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Analysis of the quality of the sales forecast

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Abstract. *This paper presents how to solve the forecasting problems in the conversational system using WinQSB and QM computer products. The study is carried out using three forecasting methods (moving average, single exponential smoothing, linear regression with time) based on sales in the last 12 weeks.*

Keywords: *forecast, moving average, single exponential smoothing, linear regression with time*

1. Introduction

Maximizing profits is the major concern of industrial decision-makers. Obviously, one of the most important factors in the amount of profit is the volume of production, along with the unit selling price, cost structure, etc. [8] Depending on the possibility of the decision maker/researcher to act on the factors in the organization's environment and to influence their evolution, internal and external factors can be identified [6]. Trying to take these factors into account (whether controllable or not) leads to the use of different prediction-US methods [8][6]:

- methods of judgment – Delphi method, expert opinion, historical analogues, etc.;
- causal methods – multiple regression analysis, correlation analysis;
- methods based on time series (dynamic) – moving average method, adjustment method, decompositional methods, etc.;
- econometric methods.

A forecasting system must ensure a significant reaction to a rapid variation of one of the elements that make up the demand and also stabilize and mitigate variations that are purely random [3].

All companies that rely on sales forecasting confirm that the most important aspect of forecasting is how the forecasting activities, the information system, and the people who produce and use the forecasts interact [2].

There are several effective measures of forecast accuracy, namely: mean error (Bias), mean absolute error, sum of squared errors and mean squared error (MSE), as well as measures of accuracy relative to a perfect forecast: percent error, mean absolute percent error (MAPE), year–to–date mean absolute percent error [4].

2. Input data

An industrial enterprise wants to estimate sales for the next periods, with the evolution over the last 12 weeks at its disposal and taking into account that the sales dynamics are not seasonal.

Week	Sales (p.u.)
1	85
2	130
3	180
4	145
5	250
6	200
7	285
8	190
9	275
10	250
11	300
12	340

Week	Historical Data
1	85
2	130
3	180
4	145
5	250
6	200
7	285
8	190
9	275
10	250
11	300
12	340

Figure 1. Problem input data in matrix form (in QM and WINQSB programs)

Figure 2. The input data of the problem in graphical form

Based on these data (Figure 1 and Figure 2), the following methods are used:

1. Moving average (MA)
2. Single exponential smoothing (SES)
3. Linear regression with time (LR)

With WinQSB and QM software, the following errors will be determined and analyzed:

- Mean Absolute Deviation (MAD) – with WinQSB and QM
- Cumulative Forecast Error (CFE) – with WinQSB
- Mean Square Error (MSE) – with WinQSB and QM
- Mean Absolute Percent Error (MAPE) – with WinQSB and QM
- Mean Error (Bias) – with QM

3. Problem solving in the conversational system

The following aspects shall be considered:

a) the determination of the forecast shall be made using the values recorded for the first 8 weeks;

b) forecast errors will be calculated over the last 4 weeks (actual sales values are known).

Following the application of the methods mentioned in section 2, the errors obtained will be analyzed and the method will be determined which is more accurate, and we will consider those data as those forecast for the coming weeks.

09-20-2022 Week	Actual Data	Forecast by 8-MA	Forecast Error	CFE	MAD	MSE	MAPE (%)	Tracking Signal	R-square
1	85.0000								
2	130.0000								
3	180.0000								
4	145.0000								
5	250.0000								
6	200.0000								
7	285.0000								
8	190.0000								
9	275.0000	183.1250	91.8750	91.8750	91.8750	8441.0160	33.4091	1.0000	
10	250.0000	206.8750	43.1250	135.0000	67.5000	5150.3910	25.3295	2.0000	
11	300.0000	221.8750	78.1250	213.1250	71.0417	5468.0990	25.5669	3.0000	
12	340.0000	236.8750	103.1250	316.2500	79.0625	6759.7660	26.7579	4.0000	
13		261.2500							
14		261.2500							
15		261.2500							
16		261.2500							
CFE		316.2500							
MAD		79.0625							
MSE		6759.7660							
MAPE		26.7579							
Trk.Signal		4.0000							
R-square									
		m=8							

Figure 3. Detailed solution offered by WinQSB –Moving average (MA) method

The first method applied in this study is the moving average (MA) method, and the results are shown in Figure 3 (WinQSB program) and Figure 4 (QM program).

