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Demand Forecast for Sim Cards Replacement in a Mobile Phone Distribution Company from Mexico

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***Abstract*:** This case study was carried out in a small authorized Mexican distribution company of chips for mobile phones, located in Mexico City, and its main objective is to increase forecasting accuracy to fulfil customer orders whilst delivery costs from the supplier to the customers are reduced. Currently, there is a competitive market due to presence of many competitors and to the entrance of new ones, as well as the pandemic environment. The company is facing pressures from its customers, who, as result of the increased demand uncertainty, require shorter delivery times compared with those previous the pandemic situation. To continue in the market, the company needs to increase the efficiency and effectiveness of its inventory, but since its forecasts are based on experience, sometimes they have high peaks in inventory and sometimes out-of-stocks, which negatively impacts profits; moreover, it takes at least three days to receive chips from suppliers and one day to activate and top-up the chips, taking at least four days to deliver to the customers. Hence, to help the company to improve demand forecasts and reduce costs for this company, it was used traditional forecasting methods, such as minimum squares, weighted moving average, Brown, Holt, and Winter (even and odd) to identify which of them best fit and that can be used to forecast next month demands, based on historical data. Mean Absolute Percentage Error, Mean Square Error, and Mean Absolute Deviation were used to identify the best model. As the analysis result, Holt method was the best model to be used for forecasting purposes, with a mean absolute deviation of 0.0103, a mean square error 0f 0.0002, and a mean absolute deviation of 0.001%, helping to the company to plan better, using a mathematical model, and reducing costs while increasing the customer satisfaction. Finally, with this application, it was highlighted the importance of using forecasting models to improve inventory of finished goods.

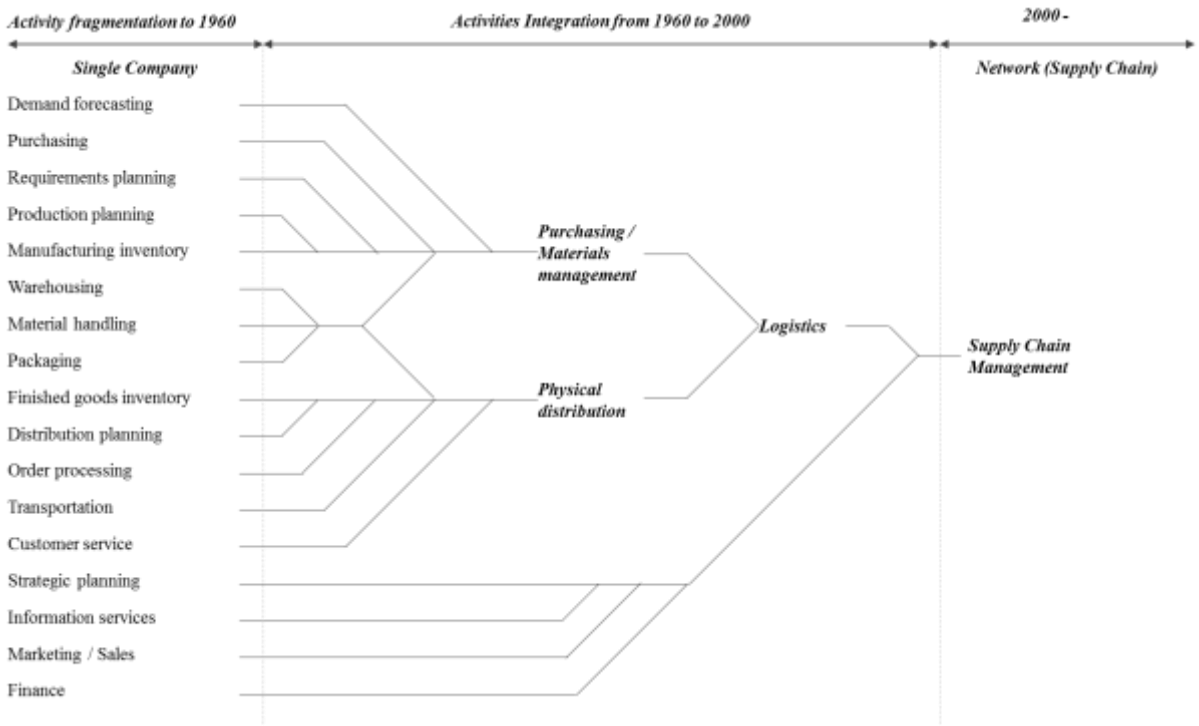
***Keywords*:** Accuracy, Demand Forecasting, Mean Absolute Percentage Error, Supply Chain, Logistics, Holt, Winter, Least Squares.

