

# **The development of a Demand Planning System for a medium sized pipe producer.**

by

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## **1. Introduction**

This project is undertaken as part of an effort to develop an Advanced Planning System (APS) - in generally available software - for a medium sized pipe producer. One of the project's focus areas is determining whether it is possible to develop the demand planning module, which is similar to a sales forecasting system, of an Advanced Planning System (APS) in generally available spreadsheet software.

One is of the opinion that there is a need in the South African manufacturing industry for a "no cost" sales forecasting system. After conversations with individuals responsible for demand planning in businesses within this industry, it is clear that judgemental forecasting is the only method they use to estimate future demand. Proctor and Gamble (P&G), Wacker Neuson South Africa and the pipe producer, whose sales data is used in this project, serve as three examples. The lack of knowledge about quantitative forecasting methods and the cost of sales forecasting systems were given as reasons for not using quantitative forecasting methods.

Therefore an opportunity exists for a "no cost" sales forecast system that uses simple quantitative forecasting methods. Generally available spreadsheet software offers enough functionality to develop a sales forecasting system that meets these needs.

A pipe producer supplies clients in the agricultural, civil, construction, industrial and petrochemical industries, primarily in South Africa, but also in Africa, Europe, Australia and the Indian Ocean Islands. A wide product range of excellent quality and good service are the pipe producer's core competencies.

During the past 2 years the pipe producer's sales have been very volatile, because of the difficult economic conditions that started in the middle of 2008 in South Africa. Since September 2008 Interest rates have been decreased 8 times to try and stimulate spending in the South African economy. The South African government has launched a variety of infrastructure expansion projects to boost spending.

The pipe producer has Make-To-Stock (MTS) and Make-To-Order (MTO) products. The MTS products' demand tends to be more constant compared to the MTO products (Soman, van Donk, & Gaalman, 2004). Pipes are normally sold by the central Warehouse or by one of nine

Warehouses to merchants. For civil projects pipes are sold to contractors from the central Warehouse.

Previously the pipe producer did not have a formal procedure for demand planning, determining the levels of safety stock or order policies. Currently demand planning is done on a monthly basis in an informal manner. Thus, for example, a person responsible for pipe extruders or part moulders will make an estimate of a month's demand and will adjust his or her estimate as the month progresses – the process is not inclusive. An effort should be made to take into account the different views of all departments who are influenced by the demand planning outcome. High stock levels of some Product Items and stock-out situations of others can be viewed as the consequence of inadequate demand planning.

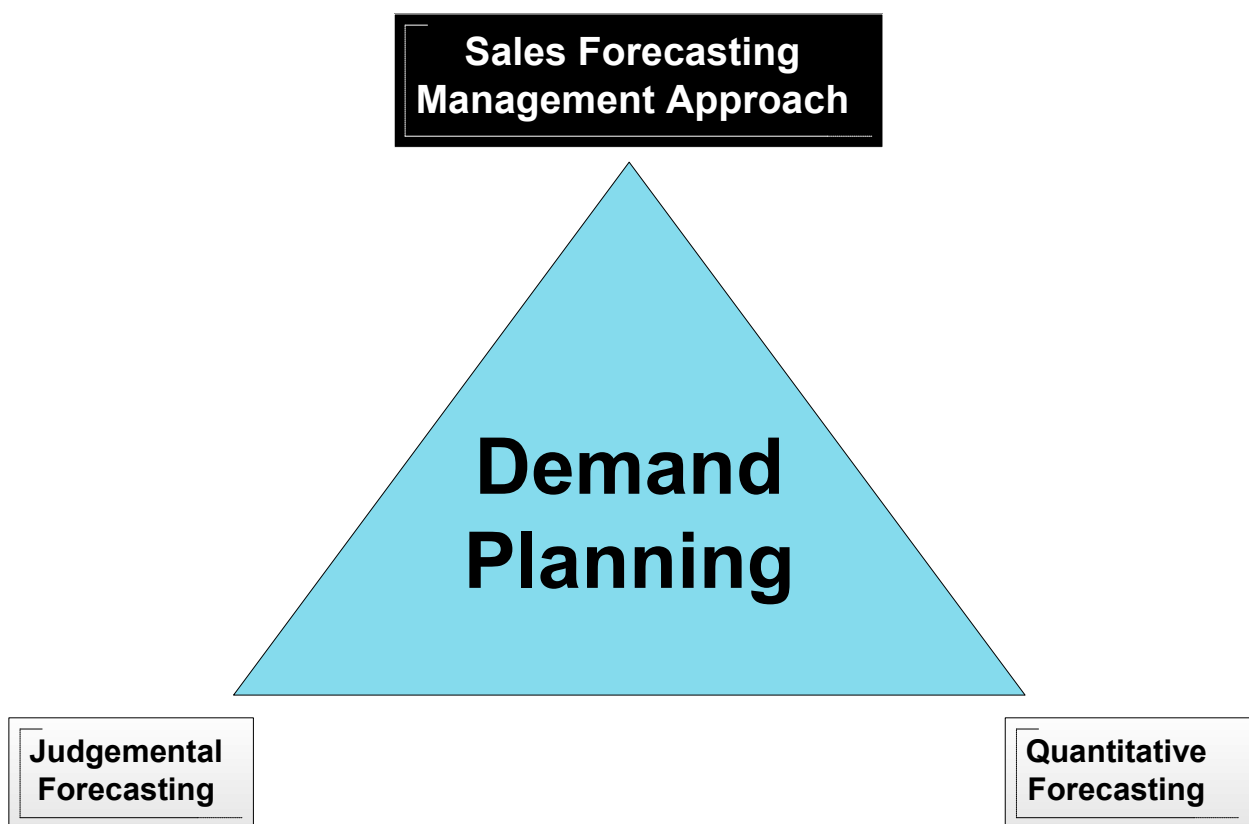
The pipe producer has a need for a Demand Planning System that will guide it in terms of the stocking policies, production capacity and financial decisions it makes.

## 2. Project Objective

The goal of the project is to develop a Demand Planning System, which includes a Sales Forecasting System in generally available spreadsheet software, for the pipe producer.

The project will arrive at its objective through the use of a sales forecasting managerial approach that integrates quantitative and judgemental forecasting methods to form a holistic demand planning solution.

Figure 1: The project objective is represented by this figure.



### **3. Project Scope**

The Demand Planning System will consist of two parts. The first will be a conceptual design of a forecasting managerial approach that will be used to manage the sales forecasting business function as part of the Demand Planning System. The second part will be a Sales Forecasting System developed in generally available spreadsheet software, which should strive to provide the same functionality that is available in most Demand Planning modules of APS.

The Demand Planning System should take into account all the pipe producer's sales channels, with a view to determine the expected demand the pipe producer should prepare for.

Demand planning will form the basis and starting point of the pipe producer's planning activities. Therefore it is of essential importance to develop a complete demand planning solution; which means that the Demand Planning System should contain both quantitative- and judgemental forecasting methods for demand planning. It is this priority, a complete demand planning solution, which fixed the project objective solely on the development of the demand planning APS module.

## **4. Literature Review**

Humanity has always had a fascination with the idea of being able to predict the future: fortune tellers, horoscopes, sangomas, time machines – demand planning is no exception to this dream. The business world can be viewed as a power boat race where businesses are steering their boats facing backward down a river with an endless amount of varying bends. Business data can be thought of as the bends of the river in the backward view that businesses have with regard to planning for future demand. The question is how to anticipate the upcoming river bends and how to do this better than one's competitors.

This chapter investigates some of the methods used by businesses to predict future demand for their product or service.

The following serves to clarify the difference between demand planning and demand management:

Demand planning can be described as the business process of deciding on the expected demand for a business' products during a set period (Wagner, 2005). Demand management is the actions a business takes to satisfy actual demand and/or decrease demand to fall within the business' supply capabilities during the planned period (Coyle, Edward, & Langley, 2003).

### ***4.1. Sales forecasting management approaches***

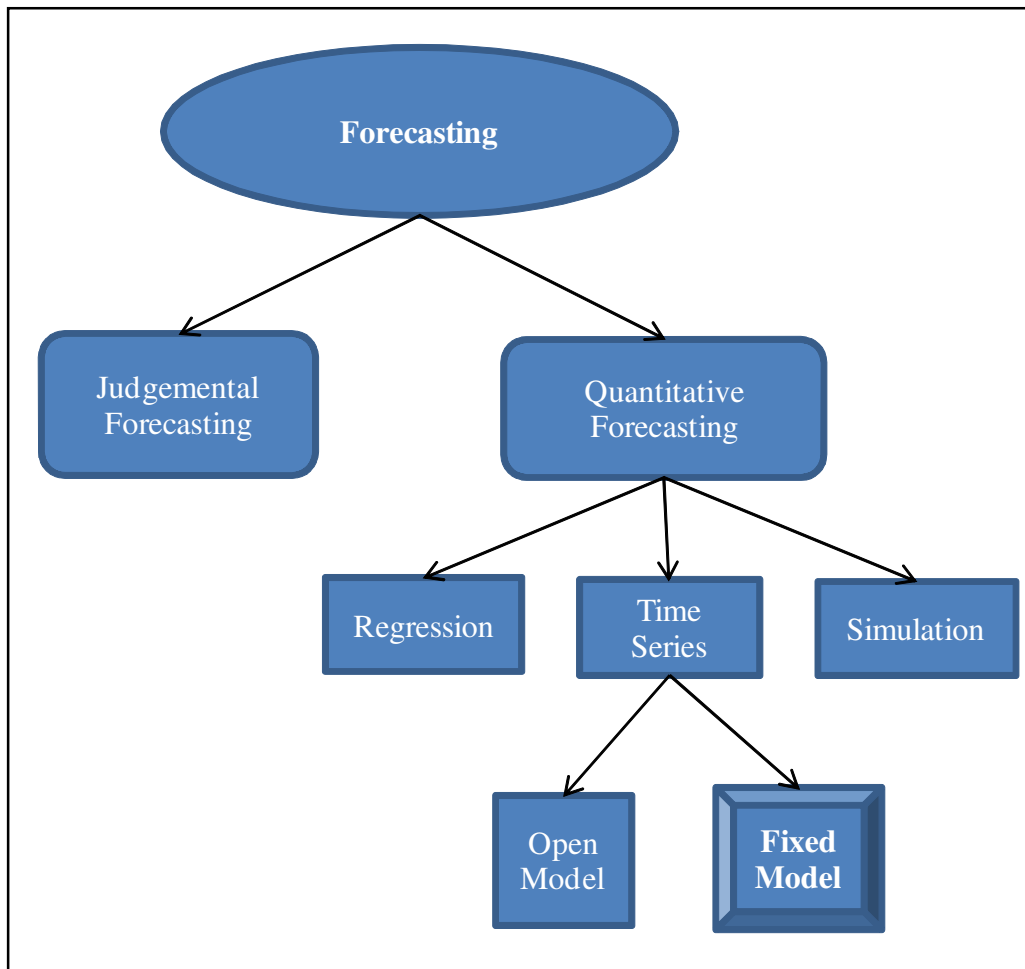
The point is made by Mentzer and Moon (2005) that it is important to first determine the management process used in a business, before attempting to develop a systems solution for that business. Examples of sales forecasting management approaches are: the lone ranger approach, the focused approach, the negotiated approach and the consensus approach. With the lone ranger approach forecasts will be done by each department on their own. In the focused approach forecasting is done by a designated department, e.g. marketing or logistics. In the negotiated approach forecasts are first developed by each department and then these departments sit around the negotiation table trying to persuade each other through internal political pressure and/or well founded or unfounded arguments why the business forecast should look the same as the one their department developed. The problem with these approaches is apparent: they do not strive for the integration of input from different functional departments that will, in the end, all be influenced by the business' sales forecasts.

Consensus forecasting has been put forward as a solution to address the lack of functional integration in the sales forecasting management approach. Consensus forecasting uses collaboration, communication and coordination to derive forecasts (Mentzer & Moon, 2005). Consensus forecasting supports the idea of making use of both quantitative and judgemental (qualitative or subjective) forecasting methods and delegating the demand planning responsibility to all the different functions within a business. A consensus committee should be established that consists of representatives from each functional department within a business. A member or members of this committee should be responsible for developing forecasts, after taking into account all the inputs from the consensus committee. The developed aggregated- and disaggregated forecasts should be compared, synchronised and approved by the consensus committee. To prevent internal political pressure from influencing forecasts and causing the forecasts to have a bias towards one functional department, these consensus meetings should be attended by the “right players” from each functional department (Blanchard, 2007). Consensus meetings are an essential part of ensuring that compromises are reached on competing interests within a business. The top management of a business will want the expected sales numbers to be in line with the strategic growth plans of the business. It is a well known fact that there are definitive trade-offs between different business functions, e.g. marketing wants a larger safety stock to ensure no stock-outs (improved customer service), while warehousing will want as little as possible inventory to reduce holding costs (Marien, 1999).

The consensus forecasting approach is expensive, because of the time it takes from key employees. A calculation should be done to determine whether more accurate forecasts will generate higher returns compared to the cost of having a consensus committee who delivers input to develop forecasts.

Buy-in, a sense of responsibility, from each business function should be the ultimate outcome of consensus forecasting. Demand is, after all, what drives a business.

**Figure 2: The aspects of forecasting that the literature review touches on.**



#### **4.2. *Judgemental forecasting***

The advantages of judgemental forecasting methods include the fact that the opinions of experienced individuals are used that has a global view of business circumstances and little data is required. Disadvantages include the fact that it takes a large amount of valuable employee time, making it costly; forecasts are only done on an aggregated level and over a long period judgemental forecasts prove to be more inaccurate than quantitative forecasting methods (Mentzer & Moon, 2005).

Some examples of judgemental forecasting methods include (Jacobs, Chase, & Aquilano, 2009):

- Historical analogy. This method is used when new products are made available to a market. Because no historical sales data exists for the new product one should try and look at the sales data of substitutable, competing and complimentary products to get an

idea of what demand can be expected for the new product. For example, if one is going to release a new brand of coffee flavoured peanut butter one can look at the historical sales of peanut butter, coffee and bread to get an idea of the expected demand for the product.

- Grass roots forecasting. The motive for this technique is that those employees whose job it is to sell a product or service will have the best potential to anticipate future demand for a product or service.
- Market research. By using market research firms, businesses can directly obtain the opinions of potential and existing customers about the needs they have for a specific type of product. From these surveys a business will be able to get an idea of the demand it can expect for a product.
- The Delphi method. This method is novel in the sense that it prevents members of a business from using direct internal political pressure to influence the outcome of judgemental forecasts. The person in a business responsible for this forecast will compile a set of questions that an identified group of employees will complete. Each participating employee's opinion will carry the same weight. The results of the first survey will be summarised and a new set of questions will be distributed to the participating employees, together with the summary of the previous round. This process will repeat itself until the forecasting range is narrow enough.

Quantitative forecasting methods can't foresee turning points in the economy. By being aware of leading economic indicators, individuals involved in judgemental forecasting may be able to accurately predict turning points in their industry. The reasoning behind leading indicators is that some industries will start to expand or contract quicker than others, therefore leading economic indicators can be seen as a type of early warning system for cyclical- and structural economic turning points (Granger, 1980).

### **4.3.      *Quantitative forecasting***

In 2005 there were already more than 70 different quantitative forecasting methods (Mentzer & Moon, 2005). Quantitative forecasting can be represented by 3 groupings: time series methods, regression (correlation) methods and simulation forecasting. One of the components of the project objective is to develop a demand planning module in generally available software.

Because of the large amount of exogenous data (data on promotions, price changes, economic measures and competitive actions) needed and the difficulty in developing regression methods and simulation forecasting in generally available software, these methods will not be reviewed here.

Time series methods can be sub-divided into Open-Model Time Series- (OMTS) and Fixed Model Time Series (FMTS) methods. OMTS methods are more sophisticated compared to FMTS methods. The main difference between the two is that OMTS methods evaluate data to determine which patterns (level, trend, seasonality and noise) exist in the data and then constructs a suitable forecasting equation, while FMTS methods use equations that assume the data has specific patterns.

*Examples of OMTS forecasting methods include:*

- Decomposition analysis aims to decompose a time series into subcomponents of trend, seasonality, cyclical and randomness. Each of these subcomponents is analysed, projected into the future and then combined as a forecast of the initial time series (Shiskin, 1961).
- Spectral analysis (Nelson, 1973), Fourier analysis (Bloomfield, 1976) and harmonic analysis all strive to decompose times series into a range of sine waves with different frequencies, phase angles and amplitudes. Although each of the different analysis methods has their own characteristic features, the aim is to identify periodicity in a time series.
- The Box-Jenkins methodology is a method for applying Auto-Regressive Integrated Moving Average (ARIMA) models. The ARIMA models have existed since the 1930s, but G.E. Box and G.M. Jenkins published a book about these models and their application in 1970. ARIMA is an umbrella term that describes a wide range of OMTS forecasting methods. Auto-regression aims to develop a function for a time series and then use this function to generate forecasted values based on the previous values of the time series. Integration refers to the summation of the elements into which the time series has been broken up to form a forecast. Moving average refers to an error term that influences a forecast (Makridakis, Wheelwright, & McGee, 1983).

An advantage of OMTS methods are that they are more accurate compared to FMTS methods when a small number of forecasts need to be made. Disadvantages include: long periods of training are required for employees to understand and use OMTS methods, OMTS methods require a large amount of analysis time, a large amount of sales data is required (normally more than 48 periods) and OMTS methods offer less accuracy over long periods when compared to FMTS and Judgemental methods (Mentzer & Kahn, 1995). Because of the difficulties involved with OMTS techniques, their use in industry has been limited (Mentzer & Cox, 1984).

Only 48 periods of sales data have been made available for the development of the Sales Forecasting System. One of the requirements that was agreed on for the Sales Forecasting System was that it should use simple, yet effective, quantitative sales forecasting methods. OMTS methods do not fit this requirement. Based on these and the other disadvantages listed above; one has decided not to use OMTS in the Sales Forecasting System.

Examples of FMTS forecasting methods include:

- Forecasting with Moving Averages. The formula for Moving Average forecasts is as follows (Mentzer & Moon, 2005):

$$F_{t+1} = (A_t + A_{t-1} + A_{t-2} + \dots + A_{t-N+1})/N \quad [1]$$

where  $F_{t+1}$  is the forecast for period  $t + 1$ ,  $A_t$  is the sales for period  $t$  and  $N$  is the number of periods in the moving average.

