ARTICLE

DETECTING ANOMALIES IN TAX REVENUES USING BENFORD'S LAW. THE CASE OF POLISH ADJUSTMENT

Luty, P., Zawolska, Z.

Piotr Luty / Wroclaw University of Economics and Business, Faculty of Management and Business, Department of Accounting Reporting and Financial Analysis, Wrocław, Poland. Email: piotr.luty@ue.wroc.pl (corresponding author)

Zuzanna Zawolska / Wroclaw University of Economics and Business, Faculty of Management and Business, Wrocław, Poland. Email: 190085@student.ue.wroc.pl

Abstract

Changes in legal regulations are a permanent element of political systems. The degree of complexity of tax systems is a characteristic feature of developing countries. The study aims to check whether changes in legal regulations cause manipulations in companies' financial data. Manipulations may result from the ambiguity of the introduced regulations (unintentional) or the deliberate actions of taxpayers (intentional). The study analyses the impact of changes in reporting information on tax income from capital sources on anomalies in financial data. In the survey, anomalies in economic data are identified using Benford's Law, using MAD (mean absolute deviation). The research sample included Polish companies reporting income information. Based on the study results, it can be concluded that the introduction of the obligation to separately report tax from capital sources caused anomalies in the distributions of digits (2-digit test) in the group of companies affected by this change. In the case of companies not generating income from capital gains in 2018–2019, the matching of the distributions was consistent. In 2020, it was at an acceptable level with the Benford distribution. The research indicates the possibility of using Benford's Law to reveal difficulties in determining tax revenues, mainly due to changes in legal regulations.

Implications for Central European audience: The article deals with the issue of detecting difficulties related to changes in legal regulations in a CEE country - Poland. The introduction of new legal regulations, including those related to income tax, is closely related to the policy of a given country. In CEE countries, introducing new tax restrictions is essential to state policy. Changing the regulations alone is not sufficient. Only effective enforcement of the Law allows the achievement of the intended goals of state policy. The proposed tool for examining the effects of changes in legal regulations will allow for assessing the effectiveness of the introduced new solutions. Additionally, the study's results can be used to detect anomalies in financial data in the Czech Republic. Based on the TCI (Tax Complexity Index) analysis, Poland and the Czech Republic have the most complicated tax system in the Visegrad Group countries. In the 2022 ranking, out of 100 countries included in the TCI index, Poland ranks 63rd and the Czech Republic 55th in Tax Code Complexity.

Keywords: Benford's Law; income tax; fraud

JEL Classification: M21, K34

Introduction

Based on the TCI (Tax Complexity Index) analysis, Poland and the Czech Republic have the most complicated tax systems in the Visegrad Group countries (Tax Complexity Index, n.d.). In the 2022 ranking, out of 100 countries included in the TCI index, Poland ranks 63rd and the Czech Republic 55th in Tax Code Complexity. The complexity of tax regulations is visible in Poland and the Czech Republic in the areas of dividends (D) and capital gains (CG). Poland ranks 63rd and the Czech Republic 59th in dividend complexity. Additionally, Poland ranks 58th and the Czech Republic 55th in the context of the complexity of capital gains regulations.

In Poland, since 2018, a division into two sources of revenue has been introduced: from capital sources and other sources. The regulations indicate that taxpayers can jointly settle income tax if they earn income from capital gains and other activities. When a loss is reported in capital sources, the tax on capital gains and other income is assessed separately. The separation of revenues resulted from the Polish Ministry of Finance's desire to reduce aggressive tax optimisation, which decreased tax inflow for the budget. The Polish Ministry of Finance is mainly directing changes to the legal regulations to large entities that can underestimate the tax base through, among other things, transactions with related entities (Gazeta Prawna, 2017; Malinowski, 2017).

The complexity of the Law results from the regulations that regulate tax issues. Introducing new legal rules and frequent changes to legal regulations result in a lack of understanding among taxpayers. In this way, they can make mistakes when calculating tax revenues. On the other hand, a change in legal regulations, particularly unfavourable for taxpayers, can lead to fraudulent behaviour and manipulation of tax revenues. This article will attempt to detect anomalies and manipulations in tax revenues resulting from a radical change in tax law provisions in Poland. The study puts forward a hypothesis: a change in tax law provisions in Poland and the introduction of separate reporting of income from capital sources causes an anomaly in the distribution of digits of income from capital gains. Anomalies and potential manipulations will be detected using Benford's Law.

The article will verify the research hypothesis that a change in tax law provisions in Poland and the introduction of separate reporting of income from capital sources causes an anomaly in the distribution of digits of income from capital gains.

