Integration of Demand Management in Production Planning and Purchasing Management: Metal Packaging Industry

The Colep Case Study

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Abstract

Nowadays, demand management and its connection to production planning process and purchasing process is a crucial issue in business management. For information to be useful it is necessary to have a collaborative work among customers and suppliers. This connection, and therefore greater interaction between the production systems and customers brings great challenges and needs for organizational, technological and resource solutions. It is in this context that the problem faced is presented, where studies are done to improve the sales forecast integration in production planning and purchasing processes in order to support decision make. This study is conducted in Colep, a metal packaging manufacturer. In this project it is characterized the demand management problem and the use of sales forecast by the production planning and purchasing departments of Colep. Additionally, a literature review is done to frame the case study in a theoretical context and to sustain the adopted solutions. To solve this problem, an optimization model of the demand management process is developed. This model is based on a more detailed forecast level. Finally, time series methods are tested in order to understand and define the one which better reflect the historical sales evolution. It is also shown the relationship between sales forecast and purchase and planning production management. This provides a means to translate demand information in raw-material needs and work centers allocation needs.

Keywords: demand management, sales and operations planning, forecast disaggregation keys, production planning, purchasing

1. Introduction

In any production sector, the optimization and the process improvement, in order to increase their efficiency and effectiveness, has become the main focus to the companies (Dittmann, 2012). The demand management process plays an important role in the relationship with purchasing and production planning. This connection aims to ensure suitable raw material on time and a low cost and, in the same time, manage the work centers load capacity. Based on conducted literature review were defined some concepts and given some considerations related to the demand management process and its connection to production planning and purchasing. Demand management is the procedure responsible for balancing the customer's needs and supply chain load capacity (Croxton, 2002). It is essential that the demand management process allows to know, on one hand, more accurately the specifications of raw materials needed, in order to keep low stock but enough to fulfil customer's

needs. On the other hand, the demand management process should enable an efficient load capacity management of the work centers.
Lambert and Cooper (2000) consider that demand management process is one of the key sub process within the supply chain management. An adequate process enables the companies to be more proactive to the anticipated demand and more reactive to unpredictable one (Croxton, 2002).
According to Hilletofth et al. (2009) the demand management process should not be consider an isolate process neither an activity resumed to sales forecast. When is being defined a production strategy, the demand management process represents a key role, since it can be changed according to changes in medium/long term demand (Olhager et al., 2001). This author defines the concept of sales and operations planning (S&OP) as the medium/long term production planning based on sales forecast. It enables a resource planning in order to determine the appropriate capacity levels to support the production planning.
Crum and Palmatier (2003) studied the demand management process and consider that it is a continuous and structured process that covers 4 phases: planning demand, communication demand, influencing demand, and prioritizing demand. The process is already implemented but the information is useless for both departments of production planning and purchasing.
The companies that have been struggling in the pursuit of operational excellence and competitive advantages recognize the impact that the forecast have in their ability to meet customer's needs and simultaneously manage their resources (Palmatier, 1998).
The main goal of this paper is to propose an alternative way of forecast that ensure that the information from sales forecast can be useful. The methodology used to propose a new demand management process will focus on changing the current product family forecast to product format forecast. This disaggregation assures unique connection between sales forecast and both correspondent work centers and appropriate raw material. After this, time series models are tested in order to define which one is better to forecast sales of each format.

2. Case Study

As mentioned previously, this paper addresses the demand management process. This process starts with the commercial and market department that in some cases receive customer's forecast, and in other cases insert on system forecast made by their own, based on market information. The forecast received by demand management department is then analyzed. Based on the analysis, there is a meeting among commercial managers and demand managers to discuss the accuracy of forecast. This meeting ends up with a consensus. The information about the agreement is then sent to production planning and purchase managers. The problem is that the forecast is based on aggregate sales by product family, and this information can be more useful to both purchase manager and production planning manager if it is disaggregated. The actual process doesn't allow to understand exactly what raw material is needed to buy, neither the amount. Besides this, it is not clear the work center in which the products are done, because each format has different components and different features (lid, bottom, ring), even within the same family. The current relationship (or lack of) between sales forecast, aggregated by family, and the correspondent work centers is exhibited in figure 1.