Instead of forecasting with an average of all the historical sales numbers, a Moving Average is preferred. This is because the more sales periods one uses to calculate an average, the less responsive the forecast will be for cyclical and seasonal changes in true sales numbers. Therefore, if one uses a small number of sales periods for a Moving Average (e.g.  $N = 3$  sales periods), the forecast will be more responsive to sudden changes in sales patterns. A Moving Average forecasting method will always lag behind seasonal changes and changes in trend. The Moving Average forecasting methods are suitable for sales that show only level and randomness (Jacobs, Chase, & Aquilano, 2009).

- Exponential Smoothing is frequently used in inventory control models where there are a large variety of items and where the low cost of forecasting is a priority. The Exponential Smoothing formula is as follows (Brown & Meyer, 1961):

$$F_{t+1} = \alpha A_t + (1 - \alpha)F_t ; 0 < \alpha < 1 \quad [2]$$

An advantage of Exponential Smoothing above Moving Averages is that one can give varying weights to the most recent period's sales and the previous forecasted value by changing the value of  $\alpha$ . However, the previous forecasted value is compiled from all previous forecasts. This is evident when one looks at how the term  $F_t$  extends:

$$F_t = \alpha A_{t-1} + (1 - \alpha)\alpha A_{t-2} + (1 - \alpha)^2 \alpha A_{t-3} + \dots + (1 - \alpha)^n \alpha A_{t-(n+1)} \quad [3]$$

(Makridakis, Wheelwright, & McGee, 1983). Where  $n$  is the total amount of periods that have been forecasted for. From the term  $A_{t-(n+1)}$  one can see that one should use initial demand as an estimate for initial forecast.

When the level of sales figures changes frequently, the  $\alpha$  value should be high. The  $\alpha$  value should be low when the sales figures show a large amount of randomness (Mentzer & Moon, 2005).

- Exponential Smoothing with Trend or Holt's Two Parameter Method (Holt's method) is used when historical sales figures show an upward or downward trend. The formulas that comprise Holt's method are as follows (Holt, Modigliani, Muth, & Simon, 1960):

$$L_t = \alpha A_t + (1 - \alpha)(L_{t-1} + T_{t-1}) ; 0 < \alpha < 1 \quad [4]$$

$$T_t = \beta(L_t - L_{t-1}) + (1 - \beta)T_{t-1} ; 0 < \beta < 1 \quad [5]$$

$$F_{t+m} = L_t + (T_t \times m) \quad [6]$$

where  $L_t$  is the level in period  $t$ ,  $T_t$  is the trend in period  $t$  and  $m$  is the period one is forecasting for.

To start a forecast with Holt's method, one should assume the initial level to be equal to the initial demand in period one and the trend to be equal to the difference between the first and second period demand.

- Exponential Smoothing with Trend and Seasonality or Winters' Three Parameter method (Winters' method) is used when sales figures show trend and a periodic upward or downward characteristic. This forecasting method requires at least one year's sales data.

The components that form part of Winters' method are formulated as follows (Winters, 1960):

$$L_t = \alpha(S_t/SA_{t-C}) + (1 - \alpha)(L_{t-1} + T_{t-1}) ; 0 < \alpha < 1 \quad [7]$$

$$T_t = \beta(L_t - L_{t-1}) + (1 - \beta)T_{t-1} ; 0 < \beta < 1 \quad [8]$$

$$SA_t = \gamma(S_t/L_t) + (1 - \gamma)(SA_{t-C}) ; 0 < \gamma < 1 \quad [9]$$

$$F_{t+m} = (L_t + (T_t \times m)) \times SA_{t-C+m} \quad [10]$$

where  $SA_t$  is the seasonal adjustment factor for period  $t$  and  $C$  is the cycle length of the seasonal pattern. For example, the value of  $C = 6$  is for a 6-month cycle length. The initial seasonal adjustment factor can be computed by estimating the average level of sales and then dividing the period with seasonality by the level. For example, if an average level of 500 sales per period is estimated and the period with seasonality shows sales of 450, one will set the initial seasonal adjustment factor equal to  $(450/500) 0.9$ .

- Adaptive Smoothing attempts to identify the most suitable value for  $\alpha$  (Trigg & Leach, 1967).

$$F_{t+1} = \alpha_t A_t + (1 - \alpha_t) F_t \quad [11]$$

$$\alpha_{t+2} = |(F_{t+1} - A_{t+1})/F_{t+1}| = |PE_{t+1}| \quad [12]$$

Therefore, the larger the percentage error for the forecast period  $t + 1$  ( $PE_{t+1}$ ), the more responsive the exponential smoothing method will be for period  $t + 2$ . The initial value of  $\alpha$  can be set equal to 0.1.

- Adaptive Exponential Smoothing with Trend and Seasonality attempts to find the best values for  $\alpha$ ,  $\beta$  and  $\gamma$  to forecast future sales. A variety of methods exist to determine the most suitable  $\alpha$ ,  $\beta$  and  $\gamma$  values (Mentzer & Moon, 2005). The simplest technique is called Adaptive Extended Exponential Smoothing (AEES) (Mentzer J. , 1988). With AEES an  $\alpha$  value is calculated in the same way as adaptive smoothing. A variety of  $\beta$  and  $\gamma$  combinations are then tested, starting from 0.05 and increasing by increments of 0.05 to 0.95. This means there will be  $(19^2)$  361 combinations. For each combination of  $\beta$  and  $\gamma$  an Exponential Smoothing forecast with Trend and Seasonality is done from the beginning of the historical sales data. The MAPE is recorded for each of these forecasts, after which the best combination of  $\beta$  and  $\gamma$  is selected. The final step is to find the optimal  $\beta$  and  $\gamma$  values through a heuristic that looks for the lowest MAPE value by

changing the  $\beta$  and  $\gamma$  values by 0.01 around the initially identified combination of  $\beta$  and  $\gamma$  values.

Advantages of FMTS forecasting methods include: it accommodates rapid changes in sales data, a large number of forecasts can easily be made because the methods are simple and a small amount of data is required (6 months or less). However, when a FMTS forecasting method is incorrectly used - e.g. a simple Moving Average method that assumes only level and noise is used to forecast sales of which the data contains seasonality – the FMTS will prove a very inaccurate method (Mentzer & Moon, 2005).

#### **4.3.1. An industry giant**

Wal-Mart is a leading industry example of how demand planning should be done. This company determines a sales profile for each of their sale-items in each of their more than 3000 stores. The system that is used to draw sales data for demand forecasting keeps a year's worth of sales data on 100 000 products (Jacobs, Chase, & Aquilano, 2009). This is a sign that Wal-Mart probably does not make use of OMTS- or regression analysis or simulation forecasting for individual products, because of the large amount of data that is required for these methods.

#### **4.3.2. Aggregated- and disaggregated forecasts**

In an investment sense, one can consider aggregated forecasts to be a diversified investment. The main argument in favour of aggregated forecasting is that an aggregated forecast's variance will be less compared to an aggregated forecast that has been compiled from a sum of disaggregated forecasts. This is because of the statistical fact that a compiled aggregated forecast's variance will be equal to the sum of variances of the disaggregated forecasts' variances (Dangerfield & Morris, 1992). It takes less time to forecast in an aggregated way and then disaggregate the forecast according to the proportion that each Product Item contributes to the aggregated sales. Views that oppose aggregated forecasting argue that by aggregating sales data valuable information is lost (Zellner, 1969). A variety of ways in which an aggregate forecasted demand can be disaggregated are given by Dangerfield and Morris (1992):

- The overall average item proportions are used to disaggregate an aggregated forecast.
- The item proportions of the previous period are used for disaggregation.

- The item proportions of the same period, as the current period, in the previous year are used for disaggregation.
- The overall average proportion that an item contributed to an aggregate forecast as well as the most recent contribution portion are used as inputs into an exponential smoothing forecast to obtain a new item contribution (Brown R. , 1962).
- The year-to-date item contributions are used to disaggregate a forecast (Hausman & Sides, 1973).

Empirical proof in specific case studies that are favour of disaggregated forecasting methods include: forecasting demand for telephones with Exponential Smoothing methods (Dunn, Williams, & Spiney, 1971), forecasting the growth of fish populations by also using Exponential Smoothing methods (Dangerfield & Morris, 1988) and using Econometric Models to forecast profit and sales (Collins, 1976).

The view is expressed that when data is disaggregated it is good practice to separate data into groups that can be forecasted with certainty and groups of data that contain inherent uncertainty (Makridakis, Wheelwright, & McGee, 1983). Separating products that are in the matured stage of their life cycle from products that are still in the growth stage of their life cycle is an example of the above.

#### **4.3.3. Issues to consider before forecasts are made**

Which products should be forecasted? It is suggested that one should take into account the degree to which a product has an influence on supply chain costs, customer satisfaction and revenue generation to answer this question (Mentzer & Moon, 2005). Questions that should be asked before deciding to do forecasts for a specific product include:

- Is the product a MTS or a MTO product?
- What is the holding cost of a unit of the product?
- What is the logistics cost involved in reshipping the product to another destination?
- Do our competitors also supply the product and are there substitutes for this product?
- Does the product have a high profit margin compared to our other products?
- How many units per forecasting period, compared to our other products, do we sell of this product?

Because it takes a considerable amount of time to create forecasts, it will be a good idea to make it the priority of forecasters to first complete the forecasts of those products that make the largest contribution to a business' profit. The ABC Analysis is an effective method for prioritising product forecasts (Coyle, Edward, & Langley, 2003). A business can assign a weight according to the relative importance of a product's gross profit, sales revenue and sales volumes to their business. This can then be used to categorise the business' products into A, B and C categories. The products in the A category will be the products that account for 80% of the above weighted metrics, category B products will be those that contribute to 15% of the weighted metrics and category C products will account for the remaining 5%. After this has been done the business can decide on a strategy to manage the sales forecast and inventory of the different categories of products.

What is the probability that the data being forecasted contains errors? The following causes of errors in data that (Morgenstern, 1963) propose, may be applicable to the pipe producer's data:

- Typing errors in data capturing or in product bar-coding.
- A conscious misrepresentation of data to meet sales targets.
- Double capturing of sales.

Three other situations that could obscure true demand through sales figures are:

- Times where there are no sales of a specific product, because the product was out of stock.
- Times where certain products were sold at a lower price as part of a promotion.
- Only registering sales in the official sales register from temporary hand written sources a few weeks after the true sales occurred.

In light of the above, one should consider the merit of including an additional information field, "stock-out", in an ERP system. For example, a demand by customer for a stocked out product should be captured. The goal of sales forecasting is not to forecast sales, because production, logistics and Warehouse storage capacity influences sales. The purpose of sales forecasts is to forecast customer demand.

Adjustment possibilities to raw data before undertaking forecasts (Makridakis, Wheelwright, & McGee, 1983) include:

- Using the Moving Average forecasting method as an estimate for missing data values or for periods where there were no sales of a product, because of a stock-out.
- Sales data of business periods can be adjusted to ensure that the forecasted figures are not overly influenced by business periods that have more business days.
- Sales data expressed in terms of prices can be adjusted to eliminate the effect of price inflation. The continuing increase in product prices, price inflation, may cause an illusion that sales figures are increasing over time when they are actually constant.
- How does supply affect demand? Prices might have been increased during periods where supply was low. Periods where there were not an adequate supply of a demanded product should be identified and the demand of that period should be adjusted.

How should one determine which forecasting methods deliver the best results? The use of a variety of metrics is recommended to gauge the performance of a forecasting method (Mentzer & Moon, 2005):

- The Forecasting Error ( $E_t$ ):

$$E_t = F_t - A_t \quad [13]$$

Where  $F_t$  is the forecast for period  $t$  and  $A_t$  is the actual sales for period  $t$ .

A positive error means a forecast was too high.

- The Percentage Error ( $PE_t$ ):

$$PE_t = \frac{E_t}{A_t} \times 100\% \quad [14]$$

This metric gives a reflection of the relative size of the forecasting error.

- The Mean Absolute Error ( $MAE$ ):

$$MAE = \sum_t^n |E_t| / n \quad [15]$$

Where  $n$  is the total amount of periods that have been forecasted for.

The absolute value ensures that positive and negative forecasting errors do not eliminate each other which will cause the cumulative forecasting error to look smaller than it truly is.

- The Mean Absolute Percentage Error ( $MAPE$ ):

$$MAPE = \sum_t^n |PE_t| / n \quad [16]$$

The relative size of the mean percentage error is reflected by this metric.

- The Year To Date Mean Absolute Percentage Error (YTD MAPE):

$$YTD MAPE = \sum_t^{t-11} |PE_t| / 12 \quad [17]$$

If a large number of sales periods have already been forecasted, the true scale of recent forecasting errors might be elusive. When forecasts have been made for many time periods, the YTD MAPE should prevent the forecaster from overlooking large forecasting errors.

- The Sales Forecasting Technique Accuracy Benchmark (SFTAB) warns the forecaster when the forecasting method that is being used is performing worse than a naive forecast would. A naive forecast will be to expect the next sales period's sales to be the same as the current period's sales. The *MAPE* for this naive defined as  $MAPE_n$ . The *MAPE* for the forecasting method that one is currently evaluating is defined as  $MAPE_c$ .

$$SFTAB = \frac{MAPE_c}{MAPE_n} \quad [18]$$

If  $SFTAB \geq 1$  one should use another forecasting method or make naive forecasts.

Lastly, it is important to have a review mechanism in place for forecasted results to monitor if any non-random forecasting errors start to occur. The view taken here is that an individual and moving range control charts will be a good indicator of whether common- or special causes are responsible for forecasting errors.

#### 4.3.4. When will sales data be “unforecastable”?

There is a view that some products' sales numbers can be “unforecastable”. It is believed that a product's sales figures are “unforecastable” if the product's sales numbers has a Coefficient of Variation (COV) higher than 0.8. The COV is defined as (Milliken, 2006):

$$COV = \frac{Standard\ Deviation}{Average\ Period\ Demand} \quad [19]$$

#### **4.3.5. Spreadsheet forecasting**

As mentioned before, one of the aims of this project is to develop the demand planning module of an APS in generally available spreadsheet software. Therefore the view of Proctor (1989, p.354) reinforces support for the project's objective. Proctor feels that spreadsheet forecasting has benefits over statistical forecasting packages in that spreadsheet forecasting:

- Allows the forecaster greater flexibility to change the parameters of his/her forecasts to address a business' specific needs.
- Allows the forecaster to gain greater understanding of how the applied forecasting methods work.

#### **4.4. *The right balance between judgemental and quantitative forecasting***

Several studies have shown that it is not possible to identify a forecasting method that will always give the most accurate forecasts for all situations [ (Ascher, 1978); (McNees, 1979); (O'Carroll, 1977)]. The point that is emphasised is that a variety of methods should be used for forecasting; whereafter demand planning decisions should be made based on common sense (Jacobs, Chase, & Aquilano, 2009).

The view is expressed that one should rely more on quantitative forecasting methods for the majority of the time, while still taking into account judgemental forecasting methods. However, when external circumstances will have an influence on demand that quantitative methods will not be able to anticipate, one should allow judgemental forecasting methods to carry more weight in deciding on expected demand (Makridakis, Wheelwright, & McGee, 1983). Over the last year and a half South Africa has experienced the dampening economic effect of the global economic downturn and is still experiencing the excitement of new economic opportunities in the aftermath of the 2010 FIFA World Cup. These are examples of external factors that will have an effect on future demand, which quantitative forecasting methods will not be able to foresee.

#### **4.5. Conclusion**

Judgemental and quantitative forecasting methods are based on the assumption that history will to some extent repeat itself in the future. To remain true to oneself one should remember that the future is unpredictable. Therefore, when one hears the phrase “forecasts show that” one should think “based on history, analysts expect”.

In defence, forecasts have proven to be the most effective tool up to date to estimate future demand. Therefore judgemental and quantitative forecasting methods will be used in an effort to develop an effective Demand Planning System for the pipe producer.

## 5. Data Analysis

Sales data from the pipe producer's Baan ERP system has been made available. This data will be used to develop a Sales Forecasting System in generally available spreadsheet software. The data contains a large amount of detailed information: Product Item Number, Order Number, Receipt Document Line Number, Warehouse Number, Month Number, Customer Number, Product Group Number, Delivery Date, Order Quantity, Standard Cost Price per Sales Unit and the Net Order Amount.

The information contained in the sales data leaves one with a variety of possible forecast grouping options. Forecasting sales per: Product Item, Client, Product Group and Warehouse. A summary of some of the possible groupings in the sales data makes it easier to identify worthwhile sales forecast grouping options.

**Table 1: A summary of some of the possible sales forecasting entity groups and how they adhere to the Pareto rule.**

	2009/2010	2008/2009	2007/2008	2006/2007
<b>Warehouses</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>10</b>
Pareto Warehouses	4	5	5	5
% of warehouses	40%	50%	50%	50%
% of sales	82%	83%	82%	82%
<b>Product Groups</b>	<b>67</b>	<b>70</b>	<b>67</b>	<b>76</b>
Pareto Groups	8	9	8	8
% of groups	12%	13%	12%	11%
% of sales	80%	83%	81%	82%
<b>Clients</b>	<b>1769</b>	<b>1777</b>	<b>1776</b>	<b>1720</b>
Pareto Clients	382	370	380	347
% of clients	22%	21%	21%	20%
% of sales	80%	80%	80%	80%
<b>Items</b>	<b>1378</b>	<b>1475</b>	<b>1398</b>	<b>1364</b>
Pareto Items	55	57	55	47
% of items	4%	4%	4%	3%
% of sales	80%	80%	80%	80%

From the table it is clear that it will take a long time to forecast for each Client and for each Product Item. Forecasts for every Client and every Product Item will not be possible, because the sales for some of these are discontinuous and have a large amount of variation.

