ANALYSIS OF DEPENDENCE BETWEEN THE RESULTS OF MARKING OF SELECTED COMPULSORY COURSES AT UNIVERSITY OF FINANCE AND ADMINISTRATION

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Abstract

This paper aims to research dependence among the results of marking of selected compulsory courses at University of Finance and Administration. In total, 238 students of full-time and part-time forms of two study fields of Bachelor of Science in Business Administration and Bachelor of Science in Banking were chosen. The groups were graduates of bachelor level degree who completed their studies in 2015. This research includes six subjects of study: mathematics 1, mathematics 2, macroeconomics, microeconomics, financial mathematics, and probability and statistics. Interdependence among the results of these subjects is researched using the methods of regression and correlation analysis. Dependence of results of individual study subjects on students' field of study is researched using chi-square test of independence. Dependence of students' assessment on their form of study, i.e. full-time or part-time, is also researched using the test of chi-square test of independence. Dependence of the mark of subject of study on gender is a part of this research as well. Tightness of mentioned dependences is measured.

Key words: Mathematics, macroeconomics, microeconomics, financial mathematics, probability and statistics

JEL Code: A22, I23, C12

Introduction

In this paper, the results of markings of selected compulsory courses of bachelor students who graduated in 2015 at University of Finance and Administration are evaluated. The attention is focused on students of full-time and part-time forms of two particular study fields – Business Administration, and Banking – and their results in six subjects of study: mathematics 1, mathematics 2, macroeconomics, microeconomics, financial mathematics and probability and statistics.

Following the syllabus of study, mathematics 1 and microeconomics is taught in 1st semester of study, mathematics 2 and macroeconomics in 2nd semester, financial mathematics in 3rd or 5th semester, respectively (depending on the field of study), and similarly probability and statistics in 3rd or 4th semester. Although the length of time between two related courses can influence the students' performance in the later course, see for example (Dills, Hernández-Julián, & Rotthoff 2016), this aspect is not taken in account in our research. Also timing relationship between exams can influence the probability of successful passing exams, see (Pope & Fillmore, 2015).

At University of Finance and Administration no admission tests are required for applicants. For this reason, it is not possible to predict the level of success at university studies based on results of the entrance exam, see for example (Kučera, Svatošová & Pelikán, 2015) or (Šperková & Nedomová, 2015).

Students' performance can depend on other various factors such as their demographic traits, see for example (Kaspříková (2012)), the gender, see (Oosterbeek & Ewijk, 2014) or (Hale & Regev, 2014), and on the form of study – full-time or part-time, respectively, see (Darolia, 2014).

In this paper the dependence between the results of marking of selected compulsory courses on the form of study, the field of study and on the gender is researched. Moreover, the double dependences between each pair marks of all subjects of study are researched.

1 Theory and methods

Chi-square test of independence in the contingency table was used when researching dependence of marks from individual subjects of study on various factors, in particular on the form of study, field of study and gender.

Methods of regression and correlation analysis were used to research the double dependence of the results always between each pair of subjects of study, see (Montgomery, Peck & Vining, 2012). The dependence of one subject of study on other five subjects of study was verified using multiple regression. It is known from the experience that the results of the evaluation of subjects of study have approximately normal distribution. White test and graphical method were used for verifying of homoscedasticity. The fact that harmful multicollinearity is not between independent variables was determined using paired correlation coefficients. The independent variables were put into the model using stepwise regression (forward selection).

2 Database

In total, 238 students of full-time and part-time forms of two study fields of Bachelor of Science in Business Administration and Bachelor of Science in Banking were chosen. The group were graduates of bachelor level degree, who completed their studies in 2015. This research includes six obligatory subjects of study: mathematics 1, mathematics 2, macroeconomics, microeconomics, probability and statistics, and financial mathematics. Short names (idents) of these six subjects of study are presented in Table 1. The results of the evaluation of individual subjects of study represent always ordinal variables, where the letters of assessment of individual study subjects were converted to numbers: $A = 1$, $B = 1.5$, $C = 2$, $D = 2.5$, $E = 3$ (evaluation $F = 4$ is not included, because there are a set of graduates). Form of study, field of study and gender represent categorical variables (factors). The calculations were processed using a statistical software package Statgraphics.

