FORECAST ERROR OF VEHICLE VISITS TO A REPAIR SHOP IN QUANTIFYING THE INVENTORIES

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Abstract: *Forecasts in logistic systems, including the aspect of inventories have the objective of reducing the effect of time delay in balancing the supply and demand. The forecast error effect can be considered, especially in case of inventories through financial losses and the level of service. The spare parts in automotive industry represent a big financial capital. It is precisely for that reason, as well as the reason of market affirmation of certain makes through the level of service of the center, that the significance of the policy of spare parts inventories management is constantly increasing. The paper shows the implementation of the ARIMA method of forecasting the vehicle visits to the repair shop, and in which way and how much the forecast error affects the capital invested in the spare parts inventories.*

Key words: *inventory management, demand forecast, forecast error*

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1. Introduction

The main characteristic of the repair shops is the service characterized by the variability in the quantity and time of serving. Independent of the subject of work, the operation planning is the subject of forecasting. The demand forecasting for a certain product represents the subject of the trend of target market demand, which proportionally depends on the presence of the competitive number of the same product on the market and its marketing recognition. From the aspect of inventories in the goods production process, the element of requirement forecast is stipulated among other things also by the capacity of the production process, and the planning of quantities and the types of inventories is proportional to the capacity with the usual triple increase (sufficiency of inventories for three days of production).

Furthermore, in the service production process the demand forecast elements are more complex and require simultaneous monitoring of exact and assumed parameters. The inventory in the service production process represents a very important element. Its availability in quantity and type is very often in literature directly connected to the level of service. The service production process is characterized also by the size of the storage capacity which directly stipulates the distribution network as well. Unlike goods production, in case of the service activity, due to the stochastic character of demand, the capacity requirements of the warehouse space vary.

Inventory management can be considered also as a subset of elements of the entire logistics planning based on the market flow forecasts. Generally, forecasting represents an attempt to determine in advance the most probable outcome for uncertain variables. The forecasts in logistics systems, also from the aspect of inventories, have the aim of reducing the effect of time delay in balancing the supply and demand. The effect of forecast error can be observed, especially in case of inventories, through financial losses and the level of service.

The spare parts in automotive industry represent great financial capital. Therefore, as well as because of the automotive market affirmation of certain makes through the level of service, the policy of spare parts inventory management is gaining in significance. Service centres software solutions for spare parts inventory management do not deal with the forecasts of vehicle visits, nor do they record the level of the realized user service. Solutions mentioned above use the warehouse history data on the inputs and outputs, and using the method of arithmetic mean, give recommendation on the quantity and type of spare part to be purchased. Thereby monitoring the level of service, as well as management of the “frozen” capital in spare parts, is left to the management staff. The objective of this paper was to show by means of ARIMA (Autoregressive integrated moving average) method the forecasting of the vehicle visits to the repair shop, as well as in which way and how much a forecast error can influence the invested capital into the spare parts inventory. Furthermore, the objective was to open the issue of software solutions for monitoring the level of service in the repair shops precisely through monitoring the forecast errors and the availability of the spare part, and the development of dynamic models in managing the “frozen” capital in order to purchase the spare parts.

By analyzing the existing literature, single factors have been considered and their influence on the set goals of this research determined. However, through past research in this area the forecast error in the function of quantification of spare parts inventory in automotive industry has not been studied at one place.

2. Spare Parts Inventories Management

The basic objective of inventory management is to determine the levels of inventories that will minimize the total operative cost with simultaneous satisfaction of the user requirements for service. In practice, a more successful policy in inventory management needs to satisfy five factors: (1) the relative importance of customers; (2) the economic significance of different products; (3) transportation policy: (4) flexibility of the production process; (5) competition policy (Ghiani et al.,2004) Taking this into consideration, the inventory management represents the financial trade-off between the cost of the inventories and the cost of the shortage of inventories. Increase in the level of inventories requires greater working capital and at the same time contributes to greater depreciation of inventories.

