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EVALUATION OF THE IMPACT OF WORK REORGANISATION IN A WHOLESALE STORE ON WEEKLY, MONTHLY, AND YEARLY CYCLICALITY DISCUSSED ON THE BASIS OF DAILY DATA

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ABSTRACT

This paper attempts to evaluate the complex cyclicality of daily data in the course of reorganisation of the work of a wholesale store. In the study concerning a selected wholesale store three cycles of weekly, monthly, and yearly duration were distinguished using a set of zero-one variables in econometric models. The study period may be divided into two parts – before and after the introduction of organisational changes in the wholesale store.

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INTRODUCTION

Changes are an inseparable element connected with the operation of every company (Drucker 2000). According to Stoner (2001), changes are nothing else but systematic striving for redesigning the organisation to adjust to dynamic environment and focusing on the achievement of new goals by the company. A common feature for the changes implemented in a company is the adjustment period, during which typical customer behaviour changes, which results in variable demand, difficult to model (Kufel, Błażejowski, Kufel 2014) and the calculated amplitudes may be affected by numerous outliers.

Modelling of the cyclicality of processes is a useful tool in planning a warehouse stock and wholesale store's sales. Periods of zero sales, which result mainly from fixed and movable feasts, are a characteristic feature of modelling the cyclicality of daily data. In micro companies, due to their specificity, the number of days with zero sales may be

higher as their share may additionally increase in the case of series disaggregation into product categories (Kufel 2010). Another element that makes cyclicality evaluation difficult are the days with highly divergent sales, which have a major and unfavourable impact on the model. Outliers may increase the residual variance of the described phenomenon and thus burden the evaluation of the modelled process.

This study aims to evaluate the impact of reorganisation of the work of a wholesale store on the cyclicality of sales described with daily data and comparative analysis of amplitudes calculated from selected cyclicality models.

This paper presents the results of 7 models estimated on the basis of numerous daily observations concerning the sales of yogurt. The research question was: how big mistakes can be made in the case of setting daily data cyclicality amplitudes in the process, which is also burdened with changes resulting from working time reorganisation. The data from the period from 2 January 2009 to 23 December 2013 comes from a selected wholesale store in which major organisational changes occurred.

ESTIMATING AMPLITUDES OF COMPLEX DAILY DATA CYCLICALITY

In the case of daily frequency economic processes we can expect cycles with yearly (connected mainly with the change of seasons of the year), monthly (connected with the payment of remuneration and taxes) or weekly (connected with the working day arrangement) frequency, and these fluctuations occur independently (Błażejowski, Kufel 2009). The arrangement of statistical data results from the company's working time organisation and may concern seven day weeks, weeks without Sundays, or weeks without Sundays and Saturdays (Kufel 2010).

The following two groups of methods are used for calculating the amplitudes of cyclical fluctuations (Błażejowski, Kufel 2009):

1. mechanical methods of calculating cyclical fluctuations,
2. analytical methods of calculating cyclical fluctuations.

The analytical methods include trend-cycle models, which describe trends using (Błażejowski, Kufel 2009):

1. a proper set of zero-one variables,
2. a proper set of harmonics.

To determine cyclical amplitudes for the occurrence of zero sales periods connected with non-working calendar days missing observations may be supplemented. In order to do this, homologous means should be calculated on the basis of observations from adjoining weeks with the following formula: $y_t = (y_{t-p}+y_{t+p})/2$. In the case of days with zero sales these periods should not be averaged, they can be described with an additional set of zero-one variables in the set:

1. of one zero-one variable for all zero sales periods,
2. adding to the model a zero-one variable for every observation with zero sales.

In the case of the series concerning single daily transactions, these processes are highly variable, which should be explained with complex cyclicality and high influence

of outliers (Kufel 2009). It should be remembered that, as a result, the characteristics mentioned above lower the quality of the econometric model, increase residual variance, and lower the degree of adjustment of the model to the data. Single transactions of high value are impossible to forecast as it is impossible to identify their determinants. One of the solutions are saturated models that include as many zero-one variables for particular periods as possible, on the assumption that: $|e_t| > S_e * u_\alpha$. Such approach is applied to describe all atypical observations (Kufel 2009).