Tab. 1: Study subjects and their abbreviations (idents)

Abbreviation (ident)	Subject of study	Abbreviation (ident)	Subject of study
B_MaB_1	Mathematics 1	B_MiE_A	Microeconomics
B_MaB_2	Mathematics 2	B_PS_A	Probability and Statistics
B_MaE_A	Macroeconomics	B_FiM	Financial Mathematics

Source: www.vsfs.cz

3 Results and discussion

Table 2 presents selected summary statistics of the results of evaluation of these considered six subjects of study, see (Triola, 2003).

The results in Table 2 only confirm the fact, already mentioned – we can see that the distributions of marks of the six study subjects are practically symmetrical, which the assumption of normality is related to. Moreover, variances of marks of all six subjects of study can be considered the same. Interestingly, the table shows that all three quartiles of all six subjects of study are the same.

Table 3 represents some selected summary statistics obtained at various levels of individual factors. These summary statistics are visualized in Figures 1–18 of a box and whisker plot. Table 4 enables more accurate consideration of the statistical dependence of

marks of individual study subjects on individual factors form of study, field of study, and gender.

Tab. 2: Summary statistics

Statistics	Subject of study					
	B_MaB_1	B_MaB_2	B_MaE_A	B_MiE_A	B_PS_A	B_FiM
Average	2.153	2.151	2.011	2.145	2.036	1.876
Median	2.000	2.000	2.000	2.000	2.000	2.000
Mode	1.000	3.000	2.000	3.000	3.000	2.000
Lower quartile	1.500	1.500	1.500	1.500	1.500	1.500
Upper quartile	3.000	3.000	3.000	3.000	3.000	2.000
Interquartile range	1.500	1.500	1.500	1.500	1.500	0.500
Variance	0.609	0.616	0.575	0.588	0.557	0.401
Standard deviation	0.780	0.785	0.758	0.767	0.746	0.633
Coefficient of variation	0.362	0.365	0.377	0.357	0.367	0.338
Skewness	-0.221	-0.227	-0.007	-0.221	-0.023	0.275

Source: own research

P-value is the smallest significance level, on which the null hypothesis of independence of the result of the evaluation of individual study subjects on the relevant factor can be rejected. We can see from Table 4 that the dependence of the mark of the subject of study of B_PS_A on form of study is statistically significant even at 1% significance level, the dependence of the mark of the subject of study of B_FiM on form of study is statistically significant only at 10% significance level and the dependence of the mark of the subject of study of B_MaE_A on gender is statistically significant at 5% significance level. Other dependences are not statistically significant even at 10% significance level.

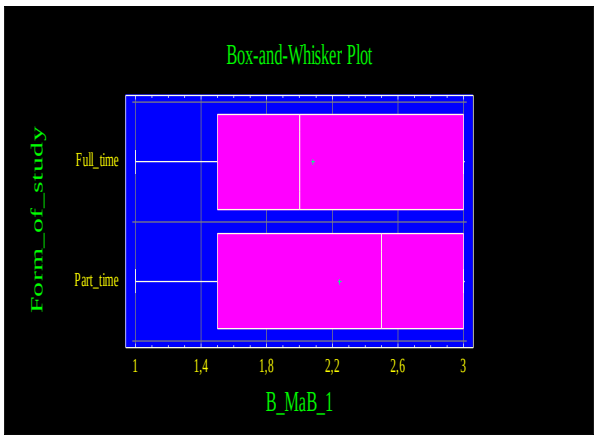
The outputs in Table 5 show double dependences always between two variables, where the first variable is considered as independent variable and the second variable as the dependent variable. The table 5 shows that the linear dependence was chosen as the most suitable in six cases, exponential dependence in two cases, double reciprocal dependence in two cases, logarithmic-x dependence in two cases, square root-x also in two cases and multiplicative dependence in one case. However, obtained coefficients (indexes) of correlation show very weak dependences.

