UNIWERSYTET TECHNOLOGICZNO-PRZYRODNICZY
IM. JANA I JEDRZEJA SNIADECKICH W BYDGOSZCZY
ZESZYTY NAUKOWE NR 256
TELEKOMUNIKACJA I ELEKTRONIKA 13 (2010) 103-114

DEMAND FORECASTING FOR SPARE PARTS

Paweł Latos, Bożydar Dubalski, Tomasz Marciniak, Beata Marciniak

University of Technology and Life Sciences
7 Prof. Kaliskiego Ave., Bydgoszcz 85-796 Poland
dubalski@utp.edu.pl, tomasz.marciniak@utp.edu.pl, beata.marciniak@utp.edu.pl

Summary: The subject of the article is an analysis of possibilities of predicting the demand for subsystems for equipment for companies which deal with servicing electronic devices. The analysis has been based on real data from one of service points. The influence of various factors that determine the need for specific replacement parts was presented. Two basic methods of prediction (quantitative and shares) were compared. Modifications of the equity method was proposed, it took into consideration a few of additional factor, such as the number of parts in store or the number of overdue repairs.

Keywords**:** demand forecast, quantitative analysis, terms of share analysis

1. INTRODUCTION

Recently, on the market of applied electronics there have occurred significant changes which are manifested by a massive scale of the manufactured equipment and its fast development and modification and drop of both production and sale costs [2], [4]. These changes have been caused by progress in the sphere of design, production of components, modules and final devices, packages, accessories logistics and the distribution networks. After -sale service, that is, the Clients service is also an element of this chain [1]. There has been observed disappearance of small service shops where single systems of very different devices have been repaired. The process usually involved exchange of basic components and the repair was made until obtainment of the final effect.

Continuously increasing integration of integrated circuits, miniaturization of elements, improving manufacture of prints and relatively high cost of components, bought in small amounts, has made a repair of small series of devices less profitable. A new type of enterprise providing this kind of services has replaced small service stores. These are big – sometimes worldwide stores which provide an overall array of after-sale services. They cooperate directly with the equipment manufacturers. In this case, the amount of the repaired equipment can be considered in terms of thousands or even tens of thousands items, monthly [3].

For such a massive scale of repair the cost of purchase of components and logistics are very low as compared to the cost of a single service point [2]. It enables not only a decrease in guarantee protection costs which are born by manufacturers but also provides grounds for constructive competitiveness between the service providers.

Another advantage provided by such big companies is the possibility of doing research and introduction of innovation [3]. With such a mass scale of operation it is possible to sacrifice one or several items without any negative consequences. New, more efficient repair methods can be developed, troublesome defects can be diagnosed properly, time and material consumption can be reduced and, moreover, elimination of faulty elements and design error is possible. Thus, the quality of manufactured devices can be significantly improved and the investment costs can be quickly returned which in turn leads to generation of profits.

The costs of supply are affected by the way of cooperation between the equipment manufacturer and the customer service system:

– ‘**traditional**’ – it involves delivery of the faulty equipment by the customer directly to the service point, its repair and return to the customer.
– ‘**goodstock**’ – the service point sends the equipment to the manufacturer who exchanges it for new. The manufacturer comes back into possession of the broken device which is then sent to be repaired. This repair, apart from removal of functional defects, involves bringing the device to a state most similar to the pre-repair one – mainly by its face lifting (removal of traces of its being used before). Repaired in this way equipment is sent back to the manufacturer and goes to ‘goodstock’, that is, to a warehouse of efficient devices from where it is supplied to another customer after a complaint of his/her device is made by him/her.

The second way provides some benefits both measurable (from the point of view of the service the costs of shipment between the manufacturer and the service are minimized thanks to their big amounts), and immeasurable (short time of waiting for new equipment which results in the customer satisfaction with the service). The disadvantage of this system from the manufacturers’ point of view is burdening them with the logistics connected with the customer (reception of damaged equipment and dispatch of the repaired one), the customer’s service and possible losses due to the equipment advertisement which in fact, has no faults (because of e.g. misunderstanding the principles of its operation)

The subject if this paper is presentation of an analysis of supplying the service store with spare parts, and more exactly, a method for forecasting the demand for these elements, its implementation in real conditions and assessment of its application effects.