Summing up, the following specifications of the model of description of the yearly, monthly, and weekly cycles were used in the study (Kufel 2009):

Model A - basic model

$$Y_t = \alpha_0 + \alpha_1 t + \sum_{i=1}^{5} b_i T_{it} + \sum_{j=1}^{30} d_j D_{jt} + \sum_{s=1}^{11} m_s M_{st} + \varepsilon_t$$

t – time variable,
T_{it} – block of zero-one variables for the description of the weekly cycle,
D_{jt} – block of zero-one variables for the description of the monthly cycle,
M_{st} – block of zero-one variables for the description of the yearly cycle,

Model B – model excluding zero sales

$$Y_t = \alpha_0 + \alpha_1 t + \alpha_2 w_t + \sum_{i=1}^{5} b_i T_{it} + \sum_{j=1}^{30} d_j D_{jt} + \sum_{s=1}^{11} m_s M_{st} + \varepsilon_t$$

w_t - zero-one variable for periods with zero sales

Model C – model excluding zero sales and outliers (one zero-one variable for all periods with outliers)

$$Y_t = \alpha_0 + \alpha_1 t + \alpha_2 w_t + \alpha_3 out_t + \sum_{i=1}^{5} b_i T_{it} + \sum_{j=1}^{30} d_j D_{jt} + \sum_{s=1}^{11} m_s M_{st} + \varepsilon_t$$

out_t – zero-one variable for periods with sales outliers, on the assumption that: $out_t = \{0$ when $Y_t < Y^*_t$, 1 when $Y_t > Y^*_t)$,
Y^*_t – sales value above which outliers are identified

Model D – model excluding zero sales and outliers (a set of zero-one variables for periods with outliers)

$$Y_t = \alpha_0 + \alpha_1 t + \alpha_2 w_t + \sum_{i=1}^{5} b_i T_{it} + \sum_{j=1}^{30} d_j D_{jt} + \sum_{s=1}^{11} m_s M_{st} + \sum_{l=1}^{n} k_l K_{lt} + \varepsilon_t$$

K_{lt} – a block of single zero-one variables for atypical observations on the assumption that: $K_{lt} = \{0$ when $Y_t < Y^*_t$, 1 when $Y_t > Y^*_t)$

Model E – saturated model

$$Y_t = \beta_0 + \sum_{j=1}^{k_0} \beta_j X_{jt} + \sum_{i=1}^{k_1} \nu_i D_{it} + v_t$$

on the assumption that: D_{it}= {1: t = t_i ; 0: t ≠ t_i}, t_i ϵ D, D = {t_1, t_2, ..., t_{k_1}}, for: $|e_t| > S_e * u_{\alpha}$, the number of additionally entered snapshot variables must be lower than the degree of freedom of the model.

Model F – variable cycle model

$$Y_t = a_{00} + a_{01}Z_t + a_{10}t + a_{11}tZ_t + \sum_{i=1}^{5}(b_{20}T_{it} + b_{21}T_{it}Z_t) +$$
$$+ \sum_{j=1}^{30}(d_{30}D_{jt} + d_{31}D_{jt}Z_t) \sum_{s=1}^{11}(m_{40}M_{st} + m_{41}M_{st}Z_t) + \varepsilon_t$$

on the assumption that: Z_t={0: t < t^* ; 1: t > t^*}, t^* – date of introduction of organisational changes.

EMPIRICAL EVIDENCE

The empirical evidence uses a series of daily observations of the value of yogurt sales (Figure 1). The data comes from the wholesale store whose product range includes primarily: yogurts, frozen food, ice-cream, cheese and other dairy products. In the analysed period, the wholesale store was expanding its activity and opened the second customer service point with ice-cream warehouses only. The first point has been open since 2012 from Monday to Friday, and the second point – from Monday to Saturday. The transaction system that records sales does not include information on the customer service point, therefore it is impossible to divide the data series into two groups. As a result, changes are visible in the statistical series in attempts of data modelling with division into sales groups manifested as zero or lowered sales on Saturday for most sales groups [table 1]. A question should be asked about its impact on the determined amplitudes of weekly, monthly, and yearly cyclicality.

The graph in Figure 1 shows a high degree of irregular interference. Preliminary analysis shows that complex cycles including zero sales and outlier periods should be expected in the covered period. The series has a strong positive asymmetry.

Table 2 presents calculated annual, monthly, and weekly cyclicality indices obtained on the basis of 6 estimated models of the studied process.