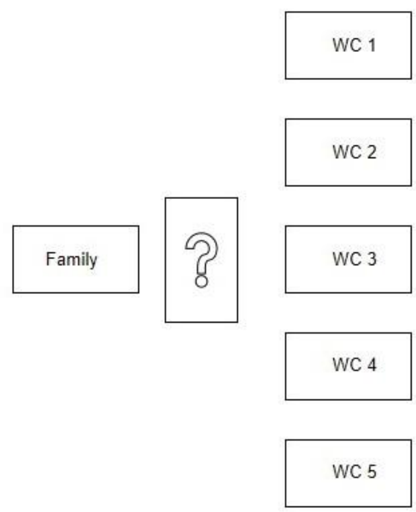

Figure 1 – Actual relationship (lack of) between sales forecast and work centers

Figure 1 shows that it is not clear to which work center the forecast should be associated, since depending on format, the work center can be different.
On the other hand, even within a family there is consumption of different raw materials. The goal is to be able to connect undoubtedly sales forecast with work center, and with the exact raw material.

3. Data Collection and Assumptions

3.1 Format Definition

The procedure adopted to define the formats within the families is described in this section. Since the information was available by family it was

necessary to disaggregate it into format. Each format is able to guarantee unequivocal information. This is, the information related to coil type, its amount consumed by can, the work center, and the components associated to the can are exclusive.
The method to define each format is resumed below:

- Collection of all SKU (stock keeping unit);
- Collection of work center correspondent to each SKU.

With all the SKU codes it is possible to analyze its structure and find the raw material (type and quantity) needed to produce it. It is also possible to find the components associated to each can.
It is an iterative method where from the final product code, is found all the information.
Figure 2 illustrates the process of collecting the data.

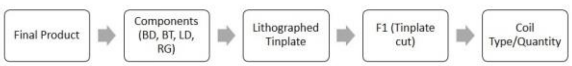

Figure 2 - Disaggregation Process

By observation of figure 2 it is understandable the process. From the final product code it is possible to find the associated components codes. With the components codes (body, bottom, lid, and ring) is reachable the lithographed tinplate. With the lithographed tinplate code, it is possible to get the cut tinplate code. Finally, having the cut tinplate code is found the type and quantity of tinplate coil.

3.2 Time Series Definition and Assumptions

The time unit considered is the month, and it was collected data from 2010, 2011, 2012 and 2013.
In this study are considered the following assumptions:

- All the forecasted volumes that assume negative values, due to behavior of the time series, are considered zero for realistic effects;
- All the volumes of raw material needs are rounded up;
- All the data related to past sales, forecast a and load capacity are presented in thousands;
- On calculations of load capacity are taken into consideration just the load associated with presented family (RO108);
- All the calculations are performed using the “Microsoft Office Excel”;
- The description “RO” is equivalent to “CY”.

4. Time Series Models

The time series models applied to the case study are:

- Additive Classical Decomposition;
- Multiplicative Classical Decomposition;
- Additive Holt-Winters;
- Multiplicative Holt-Winters;
- Exponential Smoothing;
- Moving Average.

Classical Composition

This model of time series forecast assumes that the time series incorporates four components: trend, seasonal, cyclical and the irregular component. This method consists in segregate each component and find a proper process to predict it. Another concept related to this model is the moving average. This time series model considers two methods, additive and multiplicative seasonality. The Classical Decomposition method gives the same weight to every observations.

Holt-Winters

This model is indicated to time series that presents trend and seasonality. It is based in three equations (level, trend, seasonality) each one considers three smoothing parameters, α, β, γ, respectively. This method is versatile, since it can be adapted to different time series characteristics (trend=0, for example).

Exponential Smoothing

Exponential Smoothing method is suitable to stationary time series. It uses a recursive formula that allows to update the level. This formula considers the previous level ($t-1$) with a weight ($1-\alpha$) and the observation (t) with a weight of α.

Moving Average

Moving Average method is also suitable to stationary time series. This model uses an arithmetic average of last N last observations to forecast future values.

5. Results

This section covers the application of the models to the case study described in section 2. All the models were implemented with Microsoft Office Excel.
In section 5.1 are presented and analyzed the results of the disaggregation process.

In section 5.2 six different scenarios, based on each time series model, are presented and analyzed. The scenarios are compared based on mean squared error.

5.1 Disaggregation Process

The disaggregation process to obtain information by format, presented in section 3.1, allowed the construction of 3 dynamic tables. In the following ones is considered the family RO108 (CY108).