In the case of applying the Single exponential smoothing (SES) method with the WinQSB program, first of all the work mode is chosen, i.e.:

- the method of estimating parameters is selected:
  - Assign Values
  - Search for Best
- the input data is entered
  - number of periods for forecast
  - smoothing constant alpha (α)
  - initial value F(0) if it is known

Details and Error Analysis

Amariei Olga Solution

	Sales (p.u.)	Forecast	Error	|Error|	Error^2	|Pct Error|
1	85					
2	130					
3	180					
4	145					
5	250					
6	200					
7	285					
8	190					
9	275					
10	250	193,333	56,667	56,667	3211,112	22,667%
11	300	211,667	88,333	88,333	7802,777	29,444%
12	340	230,556	109,444	109,444	11978,09	32,19%
TOTALS	2630		254,444	254,444	22991,97	84,301%
AVERAGE	219,167		84,815	84,815	7663,992	28,1%
Next period forecast		248,333	(Bias)	(MAD)	(MSE)	(MAPE)
				Std err	151,631	

Figure 4. Detailed solution offered by QM –Moving average (MA) method

The *Forecasting* module in WinQSB has built in the α coefficient simulation routine [7]. *Search the best* it is selected and then the comparison criterion (MAD, CFE, MSE or MAP), according to Figure 5, for finding of the best value.

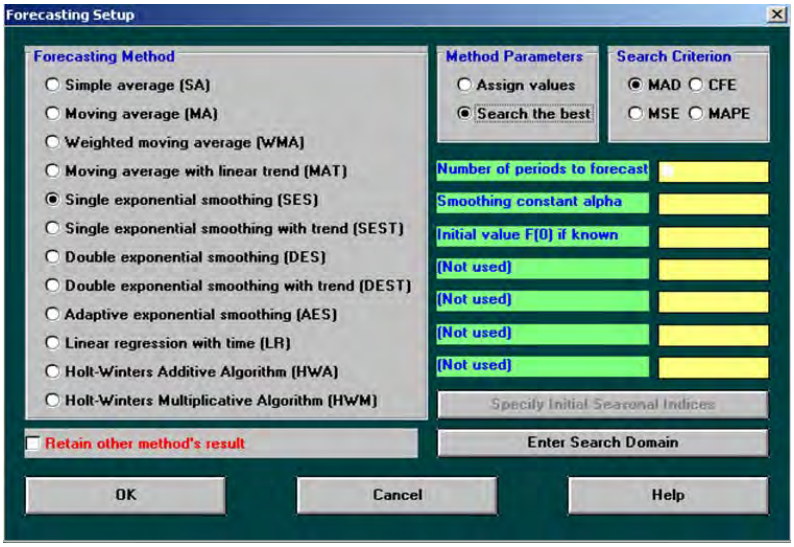

Figure 5. *Forecasting Setup* dialog window

09-20-2022 Week	Actual Data	Forecast by SES	Forecast Error	CFE	MAD	MSE	MAPE (%)	Tracking Signal	R-square
1	85.0000								
2	130.0000	85.0000	45.0000	45.0000	45.0000	2025.0000	34.6154	1.0000	
3	180.0000	108.8500	71.1500	116.1500	58.0750	3543.6620	37.0716	2.0000	
4	145.0000	146.5595	-1.5595	114.5905	39.2365	2363.2520	25.0729	2.9205	
5	250.0000	145.7330	104.2670	218.8576	55.4941	4490.3430	29.2314	3.9438	
6	200.0000	200.9945	-0.9945	217.8631	44.5942	3592.4720	23.4845	4.8855	
7	285.0000	200.4674	84.5326	302.3957	51.2506	4184.6870	24.5139	5.9003	
8	190.0000	245.2697	-55.2697	247.1261	51.8247	4023.2650	25.1675	4.7685	
9	275.0000	215.9767	59.0233	306.1493	52.7246	3955.8250	24.7044	5.8066	
10	250.0000	247.2591	2.7409	308.8903	47.1708	3517.1240	22.0813	6.5483	
11	300.0000	248.7118	51.2882	360.1785	47.5826	3428.4600	21.5828	7.5695	
12	340.0000	275.8945	64.1055	424.2840	49.0847	3490.3740	21.3348	8.6439	
13		309.8704							
14		309.8704							
15		309.8704							
16		309.8704							
CFE		424.2840							
MAD		49.0847							
MSE		3490.3740							
MAPE		21.3348							
Trk.Signal		8.6439							
R-square									
		Alpha=0.53							
		F[0]=85							