I. Introduction

This case study was based on a small supplier of chips (a distributor) of a mobile phone service supplier since they are facing increasing market competence, and sometimes they cannot deliver the correct quantity to the customer due to the lack of chips acquired, and it takes time to get them from the telephone service company. Moreover, it is also influenced by the number of carriers increasing in Mexico with a high shared market, like Telmex (a subsidiary of America Movil), Telefonica, and AT&T, Izzi, Axtel, Megacable, and Totalplay (Amr, Ezzat and Kassem, 2019; Arechavala, and Diaz-Perez, 2019; Azmi et al., 2018; Hassan, Nabil, and Rady, 2015), which puts to the company in a hurry to improve their supply chain, starting from the forecasting accuracy, since they only can sell chips from one of these carriers. Moreover, such as is stated as the OECD, the Mexican sector of telecommunications has had meaningful changes in the reform in 2013. These changes include the reduction of SIM cards, which also increased the competency; for the company, it represents a challenge to reach its customers and keep them, since they must use different strategies to be fast in the delivery so that they can improve the value delivered to the customers.

As the world is not static, everything has changed as well as the approach to analyse the market and companies; so, at first, it was analysed companies and its functions, but now the perspective is a network and its relationships (Figure 1). Due to globalization waves have grown-up, companies have implemented shoring-sourcing strategies to reduce costs, improve customer satisfaction, quality process and productivity (Vaishnavi and Suresh, 2020); which increase the complexity of the processes, due to boundaries system must be extended outside the company, improving the relationship with the stakeholders by means of relationship marketing (Taylor et al., 2015). Hence, to do it, many activities can be applied to improve the supply chain management, such as mentioned by (Bhaskar, 2007), among it can be mentioned demand forecasting, so the company can integrate the activities into the logistics planning and execution to work along with the supply chain network and achieve the supply chain management. Some trends that appear along time, such as reverse logistics, flexibility, integration and collaboration, global cost forces, global market forces, technological forces, and political forces, make it complex, even though they have existed before, they have been evolved from a single company focus to the SCM application. So, it can be observed that globalization is the enabler of the other trends (using its four forces) due to it makes market competitors increase, and customer demand is uncertain, which make products have a shorter life cycle; as a result, companies must think more about reverse logistics and supply chain integration and collaboration. Reverse logistics is important because suppliers must focus more on the logistics of damaged products returned by customers for repairing, which should be done with high efficiency, effectiveness, low cost, and agilely to get high customer satisfaction and loyalty (Vaishnavi and Suresh, 2020). Also, lean-agile strategy – also known as Leagile and it is the combination of lean and agile within supply chain - is important, which imply responsive with best practices, so it is required visibility, flexibility and integration and collaboration, which does not mean that all these trends should be satisfied at the same time to apply lean-agile, but they affect the performance of it.

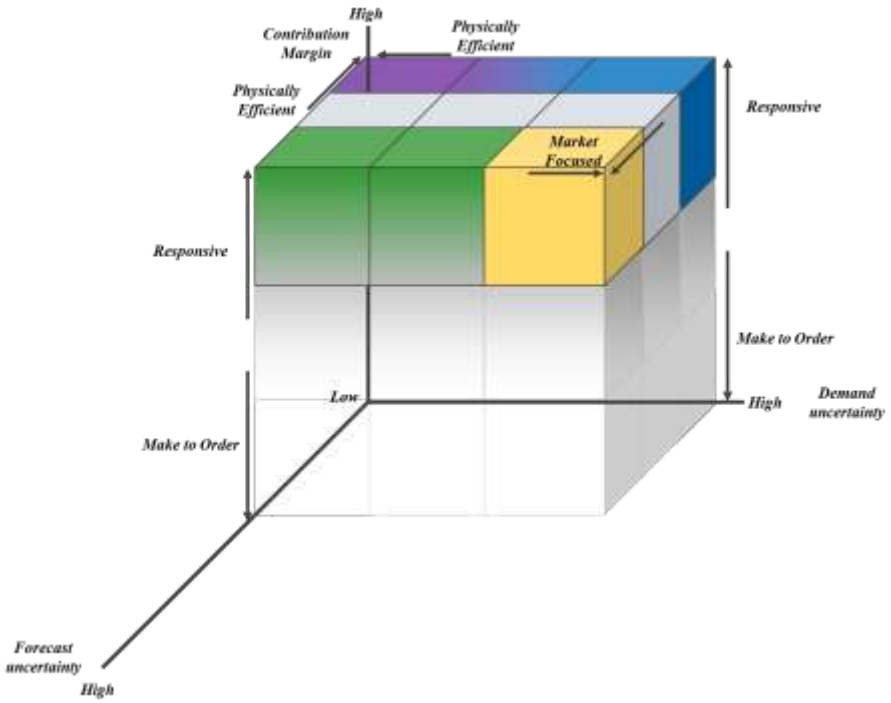
Figure 1. *SCM Evolution.*



Source: Own development with data from Bhaskar, (2007).

