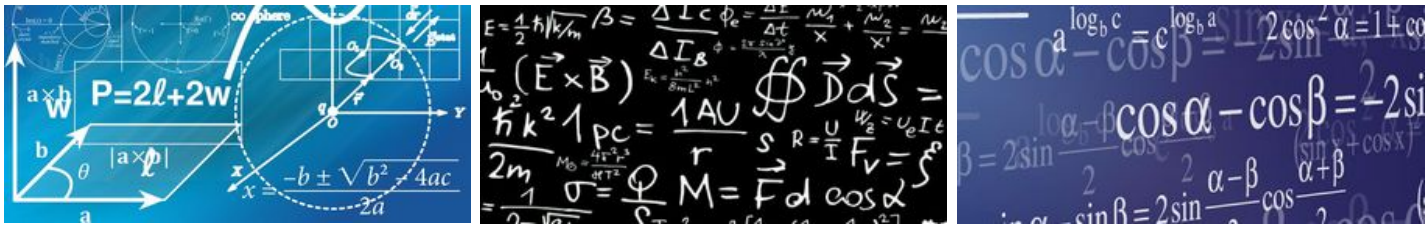

ISSN 2453-6881
2018(4)

{MERAA}

Mathematics in Education, Research and Applications

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Slovak University of Agriculture in Nitra :: Department of Mathematics, Faculty of Economics and Management

{MERAA} Mathematics in Education, Research and Applications ISSN 2453-6881

Math Educ Res Appl, 2018(4) :: Volume Index

Volume Index :: 2018(4)

Editorial Team

Scientific Board

Editorial Board

Mathematical scholarly, peer-reviewed, open access, online journal.

Publisher: Slovak University of Agriculture in Nitra :: Department of Mathematics

ISSN: 2453-6881

Journal Website: http://meraa.uniag.sk

Journal acronym: MERAA

Journal title abbreviation: *Math Educ Res Appl*

Periodicity: 2 times per year.

{MERAA} Mathematics in Education, Research and Applications ISSN 2453-6881

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Received: 2018-10-26
Accepted: 2018-12-14
Online published: 2018-12-30
DOI: https://doi.org/10.15414/meraa.2018.04.01.49-56

Original Paper

University's ripple effects on local economy: using input-output analysis to estimate multiplier effects

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ABSTRACT

Input-output analysis is a method utilizing matrix algebra to quantify interconnections and interdependencies in sectors of national economy. The technique is largely used to measure impacts of a specific sector on other sectors, impact of investment in a given sector, or modelling policy effects. With an adequate regionalization, it can be used to estimate local or regional impacts of initial change in flows of local economy. Within this paper, we use this method to estimate the total multiplier effect of Slovak University of Agriculture in Nitra (SUA) on local economy of city of Nitra. We consider university's expenditures, as well as expenditures of employees and students. Four types of multipliers were estimated, measuring increase in income, output, value-added and employment.

KEYWORDS: university, input-output analysis, multiplier effects, regional multiplier

JEL CLASSIFICATION: R15, R12, O15

INTRODUCTION

As noted by Gravino [5], the calculation of multipliers is one of the most useful analytical techniques in practice of evaluation of impact of initial autonomous change (in our case it would be the change generated by the localization of a university). To assess the effect of university spending in comparable setting in Slovakia, Rehák et al. [10] used the aggregate keynesian multiplier. Both Gravino and Rehák, however, agree that there are several drawbacks of this approach, most important being the inability to describe how multiplier effects work through the economy. To account for this, they advocate the alternative approach of using input-output analysis, which allows for sectoral disaggregation of impacts.

Input-output techniques are one special form of general-equilibrium analysis. As is known general equilibrium is achieved if demand is equal to supply in all markets of the economy and there is no need for further adjustments in any of the markets. Impact analysis, such as that suggested in our work, can also be carried out to estimate effect of many other forms of

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intervention (e.g. investments aimed at certain industries). Today, input-output (I-O) analysis is a widely used technique, usually used to analyse sectoral interdependencies, for example the structural interdependency of the agricultural sector and energy sectors in Turkey [9], the effect of multifunctional agriculture on rest of the regional economy [6], but also to estimates policy effects and implications [1, 11].

In case of Slovakia, input-output tables needed to quantify sectoral multipliers are available only on the national level, so the first step towards their quantification is to derive regional input-output table for Nitra region from its national counterpart. Boero [2] describes several methods for regionalization of national input-output tables, from survey-based, through hybrid, to several non-survey methods of estimation. In this paper, the methodological approach to this step was adopted from the works of Džupka [3], Džupka and Šebová [4] and Rehák et al. [10], who used adjusted location quotient (specifically intersectoral Flegg's location quotient) calculated from employment data, but also accounting for relative size of the region in the national economy, thus approximating the import propensity.

The aim of the paper is to estimate, using regionalized input-output table, the total impact of Slovak University of Agriculture (SUA) in Nitra on local economy of city of Nitra.

MATERIAL AND METHODS

The starting point was the symmetric matrix (I-O) derived from national I-O table with $66 \cdot 66$ matrix elements (x_{ij}), 65 of which are comprised of NACE rev. 2 economic sectors, while the last row of the matrix indicates income of employees in national I-O table and the last column of the matrix indicates final consumption of households in national I-O table. Next step is to calculate the matrix of technical coefficients $\boldsymbol{A}(a_{ij})$ that represent the amount of output of production of sector *i* needed for production of one unit of output of sector *j*, as follows:

$$a_{ij} = \frac{x_{ij}}{x_j} \tag{1}$$

When we arrange these in a table of n = 65 rows and columns we get the complete technical coefficient matrix:

$$\boldsymbol{A} = \begin{bmatrix} a_{1,1} & a_{1,2} & \cdots & a_{1,65} \\ \vdots & \vdots & & \vdots \\ a_{65,1} & a_{65,2} & \cdots & a_{65,65} \end{bmatrix} \tag{2}$$

Matrix of technical coefficients for Nitra region $\boldsymbol{R}(r_{ij})$ is derived from the $\boldsymbol{A}(a_{ij})$ matrix by multiplying it with the values of intersectoral Flegg's location quotients (*FLQ*) for each pair of sectors calculated for Nitra region [3], in case the quotient is smaller than 1 (indicating that the region imports in the corresponding sector, and the impact of increase in demand for its output generated by the initial impulse of interest would be lower than its impact at the national scale. Otherwise, the regional technical coefficients are identical to elements of matrix $\boldsymbol{A}(a_{ij})$, i.e. to national technical coefficients, jointly described by equation:

$$r_{ij} = \begin{cases} a_{ij}, & if \;\; FLQ_{ij} \geq 1 \quad for\; j = 1, \ldots, 65 \\ FLQ_{ij} \cdot a_{ij}, & if \;\; FLQ_{ij} < 1 \quad for\; j = 1, \ldots, 65 \end{cases} \tag{3}$$

The final step of calculation of regional output multiplier for Nitra region is calculation of regional Leontief model (in our case the model is closed or single-region model). Using operations from matrix algebra [8] each row of the matrix of regional I-O table can be written as:

$$x_i = r_{i1}x_1 + r_{i2}x_2 + \cdots + r_{i65}x_{65} + y_i \tag{4}$$

This can be compactly rewritten as:

$$\boldsymbol{x} = \boldsymbol{R}\boldsymbol{x} + \boldsymbol{y} \tag{5}$$

where $\boldsymbol{x}$ is the vector of volume of total production of regional sectors and $\boldsymbol{y}$ is a vector of final consumption. After some rearranging, we get:

$$\boldsymbol{y} = (\boldsymbol{I} - \boldsymbol{R})\boldsymbol{x} \tag{6}$$

$$\boldsymbol{x} = (\boldsymbol{I} - \boldsymbol{R})^{-1}\boldsymbol{y} \tag{7}$$

where $\boldsymbol{I}$ is an $n \cdot n$ identity matrix of 1s and the matrix **C** $(\boldsymbol{I} - \boldsymbol{R})^{-1}$ in latter equation (7) is the matrix containing our regional output multipliers (i.e. elements of the matrix c_{ij}). These multipliers can be further used to derive other types of multipliers. Isard et al. [8] claim that usefulness of output multipliers is limited by the fact that they add up outputs over all sectors in the regional economy, effectively treating a monetary unit's worth of output from different sectors as equally "important", whereas it could be argued that additional unit of output in Euros of automobile industry is not of equal value to the regional economy as additional unit of output in Euros of agricultural production industry. Authors further state that more interesting measures of economic impact are income, employment and value-added multipliers. Rehák et al. [10] provide a way for calculation of these types of multipliers. Income multiplier is derived by weighing elements c_{ij} of matrix $(\boldsymbol{I} - \boldsymbol{R})^{-1}$ by vector of households' coefficients h for sectors (this vector represents labour input in terms of wages needed for one Euro of output of respective sectors):

$$h \cdot (\boldsymbol{I} - \boldsymbol{R})^{-1} \tag{8}$$

Employment multiplier is derived analogously by weighing elements of matrix $(\boldsymbol{I} - \boldsymbol{R})^{-1}$ by vector of employment coefficients e for sectors (representing labour input coefficients not in monetary terms, but rather in physical measures of employment, such as employment-to-output ratio for respective sectors):

$$e \cdot (\boldsymbol{I} - \boldsymbol{R})^{-1} \tag{9}$$

Value-added multiplier is derived by weighing of matrix $(I - R)^{-1}$ by vector of value-added coefficients va calculated as a ratio of value-added for each sector and its total output:

$$va \cdot (\boldsymbol{I} - \boldsymbol{R})^{-1} \tag{10}$$

Since this type of multiplier is essentially the ratio of the total effect to the initial effect, the total multiplication effect of university on the local economy is calculated as the sum of product of regional sectoral multipliers (as calculated above) and the initial expenditures [4].

We measure three channels through which the university stimulates local economy: spending of the university itself, spending of employees and student expenditures. University expenditures were calculated through analysis of the invoices; after georeferencing the suppliers and categorizing them into NACE 2.0 categories, we consider local direct effect of

the university as amount of money spent in city of Nitra. Impact of employees and students was estimated by survey-based primary research. Questionnaire was answered by 281 out of total of 1,111 employees, and 780 out of total number of 6,033 students, which makes both samples statistically significant.

RESULTS AND DISCUSSION

The next section of paper presents results of analysis of sectoral distribution and composition of three types of impacts as defined in the previous chapter of the paper, namely the expenditures of the students, the employees and the university itself. Overall number of invoices for goods and services supplied to the university in 2015 was 31,570, out of which 31,185 invoices were issued to suppliers located in the country amounting to total of 7.8 mil. €. Pairing these invoices with specific supplier allowed for analysing both spatial dimension and sectoral aspect of university's impact. Less than a third of these expenditures was realised in Nitra region (32.95%) and only 16.74% (1.3 mil. €) within the city limits. For the purpose of this article, we consider the city to be the local economy, so further results will only reflect these expenditures. This decision was guided by the need to compare our findings with other empirical studies covering this topic (e.g. analysis of local economic impacts of universities located in other Slovak cities like Košice and Bratislava) that were carried out on the city level [7, 10]. Based on these findings we can presume that direct local economic impact of SUA expenditures is smaller than it could potentially be, since majority of its expenditures are realized outside of Nitra City and even Nitra region.

As shown in the Figure 1, there are several industries that the university supplies either exclusively or mostly on local level, namely warehousing and support activities for transport, public administration activities, water supply, sewerage and waste management (network industries), and to a lesser extent wholesale and retail. These can be jointly labelled as local services, or economic activities of non-basic sectors, thus their local procurement by the university is to be expected. Much more crucial is the finding that the university bought rubber and plastic products almost exclusively from local suppliers. There are, however, several services and products exclusively procured from suppliers outside of the local economy. These mostly fall into category of network industries not available in Nitra (specifically the electricity, gas, stream and air conditioning supply, postal and courier activities, telecommunication, and insurance and activities auxiliary to financial services) and several manufacturing industries that are concentrated in other regions of Slovakia (specifically the manufacture of textiles and leather products, chemicals and other non-metallic mineral products, computer products and electrical equipment).

