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THE COMPOSITE INDICATORS AS AN ASSESSMENT CRITERION OF MANUFACTURING BRANCHES IN POLISH ECONOMY

In the paper composite indicators have been used to evaluate the situation of manufacturing branches in the Polish economy. How the individual branches have been ordered depends on the values of particular composite indicators in a given period. The authors have checked the impact of the ways of construction composite indicator on ordering results. 21 composite indicators have been built. The indicators differ in the scope, the way of normalization and weighting of component variables.

The results of research have showed that the way of construction composite indicator have not had significance impact on ordering results of manufacturing branches in Poland.

INTRODUCTION

For evaluating the present and future economic situation of branches composite indicators may be used. The example of construction and application of such indicators for manufacturing branches in Poland has been described (Kwiatkowska-Ciotucha, Załuska, Hanczar 2000). These composite indicators were built based on a vector of component variables which were taken from official statistics (statistical reports F01). Then the values of composite indicators became a criterion of ordering branches in a given period. The situation of the particular branch was compared to the situation of remaining branches and also the situation was evaluated against the background of the whole manufacturing activities (section D in NACE). Although the composite indicator is not an ideal measure, it evaluates each branch in the same way. However one should remember that in the literature, particularly in Polish literature, one can find a lot of proposals of the composite indicator's construction. The diversity of possibilities makes it necessary for the researcher to make several individual choices. These choices regard among other things the way of the component variables' normalization or weighting. The composite indicators in the aforementioned paper were built in an arbitrary way. For those indicators all the details of construction were based on experts' opinions. But after deeper analysis

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the authors raised the following question: Has the way of the composite indicator's construction a significant impact on the evaluation of manufacturing branches in Poland and what follows the ordering results?

The aim of the paper is an attempt to answer to the foregoing question and an attempt to choose the proper way of the composite indicator's construction for the assessment of manufacturing branches in the Polish economy.

1. THE SCOPE OF RESEARCH

The research was carried out on data gathered according to the NACE (General Nomenclature of Economic Activities/Manufacture in European Community Member Countries). It covered the divisions (branches) of its section D (manufacturing). We analysed monthly data during the period from January 1995 to March 1998. The source data was taken from (*Biuletyn Statystyczny*... 1995-1998).

We had eight component variables for each branch:

1. The dynamics of incomes from sale *in fixed prices from March 1998 – index on a constant basis – January 1995 = 100%* - a stimulant.
2. The cost of obtaining income from total activity in % - a destimulant.
3. The profitability rate of gross turnover in % - *the relation of gross financial results to income from total activity* - a stimulant.
4. The profitability rate of net turnover in % - *the relation of net financial results to income from total activity* - a stimulant.
5. The liquidity ratio of the second degree - *the relation of current assets decline of stocks to short-term liabilities* - a nominant.
6. The liquidity ratio of the third degree - *the relation of current assets to short-term liabilities* - a nominant.
7. The share of the companies showing net profit among the companies in a given division in % - a stimulant.
8. Share of incomes of the companies showing net profit among the incomes of the whole activity of a division in % - a stimulant.

Based on these component variables we built several composite indicators. They differed in the scope of component variables, the variants of normalization or the way of weighting the composite indicators. Particular ways of building the composite indicators are presented in the next point. In each case, the value of the composite indicator z for each branch and period was calculated according to the following formula:

$$z_{jt} = \sum_{i=1}^{m} z_{ijt} \cdot w_i$$

Where: z_{jt} – value of the composite indicator in period t for division j,
z_{ijt} – value of the normalized i-th component variable in period t for division j,
w_i – weight ascribed to i-th component variable, $w_i \in (0,1)$, $\sum w_i = 1$,
i – number of the component variable, i = 1, ..., m,
j – number of the division, j = 17, ..., 36 (except 30),
t – number of the period, t = 1, ..., 39.