Figure 6. Detailed solution offered by WinQSB –
Single exponential smoothing (SES) method –MAD criteria

09-20-2022 Week	Actual Data	Forecast by SES	Forecast Error	CFE	MAD	MSE	MAPE (%)	Tracking Signal	R-square
1	85.0000								
2	130.0000	85.0000	45.0000	45.0000	45.0000	2025.0000	34.6154	1.0000	
3	180.0000	130.0000	50.0000	95.0000	47.5000	2262.5020	31.1966	2.0000	
4	145.0000	180.0000	-35.0000	60.0001	43.3333	1916.6670	28.8437	1.3846	
5	250.0000	145.0000	105.0000	165.0000	58.7500	4193.7490	32.1328	2.8085	
6	200.0000	249.9999	-49.9999	115.0001	57.0000	3854.9970	30.7062	2.0175	
7	285.0000	200.0000	85.0000	200.0001	61.6666	4416.6640	30.5593	3.2432	
8	190.0000	284.9999	-94.9999	105.0001	66.4285	5074.9960	33.3365	1.5806	
9	275.0000	190.0001	84.9999	190.0001	68.7500	5343.7450	33.0331	2.7636	
10	250.0000	274.9999	-24.9999	165.0001	63.8889	4819.4400	30.4738	2.5826	
11	300.0000	250.0000	50.0000	215.0001	62.5000	4587.4960	29.0931	3.4400	
12	340.0000	300.0000	40.0000	255.0002	60.4545	4315.9050	27.5178	4.2180	
13		340.0000							
14		340.0000							
15		340.0000							
16		340.0000							
CFE		255.0002							
MAD		60.4545							
MSE		4315.9050							
MAPE		27.5178							
Trk.Signal		4.2180							
R-square									
		Alpha=1							
		F(0)=85							

Figure 7. Detailed solution offered by WinQSB –
Single exponential smoothing (SES) method –CFE criteria

09-20-2022 Week	Actual Data	Forecast by SES	Forecast Error	CFE	MAD	MSE	MAPE (%)	Tracking Signal	R-square
1	85.0000								
2	130.0000	85.0000	45.0000	45.0000	45.0000	2025.0000	34.6154	1.0000	
3	180.0000	113.8000	66.2000	111.2000	55.6000	3203.7210	35.6966	2.0000	
4	145.0000	156.1680	-11.1680	100.0320	40.7893	2177.3880	26.3651	2.4524	
5	250.0000	149.0205	100.9795	201.0116	55.8369	4182.2570	29.8718	3.6000	
6	200.0000	213.6473	-13.6473	187.3642	47.3990	3383.0560	25.2621	3.9529	
7	285.0000	204.9130	80.0870	267.4512	52.8470	3888.2000	25.7352	5.0609	
8	190.0000	256.1687	-66.1687	201.2825	54.7501	3958.2130	27.0339	3.6764	
9	275.0000	213.8207	61.1793	262.4618	55.5537	3931.2990	26.4355	4.7245	
10	250.0000	252.9754	-2.9754	259.4863	49.7117	3495.4720	23.6305	5.2198	
11	300.0000	251.0712	48.9288	308.4152	49.6334	3385.3280	22.8984	6.2139	
12	340.0000	282.3856	57.6144	366.0296	50.3589	3379.3360	22.3572	7.2684	
13		319.2588							
14		319.2588							
15		319.2588							
16		319.2588							
CFE		366.0296							
MAD		50.3589							
MSE		3379.3360							
MAPE		22.3572							
Trk.Signal		7.2684							
R-square									
		Alpha=0.64							
		F(0)=85							

Figure 8. Detailed solution offered by WinQSB –
Single exponential smoothing (SES) method –MSE criteria

