stats

MDPI

Article

Sherlock Holmes Between Homogeneity Tests: Detection Power Based on Profitability Ratios in the V4 Region

Pavol Durana *, Roman Blazek and Erika Kovalova

Department of Economics, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Univerzitna 1, 010 26 Zilina, Slovakia; roman.blazek@uniza.sk (R.B.); erika.kovalova@uniza.sk (E.K.)
* Correspondence: pavol.durana@uniza.sk

Abstract: Profitability reveals the key financial ratios that ensure the long-term sustainability of an enterprise's ability to invest in further growth. Without knowledge of the course of development, particularly changes in profitability, enterprises face financial difficulties that threaten their existence. Although the homogeneity tests serve as a reliable tool for identifying changes, their application in financial management often receives insufficient attention. The aim of this research is to evaluate the detection power of homogeneity tests and identify the one with the highest ability based on testing changes in the development of profitability ratios across sectors in the Visegrad Four. Buishand's test, Pettitt's test, the SNHT, and the von Neumann test were run for 8671 enterprises during 2016–2021 and gained from Moody's Orbis. Comparison tables for ROA, ROC, ROE, ROS, ROR, and ROW using Monte Carlo simulation with a million replications identified the number of Slovak, Czech, Polish, and Hungarian enterprises in which heterogeneity was divided according to the Nomenclature of Economic Activities, NACE. The SNHT disclosed the greatest number of changes in the development of all profitability ratios. The results validate the use of selected tests for ratio assessment. Furthermore, business agencies may replicate this approach to determine the economic situation and sector performance.

Keywords: Buishand's test; change; homogeneity; Pettitt's test; profitability; SNHT; Visegrad group; von Neumann test

Citation: Durana, P.; Blazek, R.; Kovalova, E. Sherlock Holmes Between Homogeneity Tests: Detection Power Based on Profitability Ratios in the V4 Region. *Stats* **2024**, *7*, 1333–1353. https://doi.org/10.3390/stats7040077

Academic Editor: Wei Zhu

Received: 15 August 2024
Revised: 18 October 2024
Accepted: 30 October 2024
Published: 31 October 2024

1. Introduction

In today's economic environment, which is defined by rapid changes, strong competition, and globalisation, the performance, specifically the financial performance of a company, is considered a key variable. Financial performance is a concept that is closely related to financial health and, therefore, to the financial management of the company [1]. Effective financial health monitoring is critical to enterprise financial management [2]. Every business entity must know its strengths and weaknesses in terms of performance [3]. The number of financial performance indicators of the company is almost endless, but it is necessary to select those that best serve the purpose of the analysis [4]. And this is also because, despite the infinite number of financial performance measurement indicators [5], only a part of them can be meaningfully interpreted in the context of the company [6]. Economists who considered the financial performance of the company used different indicators in their studies. When evaluating a company's profitability, it is crucial to focus on the right financial indicators that provide a comprehensive picture of the company's financial health and performance [1]. In most cases, however, they used different variants of profitability indicators [4,7,8]. The issue of quantifying profitability has been very popular in many countries for a long time [9]. In addition to comparing the business with industry competition, a longer time of analysis is also important, because a short period analysis can be misleading. Tracking trends over time provides a more comprehensive picture of how a business is improving its efficiency and profitability. Early identification of the company's

potential financial issues is critical to efficient risk management and is significant for all parties engaged in the business operations [10]. Analysing profitability trends is key to understanding a company's financial health [11,12]. Market dynamics and the competitive environment are constantly changing the conditions in which businesses operate, which can have a significant impact on their profitability. Therefore, it is important not only to monitor current financial results but also to use appropriate tools to show how profitability has developed and changed.

Thus, the main aim of this paper is to evaluate the detection power of homogeneity tests and identify the one with the highest ability based on testing changes in the development of profitability ratios across sectors in the Visegrad Four.

The structure of the paper is as follows: A literature review covers the theoretical foundations of profitability ratios. The paper then describes the calculation of ratios, the methodology for homogeneity tests, and a sample of enterprises from the Visegrad region. The results highlight the detection of heterogeneity occurrences in the time series of ROA, ROA, ROC, ROE, ROS, ROR, and ROW during a selected six-year period, as well as the ability of individual homogeneity tests to identify them. The discussion compares the results to those of similar investigations. The conclusions describe future research methods and constraints.

2. Literature Review

For a business to prosper in the long term and bring its owners sufficient appreciation for the invested capital, it must produce a profit [13]. Therefore, it is very important to focus on the profitability analysis, which can be used to find out what company resources are involved in the creation of profit [14].

Profitability, or return on invested capital, is a measure of the ability to make a profit through invested capital and, thus, the ability of a business to create new resources [15]. According to Kruhlova et al. [16], profitability indicators are the most important way of evaluating business activity. In many processes in which it is necessary to consider the size of the achieved economic benefit, this analysis has an irreplaceable function [17]. Profitability indicators also serve to evaluate the success of the company's goals and the resources invested in the company. According to the authors of Gotardo et al. [18] and Zlateva et al. [19], profitability is a more concrete form of a more general efficiency measurement relationship that compares the outputs and inputs of the analysed enterprise. The output is profit, which can be considered at different levels: Earnings after Taxes (EATs), Earnings before Taxes (EBTs), Earnings before Interest and Taxes (EBITs), Earnings before Interest, Taxes, and Amortisation (EBITDAs), Net Operating Profit after Tax (NOPAT), or cash flow (CF) [11]. When deciding which of the possible profit categories to use in the calculation of individual profitability indicators, we should primarily consider the most faithful representation of reality, thereby achieving the highest informative value of individual indicators [14]. For the purposes of this paper, the EBT profit level is used. EBT is used especially when we want to analyse the operational and financial performance of the management because it is assumed that the management can decide on the financing structure which therefore influences the interest paid [20]. Profitability inputs are made up of different quantities, the profit efficiency of which must be assessed [21]. For the purposes of this contribution, outputs such as total assets, equity, sales, costs, revenues, and labour costs are used, which we consider important for the correct determination of the development of the profitability of companies in individual industries.

According to Diniz et al. [21], ensuring the right path to the efficient use of property, or return on assets (ROA) analysis, allows businesses to identify how efficiently they are using their invested resources in assets to generate profit. This indicator provides valuable information about how well a company converts its assets into profit [22]. Among the main advantages of the ROA indicator is the possibility to compare the efficiency of the use of assets between different periods or with the competition, which makes it possible to identify areas for improvement [23]. On the other hand, the disadvantage can be the

difficult interpretation of the result, since high profitability or return on assets does not necessarily mean high overall profitability of the company, especially if the assets of the company are financed primarily by foreign sources of coverage [24].

According to Fama and French [25], the correct evaluation of the efficiency of the company financing is the next necessary step in the analysis of profitability. Investors often evaluate the return on equity (ROE) as one of the most important indicators when deciding on investments in each company. This indicator provides an overview of how effectively the company uses invested capital to generate profit [24]. A high ROE indicates that the company can generate a significant profit from each euro invested, which is very attractive for investors. On the other hand, a low ROE may signal problems with capital efficiency or profit generation [9].

Yousaf and Dey [26] use three profitability indicators to measure financial performance: return on total capital, also known as ROA, return on equity (ROE), and return on costs (ROC). Return on total capital ROA was also used by Tusek et al. [27], although they also mentioned the possibility of using return on equity (ROE) or return on sales (ROS). The same or very similar indicators were also used by Kristof and Virág [11], Nwude et al. [12], Bugaj et al. [28], Bunea et al. [29], and Niresh and Velnampy [30]. Also, in our paper, the main variable will be profitability indicators, which, in the market economy, serve as the main indicator for capital allocation because they express the rate of profit.

Another important step in the analysis of the company's profitability is the evaluation of the company's operational efficiency [31], or the company's profit margin, which is quantified using the sales profitability indicator (ROS; return on sales). A rising ROS value means efficient company growth, while lower results indicate impending financial problems. In addition to the change in sales, the amount of this indicator is also affected by the change in the sales margin and the change in costs [23].

Another important indicator that was applied to the contribution is the return on costs (ROC). According to Bayaraa [32], this indicator reflects the efficiency of business management by expressing the value of the profit that falls on the units of costs incurred. The company should achieve a growing rate of profit over time in relation to costs [29].

Return on income, or operating profit margin (ROR), is a measure of a company's profitability based on the amount of revenue generated [33]. The revenue return compares the amount of net revenue generated for each euro of revenue. Return on income is a key financial metric applied in evaluating the overall performance and financial health of a business [33].