On the other hand, there are factors to respond to the market, as it is shown in Figure 2, in which it can be seen how the strategy for the supply chain can be addressed depending on the market uncertainty as well as forecast error or uncertainty, so the company must be focused on the market when there is high unpredictability in the data.

Figure 2. *Responsiveness to Market Requirements*



Source: Own development

Regarding Figure 2, as the product's contribution margin is growing and forecast and demand uncertainty is low, Supply Chain should be efficient physically; by contrast, as all these factors are high, supply chain should be more responsive to the market. Also, in some cases product's supply chain needs to be market-responsive and they need to implement agile strategies (Rahman, 2018), because the physical flows must focus on innovative products and they require fast delivery to match with a high demand uncertainty, whilst, in other cases, it is required to implement physically efficient supply chains, for which it is recommended to use lean strategies (Carillo, 2022) in order to match with functional products, which require accurate planning and replenishment with reduction of wastes, and finally, there are products that requires physically efficient and market-responsive supply chains for which it is recommended to use a combination of Lean and Agile (Leagile) strategies (Carrillo, 2022), since market demand has high uncertainty but, at the same time, it is needed to reduce costs (Chevalier, 2022).

II. Background

The management of the supply chain and organization assets is important for every company, mainly because they have limited resources, for which, along time, it has been developed different strategies whose implementation has been increasing along years such as postponement, shoring, outsourcing, quality, globalization, change on consumer demand patterns, relationship marketing and cost reduction, among others, and whose trends related to them are summarized in table 1.

Trends	Some Facts
Prior 1960	***Emerging concept: Logistics, but just in military activities***
Organisational functions	Business leading by Price, Product, Promotion and Place (4P).
Mass production	Sea container creation.
Lean Thinking (Late 1940s)	Leading by push systems.
	Materials Requirement Planning (MRP) development.
	Physical distribution was considered as Place in marketing mix.
Since 1960	***Emerging concept: Business Logistics***
Physical distribution	Business Logistics: Integration of physical distribution with physical supply.
	Application of military experience.
Since 1970	***Emerging Concept: Integrated Logistics Management***
Procurement Distribution	Increase of logistics emphasis.
	Development of JIT (Pull system) and Kanban systems.
	Transport deregulation.
	Increase of costs (such as energy and transportation.
	Growth of third-party distribution industry and transportation modes.
	Increase of advanced computer technologies (4th generation).
	Electronic Data Interchange (EDI) development.
	Use of barcodes in products.
Since 1980	***Emerging Concept: Supply Chain Management (SCM)***
Business integration	Introduction of Cross-Docking concept by Walt-mart.
Strategies alliances	IBM outsourced its activities.
Commoditisation	Introduction of Reverse Logistics concept.
Customer service	Manufacturing Resource Planning (MRP II) development.
	Late of 80's logistics management concept covers from suppliers to end customers and it is known as SCM.
	Total Quality Management (TQM) development.
	Six Sigma development.
	Theory of Constraints (TOC) development.
	Automation of production by Toyota.
	Surging of Third-Party Logistics (3PL)
Since 1990	***Emerging Concept: Logistics is defined in business environments***
Agile Manufacturing	Differentiation between Logistics and Supply Chain Management.
Business Process Reengineering	Increase of company integration.
Customisation	Increasing of imports from China.
Customer Relationship Management	Technology revolution, development of systems: Enterprise Resource Planning (ERP), Electronic Data Interchange (EDI), Customer Relationship Management (CRM), Business Intelligence (BI), etc.
Quick Response	E-commerce development.
Efficient Customer Response	Vendory-Managed Inventory (VMI) development.
	Collaborative Planning, Forecasting and Replenishment (CPFR).
	Sourcing of Fourth-Party Logistics (4PL).
	Concept of Fourth-Party Logistics (4PL) Provider is coined.
	Introduction of Leagility concept.
Since 2000	***Emerging Concept: Supply Chain Management World Class***
Leagility	Radio Frequenci Identification (RFID) in the supply chain.
Visibiluty and real time information	Production is moving to low-cost countries (South-East-Asia).
Mass customisation	Increase of competence in the market.
Reverse Logistics	Extensive investments on information Technologies (such as ERP).
3PL and 4PL	High investment on optimisation software.
Product Lifecycle	Increase of collaboration supplier-manufacturer.
Integration and Collaboration	Increase of communication and development supplier-manufacturer.
Flexibility	Creation of Electronic Supply Chain (ESC).
Transportation markets	