In models B-E the entered sets of zero-one variables turned out to be statistically relevant, adding them to the basic model (A) considerably reduced the standard error of remainders and also improved 3 information criteria. As far as the saturated model (E) is concerned, it should be added that the evaluation of the model's parameters were not significantly altered (in comparison with the basic model).

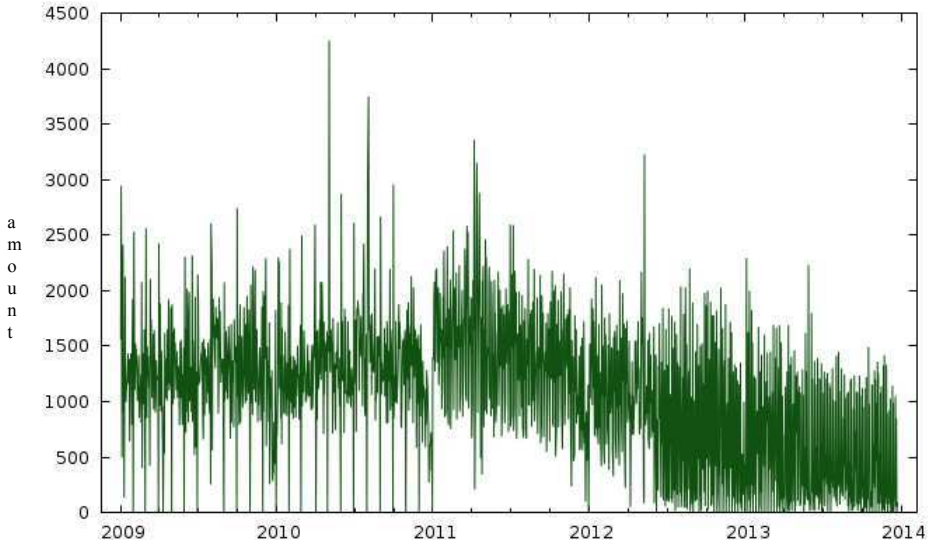

Figure 1. Daily sales value in a selected wholesale store in Poland for the period from 2 January 2009 to 30 December 2013 [group 1 - yogurts], 6-day week [n = 1562]
Source: own work on the basis of the internal data of the wholesale store.

Table 1. The number of invoiced sales days and zero sales days divided by days of the week for group 1

Day of the week	Number of days (2009/01/02-2013/12/31)	Invoiced sales	Difference	Bank holidays	**Days with zero sales**
Monday	261	246	15	10	**5**
Tuesday	261	249	12	5	**7**
Wednesday	260	252	8	4	**4**
Thursday	260	244	16	12	**4**
Friday	261	251	10	7	**3**
Saturday	261	201	60	5	**55**

Source: own work on the basis of the internal data of the wholesale store.

In Table 2, the differences in the calculated amplitudes should be noticed. In the case of models B-D, where the calculated amplitudes are significantly lower than in model A, it should be concluded that zero values and outliers had a big impact on these periods. And when the calculated amplitudes were on a similar level, the impact of these observations was insignificant.

Table 2. Calculated annual, monthly, and weekly cyclicality indices for the process of daily yogurt sales

