Radim Lenort, Petr Besta

VŠB – Technical University of Ostrava, Faculty of Metallurgy and Materials Engineering, Department of Economics and Management in Metallurgy,
17. listopadu 15, 708 33 Ostrava-Poruba, Czech Republic,
E-mail: radim.lenort@vsb.cz,

Hierarchical Sales Forecasting System for Apparel Companies and Supply Chains

Abstract
The typical problems facing with apparel companies and supply chains are forecasting errors, because fashion markets are volatile and difficult to predict. For that reason, the ability to develop accurate sales forecasts is critical in the industry. There are several research studies related to forecasting apparel goods, but very often only for one level. However, apparel companies and supply chains deal with a number of levels at which the forecasts could exist and require consistent forecasts at all of them. The paper presents a hierarchical middle-term forecasting system designed for this purpose on the basis of a literature review. The system is built by the top-down forecasting approach and verified by means of a case study in a particular apparel company. The weaknesses of the system are identified during discussion of the results acquired. A generalised concept of the ANN forecasting model is designed for elimination these weaknesses.

Key words: *apparel company, hierarchical forecasting, sales forecasting, top-down approach, forecasting system.*

Introduction

The typical problems facing with apparel companies and supply chains are forecasting errors, because fashion markets are volatile and difficult to predict. For that reason, the ability to develop accurate demand forecasts is critical in the industry. Thomassey sums up the specificities of apparel sales and related forecasts [1]:

- Horizon of forecasts – two horizons of forecast are used in that branch: (1) a medium-term horizon (i.e. one year) to plan the sourcing and production and (2) a short-term horizon (i.e. few weeks) to replenish, if necessary, and adjust the orders and deliveries of local stores.
- Life cycle of items – sales forecasts are required for basic and best selling items, while fashion items with "one shot" supply are often not taken into account in the forecasting process.
- Aggregation of sales – apparel companies commonly prefer the aggregation of their historical data related to sales according to the hierarchical classification. The family level is very suitable for sales forecasts based on time series techniques. At the lower levels, data are ephemeral; no historical data are available.
- Seasonality – the seasonality gives a global trend for sales, and this should absolutely be integrated into the forecasting system.

There are several research studies related to forecasting textile and apparel goods, but very often only for one level or for several of the lowest levels [2 - 5]. However, apparel companies and supply chains deal with a number of levels at which the forecasts could exist and require consistent forecasts at all of them.

The aim of the paper is:

- To design a hierarchical middle-term forecasting system for apparel companies and supply chains on the basis of a literature review.
- To verify the system by means of a case study in an apparel company, to evaluate its weaknesses and to offer appropriate ways for their elimination.

The benefits of searching for new advanced forecasting systems in that branch can be expected at different levels [1, 6]:

- Reduction of the bullwhip effect without major supply chain reorganisation.
- Possibility for the supplier to smooth out production, optimise its resources, decrease costs, and improve the effectiveness of the retailer's sourcing strategy.
- Reduction of lost sales, markdowns and, consequently, increase the profit margin.

Literature review

Hierarchical forecasting

Most organisations deal with multiple levels of aggregation and require consistent forecasts at all levels. The pyramid in ***Figure 1*** shows a number of levels at which the forecasts could exist.

Hierarchical forecasting (HF), a family-based forecast methodology, is a centralised forecast approach capable of satisfying a variety of forecast information requirements [7]. Forecasts of item and family demands in the HF process are produced using two approaches – "top-

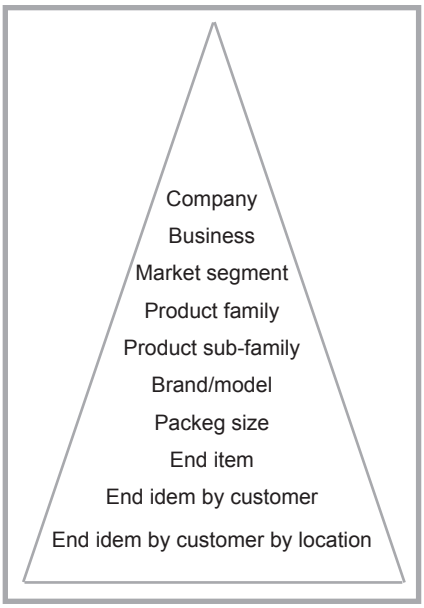

Figure 1. *The forecasting pyramid [7].*

down" and "bottom-up", or a combination of the two (sometimes called the "middle-out" approach).