2. SIGNIFICANCE OF AN EFFICIENT METHOD FOR THE SERVICE STORE SUPPLY

Providing possibilities for making a big number of repairs in a relatively short time (generally accepted standard is 48 hours from the moment of the device registration in the service to dispatching it to the user) with achievement of appropriate financial effect is a pretty difficult challenge. Each of the process critical elements is responsible for keeping the expected index (Turn Around Time) that is the time in which the device is present in the service. When the term fails to be kept for a number of times it involves loss of trust and good relations with the equipment manufacturer. This is affected by the following factors;

- failing to deliver the repaired device to the user on time,

- higher costs of the user service,
- additional costs due to equipment exchange for new forced by a given situation or due to compensation payments in the moment of the user resignation from the repair.

To avoid such a situation it is necessary to provide a proper level of the service operation elements. These include:

- human resources,
- supply with operating materials (e.g. packages),
- supply with spare parts.

The last element, and more precisely, forecasting the demand for spare parts, is the subject the present analysis.

In practice, there often occur situations when there is shortage of many parts for the most popular models of devices in the moments when they are urgently needed. It happens so because of the lack of an efficient method for forecasting the demand for elements. This problem mainly occurs in case of new models of devices in the time when they are being increasingly used. On the other hand, for models which are getting out of common use, the spare parts accumulate to such an extend that it is not possible to utilize or sell them. Apart from the listed negative effects for the producers and relations with them, there occur problems disrupting operation of the service itself. Each device- regardless of the fact whether it has spare parts in stock or not, has to be verified in terms of its series number consistence, accessories and a diagnosis must be made. When it turns out that the needed element is missing this device must be additionally prepared for storage until the delivery of necessary elements. This takes time, space and means.

Solution to these problems is one of the main goals of persons responsible for the service point efficient operation and improving its effectiveness. These actions have been exemplified on the basis of repairs of digital cameras, electronic digital frames, picture printers and pocket video cameras, performed in a service store located in Bydgoszcz.

3. FORECASTING THE DEMAND FOR ELEMENTS NECESSARY FOR SERVICE

Manufacturer of devices which undergo a repair provides the service with information concerning a monthly supply of equipment and the spectrum of these devices supplied models. It seems that such data is out of use for forecasting the demand for a particular spare part as they it does not provide useful information directly, apart from the information on human resources and the company profits. However, after a thorough analysis of the data and its calculation, it can provide basis for prediction of all actions to be taken as well as a reliable point of reference.

The issue of forecasting supplies in a traditional service model is of complex character and requires an analysis of many factors which have an impact on the number of ordered supplies. One of the most important elements of this process is the model lifetime.

For each device model the most important parameter is the time of its existence on the market (in sale) which is reflected by its presence in supplies of equipment to be repaired. When the product is launched on the market it means that is will appear more and more frequently in the supplies. Therefore, in this time the most important task is to provide the warehouses with subsystems that can meet current demand and also will create a certain safety buffer which can be used when an increase in the number of supplies has significantly exceeded earlier predictions.

The middle of the discussed period (stagnation) is a time when the rising tendency starts decreasing and then it stabilizes, though it does not mean invariability of this value within the next few successive months. Surprisingly, prognosis prepared during this time are burdened with the highest risk. It is so due to unpredictability of the stagnation period end, after which in a short time there can occur very drastic falls of the demand for these elements.