The control of spare parts inventories has an increasingly important role in modern operative management. The trade-off here is very clear: on the one hand a large quantity of spare parts binds a large amount of the capital, whereas on the other hand the insufficient quantity of spare parts on stock can result in poor user service or very expensive emergency purchase. Independent of the type of spare parts users, e.g. aircraft, motor vehicle, telephone switch, etc. from the aspect of spare parts inventory, the same rules are valid. The breakdown of the working means requires a replacement of the cause of the failure in order to be able to continue to work. The period from the moment of failure to the moment of functioning again, represents a loss for the user. The value of loss in waiting for the repair of the means can be measured by the customer through the level of service of a repair shop. Along with all the other service elements, the availability of the spare part has a very important role in assessing the level of service of the repair shop. Usually, the maintenance of the working means in the operation of repair shops distinguishes regular maintenance and maintenance due to sudden failure. In regular, planned maintenance, the range and the quantity of spare parts are known in advance and their availability depends on the applied distribution system of purchase. In case of sudden failure, the availability of the spare part, apart from the applied distribution system of purchase depends also on the inventory policy of repair shop. In the inventory policy at a repair shop for the maintenance of motor vehicles, the factor of the relative importance of customers and the competition policy play an important role. Therefore, all the leading motor vehicle manufacturers, including repair shops of certain makes, try to keep their customers by providing efficient service precisely through the inventory policy of spare parts. Spare parts inventory management policy design at the global, regional and local level is the subject of the spare parts demand forecasting. The spare parts are usually expressed in the forecasts through money value of the expressed demands, which represents the basis for the business planning within the entire network of a certain car make, both of the individual repair shop and of the regional spare parts

distributor. At the level of a certain region, in case of automotive industry and a certain car brand, the authorized distributors, in order to plan the demands for spare parts towards the very producer, follow the parameters of the entire market of goods and services, analyze the potential of the service in the region, set the goals of the organization and plan the business activities for the realization of the set goals. Everything mentioned above forms the assumption of the regional distributor for planning the annual visits of vehicles at repair shops in the specified region.

3. The Inventory Problem at Repair Shops

The study of business processes in the maintenance of motor vehicles indicates the possibilities of using the operations research methods with the aim of improving the management of the spare parts inventory levels. In the inventory management problem, the most part of the literature is oriented to goods production models which are characterized by the inventories that after in-advance planned "consumption" are replaced in a planned way by a new inventory. From the aspect of the repair shop the mentioned case would be applicable in scheduled vehicle maintenance, i.e. in advance booked and planned vehicles with a known scope of works. However, it is possible to define here as well a difference compared to the inventory planning in goods production. Independent of the definition of the spare parts demand for service activities planning, the detection of the actual condition of vehicles at service shows the actual demand for spare parts. The inventory management policy has a special significance in unexpected vehicle breakdown, i.e. unplanned customer requirements for a spare part. The spare part availability is the main element in assessing the level of service at the shop, with target values ranging between 90% and 97%. The main business process in motor vehicle maintenance, i.e. at repair shops starts by the arrival of a vehicle to the shop. The quantification and qualification of the visits of vehicles at one repair shop and the planned "over-the-counter" sales determines the quantity and type of the necessary spare parts inventories. The sub-process of purchasing the spare parts is activated by the error diagnosis, i.e. diagnosis of the defective part. The spare parts requirements are generated by stochastic error on the means during or prior to service. Furthermore, the quantity and structure of spare parts on inventories at individual repair shops depends on the forecast visits of the vehicles per type, age and probability of a certain defect. Forecasting of the annual vehicle visit to a certain repair shop, along with all the existing forecasting methods, is not simple, and mainly relies on the empirical standards of the managerial personnel. The concept of the level of service is used for the indication of probability that the part that needs replacement is available on stock, and this probability asymptotically approaches 100% as the quantity of spare parts on stock increases (Piasecki, 2003). In other words, the shortage of inventories causes the failure to realize the possible profit through sales, decrease in the level of service, and results in possible disturbances of the entire business process on the one hand. On the other hand, excessive quantity of spare parts exerts a load on the operation through the "frozen" working capital. The level of inventories depends on two basic factors: the demand – quantity of goods that is to be consumed or purchased; lead time – delay