Table 1 - Disaggregation process (Part 1)

Famlily	Work Center	Description	Coil Type	Coil Qty (Kg) (1000 Sheets)	Coil Qty (sheet/body)	Body/sheet
RO108	42008	CY 108x130 2T	61-12899	1330	0.055555	18
RO108	42008	CY 108x130 FT	61-12899	1330	0.055555	18
RO108	42008	CY 108x132 1T	61-12899	1330	0.055555	18
RO108	42008	CY 108x132 2T	61-12899	1330	0.055555	18
RO108	42008	CY 108x132 3T	61-12899	1330	0.055555	18
RO108	42008	CY 108x132 FT	61-12899	1330	0.055555	18
RO108	42008	CY 108x137 FF	61-12180	1466	0.055555	18
RO108	42008	CY 108x141,5 1T	61-12899	1330	0.066666	15
RO108	42008	CY 108x141,5 2T	61-12899	1330	0.066666	15
RO108	42008	CY 108x153 3T	61-12899	1330	0.066666	15
RO108	42008	CY 108x153 FF	61-12899	1330	0.066666	15
RO108	42008	CY 108x50 FF	61-12899	1330	0.023809	42
RO108	42008	CY 108x85 2T	61-12899	1330	0.037037	27
RO108	42008	CY 108x85 3T	61-12899	1330	0.037037	27
RO108	42008	CY 108x85 FF	61-12899	1330	0.037037	27
FN108	41080	BT 108	61-03609	887	0.027777778	36
TM108	21094	LD 108 FT	61-12898	1314	0.023809524	42
AG108	41097	RG 108 3T	61-03375	1499	0.027777778	36
AG108		RG 108 2T	purchased			
AG108		RG 108 1T	purchased			

Through table 1 it is possible to connect the defined formats and all the components with its work center and the correspondent type and quantity of raw material (tinplate coil).
Every format described is different than each other. This difference can be because of raw material type, raw material quantity, work center or the components connected do the can. The information about the components associated to each can format is presented in table 2.

Table 2 - Disaggregation process (Part 2)

Family	Format	BT	RG	LD
RO108	CY 108 3T	BT 108	RG 108 3T	
	CY 108 2T	BT 108	RG 108 2T	
	CY 108 1T	BT 108	RG 108 1T	
	CY 108 FT	BT 108		LD 108 FT
	CY 108 FF	BT 108		

By observation of table 2, it is possible to connect the format with its components. For instance, all the 3T format are composed by a BT 108 and a RG 108 3T. To find the raw material associated to each component, table 1 is consulted again.
The table 3 connects the family with its formats.

Table 3 - Disaggregation process (Part 3)

Format BI	Format Table 1
RO108	CY 108x130 2T
	CY 108x130 FT
	CY 108x132 1T
	CY 108x132 2T
	CY 108x132 3T
	CY 108x132 FT
	CY 108x137 FF
	CY 108x141,5 1T
	CY 108x141,5 2T
	CY 108x153 3T
	CY 108x153 FF
	CY 108x50 FF
	CY 108x85 2T
	CY 108x85 3T
	CY 108x85 FF

Finally, the table 3 disaggregate each family in its formats. This example shows the family RO108.
The dynamic process is described:

- Through the forecast by family, it is possible to disaggregate it to defined formats – Table 3;
- With forecast by format it is possible to connect it with its work center, and type and quantity of tinplate coil – Table 1;
- Having the demand by format and with the information about the can's body and the work center (table 1) can's format can be connected to its components – Table 2;
- Finally, knowing the components associated to the can (table 2) it is possible to find the work center and the tinplate coil necessary to produce it – Table 1.

Forecast by format enables the purchase department to buy suitable tinplate coil. On the other hand, enables the production planning department to plan mid-term load capacity of each work center (S&OP).
The next section, 5.2, describes the application of the time series models presented in section 4 to the format CY 108x132 2T.

