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A SURVEY OF FACTORS INFLUENCING SPREADSHEET RISK AWARENESS

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Abstract

Motivated both by reports on devastating financial and reputation-related consequences of spreadsheet errors and the results of previous studies suggesting a significant lack of users' awareness of spreadsheet risks, this paper provides insight into factors that influence users' perception of risks associated with creating and using spreadsheets. The survey was conducted on a sample of 161 spreadsheet users, whose attitudes were analyzed in accordance with 17 attributes. Statistically significant differences were detected among groups with different levels of self-estimated proficiency in spreadsheets, groups of users that spend different amount of time working with spreadsheets during a typical workday, groups of users who attribute greater subjective significance to spreadsheets in the tasks they perform, as well as groups of users from different management levels. Results of the statistical analysis also suggest that the perception of risks associated with spreadsheets is influenced by existence of standards and rules for spreadsheet development and uses within an organization. Results of the research presented in this paper, which point to an alarmingly low rate of use of spreadsheet features useful for risk mitigation, as well as to a prevalent lack of standards and rules for development and use of spreadsheets among the surveyed organizations, may stimulate managers to introduce such initiatives.

Key words: spreadsheet features, spreadsheet risk, spreadsheet user

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1. Introduction

Generally developed by individual users who are not experts in IT, spreadsheets coexist-often covertly-with mandated information systems, serving as unofficial complements to official IT portfolios (Kopper and Westner; Sakal et al., 2017). The need for user-developed spreadsheets typically originates from non-routine issues for which mandated information systems do not offer adequately fast and simple solutions or offer no solutions at all. Although spreadsheet-generated instant solutions have the potential to be flexible sources of low-cost innovation (Tambo and Baekgaard, 2013), improve performance and provide other benefits (Deloitte, 2015; IBM, 2010), they are also known to be sources of inadvertent subversions by overconfident users who lack consciousness of risks associated with development and use of spreadsheets, defined by Galbreth and Leblanc (2010) as "the chance of adverse operational or financial consequences due to erroneous creation, maintenance, and/or use of spreadsheet models". In the following texts, they will be referred to as "spreadsheet risks".

This paper presents some results of an empirical research aiming at investigating:

a) Whether the perception, that is, attitude towards spreadsheet risks varies among users:

- with different levels of education;
- with different self-estimated spreadsheet proficiency;
- spending different time working with spreadsheets in a typical workday;
- with different subjective assessment of significance of spreadsheets to the tasks they perform;
- working in managerial and non-managerial positions

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- at different management levels?

b) Whether the industry and size of the organisation influence the respondents' perception of spreadsheet risks?

c) Whether differences in the awareness of spreadsheet risks can be related to the frequency of use of spreadsheet features useful for risk mitigation?

This paper is composed of four sections. The "Introduction" section provides an overview of the research design and findings of a literature review on the subject of this paper. The section "Material and methods" presents the research questions, as well as an overview of the research methodology. Results of the analysis performed on questionnaire data, along with the discussion of the results are given in the "Results and discussion" section. Finally, the last section of the paper contains conclusions based on the research results.

The research involved following steps (see Fig. 1): a literature review, formulation of research questions and initial assumptions, followed by the drafting of the preliminary version of the questionnaire, which was submitted for evaluation. After some adjustments, the final version of the questionnaire was distributed to respondents in an electronic form. Upon reception of questionnaire data, the results were analyzed and subsequently interpreted. In the literature encompassed by the review, spreadsheet risks are primarily associated with errors (Beckwith et al., 2011; Caulkins et al., 2008a, 2008b; Caulkins et al., 2007a, 2007b; Chan, 2004; Cunha et al., 2011; Leon and Kalbers, 2010; McDaid and Rust, 2009; Panko, 2006; Powell et al., 2008a, 2008b, 2009; Reschenhofer et al., 2016, Raković et. al., 2019). Panko (2006) introduced fraud risks as a specific form of spreadsheet risk, while Reschenhofer and Matthes (2015) further added the risk of financial losses and the risk or violating legal regulations. Research conducted by Raković (2014) identifies risks associated with accuracy, credibility, misuse, and wrong decisions based on poor analysis, while Metz (2007) distinguished risks associated with underqualified users, lack of guidelines for spreadsheet development, and data loss.

According to results obtained by Baker et al. (2006a, 2006b, 2006c), the lack of users' awareness of spreadsheet risks is significant: only 54.2% users were somewhat aware of spreadsheet risks, while more than a quarter (26.3%) of respondents were completely unaware of them. Users' overconfidence, which is a common cause of underestimation of spreadsheet risks (Panko, 2007, 2009), often produces errors with serious financial and reputation-related consequences (Aurigemma and Panko, 2014; Caulkins et al., 2007a; Dunn, 2010; Panko, 1998, 2013; Panko and Port, 2013; Panko and Sprague, 1998; Powell et al., 2008b, 2009; Teo and Tan, 1999). Spreadsheet risks are documented in public reports available on EuSpRIG (European Spreadsheet Risk Interest Group) website. Some of the latest report on cases such as bankruptcy after financial mismanagement caused by a £5.2M spreadsheet arithmetic error, a financial loss of over 500.000$ caused by a spreadsheet error, reputation loss over a €100 million spreadsheet error, regulatory sanctions due to a spreadsheet error which caused equity value to be overstated by $100 million, loss of credibility due to a spreadsheet error exaggerating oil production, data leakage caused by emailed spreadsheet containing private data in 'hidden' columns, etc. (EuSpRIG, 2019) Studies suggest that the occurrence of spreadsheet errors is on the rise, and that between 44% and 100% of spreadsheets contain errors (Evans, 2012; Grant et al., 2009 as cited in Sakal et al., 2015). The situation is further worsened by the fact that a vast number of errors remain undiscovered, or even get concealed in attempts to maintain reputation, which is the reason that Panko and Port (2013) refer to them as "The Dark Matter (and Dark Energy) of Corporate IT".