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ISSN 2453-6881
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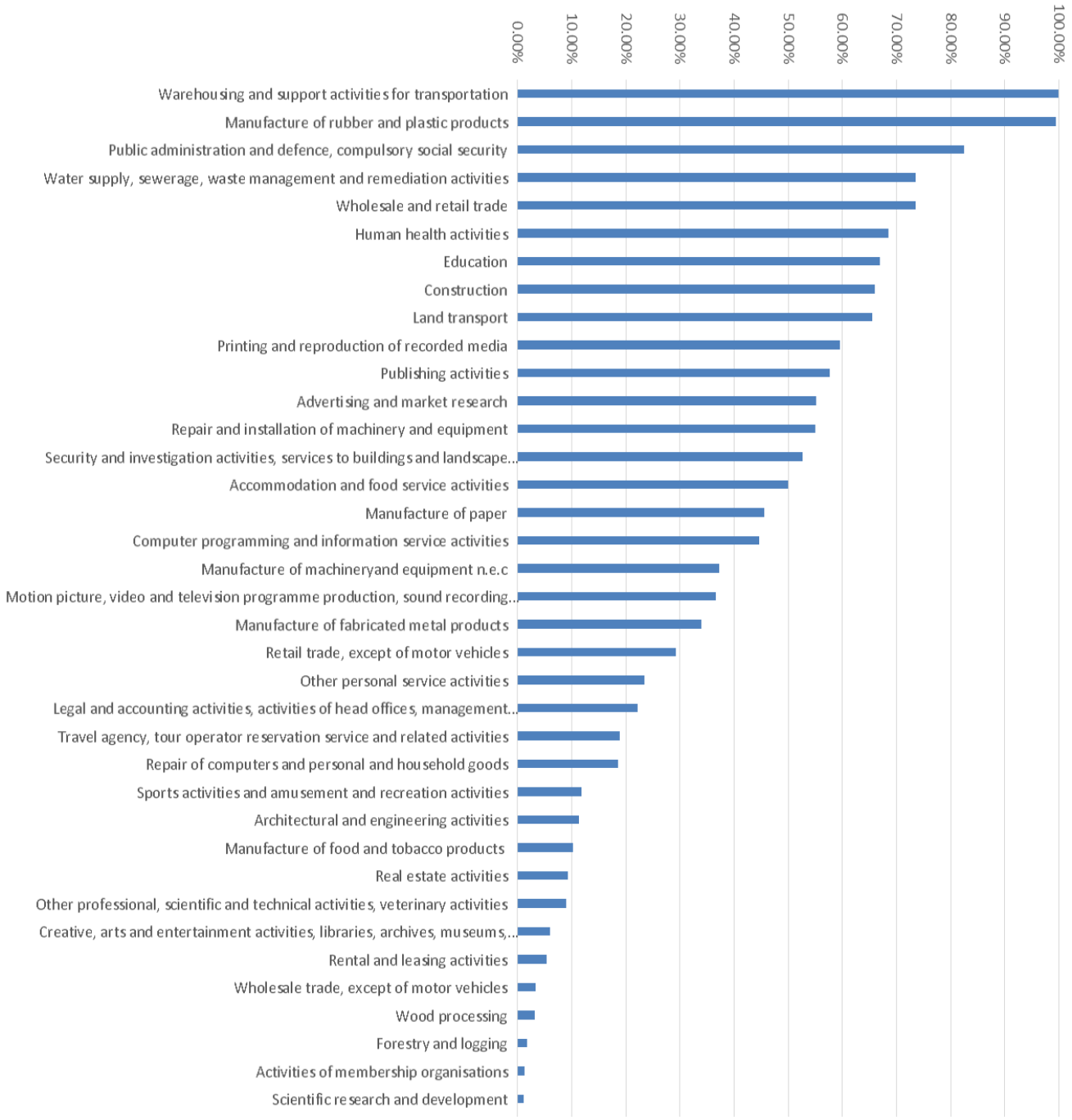

Figure 1 Share of local expenditures of Slovak University of Agriculture in Nitra according to sector in 2015

Source: Authors

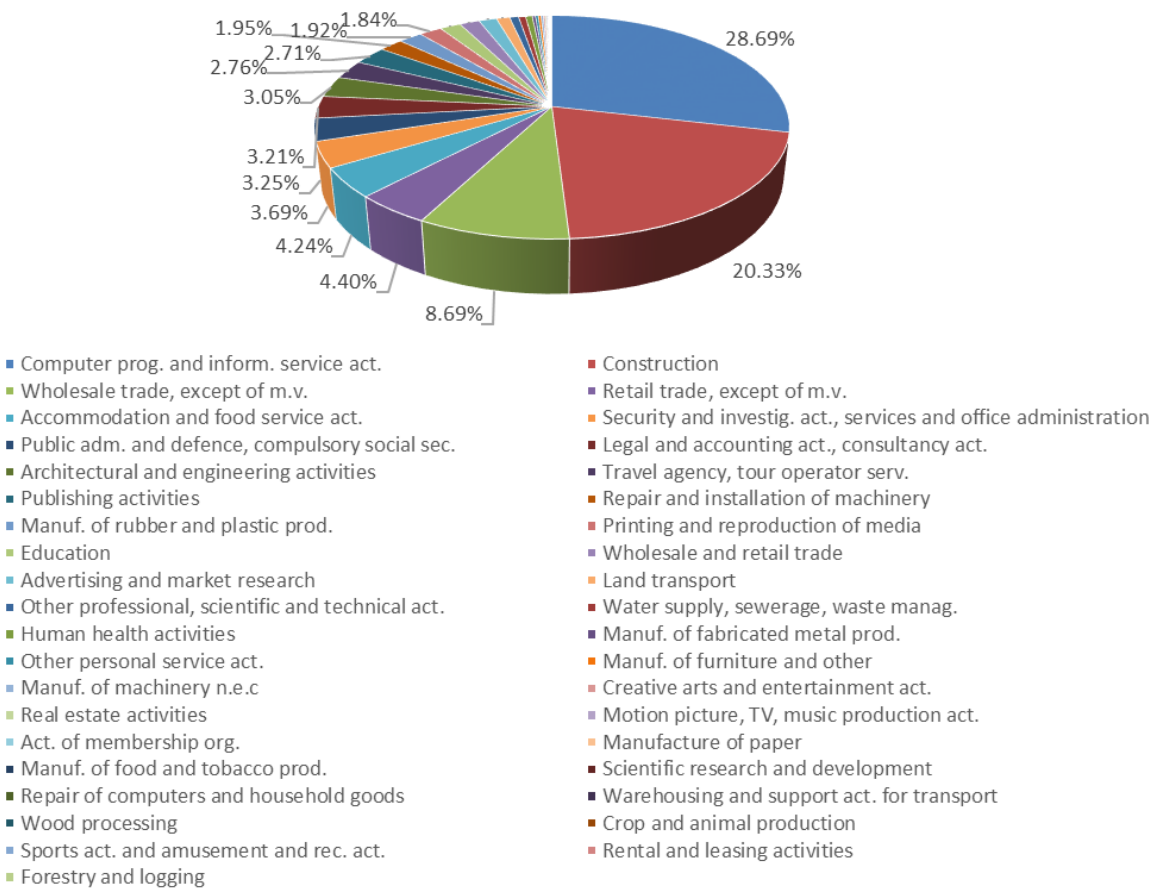

Figure 2 Sectoral composition of SUA in Nitra expenditures in Nitra City in 2015

Source: Authors

The highest nominal amount of expenditures of the university in 2015 realized in the Nitra City (as is evident from the Figure 2) was allocated on the computer programming and information services (app. 29%), closely followed by the construction industry (20%). Significant portion of annual expenditures can also be attributed to the wholesale and retail sector, while smaller but still relatively significant portions went to the accommodation and food services provision, security and administration services and other mostly local services needed for day-to-day operations. We can expect that the greatest multiplier effects of the university spending would be precisely on these sectors of the local economy, since in all other sectors individually the university spent less than 3% of overall 2015 budget on purchase of goods and services.

To estimate the total impact of employees of SUA in Nitra on the local economy, we first need to know the spending habits of an average employee. Since there is a reasonable assumption that employees on different positions (since they have different levels of income) will have different structure of expenditures, we break down the analysis according to four groups of employees. We analyse their expenditures structure according to the adjusted household final consumption expenditure structure (COICOP - Classification of individual consumption by purpose).

Table 1 Average monthly expenditures of SUA in Nitra employees in Nitra City according to COICOP categories

COICOP categories	Pedagogical staff	Research staff	Operational staff	Administrative staff
Food and non-alcoholic beverages	198.01	143.45	204.65	201.43
Alcoholic beverages, tobacco and narcotics	13.79	11.72	12.82	16.13
Restaurants and hotels, bars coffee shops	33.47	30.52	8.68	24.05
Clothing and footwear	51.47	38.10	47.56	52.59
Recreation and culture	27.60	27.07	27.31	26.21
Miscellaneous goods and services	30.27	26.38	24.81	33.04
Housing (rent)	74.18	82.03	54.71	88.88
Expenditures associated with housing (water, electricity, gas, other than rent)	67.57	70.07	148.10	85.46
Furnishings, household equipment and routine household maintenance	17.49	16.21	29.87	9.34
Health	16.34	14.21	26.72	16.88
Transport	48.32	31.97	28.14	40.48
Communication	28.17	23.97	20.04	21.02
Education	7.88	6.52	6.41	4.66
Other expenditures (gifts, repayments, personal and property insurance, financial services)	61.91	59.45	37.26	45.66
Other	0.46	0.00	8.91	5.98
Average monthly expenditures	**676.92**	**581.66**	**685.99**	**671.80**

Source: Authors

As evident from the Table 1, the results of analysis of average expenditures of university employees are rather surprising. The highest amount spent in local economy is attributed to the operational staff of the university, although this category has a considerably lower income. This result could be explained by the fact that a portion of operational staff has second jobs in addition to their position at the university and it could also mean that pedagogical and research staff spends a significant portion of their income outside of the local economy. This, however, will not affect the subsequent estimation of the multiplier effects of employees' expenditures, because in further calculation we only consider pedagogical and research staff. The rationale behind this decision is based on the assumption that operational and administrative staff would stay and work in Nitra (and thus spend their income in the local economy) even without the university being located there. Additionally, working with this assumption, we also need to eliminate those employees from our consideration that without the existence of SUA in Nitra, would either stay in Nitra, and work at a different university, or stay in Nitra and work in a different sector. Based on analysis of respondents' answers to the question of what they would do if SUA in Nitra was not located here, we estimate that out of the total of 1 111 employees of the university, only the impact of 369 of pedagogical and research staff should be considered.

The total impact of employees' spending in the local economy for one year was calculated as a product of average monthly expenditures in each group of respondents and the reduced number of all employees of the university (Table 2). In the case of employees, we consider their impact to be present throughout an entire year. We only consider their spending on

selected types of product and services, since we need them to be effectively paired with sectoral multipliers. Additionally, a lot of expenditures, although realised in the local economy, are not an income for local sectors (for example repayments, personal and property insurance and other financial services).

Table 2 Yearly direct and multiplier effects of SUA in Nitra employees on local economy in selected sectors

Type of expenditure	Direct impact	Type of sectoral multiplier	Indirect and induced impact			
			value-added	income	output	employ-ment
Expenditure on accommodation and meals	783 010.43	Accommodation and food service activities	687 421.53	336 536.55	1 719 799.91	16
Expenditure on transport	199 906.62	Land transport	127 072.12	52 930.80	357 626.49	3
Expenditure on purchases	1 236 551.38	Retail trade, except of motor vehicles	972 180.64	433 483.58	2 161 468.83	24
Total	**2 219 468.43**		**1 786 674.29**	**822 950.93**	**4 238 895.23**	**43**

Source: Authors

Table 3 Average monthly expenditures of SUA in Nitra students in Nitra City according to COICOP categories

COICOP categories	Living in Nitra in dormitory (temporary stay)	Living in Nitra in private accommodation (permanent or temporary residence)	Commuting (daily) to Nitra from the place of permanent residence	Permanently residing in Nitra (permanent residence)
Food and non-alcoholic beverages	53.95	66.00	29.50	67.16
Alcoholic beverages, tobacco and narcotics	15.88	18.61	8.43	24.88
Restaurants and hotels, bars coffee shops	22.31	21.93	19.62	28.77
Clothing and footwear	14.55	16.12	15.46	34.89
Recreation and culture	8.66	11.66	10.03	22.74
Miscellaneous goods and services	9.27	10.71	8.29	15.44
Housing (rent, boarding)	38.92	82.06	3.92	24.10
Expend. associated with housing (water, electricity, gas)	2.52	5.04	2.42	5.00
Furnishings, household equipment and routine household maintenance	0.87	2.77	1.09	2.69
Health	4.61	6.43	4.36	8.01
Transport	15.13	22.23	31.57	20.39
Communication	8.32	9.80	6.68	10.75
Education	3.28	3.58	4.93	7.59
Other expenditures (gifts, repayments, personal and property insurance, financial services)	4.95	9.42	10.74	22.75

Average monthly expenditures	**203.20**	**286.36**	**157.04**	**295.15**

Source: own calculations

The third part of a university's impact on local economy stems from the fact, that these institutions tend to attract large numbers of students from regions beyond the local economy and multiplier effects of their local expenditures can thus be attributed to the localization of the university. In contrast with university employees, we assume that both the structure and the volume of an average student will largely depend on their residence. In accordance with this assumption we disaggregate the analysis of student expenditures based on four categories.

According to our sample, the highest amount of average monthly expenditures can be attributed to the local students (Table 3). Not surprisingly, the category of students living in private accommodation in Nitra follows immediately, with only insignificantly lower average expenditures. The biggest difference between those that live in a dormitory and those living in private accommodation can be found in their expenditures on housing. In Nitra (and Slovakia generally), rents and accommodation fees at dormitories differ largely, namely due to subsidized dormitory accommodation for students. Commuters, however, spend higher share of their monthly expenditures on transport.

Table 4 Yearly direct and multiplier effects of SUA in Nitra students on local economy in selected sectors

Type of expenditure	**Direct impact**	**Type of sectoral multiplier**	**Indirect and induced impact**			
			value-added	**income**	**output**	**employ-ment**
Expenditure on accommodation and meals	1 169 011.36	Accommodation and food service activities	1 026 299.96	502 439.10	2 567 610.28	24
Expenditure on transport	972 234.64	Land transport	618 008.15	257 426.00	1 739 296.38	12
Expenditure on purchases	3 806 682.92	Retail trade, except of motor vehicles	2 992 826.27	1 334 465.00	6 654 011.01	75
Total	**5 947 928.92**		**4 637 134.38**	**2 094 330.09**	**10 960 917.68**	**111**

Source: Authors

Analogously to the reduction of the total number of employees in previous section of the paper, we had to reduce the number of students that would either choose to study at a different university in Nitra or stay and work in Nitra in order to attribute only the true impact of student expenditures to the university. According to the answers of sampled students, estimated 5 234 students out of total of 6 033 are included in quantification of total annual impact of student expenditures. In case of students, however, there are further reductions needed, since their income can come from both exogenous and endogenous sources in relation to local economy. Including the endogenous sources would mean double counting the expenditures in the local economy. This issue was resolved by further reducing the amount of expenditures for each group of students according to methodology described in Rehák, et al. ([10], p. 87.). Also, we assume that students stay in Nitra only 10 months out of the year in contrast to university employees. Yearly direct impact is thusly quantified as a product of average monthly expenditures on selected items, total number of students, reduction

coefficients mentioned previously and number of months in a year. Both direct and indirect and induced impacts of SUA in Nitra students are shown in Table 4.