between the decision on purchase and availability of goods inventories at the point of demand. The mentioned factors are subject of uncertainty: demand variability and variability of lead time (Thomopoulos, 2005). With the aim of maintaining the target level of service, the repair shops maintain inventories on safety stock. The structure and quantity of spare parts on safety stock depend both on the history data of the most common demands, groups of vehicles that arrive for service, and recommendations of the vehicle manufacturers. The level of safety stock is implicitly equalled by the trade-off between the inventory costs and inventory shortage costs. Thus, instead of considering these costs directly, they can be considered from the aspect of the level of service. The level of service is expressed by the probability that a certain quantity of safety inventories will prevent the shortage of inventories. Naturally, if the level of safety stock increases, the level of service increases as well. The selection of the level of service i.e. acceptable probability of inventory shortage depends on the selected business operation policy. However, it may be noted that 95% is the common level of service in retail inventories.

The re-order point describes the quantity of inventories which initiates the purchase. If there is no uncertainty, future demand fully known and supply completely reliable, the re-order point will equal the total forecast demand during lead time, and represents the lead time demand. Assuming that there is no deviation in the forecast, the zero level of safety inventory will represent the level of service of 50% (Thomopoulos, 1990). Unbiased forecast means that there is equal chance that future demand will be greater or smaller than the lead time demand. Lead time demand is only the forecast value. The forecast can have a deviation without being exact. The deviation in the results represents a systemic error of the forecast model. In practice, the deviations within the data on the realized operation, history data, can be used as good heuristics in forecasting the deviation of the forecast error. If the forecast demand is used instead of the mean demand in the deviation calculation, it may be seen that the forecast error is very often in correlation with the quantity of the expected deviations.

There are two basic measures for measuring the inventory system performances which is the quantity of inventories on stock and the level of service. The level of service is usually the measure of relations of the fulfilled demand and the total demand. Inventories on stock are those inventories that are available immediately at the moment when required, usually expressed in money terms. Inventories on stock are usually classified into two categories which are the safety inventories and the cycle inventories. The cycle inventories represent the share of inventories that are purchased in order to ensure the average flow of fulfilling the planned requirements according to the forecast of the future needs (Thomopoulos, 1990).

4. Application of Arima Method in Forecasting Spare Parts Inventories

This paper presents the problems in inventory planning of repair shops. The data of a repair shop have been taken as the considered problem in inventory management, which provides services in maintaining the “Audi” vehicles. The objective was to use

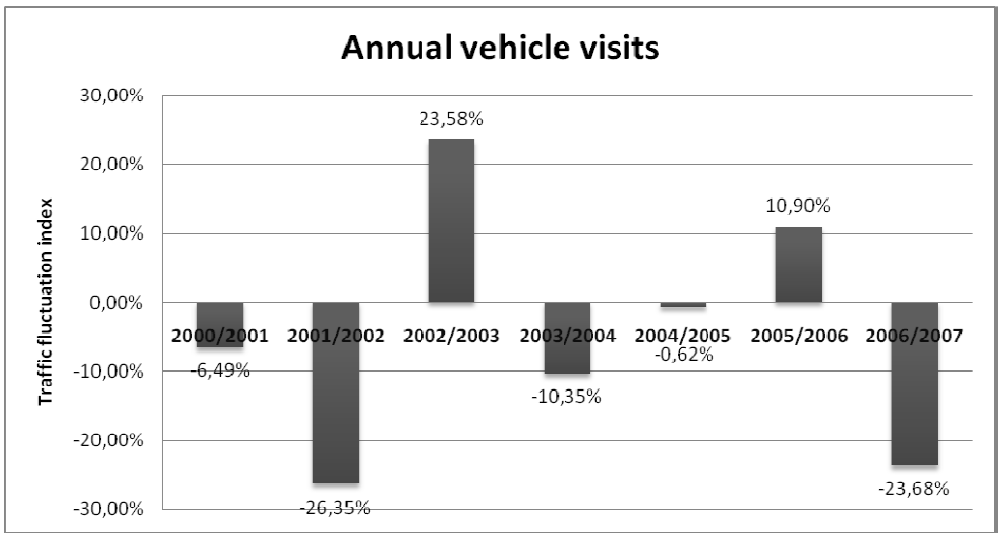
statistical methods to determine the quantity of the "frozen" capital in spare parts inventories as result of the forecast error in the visits of vehicles to the repair shop. For the statistical processing of the data the Statistic software version 8 was used. From the selected repair shop the data have been taken about the visits of vehicles per months and years, and the data have been obtained as presented in Table 1. Diagrams 1 and 2 graphically present the demand change indices regarding service at the repair shop.