09-20-2022 Week	Actual Data	Forecast by SES	Forecast Error	CFE	MAD	MSE	MAPE (%)	Tracking Signal	R-square
1	85.0000								
2	130.0000	85.0000	45.0000	45.0000	45.0000	2025.0000	34.6154	1.0000	
3	180.0000	108.4000	71.6000	116.6000	58.3000	3575.7810	37.1966	2.0000	
4	145.0000	145.6320	-0.6320	115.9680	39.0773	2383.9870	24.9430	2.9677	
5	250.0000	145.3034	104.6966	220.6647	55.4822	4528.3370	29.1769	3.9772	
6	200.0000	199.7456	0.2544	220.9191	44.4366	3622.6820	23.3670	4.9716	
7	285.0000	199.8779	85.1221	306.0412	51.2175	4226.5310	24.4504	5.9753	
8	190.0000	244.1414	-54.1414	251.8998	51.6352	4041.4960	25.0282	4.8784	
9	275.0000	215.9879	59.0121	310.9120	52.5573	3971.6130	24.5821	5.9157	
10	250.0000	246.6742	3.3258	314.2378	47.0872	3531.5520	21.9986	6.6735	
11	300.0000	248.4036	51.5964	365.8342	47.5381	3444.6160	21.5186	7.6956	
12	340.0000	275.2337	64.7663	430.6005	49.1043	3512.8030	21.2941	8.7691	
13		308.9122							
14		308.9122							
15		308.9122							
16		308.9122							
CFE		430.6005							
MAD		49.1043							
MSE		3512.8030							
MAPE		21.2941							
Trk.Signal		8.7691							
R-square									
		Alpha=0.52							
		F(0)=85							

Figure 9. Detailed solution offered by WinQSB –
Single exponential smoothing (SES) method – MAPE criteria

Using the QM program, we obtained the following results by choosing four different values for α (Figure 10).

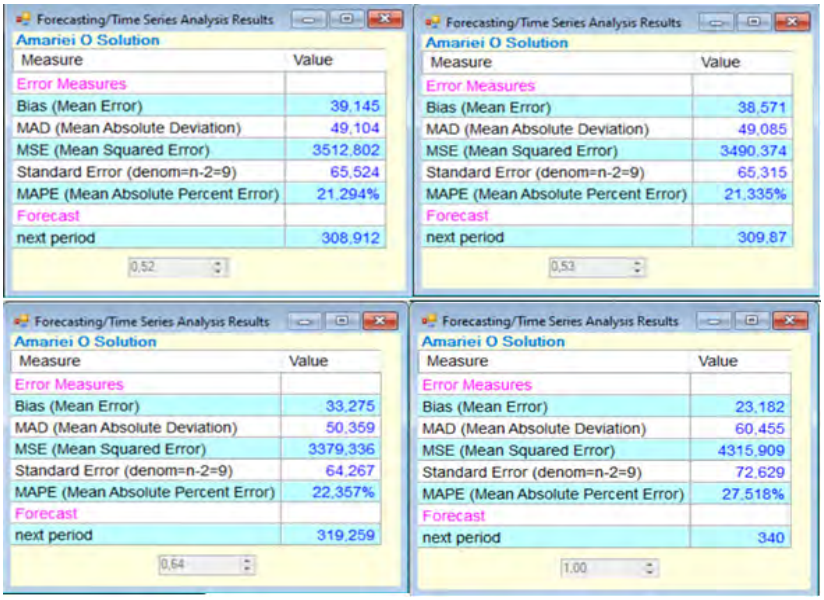

Figure 10. The solution offered by QM –
Single exponential smoothing (SES) method

The last method to be applied is Linear regression with time (LR). The results obtained with WinQSB are shown in Figure 11, and those with QM in Figure 12, in matrix form, and in Figure 13, in graphic form.