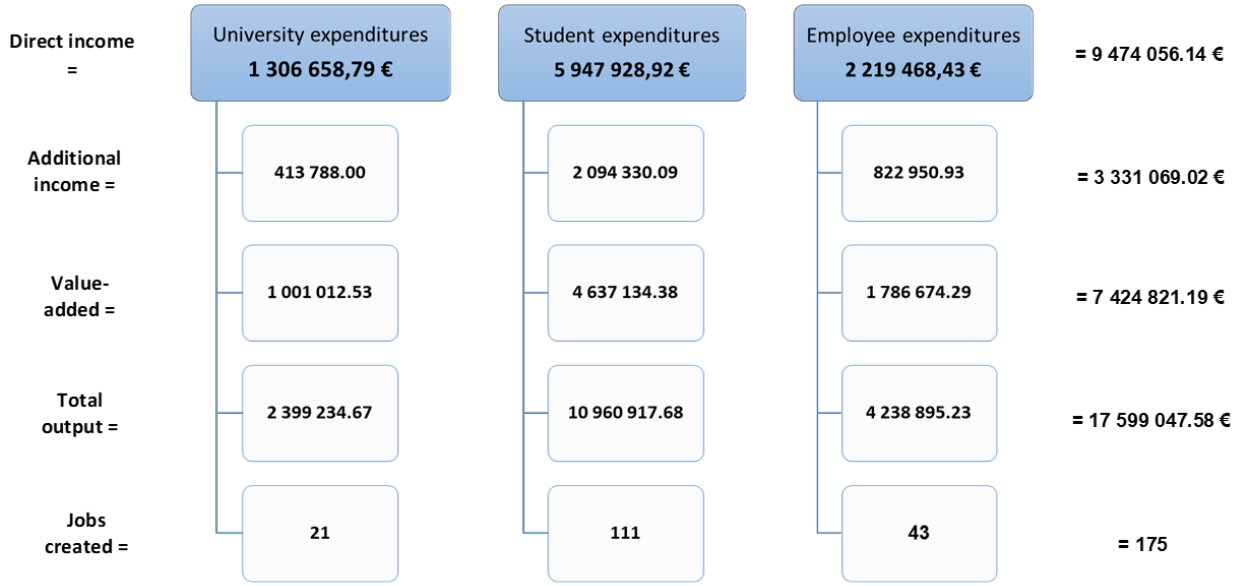

Figure 3 Total direct and multiplier effect of Slovak University of Agriculture in Nitra on local economy in 2015
Source: Authors

CONCLUSIONS

By regionalization of national input-output tables, we were able to estimate several multiplier effects of Slovak University of Agriculture in Nitra on the local economy of city of Nitra. The initial direct income in the local economy generated by purchases of the university itself, as well as local expenditures of students and employees (that would not be here, if the university did not exist) amounting to almost 10 million Euros generated a total of additional 3.3 million Euros in all sectors of the local economy, while generating 7.4 million Euros of value-added and increasing the total output of the local economy by 17.6 million Euros. In addition to these effects, the university can be accredited with creating 175 new jobs in Nitra. In conclusion we must point out, that these results could be somewhat skewed. Not only due to evident methodological issues of estimating impacts using input-output analysis, described in detail by Džupka [3], but also due to peculiarities of this specific case study. The biggest issue of note is the fact that although the university, by brining students into local economy, increases its output, these students can also generate significant push-out effect on local employees (mainly due to relatively high frequency of seeking part-time work during their studies).

ACKNOWLEDGEMENTS
This work was supported by the Slovak Research and Development Agency under the contract No. APVV-14-0512.

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{MERAA} Mathematics in Education, Research and Applications
ISSN 2453-6881
Math Educ Res Appl, 2018(4), 2

Received: 2018-10-25
Accepted: 2018-12-28
Online published: 2018-12-30
DOI: https://doi.org/10.15414/meraa.2018.04.02.60-66

Original Paper

Students' mathematical competences and exam results

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ABSTRACT

In the paper we focus on the most common logical errors in the mathematical thinking of students at the Slovak University of Agriculture in Nitra. Error analysis was based on student tests. The tasks in the tests were focused on the use of basic issues related to functions taught at the Faculty of Engineering, Slovak University of Agriculture in Nitra (SUA). The main hypothesis was that students´ results are better at final exams than at mid-term tests taken during the term. In formulating the main research hypothesis, we relied on the theoretical knowledge of the issue and the experience based on our own teaching. Pedagogical experiment was conducted in two groups. We compared the results of mid-term tests taken during the term with final exams in certain subjects to see whether the differences between study outcomes of students were significant.

KEYWORDS: function, teaching mathematics, mistakes of students, mathematical statistics

JEL CLASSIFICATION: C02, C11, I210

INTRODUCTION

Mathematics develops students' mathematical thinking that is necessary in solving a variety of problems in everyday situations, when mathematical models of thinking (logical and spatial thinking) and presentations (formulas, models, diagrams, graphs, tables) must be used. The aim of teaching mathematics at faculties of Economics is to teach students mathematical methods that will become a means of solving applied problems.

Teaching skills development must be based not only on efforts of teachers, but also on activities of students. We focus on teaching functions and their use in technical disciplines. Teaching mathematics, in general, contributes to the development of not only mathematical, but also functional thinking. Today, elementary mathematical knowledge and its insights into opportunities are considered to be at least as important as the knowledge of the national history or the laws of physics. Different ways of thinking have come along with the development of mathematics. Issues of math education are still a priority; we talk about an increasing competence of both, students and modern math teachers. Quality requirements of

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a mathematical education are still very topical. Mathematical knowledge affects the level of development of other disciplines: computer science, electronics, electrical engineering, medicine, economics, etc. Teaching mathematics conveys a specific curriculum on one hand, on the other hand it develops logical thinking. In teaching mathematics it is necessary to apply logical procedures, which can be used in solving mathematical problems as well as applying them in practice. In mathematics, the tasks are very often solved by using mathematical logic that supports the development of the logical thinking at the same time.

Pietrikova [4] verifies the validity of described hypotheses about the dependence of preferred educational styles with one of the respondents' group. The examination submitted the existence of statistically verifiable difference between preferred educational styles for all students in connection with the attended type of secondary school. As regards the students' group – boys the dominance of any educational style was not confirmed. Vice versa the statistically verifiable dependence between the age resp. the type of attended school and preferred educational style was determined for girls.

Hornyák Gregáňová [1] says that the education is basic tool for acquiring expert knowledge, which affects human capital of the labour market and professional mobility and adaptability of human resources at the labour market. It is important to educate university undergraduates for practice by using appropriate and suitable educational methods. Országhová [3] determines that some of the principal indicators can have an impact on these results. The compulsory subjects are taught in the first year of the study and this could be associated with the students' adaptation to the university system. Our students come from different types of secondary schools and they also have a different level of mathematical knowledge. Many of students assume wrongly that the university study will not contain the subject of Mathematics. Certain difficulties in the study of mathematics can be caused by the abstractness of the math language and the contents, as well. Moreover, requirements of the self-study are difficult for some students, and it is reflected in exams.

MATERIAL AND METHODS

Mathematical analysis is a part of the higher mathematics, which is taught at all faculties at the SAU in Nitra. The question remains what part of teaching mathematical analysis should be compared to other parts of mathematics. In teaching functions, there is a discussion on how to teach students to understand the terminology of functions correctly, because only in the context of the terms we can talk about mathematical sentences. The aim is to correctly understand definitions and sentences, be able to use them in further study or in solving mathematical or technical problems. The aim is to choose a teaching method that will clearly show students different concepts so that they can combine them into the right sentences. This method should contribute to a more efficient study of mathematical knowledge.

To determine the level of students' knowledge of mathematical analysis, we have decided to conduct a research involving students of the Faculty of Engineering (FE) at the Slovak Agricultural University in Nitra. To increase the mathematical competencies of students, we have set the following research objectives:

• to explore the level of students' knowledge in selected mathematical topics focused on functions,

• to compare the level of mathematical knowledge between two different groups of students of taking the course Mathematics for Technicians taught at the FE in Nitra – the mid-term test and the final exam,
• to analyse errors and procedural errors in solving individual test tasks.
In formulating the main hypothesis of the research we relied on both, the theoretical knowledge of the issue and the experience based on our own teaching practice.

Main hypothesis:
H: Involving mathematical functions into other parts of mathematics will improve a quality of students' knowledge.

The pedagogical experiment was carried out in two groups – the experimental and the control one. We were observing the changes that had occurred as a consequence of changed conditions in the experimental group (mid-term test evaluation) compared to the control group (the exam evaluation). The observation was used as an additional research method; its general objective was to identify some pedagogical phenomena and facts. When observing, we focused on a few selected activities: working alone and solving tasks in front of the class. The students themselves were the object of the observation. The goal was to find out the level of students' knowledge of mathematical logic and to determine their ability to use propositional logic in other fields of mathematics.
Location of the research: Nitra, SUA, Faculty of Engineering, 1st year students
Research time: winter term 2017/2018
Content targeting test: The test included four tasks. Every correct answer was worth six points or two points, an incorrect answer zero points.

Examples of the mid-term test:

Example 1. Determine the domain of each of the following functions $f:\quad y=\sqrt{\frac{4x-8}{-3x+9}}$.

Example 2. Find the interval of real numbers, where the function
$f:\ y=x^4-4x^3-48x^2+23x+8$ is concave.

Example 3. Finding the tangent line: Suppose you are asked to find the tangent line for a function $f:\ y=\frac{2x+3}{3x-2}$ at a given point $x = 1$.

Example 4. Write a necessary condition for extreme values.

Examples of the final exam test:

Example 1. Determine the domain of each of the following functions $f:\quad y=\sqrt{\frac{4x-8}{-3x+9}}$.

Example 2. Find the interval of real numbers where the function
$f:\ y=x^4-4x^3-48x^2+23x+8$ is concave.

Example 3. Finding the tangent line: Suppose you are asked to find the tangent line for a function $f:\ y=\frac{2x+3}{3x-2}$ at a given point $x = 1$.

Example 4. Write a necessary condition for extreme values.

RESULTS AND DISCUSSION

The results obtained in the research were processed by different statistical methods. The analysis of the results is presented in the form of texts, graphs and tables. 74 students participated in our research. The main task of the research was to compare two research samples in the control and experimental groups.

The control group

The control group consisted of 74 students. The number of gained points in individual tasks, their percentage and the total number of points in the control group for each task is given in the Table 1.

Table 1: Gained points in the test (control group)

Task No.	**1**	**2**	**3**	**4**	**Total**
100 % of points	444	444	444	148	1480
Gained points	235	237	261	79	812
Success rate in %	52.9	53.3	59	53.4	54.9

The above table shows that the lowest average success rate was achieved in the task No. 3 - Determine the domain of each of the following functions and No. 4 – find the interval of real numbers where the function is concave. The highest level of knowledge was found in the task No. 3 - find the tangent line.

The experimental group

There were 74 students in the experimental group. Students of this group were working on the tasks aimed at applying mathematical functions in solving problems.

The total number of points in the experimental group for each task is given in the Table 2. This table also shows a sum of points for each task, the percentage of gained points for each task as well as the overall evaluation of the test.

Table 2: Gained points in the test (experimental group)

Task No.	**1**	**2**	**3**	**4**	**Total**
100% of points	444	444	444	148	1480
Gained points	290	281	283	98	952
Success rate in %	65.3	63.2	63.7	66.2	64.3

When we compare both groups, it is clear that in the experimental group the total success rate increased by 9.4 %. The Table 2 shows that the lowest average success rate was reached in the task 2 and task 3 considering the sets of numbers. The highest level of knowledge was recorded in the task number 1 and 4. Evaluation of success rate in individual tasks in both, the experimental and the control group is shown in the Figure 1.

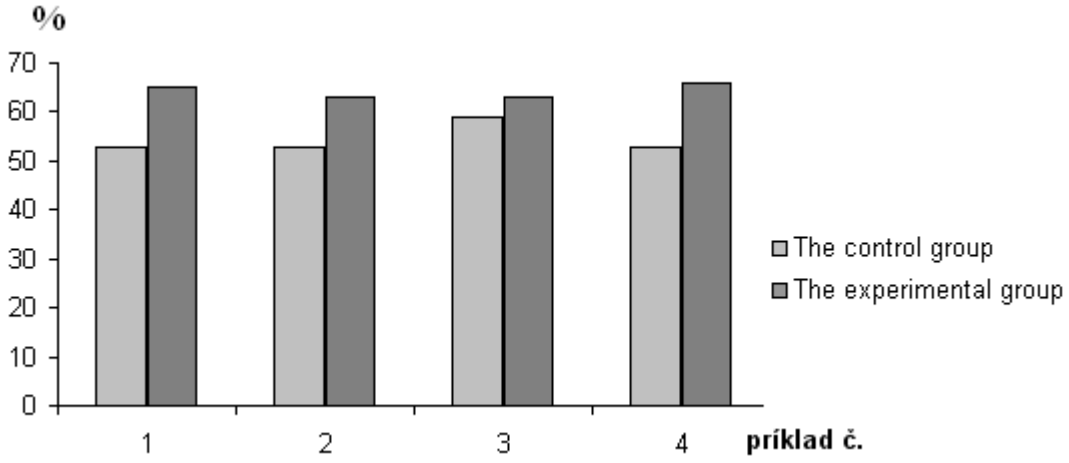

Figure 1: Evaluation of success rate in individual tasks

Testing equality of variances

In statistics, an F-test for the null hypothesis which says that the two normal populations have the same variance is sometimes used, although it needs to be used with caution as it can be sensitive to the assumption that the variables have this distribution [2]. Let's assume that samples are realizations of random selections from the normal distribution $N(\mu_1,\sigma_1^2)$ and $N(\mu_2,\sigma_2^2)$, and we will test the hypothesis, which says that variances in both groups are equal, versus the hypothesis that the variances are different (Tab. 3).