5.2 Scenarios

Additive Classical Decomposition

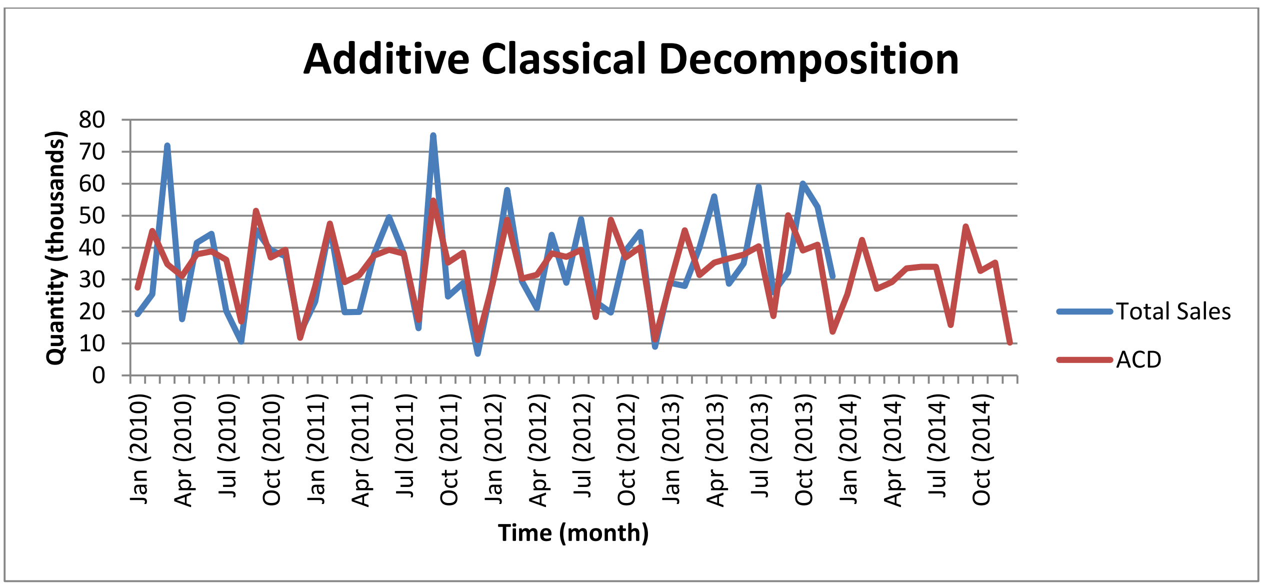

Figure 3 - Forecast with Additive Classical Decomposition to format CY 108x132 2T

Figure 3 illustrates the evolution of time series and the forecasted volumes to 2014 to CY 108x132 2T according to the Additive Classical Decomposition model. The mean squared error is 149.4.

Multiplicative Classical Decomposition

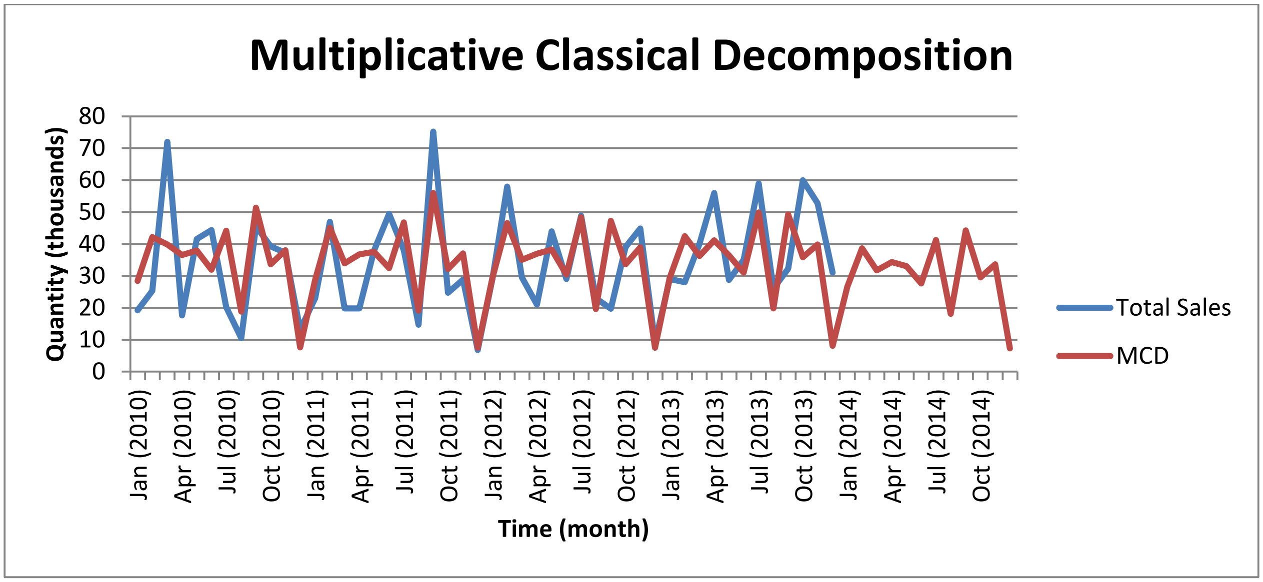

Figure 4 - Forecast with Multiplicative Classical Decomposition to format CY 108x132 2T

Figure 4 illustrates the application of Multiplicative Classical Decomposition to CY 108x132 2T. In this case the mean squared error is 157.6.