Tab. 3: Selected summary statistics at various levels of factors

Factor	Subject of study	Level of factor	Summary statistics					
			Average	Median	Lower quartile	Upper quartile	Minimum	Maximum
Form of study	B_MaB_1	Full time	2.082	2.00	1.5	3.0	1.0	3.0
		Part time	2.245	2.50	1.5	3.0	1.0	3.0
	B_MaB_2	Full time	2.135	2.00	1.5	3.0	1.0	3.0
		Part time	2.171	2.00	1.5	3.0	1.0	3.0
	B_MaE_A	Full time	1.977	2.00	1.0	3.0	1.0	3.0
		Part time	2.051	2.00	1.5	3.0	1.0	3.0
	B_MiE_A	Full time	2.085	2.00	1.5	3.0	1.0	3.0
		Part time	2.218	2.00	1.5	3.0	1.0	3.0
	B_PS_A	Full time	1.908	2.00	1.0	2.5	1.0	3.0
		Part time	2.190	2.00	1.5	3.0	1.0	3.0
	B_FiM	Full time	1.938	2.00	1.5	2.5	1.0	3.0
		Part time	1.801	2.00	1.5	2.0	1.0	3.0
Field of study	B_MaB_1	Business adm.	2.129	2.00	1.5	3.0	1.0	3.0
		Banking	2.321	2.75	1.5	3.0	1.0	3.0
	B_MaB_2	Business adm.	2.125	2.00	1.5	3.0	1.0	3.0
		Banking	2.333	2.50	2.0	3.0	1.0	3.0
	B_MaE_A	Business adm.	2.014	2.00	1.5	3.0	1.0	3.0
		Banking	1.983	2.00	1.0	2.5	1.0	3.0
	B_MiE_A	Business adm.	2.149	2.00	1.5	3.0	1.0	3.0
		Banking	2.117	2.00	1.0	3.0	1.0	3.0
	B_PS_A	Business adm.	2.046	2.00	1.5	3.0	1.0	3.0
		Banking	1.197	2.00	1.0	2.5	1.0	3.0
	B_FiM	Business adm.	1.851	2.00	1.5	2.5	1.0	3.0
		Banking	2.050	2.00	2.0	2.0	1.5	3.0
Gender	B_MaB_1	Male	2.168	2.00	1.5	3.0	1.0	3.0
		Female	2.136	2.00	1.5	3.0	1.0	3.0
	B_MaB_2	Male	2.213	2.50	1.5	3.0	1.0	3.0
		Female	2.078	2.00	1.5	3.0	1.0	3.0
	B_MaE_A	Male	2.102	2.00	1.5	3.0	1.0	3.0
		Female	1.904	2.00	1.0	2.5	1.0	3.0
	B_MiE_A	Male	2.213	2.00	1.5	3.0	1.0	3.0
		Female	2.064	2.00	1.5	3.0	1.0	3.0
	B_PS_A	Male	2.031	2.00	1.5	3.0	1.0	3.0
		Female	2.041	2.00	1.5	2.5	1.0	3.0
	B_FiM	Male	1.891	2.00	1.5	2.0	1.0	3.0
		Female	1.858	2.00	1.5	2.0	1.0	3.0