Test problem is: $H_0: \sigma_1^2 = \sigma_2^2$ versus $H_0: \sigma_1^2 \neq \sigma_2^2$

The F-test table brings $F = 1.574956$, the critical value where the level of significance is 0.025 and a test of significance is 1.473367, i.e., $F > Fkrit(1)$, and therefore the equality of variances is rejected.

Table 3: *F*-Test for Equality of Two Variances

	Control group	Experimental group
Mean	10.97297	12.86486
Variance	12.65679	8.036283
Observations	74	74
F	1.574956	
P(F<=f) one-tail	0.027075	
F Critical one-tail	1.473367	

Testing the level of students' knowledge in control and experimental groups

Because we have rejected the equality of variances, we are going to use the Two Sample Assuming Unequal Variances t-test in our testing. We will test the null hypothesis, which says that the level of students' knowledge is the same compared to the alternative hypothesis.

Our test problem: $H_0: \mu_1 = \mu_2$ versus $H_1: \mu_1 \neq \mu_2$

Table 4 shows that the statistical value of the t-test is - 3.57766. A critical value for statistical significance is 1.65589. Since the absolute value of the t-test is bigger than Critical Values, then the hypothesis H_0 is rejected. We accept the hypothesis and claim that the average level of knowledge in these groups was significantly different.

Table 4: t-Test: Two Sample Assuming Unequal Variances

	Control group	Experimental group
Mean	10.97297	12.86486
Variance	12.65679	8.036283
Observations	74	74
t Stat	-3.57766	
P(T<=t) one-tail	0.000239	
t Critical one-tail	1.65589	
P(T<=t) (2)	0.000478	
t krit (2)	1.977178	

By statistical evaluation we have found out that the involvement of mathematical function into individual parts of mathematics brings better results. Students could not find ways to recognize the elements of a certain group to differ it from the other groups; they generalized terms in tasks being solved on the basis of inadequate or secondary characters. This was evident in false arguments that students reported as reasons for incorrect solutions. Mentioned errors can be eliminated by mathematical functions in other areas of teaching mathematics (differential calculus, definite integral, indefinite integral, differential equation), not only in teaching mathematical functions. Figure 1 shows that students, who studied mathematical functions in other parts of mathematics during the term, achieved much better results in all exercises.

By statistical evaluation, we have found out that students achieved better results from individual parts of mathematics in the final exam compared to mid-term tests. The functions were also used by students in other parts of mathematics (differential calculus, integral calculus, differential equations), in which basic knowledge of functions had to be used. This is the reason why better results were seen at the final exam. The problems were that students could not find the right way to solve the tasks correctly; tasks were solved by the wrong methods. Mentioned errors can be eliminated by using definitions and theorems about functions in other areas of math's education.

CONCLUSIONS

Results of the research showed that the students achieved better results in the final exam. As a result, we can say that during lectures and seminars, there was no time to show students how to use theoretical maths in practice. In our opinion, teaching functions does not necessarily mean a waste of time, because mathematical concepts are linked together and functions are used in other parts of mathematics, too. These deficiencies caused that students did not understand the terms and principles of mathematical logic. Teachers work hard to change students' attitude to mathematics by introducing new methods. These are:

- explaining new terms by way of illustrative examples,
- specifying new terms in detail,
- determining the relationship between the terms by solving theoretical and practical tasks,
- drawing attention to the wrong ways,
- using the knowledge of mathematical logic in working with terms, definitions and theorems.

By using appropriate teaching methods, the learning process as well as students' knowledge can be improved. One way to eliminate these shortcomings is to track the right and wrong ways of thinking of students and to include functionalities into selected areas of mathematics.

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{MERAA} Mathematics in Education, Research and Applications
ISSN 2453-6881
Math Educ Res Appl, 2018(4), 2

Received: 2018-11-25
Accepted: 2018-12-28
Online published: 2018-12-30
DOI: https://doi.org/10.15414/meraa.2018.04.02.67-74

Original Paper

Comparison of daylighting in the original and reconstructed housing buildings

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ABSTRACT

The contribution is aimed at the comparison of daylighting in the original and reconstructed housing buildings. On the basis of the measurements of daylighting we calculated the values of the daylight factor in both stables. The distribution of the measuring points in the stables was different. In the original stable were two rows of measuring points, in the reconstructed stable were four rows of measuring points. The course of lighting at the measuring points was shown in program Excel using graphs. The values of the daylight factor were compared in each row in both stables using Scheffe′s test (ANOVA) and box-plot. The results show that lighting in the reconstructed building has increased significantly. The statistical analysis of the results showed that significant difference is not between the rows in which the illuminance measured ($P > 0.05$) in spite of assumption the lighting under the skylight will certainly be higher. This is caused especially inappropriately selected measuring points. There are in reconstructed stable significant differences in illuminance between the rows, that were under the skylight and rows that were located near the open side walls ($P < 0.05$). Daylighting is significantly higher under the skylight ($P > 0.05$).

KEYWORDS: daylight factor, daylighting, dairy stable, Scheffe′s test, F test

JEL CLASSIFICATION: C10

INTRODUCTION

The lighting is one of the basic factors of work environment but also stable environment. It affects not only man and his work performance, but also livestock. The sufficient light in the stable is a prerequisite for a smooth and safe work process and is necessary for animal control and care [4]. Animals need plenty of light to be able to navigate to places to feed, lying and the like. It is important for animals to see themselves, to know each other and to avoid one another [2]. According to [8], cattle are sensitive to light intensity.

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According to [3] proper lighting is an environmental factor that is often overlooked, or given little attention during the planning, construction, and maintenance of livestock facilities. However, it is just as important to the efficient operation of a livestock as ventilation, heating, or cooling. Autors [1] analyzed the lighting and the effects of day length, the daily change in day length, and heat load prevailing on test days, and on milk yield and composition of dairy cows in hot weather. The difference of 4 hours between the shortest and the longest day, plus the seasonal change in day length, accounted for the addition of 1.9 kg of milk/day for cow calving after the shortest day compared with cow calving after the longest day.

The work is aimed at monitoring of daylighting in the original and reconstructed building.

MATERIAL AND METHODS

The subject of the research was two housing buildings for dairy cows with free housing in Oponice. One building was in the original state with dimensions of ground plan 66.9 x 27.7 m. Dairy cows were housed in it in four rows of boxes. Daylighting of stable was secured by window openings that were placed in the side walls of stable. 34 windows were on each side with dimension 900 x 900 mm. Skylight was located on the ridge of a roof. Ground dimensions of the skylight were 54 x 2.4 m. The second building underwent an extensive reconstruction, where the side walls of the stable between columns made a hole in and replaced with low wall with height 600 mm. The space between columns was filled with net against flying of birds. Simultaneously, the net was used as a supporting reinforcement against the vibrating of the plastic blind. The plastic blind was used only exceptionally, mostly in winter. Hereby the side walls opened up completely.

The daylighting assessment was performed in the stables using the daylight factor DF (%). We were calculated these values from the measured values of the internal illuminance E (lx) in the individual measurement points and simultaneously measured values of the external comparative illuminance E_h (lx). According to standard STN 36 0088 [7], minimal value of DF = 1 % for dairy cows with loose housing.

The measurements were made by two identical lux-meters Testo 545. The measurement points in both stables are shown in Figures 1-4. The rows of measurement points in the original stable are shown in Figure 1 (CH1 and CH2) and in the reconstructed stable in Figure 3 (K1, K2, S1, S2). The values of the daylight factor were graphically evaluated in programme Excel. The assessment of daylighting factor values was performed in Statistica 7 using the F test and the Scheffe′s Post hoc test (ANOVA), where were evaluated differences in daylighting in individual parts of stable in both stables.

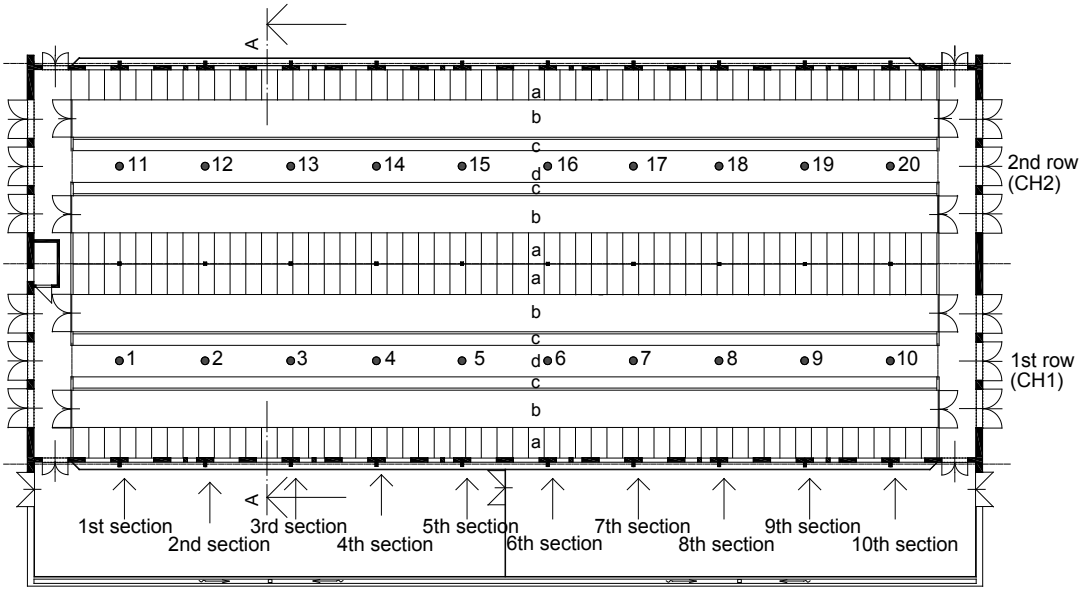

Figure 1 Ground plan of the housing building in the original housing building
a – cubicles, b – manure corridor, c – feeding trough, d – feeding passage, •1 – measurement points

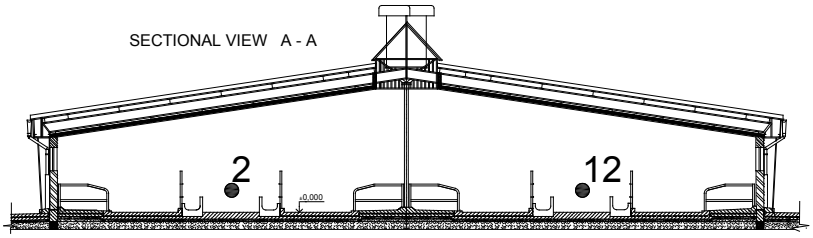

Figure 2 Cross-section of the housing building in the original housing building

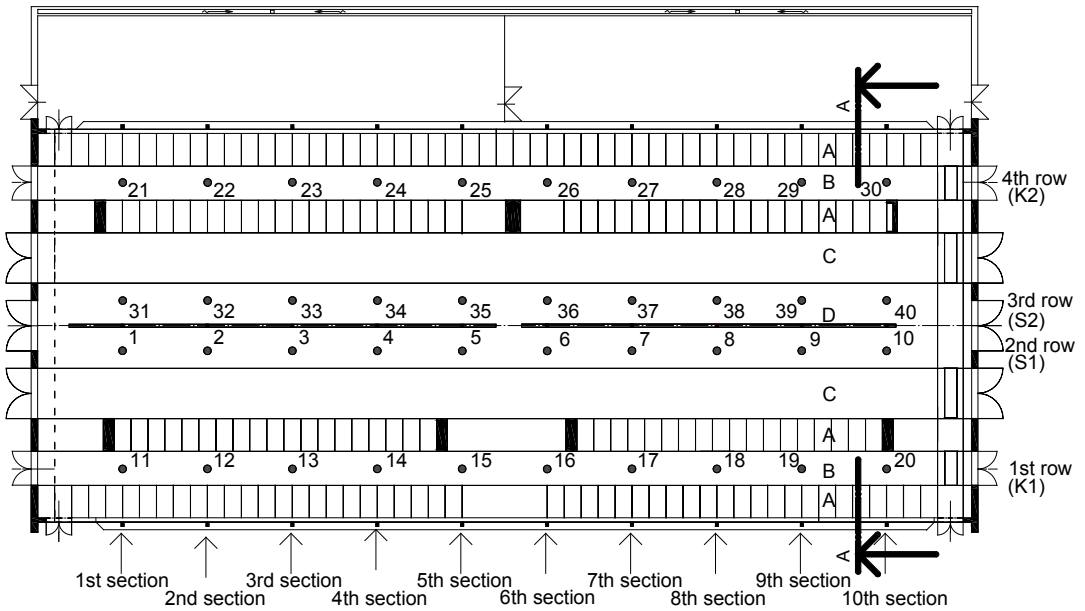

Figure 3 Ground plan of reconstructed housing building
A – cubicles, B – manure corridor, C – feeding area (with liquid manure), D – feeding passage,
•1 – measurement points

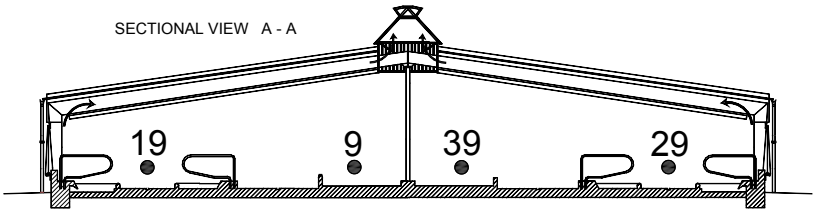

Figure 4 Cross-section of reconstructed housing building

RESULTS AND DISCUSSION

Despite the fact, that the original stable has on the roof construction skylight and gates in the front walls of the stable were open, thanks to also what daylight were in the stable, DF did not reach in any part of the stable required value. Values DF approximated to this value just at the open gates (1st section, Fig. 5). The average DF value was only 0.36 %. This value is low not only for animals but also for nursing work environment. The course of daylight factor values at the measurement points in the rows CH1 and CH2 is shown in Figure 5.