Although several papers suggest that spreadsheets are critical or very important to users' individual tasks (Baker et al., 2006a; Bewig, 2005; IBM, 2015; Weber, 2006), most organizations do not define or apply formal rules or informal guidelines for their development and use (Caulkins et al., 2008a; Leon et al., 2012). According to the results of a survey conducted by Baker et al. (2006a), 66.4% of the respondents reported that there are no standards or policies related to spreadsheets in their organizations, while 23.5% stated that their organizations rely exclusively on informal ones. Disregarding of spreadsheet risks at an organizational level is a serious mistake, since it has been proven that users' overconfidence (and in turn, risks of using spreadsheets) can be reduced if users are given explicit information on possible risks (Panko, 2009; Raković et al., 2019; Sakal et al., 2015). Extensive use of spreadsheets in business (Leon and Kalbers, 2010; Rawat et al., 2011) cannot be contributed to a general lack of alternative software (Tait and Richardson, 2013) suitable for tasks that spreadsheets are usually used for, but above all, their ease of use and flexibility (Kohlhase, 2013; Leon and Kalbers, 2010; Powell et al., 2009).

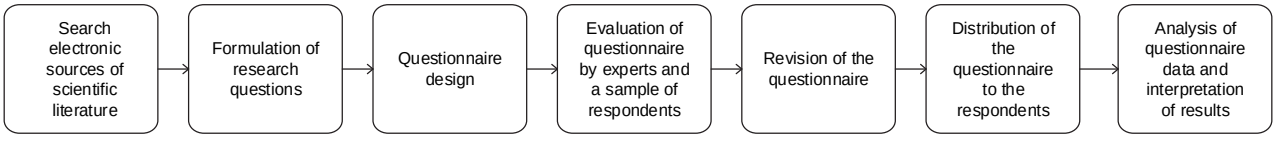

Fig. 1. Research design

Organizations operating in the financial services industry are leaders in the use of spreadsheets (McDaid and Rust, 2009). However, spreadsheets are also commonly used as tools for reporting and decision making at different levels of management, as well as in and non-managerial jobs among organizations from other industries (Bradley and McDaid, 2009; Caulkins et al., 2007a; Leon and Kalbers, 2010; Reschenhofer and Matthes, 2015). Regardless of the industry and job position, the approach to development and use of spreadsheets is mostly opportunistic, and can justifiably be labelled "quick and dirty" - generally, guided exclusively by a wish to solve their task with minimum invested effort in the shortest possible time period (Cunha et al., 2012), users are most often willing to develop just as many skills and gain just as much knowledge to permit them to solve their problems ad hoc, using the simplest possible approach, without 'excess' concern (or awareness) of possible negative side-effects (Raković, 2014; Raković et al., 2015). Consequently, users, who parenthetically lack adequate IT knowledge, very often do not know most of available spreadsheet features suitable for risk mitigation (Raković, 2014).

2. Material and methods

2.1. Research questions

Papers analyzed during a literature review provide partial insights into factors that-mostly based on descriptive statistics-can be assumed to influence awareness of spreadsheet risk. The aim of this paper is to improve the set of useful insights discovered throughout the literature review by producing a comprehensive list of factors, coupled with information on statistical significance of identified factors on spreadsheet risk awareness. In line with this, the following research questions (RQ) were formulated.

RQ1: Do respondents' attitudes towards spreadsheet risk differ significantly in accordance with the following attributes:

RQ1-1: level of education

RQ1-2: self-estimated degree of spreadsheet proficiency

RQ1-3: time spent working with spreadsheets in a typical workday

RQ1-4: subjective assessment of significance of spreadsheets to the tasks the respondent performs,

RQ1-5: managerial or non-managerial job position,

RQ1-6: management level

RQ2: Do the respondents' attitudes towards spreadsheet risk differ significantly among

RQ2-1: organisations of different sizes

RQ2-2: industries

RQ3: Do the respondents' attitudes towards spreadsheet risks differ significantly between organizations with defined rules and standards for spreadsheet development and use and ones without such rules and standards?

RQ4: Do respondents using certain spreadsheet features useful for risk mitigation differ in their perception of spreadsheet risks?

The initial assumptions are that the respondents' higher level of education, higher self-estimated spreadsheet proficiency, longer time spent working with spreadsheets in a typical workday, and higher self-assessed significance of spreadsheets to the tasks they perform can be correlated with higher awareness of risks associated with development and use of spreadsheets. It is expected that users who utilize spreadsheet features advantageous for risk mitigation are more aware of spreadsheet risks, just as the users employed by organizations with defined rules and standards for spreadsheet use and development. With the assumption that top managers accumulated their experience working on at lower management levels as well, it can be assumed that they are more aware of spreadsheet risk than middle and lower level managers. No assumptions were made in relation to the size of organization or industry, as well as the nature of the job position (non-managerial vs. managerial).