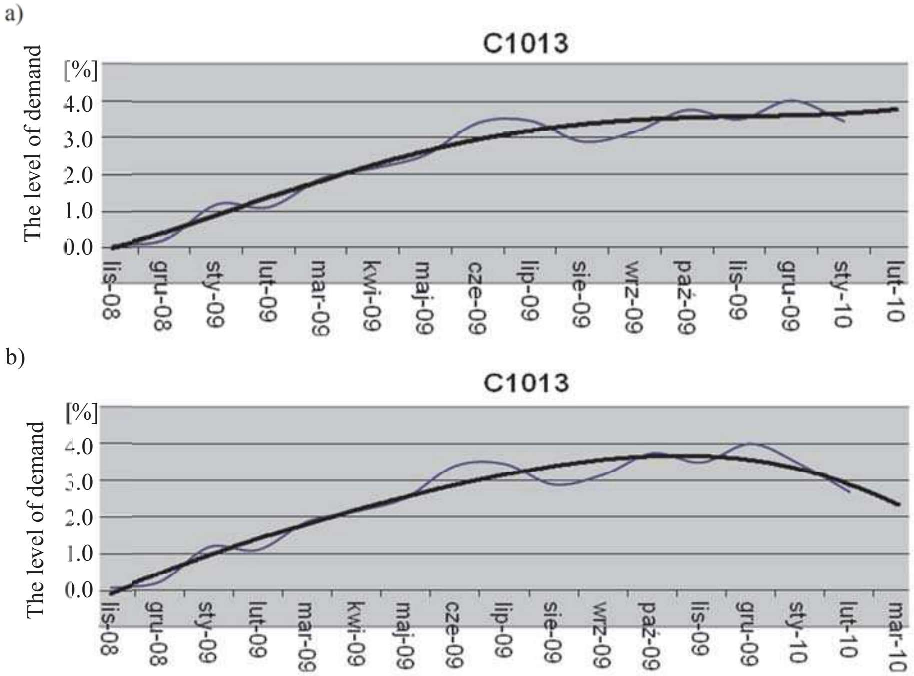

Fig. 1. Observation of the stagnation period end during the model lifetime (a) stagnation period, (b) real demand

The above figure (Fig. 1) illustrate a similar situation. For C1013 model, the stagnation period lasted until October 2009. This tendency continued for the next four months and there was no sign which would predict changes. Therefore, in February 2010 it was most likely that the demand for spare parts would stay at the same level 3.8%. However, it was in February when this tendency changed and the level decreased to approximately 2.7%. This is the type of risk that can occur in the time of stagnation.

During the end of the model lifetime the numbers of supplies decrease systematically. And the same thing should happen to the spare parts which are stored in warehouses. In this period all stock should be used with only a minimal amount of elements left. Time of this cycle depends on the segment which the model comes from, time of sale and in the final period when the supplies are rare, it should depend on profitability of guaranty repairs. The factor must be taken into consideration for better understanding of the forecasting system and its implementation.

Another important aspect that must be accounted for is the assessment method of the demand for spare parts. Here, a quantitative or share analysis can be applied. One of the first problems that occur while using a quantitative analysis for elaboration of a prognosis method is variability of the number of supplied devices. Depending on the season, the number of repairs varies significantly, according to the data available, the differences reach even several dozen percent. Thus, it is difficult to use it for predicting the demand for necessary elements. This would be possible only if the total number of supplies became constant for each month of the year.

A factor that enables observation of the tendency regardless of different quantities of supplies is the share approach. It involves determination of a given model supply quantity quotient coefficient called ‘a share’, in relation to the total supply quantity of all models of devices in a given month.

This has been illustrated in the below presented example concerning supplies in the period between 2009 and February 2010.

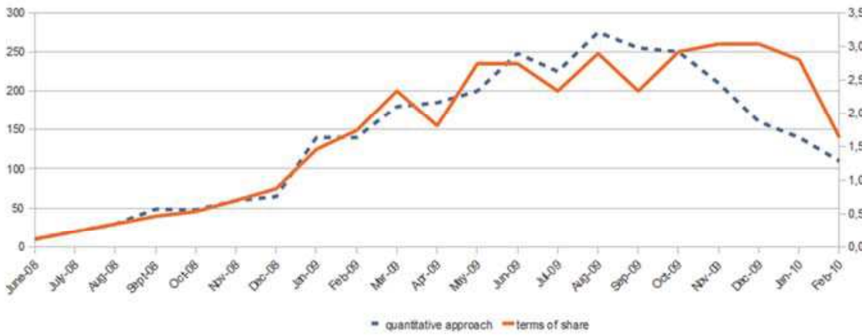

Fig. 2. Comparison of variability of quantitative approach with the share one

On the basis of observation of quantitative changes it can be said that there starts the final time for a given product. In the meantime, a chart of shares shows something else, stagnation reaches the highest values. Fluctuations range to 0.5%. When the supplies increase in the spring, share based forecasting will anticipate it. The result of an analysis with the use of the quantitative approach would be expected, further, significant falls which would result in the lack of spare parts for most of devices of a given model.