If the ridge slit has a sufficient width, it allows better light entry as windows on the external walls, because the light from the top is better and more intense distributed in the space, but the open side walls can exceed these values. The open stables often provide stronger light compared to open ridges, which are often undersized [6]. After the side walls have been removed, the illumination of the stable has increased considerably and thus the value DF. We take into account the state when the plastic blind has been pulled out. The low DF values were only at the measurement points, where the stable adjoins with milking parlor, which shadows the stable. DF did not reach the desired values at these locations. The course of daylight factor values at the measurement points in the rows K1, K2, S1 and S2 is shown in Figure 6.

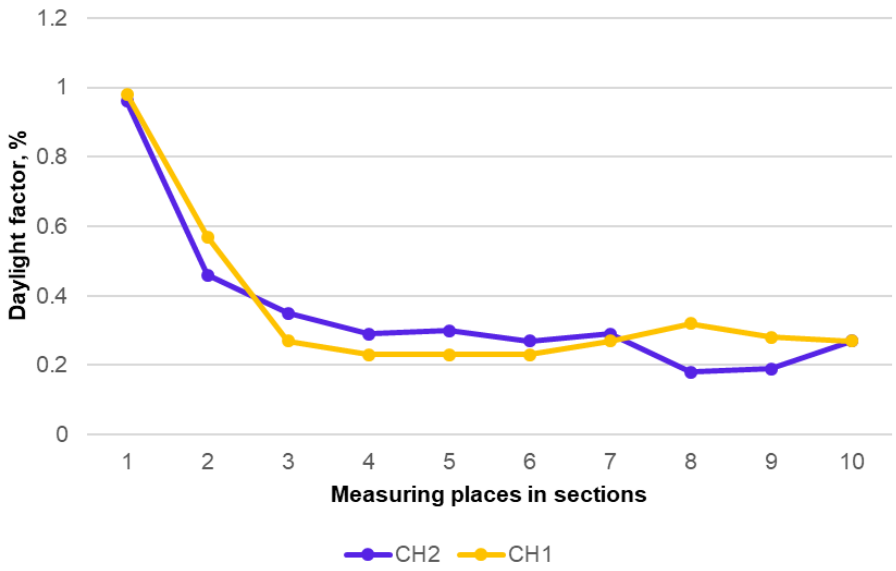

Figure 5 Daylight factor values in the original stable

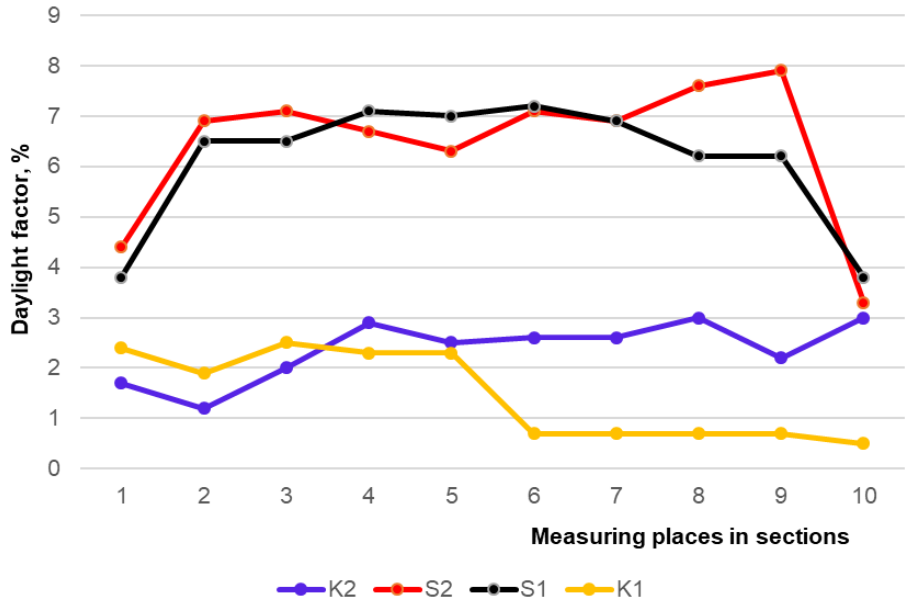

Figure 6 Daylight factor values in the reconstructed stable

Tables 1 through 3 present the descriptive statistics. In Table 1 are the basic parameters of researched daylight factor values in original stable in each row. In Table 2 are the basic parameters of researched daylight factor values in reconstructed stable in each row. In Table 3 are the basic parameters of researched daylight factor values in both stable.

Research of differences in daylight factor values in the stables was performed using the Scheffe′s Post hoc test (ANOVA, Statistica 7). Using it, we found that in the original stable, there were significant differences between the rows in which measurements were made (Table 4). There were significant differences in the reconstructed stable in the rows, where the measurements were made under the roof skylight and in the rows that were located near the open walls (Table 5).

Significant differences in illuminance between the individual parts of the stable in the original stable and in the reconstructed stable were also found using box-plot (F - test). In Figure 7 (original stable), there is no significant difference in illuminance between the examined rows ($P > 0.05$). Figure 8 (reconstructed stable) is a statistically significant difference between daylighting factors in individual rows ($P < 0.05$).

Table 1 The basic parameters of the researched values of the daylighting factor in the original stable in individual rows

Row	Count	Average value, %	Median, %	Minimum, %	Maximum, %	Standard deviation
CH1	10	0.356	0.29	0.18	0.96	0.226284
CH2	10	0.365	0.27	0.23	0.98	0.238339

Table 2 The basic parameters of the researched values of the daylighting factor in the reconstructed stable in individual rows

Row	Count	Average value, %	Median, %	Minimum, %	Maximum, %	Standard deviation
S1	10	6.12	6.5	3.8	7.2	1.272618
S2	10	6.42	6.9	3.3	7.9	1.448217
K1	10	1.47	1.3	0.5	2.5	0.869291
K2	10	2.37	2.55	1.2	3	0.594512

Table 3 The basic parameters of the researched values of the daylighting factor in the individual stables

Stable	Count	Average value, %	Median, %	Minimum, %	Maximum, %	Standard deviation
Original	20	0.3605	0.29	0.18	0.98	0.226239
Reconstructed	40	4.095	3.15	0.5	7.9	2.465968

Table 4 Original stable - Scheffe′s Post hoc test (ANOVA, Statistica 7)

Row	DF – average in %	1
CH1	0.356	****
CH2	0.365	****

1 - homogeneous groups

Table 5 Reconstructed stable - Scheffe′s Post hoc test (ANOVA, Statistica 7)

Row	DF – average in %	1	2
K1	1.47	****	
K2	2.37	****	
S1	6.12		****
S2	6.42		****

1, 2 – homogeneous groups

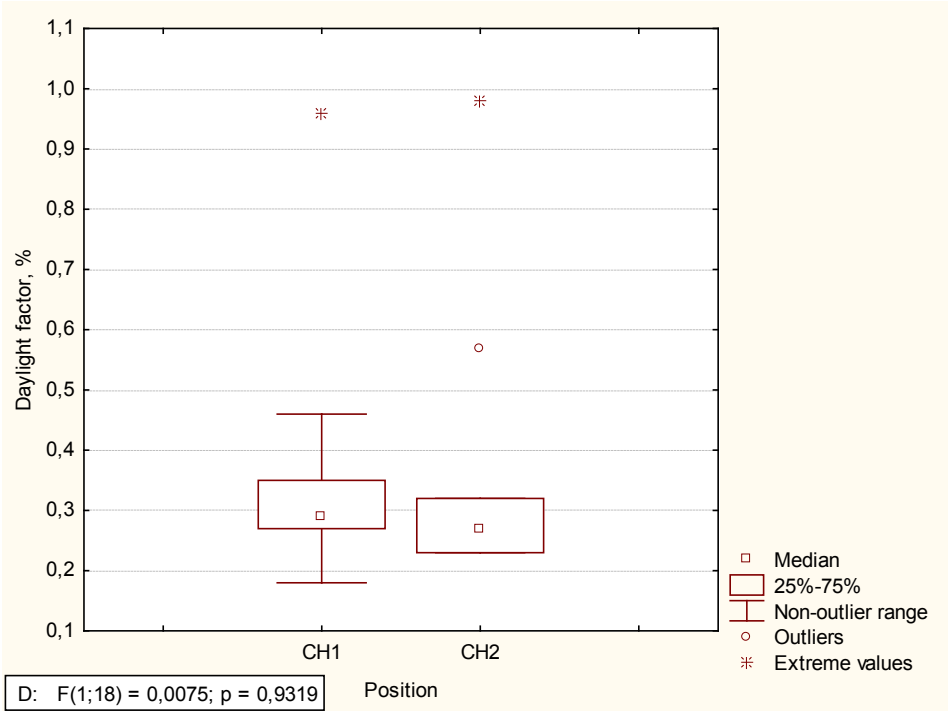

Figure 7 Box-plot of values of daylight factor in individual rows in the original stable (Statistica 7)

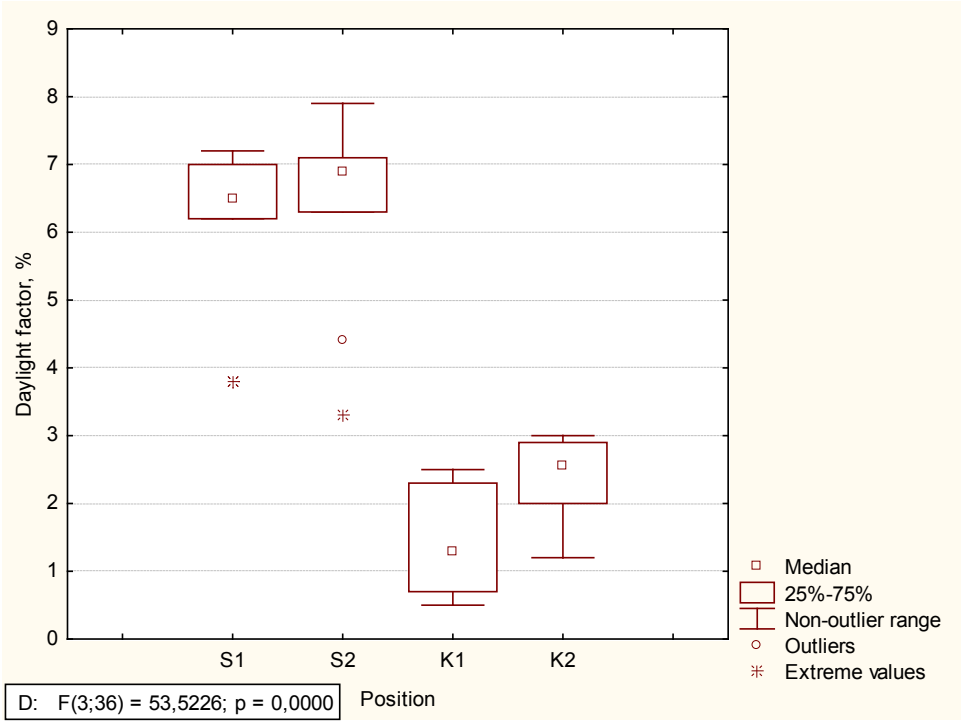

Figure 8 Box-plot of values of daylight factor in individual rows in the reconstructed stable (Statistica 7)

The distribution of lighting in the stable is very important. According to [5], light passages of varying intensity affect the movement of cows. For this reason, it is necessary to take into account not only the overall lighting, but also the lighting differences in the individual parts of the stable.

CONCLUSIONS

Even if the most daylight can be reached through the rooflight, in the case of stable with big dimensions such lighting is insufficient. The design solution of the perimeter walls directly affects the daylighting in the housing space. From the measured values, it is clear that the removal of the side walls significantly increased the values of the daylighting of the stable and hence the values of the daylight factor.

Using Scheffe's Post hoc test and the F test, we determined whether there were significant differences in the measuring sites in the one and the other stable. The places of measurement in the original stable were chosen so that we found out, what is the course of lighting in stable but we did not find out if there is a difference between the illumination under the roof skylight and in places near windows. The measuring places were better chosen in the reconstructed stable in terms of lighting. We found out there significant differences in the part of the stable under the roof skylight and in the part near the open side walls.