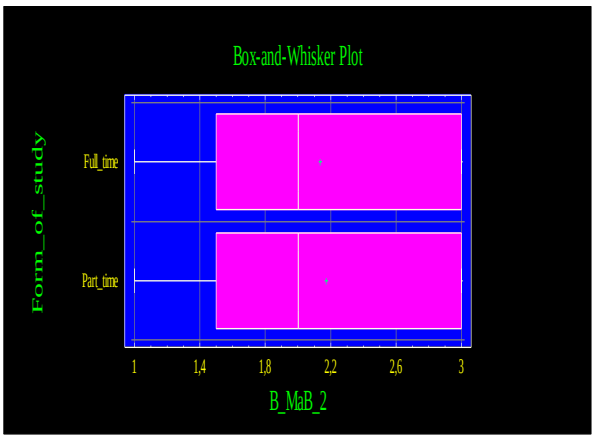
Source: own research

Fig. 1: Box-and-whisker plot – form of study – Mathematics 1



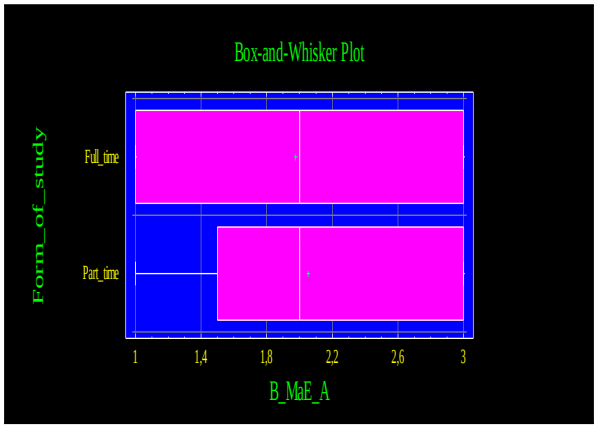
Source: own research

Fig. 2: Box-and-whisker plot – form of study – Mathematics 2



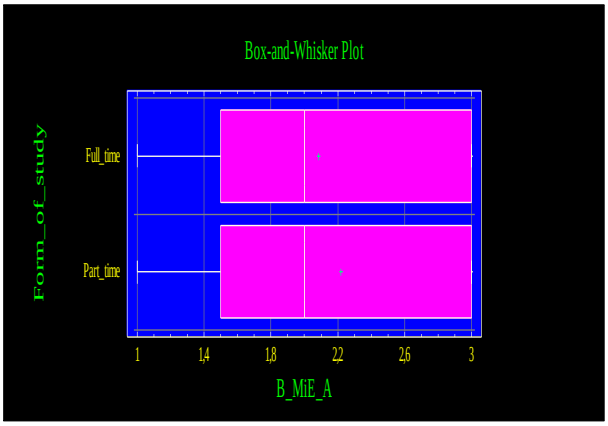
Source: own research

Fig. 3: Box-and-whisker plot – form of study – Macroeconomics



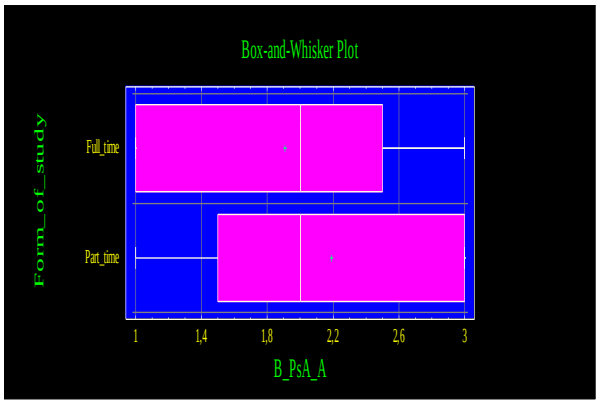
Source: own research

Fig. 4: Box-and-whisker plot – form of study – Microeconomics



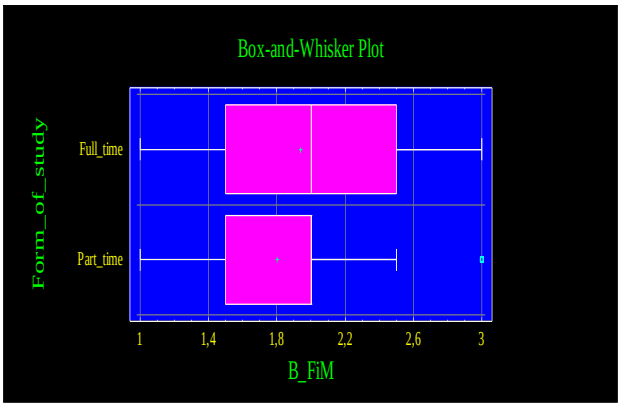
Source: own research

Fig. 5: Box-and-whisker plot – form of study – Probability and statistics



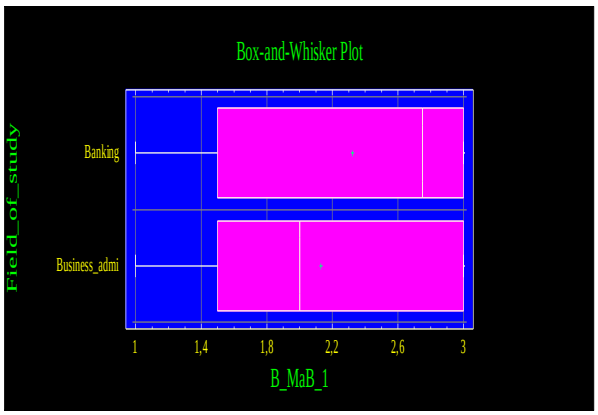
Source: own research