In scientific research, Benford's Law is used to assess the credibility of results and identify possible forgeries (Harb et al., 2023; Nigrini, 2012). Its potential in financial analyses has been widely used in tax audits, where it can help identify irregularities and detect fraud (Nigrini, 2017; Sylwestrzak, 2023). The regularities resulting from Benford's Law enable effective detection of inconsistencies that may indicate intentional manipulation. This article presents a detailed analysis of the application of Benford's Law in the context of scientific and tax research and reviews previous research in this area. Analysis of the available results allows for a better understanding of the effectiveness of this tool in detecting anomalies. The summary presents the results of the study, which illustrate the usefulness of Benford's Law.

The subsequent sections of the paper are organised as follows: Section 1 outlines the research using Benford’s Law in various research areas. Section 2 discusses the background of Benford’s Law in taxation research and develops the hypothesis. Section 3 presents the

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research results and explains observed anomalies in digit distributions. Finally, Section 7 concludes the paper and provides future research directions.

1 The use of Benford's Law in scientific disciplines

The global financial crisis of 2008 highlighted many discrepancies in the reports published by multinational corporations. The causes of fraud and accounting anomalies included, among others, fictitious entries in the accounting books, which allowed for an increase in sales or an overstatement of equity (Nigrini, 2019). Despite the existing methods for detecting accounting manipulations, their usefulness may be questioned (Harb et al., 2023). In mathematics, various ways of checking the reliability of data are used. One of the methods is based on analysing the frequency of digits, which is called Benford's Law (Berger & Hill, 2021; Li et al., 2019). The Benford method is based on the logarithmic distribution of the analysed data and compares observable values with expected values (Nigrini, 2017). The use of this method is not limited by the type of data or the period of occurrence because it directly determines the quality of the data (Dechow et al., 2010) and is simple to calculate (Amiram et al., 2015). Because it is an econometric model, its results cannot be distorted by variables not included in the study or other changes in basic parameters (Kothari et al., 2005).

This tool is used in a wide range of scientific fields. Benford's Law is mathematically related to the theory of uniform distribution (Cai et al., 2019). This relationship proved that Benford's Law applies to exponentially increasing sequences, including Fibonacci numbers (Diaconis, 1977). In economics, Benford's Law is used to detect fraud. Sylwestrzak (2023) examines the relationship between control group firms and fraudulent firms regarding financial data manipulation. The application of Benford's Law also includes creating early warning models for financial audits and researching optimisation and innovation in the enterprise's financial and accounting supervision system, considering various aspects of financial risk (Liu et al., 2024). Fraud in financial transactions is a significant corruption problem in organisations, and its detection is becoming increasingly complex. Auditors need specific analytical tools to identify them. Creating an algorithm that can be used to group transaction data can increase the effectiveness of fraud detection using Benford's Law (Wiryadinata et al., 2023).

Benford’s Law also applies to other scientific fields. In the study by Bond et al. (2022), the Benford distribution was used to analyse the degree of use of force by corrections officers against prisoners from 2008 to 2017. Mbona and Eloff (2022) analysed the casualty of malware appearing on the Internet and found a solution through intelligent malware detection. In engineering, digit pattern analysis compares electricity measurement data from smart electricity sensors (Petráš et al., 2023). In his study, Angelo (2020) points out the importance of Benford's Law for transfusion medicine. The author focuses on the quality of red blood cell storage for patients suffering from injuries and haemorrhages and the significance of this problem during the COVID-19 pandemic.

2 Benford's Law in taxes

For centuries, there has been a dispute in the public space regarding fiscal burdens between public institutions and taxpayers. On the one hand, public finances require a continuous inflow of funds in connection with implementing public tasks (Zimmermann, 2024). On the other

hand, limiting the freedom to dispose of taxpayers' funds gives rise to dissatisfaction and resistance (Papadopoulou & Hristu-Varsakelis, 2019). The scale of the tax burden on taxpayers may affect their compliance with the Law. Studies have shown that direct taxes positively impact economic development in developed countries, which cannot be confirmed in developing countries (Abd Hakim et al., 2022). Developed countries are more aware of tax burdens and their acceptance (Berens & von Schiller, 2017). Tax burdens are essential in stimulating economic development and supporting society by, for example, supporting health care (AbdelNabi et al., 2022). Financial and accounting services use Benford's Law to examine the correctness of taxpayer reports and detect fraud and manipulation (Herteliu et al., 2021). Ensuring continuity of cash flow from taxpayers to the fiscal administration becomes a critical element of redistributing state resources. For this purpose, effective detection of tax anomalies and loopholes may be necessary.

