaction, streamline their supply chain management, aim for modernization of their operations and ensuring that the employees have the highest level of training in different necessary fields to optimize work force. Through the implementation of the model provided above, small businesses will attain the first step of TQM, and hopefully, succeed in the market by reducing the cost of their operations, while excelling in their field of work.

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APPENDIX

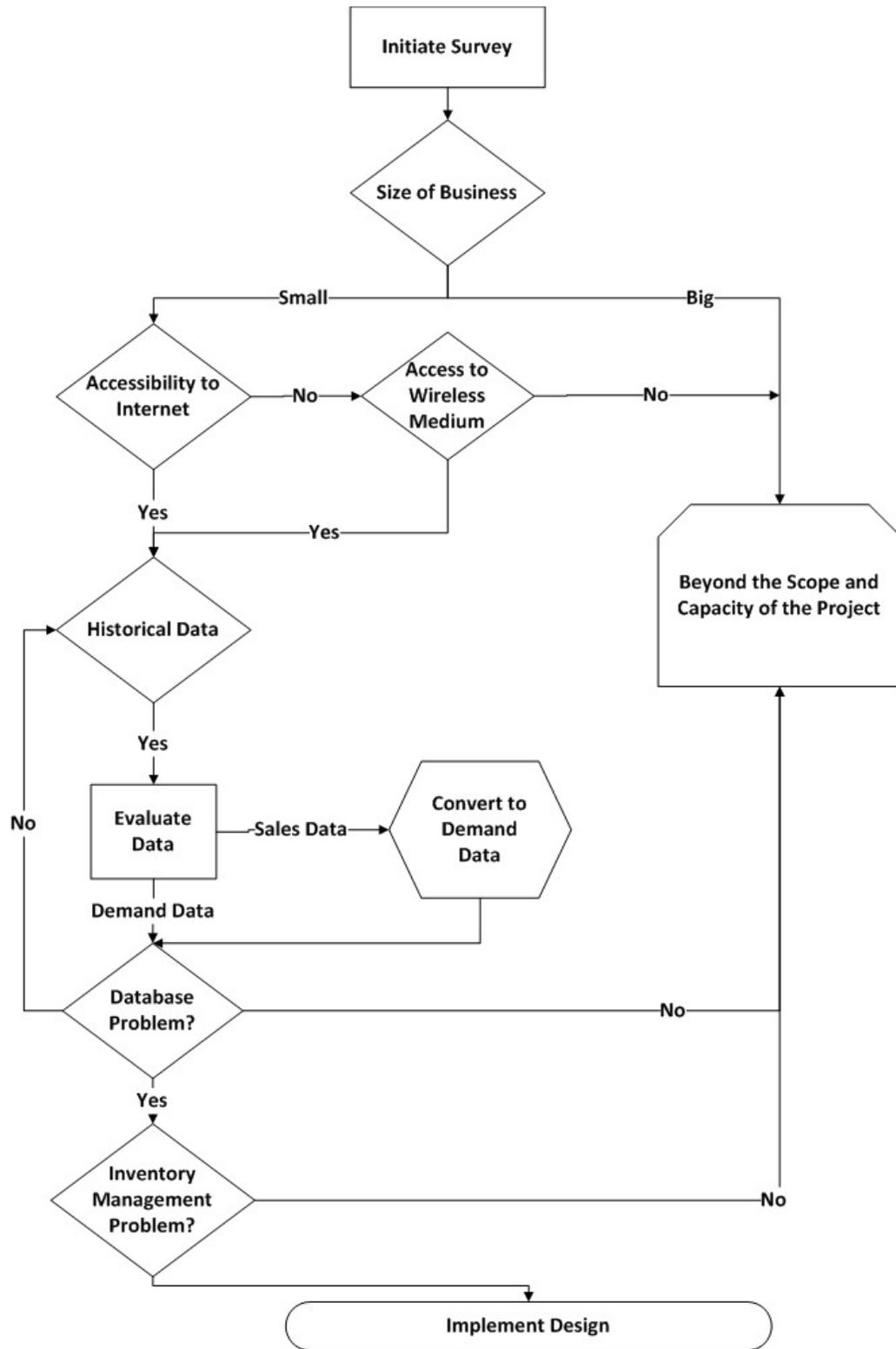


FIGURE 1

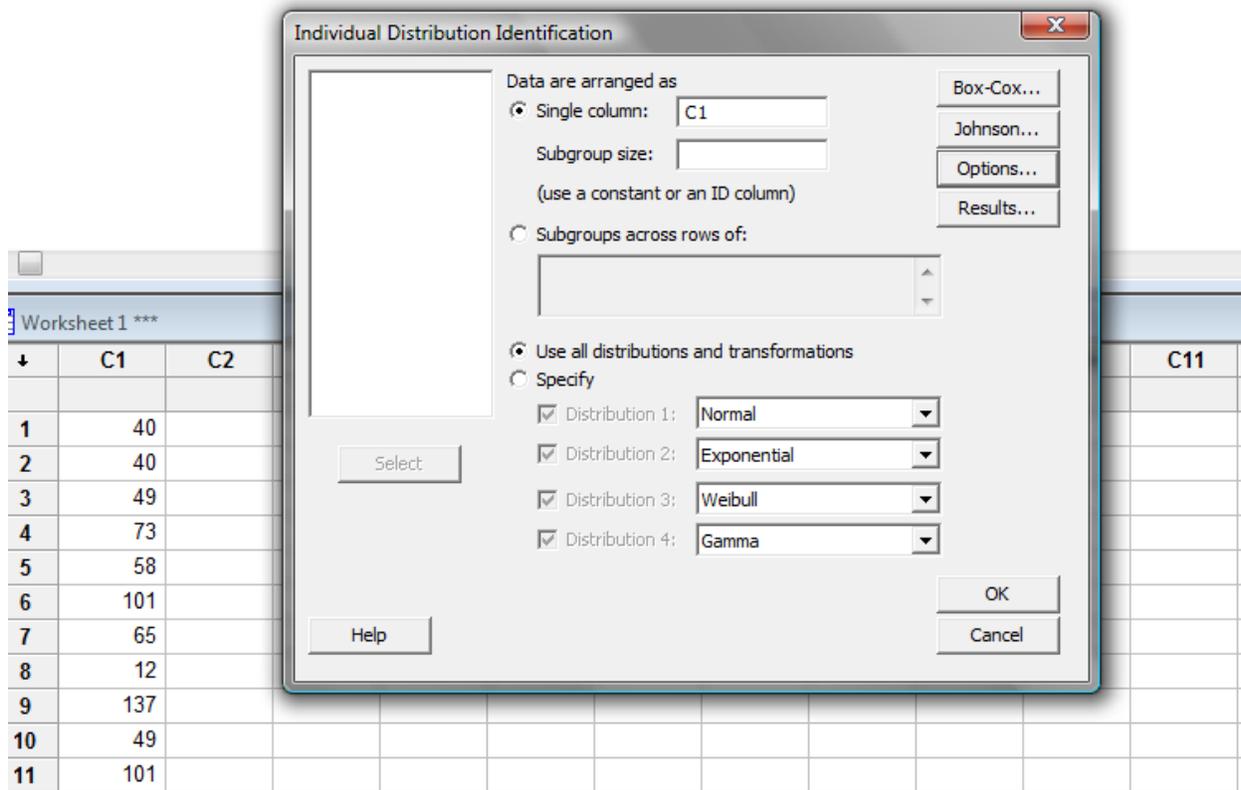


FIGURE 2

	Data Count	Average	Std. Dev	25%	Median	75%	MAX	MIN	Total
Biochemic Remedies according to Dr. Schuessler									
No. 1 Calcium fluoratum 12X	51	79	48	45	68	101	251	12	4,052