The composite indicator has the nature of a stimulant. It means that a higher value is preferable. For all the pairs of indicators, we examined the similarity of obtained orderings. We did it in two ways:

✓ by comparing the ordering of all the branches in a given month – for this purpose, Spearman's coefficient of rank correlation ρ and average value of this coefficient $\overline{\rho}$ for whole period was applied,

✓ by comparing the locations which have been occupied by a given branch in a given month – for this purpose, the differences between the locations occupied by a specific branch in individual months were calculated and then the arithmetic average d for absolute values of those differences for the whole scope of branches was calculated. Additionally $\overline{d}$ for the whole period was counted.

2. THE COMPOSITE INDICATORS CONSTRUCTION AND OBTAINED RESULTS

We applied three variants of normalization and three ways of weighting component variables. In Table 1, the variants of normalization are presented. The average value of each component variable for the whole of section D in a given period was the normalization base on the first variant (for the stimulant and the destimulant). In the second calculated technique, a comparison to the maximum (for the stimulant) or to the minimum (for the destimulant) value in a given period was made. In the third variant, a comparison to the span (the range between the maximum and minimum value of the variable X_i in a given period) was used. In each variant, the values of the nominant were normalized in the same way. Values below the lower limit of the recommended values range were normalized in the same way as the stimulant. Values higher than the upper limit of the recommended values range were normalized in the same way as the destimulant. All values within the recommended range were replaced with value equal to one.

Table 1

Variants of normalization formulas of component variables values

The nature of component variable X_i	The variant of normalization (Z_i – variable after normalization)		
	I Comparison to the average value of section D	II Comparison to max / min value in a given period	III Comparison to the range
Stimulant	$z_{ijt} = \frac{x_{ijt}}{av(x_{it})}$	$z_{ijt} = \frac{x_{ijt}}{\max\limits_j (x_{ijt})}$	$z_{ijt} = \frac{x_{ijt} - \min\limits_j (x_{ijt})}{R_{it}}$
Nominant with recommended value range $[x_{i,min} ; x_{i,max}]$	$z_{ijt} = \begin{cases} 1 & \text{for } x_{i,min} \le x_{ijt} \le x_{i,max} \\ \frac{x_{ijt}}{x_{i,min}} & \text{for } x_{ijt} < x_{i,min} \\ \frac{x_{i,max}}{x_{ijt}} & \text{for } x_{ijt} > x_{i,max} \end{cases}$		
Destimulant	$z_{ijt} = \frac{av(x_{it})}{x_{ijt}}$	$z_{ijt} = \frac{\min\limits_j (x_{ijt})}{x_{ijt}}$	$z_{ijt} = \frac{\max\limits_j (x_{ijt}) - x_{ijt}}{R_{it}}$

where: x_{ijt} – the value of the variable X_i in j-th division in period t

av x_{it} – the average value of the variable X_i for section D in period t

$\max\limits_j x_{ijt}$ – maximum value of the variable X_i in period t

$\min\limits_j x_{ijt}$ – minimum value of the variable X_i in period t

R_{it} – the range i-th variable in period t

$x_{i,\ min}$ – the value of upper limit for the recommended value range for nominant

$x_{i,\ min}$ – the value of lower limit of the recommended value range for nominant

Source: based on the papers (Bąk 1999, Strahl 1996, Walesiak 1996).

The following criteria were used for determined weightings:

A. All variables should have the same importance – the weights for all variables are the same.

B. The more diverse variables should have a higher impact – the weights of component variables are in proportion to the coefficients of variation:

$$w_i = \frac{V_i}{\sum_{i=1}^{m} V_i}$$

where: V_i – coefficient of variation of i-th component variable.

The correlation between variables should be taken into account – the weights of component variables are in proportion to coefficients of correlation of given variable with the rest of variables. These weights were obtained by the correlation matrix structure analysis (cf. Bąk 1999):

$$w_i = \frac{\left|\sum_{i=1}^{m} r_{il}\right|}{\sum_{i=1}^{m}\left|\sum_{l=1}^{m} r_{il}\right|}, \qquad i, l = 1, \ldots, m,$$

where: r_{il} – correlation coefficient between i-th and l-th component variables.