09-20-2022 Week	Actual Data	Forecast by LR	Forecast Error	CFE	MAD	MSE	MAPE (%)	Tracking Signal	R-square
1	85.0000	115.7052	-30.7052	-30.7052	30.7052	942.8065	36.1237	-1.0000	
2	130.0000	134.5163	-4.5163	-35.2215	17.6107	481.6019	19.7989	-2.0000	0.7874
3	180.0000	153.3275	26.6725	-8.5490	20.6313	558.2082	18.1386	-0.4144	0.1621
4	145.0000	172.1387	-27.1387	-35.6877	22.2582	602.7834	18.2831	-1.6034	0.4490
5	250.0000	190.9499	59.0501	23.3624	29.6166	1179.6100	19.3504	0.7888	0.2395
6	200.0000	209.7611	-9.7611	13.6013	26.3073	998.8879	16.9388	0.5170	0.3727
7	285.0000	228.5723	56.4277	70.0290	30.6102	1311.0600	17.3474	2.2878	0.3653
8	190.0000	247.3835	-57.3835	12.6456	33.9569	1558.7850	18.9542	0.3724	0.5115
9	275.0000	266.1946	8.8054	21.4509	31.1623	1394.2010	17.2040	0.6884	0.5815
10	250.0000	285.0058	-35.0058	-13.5549	31.5466	1377.3220	16.8838	-0.4297	0.7397
11	300.0000	303.8170	-3.8170	-17.3719	29.0257	1253.4350	15.4646	-0.5985	0.7988
12	340.0000	322.6282	17.3718	-0.0001	28.0546	1174.1310	14.6016	0.0000	0.7822
13		341.4394							
14		360.2506							
15		379.0618							
16		397.8729							
CFE		-0.0001							
MAD		28.0546							
MSE		1174.1310							
MAPE		14.6016							
Trk.Signal		0.0000							
R-square		0.7822							
		Y-intercept=96.8940							
		Slope=18.8112							

Figure 11. Detailed solution offered by WinQSB – Linear regression with time (LR) method

Details and Error Analysis

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	Sales (p.u.)	Time	x^2	x * y	Forecast	Error	|Error|	(E-Ebar)^2	|Pct Error|
1	85	1	1	85	115,705	-30,705	30,705	942,807	36,124%
2	130	2	4	260	134,516	-4,516	4,516	20,397	3,474%
3	180	3	9	540	153,328	26,672	26,672	711,421	14,818%
4	145	4	16	580	172,139	-27,139	27,139	736,509	18,716%
5	250	5	25	1250	190,95	59,05	59,05	3486,916	23,62%
6	200	6	36	1200	209,761	-9,761	9,761	95,279	4,881%
7	285	7	49	1995	228,572	56,428	56,428	3184,089	19,799%
8	190	8	64	1520	247,384	-57,383	57,383	3292,861	30,202%
9	275	9	81	2475	266,195	8,805	8,805	77,534	3,202%
10	250	10	100	2500	285,006	-35,006	35,006	1225,408	14,002%
11	300	11	121	3300	303,817	-3,817	3,817	14,57	1,272%
12	340	12	144	4080	322,628	17,372	17,372	301,78	5,109%
TOTALS	2630	78	650	19785		0	336,655	14089,57	175,22%
AVERAGE	219,167	6,5				0	28,055	1174,131	14,602%
Next period forecast					341,439	(Bias)	(MAD)	(MSE)	(MAPE)
Intercept	96,894						Std err	37,536	
Slope	18,811								

Figure 12. Detailed solution offered by QM – Linear regression with time (LR) method

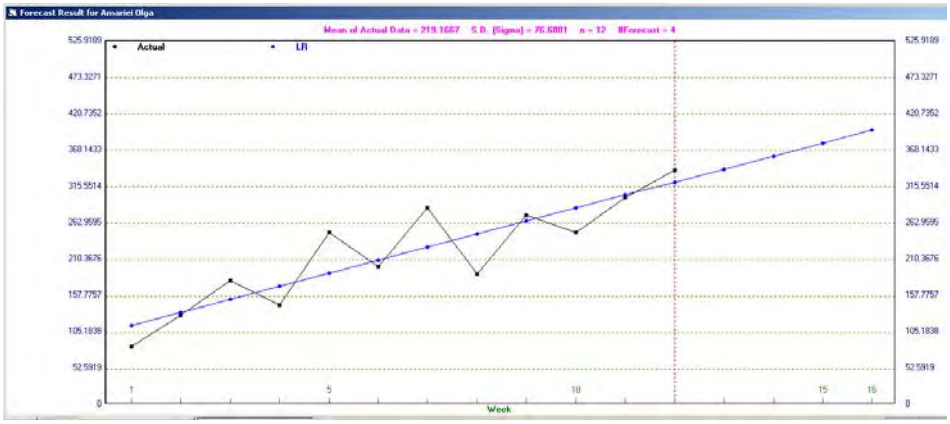


Figure 13. Results in graphic form (WinQSB)