Additive Holt-Winters

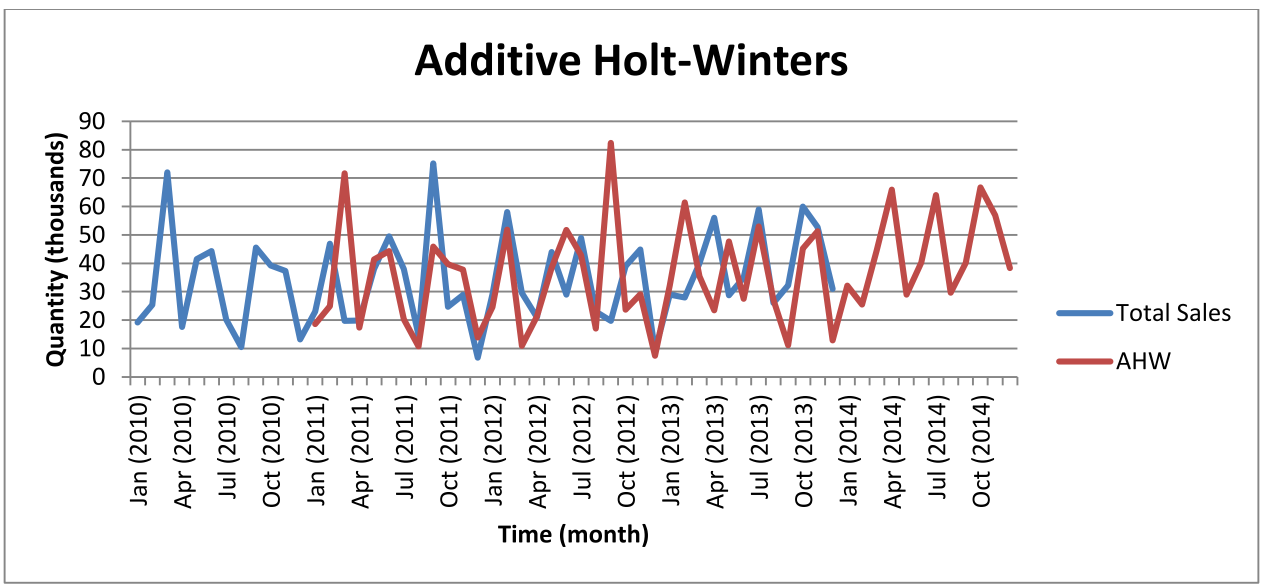

Figure 5 - Forecast with Additive Holt-Winters to format CY 108x132 2T

Figure 5 exhibits the behaviour of the CY 108x132 2T, and the forecasted volumes to 2014 according to Additive Holt-Winters. The mean squared error is 318.9.