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{MERAA} Mathematics in Education, Research and Applications
ISSN 2453-6881
Math Educ Res Appl, 2018(4), 2

Received: 2018-11-28
Accepted: 2018-12-28
Online published: 2018-12-30
DOI: https://doi.org/10.15414/meraa.2018.04.02.75-82

Original Paper

Assessment of temperature parameters in the heated and unheated part of the hall object

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ABSTRACT

The article is aimed at the assessment of the temperature of the indoor environment in the heated and unheated part of the mechanic-repair hall object. Examined hall was provisionally separating by PVC hinge in the middle (dividing the hall into a heated and unheated part), with a view to reducing the cost of heating it, which was provided by two hot air heaters. In the paper, we assessed the effect of the PVC hinge to the temperature of the indoor environment. The measurements were carried out during winter temperature extremes. In the monitored hall, the surface temperatures of the floor construction were permanently recorded in 5 minute intervals during 24 hours with the surface temperature detector DT 10 and the air temperatures by the Dataloggers Comet and then there were statistically evaluated their interdependencies. By regression analysis it was detected a significant dependence between air temperature and floor temperature at all three measuring points F1 - F3 ($P < 0.05$), in the heated part of the hall. The degree of dependence R was between 0.68 and 0.87. Similarly, it was also assessed an unheated part of the hall, where regression analysis of the results showed that there is very high dependence ($P < 0.05$) between the air temperature and the floor temperature at the measuring points F4 and F5 what is also evident from the time course of the recorded temperatures. The degree of dependence R was between 0.86 and 0.92. There were statistically compared the temperatures of the air in the heated and unheated part using the Tukey HSD test, where statistically significant differences were found, which was also confirmed by statistical analysis of F-test ($P < 0.05$). By measuring the internal air temperature, it was found that the critical point of heat leakage was the uninsulated sheet metal gate, where the lowest temperatures from -2.5 to 5 °C were measured. Due to large heat losses, the entrance gates were also separated from the heated part of the hall with PVC tarpaulin. For this reason, we focused on this part of the hall in which we statistically assessed the internal air temperature in the heated and unheated part of the hall at the entrance gates, where there were found significant differences from the statistical analysis of F-test and also by the Tukey HSD test ($P < 0.05$). In the part at the entrance gates the PVC curtain prevented a large leakage of heat. In the heated part of the hall, where was reached more stable temperature, were not recorded extreme values, as opposed to the unheated part of the hall, where occurred relatively high temperature fluctuations. Based on the results it was detected significant effect of PVC curtain on the temperature course in the hall.

KEYWORDS: heating, air temperature, surface floor temperature, hall object, PVC hinge

JEL CLASSIFICATION: Q49

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INTRODUCTION

In the past, emphasis wasn´t placed to energy performance of buildings, which we feel currently mainly in old large area buildings with high energy costs [1]. Many adverse economic aspects, in particular the significant increase in energy prices, encourage efforts to search for new alternatives in all areas of environmental engineering. Otherwise it isn't even in heating [7]. At the time of use of production facilities, floor structures are in most cases the most stressed part of the building [5]. Most industrial hall type buildings are large and the accurate design of the substructure construction is influenced by many entry parameters from the standpoint of structural analysis, building thermal technology, building hydro-insulation technology and anti-radon measures [10]. The most important internal influences can be included the indoor air temperature, the warming of the surrounding surfaces, the relative humidity of the indoor air and the movement of the indoor air [5]. Internal air temperature is influenced by variations in outdoor conditions such as temperature, solar radiation or meteorological situation [8]. The thermal and humidity conditions of the working environment are determined by temperature, relative humidity and air flow rate [11]. The objective of the hall objects modernization should be the energy consumption reduction [2], [3], interior climate improvement [6] and improvement the way of heating. Manufacturing buildings will have to very quickly adapt to the ever-changing market demands [4].

MATERIAL AND METHODS

The object of research was hall of the agricultural purpose built-construction. The height of the heated part of repair object was 8.8 m in internal dimensions of hall 36.4 x 18 m, which is 655.2 m^2 of the total heated area. Almost the entire longitudinal wall of the hall consisted of window openings of a total width of 33 m and height of 1.8 m. The heating of the repair workshop in the winter season was due to its large dimensions and associated high heating costs provisionally solved by separating of hall with PVC hinge to two parts. One part of hall was heated and the other part was unheated. In the hall there was also a large heat loss through the uninsulated entrance doors of 5.1 m wide and 5.4 m high. For this reason, the doors were also separated from the heated part of the hall in winter season by the PVC hinge. Heating of the repair workshop was ensured by two hot air heaters with maximal power 49 kW. The heating medium of the heaters was natural gas. For reasons of economies on heating costs was examined object in winter season utilized by workers only partially. The hall was heated during working hours on a thermostat set to 11 °C and out of working hours and during the weekend it was heated to 6 °C. The measurement was carried out during the winter temperature extremes at the weekend operation. By experimental examination, the internal surface temperatures of the floor structure and the internal air temperatures were considered in the examined parts of the hall. The surface temperatures of floor construction were recorded by temperature detector DT 10 in 5 minute intervals during 24 hours. In the heated part, the surface temperatures of the floor structure were monitored at 3 locations F1 - F3 and in the unheated part of the hall at the 2 points F4 and F5 (Figure 1). The internal air temperatures were measured at the same intervals using the Datalogger Comet.

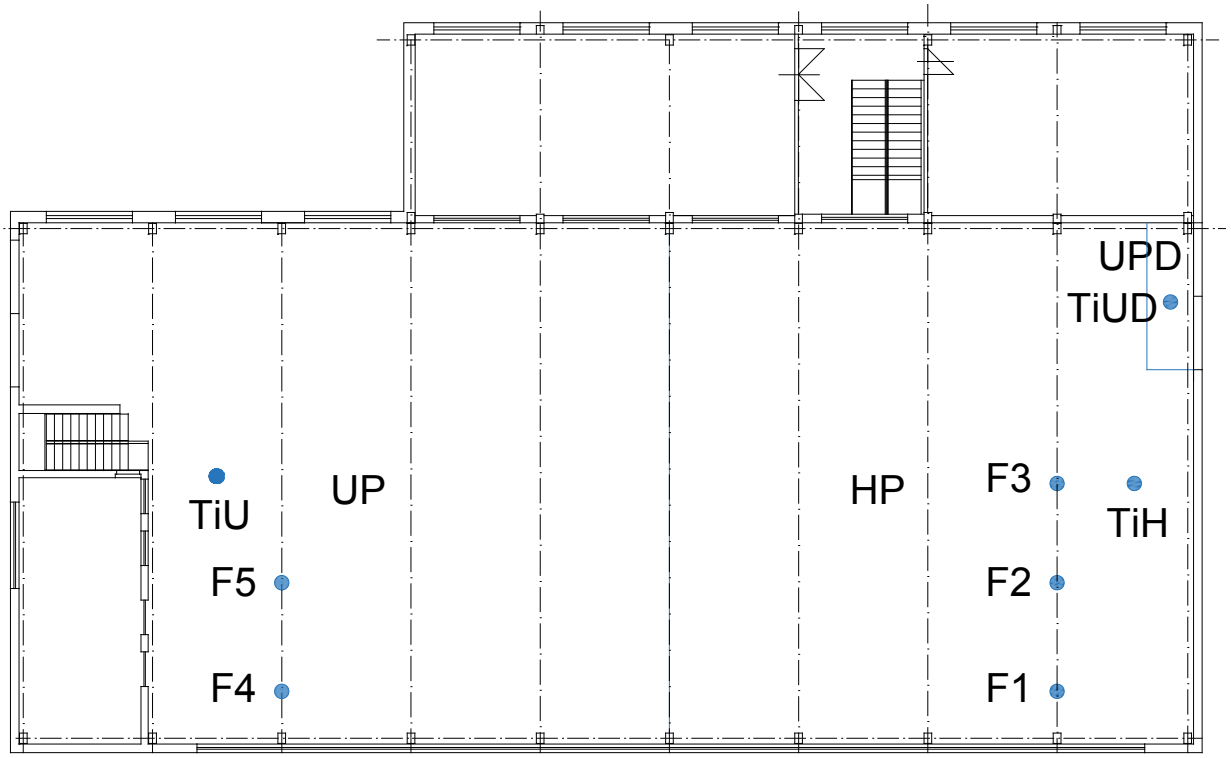

Figure 1 Scheme of measuring places in the mechanization and repair hall

F1 – F3 surface floor temperatures in heated part of hall,
F4 – F5 surface floor temperatures in unheated part of hall
TiH – internal air temperature in the heated part of hall
TiU – internal air temperature in the unheated part of hall
TiUD – internal air temperature in the unheated door
HP – heated part of hall
UP – unheated part of hall
UPD – unheated part – door

RESULTS AND DISCUSSION

The regression analysis of the results showed (Table 1) the significant dependence ($P < 0.05$) between the air temperature in the heated part of the hall and the floor temperature at all three measuring points F1 - F3. The degree of dependence R was between 0.68 and 0.87. From the measured temperature course in the heated part of the repair hall we can conclude that the internal air temperature has a significant influence on the floor temperature at the measuring points F1 - F3, as can be seen from Figure 2.

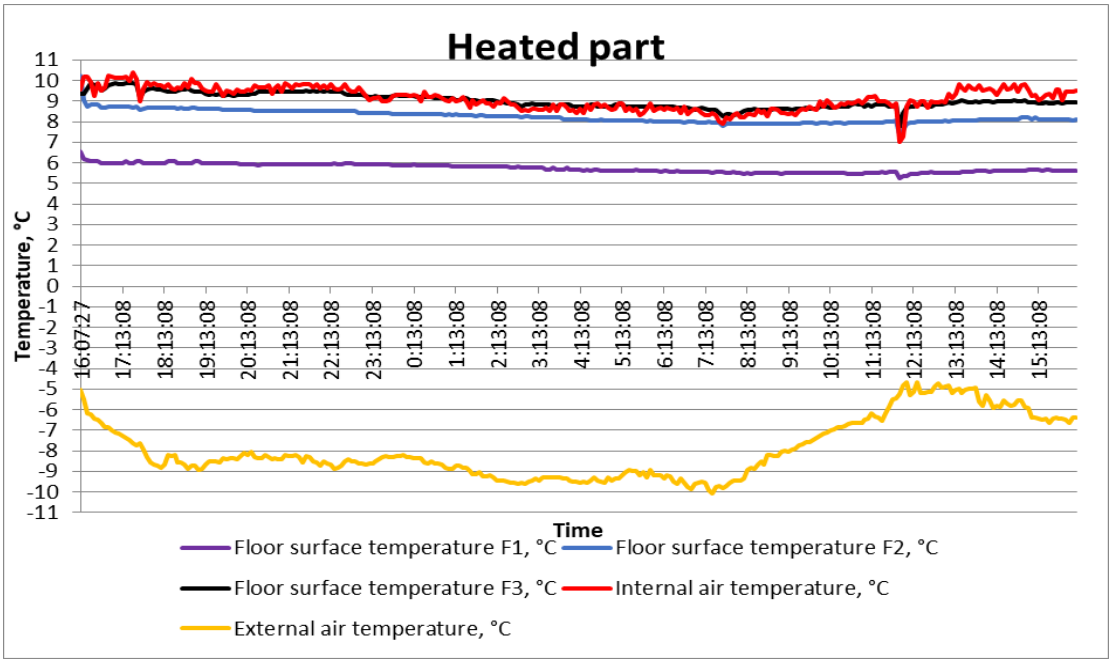

Figure 2 The time course of measured floor surface temperatures in heated part of the repair indoor object and internal and external environment temperatures

Table 1 Results of regression analysis with dependent variable Floor surface temperature, $P < 0.05$

Dependent variable	Air temperature HP
Floor surface temperature F1	R = 0.680080
Floor surface temperature F2	R = 0.741369
Floor surface temperature F3	R = 0.879005

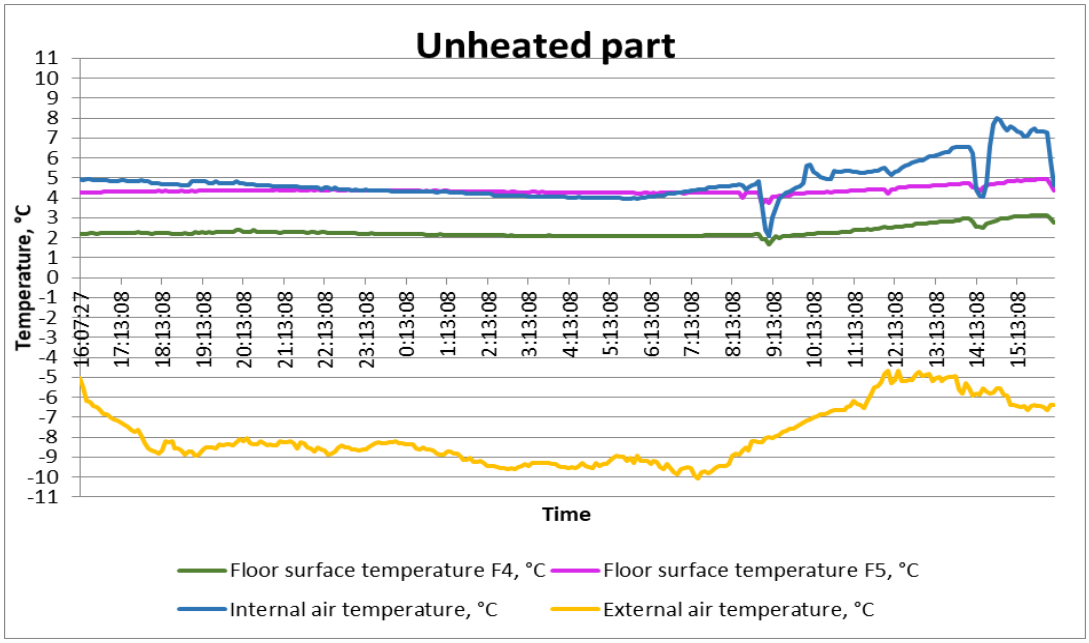

Figure 3 The time course of measured floor surface temperatures in unheated part of the repair indoor object and internal and external environment temperatures

By assessing the influence of indoor temperature in the unheated part of the hall on the floor temperature at the measuring points F4 and F5, we determined a very high dependence ($P < 0.05$) by regression analysis (Table 2). It is evident also from the time course of recorded temperatures in 24 hours (Figure 3). The degree of dependence R was between 0.86 and 0.92.