And the last of the indicators we applied was return on labour costs (ROW). The monitoring of this indicator, which compares the result of management with labour costs, is very important, especially in cross-industry settings [34]. When applying all indicators, it is necessary to consider specific factors that affect the industry in which the given company operates. Enterprises from different industries have different capital structures [35] and models of asset utilisation, which can lead to different standards for the profitability of assets. They also have a different approach to the amount of their own resources and show different values of sales. In a market full of competition, optimisation of input costs is inevitable [21]. It is important to identify areas where costs can be effectively reduced without negatively affecting the quality of products or services. Strategic planning and cost analysis can lead to a significant improvement in the financial performance of the company. Labour costs also vary widely across industries. Therefore, an individual approach to comparison is very important. According to Fama and French [25], comparing the company's profitability with the competition is a key step to ensuring competitiveness and sustainable growth. This process allows businesses to identify strengths and weaknesses in their financial performance compared to their direct competitors [20].

3. Materials and Methods

Database Orbis, provided by Moody's [36], was used to create a sample of enterprises from the Visegrad region. The final sample, after removing outliers and missing values,

consisted of 3961 Slovak (SK), 2653 Czech (CZ), 285 Polish (PL), and 1772 Hungarian (HU) enterprises. Kostrzewski et al. [37] confirm the relevance of assessing business performance by financial indicators in the Visegrad region. ROA, ROA, ROC, ROE, ROS, ROR, and ROW were calculated according to the formulas in Table 1. The mentioned ratios were calculated for all enterprises during the period of 2016–2021.

Table 1. Formulas for the calculation of profitability ratios.

Indicator	Formula	Equation
ROA	$\frac{\text{EBT}}{\text{Total Assets}}$	(1)
ROE	$\frac{\text{EBT}}{\text{Equity}}$	(2)
ROS	$\frac{\text{EBT}}{\text{Sales}}$	(3)
ROC	$\frac{\text{EBT}}{\text{Costs}}$	(4)
ROR	$\frac{\text{EBT}}{\text{Revenues}}$	(5)
ROW	$\frac{\text{EBT}}{\text{Labour Costs}}$	(6)

Homogeneity tests were preferred as they allow for an easier understanding of overall patterns in the data over time [38]. They allow for detecting if the time series may be considered homogeneous during the analysed period, or if there is any date at which significant change in the mean of data occurred. Kanovsky [39] and Agha et al. [40] recommend running Pettitt's test, the standard normal homogeneity test (SNHT), Buishand's test, and the von Neumann test. The tested hypotheses were formulated as follows:

H0: *Data (ROA, ROA, ROC, ROE, ROS, ROR, and ROW) are homogeneous (homo).*

H1: *There is a date at which there is a change in the data.*

Figure 1 illustrates examples of homogeneity and heterogeneity.

Firstly, Pettitt's test was run. It is a non-parametric rank test that can reveal a single change point in continuous data [41]. Valaskova et al. [42] note that the null hypothesis is that the T variables follow one or more distributions that have the same location parameter. The alternative hypothesis is that the year of change occurs. The non-parametric statistic is defined as follows:

$$K_T = \max|U_{t,T}| \tag{7}$$

where

$$U_{t,T} = \sum_{\text{i=1}}^{t} \sum_{\text{j=t+1}}^{T} \text{sgn}(x_i - x_j) \tag{8}$$

Here, the year of change in the time series is located at K_T, provided that the statistic is significant. The significance probability of K_T is approximated for a p-value ≤ 0.05 with

$$p \cong 2\text{exp}\left(\frac{-6\,K_t^2}{T^3 + T^2}\right) \tag{9}$$

Buishand's test was also applied. The following model with a single change Δ can be proposed:

$$x_i = \begin{cases} \mu + \epsilon_i & i = 1, \ldots, m \\ \mu + \Delta + \epsilon_i & i = m+1, \ldots, n \end{cases} \tag{10}$$

where $i = 1, \ldots, m$ is the observation order, μ is the mean of the population, and $\epsilon \approx N(0, \sigma)$. In the Buishand range test, the rescaled adjusted partial sums S_k are calculated as follows:

$$S_k = \sum_{i=1}^{k} (x_i + \overline{x}) \quad (1 \leq i \leq n) \tag{11}$$

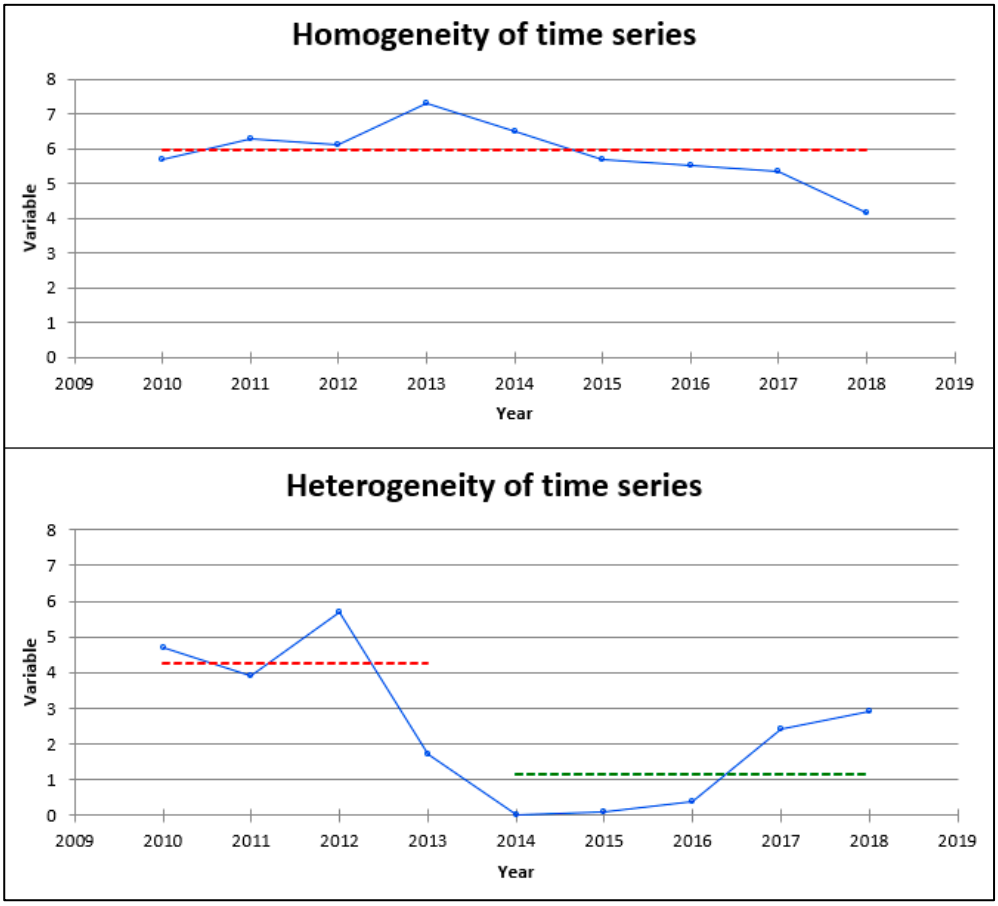

Figure 1. Comparison of homogeneity and heterogeneity.

Rescaled adjusted partial sums (Q) are obtained by dividing the values of S_k by the sample standard deviation D_x. The test statistic is calculated as follows:

$$Q = \max \left| \frac{S_k}{D_x} \right| \tag{12}$$

with

$$D_x = \sqrt{n^{-1} \sum_{i=1}^{n} (x_i - \overline{x})} \tag{13}$$

Another statistic test that could be used is the range which computes the difference between the maximum and minimum value of the rescaled adjusted partial sums. The formula is given as follows:

$$R = \frac{\max S_k - \min S_k}{D_x} \tag{14}$$

It was given critical values for both homogeneity tests $R/\sqrt{n}$ and $Q/\sqrt{n}$ [43].

Thirdly, the von Neumann test used the ratio of mean square successive (year to year) difference to the variance [44]. The test statistic is shown as follows:

$$N = \frac{\sum_{i=1}^{n-1} (x_i - x_{i+1})^2}{\sum_{i=1}^{n-1} (x_i - \overline{x})^2} \tag{15}$$

The null hypothesis is that the data are dependent. If the value of N is equal to 2, it means that the sample is homogeneous while values of N less than 2 indicate that the sample has a change point [45].