FIGURE 3

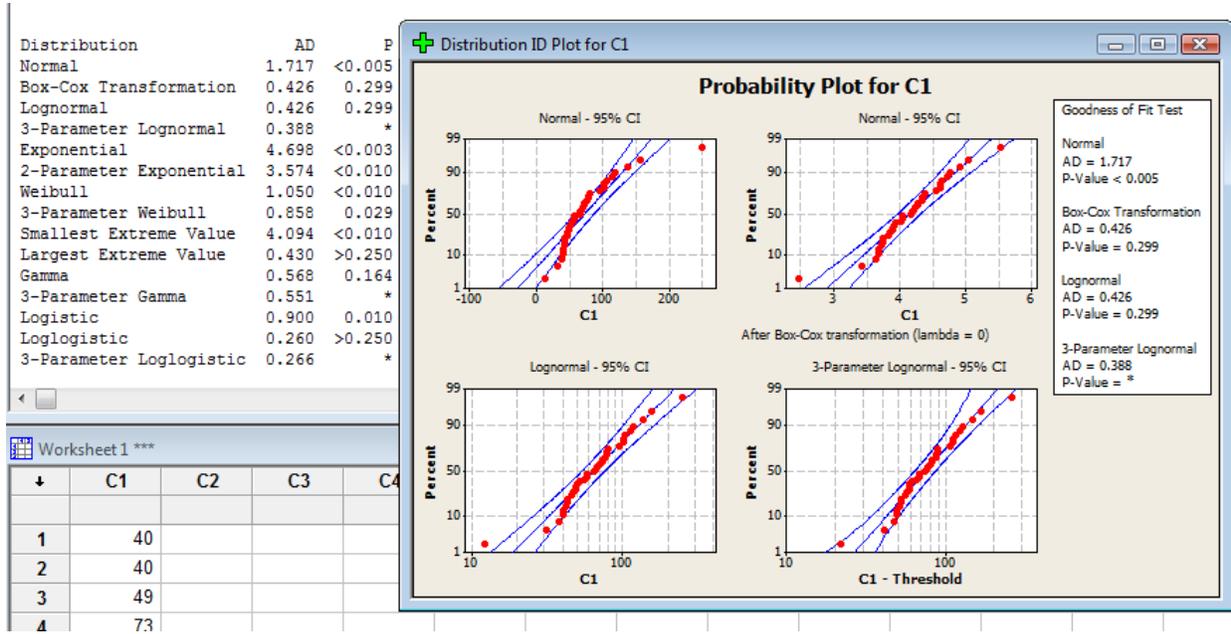


FIGURE 4

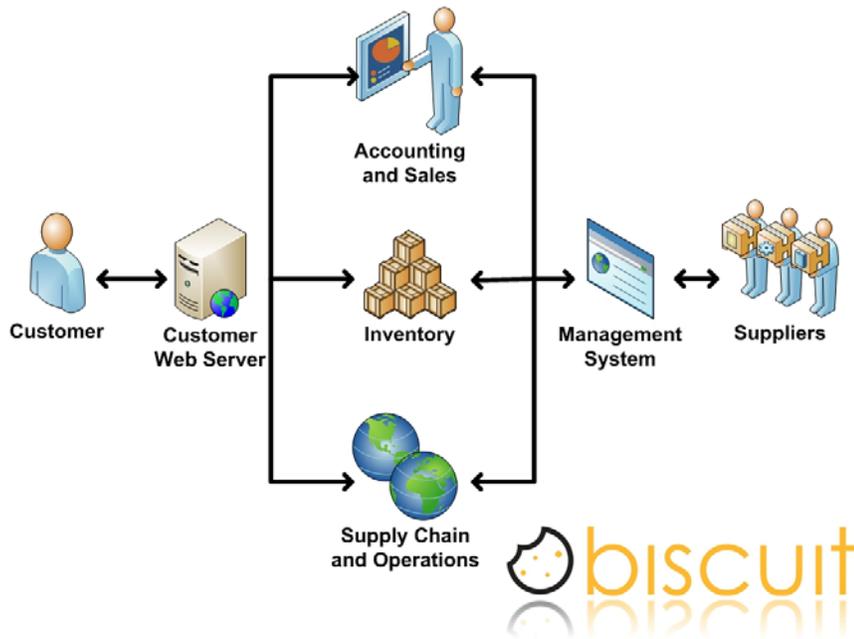


FIGURE 5

Table 1	01/06	02/06	03/06	01/07	02/07	03/07	01/08	02/08	03/08	04/06	05/06	06/06	04/07	05/07
No. 1 Calcium fluoratum	40	40	49	73	58	101	65	12	137	49	101	50	105	77
No. 2 Calcium phosphoricum	45	59	53	85	107	100	73	83	104	50	82	70	139	106
No. 3 Ferrum phosphoricum	47	29	39	36	76	36	98	93	92	59	38	54	53	43
No. 4 Kalium chloratum	61	44	0	130	125	87	122	54	74	116	84	102	138	99
No. 5 Kalium phosphoricum	32	66	63	48	52	72	82	40	63	51	71	65	53	78
No. 6 Kalium sulfuricum	43	28	33	33	46	36	32	39	76	29	39	55	30	39
No. 7 Magnesium phosphoricum	46	46	56	53	74	94	72	95	93	41	66	69	59	79
No. 8 Natrium chloratum	16	21	16	31	39	30	25	27	114	9	27	43	41	30