Table 2 Results of regression analysis with dependent variable Floor temperature, $P < 0.05$

Dependent variable	Air temperature UP
Floor surface temperature F4	R = 0.924374
Floor surface temperature F5	R = 0.866105

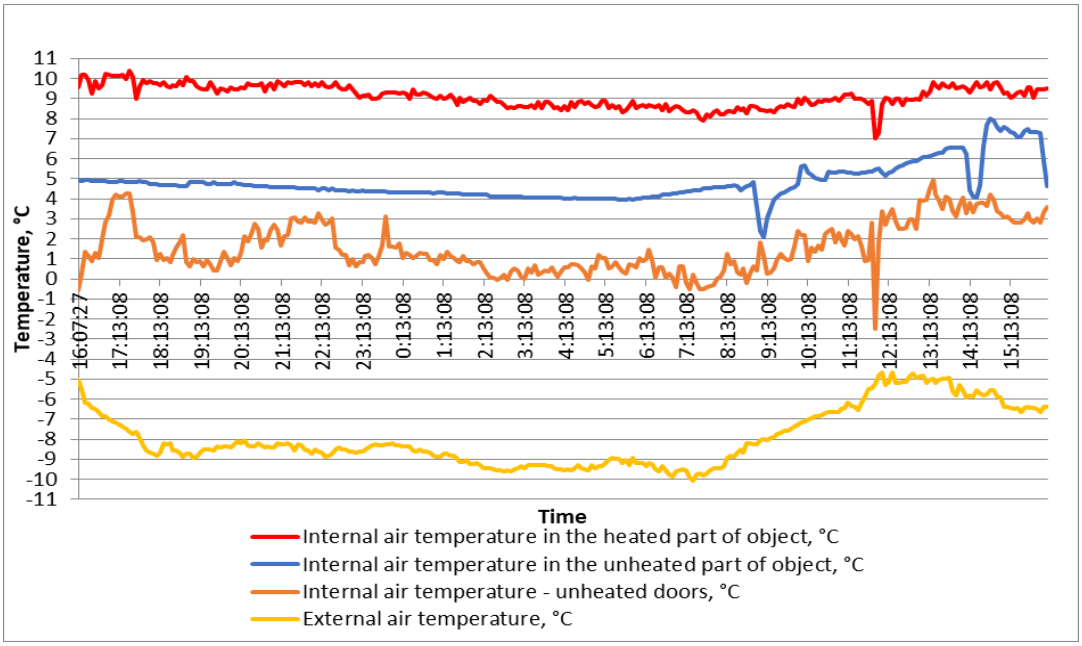

Figure 4 Comparison of air temperatures in individual parts of the hall during 24 hours in the winter season

There were compared the temperatures of the air in the heated and unheated part of the repair hall using the Tukey HSD test (ANOVA, Statistica 10). Based on this, we found statistically significant differences (Table 3, 4) between the air temperatures in the examined parts of the hall. By the F- test there were detected a statistically significant differences among indoor temperature in the heated and unheated part of the hall, shown in Figure 5 ($P < 0.05$). The air temperature in the heated part ranged from 7 to 10 °C while in the unheated part from 2 up to 8 °C during the 24-hour measurement. The lowest temperatures occurred in the unheated part at the entrance doors where the internal air temperature ranged from -2.5 to 5 °C, as can be seen in Figure 4. For this reason, we assessed the internal air temperature in the heated and unheated part of the hall at the entrance doors. By the statistical analysis of F-test we found the significant differences ($P < 0.05$) (Figure 6).

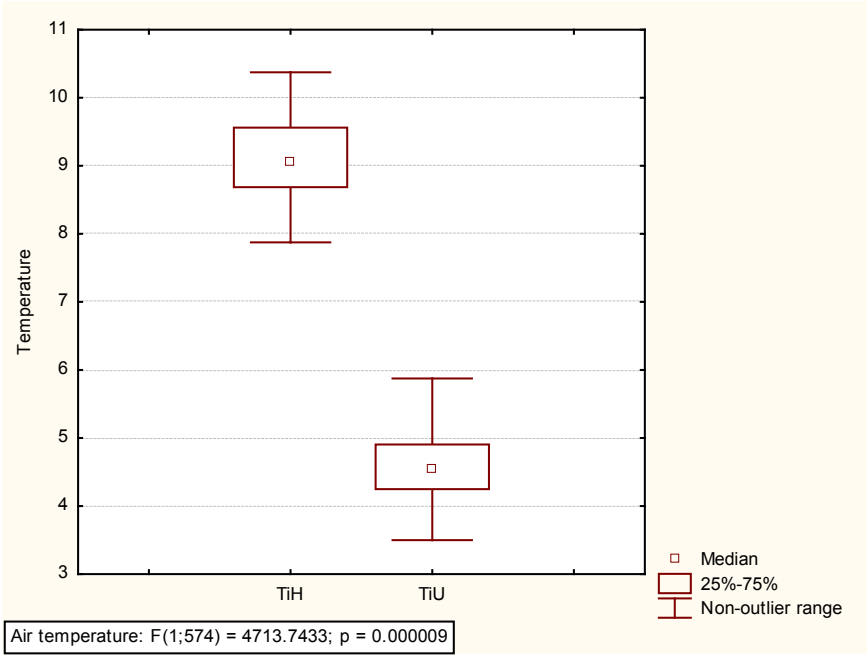

Figure 5 Comparison of internal air temperature in the heated and unheated part of hall (Statistica 10, F test, Anova, P < 0.05)

Table 3 Tukey HSD test; internal air temperature is variable in heating part of object and unheated part of object, homogeneous group, alpha =, 05000

Number	Position	Average value	Homogeneous groups	
			1	2
1	TiU	4.796007	****	
2	TiH	9.118707		****

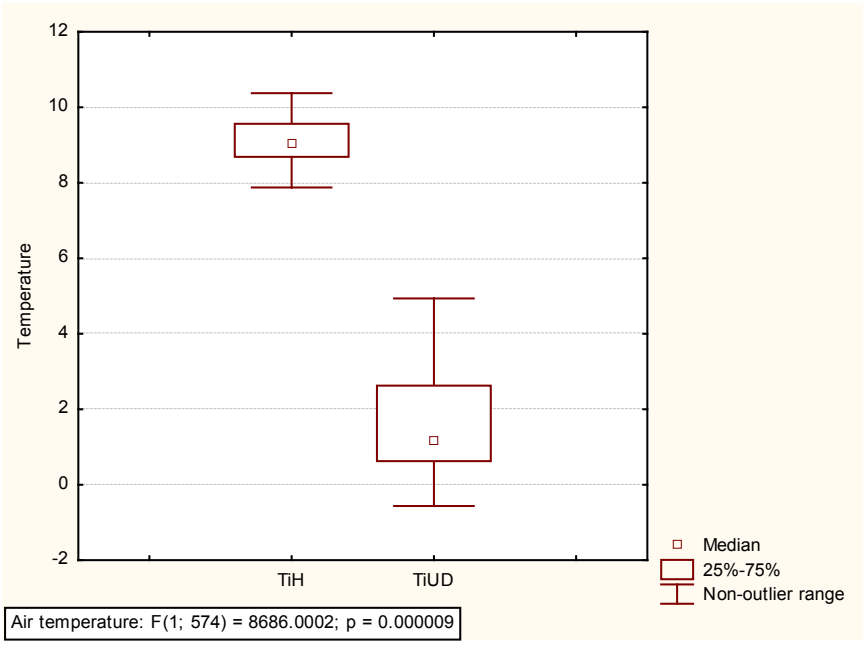

Figure 6 Comparison of internal air temperature in the heated part and unheated part at the entrance doors (Statistica 10, F test, Anova, P < 0.05)

Table 4 Tukey HSD test; internal air temperature is variable in heating part of object and unheated doors, homogeneous group, alpha =, 05000

Number	Position	Average value	Homogeneous groups	
			1	2
1	TiUD	1.572483	****	
2	TiH	9.118707		****

Based on the measured data it can be concluded, that more stable temperature was reached in the heated part of the hall, where the extreme values were not recorded [9]. In the unheated part of the hall there were relatively high temperature variations, where they significantly changed the internal air temperature. The heat from the heated part of the hall partially flowed into the unheated part, while heating the air, but the heating effect did not show up at the floor temperature in the unheated part of the hall. This may be due to the fact that a certain amount of heat primarily destined for the creation of thermal comfort in the interior escapes from the baseplate to the cooler subgrade. As indicated [10], outgoing heat represents heat losses which unfavorably affect the overall energy efficiency of the building. These heat losses represent approximately 15 to 20 % of the overall heat losses of the building [10]. The biggest heat loss occurred in the unheated part of the hall at the entrance door, where the using of PVC hinge to separate the door from the heated part of the hall was the most significant effect.

CONCLUSIONS

The heated part of hall meets only the minimum requirements for the indoor environment, when considering the minimum permissible operating temperature for a given class of work. An additional heat source should be considered at the workplace in the case of a "light work" requirement. Based on the results obtained and at the given outdoor air temperatures, which ranged from –10 to –4 °C at the time of measurement, it is possible to note the considerable influence of PVC hinge on the temperature course in the hall. The use of PVC hinges as a room divider in order to save energy for heating is a possible alternative solution especially for old large-scale hall buildings, where the possibility of thermal insulation of building structures and the exchange of transparent elements would be too expensive.

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{MERAA} Mathematics in Education, Research and Applications
ISSN 2453-6881
Math Educ Res Appl, 2018(4), 2

Received: 2018-12-01
Accepted: 2018-12-28
Online published: 2018-12-30
DOI: https://doi.org/10.15414/meraa.2018.04.02.83-87

Original Paper

Financial and insurance mathematics in practice from students´ point of view

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ABSTRACT

The general theoretical knowledge is provided to students in the bachelor's study programs and courses in educational system at the Slovak universities. Basic knowledge of higher mathematics students obtain by passing the compulsory subjects "Mathematics IA" and "Mathematics IB" in the 1st year of bachelor's degree. Practical and applied knowledge students obtain by passing the optional subject "Financial and Insurance Mathematics" in the 3rd year of bachelor's degree.
The paper deals with questionnaire survey which was conducted in subject "Financial and Insurance Mathematics" taught at the Faculty of Economics and Management of the Slovak University of Agriculture in Nitra. The aim of statistical analysis is Financial and Insurance Mathematics in practice from full-time and part-time students´ point of view. The subject of the analysis was the answers of students in the academic years 2016/17 and 2017/18. Responses were obtained by completing a short questionnaire aimed at identifying a general overview of students in this field.
The basic methods of the descriptive statistics and hypotheses testing were utilized in the assessment of the survey results. The existence of the statistically significant relations among the acquired assessments was verified by means of the χ^2–test. In case of dependence confirmation the intensity of assessed dependence was determined. The conducted questionnaire survey confirmed the existence of statistically significant differences between the answers of the students of the full-time and part-time study.

KEYWORDS: teaching of mathematics, financial and insurance mathematics, questionnaire survey, statistics

JEL CLASSIFICATION: I 21, C12

INTRODUCTION

In the contemporary society the university education is the important factor for employment opportunities on the labor market [5]. University study programs reflect the requirements of the labor market that requires creative, flexible and quick minded people [6].

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Graduates of the 1st education level at the Faculty of Economics and Management of the Slovak University of Agriculture (FEM SAU) in Nitra are prepared for various economic areas of economy and agriculture. For the graduates of FEM knowledge obtained in particular study programs and language competences create wide opportunities of application at different levels of business management in agro-food resort, companies of biological and technical services, businesses of foreign trade as well as business departments of companies in agro resort and in financial institutions. Students are educated also for the requirements of institutions of public administration and self-administration, consultancy companies, research departments and education [4].

"Financial and Insurance Mathematics" is subject taught in the 3rd year of Bachelor's study at FEM SUA in Nitra for Quantitative Methods in Economics as a compulsory subject and for Accounting as a compulsory optional subject.

Financial mathematics provides appropriate applications of mathematics in the financial area and analogically the insurance mathematics provides applications of mathematics in the insurance practice. Knowledge of financial mathematics enables more effective and rational manner of its use in borrowing or investing of financial means. Knowledge and methods shall be applied within job decisions but as well as in private decisions on finance assessment. Insurance mathematics provides better orientation in insurance products, possibilities and types of insurance and insurance practice in general [2].

Methods of financial mathematics can be applied in a lot of economic branches. Accounting, financial planning and decision making is the part of many professional courses and specialized subjects [1]. According to Papcunová and Gecíková [9] the quality of human decision making is largely contingent on their qualifications and experience.

Presentation and solving application tasks demonstrate the need to introduce new mathematical methods at faculties with economic and technical focus [3].

Knowledge obtained by the study at the FEM SUA in Nitra is utilized by graduates in trading with various commodities at foreign markets not only in the Slovak Republic but as well as within other countries of the European Union [10].

MATERIAL AND METHODS

The analysis was targeted at the responses of students of bachelor study programs at the FEM SAU in Nitra who, in school years 2016/17 and 2017/18, elected the optional subject Financial and Insurance Mathematics. Responses were obtained by means of a short questionnaire, aimed at finding out a general overview of students in this area, where they had to choose one of the Yes / No / I don't know answer. Respondents' answers were the subject of analysis from the study form point of view, since we assume that part-time students will have more practical experience. This assumption should be manifested as a statistically significant difference in the number of responses between full time and part time students (H1). In order to verify the existence of a difference in responses, a hybrid approach to statistical hypothesis validation was chosen, which takes into account both Fischer and Neyman-Pearson approaches [8]. The value of the test characteristic was determined as follows:

$$z = \frac{P_1 - P_2}{\sqrt{\frac{P_1.(1-P_1)}{n_1} + \frac{P_2.(1-P_2)}{n_2}}}$$

where P_1 and P_2 represent the ratio of one of the responses and the indices 1, 2 identify the form of the respondents' study [7]. The computed z characteristic has a normal distribution. To apply Fischer's approach, *p*-value was determined, which was compared with the level of significance α. In general, there is no reason to reject the basic hypothesis if α < *p*-value [8].