2.2. Research methodology

A questionnaire was used as a tool for data collection. The initial version of the questionnaire was subject to assessment by four experts (three spreadsheet experts and one methodologist) as to ensure alignment of questions in the questionnaire with the research questions. The questionnaire was subsequently sent to a test sample of 20 respondents. The final questionnaire, consisting of 25 questions, was developed in line with the experts' assessments and responses of the test sample. 19 of the questions were closed-type with multiple choices, while the remaining 6 were in the form of a assessment scale.

Data acquisition via the questionnaire was performed on a non-probability (purposive) sample, incorporating respondents from different industries who use spreadsheets in their tasks. The Web-based survey was created using a free online tool (Google forms) and distributed to respondents via email and LinkedIn. The questionnaire was distributed to 500 addresses. 191 of the invited respondents had submitted their responses (amounting to the response rate of 38.2%). After the elimination of inadequate and incomplete responses, 161 respondents remained in the final sample. Cronbach's alfa was computed on the sample of 161 respondents for the scale used for assessing the risk of spreadsheet use, in order to verify whether the questions in the questionnaire reliably measure the same latent variable (risk assessment) (Table 1). The value of Cronbach's alfa of 0.855 indicates a high degree of internal consistency (Cronbach, 1951).

Table 1. Scale reliability: risk of spreadsheet use

Cronbach's Alpha	*Cronbach's Alpha Based on Standardized Items*	*No of Items*
0.885	0.884	11

The same test was repeated for the scale used for assessing the frequency of use of spreadsheet features useful for risk mitigation. The computed value of Cronbach's alfa was 0.914, which suggests an even higher degree of internal consistency (Table 2).

Table 2. Scale reliability: frequency of use of spreadsheet features

Cronbach's alpha	*Cronbach's alpha based on standardized items*	*No of items*
0.914	0.917	9

The research questions were answered by determining whether there are any statistically significant differences between the means of two or more independent groups, followed by a regression analysis performed to ascertain the independent variables that are statistically significant for model fitting. Testing for statistically significant differences between the means of two or more independent groups involved splitting respondents into two or more categorical, independent groups (presented in Table 3 and Table 6), based on the value of attributes (ATR) defined within RQ1, RQ2, RQ3 i RQ4. The attributes were as follows:

ATR 1. Level of education (RQ 1-1)
ATR 2. Self-estimated degree of spreadsheet proficiency (RQ 1-2)
ATR 3. Time spent working with spreadsheets in a typical workday (RQ 1-3)
ATR 4. Respondent's subjective assessment of significance of spreadsheets to the tasks they perform (RQ 1-4)
ATR 5. Managerial or non-managerial job position (RQ 1-5)
ATR 6. Management level (RQ 1-6)
ATR 7. Size of organization (RQ 2-1)
ATR 8. Industry (RQ 2-2)
ATR 9. Existence of standards and rules for spreadsheet development and use (RQ 3)
ATR 10. Frequency of use of the worksheet protection (e.g. hiding formulas, restricting data input to certain cells) (RQ 4)
ATR 11. Frequency of use of formula auditing (RQ 4)
ATR 12. Frequency of use of macros (RQ 4)
ATR 13. Frequency of use of workbook password protection (RQ 4)
ATR 14. Frequency of use of data validation (RQ 4)
ATR 15. Frequency of use of conditional formatting (RQ 4)
ATR 16. Frequency of use of logical functions (RQ 4)
ATR 17. Frequency of use of drop-down lists (RQ 4)

Each respondent was allotted to exactly one of the groups formed for each attribute, which ensured independence of observations. The number of respondents within groups was between 5 (within ATR 1) and 103 (within ATR 11). Participation in a group was an independent variable, while the assessment of spreadsheet risk was the dependent variable. The possible values of the independent variable were 1, 2, 3, and 4, with the following meaning: 1-no risk, 2-low risk, 3-moderate risk, 4-signinficant risk.

Visual inspection pointed to a conclusion that not all data sets formed through grouping in line with the attributes fit the normal distribution. This was confirmed by the results of the Shapiro-Wilk H test. In line with these findings, the following established, nonparametric tests were selected for assessing the statistical significance of differences between the means: Kruskal-Wallis H omnibus test and Mann-Whitney U post hoc test. If the Kruskal-Wallis H omnibus test indicated existence of statistically significant differences between means of the groups, Mann-Whitney U test was used to determine which specific groups were statistically significantly different from each other. Multinomial logistic regression was selected for regression analysis due to the categorical nature of all independent variables (ATR1-ATR17) and ordinal nature of dependent variable, and the independence among the dependent variable choices that are mutually exclusive. Multinomial logistic regression does not assume normality, linearity, or homoscedasticity, although Shapiro-Wilk H tests indicated normality, while scatterplots pointed to the homoscedasticity of the datasets. Absence of multicollinearity is indicated by VIF values, which ranged from 1.000 to 4.421 (Hair et al., 2010). The software used for analysis was IBM SPSS Statistics 20.