Year/ Month	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	**Total**
2000	121	234	356	132	134	298	320	210	367	265	234	102	**2773**
2001	55	129	101	401	201	260	413	111	194	331	221	187	**2604**
2002	78	187	203	127	312	132	152	301	175	201	87	106	**2061**
2003	201	165	205	356	139	276	303	125	283	243	201	200	**2697**
2004	102	98	184	237	309	199	194	192	201	196	333	199	**2444**
2005	183	205	354	98	156	310	257	162	222	256	129	97	**2429**
2006	113	176	136	257	301	200	159	333	401	234	201	215	**2726**
2007	99	106	109	276	283	138	194	201	147	238	301	112	**2204**

Tab. 1. Visits of vehicles at the repair shop

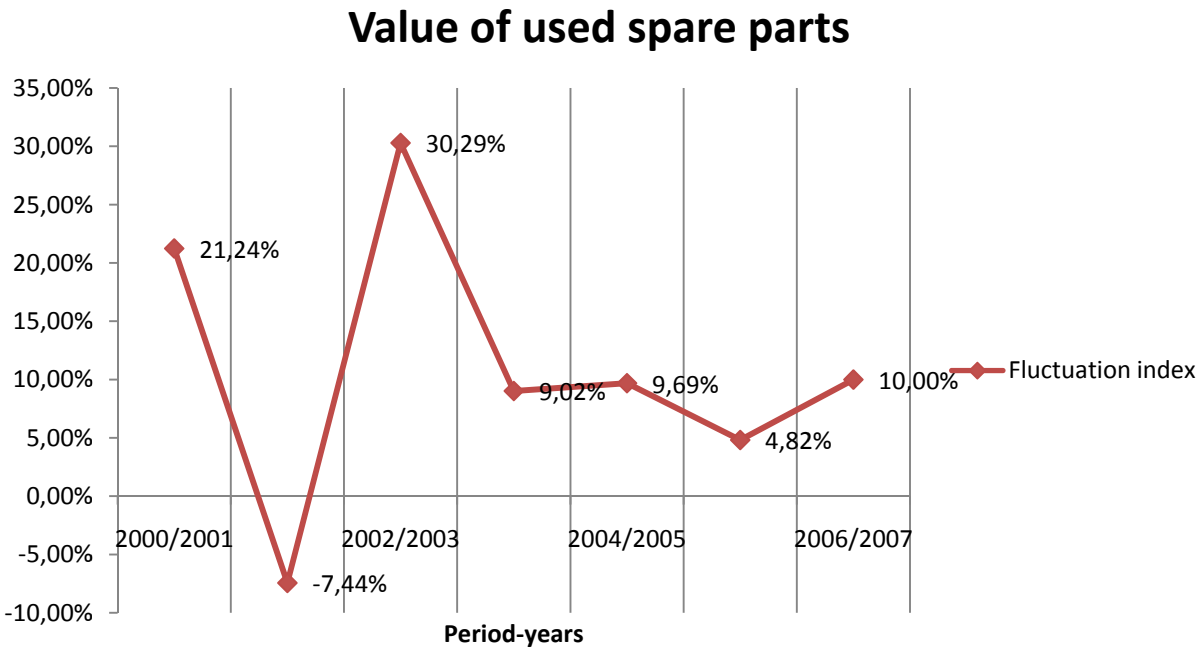
As seen from the mentioned data the number of vehicles serviced during the years shows a tendency of decrease. However, comparing the data on the used spare parts i.e. financial costs of spare parts, a trend of increase has been recorded. The spare parts inventory management in the selected repair shop is performed by means of the internal system (software solution) of the Concern of a car make, and the policy of automatic purchase of spare parts has been selected, i.e. according to the results of the set algorithm. The observed drawback of the selected inventory management policy and the spare parts purchase, in the considered case, is reflected in no rational allocation of the "frozen" capital in the spare parts, i.e. the presence of spare parts on stock has been recorded, their demand probability in the current period being very low, whereas their purchase value is very high.