Fig. 6: Box-and-whisker plot – form of study – Financial mathematics



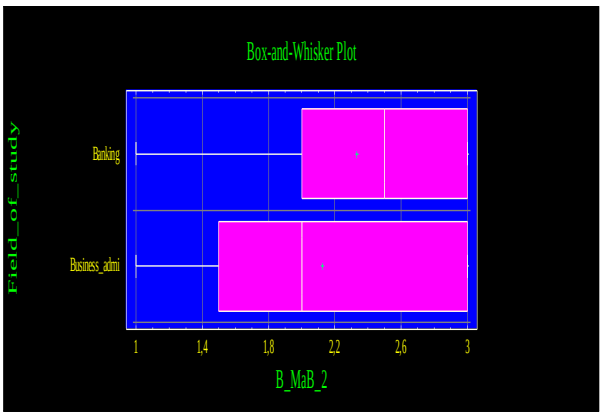
Source: own research

Fig. 7: Box-and-whisker plot – field of study – Mathematics 1



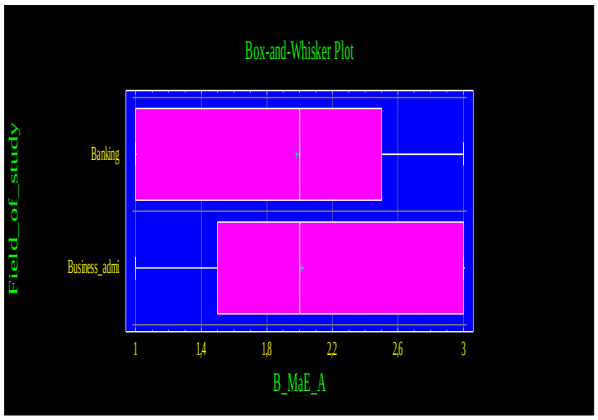
Source: own research

Fig. 8: Box-and-whisker plot – field of study – Mathematics 2



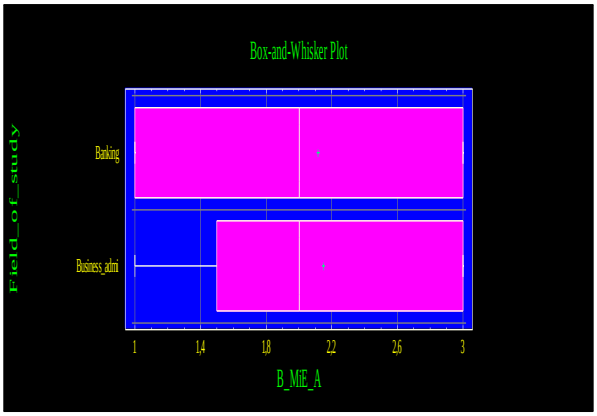
Source: own research

Fig. 9: Box-and-whisker plot – field of study – Macroeconomics



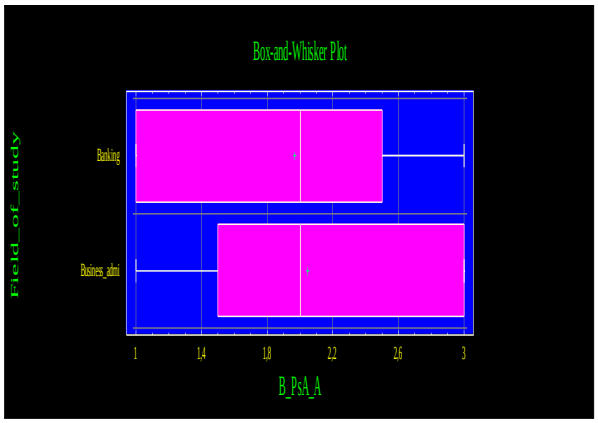
Source: own research

Fig. 10: Box-and-whisker plot – field of study – Microeconomics



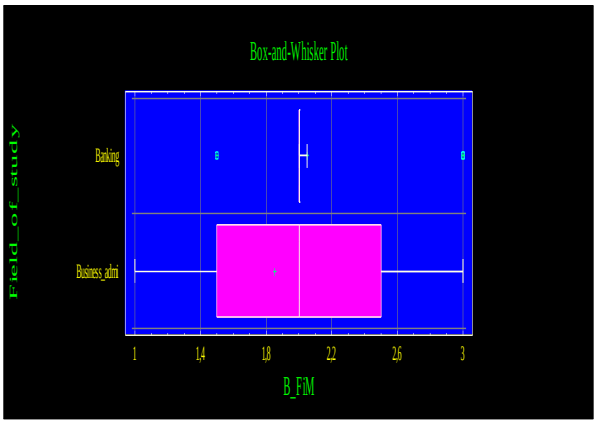
Source: own research

Fig. 11: Box-and-whisker plot – field of study – Probability and statistics



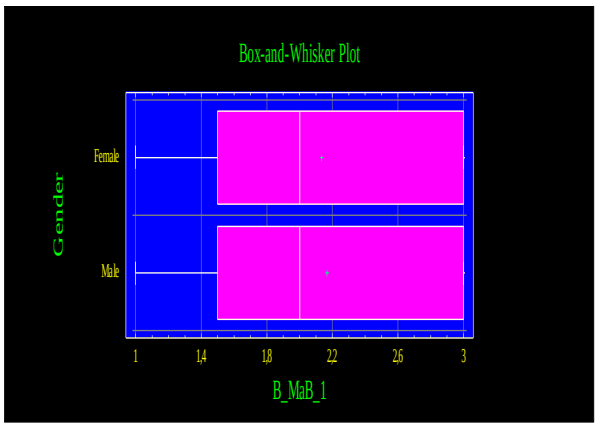