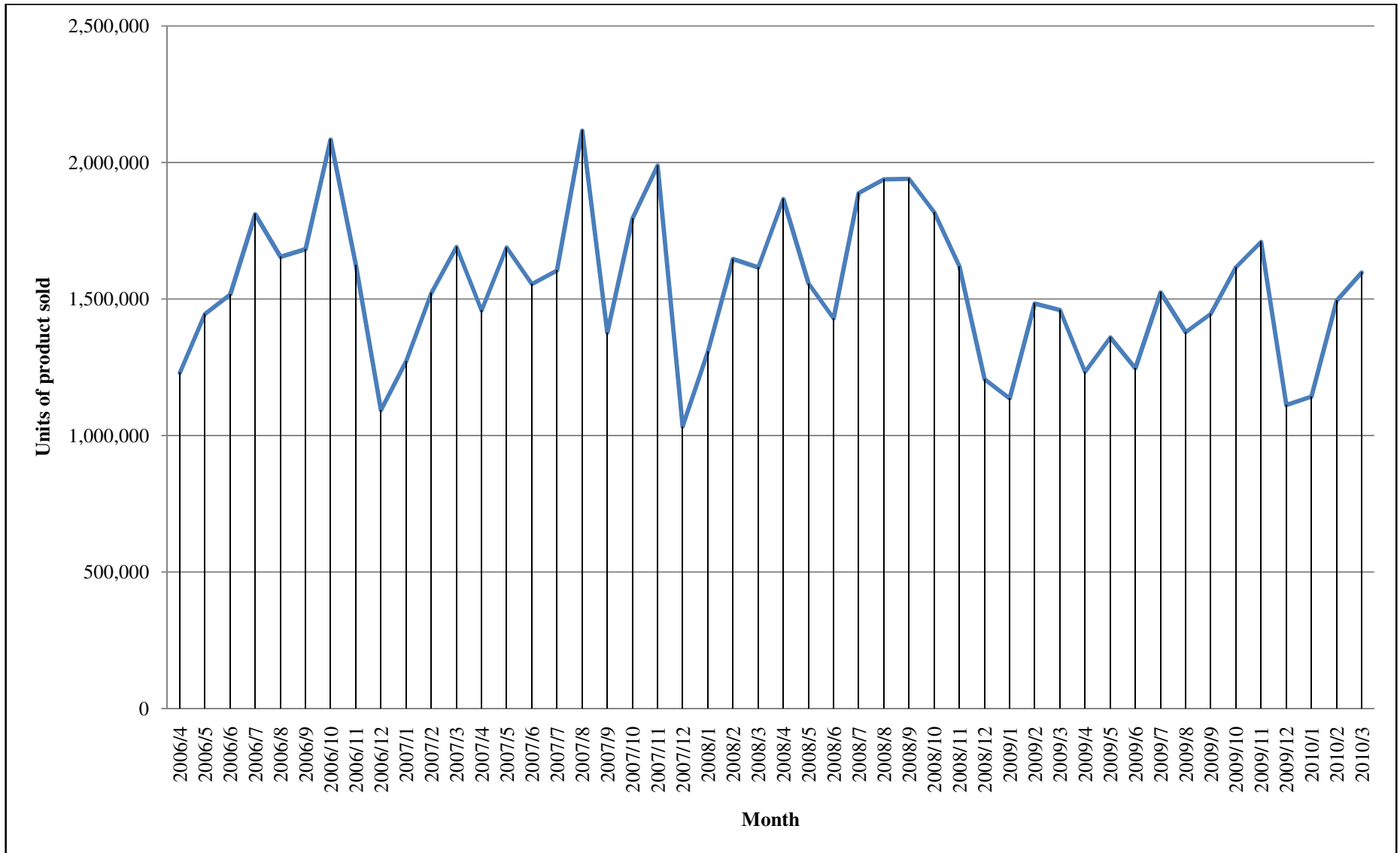
It will be wiser to do aggregated forecasts per Warehouse and Product Group. 76 forecasts, one for every Product Group, is still a large number of forecasts. According to the Pareto principle, one should be able to identify the 20% of Product Groups that are responsible for 80% of product sales. The Pareto principle is practised when one uses the ABC Analysis to categorise entities. By identifying those Product Groups that are worthwhile to forecast (as discussed in section 4.3.3) and by using the ABC Analysis, the true amount of forecasts needed should be considerably less when the execution of the conceptual design is started. If the disaggregated forecasts, derived from the aggregated forecasts, prove to be very inaccurate, a forecast per Product Item will be considered based on the relative importance of the Product Item to the pipe producer. From Table 1, one can see that during 2009/2010 40% of Warehouses were responsible for more than 82% of sales, about 12% of Product Groups were responsible for more than 80% of sales, about 22% of Clients were responsible for 80% of sales and only 4% of items were responsible for more than 80% of sales – it needs to be noted that sales are expressed as the number of items sold and not in Rand or monetary terms.

From the data summary it can be seen that the pipe producer has a relatively narrow customer base, compared to other businesses (for example a supermarket). If the pipe producer can form supply chain relationships with its major clients which are part of the 22% of the clients that are responsible for 80% of the pipe producer's sales, there exists an opportunity for Collaborative Planning, Forecasting and Replenishment (CPFR). Because of the CPFR opportunity that exists, forecasts will not be developed for the expected demand of the pipe producer's clients. The pipe producer's main clients will be in a better position to develop their own forecasts and inform the pipe producer of what future needs they expect to have.

CPFR is when supply chain partners agree to coordinate their business activities in order to realise the lowest landed cost for the supply chain's final customer. Supply chain partners will, for example, agree to share sales data and marketing plans with each other to increase the transparency of each partner's inventory levels and the orders that have been placed with the partner (Coyle, Edward, & Langley, 2003).

On the following pages, Figures 3, 4 and 5 give different perspectives with regard to the pipe producer's sales over the period from April 2006 to March 2010. All graphs and charts were drawn up based on the total number of Product Item sales and not the sales Rand of those items. Sales reflected in currency will be used to categorise Product Items into A, B and C categories according to the ABC Analysis.

**Figure 3: The number of units of all Product Items sold per month from April 2006 to March 2010 by the pipe producer.**



**Figure 4: The number of units of all Product Items sold per month by each Warehouse from April 2006 to March 2010.**

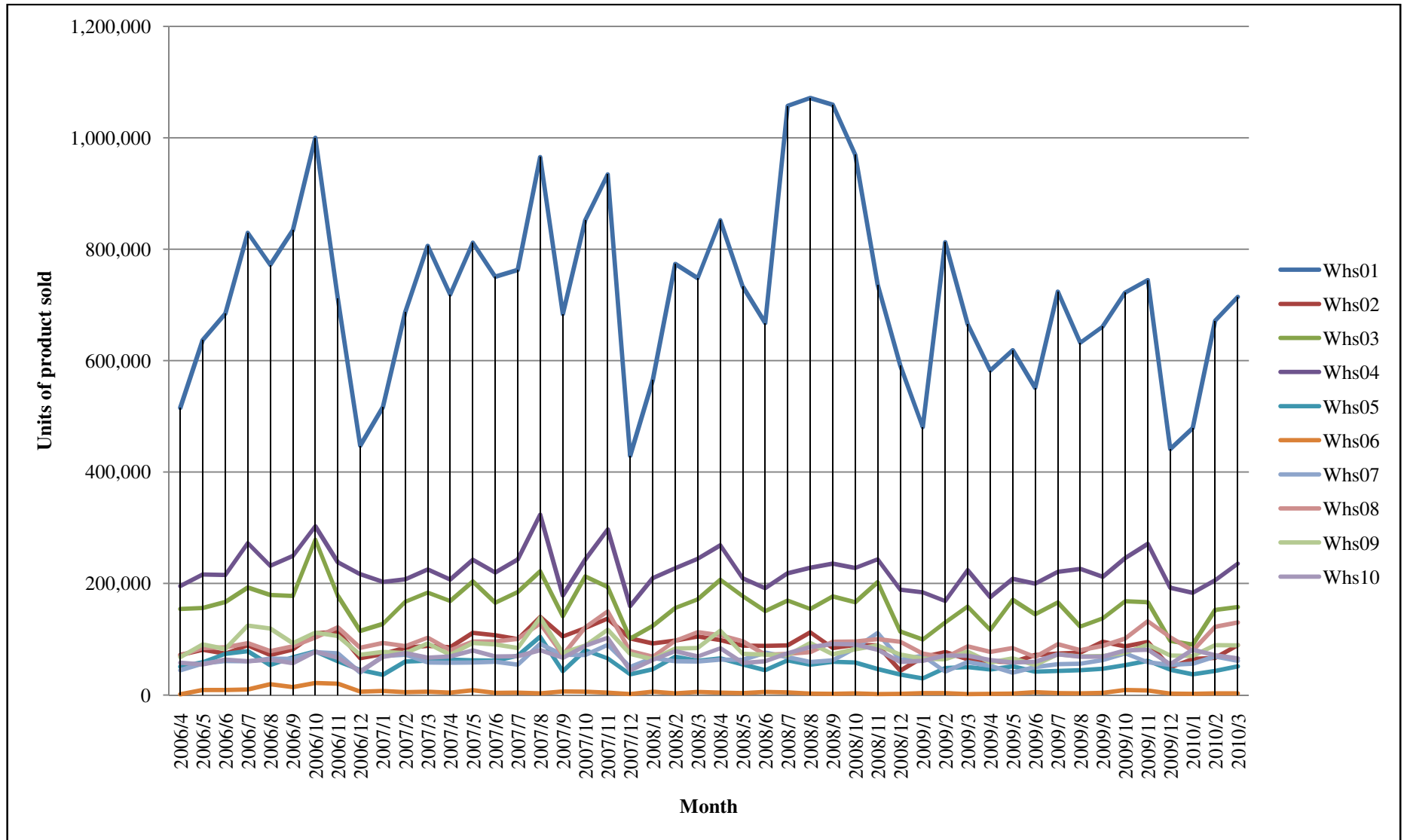
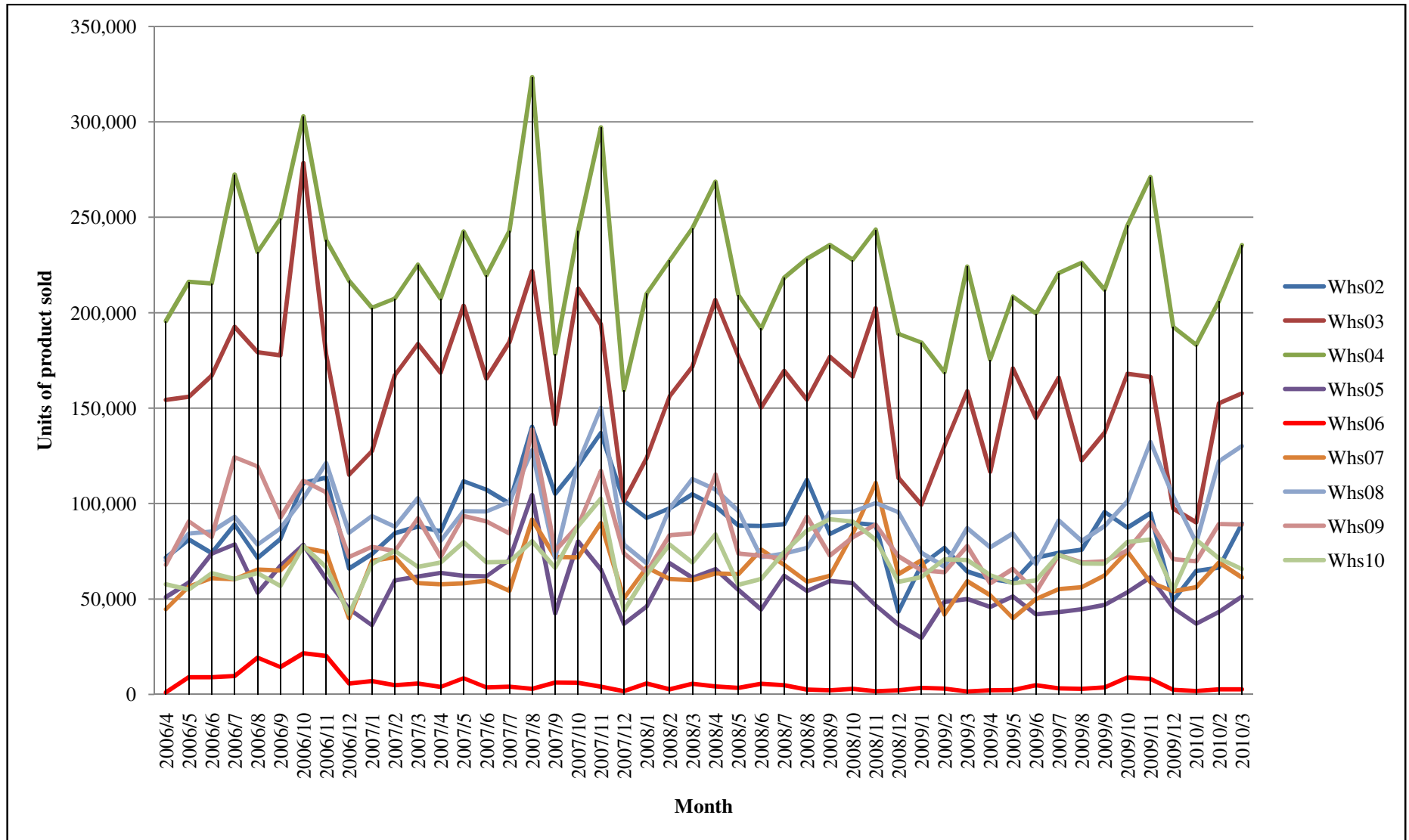


Figure 5: The number of units of all Product Items sold per month by each Warehouse, excluding Warehouse 1, from April 2006 to March 2010.



In Figure 3 the pipe producer's overall Product Item unit sales per month are given. The graph seems to show a slight downward trend, but one should keep in mind the difficult economic conditions of the past 2 years and the effect it had on sales. It is interesting to see how the sales numbers show a definite drop compared to the previous years, from September 2008 onwards. Level, noise and seasonality are prevalent in this graph:

- The graph stays within the ranges of 1 million to 2 million for the overall Product Item sales per month except for 2 months where sales are above 2 million Product Items (October 2006 and August 2007). Therefore the data has an average level between 1 million and 2 million.
- The data does contain some randomness in that the same months in different years do not have the same upward or downward tendency in the number of sales.
- Every year during December (2006, 2007, 2008 and 2009) the sales are lower compared to all other months.

The lines on the graph in Figure 4 represent the total number of Product Items sold per month by each Warehouse. One might be forgiven to think that the line which represents the sales of Warehouse 1 actually represents the total sales of the pipe producer. Warehouse 1 is the pipe producer's central Warehouse and Product Items are distributed from this Warehouse to the other Warehouses. The Product Items distributed from the central Warehouse to the other Warehouses do not count as sales; sales are recorded only once a customer purchases a Product Item from a Warehouse. It is interesting to see that Warehouses 4 and 3 and some of the other Warehouses have peak sales during the same periods as Warehouse 1 and that the majority of Warehouses also experience their lowest sales during December. The pipe producer's Warehouses are only open for business for 2 weeks during December, compared to the 4 weeks of business during every other month.

Figure 5 shows the total Product Item unit sales per month per Warehouse, excluding the central Warehouse. Out of a total of 48 months of sales data, Warehouse 10 has 14 months in which it did not sell any Product Items. Was this because of stock-outs, strikes by employees, a Warehouse expansion?

Most of the lines in the graph of Figure 5 also have the same characteristics as the graphs in Figures 3 and 4: level, noise and seasonality. It does not look like different Warehouses have different sales characteristics.

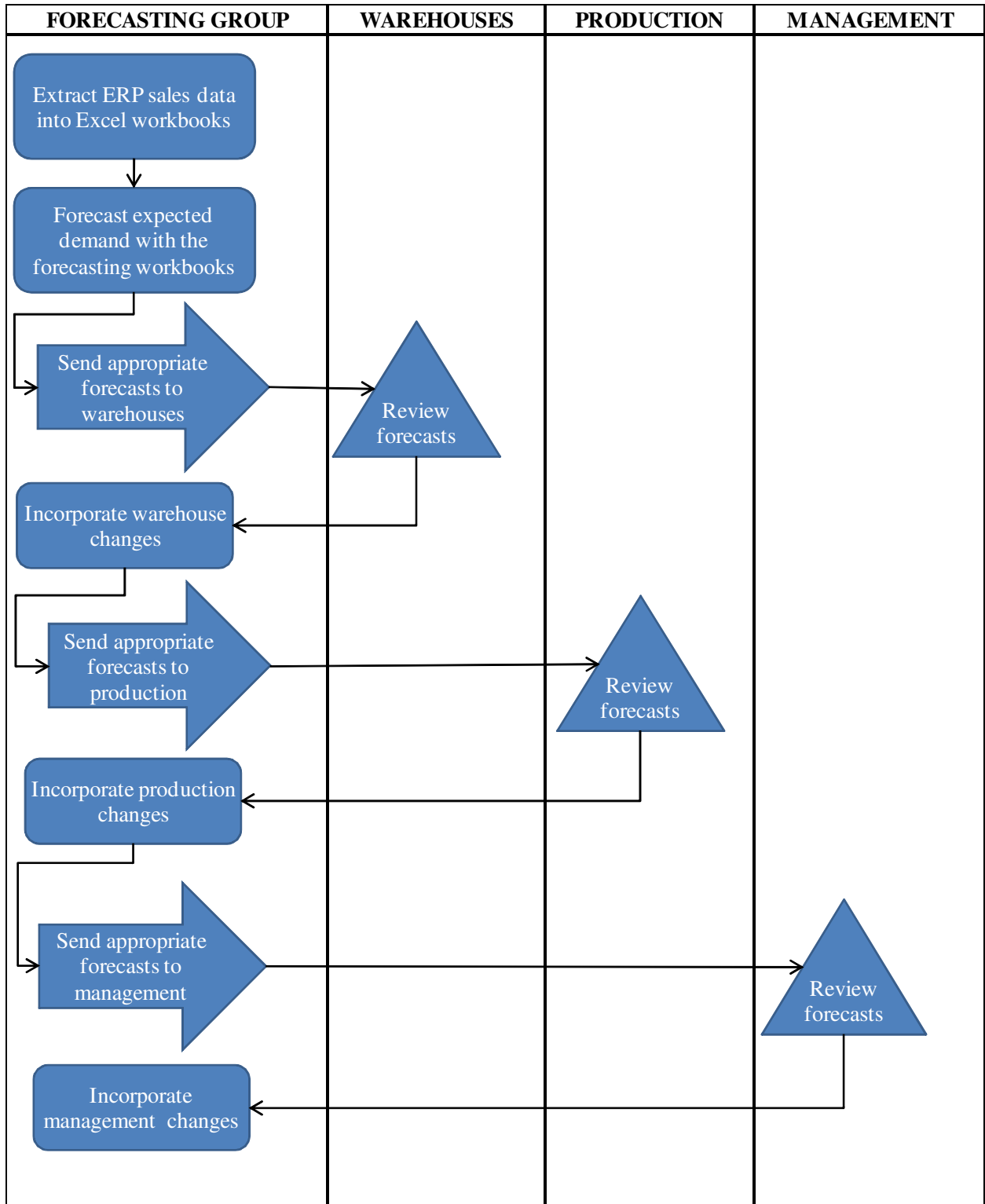
## **6. Development of the conceptual design of the Sales Forecasting Management Approach**

Figure 6 gives a reflection of the initial conceptual design that is recommended for the pipe producer's Sales Forecasting Managerial Approach. As the project's implementation progresses, more information and practical input from the pipe producer will probably lead to changes in this conceptual design. Thus, for example, additional columns may be included in the figure for logistics and finance. It should be noted that the term Warehouses in the figure can be interchanged with the word "Sales".