Table 2	Max Q1	Max Q2	Max Q3	Max Q4
	137	251	118	156
	107	139	148	119
	98	193	186	130
	130	181	98	120
	82	109	104	87
	76	86	50	52
	95	159	99	121
	114	97	105	52
	82	62	72	58
	47	55	51	68
	103	118	75	85
	55	58	44	45

Table 3	50%	25%	75%	50%	25%	75%
No. 1 Calcium fluoratum	58.00	40.00	73.00	68.00	50.00	101.00
No. 2 Calcium phosphoricum	83.00	59.00	100.00	95.00	70.00	116.00
No. 3 Ferrum phosphoricum	47.00	36.00	92.00	59.00	53.00	149.00
No. 4 Kalium chloratum	74.00	54.00	122.00	102.00	84.00	133.00
No. 5 Kalium phosphoricum	63.00	48.00	66.00	65.00	53.00	78.00
No. 6 Kalium sulfuricum	36.00	33.00	43.00	36.00	29.00	39.00
No. 7 Magnesium phosphoricum	72.00	53.00	93.00	66.00	55.00	79.00
No. 8 Natrium chloratum	27.00	21.00	31.00	32.00	27.00	43.00

Count	2000		No. 1 Calcium fluoratum		No. 2 Calcium phosphoricum				
	36.33358	51.42863	43.1008	111.7405	32.6487	101.012	50.3647	119.008	
0	72.54021	47.31508	87.337	72.04585	0	75.9945	109.237	47.093	84.3207
0.00050025	37.96772	94.4516	42.0145	110.6559	0	97.066	98.6814	67.5157	89.7217
0.0010005	66.41674	129.7586	42.0855	71.80701	0	99.0457	103.369	47.493	82.047
0.00150075	33.34643	44.6467	138	68.89626	0	110.766	62.8209	168	96.849
0.002001001	81.47523	46.34855	42.5011	80.10309	0	79.57	96.0412	168	126.355
0.002501251	79.26536	40.24067	42.9671	93.34025	0	118.459	109.949	60.9605	85.206
0.003001501	49.71369	107.0602	44.6675	62.53368	0	99.9616	66.3218	168	101.844
0.996498249	73.86762	52.44065	44.5017	84.31773	0	60.2913	129.886	56.5807	76.1426
0.996998499	36.48409	41.69825	42.1811	74.7473	0	127	104.459	168	139
0.997498749	30.5275	68.57138	41.9571	85.60424	0	16.5345	144.3	55.7179	108.878
0.997998999	59.20105	79.8379	41.937	70.86002	0	98.7372	98.6501	47.9367	65.7984
0.99849925	53.65784	70.50224	47.4992	126.2906	0	0	112.553	49.2688	77.6281
0.9989995	53.01798	84.86647	42.2588	66.12692	0	91.5671	113.21	46.49	139
0.99949975	73.9992	94.28539	41.9286	75.35017	0	107.336	93.8644	54.9507	64.0006
1	38.52313	169.2266	42.0843	70.8027	0	84.3036	77.516	168	99.3399
Expected Demand	55	83	60	88		76	91	81	99
St Dev. Of Demand	24	52	33	27		32	34	43	24