3. Results and discussion

Groups formed in line with attributes ATR 1 through ATR 9, number of respondents within each group based on the value of the attribute, as well as average values of the dependent variable for each group are presented in Table 3, while the same values for attributes ATR 10 through ATR 17 are presented in Table 6. The number of responses included in the analysis differed between among groups, ranging from 143 to 161 (excluding the groups associated with ATR 6). The reason for this is that respondents were given options to respond to each question with “I am not sure” and “I don’t know”; such responses were not considered during statistical tests. The number of responses analyzed within ATR 6 - Management level (RQ 1-6) was 71, considering that only 71 out of 161 respondents reported working on management positions at various levels.

Results of Kruskal-Wallis H tests over groups listed in Table 3 with a significance level of 0.05. are presented in Table 4. Statistically significant differences between the means are present in groups formed in accordance with the following four attributes:

Table 3. Groups formed in accordance with ATR 1 - ATR 9 and average values of the dependent variable per each group

ATR 1 - Level of education (RQ 1-1)			
Groups	***Count***	***%***	***Risk Average***
Secondary school education	16	10.00	2.69
College degree	16	10.00	2.81
University degree	72	45.00	2.31
Master's degree	51	31.87	2.37
PhD	5	3.13	2.20
	160	**100**	
ATR 2 - Self-estimated degree of spreadsheet proficiency (RQ 1-2)			
Groups	***Count***	***%***	***Risk Average***
Entry level	41	25.47	2.22
Intermediate	98	60.87	2.41
Expert	22	13.66	3.00
	161	**100**	
ATR 3 - Time spent working with spreadsheets in a typical workday (RQ 1-3)			
Groups	***Count***	***%***	***Risk Average***
0% - 25%	79	50.32	2.32
26% - 50%	39	24.84	2.28
51% - 75%	28	17.83	2.68
75% - 100%	11	7.01	2.82
	157	**100**	
ATR 4 - Respondent's subjective assessment of significance of spreadsheets to the tasks they perform (RQ 1-4)			
Groups	***Count***	***%***	***Risk Average***
Somewhat significant	25	15.53	2.36
Moderately significant	81	50.31	2.35
Exceptionally significant	55	34.16	2.53
	161	**100**	
ATR 5 - Managerial or non-managerial job position (RQ 1-5)			
Groups	***Count***	***%***	***Risk Average***
Non-managerial	90	55.90	2.44
Managerial	71	44.10	2.37
	161	**100**	
ATR 6 - Management level (RQ 1-6)			
Groups	***Count***	***%***	***Risk Average***
Lower	21	29.58	1.90
Middle	26	36.62	2.54
Top	24	33.80	2.58
	71	**100**	
ATR 7 - Size of organisation (RQ 2-1)			
Groups	***Count***	***%***	***Risk Average***
1-10 employees	32	19.88	2.34
11-49 employees	32	19.88	2.34
50-250 employees	37	22.98	2.27
250+ employees	60	37.27	2.57
	161	**100**	
ATR 8 – Industry (RQ 2-2)			
Groups	***Count***	***%***	***Risk Average***
Manufacturing	16	9.94	2.88
Trade and logistics	17	10.56	2.65
Financial services	29	18.01	2.41
Education and research	14	8.70	2.21
Public enterprises	14	8.70	2.43
IT	17	10.56	2.29
Accounting	11	6.83	2.19
Other	43	26.71	2.30
	161	**100**	
ATR 9 - Existence of standards and rules for spreadsheet development and use (RQ 3)			
Groups	***Count***	***%***	***Risk Average***
Not defined	101	70.63	2.33
Partially defined	42	29.37	2.67
	143	**100**	

1) ATR 2 - Self-estimated degree of spreadsheet proficiency (RQ 1-2);

2) ATR 3 - Time spent working with spreadsheets in a typical workday (RQ 1-3);

3) ATR 6 - Management level (RQ 1-6);

4) ATR 9 - Existence of standards and rules for spreadsheet development and use (RQ 3).

Attribute ATR 9 - *Existence of standards and rules for spreadsheet development and use* resulted in only two independent groups, whereas with other attributes where statistically significant differences were detected between the means, the number of groups was three or more. Hence, it was necessary to follow up the Kruskal-Wallis H test with a Mann-Whitney U test to determine which specific groups differed from each other. Results of the Mann-Whitney U test for groups within ATR 2, ATR 3 and ATR 6, with a significance level of 0.05, are presented in Table 5.

Results of post hoc Mann-Whitney U test indicate statistically significant differences in mean assessment of spreadsheet risk among the following pairs of groups:

1. Entry level and Expert spreadsheet proficiency (ATR 2)
2. Intermediate and Expert spreadsheet proficiency (ATR 2)
3. 0%-25% and 51%-75% of time spent working with spreadsheets in a typical workday (ATR 3)
4. 0%-25% and 76%-100% of time spent working with spreadsheets in a typical workday (ATR 3)
5. 26%-50% and 51%-75% of time spent working with spreadsheets in a typical workday (ATR 3)
6. 26%-50% and 76%-100% of time spent working with spreadsheets in a typical workday (ATR 3)
7. Lower - Top management level (ATR 6)
8. Middle - Top management level (ATR 6)