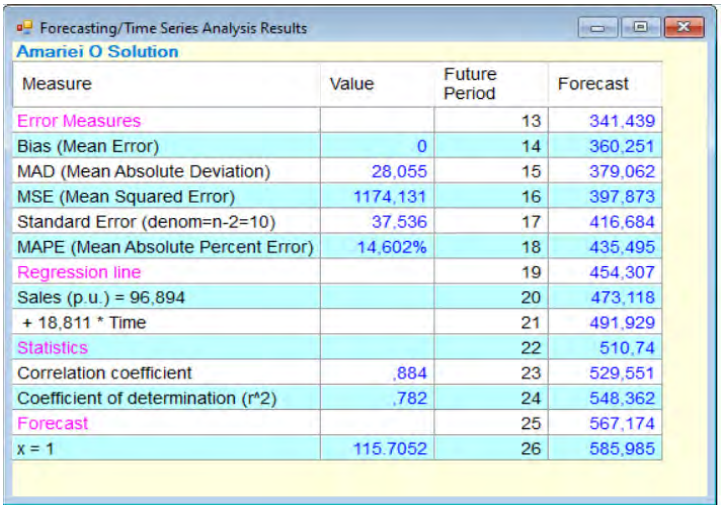
In Table 1, the results obtained with the two programs are centralized, which, in fact, was observed during the work that they are identical. The error analysis in Table 1 is carried out for each type of error.

- Mean Error (Bias) – the highest value was obtained with the MA method and the lowest for LR method, namely: 0. There is no difference between results and forecasts.
- Mean Absolute Deviation (MAD) – the highest value was obtained in the same way as in the case of Bias, for the MA method: 79,063, and the lowest was recorded in the case of the LR method (28,054).
- Cumulative Forecast Error (CFE) – the highest value of 430,60 was obtained with the SES method (α=0,52) and the lowest with the LR method (0).

Table 1. Centralized results

Method used		**Forecast value for weeks**				**Errors in forecasting**				
		9	10	11	12	Bias	MAD	CFE	MSE	MAPE
MA		183,13	206,88	221,88	236,88	79,063	79,063	316,25	6759,77	26,76
SES	α=0,52	215,99	246,67	248,40	275,23	39,145	49,104	430,60	3512,80	21,29
	α=0,53	215,98	247,26	248,71	275,89	38,571	49,08	424,28	3490,37	21,33
	α=0,64	213,82	252,98	251,07	282,39	33,275	50,36	366,03	3379,34	22,36
	α=1	190,00	274,99	250,00	300,00	23,182	60,45	255,00	4315,90	27,52
LR		266,19	285,00	303,82	322,63	**0**	**28,054**	**0**	**1174,13**	**14,60**

- Mean Square Error (MSE) – the highest value was obtained in the case of the MA method, and the lowest value, equal to 1174,13, was recorded as in all cases analyzed, in the LR method.
- Mean Absolute Percent Error (MAPE) – The highest value was also obtained with the SES method (α=1) and the lowest value was obtained with the LR method (14,60%). The lower this value, the higher the accuracy of the forecast [9]. A superior accuracy for the forecast based on the linear regression function shall be observed.


Forecasting/Time Series Analysis Results

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Measure	Value	Future Period	Forecast
Error Measures		13	341,439
Bias (Mean Error)	0	14	360,251
MAD (Mean Absolute Deviation)	28,055	15	379,062
MSE (Mean Squared Error)	1174,131	16	397,873
Standard Error (denom=n-2=10)	37,536	17	416,684
MAPE (Mean Absolute Percent Error)	14,602%	18	435,495
Regression line		19	454,307
Sales (p.u.) = 96,894		20	473,118
+ 18,811 * Time		21	491,929
Statistics		22	510,74
Correlation coefficient	,884	23	529,551
Coefficient of determination (r^2)	,782	24	548,362
Forecast		25	567,174
x = 1	115.7052	26	585,985

Figure 14. 13-26 week forecast

The study revealed that the errors were lowest when applying the simple linear regression method. The forecasting was carried out using this method and obtaining the results shown in Figure 14.

5. Conclusion

In the present paper, it was possible to observe the use of the WinQSB and QM programs in order to make sales forecasts. The study was carried out with the help of these programs, using three forecasting methods, namely: moving average, single exponential smoothing and linear regression with time.

Analyzing in the end, each type of error separately, it was found that in absolutely all cases the lowest error values were obtained in the case of applying the simple linear regression method.

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