Propositions of Transformations of Asymmetrical Nominants into Stimulants on the Example of Chosen Financial Ratios

Barbara Batóg and Katarzyna Wawrzyniak

Abstract The paper is a continuation of the Authors' research on transformation of nominants with a recommended range of values for stimulants, which should ensure the greatest possible compatibility of the order of examined objects according to the values of variable-nominant before and after their transformation. In earlier studies, the Authors focused on the symmetric nominants. The present paper attempts to propose similar solutions as in the case of the symmetrical nominant, which can be used for left- and right-handed asymmetrical nominants. In the theoretical part, the transformations proposed by other Authors were analyzed and compared with Authors' propositions. The study was carried out on the basis of selected financial ratios, which in the literature are considered to be nominants with the recommended range of values, with the assumption that the better situation of the examined object is when the values of the indicator-nominant are above the upper limit of the recommended range of values (right-handed asymmetrical nominant) or below the lower limit of this range (left-handed asymmetrical nominant). The data on the financial ratios come from Notoria Serwis and concern companies from the *Machinery industry* sector listed on the Warsaw Stock Exchange in 2018.

Keywords Asymmetrical nominants with the recommended range of values · Stimulants · Transformations · Financial ratios

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1 Introduction

The results presented in the paper are a continuation of the authors' research (Batóg and Wawrzyniak 2020) on the transformation of indicator-nominants with the recommended range of values for stimulants normalized in the range [0; 1]. The terms "stimulant" and "destimulant" were introduced in Polish literature by Hellwig (1968, 1972), and the term "nominant" was introduced by Borys (1978, 1984). When objects are ordered it is important to determine the character of the variables describing these objects, and then unify them and make them comparable by means of an appropriate normalizing transformation. In the above-mentioned studies of Batóg and Wawrzyniak, the focus was on symmetric indicators, where the situation of the examined object with the values of indicator below the lower and above the upper limit of the recommended range of values is evaluated in the same way. The closer the lower and upper limit of the recommended range of values are the indicator-nominant values, the better the situation in the examined object. If we consider two companies for which the current ratio (nominant with the recommended range of values from 1.2 to 2) is 1.1 and 2.1, respectively, then they should be evaluated equally, as the value of the current ratio in both cases is equally distant from the lower and upper limit of the recommended range of values. On the other hand, if one company has a current ratio of 1.1 and the other 2.3, the situation in the first company should be evaluated better than in the second company. In order to transfer this principle also after the transformation of the symmetrical nominant into a stimulant normalized in the range [0; 1], an Author's modification to the known in the literature formulas for the transformation of indicators-nominant into stimulants has been proposed. The aim of the study, the results of which are presented in this paper, was to propose original formulas for the transformation of right and left asymmetrical indicator-nominant to stimulants normalized in the range [0; 1], while maintaining a similar approach as in case of the symmetrical indicator-nominant. The results of the transformations obtained on the basis of the proposed transformations were compared with the results obtained on the basis of the transformations presented in the literature. The study used data on the current ratio (right-handed asymmetrical nominant) and on the debt margin (left-handed asymmetrical nominant) for companies from the *Machinery industry* sector listed on the Warsaw Stock Exchange in 2018.

2 Previous Proposition of Modification of Minimum and Maximum

In the paper of Batóg and Wawrzyniak (2020), it was proposed to modify the formulas for the transformation of the nominant to stimulant normalized in the range [0; 1], in which the symmetry of the ranges of nominant values below and above the recommended range of values was introduced by setting new minimum and maximum values. Moreover, it is assumed that the distance of the new minimum from the lower limit of the recommended range of values is the same as the distance of the new maximum from the upper limit of the recommended range of values. Thanks to this modification, the consistency of the order of the examined objects according to the values of indicator-nominant before and after the transformation was obtained.

Below we compare the results of the transformation of nominants into stimulants normalized in the range [0; 1] obtained according to the transformation proposed by Kukuła (2000) and the results of the transformation using the modification proposed by the Authors. Equation 1 presents a linear transformation of the nominant with the recommended range of values to the stimulants normalized in the range [0; 1] proposed by Kukuła. In turn, Figs. 1 and 2 show the results of this transformation in the case of symmetrical and asymmetrical ranges of nominant values below and above the recommended range of values (in short, symmetrical and asymmetrical minimum and maximum).

$$x_{ij}^{S} = \begin{cases} \frac{1}{c_{1j}-a_j}\left(x_{ij}^{N} - a_j\right) & \text{for} \quad x_{ij}^{N} < c_{1j} \\ 1 & \text{for} \quad c_{1j} \le x_{ij}^{N} \le c_{2j} \\ \frac{1}{c_{2j}-b_j}\left(x_{ij}^{N} - b_j\right) & \text{for} \quad x_{ij}^{N} > c_{2j} \end{cases} \tag{1}$$

where

x_{ij}^{N} value of jth indicator-nominant for ith object,
x_{ij}^{S} value of normalized stimulant of jth indicator-nominant for ith object,
c_{1j} lower limit of the recommended range of values of jth indicator-nominant,
c_{2j} upper limit of the recommended range of values of jth indicator-nominant,
a_j minimum value of jth indicator-nominant,
b_j maximum value of jth indicator-nominant.