Finally, the SNHT is a method created by Alexandersson [46] and assumes that a times series is normally distributed [47]. The null hypothesis $\Delta = 0$ is tested to the alternative hypothesis $\Delta \neq 0$. The test statistic is

$$T_k = kz_1^2 + (n-k)\, z_2^2 \quad (1 \leq k \leq n) \tag{16}$$

where

$$z_1 = \frac{1}{k}\sum_{i=1}^{k}\frac{x_i - \overline{x}}{\sigma} \quad z_2 = \frac{1}{n-k}\sum_{i=k+1}^{n}\frac{x_i - \overline{x}}{\sigma} \tag{17}$$

The critical value is

$$T_0 = \max_{1 \leq x \leq k} T_k \tag{18}$$

The *p*-values for all tests were estimated by a Monte Carlo simulation using 1,000,000 replicates.

4. Results

Firstly, all four tests tested the occurrence of heterogeneity (hete) in ROW according to the individual NACE (Nomenclature of Economic Activities) for all involved enterprises (Table 2). In total, Pettitt's test disclosed 1985 cases, the SNHT 2251 cases, Buishand's test 1958 cases, and the von Neumann test 1750 cases of significant change in the development of selected profitability ratios during the analysed six-year period. The individual assessments of NACEs and countries were realised to prove the ability of the tests to disclose heterogeneity despite significant specifics of sectors themselves as well as differences between similar sectors in different economic environments.

Table 2. Homogeneity tests for ROW.

ROW									
NACE	**Country**	**Pettitt's Test**		**SNHT**		**Buishand's Test**		**von Neumann Test**	
		Hete	**Homo**	**Hete**	**Homo**	**Hete**	**Homo**	**Hete**	**Homo**
A	SK	48	206	61	193	60	194	47	207
	CZ	50	205	58	197	48	207	45	210
	PL	0	2	0	2	0	2	0	2
	HU	18	77	19	76	22	73	12	83
B	SK	3	8	2	9	2	9	4	7
	CZ	1	9	1	9	2	8	3	7
	PL	0	3	1	2	0	3	0	3
	HU	2	6	1	7	1	7	3	5
C	SK	216	733	245	704	202	747	204	745
	CZ	207	666	217	656	178	695	175	698
	PL	16	76	25	67	17	75	18	74
	HU	147	427	149	425	138	436	127	447
D	SK	14	48	17	45	13	49	15	47
	CZ	17	38	14	41	13	42	13	42
	PL	4	6	3	7	4	6	4	6
	HU	8	25	7	26	8	25	7	26
E	SK	7	43	10	40	12	38	12	38
	CZ	6	34	8	32	3	37	7	33
	PL	0	4	0	4	0	4	0	4
	HU	6	21	8	19	3	24	6	21

Table 2. *Cont.*

NACE	Country	ROW							
		Pettitt's Test		SNHT		Buishand's Test		von Neumann Test	
		Hete	Homo	Hete	Homo	Hete	Homo	Hete	Homo
F	SK	60	242	73	229	53	249	46	256
	CZ	44	125	47	122	35	134	29	140
	PL	9	13	6	16	7	15	3	19
	HU	21	48	18	51	15	54	14	55
G	SK	278	887	303	862	290	875	230	935
	CZ	139	481	164	456	142	478	135	485
	PL	7	32	8	31	8	31	4	35
	HU	155	535	194	496	164	526	158	532
H	SK	71	248	94	225	87	232	68	251
	CZ	30	19	51	108	34	125	33	126
	PL	4	4	3	5	5	3	2	6
	HU	10	38	11	37	9	39	9	39
I	SK	9	33	11	31	10	32	7	35
	CZ	7	16	7	16	7	16	6	17
	PL	0	1	0	1	0	1	0	1
	HU	7	25	9	23	10	22	6	26
J	SK	39	113	41	111	30	122	27	125
	CZ	21	68	18	71	18	71	12	77
	PL	9	17	2	24	4	22	3	23
	HU	4	34	5	33	3	35	3	35
K	SK	8	14	4	18	4	18	7	15
	CZ	5	9	6	8	6	8	3	11
	PL	12	16	9	19	8	20	6	22
	HU	7	15	4	18	4	18	5	17
L	SK	32	103	42	93	34	101	30	105
	CZ	23	86	28	81	22	87	15	94
	PL	5	4	4	5	4	5	4	5
	HU	14	32	11	35	12	34	14	32
M	SK	50	214	77	187	60	204	53	211
	CZ	38	113	41	110	42	109	31	120
	PL	4	15	4	15	3	16	2	17
	HU	8	25	7	26	4	29	6	27
N	SK	27	120	37	110	32	115	25	122
	CZ	12	33	12	33	13	32	8	37
	PL	2	7	6	3	3	6	4	5
	HU	10	24	7	27	6	28	7	27
O	SK	0	1	0	1	0	1	0	1
	CZ	0	1	1	0	1	0	0	1
	PL	1	3	1	3	0	4	0	4
	HU	0	1	0	1	0	1	0	1
P	SK	1	7	0	8	1	7	1	7
	CZ	-	-	-	-	-	-	-	-
	PL	-	-	-	-	-	-	-	-
	HU	1	1	2	0	2	0	1	1
Q	SK	7	42	13	36	15	34	9	40
	CZ	5	17	2	20	5	17	4	18
	PL	2	3	2	3	2	3	3	2
	HU	1	1	1	1	1	1	1	1

Table 2. *Cont.*

NACE	Country	ROW							
		Pettitt's Test		SNHT		Buishand's Test		von Neumann Test	
		Hete	Homo	Hete	Homo	Hete	Homo	Hete	Homo
R	SK	6	10	7	9	6	10	7	9
	CZ	3	6	3	6	2	7	3	6
	PL	-	-	-	-	-	-	-	-
	HU	0	8	1	7	1	7	1	7
S	SK	2	11	2	11	2	11	2	11
	CZ	1	8	1	8	1	8	1	8
	PL	1	3	0	4	1	3	0	4
	HU	3	7	5	5	4	6	0	10
SUM		1985	6686	2251	6420	1958	6713	1750	6921

Secondly, all four tests tested the occurrence of heterogeneity in ROA according to the individual NACE for all involved enterprises (Table 3). In total, Pettitt's test disclosed 1990 cases, the SNHT 2192 cases, Buishand's test 1916 cases, and the von Neumann test 1798 cases of significant change in the development of selected profitability ratios during the analysed six-year period.

Table 3. Homogeneity tests for ROA.

NACE	Country	ROA							
		Pettitt's Test		SNHT		Buishand's Test		von Neumann Test	
		Hete	Homo	Hete	Homo	Hete	Homo	Hete	Homo
A	SK	46	208	63	191	51	203	46	208
	CZ	54	201	49	206	48	207	47	208
	PL	0	2	1	1	0	2	0	2
	HU	17	78	22	73	22	73	10	85
B	SK	2	9	2	9	2	9	2	9
	CZ	1	9	4	6	3	7	1	9
	PL	0	3	1	2	0	3	0	3
	HU	4	4	2	6	1	7	2	6
C	SK	211	738	238	711	194	755	205	744
	CZ	208	665	195	678	169	704	184	689
	PL	19	73	19	73	18	74	21	71
	HU	158	416	150	424	140	434	143	431
D	SK	20	42	18	44	17	45	19	43
	CZ	14	41	11	44	14	41	15	40
	PL	4	6	3	7	3	7	4	6
	HU	6	27	8	25	7	26	6	27
E	SK	9	41	17	33	16	34	11	39
	CZ	8	32	12	28	8	32	11	29
	PL	1	3	0	4	1	3	0	4
	HU	6	21	6	21	5	22	5	22
F	SK	59	243	62	240	51	251	39	263
	CZ	36	133	50	119	35	134	37	132
	PL	10	12	9	13	9	13	6	16
	HU	21	48	12	57	17	52	12	57
G	SK	270	895	313	852	292	873	257	908
	CZ	140	480	158	462	139	481	132	488
	PL	8	31	6	33	7	32	6	33
	HU	149	541	179	511	161	529	150	540