Multiplicative Holt-Winters

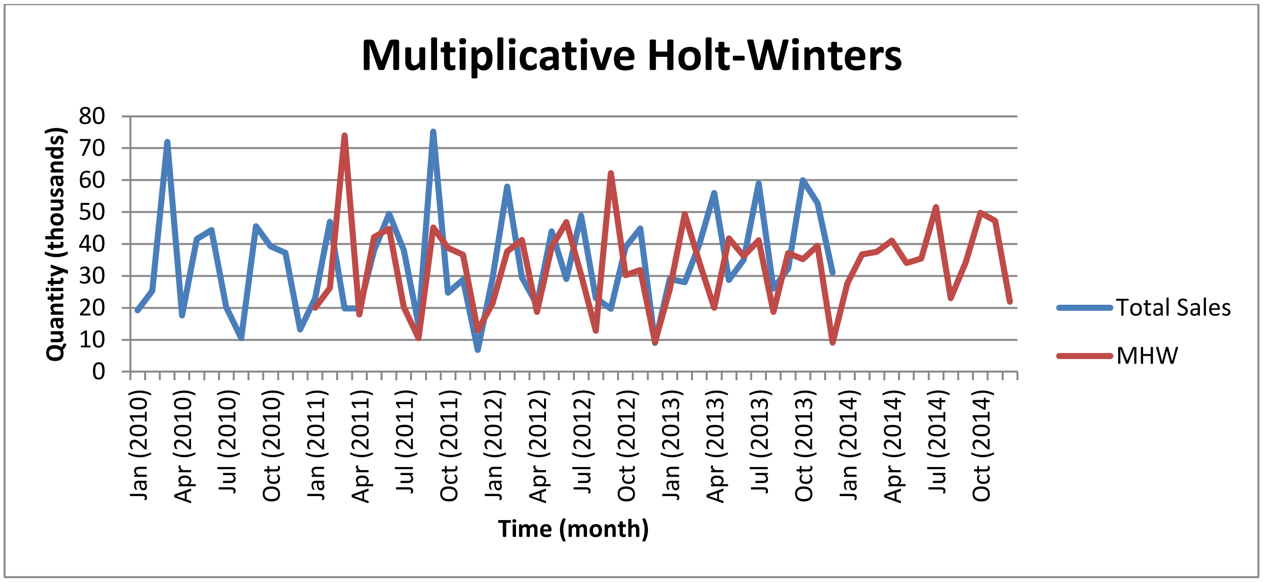

Figure 6 - Forecast with Multiplicative Holt-Winters to format CY 108x132 2T

In figure 6 is shown the evolution of time series and the forecast to 2014 by Multiplicative Holt-Winters method. In this case the mean squared error is 334.7.

Exponential Smoothing

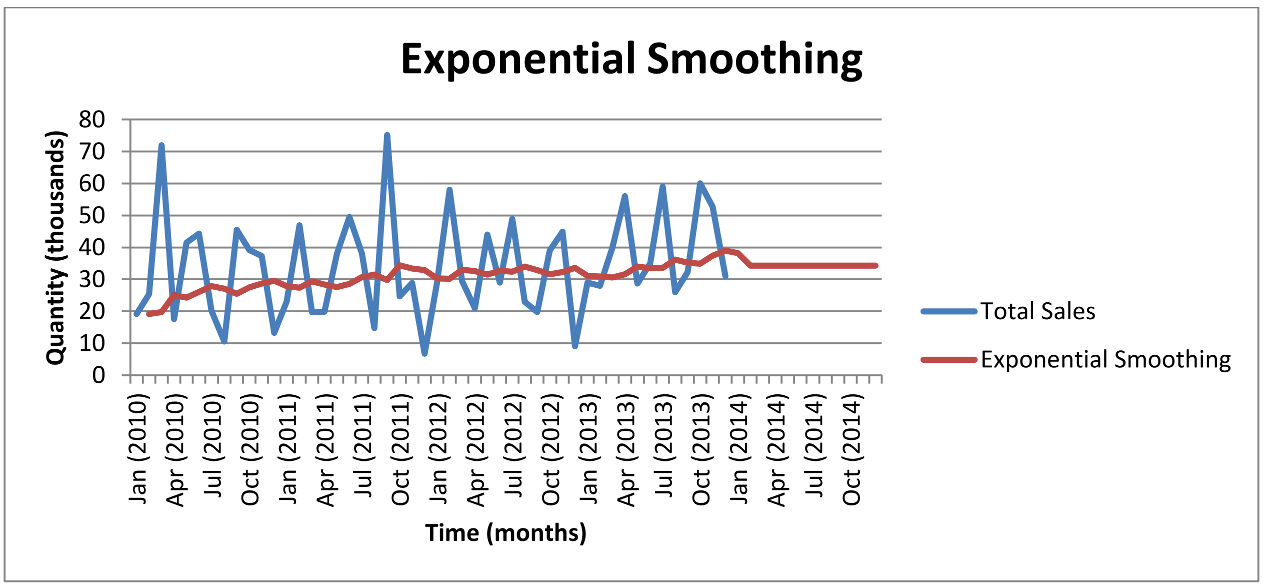

Figure 7 - Forecast with Exponential Smoothing to format CY 108x132 2T

In figure 7 is graphically presented the time series of CY 108x132 2T and its forecast according to Exponential Smoothing model. The mean squared error is 296.7.