There are two classic trends in the practice of Benford's Law. The first involves using Benford's Law as a tool in data analysis. On the one hand, Li et al. (2019) analysed financial data quality. On the other hand, Benford's Law is used in nonfinancial data analysis from various research areas. For example, Benford's Law was used for anomaly detection during the 2004 US presidential election to detect anomalies in votes cast in individual states (Anderson et al., 2022). Benford's Law assesses the reliability of data collection published by statistical offices and public announcements. Recently, during the COVID-19 pandemic, Benford's Law detected anomalies in reporting deaths or new illnesses (Campolieti, 2022). Detected anomalies in the distribution of digits of detected new COVID-19 cases may indicate, for example, deliberate misleading of public opinion or problems in diagnosing the disease. The second trend directly concerns the detection of tax and financial fraud (Pavlović et al., 2019). Goh (2020) proposed using Benford's Law to detect fraud in company accounting. Manipulation of financial data in accounting has various causes. They often result from the desire to achieve individual benefits of people responsible for company accounting (Orth et al., 2023). According to agency theory, preparers of financial reports may intentionally introduce distortions into financial data to achieve their own goals, other than those of company owners (Abernethy et al., 2017; Arroyo & Cassú, 2015). Benford's Law can also be linked to signaling theory, which reduces information asymmetry and increases the quality of company communications (Shahid et al., 2024). For this purpose, Benford's Law can be used to detect financial risk (Cerqueti et al., 2022). Financial data reliability and information asymmetry reduction are crucial for companies, public administration bodies, and society in making the right decisions.

In Central and Eastern Europe, many countries have similar experiences with the introduction of free-market changes and adjustments to legal regulations. The complexity of tax systems can be measured using the TCI. "The Tax Complexity Index (TCI) measures the complexity of a country's corporate income tax system as faced by multinational corporations. The index covers the complexity of the tax code (complexity inherent in different tax regulations) and the complexity of the tax framework (complexity that arises from the features and processes of a tax system). It can range between zero (not complex) and one (extremely complex)" (Tax Complexity Index, n.d.).

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Table 1 | Tax complexity in V4 countries (2022)

Component	Hungary	Slovakia	Czech Republic	Poland
Tax code complexity	0.43	0.38	0.56	0.61
Capital gains	0.38	0.27	0,57	0.58
Dividends	0.36	0.33	0.60	0.72
Enactment	0.36	0.50	0.46	0.57
Payment & filing	0.14	0.13	0.14	0.29

Source: (Tax Complexity Index, n.d.)

Table 1 shows that the highest level of complexity of individual elements of the tax system is in Poland (0.61) and the Czech Republic (0.56). In Hungary and Slovakia, the tax system's complexity is below 0.5. The components of the tax system selected for analysis related to income from capital sources or dividends indicate a high level of complexity in Poland (0.72) and the Czech Republic (0.60). The subject of the study is the analysis of anomalies in the distribution of income from capital sources after the change of legal regulations in Poland. In the context of the complexity of settling and paying taxes, Hungary, Slovakia, and the Czech Republic had similar indicators, and Poland had almost twice as high - 0.29. It means that the effective collection of taxes in Poland requires significant changes. Based on the indicators included in Table 1, it can be stated that the problem of the complexity of legal systems, including income from capital sources or dividends, is also visible in the Czech Republic, where tax collection is less complex.

Introducing tax obligations through new legal provisions or changes in legal requirements does not solve the problem of effective tax collection. Despite the obligation, taxpayers may avoid paying tax or influence its amount by limiting its amount. Tax avoidance may increase the likelihood of inspections by tax authorities (degl'Innocenti & Rablen, 2017). Taxpayers' tax burden-reducing behaviour is positively related to their attitude to the risk of fraud detection (Bernasconi et al., 2014). Many factors cause taxpayers to become stressed and consider tax avoidance. These may be financial factors related to the uncertainty of the behaviour of financing sources caused by the financial crisis or the Covid-19 pandemic (Best, 2022). The stressor is a psychological factor related to the misunderstanding of legal provisions as well as social norms (Dulleck et al., 2016). Another factor may be changes in legal regulations (Flinders et al., 2020), which are related to misunderstanding the changes being introduced. In this context, tax avoidance may be unintentional - lack of specialised tax advisors, lack of appropriate interpretations and uniform regulations, or intentional - deliberate use of tax loopholes or incorrect interpretations to obtain financial benefits.

Changes in legal regulations may result in the desire to manage company results to achieve additional financial benefits. Benford's Law was used to analyse the impact of financial reforms in Korea on corporate performance management (Lacina et al., 2018). The authors indicated that after the introduction of financial reforms in companies with positive financial results, the effect of earnings management could be observed at the level of the second digit test, following the Benford distribution. Changes to legal provisions may be cosmetic or

radical. In the event of radical changes in legal regulations, it is possible to observe companies' behaviour differently from the previous one. An example of a radical change in legal regulations in Poland was the separation of tax revenues from capital sources from other income. In this way, companies could not compensate for losses and income from various sources, which taxpayers negatively perceived.