Table 3. *Cont.*

NACE	Country	ROA							
		Pettitt's Test		SNHT		Buishand's Test		von Neumann Test	
		Hete	Homo	Hete	Homo	Hete	Homo	Hete	Homo
H	SK	69	250	96	223	73	246	70	249
	CZ	27	132	36	123	28	131	37	122
	PL	2	6	2	6	0	8	2	6
	HU	11	37	13	35	12	36	12	36
I	SK	10	32	15	27	14	28	7	35
	CZ	7	16	6	17	5	18	7	16
	PL	0	1	0	1	0	1	0	1
	HU	6	26	9	23	7	25	2	30
J	SK	40	112	39	113	30	122	34	118
	CZ	23	66	21	68	18	71	14	75
	PL	6	20	3	23	5	21	3	23
	HU	7	31	5	33	6	32	6	32
K	SK	6	16	4	18	4	18	5	17
	CZ	5	9	3	11	2	12	2	12
	PL	9	19	3	25	11	17	4	24
	HU	8	14	6	16	7	15	4	18
L	SK	32	103	40	95	25	110	30	105
	CZ	26	83	22	87	19	90	16	93
	PL	4	5	0	9	1	8	4	5
	HU	12	34	13	33	9	37	12	34
M	SK	61	203	78	186	68	196	50	214
	CZ	27	124	41	110	37	114	24	1227
	PL	3	16	3	16	4	15	2	17
	HU	11	22	13	20	10	23	7	26
N	SK	33	114	43	104	30	117	23	124
	CZ	11	34	13	32	13	32	9	36
	PL	2	7	4	5	3	6	4	5
	HU	9	25	9	25	9	25	8	26
O	SK	0	1	0	1	0	1	0	1
	CZ	1	0	1	0	1	0	1	0
	PL	1	3	0	4	0	4	0	4
	HU	0	1	0	1	0	1	0	1
P	SK	0	8	1	7	1	7	2	6
	CZ	-	-	-	-	-	-	-	-
	PL	-	-	-	-	-	-	-	-
	HU	1	1	0	2	0	2	1	1
Q	SK	8	41	13	36	7	42	8	41
	CZ	8	14	9	13	9	13	4	18
	PL	3	2	2	3	2	3	3	2
	HU	1	1	1	1	1	1	1	1
R	SK	8	8	7	9	7	9	4	12
	CZ	3	6	3	6	4	5	1	8
	PL	-	-	-	-	-	-	-	-
	HU	1	7	0	8	0	8	0	8
S	SK	2	11	1	12	1	12	2	11
	CZ	2	7	1	8	1	8	1	8
	PL	1	3	0	4	0	4	0	4
	HU	2	8	3	7	2	8	1	9
SUM		1990	6681	2183	6479	1916	6755	1798	6873

Thirdly, all four tests tested the occurrence of heterogeneity in ROC according to the individual NACE for all involved enterprises (Table 4). In total, Pettitt's test disclosed 1943 cases, the SNHT 2216 cases, Buishand's test 1990 cases, and the von Neumann test 1775 cases of significant change in the development of selected profitability ratios during the analysed six-year period.

Table 4. Homogeneity tests for ROC.

		ROC							
NACE	**Country**	**Pettitt's Test**		**SNHT**		**Buishand's Test**		**von Neumann Test**	
		Hete	**Homo**	**Hete**	**Homo**	**Hete**	**Homo**	**Hete**	**Homo**
A	SK	43	211	56	198	54	200	41	213
	CZ	48	207	60	195	59	196	42	213
	PL	0	2	1	1	0	2	0	2
	HU	13	82	20	75	24	71	13	82
B	SK	2	9	2	9	1	10	3	8
	CZ	2	8	2	8	2	8	3	7
	PL	0	3	0	3	0	3	1	2
	HU	2	6	3	5	3	5	1	7
C	SK	207	742	232	717	211	738	205	744
	CZ	203	670	204	669	170	703	169	704
	PL	19	73	18	74	17	75	17	75
	HU	142	432	154	420	131	443	129	445
D	SK	13	49	18	44	11	51	12	50
	CZ	14	41	10	45	7	48	11	44
	PL	3	7	5	5	4	6	4	6
	HU	9	24	7	26	8	25	5	28
E	SK	9	41	16	34	14	36	11	39
	CZ	7	33	7	33	7	33	8	32
	PL	0	4	0	4	1	3	0	4
	HU	5	22	7	20	7	20	6	21
F	SK	62	240	66	236	60	242	45	257
	CZ	44	125	51	118	35	134	33	136
	PL	12	10	8	14	10	12	7	15
	HU	22	47	18	51	15	54	16	53
G	SK	277	888	307	858	294	871	250	915
	CZ	138	482	160	460	156	464	140	480
	PL	5	34	6	33	6	33	7	32
	HU	155	535	202	488	177	513	167	523
H	SK	70	249	94	225	75	244	57	262
	CZ	29	130	31	128	27	132	28	131
	PL	3	5	5	3	3	5	2	6
	HU	10	38	8	40	6	42	9	39
I	SK	9	33	13	29	12	30	7	35
	CZ	6	17	10	13	6	17	6	17
	PL	0	1	0	1	0	1	0	1
	HU	6	26	8	24	10	22	6	26
J	SK	39	113	37	115	35	117	30	122
	CZ	21	68	18	71	16	73	11	78
	PL	10	16	6	20	6	20	4	22
	HU	4	34	6	32	6	32	7	31

Table 4. *Cont.*

NACE	Country	ROC							
		Pettitt's Test		SNHT		Buishand's Test		von Neumann Test	
		Hete	Homo	Hete	Homo	Hete	Homo	Hete	Homo
K	SK	5	17	4	18	2	20	4	18
	CZ	5	9	5	9	5	9	4	10
	PL	7	21	7	21	9	19	5	23
	HU	6	16	5	17	7	15	7	15
L	SK	31	104	39	96	35	100	33	102
	CZ	23	86	21	88	19	90	19	90
	PL	4	5	3	6	3	6	3	6
	HU	15	31	18	28	16	30	12	34
M	SK	49	215	78	186	62	202	54	210
	CZ	31	120	45	106	45	106	5	126
	PL	5	14	4	15	5	14	2	17
	HU	8	25	8	25	6	27	4	29
N	SK	31	116	39	108	29	118	30	117
	CZ	10	35	9	36	9	36	10	35
	PL	3	6	4	5	4	5	5	4
	HU	12	22	14	20	11	23	7	27
O	SK	0	1	0	1	0	1	0	1
	CZ	0	1	1	0	1	0	1	0
	PL	1	3	0	4	0	4	0	4
	HU	0	1	0	1	0	1	0	1
P	SK	1	7	0	8	1	7	2	6
	CZ	-	-	-	-	-	-	-	-
	PL	-	-	-	-	-	-	-	-
	HU	1	1	0	2	0	2	1	1
Q	SK	8	41	12	37	11	38	11	38
	CZ	5	17	3	19	5	17	6	16
	PL	3	2	2	3	2	3	3	2
	HU	1	1	0	2	1	1	0	2
R	SK	6	10	5	11	5	11	6	10
	CZ	2	7	3	6	1	8	3	6
	PL	-	-	-	-	-	-	-	-
	HU	0	8	1	7	1	7	1	7
S	SK	2	11	4	9	2	11	2	11
	CZ	1	8	2	7	1	8	1	8
	PL	2	2	1	3	3	1	1	3
	HU	2	8	3	7	3	7	0	10
SUM		1943	6728	2216	6455	1990	6681	1775	6896

Fourthly, all four tests tested the occurrence of heterogeneity in ROE according to the individual NACE for all involved enterprises (Table 5). In total, Pettitt's test disclosed 2004 cases, the SNHT 2213 cases, Buishand's test 1901 cases, and the von Neumann test 1860 cases of significant change in the development of selected profitability ratios during the analysed six-year period.

Fifthly, all four tests tested the occurrence of heterogeneity in ROR according to the individual NACE for all involved enterprises (Table 6). In total, Pettitt's test disclosed 1940 cases, the SNHT 2277 cases, Buishand's test 2016 cases, and the von Neumann test 1707 cases of significant change in the development of selected profitability ratios during the analysed six-year period.

Table 5. Homogeneity tests for ROE.