Moving Average

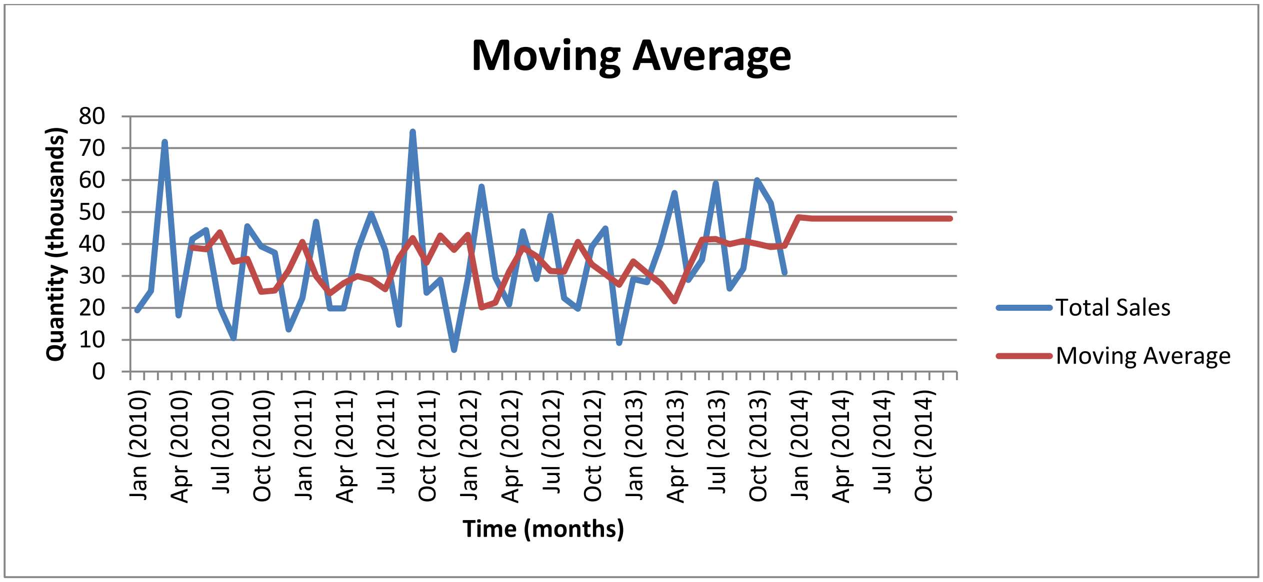

Figure 8 - Forecast with Moving Average to format CY 108x132 2T

Figure 8 presents the time series of past sales and the forecast to 2014 according to Moving Average method. The mean squared error associated to this model is 385.1.
In table 4 is indicated the mean squared error of each time series forecast model.

Table 4 - Best time series model to CY 108x132 2T

	ES	MA	ACD	MCD	AHW	MHW
EQM	296.7	385.1	149.4	157.6	318.9	334.7

Based on this criteria the best model is the Additive Classical Decomposition (ACD).
This procedure was done for all the formats of RO108.
Table 5 presents the best time series model for each format.

Table 5 - Best time series model to each format of RO108

Formato	Modelo
CY 108x130 2T	HWA
CY 108x130 FT	HWA
CY 108x132 1T	HWA
CY 108x132 2T	DCA
CY 108x132 3T	HWA
CY 108x132 FT	HWA
CY 108x137 FF	HWA
CY 108x141,5 1T	HWA
CY 108x141,5 2T	HWA
CY 108x153 3T	HWA
CY 108x153 FF	HWA
CY 108x50 FF	HWA
CY 108x85 2T	HWA
CY 108x85 3T	HWA
CY 108x85 FF	HWA

Selecting the best time series model to each format, volumes are forecasted according to past behaviour of each series.
Forecasting volumes by format it is possible to connect it with both purchase and production planning departments.

5.3 Connection with both Purchase and Production Planning Departments

Since the tinplate coil is bought with a 3 month lead time, and assuming that January is the start point of the analysis, the study is performed to April.
With the forecast volumes by format, and knowing, from table 1 and table 2, the components associated to each can, and the type and quantity of tinplate coil needed to each SKU, it is possible to determine the exact amount of raw materials needs. Table 6 indicates the forecast to April (in thousands), while the table 7 presents the raw material needs to April, according to the forecast.

Table 6 - Forecast to April by format

Format	Forecast to April 2014 (thousands of cans)
CY 108x130 2T	12.6
CY 108x130 FT	0.1
CY 108x132 1T	0
CY 108x132 2T	29.3
CY 108x132 3T	1.9
CY 108x132 FT	21.9
CY 108x137 FF	0
CY 108x141,5 1T	0.5
CY 108x141,5 2T	0.1
CY 108x153 3T	1.9
CY 108x153 FF	0.3
CY 108x50 FF	9
CY 108x85 2T	0
CY 108x85 3T	0
CY 108x85 FF	0

Table 6 presents the forecasted volumes to April based on best model to each format. According to this volumes it is possible to purchase tinplate coil in proper amounts. Table 7 indicates the raw material needs by tinplate type.