Diag. 1. Fluctuation in demand for the service in the period 2000/2007



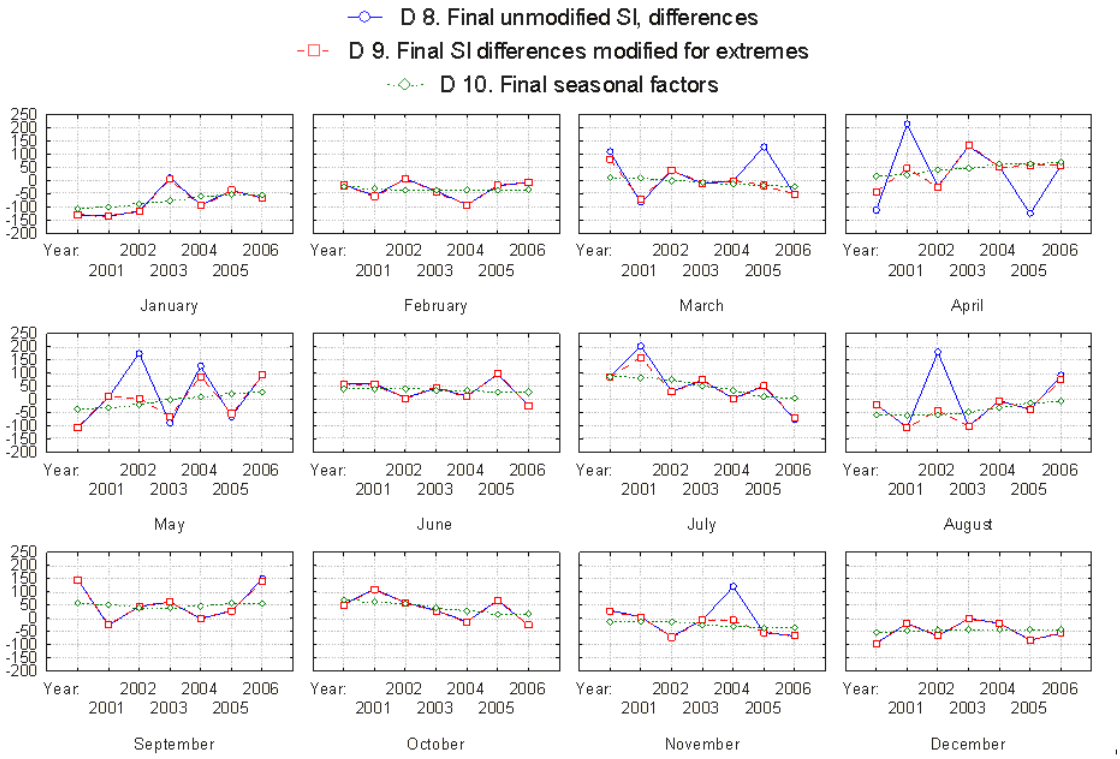
Diag. 2. Annual intervals of fluctuation in demand

Following the analysis, and in order to study the turnover of the financial means invested in the spare parts, the values of the used spare parts have been added to every fulfilled service requirement, and the data on the values of the used spare parts at the annual level have been summed up. The value of the used spare parts has been compared through the considered periods, and the fluctuation index has been presented in Diagram 3.