		ROE							
NACE	**Country**	**Pettitt's Test**		**SNHT**		**Buishand's Test**		**von Neumann Test**	
		Hete	**Homo**	**Hete**	**Homo**	**Hete**	**Homo**	**Hete**	**Homo**
A	SK	50	204	60	194	57	197	44	210
	CZ	55	200	64	191	55	200	49	206
	PL	0	2	1	1	1	1	0	2
	HU	13	82	19	76	19	76	8	87
B	SK	3	8	4	7	4	7	3	8
	CZ	4	6	3	7	3	7	1	9
	PL	0	3	0	3	0	3	0	3
	HU	2	6	3	5	2	6	2	6
C	SK	210	739	216	733	192	757	198	751
	CZ	199	674	231	642	173	700	187	686
	PL	18	74	18	74	18	74	15	77
	HU	149	425	122	452	122	452	134	440
D	SK	16	46	24	38	12	50	16	46
	CZ	13	42	14	41	8	47	13	42
	PL	3	7	4	6	4	6	4	6
	HU	5	28	9	24	8	25	4	29
E	SK	12	38	16	34	18	32	14	36
	CZ	9	31	16	24	10	30	11	29
	PL	0	4	1	3	2	2	1	3
	HU	7	20	5	22	5	22	6	21
F	SK	61	241	64	238	62	240	49	253
	CZ	44	125	44	125	34	135	41	128
	PL	12	10	4	18	7	15	8	14
	HU	23	46	14	55	11	58	15	54
G	SK	276	889	315	850	284	881	272	893
	CZ	141	479	158	462	138	482	135	485
	PL	6	33	9	30	6	33	7	32
	HU	155	535	183	507	144	546	152	538
H	SK	83	236	90	229	94	225	81	238
	CZ	31	128	45	114	39	120	37	122
	PL	2	6	2	6	2	6	1	7
	HU	10	38	9	39	9	39	10	38
I	SK	6	36	8	34	10	32	9	33
	CZ	6	17	8	15	5	18	8	15
	PL	0	1	0	1	0	1	0	1
	HU	8	24	10	22	9	23	4	28
J	SK	43	109	36	116	26	126	39	113
	CZ	13	76	28	61	12	77	8	81
	PL	7	19	6	20	4	22	3	23
	HU	7	31	8	30	8	30	6	32
K	SK	6	16	8	14	4	18	6	16
	CZ	4	10	2	12	4	10	3	11
	PL	10	18	4	24	7	21	5	23
	HU	7	15	7	15	5	17	5	17
L	SK	32	103	46	89	29	106	31	104
	CZ	23	86	17	92	19	90	17	92
	PL	3	6	1	8	1	8	4	5
	HU	13	33	18	28	11	35	10	36

Table 5. *Cont.*

NACE	Country	ROE							
		Pettitt's Test		SNHT		Buishand's Test		von Neumann Test	
		Hete	Homo	Hete	Homo	Hete	Homo	Hete	Homo
M	SK	61	203	67	197	60	204	55	209
	CZ	37	114	47	104	38	113	33	118
	PL	3	16	7	12	5	14	3	16
	HU	11	22	11	22	9	24	9	24
N	SK	32	115	39	108	30	117	30	117
	CZ	9	36	11	34	11	34	10	35
	PL	2	7	3	6	3	6	4	5
	HU	7	27	8	26	5	29	8	26
O	SK	0	1	0	1	0	1	0	1
	CZ	0	1	0	1	0	1	0	1
	PL	1	3	0	4	1	3	0	4
	HU	0	1	0	1	0	1	0	1
P	SK	1	7	1	7	2	6	2	6
	CZ	-	-	-	-	-	-	-	-
	PL	-	-	-	-	-	-	-	-
	HU	2	0	1	1	1	1	1	1
Q	SK	12	37	14	35	14	35	10	39
	CZ	7	15	8	14	6	16	5	17
	PL	2	3	2	3	2	3	2	3
	HU	1	1	2	0	1	1	1	1
R	SK	5	11	7	9	7	9	4	12
	CZ	2	7	2	7	0	9	3	6
	PL	-	-	-	-	-	-	-	-
	HU	0	8	1	7	0	8	0	8
S	SK	3	10	4	9	3	10	3	10
	CZ	2	7	2	7	2	7	1	8
	PL	1	3	0	4	1	3	0	4
	HU	3	7	2	8	3	7	0	10
SUM		2004	6667	2213	6458	1901	6770	1860	6811

Table 6. Homogeneity tests for ROR.

NACE	Country	ROR							
		Pettitt's Test		SNHT		Buishand's Test		von Neumann Test	
		Hete	Homo	Hete	Homo	Hete	Homo	Hete	Homo
A	SK	43	211	64	190	51	203	42	212
	CZ	48	207	51	204	41	214	37	218
	PL	0	2	1	1	1	1	0	2
	HU	13	82	16	79	19	76	10	85
B	SK	2	9	3	8	1	10	2	9
	CZ	2	8	2	8	3	7	3	7
	PL	0	3	1	2	0	3	1	2
	HU	2	6	4	4	3	5	2	6
C	SK	208	741	271	678	236	713	197	752
	CZ	202	671	236	637	215	658	169	704
	PL	19	73	22	70	18	74	16	76
	HU	142	432	165	409	151	423	128	446

Table 6. *Cont.*

NACE	Country	ROR							
		Pettitt's Test		SNHT		Buishand's Test		von Neumann Test	
		Hete	Homo	Hete	Homo	Hete	Homo	Hete	Homo
D	SK	13	49	14	48	9	53	13	49
	CZ	12	43	14	41	10	45	11	44
	PL	3	7	3	7	3	7	4	6
	HU	9	24	6	27	7	26	7	26
E	SK	9	41	14	36	13	37	10	40
	CZ	7	33	12	28	7	33	8	32
	PL	0	4	1	3	1	3	0	4
	HU	5	22	8	19	4	23	6	21
F	SK	62	240	84	218	69	233	43	259
	CZ	45	124	65	104	40	129	31	138
	PL	12	10	11	11	12	10	8	14
	HU	22	47	16	53	18	51	16	53
G	SK	276	889	321	844	292	873	239	926
	CZ	137	483	145	475	146	474	132	488
	PL	5	34	8	31	5	34	6	33
	HU	155	535	193	497	174	516	161	529
H	SK	70	249	64	255	61	258	60	259
	CZ	29	130	42	117	27	132	28	131
	PL	3	5	1	7	3	5	1	7
	HU	10	38	12	36	11	37	8	40
I	SK	9	33	10	32	14	28	9	33
	CZ	6	17	8	15	8	15	7	16
	PL	0	1	0	1	0	1	0	1
	HU	6	26	8	24	11	21	6	26
J	SK	38	114	40	112	26	126	25	127
	CZ	21	68	15	74	14	75	9	80
	PL	10	16	5	21	5	21	2	24
	HU	4	34	7	31	5	33	7	31
K	SK	5	17	2	20	2	20	3	19
	CZ	5	9	5	9	5	9	4	10
	PL	9	19	6	22	8	20	4	24
	HU	6	16	4	18	4	18	7	15
L	SK	31	104	32	103	33	102	31	104
	CZ	24	85	27	82	23	86	18	91
	PL	5	4	4	5	5	4	4	5
	HU	15	31	11	35	11	35	12	34
M	SK	50	214	69	195	57	207	50	214
	CZ	31	120	37	114	27	124	22	129
	PL	4	15	4	15	4	15	2	17
	HU	8	25	8	25	8	25	4	29
N	SK	30	117	36	111	29	118	27	120
	CZ	10	35	16	29	13	32	11	34
	PL	3	6	3	6	3	6	5	4
	HU	12	22	12	22	10	24	7	27
O	SK	0	1	0	1	0	1	0	1
	CZ	0	1	1	0	1	0	1	0
	PL	1	3	1	3	0	4	0	4
	HU	0	1	0	1	0	1	0	1

Table 6. *Cont.*

ROR									
NACE	**Country**	**Pettitt's Test**		**SNHT**		**Buishand's Test**		**von Neumann Test**	
		Hete	**Homo**	**Hete**	**Homo**	**Hete**	**Homo**	**Hete**	**Homo**
P	SK	1	7	1	7	1	7	2	6
	CZ	-	-	-	-	-	-	-	-
	PL	-	-	-	-	-	-	-	-
	HU	1	1	0	2	0	2	1	1
Q	SK	7	42	13	36	13	36	10	39
	CZ	5	17	6	16	7	15	5	17
	PL	3	2	3	2	2	3	3	2
	HU	1	1	0	2	1	1	0	2
R	SK	6	10	3	13	7	9	4	12
	CZ	2	7	2	7	2	7	2	7
	PL	-	-	-	-	-	-	-	-
	HU	0	8	2	6	1	7	1	7
S	SK	2	11	2	11	0	13	2	11
	CZ	1	8	1	8	0	9	1	8
	PL	1	3	0	4	1	3	0	4
	HU	2	8	3	7	4	6	0	10
SUM		1940	6731	2277	6394	2016	6655	1707	6964

Lastly, all four tests tested the occurrence of heterogeneity in ROS according to the individual NACE for all involved enterprises (Table 7). In total, Pettitt's test disclosed 1933 cases, the SNHT 2117 cases, Buishand's test 1833 cases, and the von Neumann test 1757 cases of significant change in the development of selected profitability ratios during the analysed six-year period.