The top-down approach entails forecasting a completely aggregated series, and then disaggregating the forecasts based on historical proportions [8]. These proportions may be accomplished in various ways, as demonstrated by Gross and Sohl [9]. The bottom-up approach involves forecasting each of the disaggregated series at the lowest level of the hierarchy, and then using simple aggregation to obtain forecasts at higher levels of the hierarchy [8]. Both of the approaches described will make sure that the resultant forecasts are consistent with those at either a higher or lower hierarchical level.

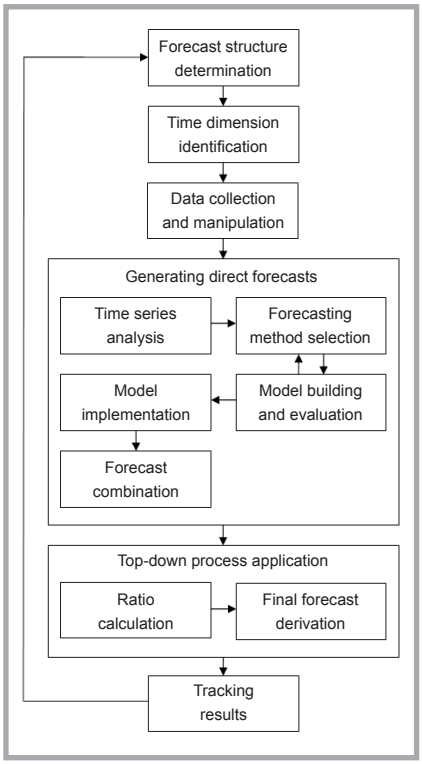

Figure 2. *Hierarchical sales forecasting system designed.*

Hierarchical sales forecasting system for apparel companies and supply chains

The following sales forecasting system was created on the basis of a literature review in the area of forecasting theory for the use of middle-term forecasting apparel companies and supply chains. Medium-term forecasts look ahead between three months and a year, and they are mostly used for the Sales and Operations Planning (S&OP) process [10].

There are two ways in which top-down and bottom-up forecasting is useful during S&OP; a process that is predicated on developing consensus-based demand and supply plans [11]:

- Development of a baseline forecast in order to take advantage of the accuracy that can be achieved by using both types in conjunction with each other.
- To get the requisite accountability and commitment from all the organisations involved in the S&OP process requires the forecasts to be aggregated and disaggregated (and possibly translated) to various levels to be reviewed and revised by each one, in terms they best understand.

Using guidelines for hierarchical forecasting by Fliedner [7] is the starting point of the system designed (see ***Figure 2***). The system designed is based on the top-down approach, which is recommended for strategic and tactical plans as well as budgets [12].

The forecasting system is based on applying six main stages:

- Forecast structure determination – determination of forecast levels, families at any level (parents) and children within any family.
- Time dimension identification – identification of the length and periodicity of the forecast.
- Data collection and manipulation – accessing and assembling appropriate data for each child and family; their getting into a form that is required for using the forecasting techniques intended.
- Generating direct forecasts – determination of direct and independent child and family forecasts, which can include:
  - Time series analysis – especially identifying the main component parts of the time series (trend, seasonal, cyclical, and irregular) as one of the most important criteria for selecting suitable forecasting techniques.
  - Forecasting method selection – determining the methods which might be good candidates for forecasting. It is recommended that more than one technique is used whenever possible, both from the group of available quantitative and qualitative methods.
  - Model building and evaluation – determining which models (from the forecasting techniques selected) provide the most accurate forecasts in terms of minimising forecasting error. If the models selected did not yield an acceptable level of accuracy, alternative models would be selected.
  - Model implementation – generating the actual model forecasts, i.e. appropriate forecasts are developed for the forecast horizon intended.
  - Forecast combination – combining the forecasts acquired if it is appropriate. When two or more methods that have different information bases are used, their combination will frequently provide better forecasts than either method alone. Wilson and Keating recommend the weighted average of simple predictions for a combined forecast [13]:

$$CF = \sum_{i=1}^{m} w_i F_i \qquad (1)$$

CF – combined forecast,
w_i – relative weight of i-th forecast (reflect forecasting error and must sum to 1.00),
F_i – forecast by means of n-th forecasting method,
m – number of combined forecasting techniques,
$i = 1, 2, ..., m$.