Table 1. Logistics and Supply Chain Management Trends

(**Source:** Own development with data from Badiru, 2014; Bhaskar and Singh, 2007; Chopra and Meindl, 2016; Da Silva, Farreira and Bahiense, 2014; Flory, 2013; Frankfurter, 2016; Ghiani, 2013; Goldschmidt and Schmieder, 2022; Habib, 2011; Harrison and Hoek, 2014;Harsono, 2011; Hollmann, Scavarda, and Thomé, 2014; Hyndman, 2014; Jain, Malviya, and Arya, 2021; Koç, Delibas and Anadol, 2022; Mangan, Lalwani, and Butcher, 2020; OECD, 2017; Rajagopalan, 2016; Rushton, 2014; Shena, 2018; Taylor et al., 2015; Vaishnavi and Suresh, 2020; Virmani and Saha)

Changes in customer behaviour modified companies focus, shifting from just product quality to the customer service inclusion by using Total Quality Management – TQM (Da Silva, Farreira, and Bahiense, 2014), technology and inter-functional and inter-organizational coordination of companies (Bhaskar, and Sight,

2007); it is the origin of the "Supply Chain Management" concept, even though it was used interchangeably with "logistics" (Gao, 2013).

Lately, 80s LSCM revolution had started and in 90's the Council of Supply Chain Management Professionals (CSCMP) marked the difference between logistics and Supply Chain Management concepts (Gao, 2013). Moreover, with the increasing strategies to improve efficiency and effectiveness of Logistics and Supply Chain Management (LSCM), companies worked closer to contribute to the value adding to the final customer [16], emerging new ways of work as partners such as Quick Response (QR), Efficient Customer Response (ECR), Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), and Collaborative Planning, Forecasting and Replenishment (CPFR), which were converted into enterprise software systems thanks to the technology revolution, which increase data availability and accuracy, planning and control of logistics activities and, as a result, the increase of visibility (Chopra and Meindl, 2016).

1.1. Forecasts Models

L-shaped Matrix from Table 2 shows that factors are considered for every method to forecast (Harsono, 2011). It shows if any method requires another to make calculations (for example, for winters method, in the row, it takes in count seasonality, and holt's method to get initial conditions, and by applying these, forecast algorithm was run).

METHOD\FACTOR	RANDOM	TREND	SEASONALITY
Least Minimum Squares	X	X	
Weighted Moving Average	X		
Brown	X		
Holt	X	X	
Winter Odd	X	X	X
Winter Even	X	X	X

Table 2. Forecasting Method (**Source**: Own development with data from Chopra and Meindl, 2016; Harsono, 2011; Hyndman, 2014)

Based on Dekier (2012) and Rushton and Baker (2014), formulas of each method are given in Table 3, whose considerations (such as randomness, trend, and seasonality factors) must be taken in count when apply in them. For each formula, it can be seen that is present factors mentioned in Table 2, whose variables are: Randomness (L), Trend (T), and Seasonality (S), each one of the for the forecast time given (t) or a determined range of time (p).

Method\Factor	Equations	
Least Minimum Squares	$\hat{y} = L + T$	(1)
	$\sum D = nL + T\sum t$	(2)
	$\sum tD = L\sum t + T\sum t^2$	(3)
Weighted Moving Average	$\hat{y} = \frac{\sum_{t=1}^{n} w_t D_t}{n}$	(4)
Brown	$F_{t+1} = L_t + T_t$	(5)
	$L_{t+1} = \alpha D_{t+1} + (1-\alpha)(L_t + T_t)$	(6)
Holt	$F_{t+1} = L_t + T_t$	(7)
	$L_{t+1} = \alpha D_{t+1} + (1-\alpha)(L_t + T_t)$	(8)
	$T_{t+1} = \beta(L_{t+1} - L_t) + (1-\beta)T_t$	(9)
Winter	$F_{t+1} = (L_t + T_t)S_{t+1}$	(10)
		(11)