The conceptual design proposes that there should be a forecaster or forecasting group (external or internal to the pipe producer) that generates initial demand forecasts for the 10 Warehouses, the identified Product Groups and Product Items according to the ABC Analysis. The applicable demand forecasts will be sent to the sales managers of the 10 Warehouses. Through judgemental forecasting the sales managers will make motivated changes to demand forecasts. The changes will be incorporated by the forecasting group and these forecasts will be sent to the production managers. Supply and capacity constraints may be motivating factors for why production managers will recommend changes to the forecasts. After the production managers' recommendations have been incorporated into the forecasts, the forecasts will be sent to the pipe producer's upper management. When the upper management have taken into account the wishes of the sales managers at the Warehouses and the constraints the production managers face, they may still adjust the forecasts to be in line with the pipe producer's strategic growth plans. The upper management's changes will be incorporated into the forecasts. The forecasts will be sent to the individuals responsible for planning, who will incorporate the forecasts into their plans and communicate them according to the pipe producer's policy.

Figure 6 was adapted from Mentzer & Moon's book (Mentzer & Moon, 2005) to fit the organisational structure of the pipe producer.

**Figure 6: The conceptual design of the recommended Sales Forecasting Management Approach.**



## **7. Conceptual formulation of the Sales Forecasting System**

The purpose of the Sales Forecasting System will be to anticipate future demand to ensure that an improved inventory management policy and capacity planning procedure can be put into place.

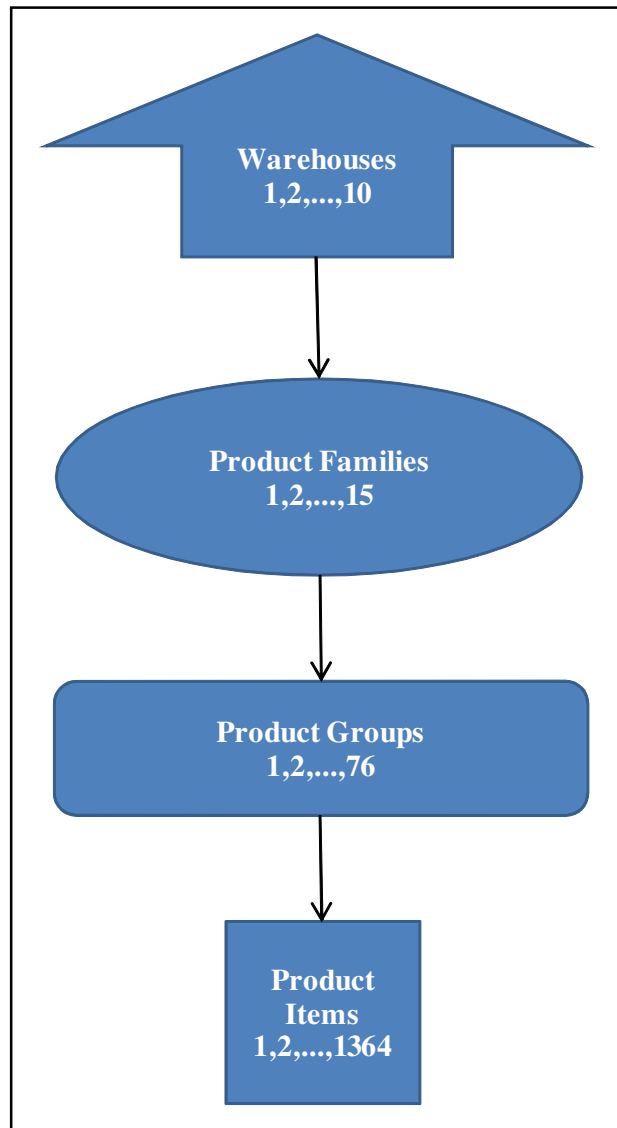
In the Sales Forecasting System, monthly time periods will be used to forecast the variable of interest, because the employees responsible for demand planning have always planned for demand on a monthly basis. This may be a factor which will determine how easily these employees will accept the overall Demand Planning System. Raw material and production lead time is also an important factor to consider when one decides on demand planning periods. Information on the lead time of inventory orders and product production was not available to the student.

The variable to be forecasted will be the sales quantity – price inflation does not have a direct impact on this variable.

As the project progressed one was made aware of another sales entity group – Product Families. Product Families will therefore be another sales forecasting entity group.

Figure 7 shows the Sales Forecasting System's different sales forecasting entity groups and defines the hierarchy of the sales forecasting entity groups discussed in this report.

**Figure 7: The pipe producer's hierarchy of sales forecasting entity groups.**



Quantitative forecasting methods

To answer the central question behind the Sales Forecasting System it is only necessary to develop forecasts for all the Product Items to determine how many units of each item have to be produced or purchased. But one should have a better chance of realising improved forecasts by doing direct Product Item forecasts and disaggregating other forecasts to a Product Item level.

Aggregated forecasts for each Warehouse's, Product Family's and Product Group's monthly demand will be generated. The sales data for the different Warehouses, Product Families and Product Groups will be tested to see if they are "forecastable" – the specific sales data's COV

should be smaller than 0.8 to use FMTS methods. If it is found that the process of forecasting for every Product Group is too time consuming, the ABC Analysis will be used to identify the most important Product Groups.

The forecasted aggregated demands per Warehouse, Product Family and Product Group will be “disaggregated” based on the Product Item Sales Contribution<sup>1</sup> (PISC). The following two methods will be used for the disaggregation of sales entity group forecasts: use the previous month’s PISC to disaggregate this month’s sales entity group forecasts and using the same month in the preceding year’s PISC to disaggregate this month’s sales entity group forecasts. Once the execution of the conceptual design has started one will decide which of the disaggregation methods will be used based on how the forecasted results compare on a historical basis.

A variety of methods will be used to determine which FMTS method proves to have the best accuracy for a specific Warehouse, Product Family or Product Group. The metrics that will be used to determine the accuracy of FMTS methods include: the Forecasting Error, the Percentage Error, Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), Year To Date Mean Absolute Percentage Error (YTD MAPE) and the Sales Forecasting Technique Accuracy Benchmark (SFTAB).

The Moving Average and a range of Exponential Smoothing forecasting methods (discussed in the section 4.3.) will be tested on historical sales data to determine which of these methods deliver the best forecasting results on a historical basis. The Moving Average and a range of Exponential Smoothing forecasting methods are chosen because of their simplicity, but other forecasting methods may also be tested and selected based on how good the results of the Moving Average and Exponential Smoothing forecasting methods are.

#### Judgemental forecasting methods

In the conceptual design of the Sales Forecasting Management Approach one can see that judgemental forecasting will be used to review some of the quantitative forecasts. Decision makers in the judgemental adjustment of quantitative forecasts are encouraged to take into account the opinions of those employees who sell the pipe producer’s products directly to its

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<sup>1</sup> The Product Item Sales Contribution (PISC) is the percentage that a Product Item contributes to the total sales quantity of a sales forecasting entity group in specific a period. Product Item 1112 may for example have contributed 3% to the total sales of Warehouse 7 in December 2009.

customers. Therefore the Grass Roots Forecasting method is one of the judgemental forecasting methods recommended to the pipe producer, because it can be done in an informal manner while managers walk around on the business premises and interact with employees. Fixed times for meetings will not have to be set and less time will be used of a large group of skilled employees. Judgemental forecasting can be more inclusive if managers can make time to talk to the grass roots employees about what they anticipate in terms of expected demand, the capacity of a machine tool and the storage space of a Warehouse.

When the forecasts are given to the sales managers, production managers and upper management, the difference between sales forecasts, sales goals and business plans should be emphasised. Sales forecasts' purpose is to anticipate expected demand. Sales goals are used to motivate sales and marketing representatives to improve the business' sales. Business plans are derived from a business strategy, normally with the goal of exceeding expected sales.

When the sales, production and upper managers make the final decision about adjustments to forecasts, they need to consider leading economic indicators to try and predict turning points in their industry. The South African Reserve Bank (SARB) has 13 sub-indicators that they use to compile South Africa's leading economic indicator. From a report on South Africa's leading economic indicators, the following economic indicators were identified which are applicable to the pipe producer (Lings, 2009):

- Opinion survey of business confidence: Manufacturing, construction and trade.
- Opinion survey of stocks in relation to demand: Manufacturing and trade.
- Opinion survey of volume of orders in manufacturing.
- Commodity prices in US dollars for a basket of South Africa's export commodities: Six-month smoothed growth rate.
- Composite leading business cycle indicator of major trading-partner countries: Percentage change over twelve months.
- Opinion survey of the average hours worked per factory worker in the manufacturing sector
- Labour productivity in manufacturing: Six-month smoothed growth rate
- Number of residential building plans passed for flats, townhouses and houses larger than 80m<sup>2</sup>.

The data requirements for the Sales Forecasting System will be outlined after its development.

How will the Sales Forecasting System be evaluated? The following are the evaluation criteria for the Sales Forecasting System:

Accuracy

- As mentioned earlier a variety of metrics should be taken into account when one wants to get a broad idea of the accuracy of a quantitative forecasting method. The MAPE will be used as the main forecasting metric to compare different forecasting methods. This is because forecasting literature shows evidence that the majority of forecasters use this metric to compare the performance of different forecasting methods in relation to each other. More substantial proof of this is given in section 7.2.
- Experienced sales managers, production managers and upper management will decide if the forecasts are reasonable or not.
- Forecasted demand will be compared with actual sales and the results of these will be communicated to the sales managers, production managers and upper management.

Ease of use

- Are the methods used to do demand planning easy to understand?
- How long does it take to do obtain forecasted results from the Demand Planning System?

Attractiveness

Is the Demand Planning System accepted by the pipe producer's employees to aid it in its demand planning? The answer to this question will only be known after the project has been completed.

Effectiveness

Has the Demand Planning System succeeded in minimising the amount of uncertainty with regards to the pipe producer's expected demand? The answer to this question will be in the affirmative if the overall stock levels in the pipe producer's sales channels have decreased. This answer will also only be known after the project has finished.

## **8. Development of a Sales Forecasting System in generally available spreadsheet software.**

### **8.1. *The Sales Forecasting System's objectives***

The Forecasting System will strive to:

- Be a tool that can be used in small and medium sized businesses, like the pipe producer's business, to develop quantitative forecasts.
- Use simple forecasting methods and a logical procedure for the execution of forecasts.
- Provide a reasonable level of forecasting accuracy for those sales entities that are "forecastable".

### **8.2. *The data flow through the Sales Forecasting System.***

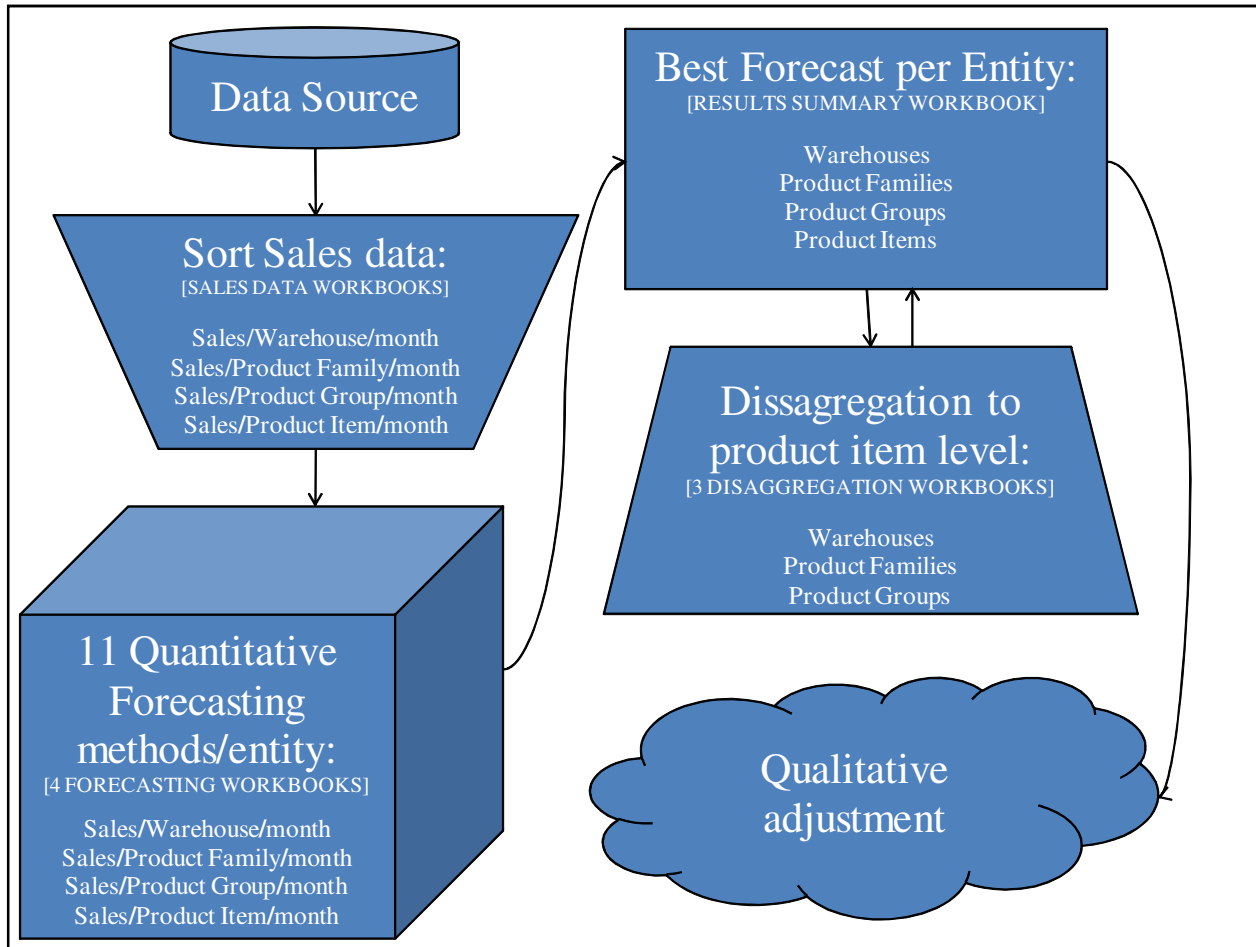
Figure 8 shows the processes and the flow of data needed to arrive at the final forecasts for the system's user.

To clarify the words sales entity and sales entity group in the following paragraphs, it can be said that an entity or a sales entity is a unit in a specific larger sales entity group. One can for example say that Product Item 1111 is a sales entity of the sales entity group called Product Items.

In the following paragraphs the explanation of how the Sales Forecasting System works will be according to how the sales data of the pipe producer was manipulated to arrive at its final forecasts. This explanation cannot be given in a generic way, because the detail may differ from client to client. For example, the system's user for a different client than the pipe producer may have to decide what an acceptable forecasting period is for the specific client's forecasts. A monthly forecasting period will not be suitable for all businesses. The pipe producer's sales data showed seasonality over annual periods. The lowest sales occur during December. The system's user will have to determine whether the sales data of their business shows seasonality and then adjust the 1 Season Winter, Average Seasonal Exponential Smoothing and the Average Seasonal Adaptive Exponential Smoothing in the forecasting workbook for the period during which seasonality occurs. An explanation of the different workbooks is given in section 8.3.

The Sales Forecasting System requires data to be in the format of the number of sales of an entity over constant periods. For example, the number of items sold by a Warehouse in one month.

**Figure 8: The required data flow in the Sales Forecasting System for the pipe producer’s sales forecast.**



Sales data can be extracted from a business’ ERP system through Structured Query Language (SQL) in the required format for forecasting. If the sales data is obtained from another data source, such as Excel Spreadsheets, the data will first have to be sorted to the correct format.

The correct format of data is copied into the forecasting workbooks where sales forecasts are developed with 11 different Fixed Model Time Series (FMTS) methods.

As mentioned in the literature review under section 4.3.3., a variety of forecasting metrics should be used to get an overall idea of the performance of a single forecasting method. One forecasting metric can be used to compare the performance of different forecasting methods in relation to each other, but one may be misled if one uses only a single forecasting metric to analyse the

performance of a forecasting method on its own. For example, the MAPE value of a forecasting method may be 0.09 over 48 periods, but this same forecasting method's YTD MAPE may be 0.2. If one only took into consideration the MAPE in this example one would have been unaware that the forecasting method's performance is worsening. Therefore in the analyses of one forecasting method it is necessary to analyse more than one forecasting metric to get a clear idea of the actual and relative size of a forecasting method's error and the averages of these errors.

In the forecasting workbooks 6 forecasting metrics are used to give an overall impression of the performance of each forecasting method that was used to forecast a sales entity. The 6 forecasting metrics are the: Forecasting Error, Mean Absolute Error, Percentage Error, Mean Absolute Percentage Error, Year To Date Mean Absolute Percentage Error and the Sales Forecasting Technique Accuracy Benchmark. Of these only the Mean Absolute Percentage Error (MAPE) metric is used to identify the best forecasting method for a specific sales entity out of the 11 FMST methods.