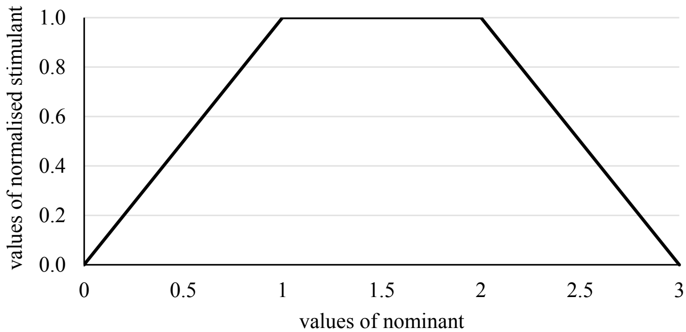

Fig. 1 Linear transformation of a nominant with a recommended range of values into a stimulant with symmetrical minimum and maximum

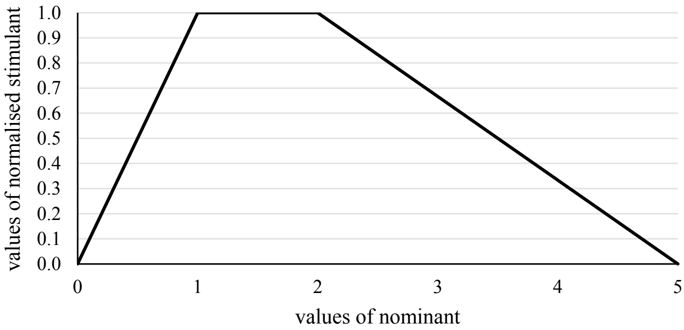

Fig. 2 Linear transformation of a nominant with a recommended range of values into a stimulant with asymmetrical minimum and maximum

Figure 1 shows that in the case of symmetrical minimum and maximum, the property is observed that the same values of the normalized stimulant are assigned to the values of the nominant equally distant from the lower and upper limit of the recommended range, that is

$$x_{ij}^{N} = 0.5 \rightarrow x_{ij}^{S} = 0,5,$$

$$x_{ij}^{N} = 2.5 \rightarrow x_{ij}^{S} = 0,5.$$

However, in the case of asymmetrical minimum and maximum (Fig. 2), this property is not observed, because

$$x_{ij}^{N} = 0.5 \rightarrow x_{ij}^{S} = 0,5,$$

$$x_{ij}^{N} = 2.5 \rightarrow x_{ij}^{S} = 0,83.$$

The modification proposed in the paper of Batóg and Wawrzyniak (2020) allows to remove this defect by setting a new minimum or maximum value according to Eqs. 2a and 2b.

$$a_j^* = \begin{cases} a_j & \text{for} \quad c_{1j} - a_j \geq b_j - c_{2j} \\ c_{1j} - \left(b_j - c_{2j}\right) & \text{for} \quad c_{1j} - a_j < b_j - c_{2j} \end{cases} \tag{2a}$$

$$b_j^* = \begin{cases} c_{2j} + \left(c_{1j} - a_j\right) & \text{for} \quad c_{1j} - a_j \geq b_j - c_{2j} \\ b_j & \text{for} \quad c_{1j} - a_j < b_j - c_{2j} \end{cases} \tag{2b}$$

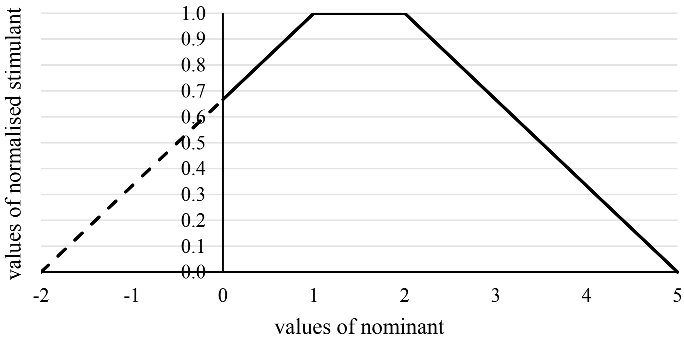

Fig. 3 Linear transformation of a nominant with a recommended range of values into a stimulant with a modified minimum

where

c_{1j} lower limit of the recommended range of values of jth indicator-nominant,
c_{2j} upper limit of the recommended range of values of jth indicator-nominant.
a_j minimum value of jth indicator-nominant before modification,
b_j maximum value of jth indicator-nominant before modification,
a_j^* minimum value of jth indicator-nominant after modification,
b_j^* maximum value of jth indicator-nominant after modification.