$$\bar{D}_t = \begin{cases} \dfrac{D_{t-\frac{p}{2}} + D_{t+\frac{p}{2}} + \sum_{i=t+1-\frac{p}{2}}^{t-1+\frac{p}{2}} 2D_i}{2p} & for\ p\ even \\ \dfrac{\sum_{i=t-\frac{p}{2}}^{t+\frac{p}{2}} D_i}{p} & for\ p\ odd \end{cases} \quad (12)\ (13)\ (14)\ (15)$$

$$L_{t+1} = \alpha \frac{D_{t+1}}{S_{t+1}} + (1-\alpha)(L_t + T_t) \quad (16)$$

$$T_{t+1} = \beta(L_{t+1} - L_t) + (1-\beta)T_t$$

$$S_{t+p+1} = \gamma\left(\frac{D_{t+1}}{L_{t+1}}\right) + (1-\gamma)S_{t+1}$$

$$S_t = \frac{D_i}{F_t'}$$

$$S_i = \frac{\sum_{j=0}^{r-1} \bar{S}_{jp+i}}{r}$$

Table 3. Formulas for Forecasting Methods (**Source:** Own Development with data from Chopra and Meindl, 2016; Dekier, 2012; Harsono, 2011; Hyndman, 2014; Rushton and Baker, 2014)

Where:

L = Level or random factor
T = Trend factor
S = Seasonal Factor
D = Demand
F = Forecasted Demand
i = ith Seasonal Demand
n = Number of historic demand periods
t = Time
w = Weight for the given demand
p = Seasonality period
α = Smoothing index for level
β = Smoothing index for trend
γ = Smoothing index for seasonality

Given that the company studied is a retailer and the fact that the only data that was collected was the demand, even though there are other methods, it will only be used methods in Table 3. It is essential to mention that, since some methods use an index to smooth the trend, level, or seasonality, as well as a weight, it will be used linear programming to determine the best index to get the most accurate result for the demand forecast.

On the other hand, to determine which method bests fits for the forecasts, are those whose metrics are the minimum, for which it is considered usually according to Harsono (2011) Mean Absolute Deviation (MAD), Mean Square Error (MSE), and Mean Absolute Percentage of Error (MAPE), which are shown in Table 4.

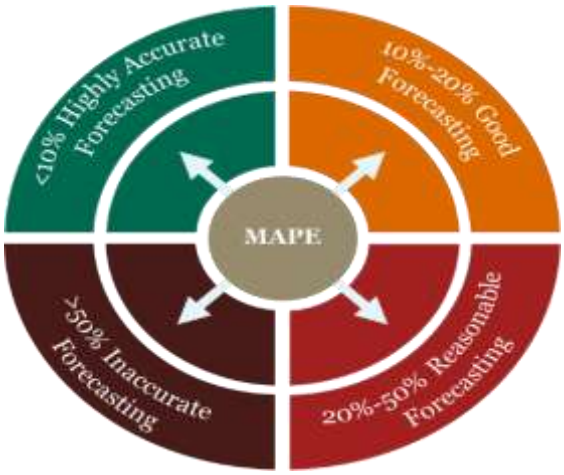
Method\Factor	Equations	
Error	$e = F - D$	(13)
Mean Absolute Deviation (MAD)	$MAD = \frac{\sum\|e\|}{n}$	(14)
Mean Square Error (MSE)	$MSe = \frac{\sum e^2}{n}$	(15)
Mean Absolute Percentage of Error (MAPE)	$MAPE = \frac{\sum \frac{\|F-D\|}{D}}{n} = \frac{\sum \frac{MAD}{D}}{n}$	(16)

Where n is the number of demand periods.

Table 4. Formulas for Fit Forecasting Metrics (**Source**: Own development with data from Harsono, 2011)

Regarding the MAPE, it is important to mention different ways of considering if the forecast is accurate or not, as shown in Figure 3.