The MAPE results are copied into a results summary workbook that expedites the process of determining the lowest MAPE value for each entity.

The research of Mentzer and Moon (2005, p.228) shows that a total of 122 (52%) out of 234 American multinational companies use the MAPE to compare the performance of the different forecasting methods they use. Therefore it was decided to use the MAPE as the ultimate metric in determining the best forecasting method.

The main reason for sales forecasting is to answer the question: "How much of Product Item X should we produce or order?" This is why the best aggregated forecasts are disaggregated to the Product Item level.

In section 4.3.2. a variety of disaggregation methods were mentioned. The Naive I (NI) forecast that assumes the demand of this period to be equal to the demand of this period in the previous year proved to be surprisingly accurate. Therefore the aggregated Warehouse, Product Family and Product Group forecasts were disaggregated to a Product Item level by using the Product Item Sales Contribution (PISC) of this period in the previous year. The acronyms given for these disaggregation forecasts are respectively WNI, FNI and GNI.

The PISC of the previous period, period  $t - 1$  if this is period  $t$ , was also used for disaggregating Warehouse, Product Family and Product Group forecasts. The acronyms given for these disaggregation forecasts are respectively WN, FN and GN. A summary of how these disaggregation methods performed relative to each other is given in section 8.5.2. and section 8.5.3.

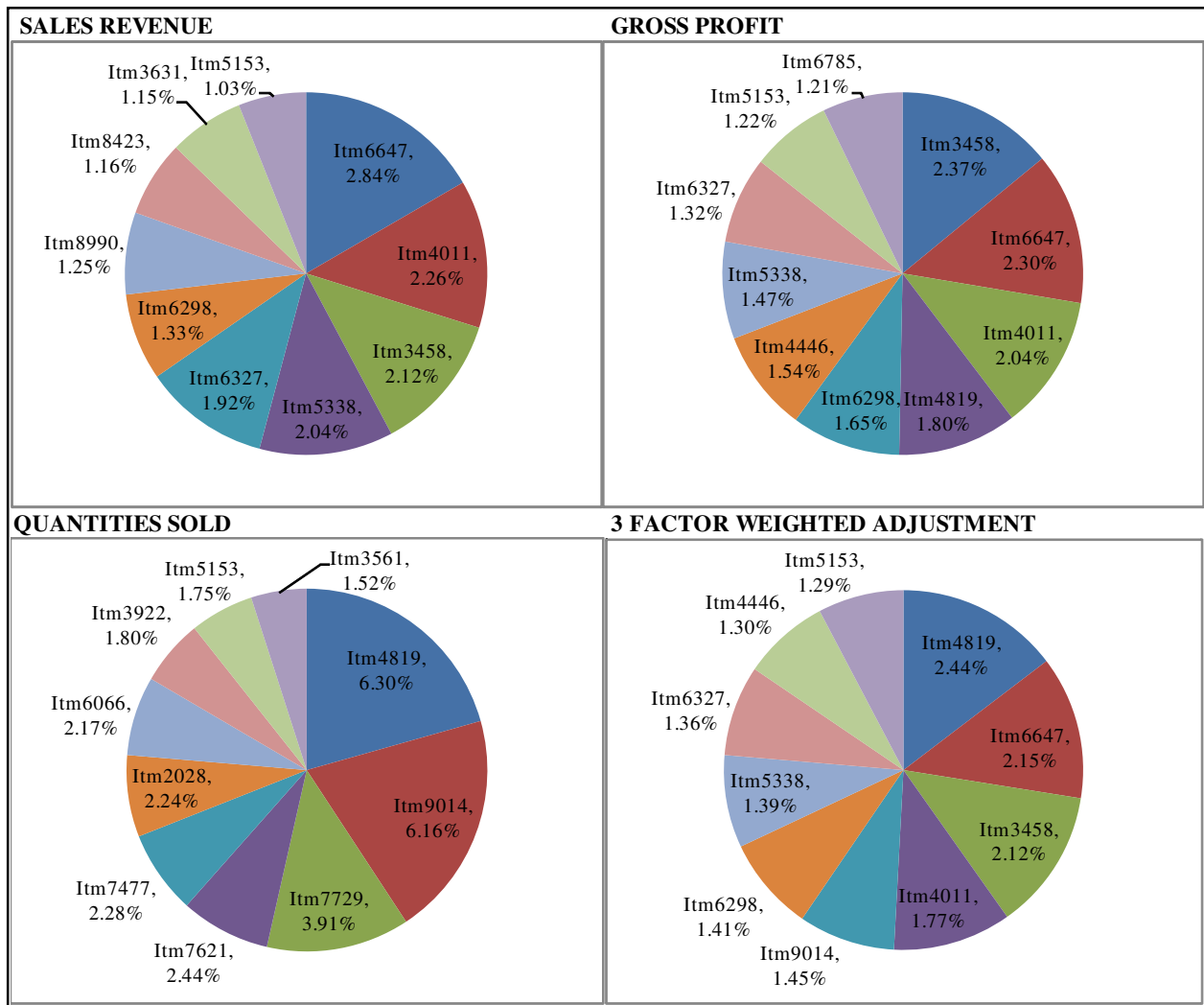
The MAPE values of the disaggregated forecasts are linked to the Results Summary Workbook to compare them with the best direct forecast MAPE values. Each Product Item's winning forecast is then considered for qualitative adjustment.

The qualitative adjustment of the Product Item forecasts will take place according to an ABC Analysis, because it will take a long time to qualitatively adjust the forecast for every Product Item that needs it. Qualitative forecasts will first be made for those products in the A category that have been identified as "unforecastable". The forecasts for those products in the A category that have higher than acceptable MAPE values will be the second group of products to be qualitatively adjusted. If deemed necessary, the same procedure will be followed for the products in the B and C categories.

The ABC Analysis has been used to categorise all of the pipe producer's Product Items according to the last year of available sales data (April 2009 to March 2010). The annual sales revenue, annual gross profit and the annual quantity of Product Items sold were selected as the metrics to categorise the pipe producer's Product Items to. Each of these metrics were assigned an importance weighting factor (0.05 for sales revenue, 0.15 for quantity sold and 0.8 for gross profit) to determine which Product Items should fall into which category – A, B or C. Figure 9 shows the top 10 Product Items for each of these 3 metrics. The pie graph in the bottom right corner shows the ranking of the Product Items after the different metrics were multiplied with the importance weighting.

It is interesting to note that Product Item 6647 contributes the most (2.84%) of all Product Items towards the pipe producer's annual sales revenue and the second most to the pipe producer's annual gross profit (2.3%), but the annual sales quantity of Product Item 6647 does not fall within the top 10 Product Items according to sales quantity. When the weight of the metrics is taken into account Product Item 6647 is the pipe producer's second most important product.

**Figure 9: The top 10 Items for each of the 3 metrics of concern and how much they contribute to that metric.**



### 8.3. The composition of the Sales Forecasting System

The following is meant to clarify the meaning of the words workbook and worksheets in this report:

An Excel file can also be called an Excel workbook. The Excel workbook may contain a number of worksheets. In the following paragraphs a discussion of the workbook format and the worksheet layout is given.

### **8.3.1. The workbook format**

There are 4 direct forecasting workbooks (one for every sales entity group), 1 results summary workbook, 3 disaggregation forecasting workbooks (one for every sales entity group, except for Product Items) and a number of sales data workbooks.

The 4 direct forecasting workbooks are: Direct Warehouses, Direct Families, Direct Groups and Direct Items.

11 different FMTS methods are used to develop sales forecasts from sales data in the forecasting workbooks. Each entity group, e.g. Warehouses, has an Excel workbook in which its forecasts are done. Each forecasting method uses 1 Excel worksheet for forecasting the sales of each entity in the entity group, e.g. 1 Exponential Smoothing forecast for each of the 10 Warehouses. The 11 FMTS methods that were used to develop sales forecasts are the: Naïve forecast (N), Naïve I forecast (NI), Naïve II forecast (NII), Moving Average of 5 forecast (MA), Exponential Smoothing (ES), Holt's 2 parameter method (H), Winters' 3 parameter method (W), 1 Season Winters' method (1SW), Average Seasonal Exponential Smoothing (ASES), Adaptive Exponential Smoothing (AES) and the Average Seasonal Adaptive Exponential Smoothing (ASAES) method. All of the above forecasting methods are used in the Direct Warehouses, Direct Families and the Direct Groups forecasting workbooks. In the Direct Items forecasting workbook only the first 5 forecasting methods were used. This is because Excel did not have enough resources (available processing capacity) to include the other forecasting methods in the seed formula. A formula that contains all the formulas for the calculations needed in the Direct Items forecasting workbook.

When one uses the above FMTS methods one is supposed to first determine what characteristics one's sales data has and then use an appropriate FMTS method to develop forecasts for each forecasting entity. The reason why so many forecasting methods were used to do forecasts for the pipe producer is because one should be able to use the Sales Forecasting System in most businesses. Therefore the Sales Forecasting System can be seen as a generic forecasting system.

The following is a description of the FMTS methods that were used in the Sales Forecasting System, but has not yet been described earlier under section 4.3.:

- Naïve (N) forecast: This method assumes that the sales for a period  $t$  will be equal to the sales in period  $t - 1$ .

$$F_t = A_{t-1} \quad [20]$$

- Naïve I (NI) forecast: The sales for period  $t$  is equal to the sales in period  $t - 12$ , if monthly forecasts or periods are used.

$$F_t = A_{t-12} \quad [21]$$

- Naïve II (NII) forecast: The sales for period  $t$  is equal to the sales during period  $t - 1$  and the difference between the sales in period  $t - 1$  and  $t - 2$ .

$$F_t = A_{t-1} + [A_{t-1} - A_{t-2}] \quad [22]$$

- 1 Season Winters' (1SW) method: Instead of adjusting every forecast with a seasonal adjustment factor ( $SA_t$ ) only the period during which seasonality is prevalent is adjusted with this factor.

$$L_t = \alpha(S_t/SA_{t-c}) + (1 - \alpha)(L_{t-1} + T_{t-1}) ; 0 < \alpha < 1 \quad [23]$$

$$T_t = \beta(L_t - L_{t-1}) + (1 - \beta)T_{t-1} ; 0 < \beta < 1 \quad [24]$$

$$SA_t = \gamma(S_t/L_t) + (1 - \gamma)(SA_{t-c}) ; 0 < \gamma < 1 \quad [25]$$

$$F_{t+m} = (L_t + (T_t \times m)) \times SA_{t-c+m} \quad [26]$$

Where  $SA_t$  is set equal to 1 for all periods during which seasonality is not present. In the case of the pipe producer  $SA_t$  was only calculated for every December.

- Average Seasonal Exponential Smoothing (ASES) method: With the ASES method the seasonal adjustment factor ( $SA_t$ ) is calculated by dividing the actual sales of a period with seasonality by the average per period demand  $D_t$ . An Exponential Smoothing forecast is then multiplied with the seasonal adjustment factor. With the ASES method the  $SA_t$  is also only calculated for the sales period with seasonality. For all the other sales periods  $SA_t$  is set equal to 0.

$$D_t = (\sum_{i=1}^t A_i)/t \quad [27]$$

$$SA_t = A_t / D_t \quad [28]$$

$$F_{t+1} = (\alpha A_t + (1 - \alpha)F_t) \times SA_t ; 0 < \alpha < 1 \quad [29]$$

- Average Seasonal Adaptive Exponential Smoothing (ASAES) method: This method is the same as the ASES method, but the  $\alpha$  value is continually adjusted based on the Percentage Error (PE) in the previous period.  $SA_t$  is only calculated for periods with regular seasonality, the other periods are set equal to 1.

$$D_t = (\sum_{i=1}^t A_i)/t \quad [30]$$

$$SA_t = A_t / D_t \quad [31]$$

$$F_{t+1} = (\alpha_t A_t + (1 - \alpha_t) F_t) \times SA_t \quad [32]$$

$$\alpha_{t+2} = |(F_{t+1} - A_{t+1}) / F_{t+1}| = |PE_{t+1}| \quad [33]$$

Figure 10 is a screen shot of the Direct Warehouses forecasting workbook. It shows the worksheets and a partial worksheet layout that one can see in the Excel direct forecasting workbooks. The direct forecasting workbooks (except the Direct Items forecasting workbook) each contain 12 worksheets: one for each of the 11 FMTS forecasting methods and an information worksheet that defines the acronyms used throughout the workbook. The Direct Items forecasting workbook has 6 worksheets: an information worksheet and one worksheet for each of the 5 FMTS methods that are used to forecast for Product Items.

A separate Results Summary Workbook is used to determine the best forecasting method for every forecasting entity. Figure 11 shows the worksheets in the results summary workbook and a part of the layout. The Results Summary Workbook contains 12 worksheets: one information worksheet, 4 worksheets for the direct forecasting entity groups, 6 worksheets for the disaggregation methods (Disaggregated Warehouses Naive (DWN), Disaggregated Warehouses Naive I (DWN I), Disaggregated Product Families Naive (DFN), Disaggregated Product Families Naive I (DFN I), Disaggregated Product Groups Naive (DGN) and Disaggregated Product Groups Naive I (DGN I)) and a worksheet (i\_vs\_D) to determine the best forecasting method for each Product Item from the disaggregated and direct forecasting worksheets.

The 3 disaggregation workbooks are: Disaggregated Warehouses, Disaggregated Families and Disaggregated Groups. These 3 disaggregation workbooks each use two disaggregation methods: the Naive method (PISC  $t - 1$ ) and the Naive I method (PISC  $t - 12$  if  $t$  represents months). The Best direct Forecasts (BF) of Warehouses, Product Families and Product Groups are disaggregated in the disaggregation workbooks.

Figure 12 shows the 9 worksheets in the Disaggregated Warehouses workbook that one can see in every disaggregation workbook: an information sheet, BF worksheet, true Product Item sales worksheet, 4 worksheets containing the PISC for each year and 2 disaggregation worksheets.

Figure 10: The layout of the direct forecasting workbooks in which the FMTS forecasts are developed for a sales entity group.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1		Sales/Mon	Sales/Mon	Sales/Mon	Sales/Mon	Sales/Mon	Sales/Mon	Sales/Mon	Sales/Mon	Sales/Mon	Sales/Mon	Sales/Mon	ES
2													Whs01
3	COV	0.226324	0.233117	0.222492	0.150853	0.251995	0.849194	0.207052	0.202245	0.216899	0.173514	0.178531	α
4		Whs01	Whs02	Whs03	Whs04	Whs05	Whs06	Whs07	Whs08	Whs09	Whs10	overall	0.10
5	2006/4	515294	71608	154261	195593	50944	998	44606	70285	67950	57707	1229246	515,294
6	2006/5	637054	81169	155983	216171	58545	9052	56523	84294	90642	54938	1444371	515,294
7	2006/6	684498.8	74102	167038	215332.5	73681	9070	60862	85380	82482	63563.06	1516009	527,470
8	2006/7	829613.5	89030	192630	272391	78611	9596	60349	93036	124322	60551	1810130	543,173
9	2006/8	771732	71497	179333	231771	53306	19316	65381	78547	119468	63541	1653892	571,817
10	2006/9	834368	81443	177606	249413	67373	14288	64943	87026	92657	56835	1725952	591,808
11	2006/10	999886	110770	278474	302952	78315	21554	76840	102741	111940	77737	2161209	616,064
12	2006/11	712246	113618	178106	238082	60607	20224	74507	121226	105925	66724	1691265	654,447
13	2006/12	447401	65931	115089	216660	44732.7	5735	39934	84747	72016	42057	1134303	660,227
14	2007/1	516572	73575	127488	202635	36265	6965	69991	93463	77376	68353	1272683	638,944
15	2007/2	687466	84462	167303	207421	59769	4840	71922	87826	75031	75147	1521187	626,707
16	2007/3	805997.5	88058	183579	225160	61706	5712	58338	102891	92318	66825	1690585	632,783
17	2007/4	718425	85505	168570	207315	63612	3983	57656	80444	72028	69155	1526693	650,104
18	2007/5	811882.4	111667	203631	242603.5	62166	8559	58244	96006	93503	79754	1768016	656,936
19	2007/6	750491.9	107310.1	165529	219625	61898	3631	59547	95817	90629	69232	1623710	672,431
20	2007/7	762625	100010	184588	242817.5	70497	4024	54306	100830	84388	69430	1673516	680,237
21	2007/8	965144.5	140233	221710	323431	104430	2944	91534	127942	138788	80276	2196433	688,476
22	2007/9	683743	105137	141510	178369	42518	6238	71979	71568	75211	66295	1442568	716,143
23	2007/10	852206.8	119974	212585	243018	80164	6061	71778	121209	88488	88296	1883780	712,903
24	2007/11	934147.2	137025	193865	297023.5	65426	4073	89818	150161	117227	102564	2091330	726,833
25	2007/12	429039	101390	101263	159349	36906	1604	50324	78493	73982	43851	1076201	747,565
26	2008/1	565338	92504	123878	209917	46041	5667	66605	68790	63991	62865	1305596	715,712
27	2008/2	773695	97537	156170	227329	68778	2666	60485	97327	83442	78457	1645886	700,675
28	2008/3	748225	104855	171711	244348	61154	5652	59847	112898	84282	69081	1662053	707,977
29	2008/4	851988	98535	206664	268632	65728	4181	63349.24	107351	115215	83875	1865518	712,001
30	2008/5	732788	88499	177163	209404	54753	3371	63081	96119	73745	57414	1556337	726,000
31	2008/6	667426.5	88257	150333	191734	44536	5647	75886	71895	72719	60465	1428899	726,679
32	2008/7	1056929	89086	169482	218384	62308	4777	67787	73768	71111	74525	1888157	720,754
33	2008/8	1071140	112463	154438	228285	54178	2511	59111	76781	93250	85875	1938032	754,371
34	2008/9	1059232	84013	176948	235512	59515	2141	62196	95430	72778	91771	1939536	786,048

Figure 11: The layout of the Result Summary Workbook in which the MAPE values of the FMTS forecasting and disaggregation methods are evaluated.