In Table 2, the weights of particular component variables are shown. They were calculated depending on the way of weighting. We observed large differences among the obtained weights, particularly for variable number 1 – *the dynamics of incomes from sales* – and variable number 2 – *the cost of obtaining income from total activity.*

Table 2

Weights (in %) of component variables obtained for particular way of weighting

Way of weighting	The component variable							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
A	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
B	17.0	3.0	14.0	13.0	15.0	18.0	10.0	10.0
C	8.0	13.0	16.0	15.0	11.0	11.0	12.0	14.0

Source: own research.

During the first step of the analysis nine composite indicators Z_l were built. They were based on the whole of component variables. We took into account indicators which differed in variants of normalization (I, II, III), or the ways of weighting component variables (A, B, C).

Table 3

The average values of Spearman's coefficient of rank correlation $\overline{\rho}$ for the whole examined period where orderings of manufacturing branches were obtained for pairs of composite indicators Z_l

Composite indicator Z_l	I A	I B	I C	II A	II B	II C	III A	III B	III C
I A		0.983	0.987	0.989	0.984	0.978	0.984	0.987	0.972
I B	0.983		0.959	0.968	0.977	0.948	0.955	0.975	0.937
I C	0.987	0.959		0.990	0.977	0.993	0.987	0.977	0.986
II A	0.989	0.968	0.990		0.989	0.991	0.987	0.985	0.981
II B	0.984	0.977	0.977	0.989		0.976	0.972	0.984	0.962
II C	0.978	0.948	0.993	0.991	0.976		0.986	0.972	0.990
III A	0.984	0.955	0.987	0.987	0.972	0.986		0.984	0.991
III B	0.987	0.975	0.977	0.985	0.984	0.972	0.984		0.968
III C	0.972	**0.937**	0.986	0.981	0.962	0.990	0.991	0.968	

Key: I, II, III – the variant of normalization of component variables,
A, B, C – the way of weighting of component variables.
Source: own research.

Table 4

The average differences $\overline{d}$ of the location occupied by manufacturing branches for the whole examined period by ordering based on pairs of composite indicators Z_l

Composite indicator Z_l	I A	I B	I C	II A	II B	II C	III A	III B	III C
I A		0.57	0.48	0.40	0.57	0.66	0.55	0.46	0.79
I B	0.57		0.94	0.77	0.61	1.06	1.01	0.65	1.24
I C	0.48	0.94		0.42	0.75	0.30	0.50	0.73	0.49
II A	0.40	0.77	0.42		0.47	0.40	0.49	0.56	0.65
II B	0.57	0.61	0.75	0.47		0.77	0.85	0.58	1.04
II C	0.66	1.06	0.30	0.40	0.77		0.55	0.83	0.44
III A	0.55	1.01	0.50	0.49	0.85	0.55		0.58	0.40
III B	0.46	0.65	0.73	0.56	0.58	0.83	0.58		0.91
III C	0.79	**1.24**	0.49	0.65	1.04	0.44	0.40	0.91	

Key: I, II, III – the variant of normalization of component variables,
A, B, C – the way of weighting of component variables
Source: own research.

In Table 3, the average values of Spearman's rank correlation coefficient $\overline{\rho}$ for the whole examined period are shown. The orderings of manufacturing branches were obtained for pairs of the composite indicators Z_l. In Table 4, the average differences of the location $\bar{d}$ are presented. They were calculated as a mean of the absolute values of the differences between the locations occupied by all manufacturing branches in all periods. It may be noticed that these compared orderings are very similar. The lowest value in Table 3 is very high (0.937) and the highest average value of differences between locations is only 1.24. It may be pointed out that all Spearman's coefficients for the analysed ordering pairs and for all individual periods are statistically significant (at the level $\alpha = 0.01$).

Additionally, based on the data from Table 3 and Table 4 for each composite indicator Z_l, we calculated the average values of Spearman's coefficient Θ and the average differences Δ of the location. The value of Θ (Δ) informs us of the average similarity (difference) of ordering of manufacturing branches obtained for the particular composite indicator Z_l and orderings obtained for all remaining composite indicators Z_l. The results are presented in Table 5.