Figure 3. MAPE Assessment Criteria



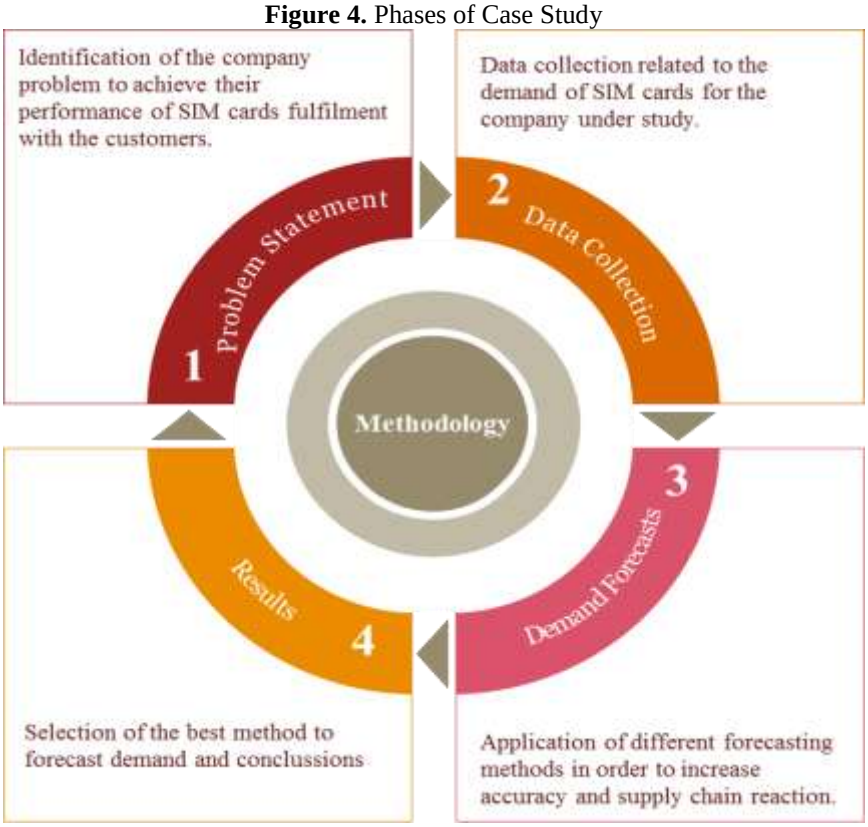
Source: Own development with data of Gilliland, (2012).

III. Methodology

The research was developed using a four-stage methodology (Figure 4) which are:

1) Problem statement: it is described what is the main problem to solve, related to the fulfilment of the client requests of SIM cards, so the logistics and supply chain performance can be improved.
2) Data collection: it was collected data related to the monthly demand for SIM cards from customer (it includes delivered and not delivered chips).
3) Demand forecasts: It was applied different forecast methods, so it can be obtained the most accurate method to calculate the demand.
4) Results: it is selected the method that best fits the demand according to the MAPE (Figure 3), and it will be used to forecast each month demand.

Figure 4. Phases of Case Study



Source: Own development.

IV. Results

1.2. Problem Statement

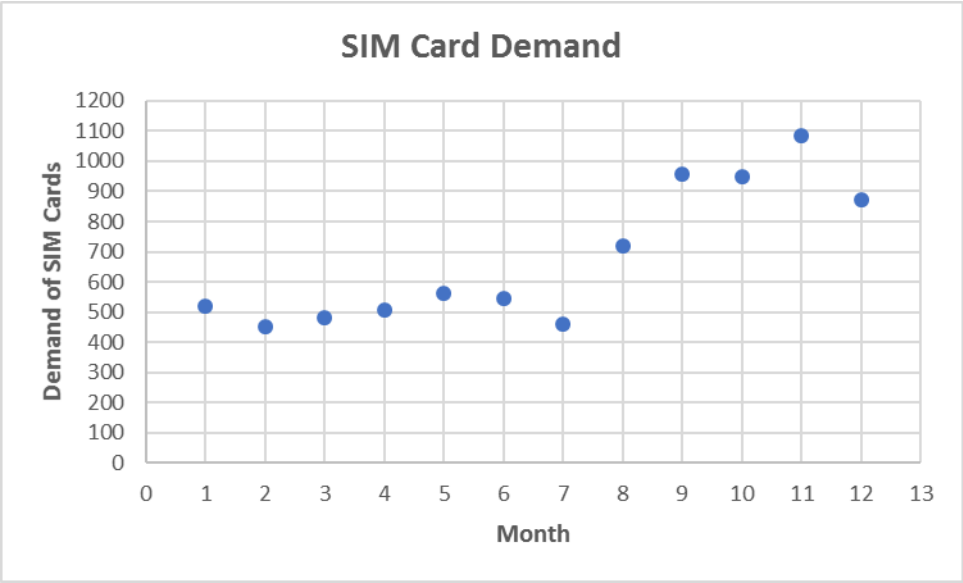
This case study was carried out for a company that buys and distribute SIM cards for mobile phones for a determined carrier. This is a small business and relatively new, so they do not have so much information details to forecast the demand or any factors that help to improve the efficiency and effectiveness of its supply chain, mainly because they do not use to consider data as important as it is. They think they can implement different strategies of delivery and plan one day in advance; however, sometimes when they arrive to the customers, it is found out that the quantity of chips that are delivering is lower than required for the customer, since these clients do not also receive the chips on time, or they do not use any method to forecast based on past request. It is important also to mention that the company is looking for improvement of the chips forecasts since the competition is growing and when the customer did not receive what they need, they change of supplier.