variable	model A	model B	model C	model D	model E*
Monday	-187,7873333	-212,66365	-209,615	-209,29	-150,775
Tuesday	115,0666667	105,98305	95,44382	94,71	105,6043
Wednesday	160,7496667	127,37805	129,9658	128,58	222,6483
Thursday	-116,4673333	-139,69955	-143,234	-145,79	-246,91
Friday	336,0296667	311,61705	308,5058	312,73	415,2353
Saturday	*-307,5913333*	*-192,61495*	*-181,07*	*-180,94*	*-345,8*
January	48,46941667	49,4455	46,47383	51,72683	20,54058
February	-12,32858333	6,8585	20,62683	20,67083	0,366583
March	66,42241667	65,7895	77,46483	77,33883	69,56858
April	66,02941667	71,8865	53,34883	52,95983	54,79058
May	38,23241667	23,4455	5,320833	-4,55017	16,55958
June	-43,52358333	-49,7845	-37,9342	-37,9002	-29,5234
July	32,98341667	-7,8485	2,008833	1,864833	30,47858
August	88,90041667	54,9885	21,20083	19,14383	73,44958
September	-51,74358333	-53,9705	-42,9262	-42,8672	-38,1564
October	22,52541667	26,3485	21,16483	27,97783	34,76958
November	14,44241667	47,4665	57,20483	57,42683	31,48458
December	*-270,4095833*	*-234,6255*	*-223,95*	*-223,79*	*-264,33*
day 1	323,5542903	331,4662581	302,9037	321,2914	388,3473
day 2	80,12629032	85,73325806	58,61273	59,89543	56,29329
day 3	80,31729032	71,08025806	6,513729	20,55143	9,34129
day 4	157,5772903	113,9382581	48,20373	23,83543	120,7803
day 5	168,4172903	147,3842581	156,6977	156,6094	156,2283
day 6	-12,69370968	-31,82374194	-19,9803	-19,9416	-15,5267
day 7	105,7132903	95,31525806	106,6387	106,6764	124,8323
day 8	48,99029032	19,23425806	-8,81927	-6,76757	-3,35971
day 9	-68,24870968	-62,87974194	-53,3093	-53,2656	-57,9527
day 10	26,08929032	16,61325806	-9,82127	-18,4886	7,22829
day 11	-21,98770968	-48,74274194	-38,0213	-38,1986	65,02429
day 12	134,1722903	132,2522581	141,8787	141,7504	134,4463
day 13	30,58729032	8,477258065	20,07873	20,13143	-2,93071
day 14	43,42329032	16,42125806	-10,1713	-12,8696	42,43929
day 15	-22,44470968	-35,10174194	-24,1483	-24,3586	-11,5117
day 16	-13,79370968	-9,120741935	0,621729	0,662426	-4,27471
day 17	34,35629032	7,844258065	19,31373	19,40643	41,11329

day 18	50,58729032	23,44425806	34,09173	33,95443	80,11129
day 19	-13,59070968	-32,41974194	-22,9743	-23,1246	-13,2307
day 20	4,458290323	-17,89074194	-6,36527	-6,30357	-32,1297
day 21	-67,45670968	-94,69714194	-83,8919	-83,8858	-30,4967
day 22	75,61029032	28,04025806	38,69673	38,43343	61,42029
day 23	-127,4327097	-122,9990419	-113,332	-113,282	-140,316
day 24	-0,528709677	-25,76474194	-14,1553	-14,0846	-53,9787
day 25	-17,56570968	-61,26674194	-50,3443	-50,5516	11,61129
day 26	-65,56870968	-83,27674194	-73,598	-73,8095	-63,9637
day 27	-62,68070968	-49,30074194	-37,2623	-37,0626	-94,2017
day 28	-130,1097097	-136,6858419	-125,215	-125,185	-93,2387
day 29	42,26929032	13,03625806	24,10373	23,93343	19,26829
day 30	-287,6687097	-108,8979419	-96,2001	-95,9613	-198,63
day 31	*-494,4787097*	*-189,4127419*	*-170,75*	*-169,99*	*-502,74*

*Identification of atypical observations for which process residues were higher in terms of module than the product of the remainder standard error and critical value for the values: S(e)=519,9433 and u_{α}= 2.17

Source: own work on the basis of the internal data of the wholesale store.

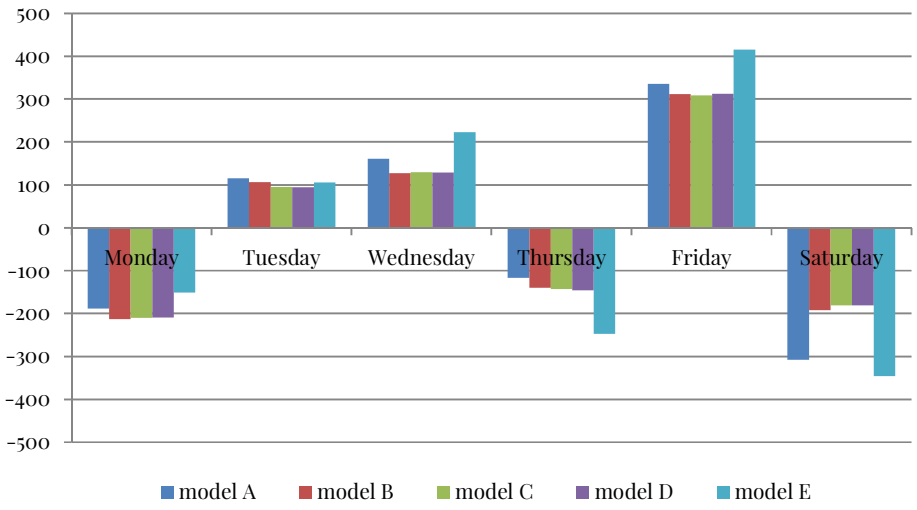

Figure 2. Amplitudes of weekly cyclicality for the process of daily yogurt sales in the wholesale store (n=1562) calculated for model A, B, C, D and E

Source: own work on the basis of gretl data.