- Top-down process application – determination of child forecasts derived from the top level family with the following proration procedure [7]:

- Ratio calculation – calculation of the ratio of the direct child forecast and sum of the direct child forecasts comprising its family:

$$r_i = \frac{DCF_i}{\sum_{i=1}^{n} DCF_i} \quad (2)$$

i – ratio of i-th child,
DCF_i – direct forecast of i-th child,
n – number of children in its family,
$i = 1, 2, ..., n$.

- Final forecast derivation – multiplication of the final parent forecast by this ratio:

$$FCF_i = FPF \cdot r_i \quad (3)$$

FCF_i – final forecast of i-th child,
FPF – final parent forecast.

- Tracking results – continuous tracking of how well the forecasts compare with the actual values observed during the forecast horizon. Over time, even the best of techniques and models are likely to deteriorate in terms of accuracy and need to be respecified or replaced with an alternative method [13].

Case study

Possible applications of the hierarchical sales forecasting system designed were verified by a case study of an apparel company which belongs to the leading traditional producers of clothing in central Europe. The most important range of products includes overcoats, jackets, and dresses designed for prestigious world brands. The production of clothes is characterised by a high level of both technological processing and quality. An overwhelming majority of production is intended for export.

Forecast structure determination

In the medium-term, sales are forecasted on three levels (see ***Figure 3***). The top level includes the total sales of the plant, divided into two market families – inland and outland, each of which is further divided into four main product families – overcoats, jackets, dresses, and others. When focussing on prestigious world brands, the forecasting of foreign sales plays a key role.

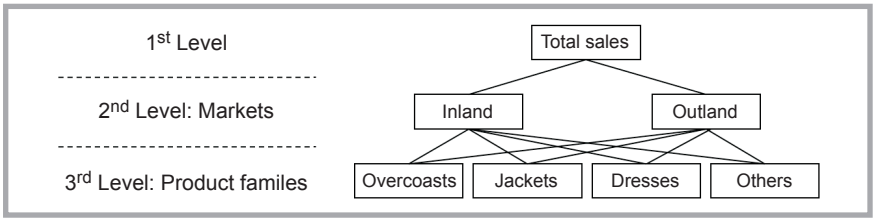

Figure 3. *Scheme of the company's forecast structure.*

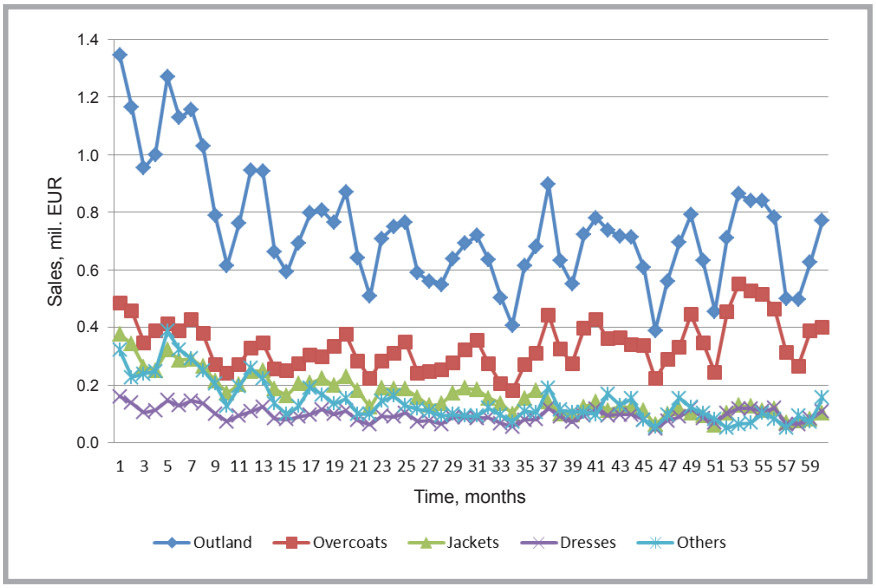

Figure 4. *Time series plot for outland sales.*

Time dimension identification

The forecast is carried out on a monthly basis. The length of the forecasting horizon is one year (from 1 January to 31 December), i.e. 12 months.

Data collection and manipulation

Company sales are characterised by rather significant seasonal fluctuations. The lower sales periods are usually February & March and September & October. Autumn and winter seasons are produced from April to August, and spring and summer seasons are produced from November to January. Particularly the forecasting of foreign sales is performed for the purpose of S&OP. The periods with lower sales are used for domestic market production and for retail networks of the company. The periods of higher sales must be covered by cooperation.

Sales of product families intended for foreign markets during the period of 2007 to 2011 (60 month) are demonstrated in ***Figure 4***. With regards to the sensitive nature of information, monthly sales data were determined by simulation using officially available annual data of company sales.