Figure 3 presents the linear transformation of a nominant with a recommended range of values into a stimulant with a modified minimum (Eq. 2a). Thanks to this modification we get the same values of the normalized stimulant for the nominant values which are in the same distance from a recommended range of values:

$$x_{ij}^N = 0.5 \rightarrow x_{ij}^S = 0,83,$$

$$x_{ij}^N = 2.5 \rightarrow x_{ij}^S = 0,83.$$

3 Proposals of Nonlinear Transformation of Nominant into Stimulants Normalized in the Range [0; 1]

In the literature, one can find various proposals for the transformation of the nominant into stimulants (e.g., Strahl and Walesiak 1997; Strahl and Dziechciarz 1999; Kukuła 2000; Kowalewski 2002; Wójciak 2003). They use both linear and nonlinear transformations. In this part of the paper, the original proposals of non-linear transformations of the nominant with the recommended range of values into stimulant normalized in the range [0; 1] are presented. These proposals are based on the exponential and logarithmic functions with the use of minimum or maximum modifications so that the applied transformation is characterized by the symmetry of minimum and maximum to a recommended range of values. This is a reference to the modification which the Authors proposed for a linear transformation (Eqs. 2a and 2b).

Since the proposals for nonlinear transformations will concern the symmetrical and right- and left-handed asymmetrical nominants, the definitions of such nominants proposed by Kowalewski (2002, 2006) are recalled here.

A symmetrical nominant is a nominant for which the values below the lower and upper limits of the recommended range of values are evaluated equally—the closer the limits the better and the further the limits the worse.

A right-handed asymmetrical nominant is a nominant for which the values above the upper limit of the recommended range of values are evaluated better than the values below the lower limit of the recommended range of values. A left-handed asymmetrical nominant is a nominant for which the values below the lower limit of the recommended range of values are evaluated better than the values above the upper limit of the recommended range of values.

Transformations described by Eqs. 3 and 4 refer to the symmetrical nominant. They differ in the rate of decrease of obtained values of normalized stimulant.

Transformation described by Eq. 3 refers to the case when the decrease of values of the normalized stimulant close to the lower and upper limits of a recommended range of values is faster than for values close to minimum and maximum (convex functions).

$$x_{ij}^{S} = F_j\left(x_{ij}^{N}\right) = \begin{cases} e^{\alpha_j x_{ij}^{N} + \beta_j} - e^{a_j^*} & for \quad x_{ij}^{N} < c_{1j} \\ 1 & for \quad c_{1j} \le x_{ij}^{N} \le c_{2j} \\ e^{\alpha_j (c_{1j} + c_{2j} - x_{ij}^{N}) + \beta_j} - e^{a_j^*} & for \quad x_{ij}^{N} > c_{2j} \end{cases} \tag{3}$$

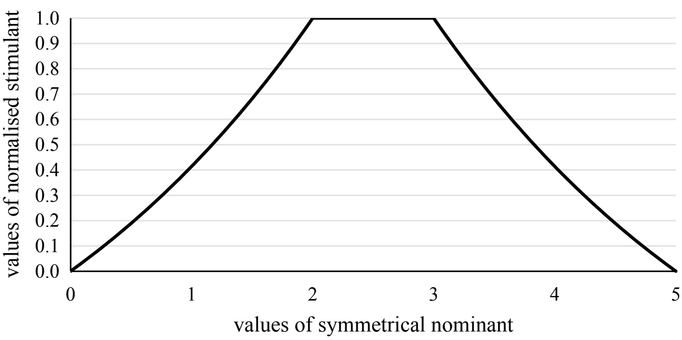

Fig. 4 Nonlinear transformation of a symmetrical nominant into a normalized stimulant according to Eq. 3

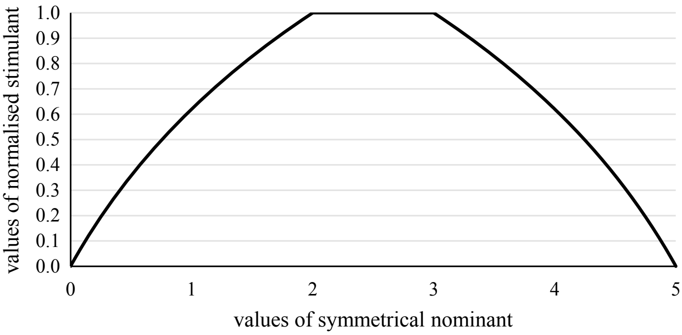

Fig. 5 Nonlinear transformation of a symmetrical nominant into a normalized stimulant according to Eq. 4

where

$\alpha_j = \frac{\ln\left(1+e^{a_j^*}\right)-a_j^*}{c_{1j}-a_j^*},\ \beta_j = a_j^*(1-\alpha_j)$

The values of a normalized stimulant obtained using Eq. 3 are presented in Fig. 4.

Transformation described by Eq. 4 refers to the case when the decrease of values of the normalized stimulant close to the lower and upper limits of a recommended range of values is slower than for values close to minimum and maximum (concave functions).

$$x_{ij}^S = F_j\left(x_{ij}^N\right) = \begin{cases} \ln\left(\alpha_j x_{ij}^N + \beta_j\right) & for \quad x_{ij}^N < c_{1j} \\ 1 & for \quad c_{1j} \le x_{ij}^N \le c_{2j} \\ \ln(\alpha_j(c_{1j}+c_{2j}-x_{ij}^N)+\beta_j) & for \quad x_{ij}^N > c_{2j} \end{cases} \tag{4}$$

where

$\alpha_j = \frac{e-1}{c_{1j}-a_j^*},\ \beta_j = 1-\alpha_j a_j^*$

The values of a normalized stimulant obtained using Eq. 4 are presented in Fig. 5.