Table 5	Random Function				Conditional Factor			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	GENLNOM	GENLNOM	GENLNOM	GENLNOM	COND	COND	COND	COND
No. 1 Calcium fluoratum	36.33358	51.42863	43.1008	111.7405	36.3336	51.4286	43.1008	111.74
No. 2 Calcium phosphoricum	32.64872	101.012	50.3647	119.0082	32.6487	101.012	50.3647	119.008
No. 3 Ferrum phosphoricum	106.3697	222.708	42.1665	170.8509	106.37	213	42.1665	150
No. 4 Kalium chloratum	129.074	66.60124	57.847	73.59257	129.074	66.6012	57.847	73.5926
No. 5 Kalium phosphoricum	52.01345	84.48598	39.5739	81.52051	52.0135	84.486	39.5739	81.5205
No. 6 Kalium sulfuricum	37.67205	28.63462	30.5238	46.4596	37.672	28.6346	30.5238	46.4596
No. 7 Magnesium phosphoricum	42.49327	100.3963	58.1083	71.23459	42.4933	100.396	58.1083	71.2346
No. 8 Natrium chloratum	25.06561	42.52247	23.4188	9.63089	25.0656	42.5225	23.4188	9.63089

Table 7									
	Total Q1	Total Q2	Total Q3	Total Q4					
	556.364	806.286	506.5	862.289					
	1881.94	2328.22	2013.77	1821.2					
	1996.46	2082.3	1687.85	2004.06					
	2242.28	2445.94	1607.29	2201.51					
	1799.7	1889.51	2227.84	2413.22					
	1801.07	2143.78	1771.51	2477.08					
	2126.53	1798.44	1600.62	2435.84					
	2237.18	2324.15	2208.82	2402.34					
	2269.39	2374.44	1507.51	1928.19					
	1726.77	2515.41	1794.56	2211.65					
	1486.08	2566.54	1603.88	2167.49					
	1862.26	2259.93	1560.68	2284.05					
	1535.5	2538.33	1830.21	2150.22					
	1545.13	2778.82	2192.02	2245.05					
	1965.66	1935.7	1572.48	2324.35					
	1620.83	2356.67	2438.45	2364.4					
STDev	243	318	279	233	25%	1651	2007	1559	2013
Average	1816	2245	1773	2178	75%	1975	2446	1954	2329

Table 8				
	Total Q1	Total Q2	Total Q3	Total Q4
	10011.90	12386.1	9309.81	9688.78
	10621.2	11077.9	8979.37	10661.6
	11928.9	12924.4	8420.67	11712
	9574.39	9918.6	10020.5	12838.3
	8709.75	12024	10373.4	11865.3
	12073.2	12521.5	7983.77	10258
	9186.4	13074.2	8733.91	11766
	7905.93	13485.3	8367.05	11531.1
	9907.25	11814.1	8200.59	12151.1
	8168.88	13503.9	8647.74	11439.2
	8220.09	13971.2	10134.7	11869.9
	10457.31	10297.9	8136.84	12365.5
	8622.84	11863.8	10864.1	12578.6
E(Profit)	9658.5	11683.2	8747.6	11574.2

TABLE 10

	Q1	Q2	Q3	Q4	Total	Profit
No. 1 Calcium fluoratum	193	262	153	259	867	15660.77
No. 2 Calcium phosphoricum	279	333	196	319	1127	20343.06
No. 3 Ferrum phosphoricum	174	292	186	242	893	16133.24
No. 4 Kalium chloratum	271	371	215	278	1134	20475.7
No. 5 Kalium phosphoricum	195	224	183	232	833	15046.68
No. 6 Kalium sulfuricum	114	115	101	135	465	8392.038
No. 7 Magnesium phosphoricum	242	224	195	210	871	15736.94
No. 8 Natrium chloratum	86	116	128	128	458	8270.973
No. 9 Natrium phosphoricum	102	115	96	132	445	8042.734
No. 10 Natrium sulfuricum	109	118	128	125	480	8662.709
No. 11 Silicea	124	175	135	154	588	10615.44
No. 12 Calcium sulfuricum	93	117	84	95	388	7010.475
Total	1980	2460	1800	2310	8550	154390.8
Profits	35754	44421	32503	41713		

TABLE 11

Fields	Description
Pharmacy ID	Each pharmacy will be provided a special ID by UltraMed for ease of identification. The codes will only be given to pharmacies that have an established contract with UltraMed.
Product Quantity	All the products will be listed with an empty field next to each product to designate quantity needed. This operation will maintain consistency as the format of the tables will be universal throughout the worksheet, and modification of the information can be easily completed.
Delivery Method	UltraMed provides two delivery methods, Express and Standard. The standard method is free of charge; whereas express delivery will be charged and will be added to the invoice.