Figure 4 clearly shows a gradual decrease in foreign sales caused especially by the world economic crisis and strong competition from low-cost countries (Asiatic and south-east European countries). Although the sales of product families of overcoats are gradually increasing, the sales of other product families are continuously decreasing.

Generating direct forecasts

Using the time series analysis in statistical software STATGRAPHIC Plus 5.0, the significant seasonal and trend components were identified. With regards to this fact, suitable adaptive and Box-Jenkins methodology techniques were chosen for sales forecasting. Models were built and evaluated using statistical software STATGRAPHIC Plus 5.0. The most accurate forecasts, in terms of minimising forecasting error were provided by Box-Jenkins models (see ***Table 1***). The direct forecasts are presented in ***Table 2***.

Top-down process application

Use of the proration procedure for obtaining the product families' level forecasts is stated in ***Table 2***.

Table 1. The most accurate forecast models and their error statistics.

Sales	Outland	Overcoats	Jackets	Dresses	Others
SARIMA model	(2,1,2)× (2,1,2)12c	(0,0,2)× (2,1,2)12	(0,1,1)× (1,0,2)12	(0,1,2)× (2,1,0)12c	(2,1,2)× (1,1,2)12
RMSE	0.0504	0.0293	0.0133	0.0061	0.0277
MAE	0.0350	0.0221	0.0106	0.0037	0.0199
MAPE	5.0303	7.2227	7.3826	4.1433	18.2188
ME	-0.0031	0.0007	0.0011	0.0003	0.0033
MPE	-0.8149	-0.1557	0.8523	-0.1197	1.1081

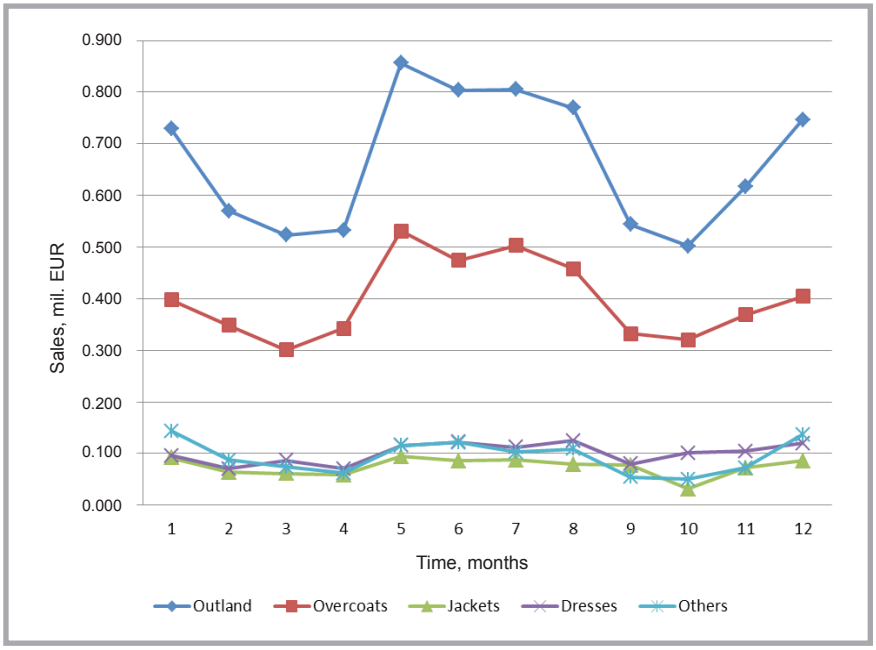

Figure 5. Final forecasts for the first and second level.

The final forecasts of the outland, overcoats, jackets, dresses, and others sales are graphically presented in ***Figure 5***. The forecasts acquired at the product families' level are consistent with the outland sales forecast.

Discussion of results

Despite the fact that the time series analysis currently provides a number of very high quality tools for sales forecasting, their application in the apparel industry is limited. The main reason is the fact that the use of historical data for the purpose of forecasting does not take into account other, in many cases absolutely essential, factors influencing future sales:

- Trade negotiations with key customers – customers address several apparel companies at the same time using pattern inquiries before each season. Future sales depend on the ability of the producer to prepare and to succeed with a competitive offer.
- Economic development in sales markets the influence of the economic situation in the markets on sales is illustrated by the current world economic crisis, which has caused a significant drop in sales in all central European apparel companies.
- Competition from low-cost countries – the current influence of importers from low-cost countries is gradually decreasing. Particularly producers in Asia are facing continuous growth of labour costs and are not able to provide prices as low as in previous years. Another reason of weaker competition from low-cost countries is represented by the persistent low quality of goods offered.
- Weather – with regard to the character of apparel industry products, weather plays a significant role in the amount of sales.
- Strategic plans of the company – strategic decisions related especially to the production range and markets have a fundamental impact on company sales. An extension of the production range and entry to new markets will probably be associated with increasing sales and vice versa.