The tax reform introduced separate reporting and determination of income from capital sources. Revenues from capital sources include dividends, income from the redemption of a share (share) or the reduction of its value, interest on a capital share, income obtained following transformation, merger or division of entities, income from the disposal of a share (shares), including disposal made with a view to their redemption, income from securities and derivative financial instruments. The new regulation was introduced in 2018 and has been in force since the 2018 tax year. Other revenues and incomes refer to the essential economic activity of companies. Examples of other revenues are revenues from the sale of products, services, and other tangible and intangible assets used in running the business.

Introducing reforms and changes in legal provisions always arouses taxpayer resistance. Uncertainty in applying new legal requirements and negative consequences concern a selected group of taxpayers who obtained income from capital sources.

The study hypothesised:

H1: A change in tax law provisions in Poland and the introduction of separate reporting of income from capital sources cause an anomaly in the distribution of digits of income from capital gains.

3 Research methodology

Financial data on the value of revenue obtained in the tax year exceeding EUR 50 million for individual taxpayers was obtained from the Ministry of Finance's website (accessed: March 27, 2024). According to applicable regulations, the minister responsible for public finance is obliged to disclose individual data from corporate income tax returns publicly. Table 2 presents the number of companies in the research sample, divided into 2018–2022, covering all companies included in the Ministry of Finance database.

Table 2 | Research sample (number of companies)

Year	Revenues from capital gains	Revenues from other sources	Income from capital gains	Income from other sources
2018	2,370	2,373	2,110	2,096
2019	456	2,768	363	2,469
2020	392	2,591	296	2,328
2021	478	3,270	375	2,990
2022	517	3,902	403	3,580
Total	4,213	14,904	3,547	13,463

Source: own study based on data from the Ministry of Finance

Table 2 shows that since 2019, there has been a significant reduction in the number of companies that disclosed income from capital sources. It may be related to changes in legal regulations and the departure from transactions recognised by the tax system as capital sources. Changes to the legal rules entered into force in 2018, but closing the investment or changing the business profile does not happen immediately and takes time.

Table 3 | Descriptive statistics for tax revenues

Name	Year	No.	Mean (mil PLN)	Median (mil PLN)	Min. (mil PLN)	Max. (mil PLN)	Std. dev. (mil PLN)
Revenues capital sources	2022	517	289	3	0	42,131	2,074
Revenues capital sources	2021	478	845	3	0	323,429	14,809
Revenues capital sources	2020	392	330	3	0	51,999	2,789
Revenues capital sources	2019	456	707	3	0	78,646	5,375
Revenues capital sources	2018	2,370	88	0	0	85,724	1,866
Other revenues	2022	3,902	1,850	465	0	1,932,851	31,654
Other revenues	2021	3,270	1,520	450	0	1,213,354	21,629
Other revenues	2020	2,591	1,694	458	0	1 422 823	28,219
Other revenues	2019	2,768	1,476	421	0	1,163,066	22,374
Other revenues	2018	2,373	1,621	422	0	1,001,769	22,010

Source: own study

The next step is to select companies affected by the change in legal regulations. Therefore, only companies that 2018-2022 disclosed both revenues from capital gains and revenues from other income were selected. For this purpose, companies that do not disclose income from capital gains or whose value was zero were removed from the database. After introducing the restrictions, the size of the research sample is presented in Table 4.

Table 4 | Adjusted research sample (number of companies)

Year	Number of companies
2018	453
2019	428
2020	373
2021	450
2022	487
Total amount	2,191

Source: own study

The difficulty of interpreting new legal provisions and the unfavourable separate settlement of tax on capital sources and other income may result in errors and manipulation of tax information.

Benford's Law assumes that the digits in numbers should have a logarithmic distribution, as the formula BL(d) describes. The beginnings of the analysis of the frequency of occurrence of a number date back to the 19th century. At that time, Newcomb noticed that people were more likely to look for solutions in mathematical tables for numbers starting with the digit 1 than 9. Therefore, the digits in values describing natural or financial phenomena without manipulation should be consistent with the Benford distribution. According to Nigrini (2012), the sample for testing Benford's Law should meet the appropriate criteria:

- The records should represent the sizes of facts or events. Examples of such data would include the towns' and cities' population and river flow rates. Financial examples include the market values or companies' revenues on the major U.S. stock exchanges or the daily trading volumes of companies on the London Stock Exchange.
- There should be no built-in minimum or maximum values for the data, except perhaps for a minimum of 0 for data that can only be made up of positive numbers (election results, population counts, or inventory counts).
- The records should not be numbers used to identify numbers or labels.

The frequency of occurrence of specific digits in a given place in a number can be described by the logarithmic formula proposed by Benford. We calculate the Benford distribution as follows (Nigrini, 2012):

$$BL(d) = \log\left(1 + \frac{1}{d}\right) \tag{1}$$

Where:

d – number of digits.