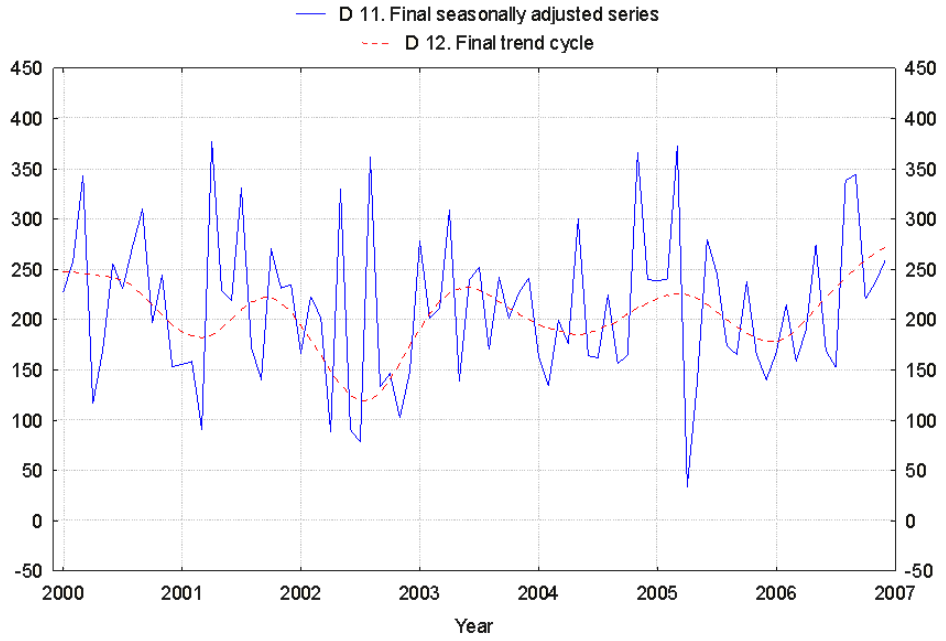


Diag. 3. Change in values of the spare parts used in service provision

In order to observe the demand trend the seasonal components have been analyzed with additive adjustment of the seasonality in the period from January 2000 to December 2006 (Table 1). Data for 2007 have not been taken into consideration during the analysis but these are later used as the indicator of the quality of forecast and forecast error on the applied forecasting method.



Diag. 4. Demand trends per months and years



Diag. 5. Summed up data and total seasonally adjusted series

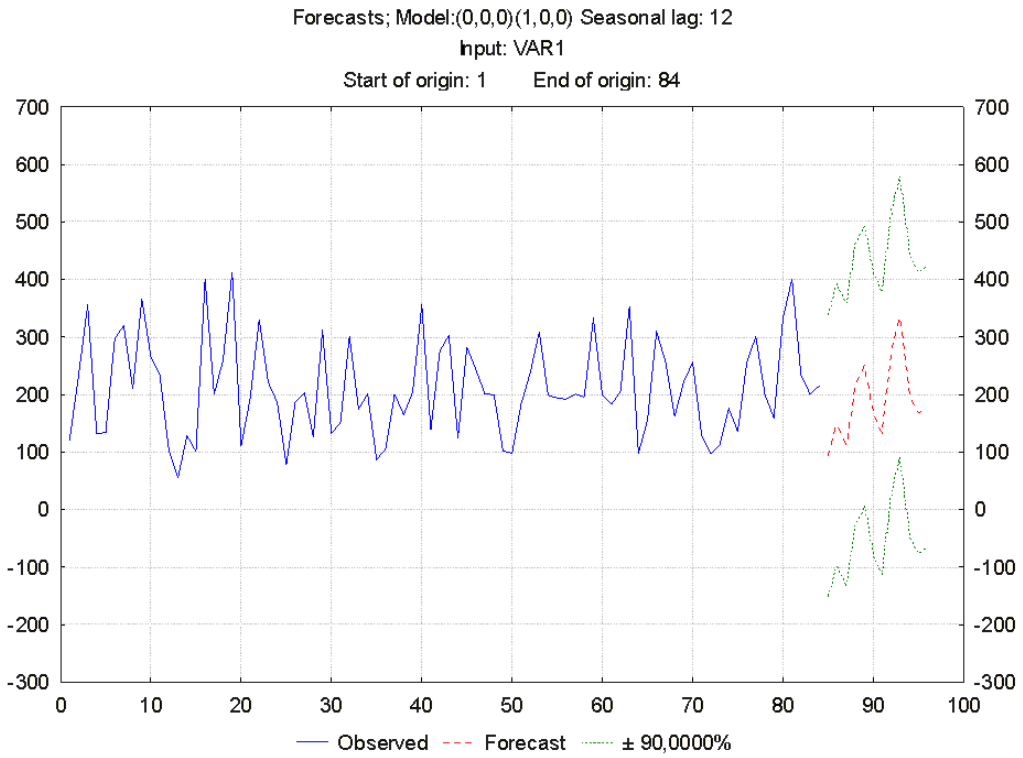
As part of the statistical analysis of data the correction of extreme values has been carried out in order to raise the quality of processing and the expectation of irregularities and seasonality of data (MSR) have been calculated comparatively per years and months (Hill & Lewicki, 2007). In forecasting the inventory demand for 2007 the ARIMA method was used. A model was looked for (seasonal autoregressive; seasonal differencing; seasonal moving average parameter) with the least forecast error and the model (0,0,1) has been found most suitable. The number of observed events (monthly visits of vehicles at the repair shop from 2000 to 2006)