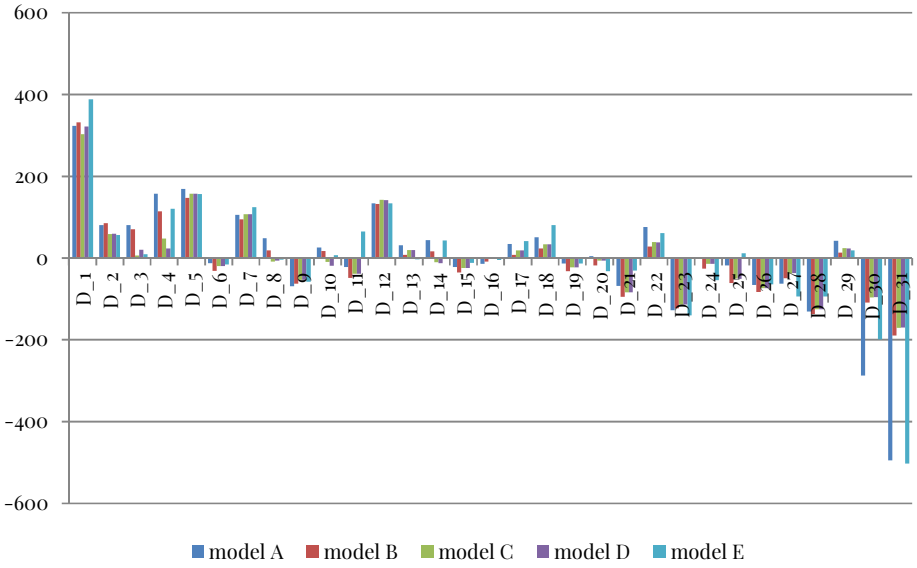

Figure 3. Amplitudes of monthly cyclicality for the process of daily yogurt sales in the wholesale store (n=1562) calculated for model A, B, C, D and E
Source: own work on the basis of Gretl data.

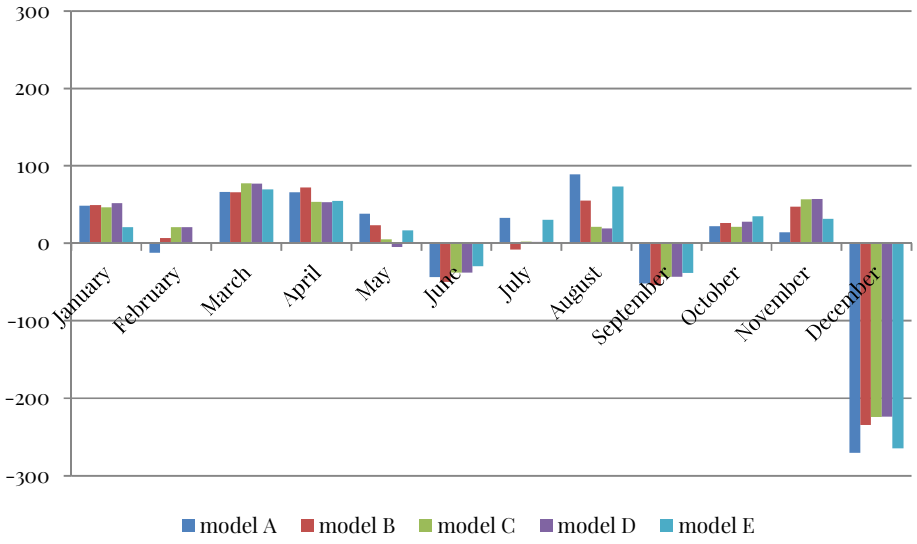

Figure 4. Amplitudes of yearly cyclicality for the process of daily yogurt sales in the wholesale store (n=1562) calculated for model A, B, C, D and E
Source: own work on the basis of gretl data.

To make a comprehensive evaluation of the effects of the fact that one of the two customer service points was closed on Saturdays on the modelling of cyclicality described on the basis of daily data, an additional model F was calculated in two variants and amplitudes were also set for this model [Fig. 5-10].