Table 4. Results of Kruskal-Wallis H test-ATR 1-9

Attribute	*H statistics*			*Asymp. Sig*	*Significance at p < 0.05*
	Adjusted H	*d.f.*	*N*		
ATR 1 - Level of education (RQ 1-1)	9.364	4	160	0.053	not significant
ATR 2 - Self-estimated degree of spreadsheet proficiency (RQ 1-2)	11.664	2	161	0.009	significant
ATR 3 - Time spent working with spreadsheets in a typical workday (RQ 1-3)	10.117	3	157	0.018	significant
ATR 4 - Respondent's subjective assessment of significance of spreadsheets to the tasks they perform (RQ 1-4)	0.930	2	161	0.628	not significant
ATR 5 - Managerial or non-managerial job position (RQ 1-5)	0.271	1	161	0.603	not significant
ATR 6 - Management level (RQ 1-6)	10.495	2	71	0.005	significant
ATR 7 - Size of organisation (RQ 2-1)	3.851	3	161	0.278	not significant
ATR 8 – Industry (RQ 2-2)	10.688	7	161	0.153	not significant
ATR 9 - Existence of standards and rules for spreadsheet development and use (RQ 3)	7.081	1	143	0.007	significant

Table 5. Mann-Whitney U test-ATR 2, ATR 3 i ATR 6

Groups	*U*	*z-score*	*Asymp. Sig. (2-tailed)*	*Significance at p < 0.05*
ATR 2 - Self-estimated degree of spreadsheet proficiency (RQ 1-2)				
Entry ↔ Intermediate	1776.5	-1.184	0.236	not significant
Entry ↔ Expert	258.0	-2.942	0.003	significant
Intermediate ↔ Expert	713	-2.672	0.008	significant
ATR 3 - Time spent working with spreadsheets in a typical workday (RQ 1-3)				
0% - 25% ↔ 26% - 50%	1524.5	-0.102	0.919	not significant
0% - 25% ↔ 51% - 75%	809.0	-2.265	0.024	significant
0% - 25% ↔ 76% - 100%	283.0	-2.011	0.044	significant
26% - 50% ↔ 51% - 75%	371.0	-2.454	0.014	significant
26% - 50% ↔ 76% - 100%	127.0	-2.287	0.022	significant
51% - 75% ↔ 76% - 100%	137.0	-0.584	0.559 (1)	not significant
ATR 6 - Management level (RQ 1-6)				
Lower ↔ Middle	305.0	-0.151	0.880	not significant
Lower ↔ Top	140.5	-2.714	0.007	significant
Middle ↔ Top	147.5	-2.917	0.004	significant

Note: (1) Exact. Sig. [2(1-tailed Sig.)]= 0.612*

As stated previously, ATR 10-17 allow observing the independent variable *Assessment of spreadsheet risk* in relation to the frequency of use of spreadsheet features suitable for spreadsheet risk mitigation. Analysis was carried out on responses where the frequency of use of mentioned features was rated 1 through 6 (1-I do not use it at all, 6- I use it very frequently). In accordance with the respondents' assessments, 6 groups were formed within the attributes ATR 10 – 17, each.

The number of respondents in each group, along with the average values of the dependent variable, and a histogram of reported frequencies of use for each feature are presented in Table 6. Results of the Kruskal-Wallis H test for groups formed in accordance with ATR 10 - ATR 17 are given in Table 7. Kruskal-Wallis H test had indicated the need for post hoc testing of groups associated with attributes ATR 14 - *Data Validation* and ATR 15 - *Conditional formatting.* Results of a Mann-Whitney U test with a significance level of 0.05 on the aforementioned groups are presented in Table 8 and Table 9. Modell fitting information of the multinomial logistic regression analysis are presented in Table 10. Modell fitting information presented in Table 10 indicate statistical significance (with a significance level of 0.05) of following dependent variables: ATR 2 - *Self-estimated degree of spreadsheet proficiency*, ATR 3 - *Time spent working with spreadsheets in a typical workday*, ATR 4 - *Respondent's subjective assessment of significance of spreadsheets to the tasks they perform*, as well as independent variables related to spreadsheet features useful for risk mitigation: ATR 10 - *Worksheet password protection*, ATR 11 - *Formula auditing*, ATR 12 - *Macros*, ATR 13 - *Workbook password protection*, ATR 14 - *Data validation*, ATR 15 - *Conditional formatting*.

Based on the descriptive statistics presented in Table 3 and Table 6, it can be concluded that an average spreadsheet user is well educated, i.e. holds a BSc or a MSc degree (76.87%), assesses their spreadsheet proficiency as intermediate (60.87%), and usually spends up to 25% of their typical workday working with spreadsheets (as reported by 50.32% of the respondents).

An average user considers spreadsheets moderately significant to the tasks they perform (50.31%). The likelihood of them working on a non-managerial position is approximately 10% greater than being in management-55.90% vs. 44.10%. If they are managers, they are equally likely to be at the lower, middle or top level.