The forecasting method of a demand for elements which is still quite widely applied is based on a simple calculation concerning only spare parts without accounting for any other factors. Data on the wear of parts from the three preceding months is being collected, and the mean is being calculated. This mean provides basis for making an order for a manufacturer.

For comparison of both forecasting methods an element called ‘COVER AY’ – battery plate new design’ of a C180 model present in repairs for the last three months (usually an intensive increase in the quantity of supplies starts then) has been used as an example.

Table 1. Comparative analysis of forecasting methods

Month	09 06	09 07	09 08	09 09	09 10	09 11	09 12	10 01	10 02
Quantity of supplies	7	24	34	69	60	78	49	95	117
Share	0.07%	0.24%	0.33%	0.59%	0.68%	1.07%	0.87%	1.76%	2.46%
Monthly forecasting of supplies	6438	6783	6628	5960	5762	5786	5660	4753	5874
Demand forecasting in terms of quantity	x	x	x	8	15	19	25	22	26
Demand forecasting in terms of share	x	x	x	8	17	18	28	33	61
Real use	2	9	12	25	21	28	17	34	42

If for the first three months of forecasting the differences between both methods are slight, they become clear once the model enters the period of intensive development.

Table 2. Comparison of the forecasting systems accuracy

	Summary 2009 09 – 2009 11		Summary 2009 12 – 2010 02		Summary 2009 09 – 2010 02	
	Quantity	Error	Quantity	Accuracy	Quantity	Accuracy
Demand forecasting quantitatively	42	– 41.7%	73	– 21.5%	115	– 31.1%
Demand forecasting in terms of share	43	– 40.3%	122	+ 31.2%	164	– 1.8%
Real use	74		93		167	

Data covering the analyzed forecasting time gives a picture of differences in operation of both methods. In the stage of an intensive increase the share forecasting is of great advantage, that is, progression of predictability. In this way it is possible to compensate inaccuracy of prognosis which occurred during the trend formation. The period from September to November was closed with a similar, quite low accuracy. In the next three month the period a change can already be seen. The share forecasting exceeds a current demand by 30%, compensating, however, the previous prognosis which in effect provides accuracy similar to the equipment real needs. Quantitative forecasting does not, due to its nature, provide any significant correction.

In the chart Fig. 3, a comparison of prognosis with verifying them real data, has been demonstrated.

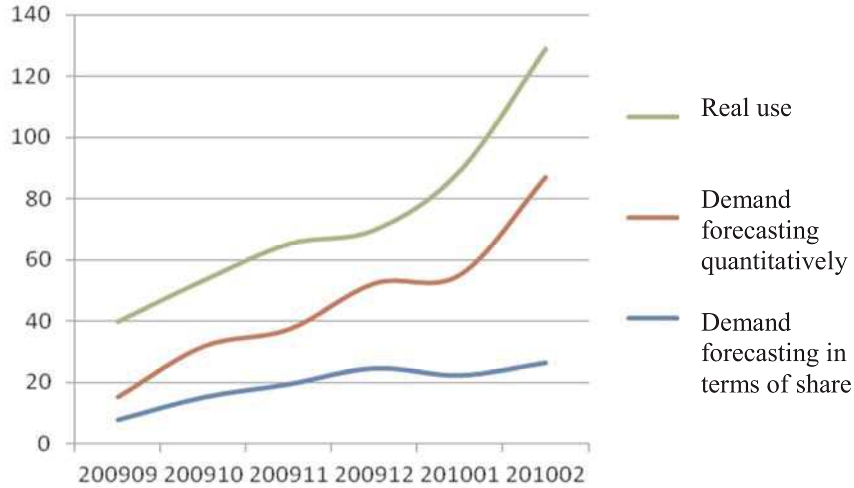

Fig. 3. Comparison of prognosis with real data

Thus, a conclusion can be formulated that the share forecasting has the ability of immediate reaction to the trend changes.