Table 7 - Tinplate Coil needs to April

Type of Raw Material	Needs to Abril (Kg)
61-12899	5453
61-03609	1952
61-12898	789
61-03375	300
61-12180	0

Analysing the information above it is possible to forecast the right amount of each tinplate coil.
On the other hand, the disaggregation process done enables the production planning manager to support decisions regarding to temporary job contract, increase or decrease the number of shifts, do in advance or postpone production, and so on.
The study presented in this paper is about the family RO108. After the disaggregation it is possible to connect unequivocally forecast with the correspondents work centers. The following figure illustrates this relationship.

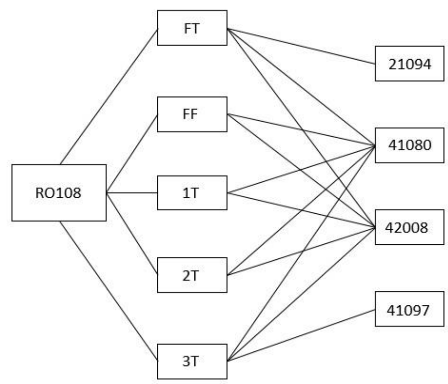

Figure 9 - Relationship between formats forecast and work center

Knowing the forecast by format, it is possible to forecast the load capacity of each work center.
Table 8 shows the load allocated in work center 42008 (values in thousands of cans).

Table 8 - Load in WC 42008 (in thousands of cans)

WC	42008
Jan Load	75.3
Feb Load	89.9
Mar Load	74.1
Apr Load	77.6

The maximum load capacity of work center 42008 is indicated below in table 9. It is known that this work center works one shift a day (8h), and that its efficiency is 55% on 3900 cans each hour. All this information is considered in table 9.

Table 9 - Maximum capacity of work center 42008 (in thousands of cans)

WC	Jan	Feb	Mar	Apr
42008	395	343.2	360.36	377.52

Finally it is presented the S&OP by work center. This information is summarized in figure 10.

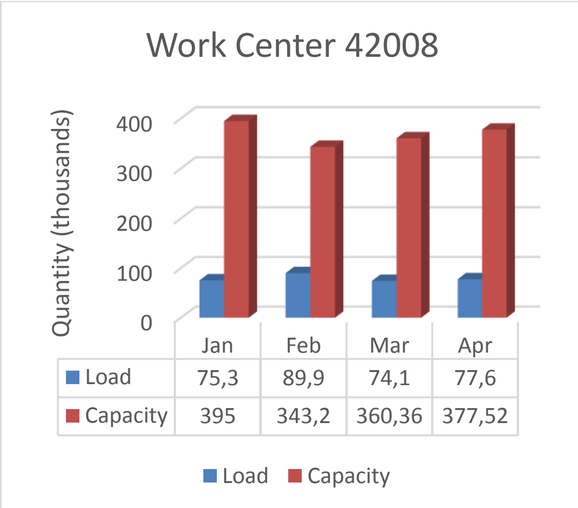

Figure 10 - S&OP in work center 42008

Observing the figure 10 it is possible to conclude that family RO108 gives a low contribute to this work center, less than 25% of all the capacity to each month. It can be fulfilled with another formats.

6. Conclusions

The problem studied in this paper is related to the improvement in the demand plan process management. This study shows the importance that the disaggregation of families into formats has for the company. Demand management department has been receiving sales forecast aggregated by family, and the information is useless for both the departments of production planning management and purchase management.
By forecast format sales it turns possible to connect the information and to integrate it into production planning management and in purchase management. It is possible to find the real need of each tinplate coil, the main raw material in metal packaging industries. On the other hand it is allowed to manage the work centers properly, and efficiently.
Based on the conducted literature review it was pointed out the importance of the demand management process along the supply chain management, and a new model of sales forecast was developed. The results show that according to the disaggregation process used, the information about sales forecast can be useful. This information can help the decision make.
Some future studies can also be performed regarding the problem addressed in this paper.

First it would be important to analyze new time series models, or even statistical forecast models in order to better predict future sales, and get more accurate information. Another solution, and probably the best one, could come from the market and commercial department. This department could make efforts to receive forecast by format directly from the customers. Thus it is expected that the work done can be a useful tool to support the decision make for both the production planning management and purchase management departments.

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