Based on those mentioned above, it is important to forecast the demand accurately, so the company can deliver to the customer the right quantity, in the right moment and keep their customer satisfied because of demand fulfilment, so the decision making in selecting the right number of chips to deliver is essential for them. So, it will be applied different methods, but before doing it, it will be graphing the demand to know the behaviour and the factors (random factor or level, trend, and seasonality) that are implicit in the demand, which are important to get an accurate forecast, increasing the efficiency, effectiveness and revenue for the company, as well as it will help to avoid losing customers because of the lack of inventory. Once the methods are assessed, it will be selected the best to fit the demand based on the MAPE metrics.

1.3. Data Collection

Data collection was carried out by retrieved historic demand from the excel files of the company since they record sales and the chips that could have been sold if they had inventory. However, the level of details shown is monthly and the only data that can be used from a timeline of one year, since the data from previous year was used for training and testing, which will let to identify the demand behaviour. The real demand is shown in Figure 5, showing how the behaviour is for each month, starting from January.

Figure 5. Monthly Demand for SIM Cards.



Source: Own development

On the chart, it can be seen that the demand has a random component from months 1 to 7, as well as a growth or trend component from months 8 to 12, showing a slight seasonality every three or four months. Hence, it indicates that it could be possible to use a method that considers level, trend and seasonality; however, since the seasonality is almost null, it could be useful a method with level and trend only, but it has to be assessed based on the results of each forecasting method.

1.4. Forecasting

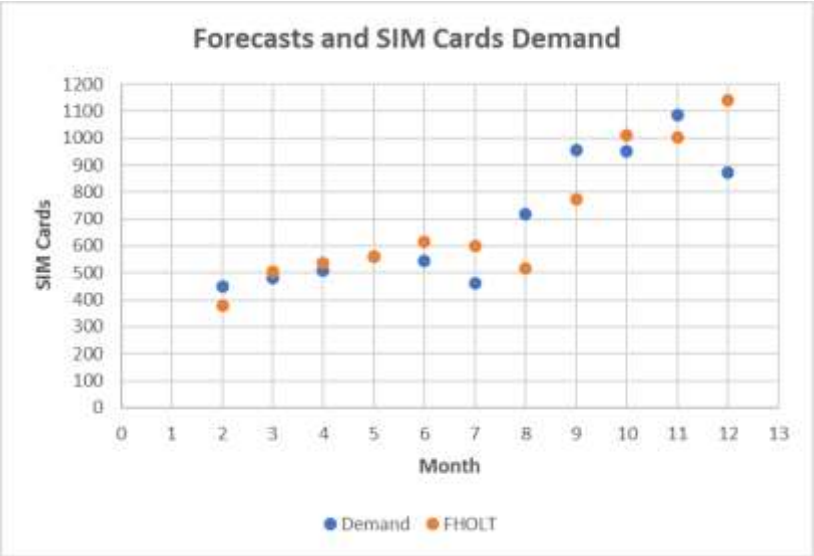
Once it was applied the methods mentioned in Table 3 with their respective formulas (simple exponential smoothing or Brown Method, weighted moving average, minimum square method, double exponential smoothing or holt, and holt-winters method or triple exponential smoothing), it was carried out the analysis of the results, which are shown in Table 5. As it is shown, there are different metrics, even though the decision will be made based only on the MAPE metric, since it measures the accuracy and the best fit based on Figure 3.

Method	α	β	γ	$\bar{e}$	MAD	MSE	MAPE
Least Minimum Squares				-63.6120	115.4172	19,645.8207	18.434%
Weighted Moving Average	0.9998	0.0001	0.0001	-43.4634	114.3266	21,905.5518	14.899%
Brown	0.9999			-32.2779	102.6341	18,435.8889	14.168%
Holt	0.9999	0.0001		0.0004	0.0103	0.0002	0.001%
Winter Odd (p=3)	0.9999	0.9149	0.0008	16.1912	90.9041	15,272.3331	13.897%
Winter Even (p=4)	0.3813	0.1589	0.0334	47.7505	121.7086	24,990.7364	18.732%

Table 5. Forecasting Methods Results (**Source**: Own development)

In Table 5, it is able to be seen that all the forecast methods have a MAPE less than 20%, but just one of them has a MAPE less than 10% it means, the least minimum squares, weighted moving average, brown, winter odd and winter even are good forecasting methods or showed good forecasts; however, the holt method is highly accurate since the MAPE is less than 10%, so it is the method that will be selected to forecast the demand for SIM cards.