was 84, with level of reliability 0.90 and given forecast of 12 months. Results of forecast of the visit of vehicles to the repair shop in 2007 are presented in Table 2.

Month	Forecast	Below 90%	Above 90%	Std. error	Mo nth	Forecast	Below 90%	Above 90%	Std. error
1st	94,3352	-150,613	339,2833	147,2557	7.	132,7372	-112,211	377,6853	147,2557
2nd	146,9292	-98,019	391,8773	147,2557	8.	277,9967	33,049	522,9448	147,2557
3rd	113,5362	-131,412	358,4843	147,2557	9.	334,7648	89,817	579,7129	147,2557
4th	214,5500	-30,398	459,4981	147,2557	10.	195,3490	-49,599	440,2971	147,2557
5th	251,2823	6,334	496,2304	147,2557	11.	167,7998	-77,148	412,7479	147,2557
6th	166,9650	-77,983	411,9131	147,2557	12.	179,4874	-65,461	424,4355	147,2557

Tab. 2. Forecast of vehicle visits per months with level of reliability ± 90%

Graphical presentation of Table 2 is given in Diagram 6.



Diag. 6. Forecast of vehicle visits per months in 2007

After obtaining the forecast results according to ARIMA method, in determining the forecast error two observation methods have been applied. First, the obtained forecast results have been compared to the actual data per months through the number of vehicle visits and the value of used spare parts, which yielded the result of 72 vehicles more than the actual number of vehicle visits for 2007. Another way of observation was the calculation of the standard deviation, which yielded the forecast error result of 79 vehicles more than the actual number of visits in 2007.

The number of 72 vehicles more has been selected as the relevant data of forecast error in this case, since the applied method understood the dynamic monthly transfer of the frozen capital in spare parts, having thus optimized the spare parts purchase. The forecast error expressed in the value of "frozen" capital for the observed year 2007 would amount to HRK865,698.70, i.e. HRK72,141.56 monthly.

5. Conclusion

The role of controlling the spare parts inventories is becoming increasingly important in the modern operative management. The trade-off is here very clear: on the one hand large quantity of spare parts binds a large amount of capital, whereas on the other hand, too small quantity of spare parts on stock can result in poor customer service or very expensive emergency purchase. The creation of the spare parts inventory management policy at the global, regional and local level is the subject of spare parts demand forecast. The spare parts in forecasts are usually expressed in money value of the expressed demand, which represents the basis for business planning within the entire network of a certain car make, both of individual repair shop and the regional spare parts distributor. Spare parts in automotive industry represent big financial capital. Software solutions of repair shops for spare parts inventory management do not treat the forecasts of vehicle visits, nor do they record the level of the realized customer service, but based on the history records on inputs and outputs from the warehouse, using the method of arithmetic mean, give recommendations on the quantity and type of spare part to be purchased. By using statistical methods in demand forecasting, and by comparison of the obtained data with the realized turnover of spare parts inventory, it is possible to design models of managing the "frozen" capital in order to purchase the spare parts.

The application of the ARIMA method in spare parts inventory management for the future periods of work of the selected repair shop, with comparative analysis of the results of the "VW" Concern software solution can ensure sufficiently good data for the construction of a new model in spare parts inventory management. Certainly, it is necessary to apply the same methodology of data processing on the entire network of synonymous repair shops in the Republic of Croatia. The result would be the rationalization in inventory management at the level of a service network, improvement in the availability of spare parts through the possibility of exchange between service partners, including the levels of the quality of the provided service.

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