Table 7. Homogeneity tests for ROS.

ROS									
NACE	**Country**	**Pettitt's Test**		**SNHT**		**Buishand's Test**		**von Neumann Test**	
		Hete	**Homo**	**Hete**	**Homo**	**Hete**	**Homo**	**Hete**	**Homo**
A	SK	44	210	57	197	52	202	45	209
	CZ	48	207	57	198	43	212	39	216
	PL	0	2	0	2	1	1	0	2
	HU	13	82	18	77	16	79	10	85
B	SK	1	10	3	8	2	9	3	8
	CZ	2	8	3	7	3	7	3	7
	PL	0	3	0	3	0	3	1	2
	HU	2	6	2	6	2	6	1	7
C	SK	209	740	234	715	205	744	203	746
	CZ	202	671	200	673	177	696	168	705
	PL	19	73	18	74	14	78	16	76
	HU	140	434	127	447	115	459	122	452
D	SK	13	49	15	47	14	48	13	49
	CZ	12	43	14	41	11	44	10	45
	PL	3	7	5	5	5	5	4	6
	HU	10	23	7	26	7	26	7	26

Table 7. *Cont.*

NACE	Country	ROS							
		Pettitt's Test		SNHT		Buishand's Test		von Neumann Test	
		Hete	Homo	Hete	Homo	Hete	Homo	Hete	Homo
E	SK	9	41	16	34	17	33	10	40
	CZ	7	33	7	33	6	34	7	33
	PL	0	4	1	3	0	4	0	4
	HU	5	22	7	20	7	20	6	21
F	SK	64	238	71	231	57	245	47	255
	CZ	45	124	55	114	38	113	32	137
	PL	11	11	6	16	8	14	8	14
	HU	22	47	26	43	23	46	14	55
G	SK	276	889	288	877	269	896	259	906
	CZ	135	485	145	475	121	499	139	481
	PL	5	34	7	32	6	33	6	33
	HU	155	535	181	509	150	540	164	526
H	SK	69	250	87	232	68	251	55	264
	CZ	28	131	27	132	20	139	29	130
	PL	3	5	1	7	2	6	1	7
	HU	9	39	10	38	10	38	8	40
I	SK	9	33	12	30	10	32	9	33
	CZ	6	17	6	17	10	13	7	16
	PL	0	1	0	1	0	1	0	1
	HU	6	26	8	24	9	23	6	26
J	SK	38	114	31	121	32	0	29	123
	CZ	21	68	19	70	15	74	12	77
	PL	10	16	4	22	5	21	3	23
	HU	4	34	9	29	9	29	6	32
K	SK	4	18	5	17	4	18	3	19
	CZ	5	9	4	10	4	10	4	10
	PL	9	19	7	21	8	20	4	24
	HU	7	15	7	15	6	16	7	15
L	SK	31	104	42	93	33	102	29	106
	CZ	23	86	26	83	17	92	17	92
	PL	5	4	6	3	6	3	4	5
	HU	15	31	15	31	11	35	12	34
M	SK	49	215	67	197	58	206	61	203
	CZ	29	122	38	113	35	116	27	124
	PL	4	15	7	12	5	14	2	17
	HU	9	24	10	23	6	27	5	28
N	SK	30	117	38	109	27	120	26	121
	CZ	10	35	13	32	13	32	9	36
	PL	3	6	4	5	1	8	4	5
	HU	12	22	9	25	8	26	7	27
O	SK	0	1	0	1	0	1	0	1
	CZ	0	1	0	1	0	1	0	1
	PL	1	3	0	4	0	4	0	4
	HU	0	1	0	1	0	1	0	1
P	SK	1	7	2	6	2	6	2	6
	CZ	-	-	-	-	-	-	-	-
	PL	-	-	-	-	-	-	-	-
	HU	1	1	1	1	1	1	1	1

Table 7. *Cont.*

NACE	Country	ROS							
		Pettitt's Test		SNHT		Buishand's Test		von Neumann Test	
		Hete	Homo	Hete	Homo	Hete	Homo	Hete	Homo
Q	SK	7	42	8	41	7	42	10	39
	CZ	5	17	5	17	6	16	5	17
	PL	3	2	2	3	2	3	3	2
	HU	1	1	0	2	1	1	0	2
R	SK	6	10	7	9	8	8	5	11
	CZ	2	7	2	7	1	8	3	6
	PL	-	-	-	-	-	-	-	-
	HU	0	8	1	7	0	8	1	7
S	SK	2	11	2	11	0	13	2	11
	CZ	1	8	1	8	0	9	1	8
	PL	1	3	0	4	1	3	0	4
	HU	2	8	4	6	3	7	0	10
SUM		1933	6738	2117	6554	1833	6718	1757	6914

Figure 2 portrays the summary of the provided tests. The SNHT identified the greatest number of enterprises in which significant changes in profitability occurred. Individually, ROA, ROA, ROC, ROE, ROS, ROR, and ROW demonstrated this ability. To summarise, there were 13,266 changes for all NACEs, all countries, and all ratios.

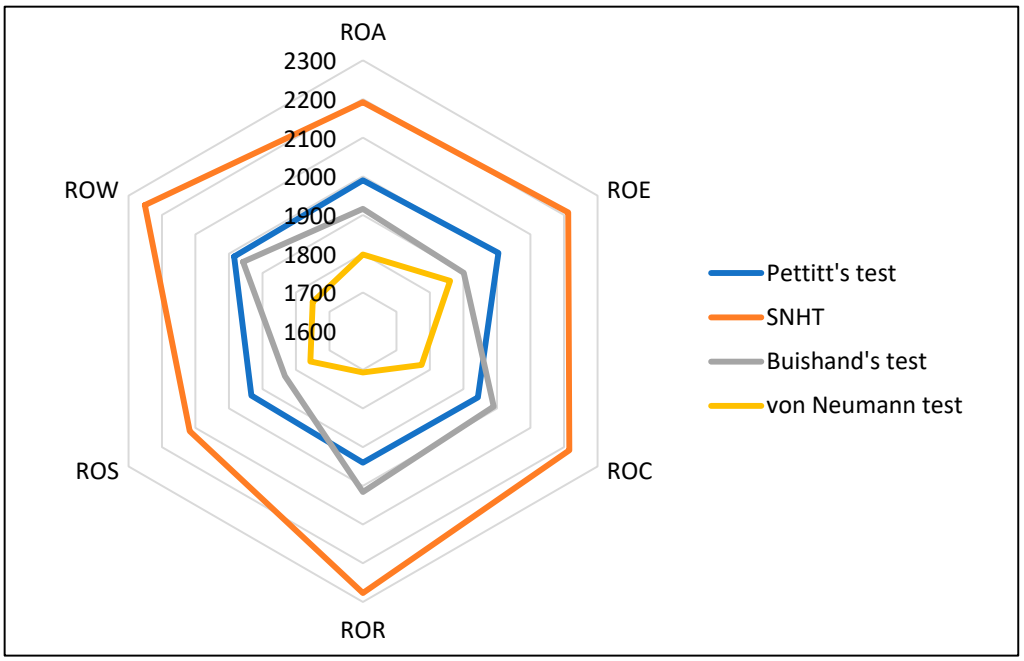

Figure 2. Comparison of all homogeneity tests for all profitability ratios.

The von Neumann test indicated the lowest number of enterprises in which significant changes in profitability occurred for all ratios. To summarise, there were 10,647 changes for all NACEs, all countries, and all ratios.

Pettitt's test detected 11,795 changes, and Buishand's test detected 11,614 changes.

The results show that it is possible to use all tests to detect changes in the development of profitability ratios across countries and sectors. The SNHT was the most effective, followed by Pettitt's test, Buishand's test, and the von Neumann test. The large sample size of 8671 enterprises from the Visegrad region and the 19 sectors tested offer evidence

that these tests are adaptable and reliable for detecting structural changes, not only in profitability ratios but also potentially in other financial metrics.

5. Discussion

The SNHT may offer better detection power than the other three tests because it tends to be more sensitive to sudden changes in a time series. This means that if there is a sudden breakpoint (significant year of change in our case) in profitability ratios within an enterprise, the SNHT is better able to detect it compared to other tests, which may be more sensitive to gradual or continuous changes.

The second reason is its robustness to overall trends. SNHTs run effectively in situations where there is an overall trend or structural change in the data but with significant localised deviations. Other tests, such as the von Neumann test, are more sensitive to the overall variability of the data, whereas the SNHT focuses more on identifying individual points or smaller sections of the time series where sudden breakpoints have occurred.