Similar transformations can be made for the right-handed and left-handed asymmetrical nominants. The transformation of the right-handed asymmetrical nominant is presented by Eq. 5 (convex function on the left side of the recommended range of values and concave function on the right side of the recommended range of values).

$$x_{ij}^S = F_j\left(x_{ij}^N\right) = \begin{cases} e^{\alpha_{j1}x_{ij}^N+\beta_{j1}} - e^{a_j^*} & for \quad x_{ij}^N < c_{1j} \\ 1 & for \quad c_{1j} \le x_{ij}^N \le c_{2j} \\ \ln(\alpha_{j2}(c_{1j}+c_{2j}-x_{ij}^N)+\beta_{j2}) & for \quad x_{ij}^N > c_{2j} \end{cases} \tag{5}$$

where

$$\alpha_{j1} = \frac{\ln\left(1+e^{a_j^*}\right)-a_j^*}{c_{1j}-a_j^*},\ \beta_{j1} = a_j^*\left(1-\alpha_{j1}\right),$$

$$\alpha_{j2} = \frac{e-1}{c_{1j}-a_j^*},\ \beta_{j2} = 1-\alpha_{j2}a_j^*$$

The values of a normalized stimulant obtained using Eq. 5 are presented in Fig. 6.

The transformation of the left-handed asymmetrical nominant is presented by Eq. 6 (concave function on the left side of the recommended range of values and convex function on the right side of the recommended range of values).

$$x_{ij}^S = F_j\left(x_{ij}^N\right) = \begin{cases} \ln\left(\alpha_{j1}x_{ij}^N + \beta_{j1}\right) & for \quad x_{ij}^N < c_{1j} \\ 1 & for \quad c_{1j} \le x_{ij}^N \le c_{2j} \\ e^{\alpha_{j2}\left(c_{1j}+c_{2j}-x_{ij}^N\right)+\beta_{j2}} - e^{a_j^*} & for \quad x_{ij}^N > c_{2j} \end{cases} \tag{6}$$

where

$$\alpha_{j1} = \frac{e-1}{c_{1j}-a_j^*},\ \beta_{j1} = 1-\alpha_{j1}a_j^*$$

$$\alpha_{j2} = \frac{\ln\left(1+e^{a_j^*}\right)-a_j^*}{c_{1j}-a_j^*},\ \beta_{j2} = a_j^*\left(1-\alpha_{j2}\right)$$

The values of a normalized stimulant obtained using Eq. 6 are presented in Fig. 7.

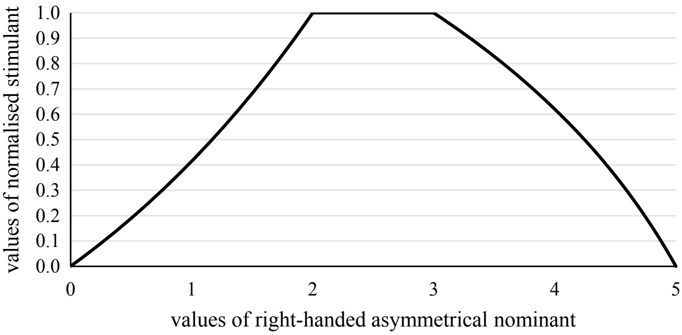

Fig. 6 Nonlinear transformation of a the right-handed asymmetrical nominant into a normalized stimulant according to Eq. 5

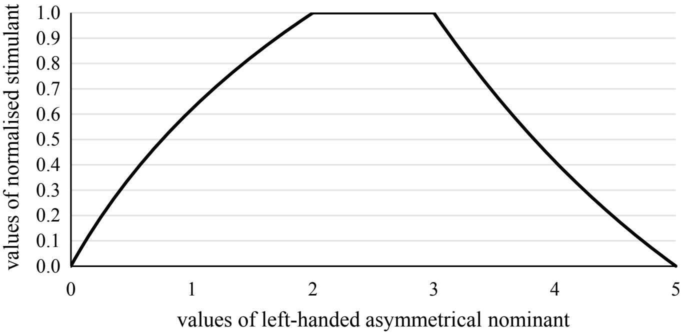

Fig. 7 Nonlinear transformation of a the left-handed asymmetrical nominant into a normalized stimulant according to Eq. 6

4 Data and Empirical Results

The empirical verification of values normalized in the range [0; 1] of the stimulant obtained by means of proposed nonlinear transformations of symmetrical and asymmetrical nominants was performed using two indicators-nominants with the recommended range of values. The theoretical recommended ranges of values can be found, among others, in works of Gabrusewicz (2014), Hozer et al. (1997), Sierpińska and Jachna (2004), Waśniewski and Skoczylas (2004). These indicators-nominants are:

- current ratio—the right-handed asymmetrical nominant (theoretical recommended range of values: [1.2; 2]),
- debt margin—the left-handed asymmetrical nominant (theoretical recommended range of values: [0.57; 0.67]).