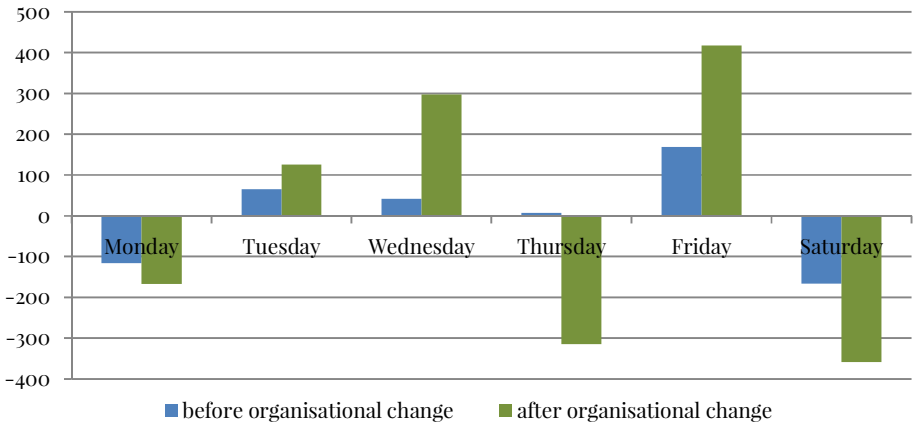

Figure 5. Amplitudes of weekly cyclicality for the process of daily yogurt sales in the wholesale store (n=1562) calculated for model F
Source: own work on the basis of gretl data.

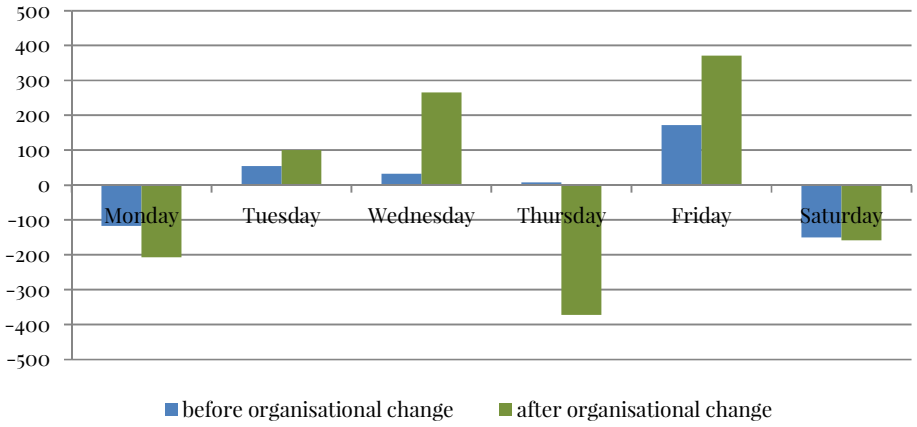

Figure 6. Amplitudes of weekly cyclicality for the process of daily yogurt sales in the wholesale store (n=1562) calculated for model F with the exclusion of zero sales and outlier periods
Source: own work on the basis of Gretl data.

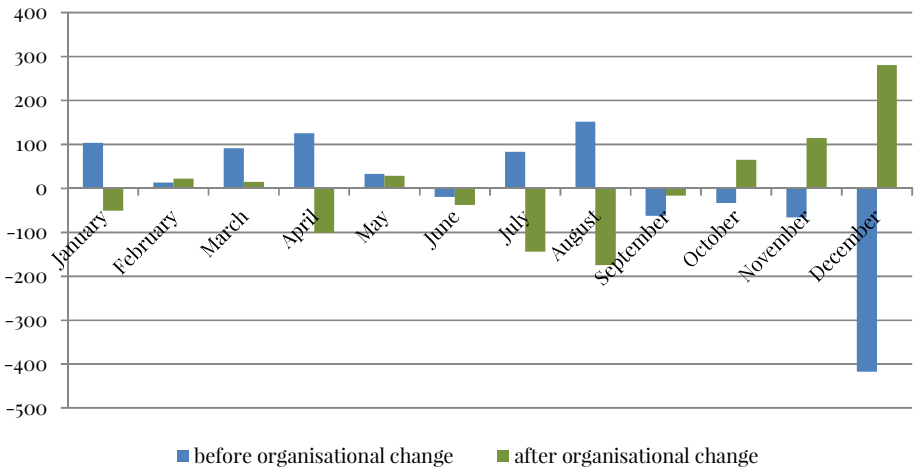

Figure 7. Amplitudes of yearly cyclicality for the process of daily yogurt sales in the wholesale store (n=1562) calculated for model F
Source: own work on the basis of gretl data.