The SNHT uses a normal distribution. There is a symmetric distribution of test statistics. This allows it to be more robust against extreme values in the sample as well as noise in the time series of the profitability ratios. In addition, the explanation of the higher detection power of the SNHT may be caused by using large datasets, as in this study.

In comparison to our results, we discuss the investigation from the region that also used homogeneity tests on the issue of financial management. Durana et al. [48] capture significant changes in the development of EBITDAs in the transport sector (NACE H) during 2010–2019. The year 2013 was a specific change point for 830 Slovak and 1042 Hungarian enterprises. The year 2014 was a specific changing point for 397 Czech enterprises. The year 2015 was a specific change point for 757 Polish enterprises. Buishand's test, which used 1,000,000 Monte Carlo simulations, served as the basis for these results.

Valaskova et al. [42] use Pettitt's test with 10,000 Monte Carlo simulations to identify the year of change in EBITDAs individually for 1058 Slovak enterprises, 688 Czech enterprises, 1376 Polish enterprises, and 731 Hungarian enterprises from 2010 to 2018. The results showed that all countries had the same significant year of change. The year 2013 split the development of business profit into two homogeneous series, each showing a positive change over time.

Bugaj et al. [28] also use Pettitt's test with 100,000 Monte Carlo simulations to detect the positive or negative shifts, or no shift, in the development of 534 transport businesses from the Visegrad Four (V4) region during 2016–2021. They confirm that more than 25% of enterprises involved in Industry 4.0 had positive shifts in ROA, ROC, ROS, and ROR despite the worldwide negative effect of the COVID-19 pandemic on profitability. The ratios were based on EBTs, and the sample consisted of 159 Czech, 48 Hungarian, 8 Polish, and 319 Slovak enterprises. Durana and Valaskova [49] also focus on the effect of the COVID-19 pandemic and specific components of Industry 4.0 smart sensors in the environment of small- and medium-sized enterprises (SMEs) mapping the period of 2016–2021. They ran Pettitt's test with 100,000 Monte Carlo simulations to see if pandemic years (2020 or 2021) affected EBITDAs development disruptions. They confirmed significant changes in the time series of 1221 Slovak, 259 Czech, 855 Polish, and 2156 Hungarian enterprises. The results showed that more than 80% of SMEs using smart sensors balanced their earnings during crises. It confirms that the advent of the Industry 4.0 paradigm is particularly important for the sustainment of the competitive edge of SMEs [50].

Durana et al. [51] disclose parallels between Slovak and Bulgarian economics and business finance. They analyse the occurrence of earnings management for 1347 Slovak enterprises and 1839 Bulgarian enterprises over the period of 2010 to 2018. The analysis was conducted using the SNHT and a von Neumann Monte Carlo simulation with 1,000,000 replicates. According to the EBITs, there was a significant change in earnings management in 2014, which was consistent with the positive development of ease of doing business in both countries. Durana et al. [52] also confirm parallels but indicate differences between countries in the V4 and Baltic regions. The status of earnings management was set

based on the observations of 1089 Slovak enterprises, 722 Czech enterprises, 766 Hungarian enterprises, 1966 Polish enterprises, 483 Latvian enterprises, 501 Lithuanian enterprises, and 649 Estonian enterprises. The year 2014 highlights acceleration in earnings management for the Visegrad region, and the year 2016 is typically multiplicative in earnings management for the Baltic regions. The mentioned changes in the development of EBITs were gained by the SNHT and a von Neumann Monte Carlo using 1,000,000 replicates of a Monte Carlo simulation during the 9-year period of 2010–2018.

6. Conclusions

The aim of this paper was to evaluate the detection power of homogeneity tests and identify the one with the highest ability based on testing changes in the development of profitability ratios across sectors in the Visegrad Four. The SNHT detected the most occurrences of heterogeneity for all six profitability ratios based on Monte Carlo simulations. This approach is reproducible for other markets and is also recommended for other ratios for liquidity (e.g., cash ratio, quick ratio, current ratio), indebtedness (e.g., total indebtedness ratio, debt-to-equity ratio, interest coverage ratio), and activity (e.g., collection period ratio, credit period ratio, asset turnover ratio) to detect significant changes in their development.

The research also identified that the changes in profitability ratios had occurred in all involved NACEs, but there were no balanced samples and no focus on the momentum in performance. We may concentrate our future research efforts on preparing well-balanced samples from the Visegrad region. In future studies, trend tests should be used to reveal any positive or negative shifts in the profitability ratios of Slovak, Czech, Polish, and Hungarian businesses. This will establish an opportunity to benchmark the development (upward or downward) of profitability across these countries and sectors.

Author Contributions: Conceptualisation, P.D. and R.B.; methodology, P.D.; software, P.D.; validation, R.B. and E.K.; formal analysis, R.B. and E.K.; investigation, R.B. and E.K.; resources, R.B. and E.K.; data curation, P.D.; writing—original draft preparation, R.B.; writing—review and editing, E.K.; visualisation, R.B.; supervision, P.D.; project administration, P.D.; funding acquisition, P.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

Acknowledgments: This research was financially supported by the Slovak Research and Development Agency—Grant VEGA 1/0677/22: Quo Vadis, Bankruptcy Models? Prospective Longitudinal Cohort Study with Emphasis on Changes Determined by COVID 19.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Dash, S.R.; Sethi, M.; Swain, R.K. Financial condition, working capital policy and profitability: Evidence from Indian companies. *J. Indian Bus. Res.* **2023**, *15*, 319–355. [CrossRef]
2. Valaskova, K.; Gajdosikova, D.; Belas, J. Bankruptcy prediction in the post-pandemic period: A case study of Visegrad Group countries. *Oeconomia Copernic.* **2023**, *14*, 253–293. [CrossRef]
3. Valaskova, K.; Gajdosikova, D.; Lazaroiu, G. Has the COVID-19 pandemic affected the corporate financial performance? A case study of Slovak enterprises. *Equilib. Q. J. Econ. Econ. Policy* **2023**, *18*, 1133–1178. [CrossRef]
4. Kumar, V.; Thrikawala, S.; Acharya, S. Financial inclusion and bank profitability: Evidence from developed market. *Glob. Financ. J.* **2022**, *53*, 100609. [CrossRef]
5. Veselinovic, D.; Antoncic, J.A.; Antoncic, B.; Grbec, D.L. Financial self-efficacy of entrepreneurs and performance. *J. Dev. Entrep.* **2022**, *27*, 2250002. [CrossRef]
6. Feroz, E.H.; Kim, S.; Raab, R.L. Financial statement analysis: A data envelopment analysis approach. *J. Oper. Res. Soc.* **2003**, *54*, 49–58. [CrossRef]