In addition to the theoretical recommended ranges of values, the verification also used the empirical recommended ranges of values determined according to the formula:

$$[M - MAD; M + MAD], \tag{7}$$

where

M median,
MAD median absolute deviation (Młodak 2006)

The data on selected indicators refer to companies from the *Machinery industry* sector listed on the Warsaw Stock Exchange in 2018.

Figures 8, 9, 10, 11 show the results of the nonlinear transformation of current ratio assuming that it is a symmetrical nominant. Figures 8 and 10 present the values of normalized stimulants obtained according to nonlinear transformations (downward and upward quadratic functions) proposed by Kukuła (2000) with the

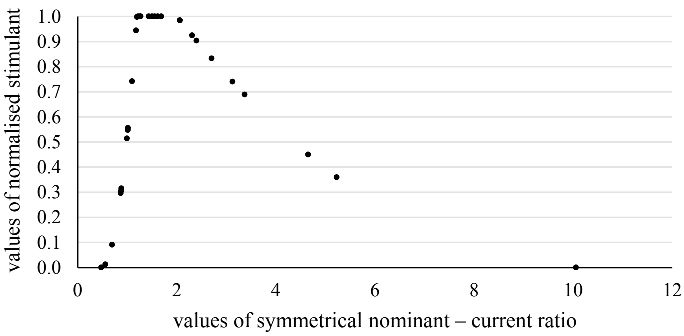

Fig. 8 Current ratio—nonlinear (upward quadratic function) transformation of the symmetrical nominant proposed by Kukuła (2000) with the theoretical recommended range of values

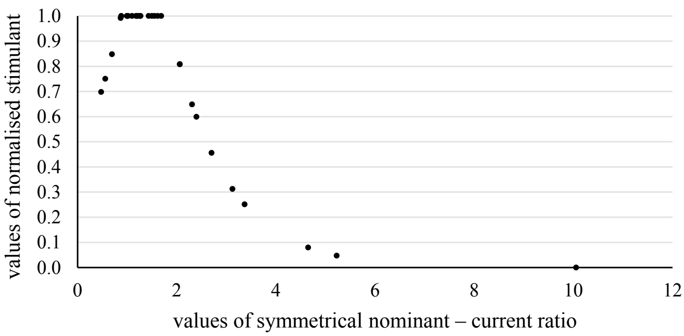

Fig. 9 Current ratio—nonlinear transformation of the symmetrical nominant proposed by Authors (Eq. 3) with the empirical recommended range of values

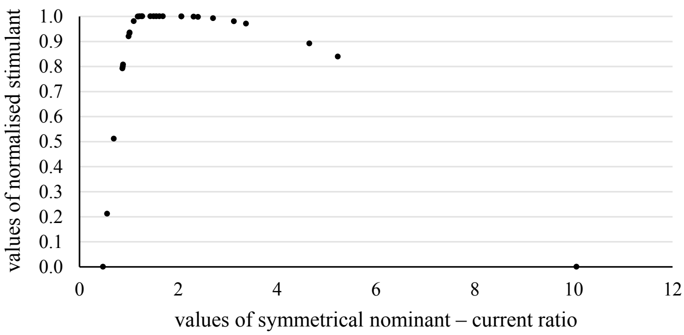

Fig. 10 Current ratio—nonlinear (downward quadratic function) transformation of the symmetrical nominant proposed by Kukuła (2000) with the theoretical recommended range of values

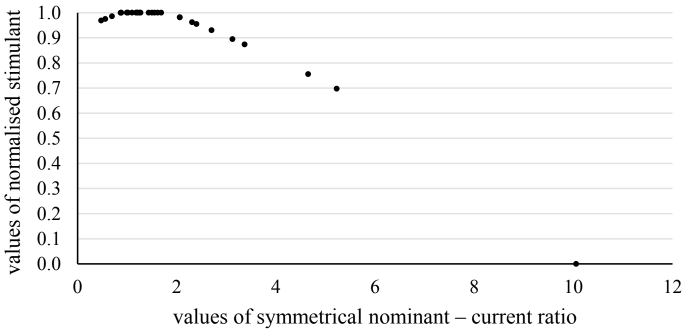

Fig. 11 Current ratio—nonlinear transformation of the symmetrical nominant proposed by Authors (Eq. 4) with the empirical recommended range of values

theoretical recommended range of values [1.2; 2]. Figures 9 and 11 present the values of normalized stimulants obtained according to nonlinear transformations proposed by Authors (Eqs. 3 and 4) with the empirical recommended range of values [0.88; 1.82].