Based on the calculation formula for the Benford distribution, you can obtain information about the frequency of digits in the number in the first place from the left for the first-digit test. Figure 1 shows the Benford distribution for the first digit.

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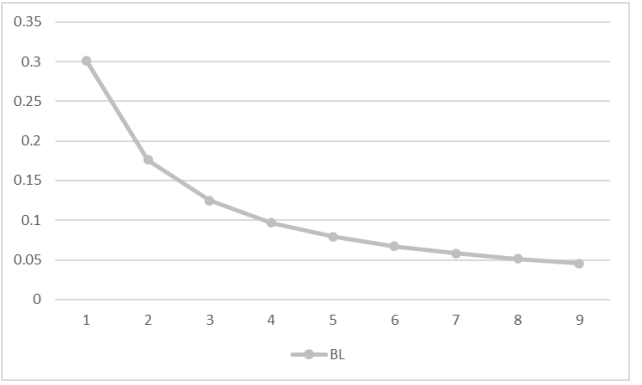
Figure 1 | Benford's distribution – 1-digit test

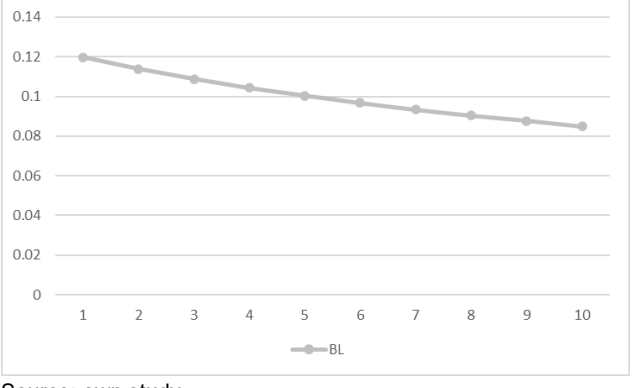


Source: own study

Based on Figure 1, it can be concluded that according to the test of the first digit in the number describing a specific studied phenomenon, the digit 1 occurs most frequently (30%), and the digit 9 occurs least frequently (4%). Deviations between the empirical distributions (for example, the distribution of tax revenue digits) and the theoretical one (Benford distribution) may indicate anomalies, the occurrence of which requires explanation. The first digit in the number may be subject to manipulation due to rounding used by companies in reporting financial data. Anomalies may also result from the construction of the research sample (limitation of companies in terms of the size of a specific research variable). In such a case, the test of the second digit can be performed.

Benford's distribution function can also determine the frequency of digits in a number in further positions. Figure 2 shows the digit distribution for the Benford second-digit test.

Figure 2 | Benford's distribution – 2-digit test



Source: own study

While the first digit test covers the range of digits from 1 to 9, the second digits range from 0 to 9. Based on Figure 2, it can be concluded that the second most common digit in a number is 0 (12%), and the least common digit is 9 (8%).

The fit of empirical distributions (for example, the digit test for tax revenues) can be examined using statistical tools. In this study, MAD (Mean Absolute Deviation):

$$MAD = \frac{1}{n}\sum_{i=1}^{n} |x_i - m(X)| \quad (2)$$

Where:

m(X) – average data value,

n – number of data values,

x_i– data values in the set.

Depending on the level of MAD, it can be considered a close fit, an acceptable fit, a marginal fit, or no fit. The ranges for MAD are presented in Table 5 (Nigrini, 2012).

Table 5 | Ranges for Mean Absolute Deviation

Digit	Range	Conclusion
First-digit	0.000–0.006	close conformity
	0.006–0.012	acceptable conformity
	0.012–0.015	marginally acceptable conformity
	above 0.015	nonconformity
Second-digit	0.000–0.008	close conformity
	0.008–0.010	acceptable conformity
	0.010–0.012	marginally acceptable conformity
	above 0.012	nonconformity

Source: Nigrini (2012)

Benford distribution is a method often used to check for anomalies. Sinaga and Sudharma (2024) used MAD to check data quality for an epidemiological monitoring system. It was also used by Capalbo et al. (2023) and Morales et al. (2022). MAD was also used by Fernandes et al. (2024), Roy Choudhury (2022). MAD is not the only method for determining the degree of fit of distributions, but it is a commonly used method (Nigrini, 2012).

Benford's Law will be a tool for checking the correctness of tax information submitted by taxpayers. The analysis will be done on revenues from capital sources and other income. For example, if the revenues from capital sources amount to EUR 845 million, the first digit of the revenue is 8, and the second digit is 4. The first-digit test will examine the frequency of a specific digit as the first digit of the revenue among all companies reporting revenues from capital sources in the research sample.

Benford's method is based on the logarithmic distribution of the analysed data and compares observable values with expected values (Nigrini, 2017). The use of the mentioned method is not limited by the type of data or the period of occurrence because it directly determines the data quality (Dechow et al., 2010) and is simple to calculate (Amiram et al., 2015). Since it is an econometric model, its results cannot be distorted by variables not included in the study or other changes in basic parameters (Kothari et al., 2005).