Table 6. Groups formed in accordance with ATR 10 - ATR 17 and average values of the dependent variable for each group

Attribute		***Group (assessments)***						***Total***
		1	***2***	***3***	***4***	***5***	***6***	
ATR 10 - Worksheet protection	Count	100	15	11	15	2	14	157
	%	63.69	9.55	7.01	9.55	1.27	8.92	100.00
	Risk Average	2.39	2.73	2.36	2.47	1.00	2.50	
ATR 11 - Formula auditing	Count	103	14	13	10	5	6	151
	%	68.21	9.27	8.61	6.62	3.31	3.97	100.00
	Risk Average	2.42	2.57	2.23	2.40	3.00	2.50	
ATR 12 - Macros	Count	94	13	20	7	8	4	146
	%	64.38	8.90	13.70	4.79	5.48	2.74	100.00
	Risk Average	2.43	2.31	2.60	2.57	2.25	3.00	
ATR 13 - Workbook protection	Count	93	9	18	15	8	13	156
	%	59.62	5.77	11.54	9.62	5.13	8.33	100.00
	Risk Average	2.43	2.33	2.22	2.67	2.25	2.54	
ATR 14 – Data validation	Count	83	17	19	11	10	13	153
	%	54.25	11.11	12.42	7.19	6.54	8.50	100.00
	Risk Average	2.35	2.59	2.21	2.91	2.80	2.38	
ATR 15 - Conditional formatting	Count	72	11	21	14	12	18	148
	%	48.65	7.43	14.19	9.46	8.11	12.16	100.00
	Risk Average	2.44	2.09	2.38	2.00	3.00	2.56	
ATR 16 – Logical functions	Count	40	25	25	26	11	29	156
	%	25.64	16.03	16.03	16.67	7.05	18.59	100.00
	Risk Average	2.43	2.16	2.40	2.42	3.00	2.41	
ATR 17 – Drop-down lists	Count	56	16	22	19	13	30	156
	%	35.90	10.26	14.10	12.18	8.33	19.23	100.00
	Risk Average	2.54	2.06	2.50	2.26	2.69	2.33	

Table 7. Results of the Kruskal-Wallis H test-features suitable for risk mitigation (ATR 10 - ATR 17)

Attribute	*H statistics*			*Asymp. Sig.*	*Significance at p < 0.05*
	Adjusted H	*d.f.*	*N*		
ATR 10 - Worksheet password protection	8.548	5	157	0.129	not significant
ATR 11 - Formula auditing	5.573	5	151	0.350	not significant
ATR 12 - Macros	5.808	5	146	0.325	not significant
ATR 13 - Workbook password protection	3.447	5	156	0.631	not significant
ATR 14 - Data validation	11.195	5	153	0.480	significant
ATR 15 - Conditional formatting	13.371	5	148	0.020	significant
ATR 16 - Logical functions	8.793	5	156	0.118	not significant
ATR 17 - Drop-down lists	8.396	5	156	0.136	not significant

Table 8. Results of a Mann-Whitney U test-ATR 14

ATR 14 - Conditional formatting				
Groups	*U*	*z-score*	*Asymp. Sig. (2-tailed)*	*Significance at p < 0.05*
1 ↔ 2	288.500	-1.621	0.105	not significant
1 ↔ 3	751.500	-0.045	0.964	not significant
1 ↔ 4	356.000	-1.903	0.057	not significant
1 ↔ 5	267.000	-2.289	0.022	significant
1 ↔ 6	591.000	-0.620	0.535	not significant
2 ↔ 3	80.500	-1.555	0.120 [6]	not significant
2 ↔ 4	71.500	-0.382	0.703 [2]	not significant
2 ↔ 5	21.000	-3.115	0.002 [3]	significant
2 ↔ 6	66.500	-1.594	0.111 [4]	not significant
3 ↔ 4	103.000	-1.604	0.109 [5]	not significant
3 ↔ 5	76.500	-2.028	0.043 [6]	significant
3 ↔ 6	169.500	-0.589	0.556 [7]	not significant
4 ↔ 5	30.000	-2.959	0.003 [8]	significant
4 ↔ 6	83.000	-1.726	0.084 [9]	not significant
5 ↔ 6	81.000	-1.210	0.226 [10]	not significant

Notes: [1] Exact. Sig. [2(1-tailed. Sig.)] = 0.168, not corrected for ties. [2] Exact. Sig. [2*(1-tailed. Sig.)] = 0.767, not corrected for ties. [3] Exact. Sig. [2*(1-tailed. Sig.)] = 0.004, not corrected for ties. [4] Exact. Sig. [2*(1-tailed. Sig.)] = 0.146, not corrected for ties. [5] Exact. Sig. [2*(1-tailed. Sig.)] = 0.145, not corrected for ties. [6] Exact. Sig. [2*(1-tailed. Sig.)] = 0.063, not corrected for ties. [7] Exact. Sig. [2*(1-tailed. Sig.)] = 0.587, not corrected for ties. [8] Exact. Sig. [2*(1-tailed. Sig.)] = 0.004, not corrected for ties. [9] Exact. Sig. [2*(1-tailed. Sig.)] = 0.107, not corrected for ties. [10] Exact. Sig. [2*(1-tailed. Sig.)] = 0.267, not corrected for ties*

Table 9. Results of a Mann-Whitney U test-ATR 15

ATR 15 - Data validation				
Groups	*U*	*z-score*	*Asymp. Sig. (2-tailed)*	*Significance at p < 0.05*
1 ↔ 2	547.000	-1.347	0.178	not significant
1 ↔ 3	753.000	-0.340	0.734	not significant
1 ↔ 4	227.000	-2.999	0.003	significant
1 ↔ 5	300.500	-1.588	0.112	not significant
1 ↔ 6	511.500	-0.336	0.737	not significant
2 ↔ 3	125.500	-1.225	0.220 [1]	not significant
2 ↔ 4	67.500	-1.409	0.159 [2]	not significant
2 ↔ 5	73.500	-0.611	0.541 [3]	not significant
2 ↔ 6	97.000	-0.605	0.545 [4]	not significant
3 ↔ 4	51.500	-2.610	0.009 [5]	significant
3 ↔ 5	63.500	-1.524	0.127 [6]	not significant
3 ↔ 6	111.500	-0.492	0.622 [7]	not significant
4 ↔ 5	52.500	-0.203	0.839 [8]	not significant
4 ↔ 6	43.500	-1.885	0.059 [9]	not significant
5 ↔ 6	49.500	-1.008	0.314 [10]	not significant