Table 5

The average values of Spearman's coefficient Θ and the average differences Δ of the location for the whole examined period between the particular composite indicator Z_l and the all remaining composite indicators Z_l

Composite indicator Z_l	I A	I B	I C	II A	II B	II C	III A	III B	III C
Θ	0.983	0.963	0.982	0.985	0.978	0.979	0.981	0.979	0.973
Δ	0.56	0.86	0.58	0.52	0.71	0.63	0.62	0.66	0.74

Key: I, II, III – the variant of normalization of component variables,
A, B, C – the way of weighting of component variables.
Source: own research.

The highest value of Θ (0.985) and the lowest value of Δ (0.52) were obtained for composite indicator Z_l IIA. It means that the ordering based on this indicator was the most similar to other orderings. It may be pointed out that for indicators IA and IC the values of Δ were also less than 0.6.

We then took into account indicators which not only differed in variants of normalization, or the ways of weighting of component variables, but also in the number of component variables. We reduced the scope of the component variables. First we skipped variables with low values diversity. It was variable number 2 – *the cost of obtaining income* ($V_i < 10\%$). Later we omitted variables which were highly correlated with other variables and at the same time they had a lower coefficient of variation. Variables numbers 4 and 5 (*the profitability rate of net turnover in %* and *the liquidity ratio of the second degree)* were excluded. Finally, we built the composite indicators Z_2 that contained five component variables.

Additionally we tested the arbitrary composite indicator Z_3 (cf. Kwiatkowska-Ciotucha, Załuska, Hanczar 2000). That indicator consists of four component variables – the numbers 1, 3, 6 and the new variable, which was calculated as an average of variables number 7 and 8. The first normalization variant was applied. The highest weight (0.4) was given to the variable number 3 (*the profitability rate of net turnover*); the remaining variables were given the same weight of 0.2.

We examined the similarity of orderings for all the possible pairs of the indicators Z_1, Z_2 and Z_3. Selected results are presented in Table 6. It may be pointed out that these compared orderings are still very similar. The lowest average value of Spearman's coefficient is 0.906, and the highest average value of differences between the locations is 1.60. As before, all Spearman's coefficients for all particular periods are statistically significant (at the level $\alpha = 0.01$).

Table 6

The average values of Spearman's coefficient of rank correlation $\overline{\rho}$ and the average differences of location $\overline{d}$ for the whole examined period obtained for pairs of composite indicators Z

Composite indicator	$\overline{\rho}$		$\overline{d}$	
	Z_2 I C	Z_3 I	Z_2 I C	Z_3 I
II A	0.957	0.927	1.06	1.43
I B	0.967	**0.906**	0.95	**1.60**
I C	0.959	0.947	1.03	1.18

Key: I, II, III – the variant of normalization of component variables,
A, B, C – the way of weighting of component variables.
Source: own research.

CONCLUSIONS

In the research, 21 composite indicators were built for the evaluation of manufacturing branches in Polish economy. These composite indicators differed in the scope of component variables (eight, five or four variables), the variants of normalization (three variants) and the way of weighting the composite indicators (three ways). The similarity of obtained ordering results were checked for over seventy pairs of composite indicators. In all cases the compared orderings were very similar.

The most similar orderings can be noticed for composite indicators which differed only in the variants of normalization. For example for composite indicators based on the whole scope of component variables and where weights were in proportion to the coefficient of variation (C way of weighting) the average differences between the location were as following: 0.30 (IC and II C), 0.49 (I C and III C), 0.44 (II C and III C). It means that the variant of component variables' normalization has the least impact on ordering results. Also the way of component variables weighting has a very small impact on results. We obtained very similar ordering results for pairs of indicators whose particular component variables had significant different weights. We observed higher discrepancies (but still small) when we compared indicators with a various number of component variables.

After analysis of all obtained results we came to the conclusion that the way of the composite indicator's construction has not a significant impact on the ordering results of manufacturing branches in Poland. Owing to this conclusion we suggest that all of the analysed composite indicator may be property criterion of evaluation. In our opinion the most adequate indicators should be Z_l IIA, Z_l IA and Z_l IC which gave orderings most similar to each other.

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