The comparison of the values of normalized stimulants, which are presented in Figs. 8 and 9, shows significant differences. This can be illustrated on the basis of two selected values of the current ratio: 0.69 and 2.39, which lie below the lower limit and above the upper limit of the recommended range of values, respectively. In the case of Fig. 8, the values of normalized stimulant are equal to:

$$x_{ij}^{N} = 0.69 \rightarrow x_{ij}^{S} = 0.09,$$

$$x_{ij}^{N} = 2.39 \rightarrow x_{ij}^{S} = 0.90.$$

But in the case of Fig. 9, the values of normalized stimulant are equal to:

$$x_{ij}^{N} = 0.69 \rightarrow x_{ij}^{S} = 0.85,$$

$$x_{ij}^{N} = 2.39 \rightarrow x_{ij}^{S} = 0.60.$$

The situation is similar when we compare Figs. 10 and 11. In this case, the values of normalized stimulants for selected values of the current ratio are equal to:

- Figure 10.

$$x_{ij}^{N} = 0.69 \rightarrow x_{ij}^{S} = 0.51,$$

$$x_{ij}^{N} = 2.39 \rightarrow x_{ij}^{S} = 0.99,$$

- Figure 11.

$$x_{ij}^{N} = 0.69 \rightarrow x_{ij}^{S} = 0.98,$$

$$x_{ij}^{N} = 2.39 \rightarrow x_{ij}^{S} = 0.95.$$

The following figures (Figs. 12, 13) illustrate the results of the nonlinear transformation of current ratio under the assumption that current ratio is a right-handed asymmetrical nominant. Figure 12 presents the values of normalized stimulant calculated by means of transformation proposed by Kowalewski (2002) with the theoretical recommended range of values [1.2; 2]. In turn, Fig. 13 presents the values of normalized stimulant calculated by means of transformation given by Eq. 5 with the empirical recommended range of values [0.88; 1.82].

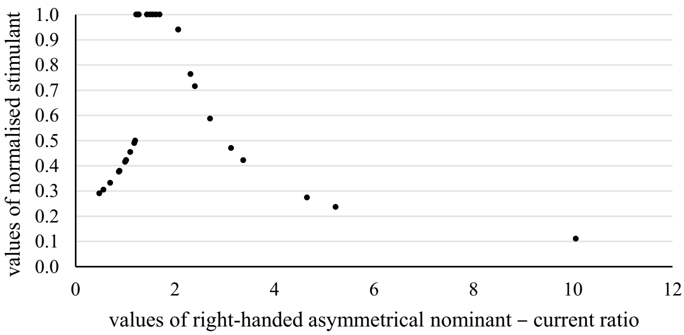

Fig. 12 Current ratio—nonlinear transformation of the right-handed asymmetrical nominant proposed by Kowalewski (2002) with the theoretical recommended range of values ($k_p = 2,\ k_l = 1$)

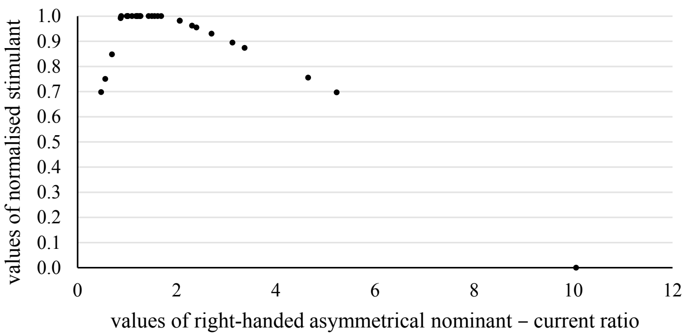

Fig. 13 Current ratio—nonlinear transformation of the right-handed asymmetrical nominant proposed by Authors (Eq. 5) with the empirical recommended range of values

The values of the normalized stimulants obtained according to Kowalewski's proposal and according to Eq. 5 for the current ratio values of 0.69 and 2.39 are, respectively, equal to:

- Figure 12.

$$x_{ij}^{N} = 0.69 \rightarrow x_{ij}^{S} = 0.33,$$

$$x_{ij}^{N} = 2.39 \rightarrow x_{ij}^{S} = 0.71.$$

- Figure 13.

$$x_{ij}^{N} = 0.69 \rightarrow x_{ij}^{S} = 0.85,$$

$$x_{ij}^{N} = 2.39 \rightarrow x_{ij}^{S} = 0.95.$$

Figures 14, 15, 16, 17 show the results of the nonlinear transformation of debt margin assuming that it is a symmetrical nominant. Figures 14 and 16 present the values of normalized stimulants obtained according to nonlinear transformations (downward and upward quadratic functions) proposed by Kukuła (2000) with the theoretical recommended range of values [0.57; 0.67]. Figures 15 and 17 present the values of normalized stimulants obtained according to nonlinear transformations proposed by Authors (Eqs. 3 and 4) with the empirical recommended range of values [0.28; 0.68].