	A	B	C	D	E	F	G	H	I	J	K	L
56		N	NI	NII	MA	ES	H	W	1SW	ASES	AES	ASAES
57		Whs01	Whs01	Whs01	Whs01	Whs01	Whs01	Whs01	Whs01	Whs01	Whs01	Whs01
58		Whs01N	Whs01NI	Whs01NII	Whs01MA	Whs01ES	Whs01H	Whs01W	Whs011SW	Whs01ASES	Whs01AES	Whs01ASAES
59	2006/4	0.00	0.00	0.00	1.00	0.00	0.00	0.47	0.47	0.00	0.00	0.00
60	2006/5	0.19	0.00	0.00	1.00	0.10	0.00	0.33	0.33	0.10	0.10	0.10
61	2006/6	0.13	0.00	0.11	1.00	0.14	0.05	0.31	0.31	0.14	0.13	0.13
62	2006/7	0.15	0.00	0.11	1.00	0.19	0.05	0.27	0.27	0.19	0.18	0.18
63	2006/8	0.13	0.00	0.16	1.00	0.20	0.11	0.29	0.29	0.20	0.17	0.17
64	2006/9	0.12	0.00	0.16	0.86	0.22	0.15	0.31	0.31	0.22	0.18	0.18
65	2006/10	0.13	0.00	0.15	0.77	0.24	0.15	0.29	0.29	0.24	0.20	0.20
66	2006/11	0.16	0.00	0.23	0.70	0.22	0.24	0.36	0.36	0.22	0.18	0.18
67	2006/12	0.22	0.00	0.20	0.72	0.25	0.45	0.53	0.53	0.25	0.25	0.25
68	2007/1	0.21	0.00	0.26	0.69	0.25	0.56	0.63	0.63	0.25	0.23	0.23
69	2007/2	0.21	0.00	0.25	0.63	0.23	0.59	0.65	0.65	0.23	0.23	0.23
70	2007/3	0.21	0.00	0.23	0.59	0.23	0.59	0.64	0.64	0.23	0.23	0.23
71	2007/4	0.20	0.00	0.23	0.55	0.22	0.61	0.64	0.65	0.22	0.22	0.22
72	2007/5	0.19	0.22	0.23	0.53	0.22	0.60	0.63	0.64	0.22	0.22	0.22
73	2007/6	0.19	0.15	0.23	0.50	0.21	0.60	0.63	0.63	0.21	0.21	0.21
74	2007/7	0.17	0.13	0.22	0.47	0.21	0.60	0.62	0.62	0.21	0.21	0.21
75	2007/8	0.18	0.15	0.22	0.45	0.21	0.57	0.59	0.60	0.21	0.21	0.21
76	2007/9	0.19	0.16	0.25	0.44	0.20	0.58	0.58	0.60	0.20	0.21	0.21
77	2007/10	0.19	0.16	0.27	0.42	0.20	0.56	0.56	0.58	0.20	0.20	0.20
78	2007/11	0.19	0.17	0.26	0.40	0.20	0.54	0.54	0.55	0.20	0.20	0.20
79	2007/12	0.23	0.16	0.32	0.43	0.23	0.58	0.56	0.57	0.22	0.23	0.23
80	2008/1	0.24	0.15	0.36	0.43	0.23	0.58	0.56	0.57	0.22	0.23	0.22
81	2008/2	0.24	0.15	0.34	0.41	0.22	0.56	0.54	0.55	0.22	0.23	0.23
82	2008/3	0.23	0.14	0.34	0.40	0.22	0.54	0.52	0.53	0.21	0.23	0.22
83	2008/4	0.22	0.14	0.33	0.39	0.21	0.52	0.50	0.51	0.21	0.23	0.23
84	2008/5	0.22	0.14	0.33	0.38	0.21	0.50	0.48	0.50	0.21	0.23	0.22
85	2008/6	0.22	0.14	0.32	0.37	0.20	0.49	0.47	0.48	0.20	0.22	0.21
86	2008/7	0.22	0.15	0.33	0.36	0.21	0.48	0.46	0.47	0.20	0.22	0.22
87	2008/8	0.21	0.14	0.33	0.36	0.21	0.48	0.46	0.47	0.20	0.22	0.22

Figure 12: The layout of the worksheets in the disaggregation workbooks where the Best Forecasts are disaggregated.

	BBB	BBC	BBD	BBE	BBF	BBG	BBH	BBI	BBJ	BBK	BBL
1	PISC*BF	PISC*BF	PISC*BF	PISC*BF	PISC*BF	PISC*BF	PISC*BF	PISC*BF	PISC*BF	PISC*BF	PISC*BF
2											
3											
4	Whs09/2006/1	Whs09/2007/1	Whs09/2007/2	Whs09/2007/3	Whs09/2007/4	Whs09/2007/5	Whs09/2007/6	Whs09/2007/7	Whs09/2007/8	Whs09/2007/9	Whs09/2007/10
5	Whs09	Whs09	Whs09	Whs09	Whs09	Whs09	Whs09	Whs09	Whs09	Whs09	Whs09
6	2007/1	2007/2	2007/3	2007/4	2007/5	2007/6	2007/7	2007/8	2007/9	2007/10	2007/11
7	Whs09/2007/1	Whs09/2007/2	Whs09/2007/3	Whs09/2007/4	Whs09/2007/5	Whs09/2007/6	Whs09/2007/7	Whs09/2007/8	Whs09/2007/9	Whs09/2007/10	Whs09/2007/11
8	11496	10968	12425	10999	10762	12329	12509	9636	12710	12719	7904
9	150	77	312	376	182	239	143	134	115	142	157
10	1629	862	1196	1227	1165	972	1225	1097	1583	892	1109
11	0	0	0	0	0	0	0	0	0	0	0
12	932	887	679	933	819	1180	1211	1246	1085	794	1567
13	31	22	40	28	5	42	54	67	87	9	191
14	2271	2413	2024	3745	3987	1298	1653	2430	1157	2507	1180
15	516	421	221	447	291	352	675	275	272	225	319
16	24	43	4	21	9	-39	18	5	35	4	8
17	890	741	1139	1084	1492	1311	1521	813	771	1267	1033
18	570	811	631	455	798	810	620	1062	526	548	650
19	2294	1341	1905	1787	1744	1836	1756	1809	1202	2613	2063
20	351	225	306	363	277	416	407	373	338	970	279
21	0	0	136	108	0	0	0	0	35	0	0
22	644	400	400	602	773	586	571	896	551	898	960
23	0	0	0	0	0	0	0	0	0	0	0
24	808	231	530	184	286	324	479	283	430	626	347
25	32	37	3	39	21	-29	42	20	23	14	30
26	464	333	382	628	364	468	355	640	512	259	560
27	1685	1266	1335	1619	1390	1538	1616	1354	1350	1435	1249
28	323	239	277	162	250	153	232	336	222	306	320
29	6	14	0	0	0	0	0	0	0	0	0
30	753	1371	134	663	883	655	791	859	870	775	560
31	0	0	0	0	7	0	0	0	4	0	0
32	151	116	98	141	137	164	193	89	225	95	156
33	225	264	247	83	261	364	354	511	332	352	398
34	71	77	17	28	58	63	38	65	29	30	110
35	1410	1530	1688	1290	1078	1238	1414	1207	1240	2231	1483
36	238	227	173	328	205	191	300	286	191	301	280
37	4822	3760	3749	4329	4278	4987	3859	3245	3871	3764	4138
38	342	336	388	334	284	427	317	473	270	352	358
39	136	179	140	251	10	130	143	224	270	280	221

### 8.3.2. The worksheet layout

As mentioned earlier there are 6 forecasting metrics that are used to analyse the performance of every forecast in the forecasting workbooks. These 6 forecasting metrics are the: Forecasting Error (FE), Mean Absolute Error (MAE), Percentage Error (PE), Mean Absolute Percentage Error (MAPE), Year To Date Mean Absolute Percentage Error (YTD) and the Sales Forecasting Technique Accuracy Benchmark (SFTAB).

On each forecasting worksheet the metrics appear in the above order, horizontally across the sheet, after the original sales data and the sales forecasts. A depiction of this is given in Figure 13. In this figure one can see that the calculations for a forecasting method on a worksheet are all grouped together. Practically this means that all the forecasts for warehouses are done next to each other in numerical order for Warehouse 1 to 11. Some forecasting methods require preliminary calculations from the initial sales data before the true forecasts can be made. Winters' 3 parameter method is an example of this, because the level, trend and seasonal adjustment factor need to be calculated first before the forecasted value can be calculated. After the forecasts for a worksheet have been done, the first forecasting metric is calculated – the Forecasting Error is now for example calculated for Warehouse 1 to 11. The other 5 forecasting metrics follows. The SFTAB requires preliminary calculations, because the MAPE needs to be calculated for a Naive I forecast. This MAPE is used as the denominator while the MAPE of the forecasting method that is used on the worksheet acts as the numerator in the calculation of the SFTAB.

Figure 13: The layout of each one of the forecasting worksheets in each forecasting workbook.

<b>Sales Data</b>	<b>(Forecasting Elements Preparation and) Actual Forecast</b>	<b>Forecasting Error</b>	<b>Mean Absolute Error</b>	<b>Percentage Error</b>	<b>Mean Absolute Percentage Error</b>	<b>Year To Date Mean Absolute Percentage Error</b>	<b>Preparation for SFTAB and Sales Forecasting Technique Accuracy Benchmark</b>
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In the Results Summary Workbook the best forecasting method for every sales entity is singled out by a formula and conditional formatting. The MAPE values in the Results Summary Workbook are updated with links to the forecasting workbooks. The worksheet layout in this workbook is numerically ordered according to the sales entity group, for example Product Family 1 to 15. For each sales entity the best MAPE value is identified from the 11 forecasting methods used (5 methods in the case of Product Items). For example, for every month 11 MAPE values are related to every one of the 76 Product Groups and for each of these Product Groups the lowest MAPE value for the last month of sales are identified.

Figure 14 shows the process followed to disaggregate the Best direct Forecast (BF) to a Product Item level in the 3 Disaggregation Workbooks.

The BF per sales entity is determined in the Results Summary workbook and linked to the disaggregation workbooks. The monthly PISC are determined in the Sales Data Workbooks with Excel Pivot Tables and linked to the disaggregation workbooks. The product of the BF and PISC disaggregates the BF of a Warehouse or Product Family or Product Group into an estimate of the sales for a specific Product Item during a specific month. It is necessary to calculate the sum of all the PISC multiplied by the BF for a specific Product Item in a month, because a Product Item may have sales in more than one sales entity of a sales entity group. Item 2264 may, for example, have been sold in Warehouse 6, 7 and 10 during August 2007 – the sum of the August 2007 sales of Item 2264 in each Warehouse will give the disaggregated sales of Product Item 2264 during August 2007. The true Product Item sales per month and the disaggregated sales are used to calculate the absolute Percentage Error. The MAPE is calculated as the average of absolute Percentage Errors.

**Figure 14: The layout of each of the disaggregation sheets in the 3 disaggregation workbooks.**

<b>Best direct Forecast (BF) per Sales Entity</b>	<b>Product Item Sales Contribution (PISC) per Month</b>	<b>BF x PISC for each Product Item per Month</b>	<b>Sum of PISC x BF to get the Total Sales of each Product Item per Month</b>	<b>True Product Item Sales per Month</b>	<b>Absolute Percentage Error</b>	<b>Mean Absolute Percentage Error (MAPE)</b>
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The best disaggregated forecast is identified for every Product Item are then compared with the best direct Product Item forecast to identify the winner between these two. This is done in the Results Summary Workbook.

#### **8.4. *Recommendations for practical use of the Sales Forecasting System***

Initially 1 employee at the pipe producer can take the responsibility of developing forecasts with the Sales Forecasting System on a part-time basis. At the end of a month, the employee can extract that month's sales data from the ERP system and use it to develop Product Item forecasts for the next 2 or more months. The priority of developing forecasts for specific sales entities is determined by that sales entity's ABC categorisation and the lead time of the sales entity, if it is a Product Item.

The forecasting accuracy of Product Items in the A category can be monitored on a monthly basis. The forecasting accuracy of those category B Product Items that are not complementary to Product Items in category A can be monitored on a quarterly basis. The forecasting accuracy of Category C Product Items that doesn't have an influence on the sales of category A Product Items can be reviewed bi-annually.

#### **8.5. *The results of the forecasts for the pipe producer***

##### **8.5.1. Direct forecasts**

Table 2 gives an overview of which forecasting method had the lowest MAPE when it was used to develop forecasts for the sales entities.

The pipe producer considers a MAPE value of 20% or higher as unacceptable. According to Mentzer and Moon (2005, p.227) the average MAPE results that a group of 92 US multinationals accept in their forecasts are 11% for Product Families and 16% for Product Items.

In Tables 2 and 3 the cells and the font of the MAPE values that are higher or equal to 0.2 are marked in red, while the COV values that are higher or equal to 0.8 are striked through with a line. Where the MAPE value of a sales entity is indicated as "--" it means that there were no sales over a period of 4 years (from April 2006 to March 2010) for that entity.

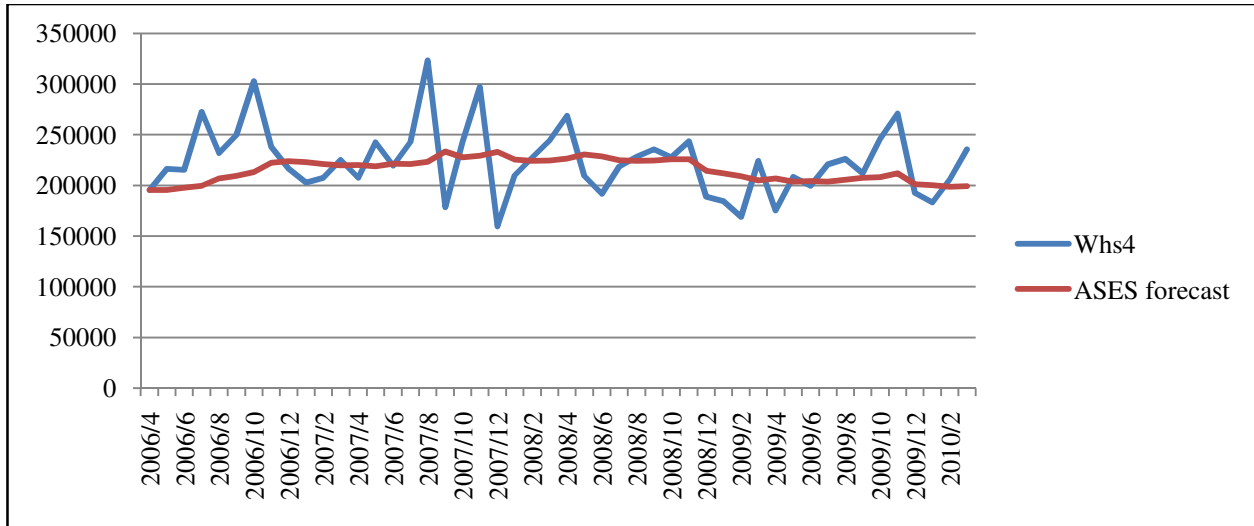
If the disaggregation of Warehouses' forecasts to the Product Item level proves to be successful, qualitative forecasts should be developed for Warehouse 6 to see if these forecasts will provide a better MAPE value. Warehouse 6 has a Coefficient of Variation (COV) of 0.85. Therefore this Warehouse's sales data is considered to be "unforecastable".