7. Putri, P.I.; Rahayu, K.N.; Rahmayani, D.; Siregar, M.E.S. The effect of green banking and financial performance on banking profitability. *Qual. Access Success* **2022**, *23*, 38–46. [CrossRef]
8. Lehenchuk, S.; Serpeninova, Y.; Zavalii, T.; Juhaszova, Z.; Kordosova, A. The impact of financial performance on the profitability of advertising agencies in the Slovak Republic. *Strateg. Manag.* **2022**, *28*, 41–50. [CrossRef]
9. Chhaidar, A.; Abdelhedi, M.; Abdelkafi, I. The effect of financial technology investment level on European banks' profitability. *J. Knowl. Econ.* **2023**, *14*, 2959–2981. [CrossRef]
10. Durica, M.; Frnda, J.; Svabova, L. Artificial neural network and decision tree-based modelling of non-prosperity of companies. *Equilib. Q. J. Econ. Econ. Policy* **2023**, *18*, 1105–1131. [CrossRef]
11. Kristóf, T.; Virág, M. What drives financial competitiveness of industrial sectors in Visegrad Four countries? Evidence by use of machine learning techniques. *J. Compet.* **2022**, *14*, 117–136. [CrossRef]
12. Nwude, E.C.; Allison, U.P.; Nwude, C.A. The relationship between working capital management and corporate returns of cement industry of emerging market. *Int. J. Financ. Econ.* **2020**, *26*, 3222–3235. [CrossRef]
13. Fenyves, V.; Nyul, B.; Dajnoki, K.; Bács, Z.; Tomori, G. Profitability of pharmaceutical companies in the Visegrad Countries. *Monten. J. Econ.* **2019**, *15*, 99–111. [CrossRef]
14. Popescu, A.; Marcuta, A.; Tindeche, C.; Angelescu, C.; Marcuta, L. Profit and profitability of the commercial companies dealing with dairy farming. *Sci. Pap. Ser. Manag. Ec.* **2020**, *20*, 447–460.
15. Cathala, C. Net operating loss policies in Poland—A tool for tax neutrality and firm's antifragility. *Financ. Internet Q.* **2022**, *18*, 68–79. [CrossRef]
16. Kruhlova, O.; Kozub, V.; Kozub, S.; Naumova, T.; Akimova, N.; Tverdokhlib, K. Influence of economic and non-economic factors on the profitability of the enterprise. *Financ. Credit Act.* **2023**, *1*, 193–205. [CrossRef]
17. Krstic, B.; Bonic, L.; Radjenovic, T.; Vajutovic, M.J.; Ognjanovic, J. Improving profitability measurement: Impact of intellectual capital efficiency on return on total employed resources in smart and knowledge-intensive companies. *Sustainability* **2023**, *15*, 12076. [CrossRef]
18. Gotardo, R.; Zanin, A.; Kruger, S.D. Relation of operational and financial cycles in the profitability of an industrial company. *Rev. Ges. Sec.* **2023**, *14*, 1555–1569. [CrossRef]
19. Zlateva, P.; Galabov, M.; Velev, D. An approach to analysis of the impact of natural disasters on the economic efficiency and profitability of business. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.* **2023**, *48*, 403–408. [CrossRef]
20. Gomes, L.B.; Ferreira, R.; Kroenke, A. Does economic freedom moderate the relationship between profitability and capital structure? *Contab. Ges. Gov.* **2023**, *26*, 345–377. [CrossRef]
21. Diniz, R.d.C.d.L.; Formigoni, H.; Segura, L.C. Economic freedom and business profitability. *Int. Sci. Conf. Ec. Soc. Dev.* **2020**, *56*, 170–180.
22. Prusty, T.; Waleed, M. Corporate governance and profitability: Evidence from Indian IT companies. *Fin. Mark. Inst. Risks* **2018**, *2*, 68–75. [CrossRef]
23. Meixnerova, L. Evaluation of selected financial aspects in the Czech Republic: A research study about the international activities of Czech business. *Innov. Ec. Symp.* **2017**, *39*, 01020. [CrossRef]
24. Zainudin, R.; Mahdzan, N.S.; Mahamad, N.N. Internationalisation and financial performance: In the case of global automotive firms. *Rev. Int. Bus. Strategy* **2021**, *31*, 80–102. [CrossRef]
25. Fama, E.F.; French, K.R. Testing trade-off and pecking order predictions about dividends and debt. *Rev. Financ. Stud.* **2002**, *15*, 1–33. [CrossRef]
26. Yousaf, M.; Dey, S.K. Best proxy to determine firm performance using financial ratios: A CHAID approach. *Rev. Econ. Perspect.* **2022**, *22*, 219–239. [CrossRef]
27. Tousek, Z.; Hinke, J.; Malinska, B.; Prokop, M. The performance determinants of trading companies: A stakeholder perspective. *J. Compet.* **2021**, *13*, 152–170. [CrossRef]
28. Bugaj, M.; Durana, P.; Blazek, R.; Horak, J. Industry 4.0: Marvels in profitability in the transport sector. *Mathematics* **2023**, *11*, 3647. [CrossRef]
29. Bunea, O.I.; Corbos, R.A.; Popescu, R.I. Influence of some financial indicators on return on equity ratio in the Romanian energy sector—A competitive approach using a DuPont-based analysis. *Energy* **2019**, *189*, 116251. [CrossRef]
30. Niresh, J.; Velnampy, T. firm size and profitability: A study of listed manufacturing firms in Sri Lanka. *Int. J. Bus. Manag.* **2014**, *9*, 57–64. [CrossRef]
31. Fauziyah, S.A.; Djamaluddin, S. The effect of financial performance on the profitability of coal mining company subsectors in Indonesia Stock Exchange. *J. Soc. Sci.* **2021**, *2*, 697–710. [CrossRef]
32. Bayaraa, B. Financial performance determinants of organizations: The case of Mongolian companies. *J. Compet.* **2017**, *9*, 22–33. [CrossRef]
33. Rahin, M.M.; Hassan, M.S.; Mohiuddin, M. Impacts of profitability and growth on stock returns of the listed manufacturing companies at Dhaka stock exchange in Bangladesh. *Int. J. Manag. Financ. Account.* **2023**, *15*, 372–392. [CrossRef]
34. Ginieis, M.; Hernández-Lara, A.B.; Sánchez-Rebull, M.V. Influence of airlines' size and labour costs on profitability. *Aviation* **2020**, *24*, 157–168. [CrossRef]

35. Alfadhli, M.S.; Alali, S. The Effect of bank size on financial performance: A case study on Kuwaiti banks keywords bank assets size return on assets (ROA) return on equity (ROE) shareholder's equity Kuwaiti banks OLS regression. *J. Insur. Financ. Manag.* **2021**, *4*, 11–15.
36. Moody's. Orbis. Available online: https://www.moodys.com/web/en/us/capabilities/company-reference-data/orbis.html (accessed on 1 October 2022).
37. Kostrzewski, M.; Vojtekova, S.; Vlckova, M. Bankruptcy prediction for the manufacturing sector in V4 countries. *Ekon. Manaz. Spektrum* **2023**, *17*, 48–64. [CrossRef]
38. Vasenska, I.P. Economic implications of deep machine learning for tourism time series forecasting. *Ekon. Manaz. Spektrum* **2024**, *18*, 90–101. Available online: https://ems.uniza.sk/wp-content/uploads/EMS_1_2024_08_Vasenska.pdf (accessed on 1 October 2022).
39. Kanovsky, M. The research effectivity of Slovak universities: Quantitative analysis of trends 2008–2017. *Sociol. Slov. Sociol. Rev.* **2018**, *50*, 429–447. [CrossRef]
40. Agha, O.M.A.M.; Bağçacı, S.Ç.; Şarlak, N. Homogeneity analysis of precipitation series in North Iraq. *IOSR J. Appl. Geol. Geophys.* **2017**, *5*, 57–63. [CrossRef]
41. Pettitt, A.N. A non-parametric approach to the change-point problem. *J. R. Stat. Soc. C Appl. Stat.* **1979**, *28*, 126–135. [CrossRef]
42. Valaskova, K.; Gavurova, B.; Durana, P.; Kovacova, M. Alter ego only four times? The case study of business profits in the Visegrad group. *E M Econ. Manag.* **2020**, *23*, 101–119. [CrossRef]
43. Kliestik, T.; Valaskova, K.; Nica, E.; Kovacova, M.; Lazaroiu, G. Advanced methods of earnings management: Monotonic trends and change-points under spotlight in the Visegrad countries. *Oeconomia Copernic.* **2020**, *11*, 371–400. [CrossRef]
44. Von Neumann, J. Distribution of the ratio of the mean square successive difference to the variance. *Ann. Math. Stat.* **1941**, *12*, 367–395. [CrossRef]
45. Buishand, T.A. Some methods for testing the homogeneity of rainfall records. *J. Hydrol.* **1982**, *58*, 11–27. [CrossRef]
46. Alexandersson, H. A homogeneity test applied to precipitation data. *J. Climatol.* **1986**, *6*, 661–675. [CrossRef]
47. Kang, H.M.; Yusof, F. Homogeneity tests on daily rainfall series. *Int. J. Contemp. Math. Sci.* **2012**, *7*, 9–22.
48. Durana, P.; Valaskova, K.; Blazek, R.; Palo, J. Metamorphoses of earnings in the transport sector of the V4 region. *Mathematics* **2022**, *10*, 1204. [CrossRef]
49. Durana, P.; Valaskova, K. The nexus between smart sensors and the bankruptcy protection of SMEs. *Sensors* **2022**, *22*, 8671. [CrossRef]
50. Capestro, M.; Rizzo, C.; Kliestik, T.; Peluso, A.M.; Pino, G. Enabling digital technologies adoption in industrial districts: The key role of trust and knowledge sharing. *Technol. Forecast. Soc. Chang.* **2024**, *198*, 123003. [CrossRef]
51. Durana, P.; Valaskova, K.; Chlebikova, D.; Krastev, V.; Atanasova, I. Heads and tails of earnings management: Quantitative analysis in emerging countries. *Risks* **2020**, *8*, 57. [CrossRef]
52. Durana, P.; Ginevicius, R.; Urbanski, M.; Podhorska, I.; Tumpach, M. Parallels and differences in earnings management of the Visegrad Four and the Baltics. *J. Compet.* **2021**, *13*, 39–55. [CrossRef]