Notes: [1] Exact. Sig. [2(1-tailed. Sig.)] = 0.257, not corrected for ties. [2] Exact. Sig. [2*(1-tailed. Sig.)] = 0.225, not corrected for ties. [3] Exact. Sig. [2*(1-tailed. Sig.)] = 0.570, not corrected for ties. [4] Exact. Sig. [2*(1-tailed. Sig.)] = 0.592, not corrected for ties. [5] Exact. Sig. [2*(1-tailed. Sig.)] = 0.021, not corrected for ties. [6] Exact. Sig. [2*(1-tailed. Sig.)] = 0.151, not corrected for ties. [7] Exact. Sig. [2*(1-tailed. Sig.)] = 0.650, not corrected for ties. [8] Exact. Sig. [2*(1-tailed. Sig.)] = 0.863, not corrected for ties. [9] Exact. Sig. [2*(1-tailed. Sig.)] = 0.106, not corrected for ties. [10] Exact. Sig. [2*(1-tailed. Sig.)] = 0.343, not corrected for ties*

Table 10. Multinomial logistic regression model fitting information

Independent variable	*Chi-Square*	*df*	*Sig.*	*Significance at p < 0.05*
ATR 1 - Level of education (RQ 1-1)	24.100	18	0.152	not significant
ATR 2 - Self-estimated degree of spreadsheet proficiency (RQ 1-2)	19.910	9	0.018	significant
ATR 3 - Time spent working with spreadsheets in a typical workday (RQ 1-3)	22.937	12	0.028	significant
ATR 4 - Respondent's subjective assessment of significance of spreadsheets to the tasks they perform (RQ 1-4)	30.970	15	0.009	significant
ATR 5 - Managerial or non-managerial job position (RQ 1-5)	0.987	3	0.804	not significant
ATR 6 - Management level (RQ 1-6)	18.866	6	0.004	significant
ATR 7 - Size of organisation (RQ 2-1)	8.733	9	0.462	not significant
ATR 8 - Industry (RQ 2-2)	19.542	21	0.550	not significant
ATR 9 - Existence of standards and rules for spreadsheet development and use (RQ 3)	15.139	12	0.234	not significant
ATR 10 - Worksheet password protection (RQ 4)	36.120	18	0.007	significant
ATR 11 - Formula auditing (RQ 4)	43.240	18	0.001	significant
ATR 12 - Macros (RQ 4)	47.551	18	0.001	significant
ATR 13 - Workbook password protection (RQ 4)	29.159	18	0.046	significant
ATR 14 - Data validation (RQ 4)	38.357	18	0.003	significant
ATR 15 - Conditional formatting (RQ 4)	36.516	18	0.006	significant
ATR 16 - Logical functions (RQ 4)	23.302	18	0.179	not significant
ATR 17 - Drop-down lists (RQ 4)	27.458	18	0.071	not significant

An average spreadsheet user is most likely employed by a company with more than 250 employees (37.27%), while the likelihood of them being from a company with fewer employees (up to 10, between 11 and 49, or between 50 and 250) is approximately 20% for each category. In terms of industry, they are most frequently working in financial services (18.01%), followed by organisations in trade/logistics, IT, and manufacturing. Unfortunately, they are most likely (70.63%) to be developing and using spreadsheets without any, even informal organisational standards or rules. If this is not the case (29.37%), they can only rely on partial, informal standards and rules, often shared verbally. None of the respondents reported knowledge of any official strategy for managing spreadsheets in their organisations. An average user does not use spreadsheet features suitable for risk mitigation sufficiently. With the 6-degree scale used in the questionnaire (1 - I do not use it at all, 6 - I use it very frequently), the average assessment of frequency of use for 2 out of 8 features was lower than 2.00 (formula auditing - 1.80/6.00 and macros - 1.86/6.00). Four features received average scores significantly less than 3.00/6.00 (worksheet protection - 2.02/6.00, workbook protection - 2.19/6.00, data validation - 2.26/6.00, conditional formatting -2.57/6.00), while only two features received average scores just above 3.00 (logical functions – 3.19/6.00 and drop-down lists - 3.04/6.00). The average spreadsheet user assesses the risk associated with creation and use of spreadsheets 2.41/4.00.

In terms of standards and rules for development and use of spreadsheets, research results indicate that there are similarities with the presented findings of Baker et al. (2006a) presented in the literature review: 70.63% of the respondents are employed by organisations where such rules are absent (compared to 66.4% in a related research), while 29.37% reported existence of such standards, only in an informal fashion (vs. 23.5% in a related research). Users' awareness of spreadsheet risks and the significance of spreadsheets to their task was, however, somewhat different than in related studies. To be exact, 9.32% of respondents consider that there is no risk at all (vs. 26.3% in related research), while 49.07% of them consider this risk to be low, and 39.92 to be moderate (vs. 54.2% somewhat aware, according to a related research). When it comes to the significance of spreadsheets to respondent's tasks, 51.31% considered them as moderately significant, while 34.16% reported that they were exceptionally important. However, the results of a related research suggest that 49% of respondents consider them as critical and 33.6% very important.