An important element for the forecasting system is the use of the trend line (it is a monotonic component in the model of dependence of the component statistic feature on the time of a given phenomenon observation).

Having accepted the assumption that data on the quantity of a particular model supply and their share are known, it is possible, on their basis, to make a prognosis using its graphic image. From the point of view of statistics, in order to make any prediction, it is necessary to have at least three measurement points (e.g. observation summing up three months). Having this data one can take up the most important action. On the basis of a current data analysis, the line of trend is determined , that is, an approximating line which is a kind of averaging whose aim is to define the general trend for the available set of data.

Basing on the determined trend line in the scope of the determined data it is necessary to increase its continuity by another period.

In this way current tendency is used for prediction of the studied value.

The line trend (in black) shown in the above figure (Fig. 4), built on the basis of real values (in blue) was used for definition of model C180 share in supplies in March 2010. There is the question of choice of the kind of the line. It is possible to choose from several kinds of lines(linear, multinomial, exponential). In the initial phase of the system creation it was found that the best appropriate in terms of accuracy is the line of multinomial approximation one:

The choice of the multinomial degree mainly depends on such factors as:

- The model life phase. The longer it is repaired (the more measurement data) the higher degree of the multinomial ensures better approximation.
- Intensity and fluctuations of the share. Drastic changes in this range can even cause a necessity of using high degrees in the early phase of life.
- Expected changes of the trend. Observing oscillations, it is possible to infer what changes will be likely to happen in the nearest time (e.g. switching a rising trend to a lateral or decreasing one, where the rising trend means an increase in a variable in

time value and decreasing trend means a fall of a variable in time value. Lateral trend stands for lack of distinct rising or falling trend. Each degree of the multinominal is characterized by a different prognosis progression. This is a basis on which the degree adjusted to current needs- should be chosen-progressive in the phase of rising, preservative at the end of the model life.

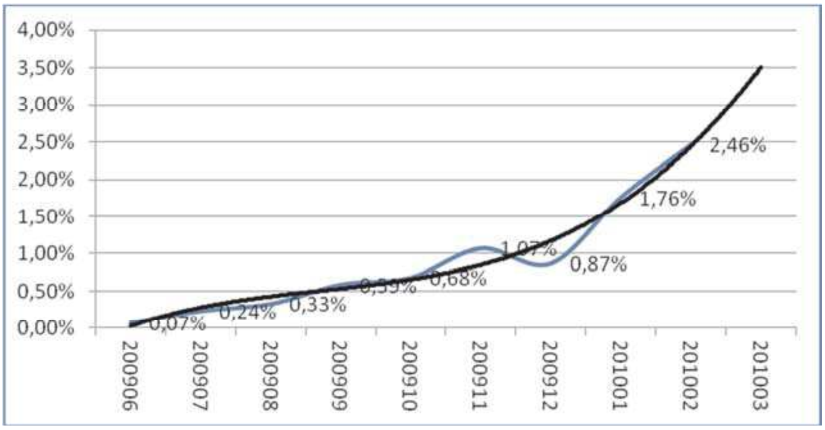

Fig. 4. Visualization of the trend line

4. CONSTRUCTION OF FORECASTING MODELS AND ASSOCIATION OF DATA CONNECTED WITH SUPPLIES OF EQUIPMENT MODELS WITH DATA ON DEMAND FOR SPARE PARTS

Being in the possession of elaborated data on the shares it is possible to go on to prepare a prognosis of the models supplies. Knowing the overall monthly prognosis of supplies and a share of a given model in global supplies one must multiply these two factors in order to receive an absolute number of supplies planned for the next month.