That is why it is necessary to look for such tools of hierarchical forecasting in apparel companies and supply chains that make it possible to include not only historical data concerning sales but also other factors having an essential impact on the forecast quality. Suitable tools to be applied in this sphere may include anartificial neural network (ANN). These models can be exposed to large amounts

Table 2. Top-down process for the product families' level.

Month	Direct forecasts (mil. EUR)					Sum (mil. EUR)	Ratios				Final forecasts (mil. EUR)			
	Outland	Overcoats	Jackets	Dresses	Others		Overcoats	Jackets	Dresses	Others	Overcoats	Jackets	Dresses	Others
1	0.7286	0.4183	0.0962	0.1009	0.1509	0.7663	0.5458	0.1255	0.1317	0.1970	0.3977	0.0915	0.0959	0.1435
2	0.5699	0.3467	0.0633	0.0704	0.0867	0.5671	0.6113	0.1117	0.1241	0.1529	0.3483	0.0636	0.0707	0.0872
3	0.5231	0.2681	0.0546	0.0772	0.0658	0.4657	0.5756	0.1173	0.1659	0.1413	0.3011	0.0614	0.0868	0.0739
4	0.5329	0.3723	0.0640	0.0765	0.0671	0.5798	0.6420	0.1104	0.1319	0.1157	0.3421	0.0588	0.0703	0.0617
5	0.8562	0.4367	0.0776	0.0946	0.0949	0.7037	0.6206	0.1102	0.1344	0.1348	0.5313	0.0944	0.1151	0.1154
6	0.8035	0.4418	0.0802	0.1139	0.1130	0.7489	0.5899	0.1070	0.1521	0.1509	0.4740	0.0860	0.1222	0.1212
7	0.8055	0.4600	0.0801	0.1027	0.0940	0.7368	0.6243	0.1088	0.1393	0.1276	0.5029	0.0876	0.1122	0.1028
8	0.7700	0.4190	0.0724	0.1143	0.0992	0.7049	0.5944	0.1027	0.1622	0.1407	0.4577	0.0791	0.1249	0.1083
9	0.5439	0.2698	0.0630	0.0648	0.0442	0.4417	0.6107	0.1425	0.1466	0.1002	0.3322	0.0775	0.0798	0.0545
10	0.5019	0.2488	0.0240	0.0783	0.0387	0.3897	0.6384	0.0616	0.2008	0.0993	0.3204	0.0309	0.1008	0.0498
11	0.6171	0.3414	0.0667	0.0969	0.0669	0.5720	0.5969	0.1167	0.1695	0.1170	0.3683	0.0720	0.1046	0.0722
12	0.7465	0.3675	0.0776	0.1089	0.1240	0.6779	0.5421	0.1144	0.1606	0.1829	0.4047	0.0854	0.1199	0.1365

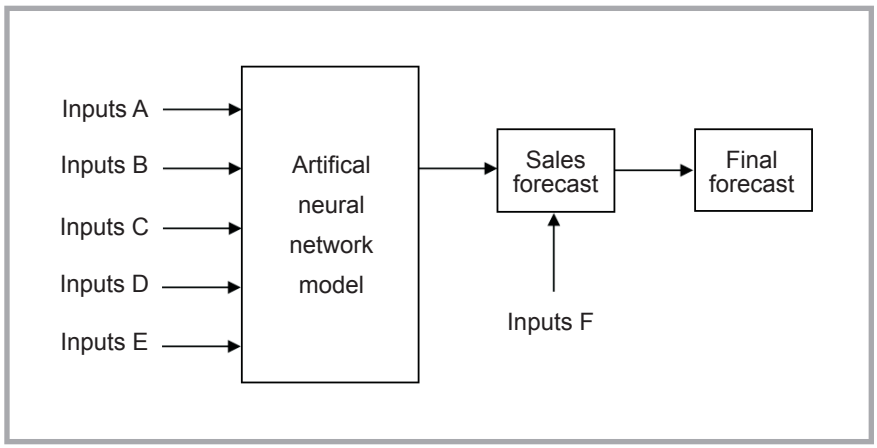

Figure 6. *Generalised concept of ANN forecasting model.*

of data and discover patterns as well as relationships within them [14].