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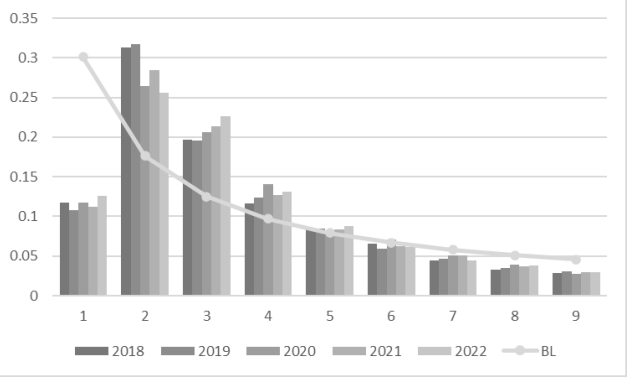
4 The research results

The study will analyse the distribution of digits after the introduction of changes in tax regulations in Poland and the introduction of separate settlements of capital gains tax. For this purpose, the research sample will be divided into two tax titles (tax on other income and tax on capital sources).

The study will be conducted on a group of companies that were unaffected by the change in legal regulations due to the lack of reporting of transactions related to capital source revenues. The second group of companies includes companies that reported capital source revenues, so these were the companies to which the change in legal regulations was addressed, assuming the limitation of aggressive tax optimisation related to operations on capital sources. A test of the first digit and a test of the second digit will be conducted for both groups of companies. Based on the literature review, as well as the assumptions of the Ministry of Finance for the introduced change in legal regulations, we assume that in the first group of companies, the frequency of digits in revenues will be consistent with the Benford distribution. Dividing taxation into two parts (capital sources and other income) should be neutral for companies that do not report capital source revenues. In the case of the second group of companies, to which the change in legal regulations was mainly addressed, we assume that the empirical distributions of digits will be inconsistent with the theoretical Benford distribution. Such a situation may suggest that the companies used capital sources for tax optimisation.

The first test covers companies theoretically unaffected by the change in legal regulations. These companies reported only revenues from other income (Fig. 3).

Figure 3 | 1-digit test for other income, companies unaffected by the law adjustment



Source: own study

Figure 3 shows that the digit 1 occurs less frequently than according to the Benford distribution (BL line in Figure 1). The lack of compliance with the distributions for all analysed years, 2018-2022, results from the limitation for companies that must report to the ministry data on revenues, costs, and income, divided into capital gains and other income. The

minimum threshold for the reporting obligation is EUR 50,000,000. Assuming the average euro to Polish zloty exchange rate between 4.0 and 5.0, tax revenues in the group subject to reporting obligation will start with the number 2 (EUR 50 million * 4.0 PLN/EUR = PLN 200 million, EUR 50 million *5,0 PLN/EUR = PLN 250 million), not number 1, as it should be.

The measure of fit of distributions (MAD) indicates the lack of compliance of empirical distributions with the Benford distribution (Table 6).

Table 6 | MAD 1-digit test for other income, companies not affected by the law adjustment

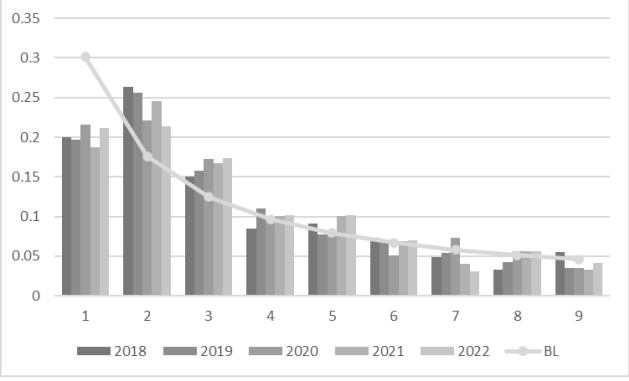
2018	2019	2020	2021	2022
0.051995	0.054277	0.049119	0.051341	0.049691

Source: own study

In all analysed years, MAD (Table 6) was above 0.015, which means there was a nonconformity of distributions. In this case, the nonconformity did not result from data manipulation but resulted from data limitations (companies with a minimum EUR 50 million revenue).

In the case of companies affected by the change in tax regulations, the companies reported revenues from other sources and revenues from capital sources separately; the first digit test also confirms the existence of anomalies in the distributions (Fig. 4).

Figure 4 1-digit test for other income, companies affected by the law adjustment



Source: own study

The descriptive statistics analysis from Table 3 indicates that the share of revenues from capital gains in total tax revenues is low. It means that the value of revenues or income from capital gains does not affect the value of the first digit of total revenues or income. Table 7 presents the MAD for the first digit of the other income test and indicates that the distributions are inconsistent.