The values of the normalized stimulants obtained according to Kukuła's proposal and according to Eq. 3 for the debt margin values of 0.24 and 0.71 are, respectively, equal to:

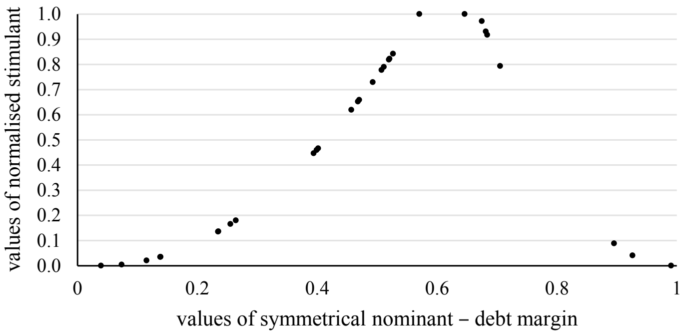

Fig. 14 Debt margin—nonlinear (upward quadratic function) transformation of the symmetrical nominant proposed by Kukuła (2000) with the theoretical recommended range of values

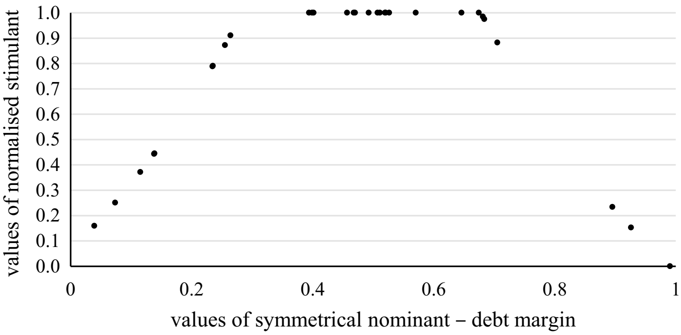

Fig. 15 Debt margin—nonlinear transformation of the symmetrical nominant proposed by Authors (Eq. 3) with the empirical recommended range of values

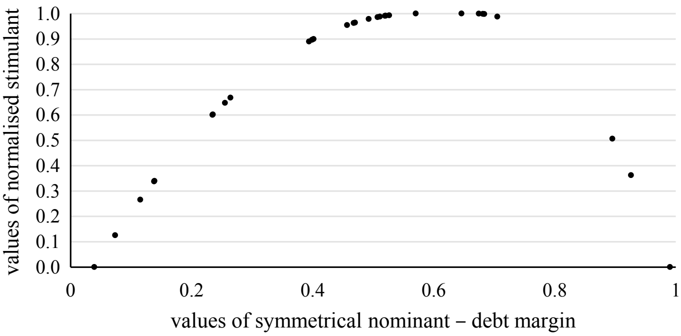

Fig. 16 Debt margin—nonlinear (downward quadratic function) transformation of the symmetrical nominant proposed by Kukuła (2000) with the theoretical recommended range of values

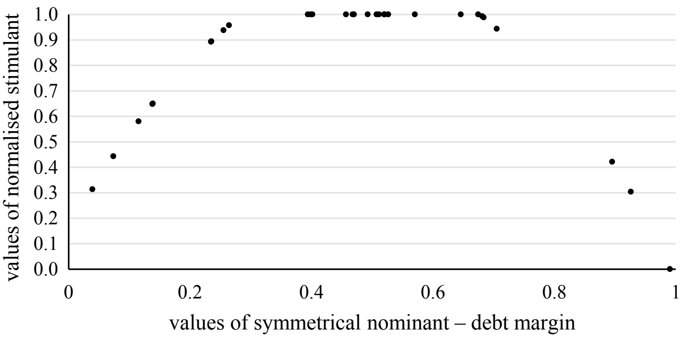

Fig. 17 Debt margin—nonlinear transformation of the symmetrical nominant proposed by Authors (Eq. 4) with the empirical recommended range of values

- Figure 14.

$$x_{ij}^N = 0.24 \rightarrow x_{ij}^S = 0.14,$$

$$x_{ij}^N = 0.71 \rightarrow x_{ij}^S = 0.79.$$

- Figure 15.

$$x_{ij}^N = 0.24 \rightarrow x_{ij}^S = 0.79,$$

$$x_{ij}^N = 0.71 \rightarrow x_{ij}^S = 0.88.$$

In the case of the transformations shown in Figs. 16 and 17, differences in the obtained values of the normalized stimulants can also be observed. According to the transformation proposed by Kukuła (Fig. 16), these values are equal to:

$$x_{ij}^N = 0.24 \rightarrow x_{ij}^S = 0.60,$$

$$x_{ij}^N = 0.71 \rightarrow x_{ij}^S = 0.99.$$

While in the case of transformation given by Eq. 4, we obtain:

$$x_{ij}^N = 0.24 \rightarrow x_{ij}^S = 0.89,$$

$$x_{ij}^N = 0.71 \rightarrow x_{ij}^S = 0.94.$$

Figures 18 and 19 illustrate the results of the nonlinear transformation of debt margin under the assumption that debt margin is a left-handed asymmetrical nominant. Figure 18 presents the values of normalized stimulant calculated by means of transformation proposed by Kowalewski (2002) with the theoretical recommended range of values [0.57; 0.67]. In turn, Fig. 19 presents the values of normalized stimulant calculated by means of transformation given by Eq. 6 with the empirical recommended range of values [0.28; 0.68].