Results of a Kruskal-Wallis H omnibus test and Mann-Whitney U post hoc test tests suggested that initial assumptions were true in case of the following attributes:

ATR 2 - Self-estimated degree of spreadsheet proficiency (RQ 1-2)

ATR 3 - Time spent working with spreadsheets in a typical workday (RQ 1-3)

ATR 6 - Management level (RQ 1-6)

ATR 9 - Existence of standards and rules for spreadsheet development and use (RQ 3)

More specifically, the initial assumptions are true for the following groups:

ATR 2 - expert spreadsheet users (making up 13.66% of the sample) are more aware of spreadsheet risks (risk average 3.00/4.00) compared to entry level users (composing 25.47% of the sample, with a risk average of 2.22/4.00) and intermediate users (60.87% of the sample, with a risk average of 2.41/4.00). The difference between entry level and intermediate user is not statistically significant.

ATR 3 - users who typically spend more than half of their typical workday using spreadsheets are significantly more aware of spreadsheet risks compared to their colleagues who use spreadsheets less. The first group encompasses users who spend 51% to 75% and 76% to 100% of time working with spreadsheets (17.83% of respondents, risk average of 2.68/4.00, and 7.01% of respondents, risk average of 2.82/4.00, respectively), while the second group is composed of users working with spreadsheets up to a quarter of a typical workday (50.32% of respondents, risk average of 2.32/4.00) and ones working with spreadsheets from 26% to 50% of a typical workday (24.84% of respondents, risk average of 2.28/4.00).

ATR 6 - with a score of 2.58/4.00, top managers (33.8% of the sample) statistically significantly differ in terms of risk average than both middle managers (36.62% of the sample, risk average of 2.54/4.00) and lower-level managers (risk average of 1.90/4.00).

ATR 9 - Users working for organizations with partially defined standards and rules for spreadsheet development (29.37% of the sample; risk average: 2.67/4.00) significantly differ in terms of awareness from their counterparts from organizations lacking such standards and rules (70.63% of the sample; risk average: 2.33).

When it comes to the intensity of use of spreadsheet features useful for spreadsheet risk mitigation, the tests indicated the existence of statistically significant differences among some of the groups formed in accordance with ATR 14 – *Data validation* and ATR 15 - *Conditional formatting*. However, this was insufficient to corroborate the initial assumption that users who utilize spreadsheet features for risk mitigation at a greater extent are more aware of spreadsheet risk, owing to the fact that the average assessment of frequencies of use were low for all spreadsheet features.

Modell fitting information of multinomial logistic regression point to conclusions similar to the performed Kruskal-Wallis H omnibus test and Mann-Whitney U post hoc test: ATR 4 - *Respondent's subjective assessment of significance of spreadsheets to the tasks they perform (RQ 1-4)* was added to the list of attributes that substantiate initial assumptions, while ATR 9 - Existence of standards and rules for spreadsheet development and use (RQ 3) was removed.

Although model fitting information indicate a statistical significance of 6 out of 8 attributes associated with spreadsheet features for risk mitigation, they are deemed *insufficient* to corroborate the initial assumption for already stated reasons.

4. Conclusions

Results of this empirical research suggest that risks associated with development and use of spreadsheets are assessed significantly higher by users who (1) have a greater level of spreadsheet proficiency, (2) spend a greater portion of their typical workdays using spreadsheets, (3) attribute higher subjective significance to spreadsheets in the tasks they perform (4) are employed by organizations with (informal) standards and rules for development and use of spreadsheets. Results also suggest that top managers are significantly more aware of spreadsheet risks, compared to their colleagues in middle and lower management positions.

It can be concluded that establishment of standards and rules for development and use of spreadsheets is a way to increase users' awareness of spreadsheet risks. Given the top management's awareness of spreadsheet risks confirmed by the research, such initiatives should be met with adequate support.

Initial assumptions that users with different (1) levels of education, and (2) frequencies of use of spreadsheet features suitable for risk mitigation could not be corroborated by research results. Nevertheless, the results of investigation into the aforementioned initial assumptions give basis for pessimistic prognoses. An average spreadsheet user uses the majority of spreadsheet features suitable for risk mitigation at an alarmingly low rate, and the organization they are employed at, as a rule, has no established standards for spreadsheet development their use. Such rules often do not exist, even in an informal manner. It can be concluded that spreadsheets, among the surveyed organizations, remain a latent source of wrong management decisions with possible serious consequences, which may not be just financial.

There are several limitations to this research. Firstly, the reliability of generalization inferred from a purposed sample is lower compared to a random sample. Next, assessments of spreadsheet proficiency, existence of spreadsheet risk, as well as the frequency of use of spreadsheet features may have been less subjective if there was a possibility to conduct some type of an ethnographic interview, coupled with tests of respondents' spreadsheet skills and insight into their spreadsheets. However, there were several obstacles to practical application of this approach, primarily because researchers are generally not allowed to access spreadsheets with confidential data.

The research may serve as a basis for a new one, investigating best practices in raising users' and managers' awareness of spreadsheet risks, as well as the efficiency of various forms of such initiatives. Development of a framework for establishing standards and rules for spreadsheet creation and use imposes itself as another interesting potential subject of future research.

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