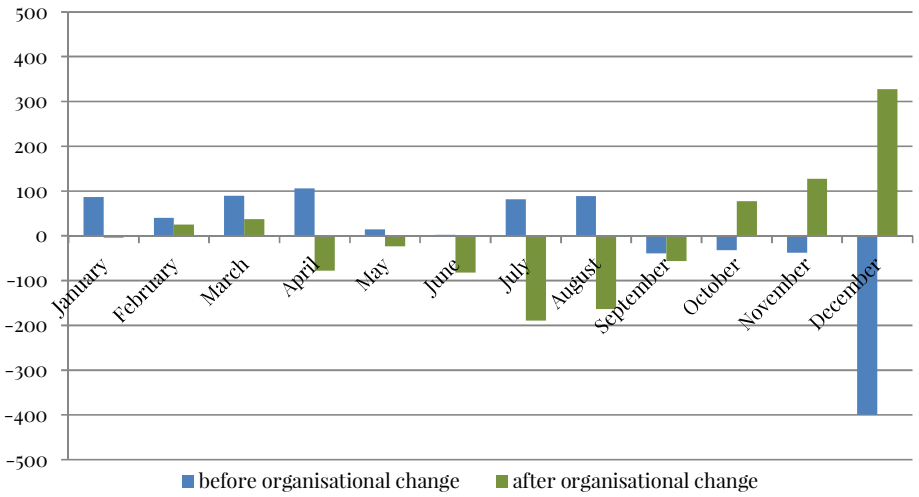

Figure 8. Amplitudes of yearly cyclicality for the process of daily yogurt sales in the wholesale store (n=1562) calculated for model F with the exclusion of zero sales and outlier periods
Source: own work on the basis of gretl data.

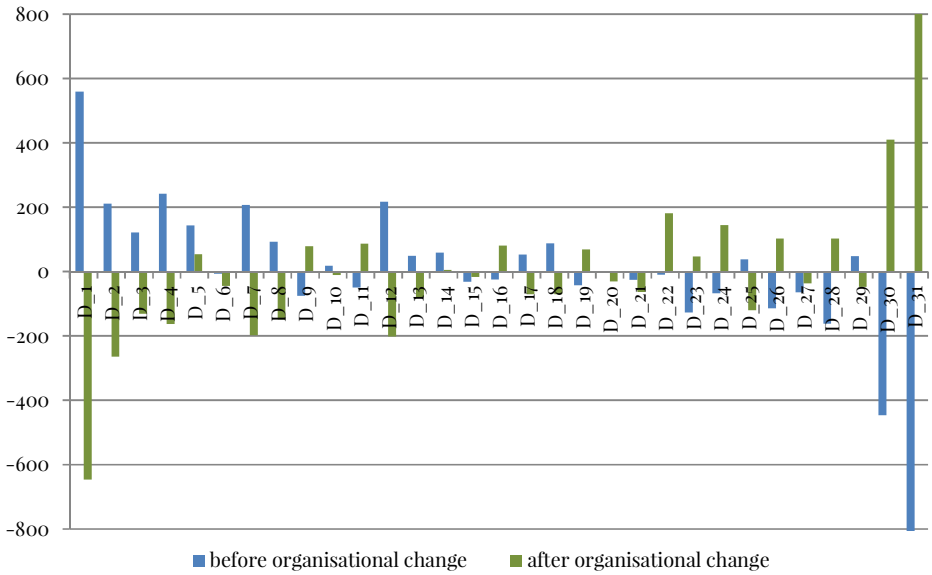

Figure 9. Amplitudes of monthly cyclicality for the process of daily yogurt sales in the wholesale store (n=1562) calculated for model F
Source: own work on the basis of gretl data.