The values of the normalized stimulants obtained according to Kowalewski's proposal and according to Eq. 6 for the debt margin values of 0.24 and 0.71 are, respectively, equal to:

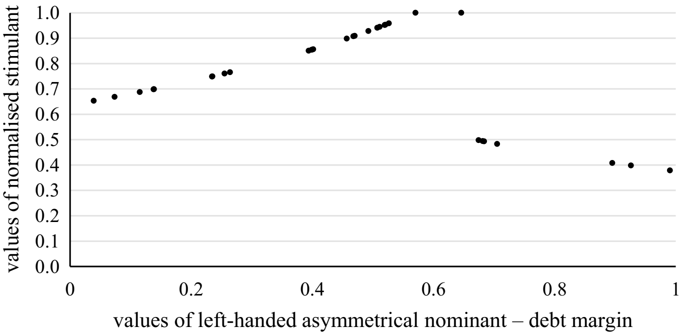

Fig. 18 Debt margin—nonlinear transformation of the left-handed asymmetrical nominant proposed by Kowalewski (2002) with the theoretical recommended range of values ($k_p = 1,\ k_l = 2$)

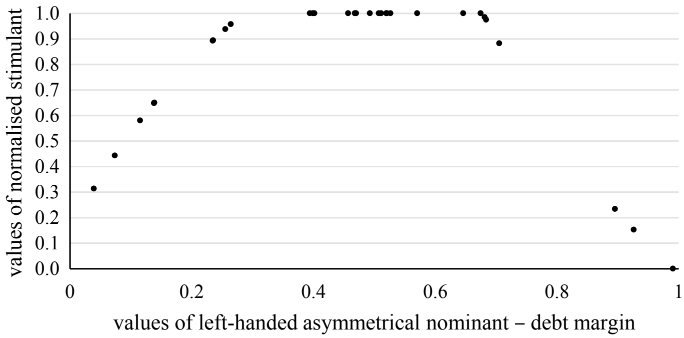

Fig. 19 Debt margin—nonlinear transformation of the left-handed asymmetrical nominant proposed by Authors (Eq. 6) with the empirical recommended range of values

- Figure 18.

$$x_{ij}^N = 0.24 \rightarrow x_{ij}^S = 0.75,$$

$$x_{ij}^N = 0.71 \rightarrow x_{ij}^S = 0.48.$$

- Figure 19.

$$x_{ij}^N = 0.24 \rightarrow x_{ij}^S = 0.89,$$

$$x_{ij}^N = 0.71 \rightarrow x_{ij}^S = 0.88.$$

5 Conclusions

The study shows that the proposed by Authors' nonlinear transformations of symmetrical and asymmetrical nominants into stimulants normalized in the range [0; 1] allow to obtain a higher consistency of the order of the examined objects (companies) before and after the transformation. This is evidenced by the values of normalized stimulants obtained by means of those transformations, which, in comparison with the values of normalized stimulant obtained according to Kukuła's and Kowalewski's proposals, reflect much better the original ordering of objects (companies) resulting from the values of indicators-nominants.

The paper focuses on nonlinear transformations that can be applied for both symmetrical and asymmetrical nominants. In the case of symmetrical nominations, two approaches have been proposed which differ in the rate of decrease in the values of the normalized stimulant below the lower limit and above the upper limit of the recommended range of values. Nonlinear transformations have been proposed for asymmetrical nominants, which are a combination of nonlinear transformations for symmetrical nominants. Therefore, for the right-handed asymmetric nominants, the transformation of the values of nominant above the upper limit of the recommended range of values was conducted by nonlinear transformation according to Eq. 4 (slower decrease of values of normalized stimulant, i.e., stimulant values closer to 1), while the transformation of the values of nominant below the lower limit of the recommended range of values was conducted by nonlinear transformation according to Eq. 3 (faster decrease of values of normalized stimulant, i.e., stimulant values closer to 0)—the combination of these two cases is given by Eq. 5. In turn, for the left-handed asymmetric nominants, the transformation of the values of nominant above the upper limit of the recommended range of values was conducted by nonlinear transformation according to Eq. 3 (faster decrease of values of normalized stimulant, i.e., stimulant values closer to 0), while the transformation of the values of nominant below the lower limit of the recommended range of values was conducted by nonlinear transformation according to Eq. 4 (slower decrease of values of normalized stimulant, i.e., stimulant values closer to 1)—the combination of these two cases is given by Eq. 6.

In all proposed formulas for nonlinear transformations, the principle of symmetry of the ranges of the values of nominant below and above the recommended range of values has been kept by calculating new minimum or maximum values, assuming that the distance of the new minimum from the lower limit of the recommended range of values is the same as the distance of the new maximum from the upper limit of the recommended range of values.

In conclusion, it is worth mentioning that the proposed nonlinear transformations make it possible to obtain the values of a stimulant with greater diversity, i.e., there is a possibility of greater diversity in the final evaluation of the examined companies. On the other hand, the use of the empirical recommended range of values instead of the theoretical recommended range of values makes it possible to link the transformation with the specificity of the functioning of companies in a given economic sector—thanks to this, more companies will obtain transformed values closer to 1 than when the theoretical recommended range of values had been used.

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