Table 3. Method of making a prognosis of a device model supply

Model	Trend	Supply prognosis	Planned number of devices
C1013	0.0240	5975	143
C140K	0.0410	5975	245
C180K	0.0340	5975	203
C182	0.0120	5975	72
C190	0.0260	5975	155
C300	0.0000	5975	0
C310	0.0000	5975	0
C330K	0.0009	5975	5

With a mass character of being made repairs, forecasting of the number of spare parts indispensable for the store operation is subject to laws of statistics. Each model has faults characteristic for itself which involve replacement of precisely defined parts. Due to recurrence, it is possible, here, to make use of the share approach, but it will refer only to selected parts. This index is calculated in a different way. In this case, a ratio of the number of used parts to the number of repairs performed in the studied period, is taken into consideration. Hypothetically, this time could be relatively short e.g. three months. However, it should be considered that despite of forecasting accuracy, there can occur situations when a part is missing for a longer time, e.g. because of its manufacturer' s fault, as they did not provide sufficient supplies at the moment the device was launched on the market. This factor can distort prognosis for a few following months. For this reason, a longer time e.g. 12 months, should be accounted for. This time is sufficient for compensation of some periods of a part unavailability as it enables, to some extent, flexibility of the parts wear division and minimization of the seasonal impact on the demand for spare parts. The mean life time for devices which were used for this analysis is from one and a half to three years. Thus, if during this time there will occur changes within the spectrum of appearing defects it on an every time basiswill be possible to be defined to a limited degree.

Table 4. Comparison of shares of C1013 model parts

Model	Part number	Part name	Completed repairs	Amount used parts	The share parts
C1013	2F7112	MONITOR LCD – AUO VJ	2828	111	3.93%
C1013	2F7480	MONITOR LCD – Wintek	2828	18	0.64%
C1013	3F6204	Fuse – 1.25A	2828	1	0.04%
C1013	4F8467	BOARD – main, for Wintek LCD	2828	18	0.64%
C1013	4F8468	BOARD – main, for GPT LCD	2828	54	1.91%
C1013	4F8569	HOLDER – monitor LCD	2828	3	0.11%
C1013	4F8571	BOARD AND FRAME AY – switch	2828	20	0.71%
C1013	4F8572	BOARD AND STROBE AY – power	2828	200	7.07%
C1013	4F8580	COVER AY – front, silver, C1013	2828	95	3.36%
C1013	4F8581	COVER AY – back, silver, C1013	2828	144	5.09%
C1013	4F8582	DOOR AY – battery, silver, C1013	2828	22	0.78%
C1013	4F8583	LENS AY – with CCD	2828	351	12.41%
C1013	4F8584	BOARD – main, for AUO LCD	2828	318	11.24%
C1013	4F8594	MONITOR LCD – GPT 2 LED	2828	15	0.53%
C1013	4F8651	LENS AY – without CCD	2828	167	5.91%

The above presented Table 4 shows exemplary calculations of the part share. Having this data it is enough to multiply it by the planned numbers of the model supplies.

Table 5. Visualization of the demand for spare parts

Model	Part number	Share	*	Estimated number of parts	=	Part forecasting
C1013	2F7112	0.03930	*	143	=	6
C1013	2F7480	0.00640	*	143	=	1
C1013	3F6204	0.00040	*	143	=	0
C1013	4F8467	0.00640	*	143	=	1
C1013	4F8468	0.01910	*	143	=	3
C1013	4F8569	0.00110	*	143	=	0
C1013	4F8571	0.00710	*	143	=	1
C1013	4F8572	0.07070	*	143	=	10
C1013	4F8580	0.03360	*	143	=	5
C1013	4F8581	0.05090	*	143	=	7
C1013	4F8582	0.00780	*	143	=	1
C1013	4F8583	0.12410	*	143	=	18
C1013	4F8584	0.11240	*	143	=	16
C1013	4F8594	0.00530	*	143	=	1
C1013	4F8651	0.05910	*	143	=	8

This provides a rational number of particular parts which will be necessary to ensure the model repairs in the next month.

Determination of the number of necessary parts is not the final stage of the order creation. These factors also have to be accounted for:

– warehouse states, that is, the number of parts which are already in stock. They must be substracted from the so far done calculations,
– demand for devices whose repair has been stopped until delivery of spare parts, that is, devices for whose repair necessary spare parts were missing already before preparation of an order. These values must be added to the calculations.