**Table 2: The Winning Forecasting Methods (WFM) that realised the lowest MAPE value for the different sales entities.**

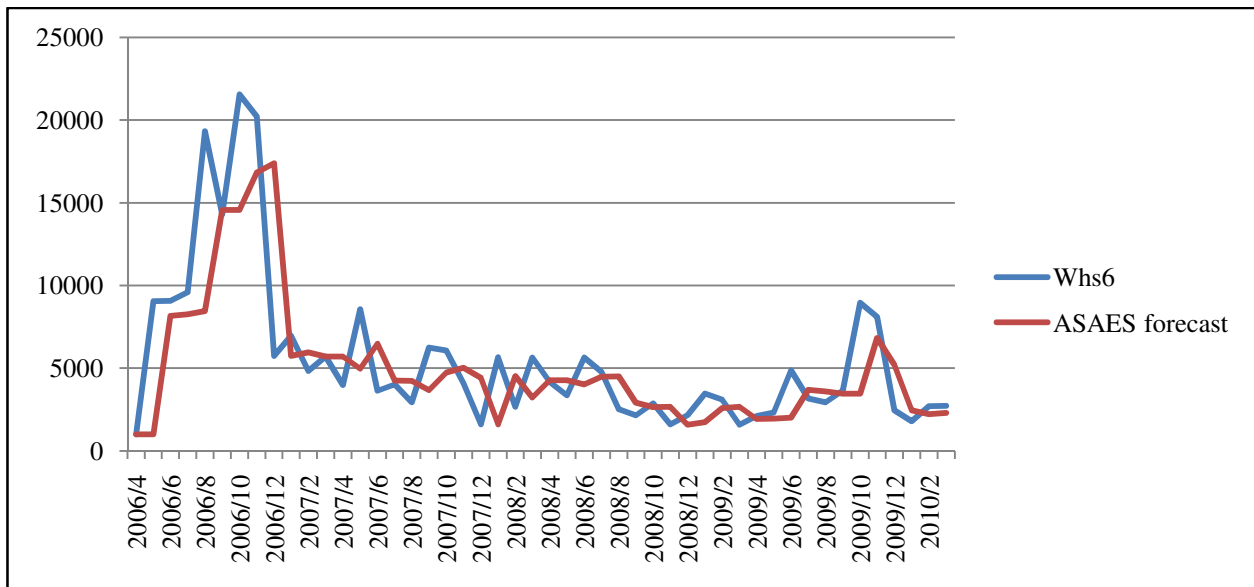
Warehouse	1	2	3	4	5	6	7	8	9	10	overall									
WFM	ASES	ASES	NI	ASES	ASES	ASAES	ASES	ASES	ASES	ASES	ASES									
MAPE	0.19	0.17	0.16	0.11	0.17	0.40	0.16	0.16	0.15	0.14	0.15									
COV	0.23	0.23	0.22	0.15	0.25	<u>0.85</u>	0.21	0.20	0.22	0.17	0.18									
Product Family	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15					
WFM	ASAES	ASES	NI	AES	ASAES	ASES	ASAES	ISW	ASES	ASAES	ES	ASAES	ASAES	ASAES	ASES					
MAPE	0.13	0.14	0.22	2.69	0.49	0.17	0.88	0.09	0.38	0.30	2.99	0.27	0.29	0.19	0.20					
COV	0.18	0.18	0.29	<u>2.22</u>	0.54	0.28	<u>0.91</u>	<u>2.48</u>	0.41	0.49	<u>2.15</u>	<u>3.31</u>	0.31	0.27	0.27					
Product Group (PG)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
WFM	-	NI	ASES	ASAES	NI	ASAES	NI	NI	NI	NI	NI	NI	-	NI	NI	NI	NI	NI	NI	ASAES
MAPE	-	0.16	0.17	0.61	0.21	0.35	0.13	0.11	0.11	0.21	0.17	0.32	-	0.10	0.13	0.13	0.14	0.11	0.12	5.44
COV		0.26	0.24	0.49	0.26	0.63	0.18	0.17	0.16	0.31	<u>3.69</u>	0.46		0.19	0.21	0.21	0.23	0.15	0.19	<u>1.16</u>
PG	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
WFM	NI	ASES	NI	NI	NI	NI	NI	NI	NI	NI	ASAES	NI	AES	ASAES	NI	NI	NI	NI	NI	NI
MAPE	0.52	0.63	0.56	0.48	0.28	0.69	23.25	0.34	0.45	0.33	1.20	27.48	16.30	0.79	3.92	10.06	0.00	0.48	0.28	0.33
COV	0.62	0.61	0.67	0.41	0.39	0.60	<u>2.32</u>	0.52	0.48	0.56	<u>1.00</u>	<u>1.59</u>	<u>1.78</u>	0.71	<u>0.85</u>	<u>1.14</u>	<u>1.73</u>	0.48	0.40	0.48
PG	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
WFM	AES	ASAES	ASAES	NI	NI	NI	NI	NI	ASAES	N	MA	-	NI	ASAES	ASAES	NI	ASAES	NI	ASAES	ASAES
MAPE	1.20	6.79	2.56	0.22	0.35	0.20	0.18	0.26	1.30	1.25	2.97	-	0.21	0.30	1.24	0.51	0.33	0.24	0.18	48.13
COV	<u>1.00</u>	<u>3.85</u>	<u>1.42</u>	0.43	0.63	0.31	0.24	0.35	<u>0.80</u>	0.80	<u>7.35</u>		0.37	0.46	<u>1.05</u>	<u>1.68</u>	<u>3.06</u>	0.30	0.23	<u>3.75</u>
PG	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76				
WFM	ASAES	NI	NI	NI	NI	NI	-	NI	NI	NI	NI	N	MA	NI	NI	NI				
MAPE	1.14	0.27	0.30	0.09	5.32	20.30	-	0.06	0.09	0.16	0.17	18.13	0.24	1.38	0.67	0.50				
COV	<u>1.35</u>	0.44	0.51	0.19	<u>2.34</u>	<u>3.93</u>		<u>3.69</u>	0.15	0.33	0.25	<u>3.03</u>	0.49	<u>2.66</u>	<u>4.44</u>	0.78				

Figure 15 and 16 gives a graphical depiction of how the best forecasting methods for each Warehouse performed when one considers the Warehouses whose forecasts had the best and worst MAPE.

**Figure 15: Warehouse 4 achieved the best MAPE value of all Warehouses.**



**Figure 16: Warehouse 6 had the worst MAPE of all the Warehouses.**



The Product Families with a COV of higher than 0.8 are Product Family 4, 7, 8, 11 and 12. Therefore Product Family 3, 5, 9, 10, 13 and 15 do not meet the pipe producer's MAPE

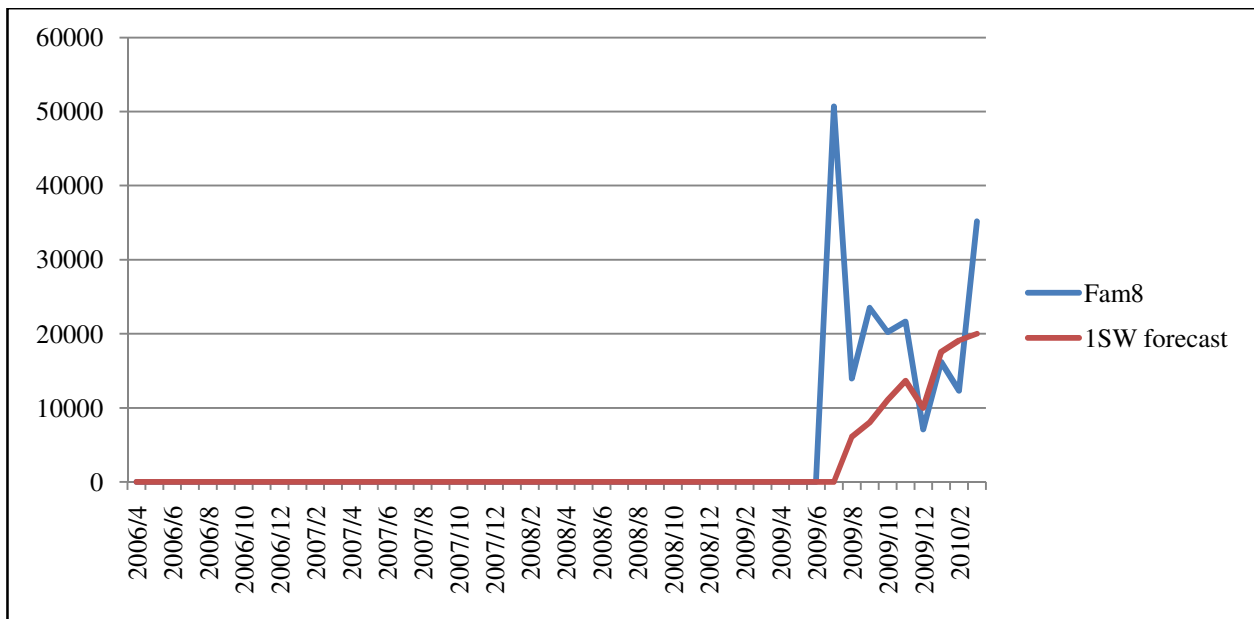
requirement and an out of bounds COV cannot be used as a reason for this. Not one of the eleven forecasting methods proved to be good enough to forecast the sales of these Product Families with the level of accuracy required by the pipe producer.

Figure 17 and 18 display how the most effective forecasting method for each Product Family forecasted the expected sales values for the Product Families that had the best and the worst MAPE value.

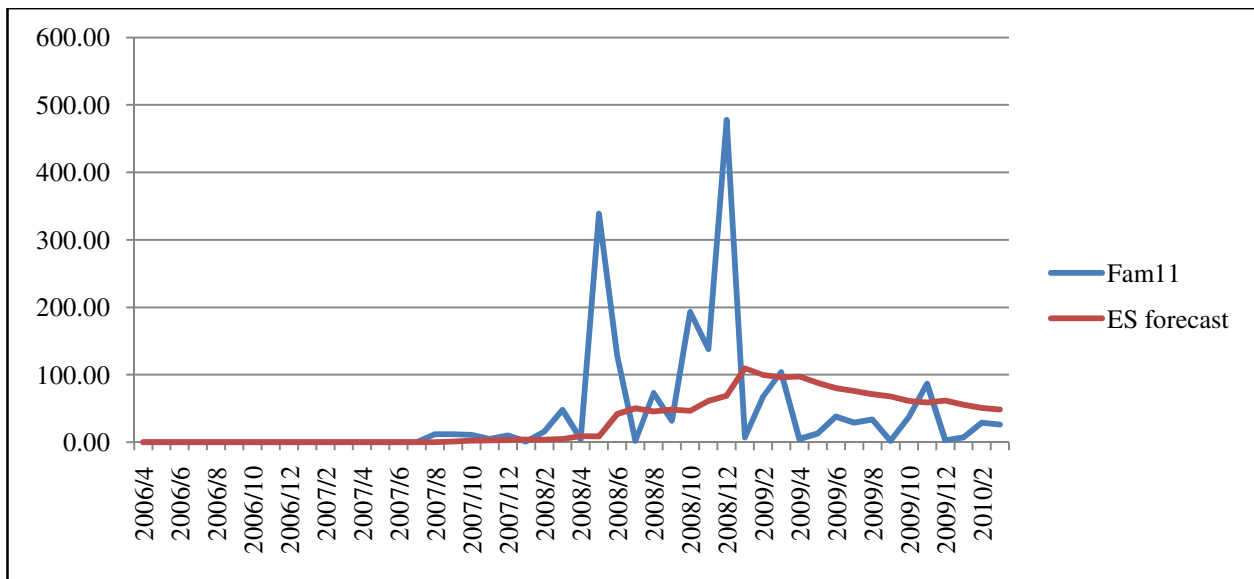
From Figure 17 one can see that Product Family 8 is a new Product Family for the pipe producer. It is strange that Product Family 8 had the best MAPE value of all 15 Product Families even though it had a high COV of 2.48. The formula that is used in Excel doesn't take into account those sales periods during which 0 sales took place in the calculation of the MAPE.

It can be seen in Figure 18 that it difficult to achieve a low MAPE value when sales entities have 0 sales values in some periods. Product Family 11 had a COV of higher than 0.8 and therefore the poor MAPE is understandable.

**Figure 17: Product Family 8 had the best MAPE value of all the Product Families.**



**Figure 18: Product Family 11 had the worst MAPE value of all the Product Families.**



The Product Groups with a COV higher than 0.8 are Product Group 11, 20, 27, 31, 32, 33, 35,36, 37, 41, 42, 43, 49, 51, 55, 56, 57, 60, 61, 65, 66, 68, 72, 74 and 75.

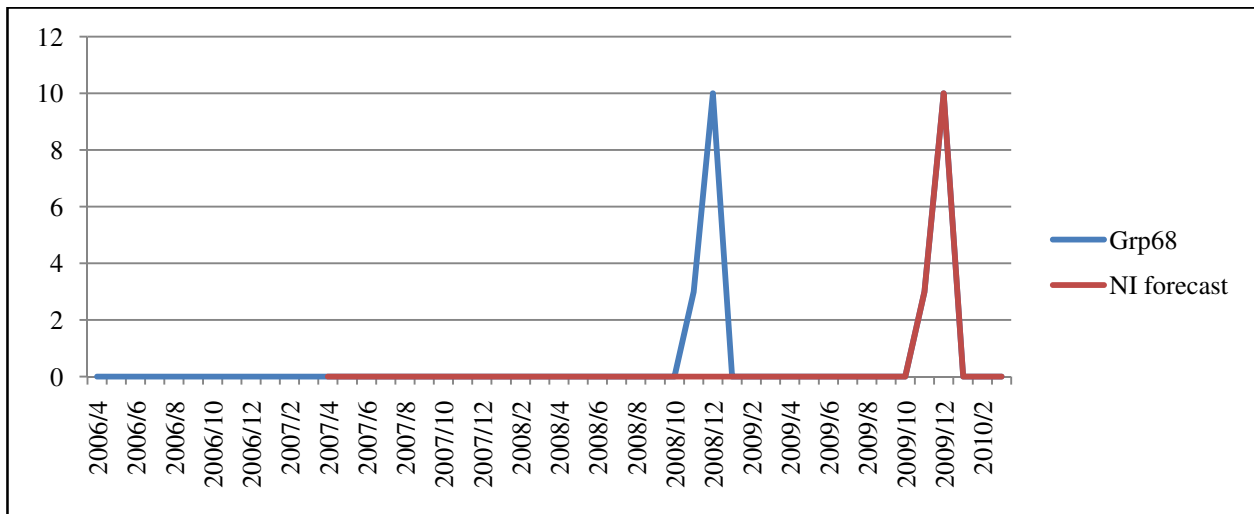
Product Groups 4, 5, 6, 10, 12, 21 to 26, 28 to 30, 34, 38 to 40, 44, 45, 48, 50, 53, 54, 58, 62,63, 73 and 76 does not have a COV higher than 0.8, but have a higher MAPE value than 0.2. Therefore it can be concluded that the specific FMTS forecasting methods that have been used are not adequate to forecast the sales of these Product Groups.

From Figure 19 it is clear that the MAPE metric can be misleading. Product Group 68 had the best MAPE value, but this Product Group only had 4 periods in which sales occurred – November and December of 2008 and 2009. The forecast for November and December 2009 was exactly equal to the sales in these periods. It should be the company policy that these Product Groups, like 68, should be of the Make-To-Order (MTO) type if all of the following is true for a Product Group:

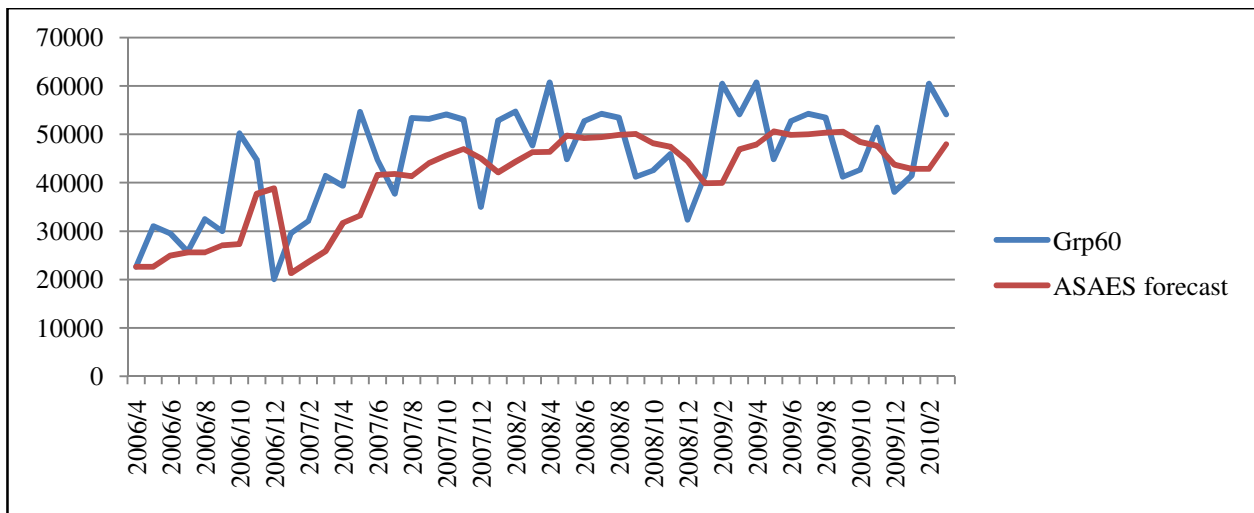
- The holding cost is high for the items that make up a Product Group
- The Product Group has a B or C categorisation and doesn't influence the sales of category A Product Items
- The Product Group has a sales pattern like that of Product Group 68.

It is clear from the graph of Product Group 60's sales in Figure 20 that it should have a high COV. It is understandable that the best forecast for Product Group 60 had a MAPE value of 48.13, because a COV of 3.75 is far above 0.8.

**Figure 19: Product Group 68 had the best MAPE value.**



**Figure 20: Product Group 60 had the worst MAPE value.**



**8.5.2. Disaggregated forecasts**

All higher level forecasts like the number of sales per Warehouse, the number of sales per Product Family and the number of sales per Product Group have been disaggregated to the Product Item level. This was done to increase the chances of developing improved forecasts and to answer the central question of: “How many of Product Item X do we expect to sell in period Y?”