Table 7 | MAD 1-digit test for other income, companies affected by the law adjustment

2018	2019	2020	2021	2022
0.031385	0.028669	0.025679	0.031915	0.026919

Source: own study

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The inability to use the first-digit test means that the analysis must use the second-digit test to assess the conformity or nonconformity of distributions.

The difficulties in interpreting the new legal provisions, as well as the negative reception of new solutions in determining income tax by companies, will be confirmed by the results of the second-digit test. The results of the second digit test will indicate the presence or absence of anomalies in the distribution of digits.

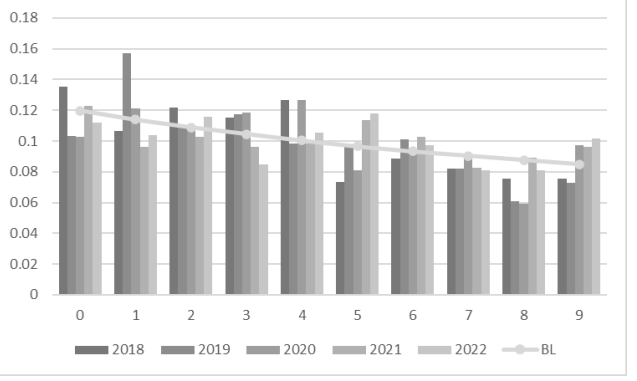
An analysis of empirical and theoretical distributions for the second digit will be conducted in the latter part of the study. The study will be conducted separately for the companies to which the change in legal regulations was addressed (they report revenues from capital sources) and for the remaining companies. The analysis will focus on the frequencies of occurrence of digits from 0 to 9, in second place in revenues from capital sources and other revenues.

We assume that the second digit test will show that in the group of companies to which the change in tax law regulations was addressed in 2018, on the separation of income calculations to limit aggressive tax optimisation, there will be anomalies in the distributions of digits. Such a situation will confirm the research hypothesis put forward in the study.

A separate second-digit test will be conducted for revenues classified as other income and revenues from capital sources. This analysis concerns companies potentially affected by the change in legal regulations because these companies reported revenues from capital sources.

Figure 5 shows the distribution of the second digit for revenues from other sources.

Figure 5 | 2-digit test for other income, companies affected by the law adjustment



Source: own study

The second digit test for other income indicated the occurrence of anomalies in the distributions (Figure 5). From 2018 to 2020, MAD suggests that the distributions are inconsistent with the Benford distribution. In 2021–2022, MAD indicates a marginal conformity of distributions (Table 8).

Table 8 | MAD 2-digit test for other income, companies affected by the law adjustment

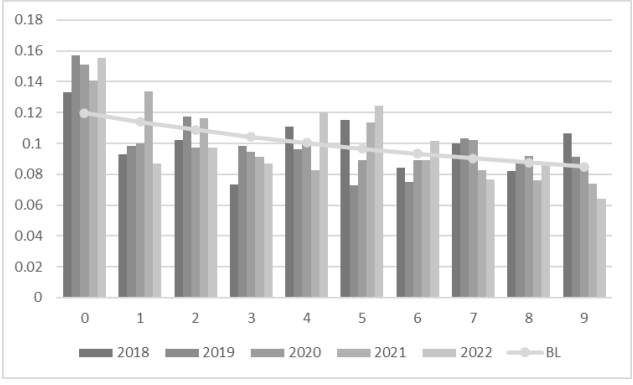
2018	2019	2020	2021	2022
0.013151	0.0131	0.012614	0.008451	0.010825

Source: own study

The lack of conformity between the empirical (second digit of revenues from other income) and theoretical (Benford) distributions in the first three years of the change in legal regulations may indicate difficulties in interpreting the new regulations or conscious changes in the activities related to tax revenues.

Analysis of the distributions of digits (second digit test) for revenues from capital sources and the appearance of anomalies in the distributions will confirm the belief that this group of revenues may be related to aggressive tax optimisation. For revenues from capital sources, the second digit test also indicates the occurrence of anomalies in the distributions (Fig. 6).

Figure 6 | 2-digit test for capital sources income



Source: own study

The fit of distributions (MAD) measure for almost all studied periods indicates a lack of fit. Only in 2020 is the MAD at the level of marginal adjustment of distributions (Table 9).

Table 9 | MAD 2-digit test for capital sources income

2018	2019	2020	2021	2022
0.014679	0.013453	0.009734	0.013079	0.018199

Source: own study

The lack of consistency of the distributions (Table 8 and Table 9) in the first years after the introduction of the change in the legal regulations on separate taxation of income from capital sources and other sources, together with the increasing number of companies that did not report income from capital sources (Table 10), may indicate a departure from the attempt to optimise income by companies using financial operations related to capital sources.