Source: own research

Fig. 12: Box-and-whisker plot – field of study – Financial mathematics



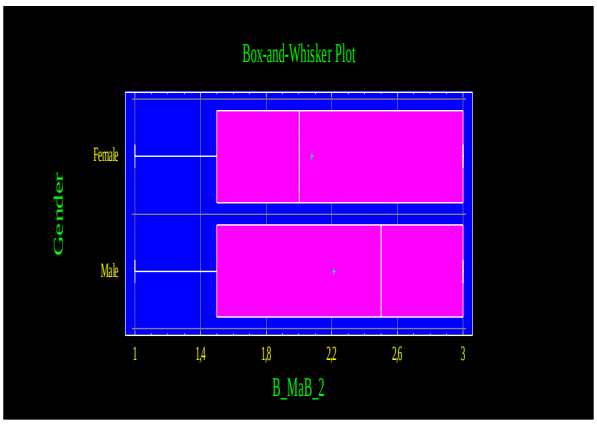
Source: own research

Fig. 13: Box-and-whisker plot – gender – Mathematics 1



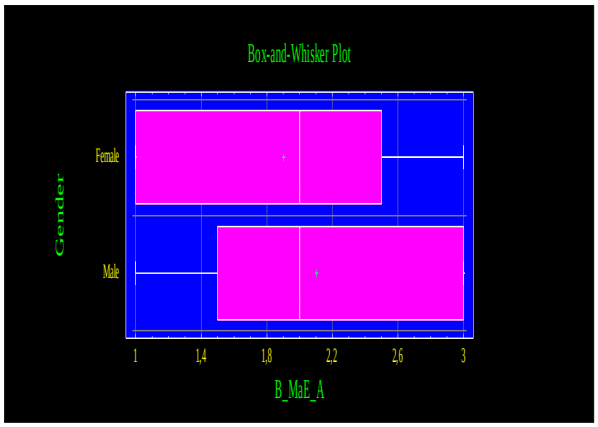
Source: own research

Fig. 14: Box-and-whisker plot – gender – Mathematics 2



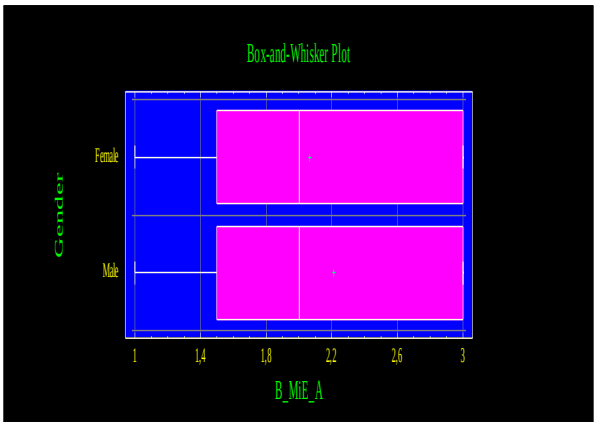
Source: own research

Fig. 15: Box-and-whisker plot – gender – Macroeconomics



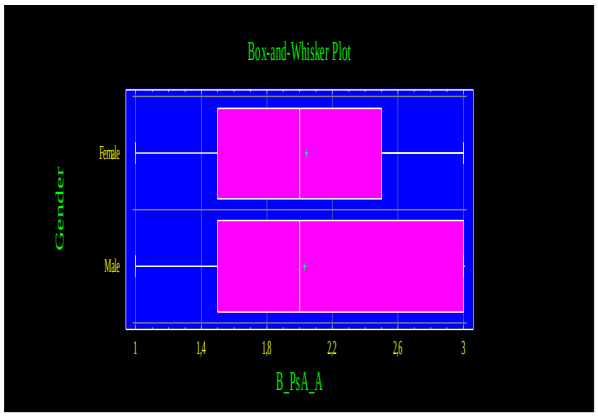
Source: own research

Fig. 16: Box-and-whisker plot – gender – Microeconomics



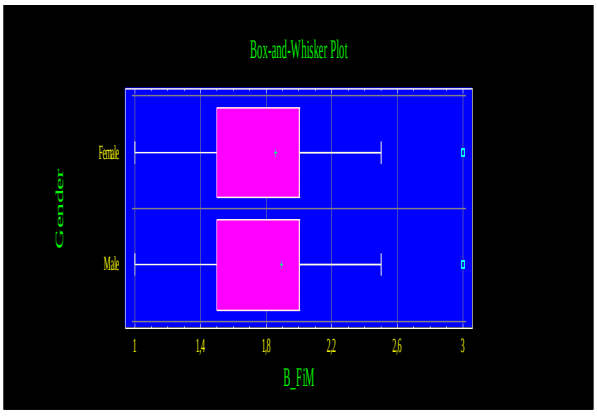
Source: own research

Fig. 17: Box-and-whisker plot – gender – Probability and statistics



Source: own research

Fig. 18: Box-and-whisker plot – gender – Financial mathematics



Source: own research

Tab. 4: Dependence of the mark of subject of study on form of study, on field of study and on gender (at 1%, 5% and 10% significance level)

Subject of study	Form of study		Field of study		Gender	
	P-value	Result of test	P-value	Result of test	P-value	Result of test
B_MaB_1	0.1202	unproven	0.2222	unproven	0.7549	unproven
B_MaB_2	0.7205	unproven	0.1747	unproven	0.1862	unproven
B_MaE_A	0.4530	unproven	0.8337	unproven	0.0450	proven at 5% s. l.
B_MiE_A	0.1833	unproven	0.8293	unproven	0.1356	unproven
B_PS_A	0.0035	proven at 1% s. l.	0.5888	unproven	0.9160	unproven
B_FiM	0.0955	proven at 10% s. l.	0.1078	unproven	0.6837	unproven