The discussed analysis has provided basis for elaboration of a program to be used by companies for forecasting supplies to be implemented in the company network server. Many protections have been created as well as they provide security for data storage, so that an unauthorized person will not have access to it.

The main source of all kinds of data used In the system operation is an administered by the company system of database applications, being the basis of reporting all actions happening every day. These include: the device registration, registration of the part, their location in the warehouse , the repair, wear of components, performance of different tests, protection of accessories, gathering data on the performed deliveries, inventory invoicing and financial matters.

The program provides the following possibilities of revision of the devices and their components in the quantitative and share approach:

- review according to months – displays a list of all devices registered In the assigned period,
- review according to models – displays a list of all items of the device given model whose name has been entered into the field of the form,
- comprehensive review – displays a list of all registered devices without any limiting criteria.

The planned total number of supplies In term of particular months of the current year. Warehouse states are reviewed:

- according to the models, which displays a list with all data on a given model part share,
- according to the part number, which displays information on the share of a particular part,
- according to the part type, which makes it possible to look over a Table in terms of module types, which is expressed by search of the attribute,
- comprehensive review, displays a list of all data on all parts share with no limiting criteria.

5. CONCLUSIONS

The idea of the proposed method for forecasting a demand for spare parts has been tested in comparison with the already existing prediction method.

According to expectations, the system improved the quality of the service supply during a few months to such a degree that repair arrears due to insufficient number of orders were made up. There also followed another significant change. Earlier the orders had been sent twice a month, since then once a week. To justify this, was presented a comparison of real data on forecasting supplies of models and their actual quantities that were provided for repair in March 2010. Seven models of cameras were taken into consideration, whose supplies were the biggest, being thereby the most significant part of this segment.

Table 6. Comparison of supply prognosis of models with actual numbers of supplies in March 2010

Model	C140	C180	C182	C190	C813	C913	C1013
Forecast quantities	149	108	48	84	108	191	90
Number of actual supplies	169	133	48	94	83	177	125
Accuracy of prognosis [%]	88.39	80.86	99.58	88.99	129.58	108.02	71.70

This result proves that the system makes it possible to achieve fairly good accuracy and efficiency which are dependent on appropriate prediction of demand for materials necessary for regular operation.

The above listed improvements have contributed to the corporate image better reputation both in the eyes of the manufacturers and customers. It also increased its reliability as well as and the quality of repairs and trust of cooperating companies. Having rationalized the process of supply made it possible to focus attention and means on making further improvements upon other elements of the offered services.

BIBLIOGRAPHY

[1] Cieślak M., 2000. Economic Forecasting: methods and applications (in Polish), PWN, Warszawa.

[2] Jiafu R., Zongfang Z., Fang Z., 2009. The Forecasting Models for Spare Parts Based on ARMA, World Congress on Computer Science and Information Engineering, pp. 499-503.
[3] Krupa K., 2008. Modeling, simulation and forecasting: continuous systems (in Polish), WNT, Warszawa.
[4] Yun Ch., Heng Z., Li Y., 2010. Demand Forecasting in Automotive Aftermarket Based on ARMA Model, International Conference on Management and Service Science (MASS), pp. 1-4.

PROGNOZOWANIE ZAPOTRZEBOWANIA NA CZĘŚCI ZAMIENNE

Streszczenie

W artykule zaprezentowana analizę porównawczą różnych metod prognozowania zapotrzebowania na części zamienne w punktach serwisowych. Przedstawiona analiza została praktycznie zweryfikowana w oparciu o rzeczywiste dane pochodzące z jednego z punktów serwisowych. W pracy przedstawiono wpływ różnego typu czynników od których zależy zapotrzebowanie na określone części zamienne. Porównano dwie podstawowe metody predykcji: ilościową i udziałową. Zaproponowano modyfikacje w metodzie udziałowej uwzględniające dodatkowe czynniki jak np. ilości poszczególnych części znajdujące się w magazynach czy konieczność dokonania zaległych napraw.

Słowa kluczowe: prognozowanie zapotrzebowania, metoda ilościowa, metoda udziałowa