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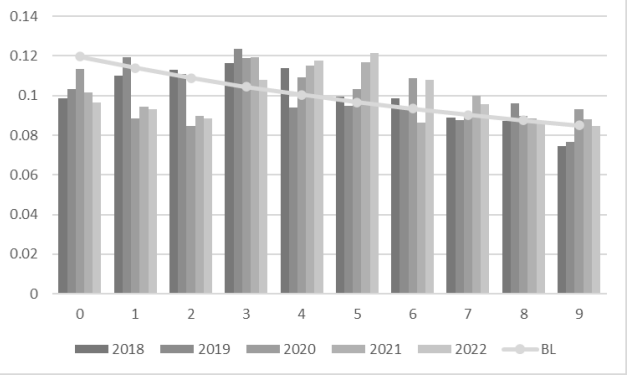
Table 10 | No. Companies not reporting capital sources income

Year	Number	% in the total number of companies
2018	1,883	79
2019	2,339	85
2020	2,217	86
2021	2,820	86
2022	3,414	87

Source: own study

Based on Table 10, the number of companies that did not report capital sources has an increasing trend in the analysed period of 2018–2022. It may mean that companies have changed the profile of their activities and moved away from disclosing capital sources. In 2018, 79% of companies did not report revenues from capital sources (21% reported revenues from capital sources). Table 10 shows the decreasing share of companies reporting revenues from capital sources in the years following the introduction of changes to the Law separating the taxation of income from capital sources and other sources. The final confirmation of tax optimisation by companies using revenues from capital sources is to check whether there are any anomalies in the distribution of digits (test of the second digit of revenues) for companies that do not report revenues from capital sources. The second digit test for companies that did not report income from capital sources indicates the existence of anomalies (Fig. 7). The analysis of the fit of the distributions (Table 11) for the years 2018–2020 suggests at least a marginal level of compliance of the distributions.

Figure 7 | 2-digit test for other income, companies unaffected by law adjustment.



Source: own study

At the level of revenues from other sources, a comparison of the compliance of the distributions with the Benford distribution of companies that reported revenues from capital sources (Table 8) and companies that did not report capital sources (Table 11) shows opposite results (second digit test for other income).

Table 11 | MAD 2-digit test for other income, companies not affected by the law adjustment

2018	2019	2020	2021	2022
0.007529	0.007082	0.011194	0.012685	0.013068

Source: own study

In the initial years 2018–2020, after the introduction of changes in tax regulations, companies that had to report capital sources did not have compliant distributions, while in companies that did not report capital sources, the distributions were acceptably compliant. Interestingly, in the last years of the analysed period, 2021–2022, the situation was reversed, and companies that did not report revenues from capital sources had distributions inconsistent with the Benford distribution. In 2021–2022, companies that disclosed revenues from equity sources had the distribution of the second digit consistent with the Benford distribution.

Conclusions

An efficient public system requires a continuous supply of tax revenue (Zimmermann, 2024). Changes in tax regulations may have a different effect, leading to a decrease in tax collection. This situation is mainly observed in developing countries (Berens & von Schiller, 2017), including Poland. The analysis of the compliance of the distributions with Benford's Law for companies reporting and not reporting income from capital sources in the years 2018–2022 reveals interesting phenomena. In the first years after introducing changes in tax regulations, companies reporting income from capital sources showed distributions that deviated from the Benford distribution. The deviation of the results from the expected Benford distribution was because companies had to adapt to the new reality. Companies that started to report capital gains and other income separately had to implement the applicable new rules in the reports prepared for the Ministry of Finance, which could be cumbersome for them as this obligation was introduced.

In contrast, companies reporting such income were more compliant. In the later period, 2021–2022, the situation was reversed; companies that did not report capital gains income began to show distributions that were not in line with Benford's Law, while companies that reported capital gains income were in line. The discrepancy between 2021 and 2022 may indicate that companies reporting in this period found a way to report biased information. This change may indicate that changing tax rules and their implementation significantly impact how companies report income. Analysing compliance with Benford's Law may be a helpful tool to monitor these changes.

The study's main limitation is that the research sample consists of Polish companies reporting revenues above EUR 50 million. These are large companies that are often subject to additional regulations related to auditing, financial supervision, or stock exchange supervision. Such limitations should be another reference point for the quality of the reports produced, as they rely on the control of the Ministry of Finance and external institutions.

In further research, we would like to focus on smaller entities and check whether the detected anomalies resulted in lower income tax revenues for the budget. The detected anomalies in the distribution of tax revenue digits should coincide with increased official checks (degl'Innocenti & Rablen, 2017). Additionally, further research will focus on comparing the

original tax revenue data with the modified data (due to the detection of an error or official checks).

Limitations

The survey was conducted on a sample of Polish companies with revenues exceeding EUR 50 million.

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