Figure 6. Monthly Demand and Forecasts for SIM Cards.



Source: Own development

Figure 6 shows how close are the demand and the forecasts, so the percentage of error is low for the Holt method, being it more accurate to be used as a forecast method to plan inventory and buying of SIM cards so the customers cannot be lost since their needs are not fulfilled. Hence, even though the forecasts are closer for the holt method than the rest of them, if new demand is presented or it changes, the method also must be changed, it means, not because it works this time with high accuracy it will always be that way, so it is important to monitor the demand behaviour so that it can be changed the method or reduced the error by using other techniques. The most important here is that the company at least now has a tool to determine how many SIM cards must acquire to fulfil market demand, increasing the value perceived by customers. Moreover, in this method, according to Table 5, the higher weight of the demand is given to the level factor, instead of the trend factor, which has a small value, which is about 0.0001, whilst the level index (alpha) is about 0.9999, which was optimized using linear programming, so the index was optimal for each case.

V. Discussion and conclusions

Regarding the case study analysed, it was found out that traditional forecasting methods like holt can be used to forecast the demand, it is because the MAPE is less than 10%, the rest of the methods can be used, but the percentage of error is between 10% and 20%, which makes them suitable. However, they cannot forecast as suitable as expected, so the only method to be used is holt or simple exponential smoothing. In spite of this result, it is important to mention that if there were information available regarding costs and type of clients, the forecasts could be done using a Pareto rule, it means selecting only the 20% of the customers with the 80% of the sales, it could be more focused forecasting for the customers, and it could be applied some supply chain strategies as mentioned before to improve the efficiency and effectiveness of it. Moreover, even though it has been calculated demand forecast with minimum error and despite it will help meet the objectives of the company without sacrificing service level, there are some important factors like costs, distances and some sales promotions that should be taken in count to get a better logistics process.

On the other hand, it is important to mention that, in order to have an improved planning and with minimum error or reduced error, it should be considered the lead time and the whole process, which will help to improve the whole logistics and supply chain process since it will be taken in count transportation times or delivery times, which is important by the customer, since when they have a client who is going to buy a chip, he is not willing to wait more than a minute to get them, so the company should consider times to send the product to the shops so the customer can have their product in the right moment and in the right quantity. Moreover, other factors that would help to improve the forecasts and use other methods, such as linear regression, are costs, promotions, and other strategies they implement, so it can be reduced costs, creating a leaner supply chain, as well as a customer focused process, improving business capabilities, as well as customer perception by increasing the value, as stated by Karagöz**,** (2021), which is shown in Figure 7.

Figure 7. Value Definition

Source: Own development with data from Karagöz, (2021).

Traditional forecasting methods are suitable depending on the factors that have an influence in independent demand (such as randomness, trend and seasonality) but it is important to mention that there could be other factors or variables affecting the demand and that should be aborded in a different way (such as delivery times, customer satisfaction, promotions, etc), which are related with the value definition stated by Karagöz, (2021); so, they will fulfil customer requests with the minimum inventory, because even though the company is currently dealing with lack of inventory to satisfy customer demands, they should have some products in stock so they can satisfy the customer faster, but those levels should be studied using other approaches of dependent demand. Hence, the recommendation for the company is the analysis of inventory management, so it could improve the supply chain and logistics even better, it means, not only focused on final products and independent demand, but also planning the inventory management, costs, and the logistics and supply chain network, so that the customer satisfaction and value is increased.

Finally, it is important to mention that, as it was analysed, not necessarily the more complex method will be the solution or will work, since it depends on the demand behaviour. Also, it must be forecasted by using data related to the demand, since most of the times it is used sales, but it does not necessarily imply that the forecasts are accurate since they not reflect the demand. Hence, the selected method reflects the reality for the company since it used the demand to forecast new data. Moreover, if there would be more details, it could be created a more accurate forecast, applying other tools like linear programming (as it was applied) or linear regression, which was not applied in this case, but that can be possible to do if we had more than one variable, which is further research to be done for this case study.

Disclosure Statement

The authors declare no conflict of interest.

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