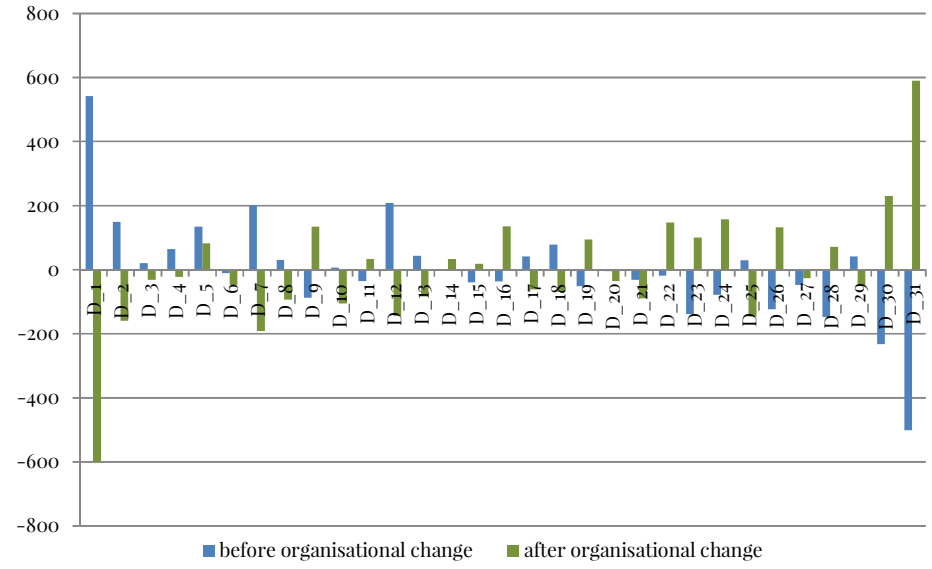

Figure 10. Amplitudes of monthly cyclicality for the process of daily yogurt sales in the wholesale store (n=1562) calculated for model F with the exclusion of zero sales and outlier periods
Source: own work on the basis of gretl data.

The application of F-test confirms the significance of the difference between the A and F model. It should be emphasised that parameter estimates in model F suggest that the zero-one variables were significant for the periods before and after organisational change.

Differences in cyclical fluctuations with the analysed period divided into two subperiods could be observed intuitively already during preliminary analysis of Figure 1 as after 2012 the value of sales was lower than before. Saturday was an interesting case, in Figure 9 that presents amplitudes of weekly cyclicality with the exclusion of zero sales and outlier periods the amplitudes are similar. Higher share of zero sales periods that was the effect of organisational changes lowered the evaluation of this parameter for Saturday considerably.

CONCLUSION

The cyclicality of economic processes is mainly the result of the changing seasons of the year, payment of remuneration and taxes, working day arrangement, etc. Such factors are quoted in most handbooks connected with the analysis of cyclicality of economic phenomena. These basic causes have direct influence on the regularity of economic processes, but on the other hand, there are numerous other factors that also affect the evaluation of cycle amplitudes. Some of them are noticeable only in descriptions based on daily data. Such factors include all actions connected with customer behaviour changes, which causes variable demand, such as promotional actions, changes of the company's organisation of work (e.g. work reorganisation, change of location of the customer service point). In practice, such series require an individual approach, detailed and diligent analysis of the periods that have a significant impact on the evaluation of the cyclicality of processes, and a decision concerning the method of their description. The selection of the method of description of the days with outlier or zero values is also arbitrary (it depends on the person conducting the study). Nevertheless, deeper analysis recommendations can be formulated (concerning the choice of several specifications). If detailed analysis of the series including the factors affecting the changes in its structure is not conducted, the conclusion drawn on the basis of the set amplitudes may be encumbered with an error.

It should also be emphasised that in the case of the analysed wholesale store the covered period was characterised by a negative trend, which should be explained mainly with the factors connected with the company's environment, i.e. appearance of other wholesale stores and supermarkets on the local market (which are a big threat for micro enterprises). The database of the customers of the wholesale store was also analysed, which was relatively constant in the covered period, and the changes in order value were subject to a falling trend. The customers of the wholesale store included mainly small local shops, whose share in the sales on the local market decreased after chain stores with competitive prices entered the market. This change was noticeable in the amplitudes calculated with model F (with the division into the period before and after organisational changes). In the latter period (after organisational changes) a decrease of the average value of sales in particular months was noticeable (it is also confirmed by the analysis of Figure 1).

Summing up the results obtained it should be said that the modelling of phenomena described on the basis of high observation frequency may be difficult. The construction of models based on zero-one variables makes it possible to create models with better properties, which concerns mainly a smaller standard error of remainders. Inclusion of additional zero-one variables in the model means in practice exclusion of influence of a given observation.

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