**Table 3: The Winning Forecasting Method (WFM) and Winning Disaggregation Method (WDM) for the first 64 category A Product Items.**

<b>Item</b>	<b>4819</b>	<b>6647</b>	<b>3458</b>	<b>4011</b>	<b>9014</b>	<b>6298</b>	<b>5338</b>	<b>6327</b>	<b>4446</b>	<b>5153</b>	<b>5122</b>	<b>5782</b>	<b>6153</b>	<b>7619</b>	<b>6327</b>	<b>2751</b>
WFM	NI	NI	MA	NI	NI	NI	N	NI	NI	NI	NI	NI	NI	NI	NI	NI
MAPE	0.13	0.12	0.16	7.51	0.13	0.75	0.26	0.14	0.27	0.18	0.14	0.18	0.16	0.14	0.14	0.16
COV	0.20	0.17	0.24	0.25	0.18	0.58	0.21	0.25	0.26	0.29	0.20	0.26	0.23	0.19	0.21	0.23
WDM	WNI	WNI	WN	WNI	WNI	WN	WN	GN	GN	WN	WNI	WN	WN	WNI	GN	WN
MAPE	0.16	0.20	0.22	0.70	0.15	0.75	0.22	0.17	0.27	0.22	0.16	0.21	0.17	0.18	0.17	0.20
<b>Item</b>	<b>5229</b>	<b>6785</b>	<b>7550</b>	<b>2207</b>	<b>7912</b>	<b>3571</b>	<b>4989</b>	<b>6647</b>	<b>3631</b>	<b>7934</b>	<b>5855</b>	<b>5338</b>	<b>2033</b>	<b>5828</b>	<b>9131</b>	<b>9673</b>
WFM	NI	NI	MA	NI	N	ES	NI	NI	NI	NI	NI	N	NI	NI	NI	NI
MAPE	0.16	0.17	0.14	0.16	0.24	0.19	0.17	0.12	0.10	0.14	0.12	0.26	0.11	0.16	0.11	0.12
COV	0.21	0.25	0.21	0.21	0.30	0.24	0.24	0.17	0.15	0.22	0.19	0.31	0.18	0.23	0.20	0.19
WDM	WNI	WN	WNI	WNI	FNI	WNI	WNI	WNI	GNI	WNI	GNI	WN	GNI	FNI	GNI	GNI
MAPE	0.15	0.19	0.18	0.19	0.48	0.23	0.18	0.20	0.13	0.16	0.16	0.22	0.15	0.17	0.15	0.16
<b>Item</b>	<b>4831</b>	<b>9103</b>	<b>3458</b>	<b>2231</b>	<b>8634</b>	<b>7233</b>	<b>7232</b>	<b>1933</b>	<b>8963</b>	<b>1668</b>	<b>9575</b>	<b>1351</b>	<b>5994</b>	<b>1627</b>	<b>6707</b>	<b>7975</b>
WFM	NI	N	MA	NI	NI	NI	NI	NII	NI	MA	NI	NI	NI	MA	NI	ES
MAPE	0.25	0.31	0.16	0.15	0.11	0.23	0.14	0.94	0.21	0.14	0.17	0.11	0.21	0.17	0.12	0.14
COV	0.29	0.68	0.21	0.22	0.20	0.32	0.20	0.37	0.28	0.21	0.23	0.21	0.31	0.30	0.16	0.17
WDM	WNI	WN	WN	WNI	GNI	WN	WNI	WN	WN	GN	WNI	GNI	WN	WN	WNI	GN
MAPE	0.28	0.25	0.22	0.19	0.14	0.23	0.17	0.93	0.21	0.22	0.19	0.14	0.21	0.24	0.15	0.18
<b>Item</b>	<b>3565</b>	<b>6322</b>	<b>3293</b>	<b>5422</b>	<b>5162</b>	<b>6896</b>	<b>8790</b>	<b>2537</b>	<b>8041</b>	<b>4343</b>	<b>9018</b>	<b>6505</b>	<b>1358</b>	<b>2608</b>	<b>3932</b>	<b>7143</b>
WFM	NI	MA	ES	N	N	NI	NI	NI	N	NI	NI	NI	MA	NI	NI	NI
MAPE	0.20	0.21	0.20	0.22	0.14	0.13	0.13	0.15	0.43	0.29	0.22	0.14	0.23	0.17	0.16	0.17
COV	0.29	0.30	0.29	0.33	0.22	0.21	0.21	0.20	0.38	0.32	0.32	0.19	0.43	0.30	0.20	0.24
WDM	WNI	WNI	WN	WN	WN	WNI	GNI	WNI	WN	FNI	WN	GNI	WN	WN	GN	WNI
MAPE	0.22	0.22	0.23	0.24	0.19	0.17	0.17	0.19	0.45	0.24	0.22	0.19	0.25	0.21	0.19	0.22

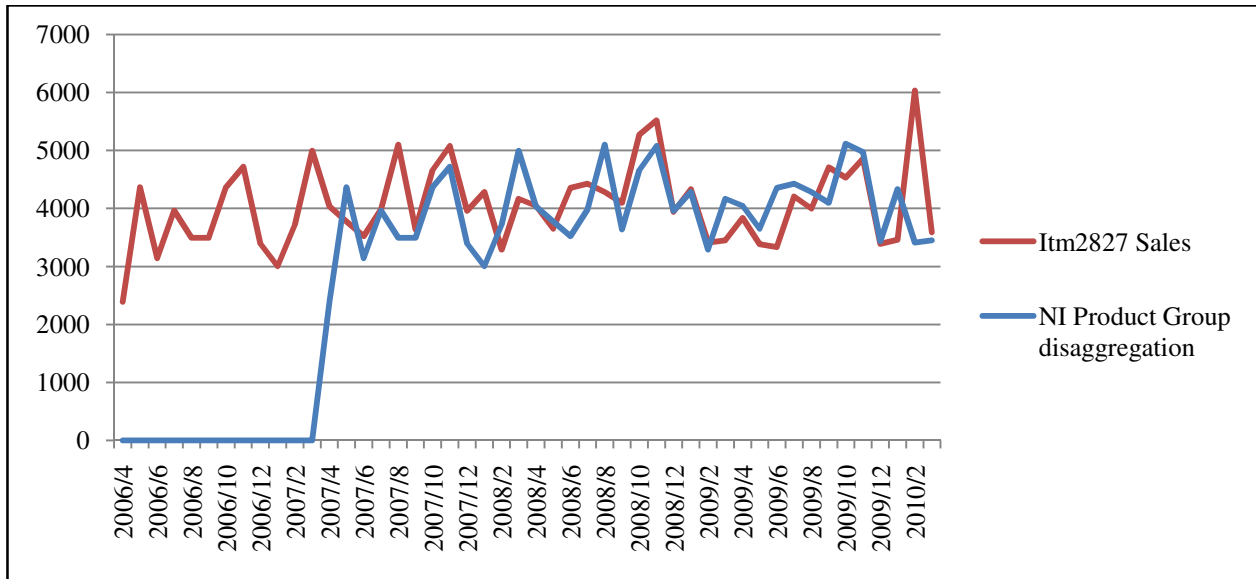
Table 3 shows how the direct Product Item forecasts compares to the best forecasts of Warehouses, Product Families and Product Groups which have been disaggregated to a Product Item level.

From Table 3 one can see that every time the MAPE value of a disaggregated forecasted were higher than 0.2, the direct Product Item forecast's MAPE was also higher than 0.2. But out of 64 forecasts 9 disaggregated forecasts had a MAPE value of higher than 0.2 when the direct Product Item forecast did not have a MAPE value higher than 0.2. Out of 64 category A Product Items the direct Product Item forecasts delivered 54 of the best MAPE values, while the disaggregated forecasts delivered the other 10 best MAPE values. It seems as if direct forecasts for Product Items truly outperform disaggregated forecasts. A combination of the two methods may still be preferred for the Product Items where the disaggregated forecasts' MAPE values proved to be better than the direct Product Item forecasts.

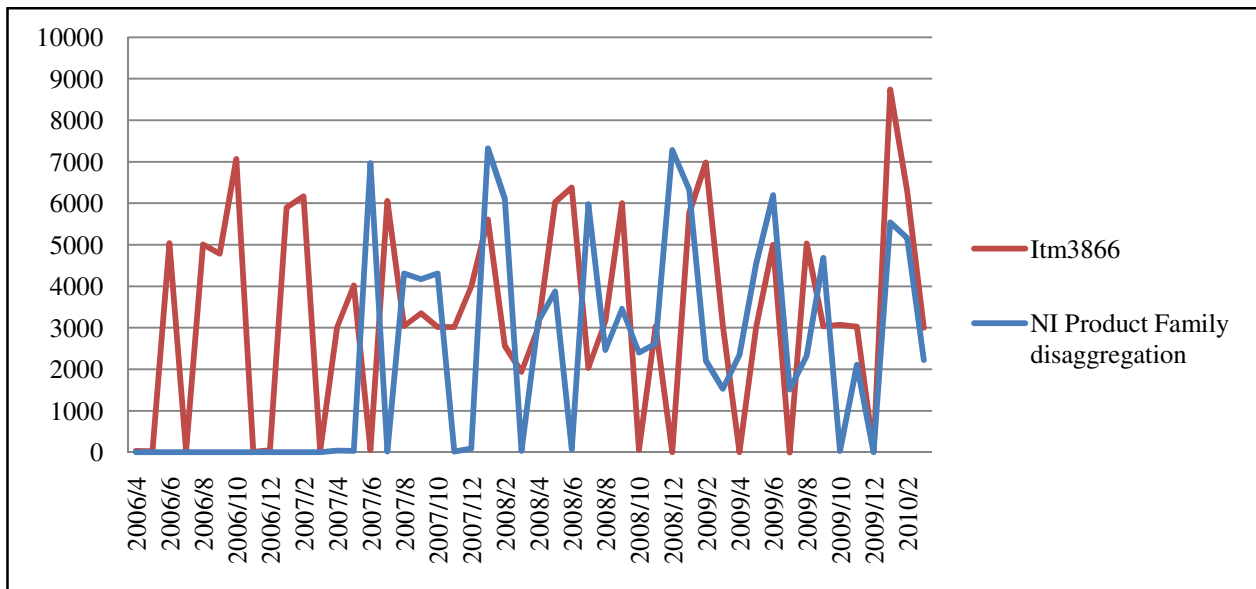
It has to be noted that there is not a single Product Item in Table 3 whose sales has a COV larger than 0.8, which means that all of these Product Items' sales are "forecastable". 21 of the forecasted values did have a MAPE of higher than 0.2. The lowest MAPE value for disaggregated forecasts was 0.12 for Product Item 2827. This Product Item's sales had a COV of 0.17. The worst MAPE value was 2497 for Product Item 3866 and the COV for this Product Item's sales were 0.73.

The graphs that show how the disaggregated forecasted sales compare to actual sales of the Product Items 2827 and 3866 can be seen in Figure 21 and 22.

**Figure 21: The disaggregated forecast for Product Item 2827 realised the best MAPE value of all disaggregated forecasts.**



**Figure 22: The disaggregated forecast for Product Item 3866 had the worst MAPE value of all disaggregated forecasts.**



### 8.5.3. Forecasting results summary

From the above analysis of the different entity groups it is clear that the sales entities in each sales entity group which had the worst MAPE value also had a COV of higher than 0.8 (except for the disaggregated forecasts). One can therefore say that the theory of the “unforecastables”,

which states that sales data with a COV larger than 0.8 cannot be successfully forecasted, proved to be true in this project.

Table 4 shows how many times a forecasting method provided the best MAPE when it was used to forecast sales for a specific sales entity group. As mentioned earlier only 5 forecasting methods were used to forecast the sales of Product Items.

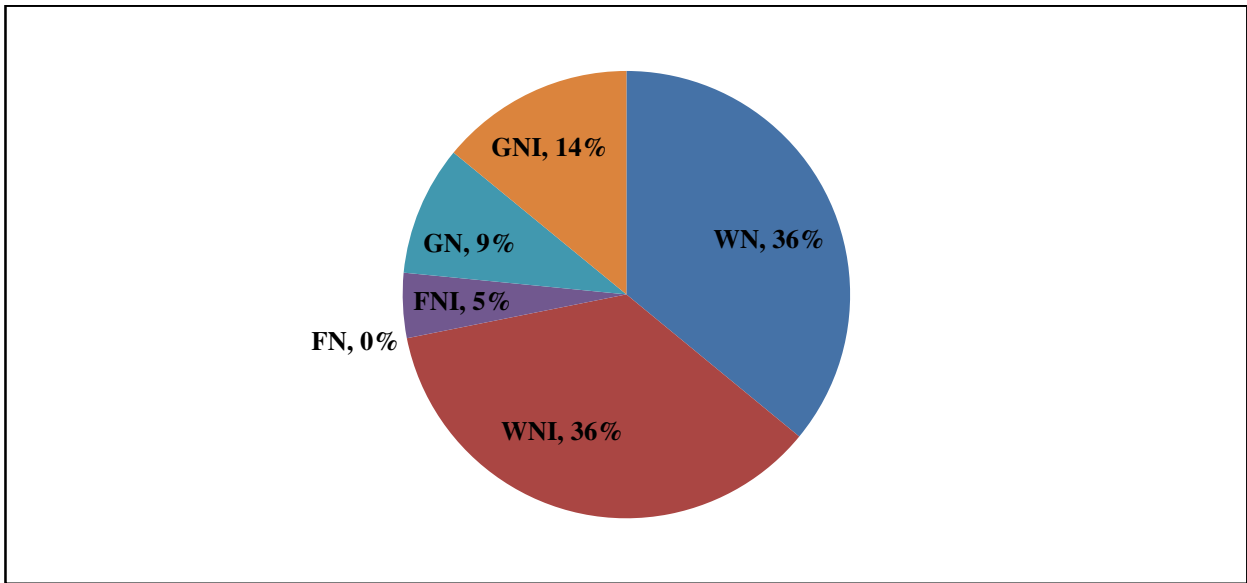
**Table 4: The number of times a direct forecasting method achieved the best MAPE value.**

<b>Forecasting Method</b>	<b>N</b>	<b>NI</b>	<b>NII</b>	<b>MA</b>	<b>ES</b>	<b>H</b>	<b>W</b>	<b>1SW</b>	<b>ASES</b>	<b>AES</b>	<b>ASAES</b>
<b>Warehouses</b>	0	1	0	0	0	0	0	0	9	0	1
<b>Product Families</b>	0	1	0	0	1	0	0	1	4	1	7
<b>Product Groups</b>	3	48	1	2	0	0	0	0	2	2	14
<b>Product Items</b>	15	70	1	11	5	-	-	-	-	-	-

From Table 4 it is interesting to note that the ASES forecasting method were the best method to do forecasts for Warehouses according to each forecasting method’s MAPE value. The ASES forecasting method was the second best method to do forecasts for Product Families, while the ASAES forecasting method was the best for forecasting Product Families. Surprisingly the simple NI forecasting method was the best in forecasting sales for Product Groups, while the ASAES forecasting method was the second best. It is clear that the NI forecasting method is the best method to forecast sales for the majority of Product Items.

When one considers the above best forecasting methods for every sales entity group and look at Table 2 and 3 one can see that the ASES and NI forecasting methods realised acceptable MAPE values for most of the sales entities where they were the best forecasting methods. This is however not the case for the ASAES forecasting method.

**Figure 23: The percentage of time a disaggregation method realised the best MAPE value.**



The direct Warehouse forecasts delivered the best overall average MAPE value of 0.18, compared to 0.63 for direct Product Family forecasts and 2.98 for direct Product Group forecasts. The difference in these MAPE results is understandable if one thinks of Warehouses as being more diversified than Product Families and Product Families being more diversified when compared to Product Groups. The overall average MAPE values above supports the good performance of the disaggregated Warehouse forecasts in relation to the disaggregated Product Family and disaggregated Product Group forecasts. The performance of the 6 disaggregation approaches relative to each other is reflected in Figure 23.

Keeping in mind the above analysis of the Sales Forecasting System results, one can conclude that the Sales Forecasting System proved to be successful in forecasting for:

- 9 out of 10 Warehouses, where 1 Warehouse's sales data had a COV higher than 0.8.
- 5 out of 15 Product Families, where 5 Product Families' sales data had a COV higher than 0.8.
- 24 out of 76 Product Groups, where 25 Product Groups' sales data had a COV higher than 0.8.
- 43 out of 64 category A Product Items. 43 category A Product Items are successfully forecasted when the direct and disaggregated forecasts are taken into account.

#### **8.5.4. The Conclusion on the Sales Forecasting System**

During this project one has realised that there are disadvantages involved in developing a sales forecasting System in Excel. These include:

- Depending on the processing capacity of the computer one is using, it can take a long time to do forecasts for large amounts of data.
- Excel may not have enough processing capacity to simultaneously do forecasts for all the data one wants to do forecasts for. The laptop on which the forecasts were developed had an Intel Duo CPU, 2GB RAM and a 1.6 GHz processor.
- Unlike a Commercial Of The Shelf (COTS) forecasting system a forecasting system developed in Excel 2007 will consist of more than one component or workbook, if one assumes that the client will have as much sales data as the pipe producer. The sorting of the sales data, forecasting from the sales data, identification of the best forecasting method for each forecasting entity, disaggregation of the best forecasts and qualitative adjustment of forecasts cannot take place in a single program that automatically takes the user through the above processes.
- The Sales Forecasting System that was developed in Excel 2007 and cannot be used in Excel 2003, because Excel 2003 does not provide the same capacity. Excel 2007 provides its user with 16 384 columns and 1 048 576 rows, therefore 17 179 869 184 cells per worksheet. Excel 2003 provides one with 256 columns and 65 536 rows which constitute 16 777 216 cells per worksheet.

Why should one develop a forecasting system in Excel?

Because the advantages of a forecasting system in Excel are:

- The Excel software is considered to be generally available spreadsheet software in businesses.
- One can see, understand and adapt the type of formulas one uses for forecasting.
- No or little training will be required for employees that are used to the functions provided in Excel.
- Data can easily be exported from Excel to other business planning tools like SAP or Oracle and the same goes for importing data into Excel.

- If one can say that the Sales Forecasting System in Excel performs almost the same as a COTS forecasting package, one would be able to say that Excel is relatively cheap.

The following is an answer to the evaluation criteria for the Sales Forecasting System listed at the end of section 7:

#### Accuracy

The Sales Forecasting System can be used to successfully forecast the sales for a business like the pipe producer, but it will not be able to forecast the sales of entities that have a COV higher than 0.8. The Sales Forecasting System may in some instances not be able to forecast the sales of an entity with a reasonable margin of accuracy even though the sales data do not have a large amount of variation.

#### Ease of use

5 of the 11 forecasting methods used in the Sales Forecasting System need less than 3 inputs for their formulas. Of the other 6 FMTS methods, Winters' Method is the most complex forecasting method that the Sales Forecasting System uses and this method is not considered complicated compared to other OMTS, regression and simulation forecasting methods.

It should not take the individual responsible for developing forecasts longer than 3 work days to complete Product Item forecasts - ignoring the amount of time it will take to receive input from Warehouses, Production and Management.

#### Attractiveness and Effectiveness

The belief is that the demand planning employees will accept the Sales Forecasting System when they realise that this tool aids them in generating objective demand forecasts, saves them time and that the system supplies them with quantitative forecasting data to support the demand forecasts that they present to management.

There is almost no doubt that the Sales Forecasting System, combined with sound judgemental forecasts, will reduce the uncertainty regarding the pipe producer's expected demand.

Is it possible to develop the Demand Planning module of an APS in generally available spreadsheet software?

According to the developer of the APS in generally available software the Sales Forecasting System will be used to generate expected sales data which will act as input into the APS.

Therefore it can be concluded that the Sales Forecasting System will act as the Demand Planning module of an APS to be developed in generally available spreadsheet software.

## **9. Conclusion**

The Sales Forecasting System can be a valuable tool that industrial engineers can use to add value a business' existing forecasting process, because many businesses do not use any quantitative forecasting methods.

In many businesses industrial engineers are responsible for inventory and production management. Here the Sales Forecasting System offers the industrial engineer the opportunity to lower inventory and stock-out costs through improved demand planning.

When judgemental forecasts are made they can be compared to the quantitative forecasts from the Sales Forecasting System to see if the judgemental forecasts are rational or reasonably in line with the Sales Forecasting System's forecasts.

If all forecasts in a business are decided on through judgemental forecasting methods, time can be saved by using quantitative forecasting methods for some of these forecasts. Therefore the Sales Forecasting System can help to lighten the load on individuals responsible for demand planning.

Through the input from employees responsible for planning, the Demand Planning System can act as a demand planning resource for the pipe producer. The commitment from upper management to effectively manage the sales forecasting business function will be an essential factor for improving the pipe producer's demand planning. Improved demand planning can act as the first step in the direction of improved operational planning and ultimately a lower landed cost for the customer.

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