Source: own research

Tab. 6: Double dependences

Variables	Dependence	P-value of total F-test	Coefficient (index) of correlation	Variables	Dependence	P-value of total F-test	Coefficient (index) of correlation
B_MaB_1 B_MaB_2	linear[1]	0.0000	0.6929	B_MaB_2 B_FiM	double reciprocal	0.0000	0.3585
B_MaB_1 B_MaE_A	linear	0.0000	0.3830	B_MaE_A B_MiE_A	multiplicative[2]	0.0000	0.3765
B_MaB_1 B_MiE_A	exponential[3]	0.0000	0.2801	B_MaE_A B_PsA_A	linear	0.0000	0.3284
B_MaB_1 B_PsA_A	linear	0.0000	0.5093	B_MaE_A B_FiM	square root-x	0.0000	0.3005
B_MaB_1 B_FiM	double reciprocal[4]	0.0000	0.3123	B_MiE_A B_PsA_A	linear	0.0000	0.2731
B_MaB_2 B_MaE_A	logarithmic-x[5]	0.0000	0.3880	B_MiE_A B_FiM	linear	0.0024	0.1958
B_MaB_2 B_MiE_A	exponential	0.0001	0.2538	B_PsA_A B_FiM	logarithmic-x	0.0000	0.2990
B_MaB_2 B_PsA_A	square root-x[6]	0.0000	0.4953				

Source: own research

[1] Linear: $Y = a + bx$
[2] Multiplicative: $Y = a*x\hat{}b$
[3] Exponential: $Y = \exp(a + bx)$
[4] Logarithmic-x: $Y = a + b*\ln(x)$
[5] Double reciprocal: $Y = 1/(a + b/x)$
[6] Square root-x: $Y = a + b*\mathrm{sqrt}(x)$

Table 6 represents the results of multiple regression analysis. One of six variables representing the marks of one subject of study is always dependent variable and other five variables with the marks of other subjects of study are considered as independent variables, from which the variables are put into a model using stepwise regression (forward selection). In Table 6, we can see which of the independent variables has a statistically significant effect on the corresponding dependent variable at 5% significance level.

Compared to Table 5, Table 6 takes into account the existence of the other independent variables in the model, while Table 6 assumes that only two variables are in the model.

Tab. 7: Multiple regression analysis

Dependent variable	Signigicant independent variable	P-value	Dependent variable	Signigicant independent variable	P-value
B_MaB_1	B_MaB_2	0.0000	B_MiE_A	B_MaE_A	0.0000
	B_MaE_A	0.0419		B_PsA_A	0.0029
	B_PsA_A	0.0051			
B_MaB_2	B_MaB_1	0.0000	B_PsA_A	B_MaB_1	0.0000
	B_PsA_A	0.0000		B_MaB_2	0.0000
	B_FiM	0.0124		B_MiE_A	0.0075
B_MaE_A	B_MaB_2	0.0000	B_FiM	B_MaB_2	0.0001
	B_MiE_A	0.0000		B_MaE_A	0.0040
	B_FiM	0.0140			

Source: own research

Conclusion

In this study, a dependence of the mark of examination from six selected obligatory subjects of study at University of Finance and Administration on three factors – form of study, field of study, and gender – was analyzed. Chi-square test of independence in the contingency table was used in verifying the dependences.

The dependence of the results of examination from individual selected study subjects on the appropriate factor has not been proven in most cases. This dependence has been proven only in three cases, i.e. in one case at 1%, 5% and 10% significance level. However, even in

these cases, the intensity of dependence was extremely weak using Cramer contingency coefficient.

Very weak double dependences between the results of marks of each pair of study subjects are shown from the results of regression and correlation analysis. However, the obtained dependences are statistically significant even at 1% significance level. Within multiple regression, when mark from one subject of study was considered as dependent variable and marks of other study subjects were taken as independent variables, which were inputted in a model, only from two to three independent variables were taken in model at 5% significance level.

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