The generalised concept illustrated in figure 6 can be used for sales forecasting at the single levels of the hierarchy in apparel companies and supply chains.

Inputs for an ANN forecasting model can be divided into six groups:

- Inputs A – historical data regarding sales of the apparel company or supply chain.
- Inputs B – data expressing the success of the apparel company or supply chain in negotiations with key customers (e.g. as a ratio of the quantity inquired and actually ordered).
- Inputs C – data taking into account apparel goods market development (e.g. in form of apparel market indexes).
- Inputs D – data related to the competitiveness of low-cost countries (e.g. as the amount of labour costs in the apparel industry).
- Inputs E – data taking into account weather.
- Inputs F – correction of sales forecasts acquired by the ANN forecasting model related to the strategic plans of the company.

Conclusion

The current situation on the apparel markets is characterised by relatively high fluctuations of customer demand, which makes the forecasting process at various company levels more and more difficult, especially from the point of view of quality forecasts used in S&OP. In many apparel companies, this process runs almost purely on the basis of the experience of company managers. That is why a complex hierarchical sales forecasting system based on the top-down forecasting approach and use of forecasting techniques, which would make it possible to include not only historical data concerning sales progress but also other factors having an essential impact on the forecast quality, should be designed and applied.

Based on the findings acquired, future research work can be defined in the following directions:

- Verification of the generalised ANN concept for sales forecasting at single levels of the hierarchy.
- Identification of special forecasting methods and models for families which are characterised by sporadic sales – the use of traditional forecasting models for the families described is very problematic.

Acknowledgement

The work was supported by specific university research of the Ministry of Education, Youth and Sports of the Czech Republic No. SP 2012/42 and SP 2013/49.

References

1. Thomassey S. Sales forecasts in clothing industry: The key success factor of the supply chain management. *International Journal of Production Economics* 2010; 128, 2: 470–483.
2. Frank C, Garg A, Sztandera L, Raheja A. Forecasting women's apparel sales using mathematical modeling. *International Journal of Clothing Science and Technology* 2003; 15, 2: 107–125.
3. Thomassey S, Happiette M, Castelain JM. A global forecasting support system adapted to textile distribution. *International Journal of Production Economics* 2005; 96, 1: 81–95.
4. Thomassey S, Happiette M, Castelain JM. A short and mean-term automatic forecasting system - application to textile logistics. *European Journal of Operational Research* 2005; 161, 1: 275–284.
5. Ozbek A, Akalin M, Topuz V, Sennaroglu B. Prediction of Turkey's Denim Trousers Export Using Artificial Neural Networks and the Autoregressive Integrated Moving Average Model. *FIBRES & TEXTILES in Eastern Europe* 2011; 19, 3: 10–16.
6. Bakalarczyk S. Innovation of the Polish Textile Sector with Respect to Antibacterial and Bacteriostatic Textiles. *FIBRES & TEXTILES in Eastern Europe* 2012; 20, 2: 13–17.
7. Fliedner G. Hierarchical forecasting: issues and use guidelines. *Management and Data Systems* 2001; 101, 1: 5–12.
8. Hyndman RJ, Ahmed RA, Athanasopoulos G, Shang HL. Optimal combination forecasts for hierarchical time series. *Computational Statistics and Data Analysis* 2011; 55, 9: 2579–2589.
9. Gross CW, Sohl JE. Disaggregation methods to expedite product line forecasting, *Journal of Forecasting* 1990; 9, 3: 233–254.
10. Takala J, Malindžák D, Straka M, et al. *Manufacturing Strategy – Applying the Logistics Models*, Vaasa: Vaasan yliopisto – University of Vaasa, 2007.
11. Lapide L. Top-down & bottom-up forecasting in S&OP. *The Journal of Business Forecasting* 2006; 25, 2: 14-16.
12. Kahn K. B. Revisiting top-down versus botton-up forecasting. *The Journal of Business Forecasting* 1998; 17, 2: 14-19.
13. Wilson JH, Keating B. *Business Forecasting with Accompanying Excel-Based ForecastX™ Software*. McGraw-Hill Companies, 2002.
14. Levenbach H, Cleary JP. *Forecasting: Practice and Process for Demand Management*. Duxbury, 2006.

Received 26.06.2012 Reviewed 16.04.2013