RESULTS AND DISCUSSION

The questionnaire was filled out by 129 students, namely 102 (79.07%) were full-time and 27 (20.93%) were part time FEM students (Table 1). The structure of the group of students according to the type of secondary school can be considered to be the same for graduates of grammar schools (GS) and business schools (BS) or hotel academies (HA) (Table 2). There is a statistically significant difference in case of a secondary school of another type, which means that such respondents have higher ratio in the group of part time students than in the group of full-time students.

Table 1 Structure of students according to the type of secondary school and form of study

Type of secondary school	Form of study		Total
	full time	part time	
Grammar school	23.26 %	3.88 %	27.13 %
Business schools or hotel academies	50.39 %	13.18 %	63.57 %
Other	5.43 %	3.88 %	9.30 %
Total	79.07 %	20.93 %	100.00 %

Source: authors' calculations

By analyzing the respondents' answers, whether they had to deal with problems of financial or insurance mathematics in real life we found that, in case of the positive answer, there is no difference between full time and part time students. However, the response No was more frequent in case of part time students than in case of full time students (Table 2). Comparison of question answers regarding professional guidance of respondents lead to similar results. There is no statistically significant difference between the analyzed groups of students in their perspectives to work in financial or insurance practice but there is a statistically significant difference in negative answers to these questions. Also in this case (No answer) the ratio of part time students is higher than that of full time students.

As mentioned above, the questionnaire survey was conducted at the first meeting with students in both forms of study before they were introduced to the content of the subject. For this reason we assume that in case of answers to questions: "Did you use something from financial (insurance) math in practical life?" there will be differences in respondents' answers. Differences exist in answers to a question regarding financial mathematics, where surprisingly, full time students responded Yes (55.88%) more frequently than part time students of the Accounting study program (37.04%), who on the contrary opted more often the answer No (51.85% vs. 30.39%).

There is no statistically significant difference in responses between comparative groups of respondents in terms of their perception of applications of insurance math in practical life (Table 2).

Table 2 Results of mutual interactions determined in the survey

		Value of testing statistics	**Critical value**	**Acquired assessment**
		z		***p*-value**
Type of secondary school Grammar school (GS), Business schools or hotel academy (BS/HA), other	G	1.13		0.870
	BS/HA	0.07		0.530
	other	-1.85		0.032
Did you meet with problems of financial mathematics in practical life?	yes	1.37		0.085
	no	-1.76		0.039
Did you meet with problems of insurancel mathematics in practical life?	yes	0.67	$CV_{0.05} = 1.64$	0.251
	no	-1.81		0.035
Did you use something from financial math in practical life?	yes	1.79		0.037
	no	-2.02	$CV_{0.01} = 2.32$	0.022
Did you use something from insurance math in practical life?	yes	0.76		0.223
	no	-1.61		0.054
Would you like to work after graduating in financial practice?	yes	0.26		0.397
	no	-1.83		0.034
Would you like to work after graduating in insurance practice?	yes	1.32		0.093
	no	-1.99		0.023

Source: authors' calculations

Table 2 shows the value of a test criterion for comparison of answers of both full time and part time students. Positive values were obtained if responses of a given type were prevalent at full time students, while a negative *z*-value indicates the prevalence in responses of part time students. Thus, the verified differences in answers of full time and part time students can be considered statistically significant (p-value < 0.05), but not highly demonstrable (p-value > 0.01).

CONCLUSIONS

The aim of the survey was to find out if there is a difference in answers to questions about experience with financial and insurance mathematics in practice. It can be assumed that the difference in responses is due to the fact that part time students have more practical work experience, and in their work they might have met financial and insurance mathematics more often than full-time students. The conducted survey confirmed the existence of statistically significant differences between the answers of full time and part time students. These differences were confirmed primarily in case of negative answers.

Many students of FEM SUA in Nitra, regardless of their form of study, are encountering a lot of financial and insurance products offered by different banks and insurance companies or agencies that offer these bank and insurance products to their clients. Therefore, before the survey was conducted, it was not clear whether the difference in responses would be explicit.

ACKNOWLEDGEMENTS

This contribution was created with support of project KEGA 029SPU-4/2018 Digital educational applications in mathematics.

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{MERAA} Mathematics in Education, Research and Applications
ISSN 2453-6881
Math Educ Res Appl, 2018(4), 2

Received: 2018-11-26
Accepted: 2018-12-28
Online published: 2018-12-30
DOI: https://doi.org/10.15414/meraa.2018.04.02.88-92

Original Paper

Quantitative tools of municipal financial resources assessment in the Slovak Republic

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ABSTRACT

In the Slovak Republic the system of assessment of a financial efficiency in the local self-government is complicated. This is due to the fact that the local self-government is not primarily supposed to provide the profit, but to guarantee services for inhabitants which will increase the quality of their lives. Despite the fact of this difficulty, some special methods are created for the analysis of the financial performance of the local self-government and the quantitative tools belong to the effective means of this process. The basis of the financial assessment is the calculation of the financial parameters, which allow to rate the effectiveness of the financing of the municipality. The main objective of this paper is the measuring of the financial performance of municipalities in the Slovak Republic via selected financial parameters. The data are evaluated in the time period 2000 – 2015 with the prediction for year 2016. The calculations and modeling outputs were carried out by tools of MS Excel. The graphical outputs illustrate corresponding trend lines with the changes in values and forecasts for a following period. Calculated indicators represent the exact tool for a rating of the financial efficiency of local municipalities.

KEYWORDS: municipality, self-government, financial parameters, modeling, trend lines

JEL CLASSIFICATION: C52, H72, R50

INTRODUCTION

In the Slovak Republic a "municipality" is an independent territorial and administrative unit which is defined as a legal entity managing its own assets and financial resources (own revenues as well as state subsidies) under the conditions laid down by the law [1]. In 1999, the Slovak Republic had one of the top priorities, the reform of public finance management. The fiscal consolidation is currently based on savings in public expenditures, but also on stimulating public budget revenues. The financial independence of the territories belongs to

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the important financial characteristics, which include the right to have sufficient resources and also the responsibility of local governments in formation and use territorial resources [3].

The reform of the public finance system also involved the fiscal decentralization with aim to strengthen the transparency of public finances, to promote the management approach and the responsibility for managing the each subjects of public administration in Slovakia. The prerequisite for successful management of local self-government is to take the right decisions that lead to the effectiveness, economy and efficiency of public funds. One of the major tools, which lead to the best decisions, is the financial analysis [12]. The financial department of the municipality is the competent authority to make financial analysis. The municipality can make financial analysis:

- "Ex post" – that assesses the current and previous financial situation. It discovers the causes of achieved results.
- "Ex ante" – that forecasts financial-economic results.

Fabbozi and Peterson [4] state that the financial analysis is the useful tool of financial management exploring of risks and expecting of returns. Kameníčková [7] considers the financial analysis as a standard tool of assessment the financial situation of any entity. It is a tool that provides a comprehensive and detailed look at the progress and on what assumptions are created for the future development. The basis of the financial analysis is the creation of indicators, which can be used for analyzing and modeling process [10]. The quantitative evaluation is based on analysis of indicators of income, expenses and debt [6]. If the credibility of the municipality is conceived in a wider content, then it enables to evaluate a complex situation of the municipality on the basis of its three components: financial credibility, property and development credibility [14]. It also confirms Liuta et al. [8] that the financial capacity of a local budget determines the competitiveness of a region and secures the effective implementation of its economic objectives. In the regional context, it shows the feasibility of financial security of regional development in its conformity with the national policy objectives, regional resources and interests.

The indicators of financial credibility of the municipality can greatly assist in the decision-making of the municipal/city council and mayor of the municipality/city [2]. These indicators could be also useful for the subjects with the financial resources if the municipality wants to provide for their development plans, for example for banks, financial funds or for projects financed by additional resources from the European Union. Fiľa and Schwarczová [5] state, that this trend has to be definitely followed by the state and public administration as well as by regional and local municipalities, since the identification and consequent accessibility of information is perceived by the citizens as the tool of public control and at the same time the way of permanent enhancement of the level of provided public services. The good financial condition of the municipalities is reflected in the successful development of the regions. The positive trend for the national economy is represented by small and medium-sized enterprises at the regional level, which are focused on innovation, productivity, economic growth, job creation [9] and also on the raising the living standards of the population [11].

MATERIAL AND METHODS

In the Slovak Republic the local self-governments are represented by municipalities. Modeling the creditworthiness of municipalities is based on quantitative and qualitative parameters, which are an important factor in the decision making of banks, investors and

business partners on the possibilities of future cooperation. The financial parameters inform about the development and condition of the municipal budget. In the paper [13] authors Vomočil, Hájek and Olej proposed financial parameters for evaluating the financial credibility of a municipality and the experimental data are collected directly from the municipal budget. We selected from the proposed parameters and applied in assessing the financial credibility of the Slovak municipalities the following ones:

$$P1 = \frac{\text{current incomes of municipalities}}{\text{current expenditures of municipalities}} \quad (1)$$

$$P2 = \frac{\text{non-tax revenues of municipalities}}{\text{total revenues of municipalities}} \quad (2)$$

$$P3 = \frac{\text{capital expenditures of municipalities}}{\text{total expenditures of municipalities}} \quad (3)$$

According to authors [13], the first parameter P1 expresses the quality of the financial management of the municipality. If the value of P1 is greater than 1, it means that the current budget is in surplus. The financial situation of municipality can be rated as good and the municipality can use the current budget surplus to financing its commitments. The second parameter P2 is an important indicator of the fiscal autonomy of the municipality, which is the basis of decision-making in addressing municipal financing through a debt financing tools. The value of this parameter is in the range of <0, 1>. If the rate of P2 is increasing, then the municipality has the lower need to borrow financial resources. The third parameter P3 indicates the level of possible development of the municipality. Higher parameter value (range in interval <0, 1>) means an investment activity and municipality development based on the correct financial management.

Analyzed data of mentioned parameters represent the time series. We applied tools of MS Excel for the modeling outputs via trend lines. The graphical presentation of the data is in the form of a trend line which illustrates the changes in input data or forecasts of future data.

Basic data sets for analysis have been obtained from the Ministry of Finance of the Slovak Republic from the state final account. In the contribution it was investigated the development of the financial credibility of all the municipalities in Slovakia in the form of the cumulative assessment.

RESULTS AND DISCUSSION

The main aim of this paper is to present quantitative tools for evaluation of the financial performance of local self-government and apply the selected indicators to the evaluation of the development of municipal financial conditions in the Slovak Republic. Financial indicators are evaluated in the time period 2000 – 2015 with the prediction for 2016.

In the Slovak Republic current incomes of municipalities are represented by tax incomes, non-tax incomes and grants, and transfers. The total current incomes of municipalities showed an increasing trend during the period 2001 – 2003 (Figure 1). The shares tax, which makes an average of 80% of the total tax incomes of the municipalities, has the most important impact

on the development of the total current incomes. In 2005 the fiscal decentralization took place in Slovakia, which presented a significant change in the financing of municipalities.

In response to the financial crisis (2009) the government introduced fiscal measures to revive aggregate demand by recapitalizing banks and adopting sizeable fiscal stimulus packages which were mostly based on higher government expenditures. On the basis of regulation No. 868 (dated from December 2, 2009) the municipalities got special subsidy from the state budget of the Slovak Republic in the total amount 100 mil. €. This subsidy covered the loss of tax on personal incomes and improved the financial situation in 2010. The subsidy was sent to all towns and municipalities during the December 2009 in the amount of uniformly 8.56% from the yield of the tax for the given municipality. Since 2011, total current incomes had increased every year. The results in Figure 1 confirm that municipalities planned a surplus current budget, which means that current incomes would exceed current expenditures.

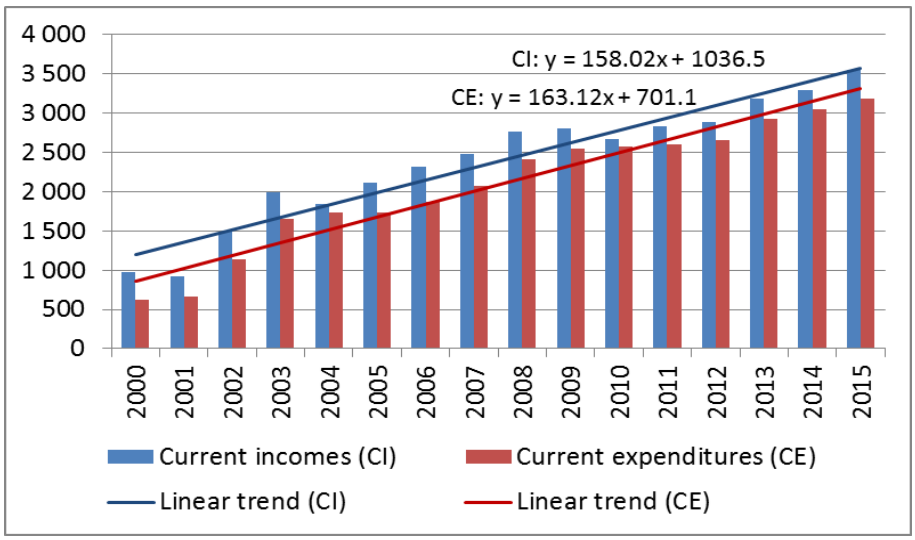

Figure 1 Development of total current incomes and total current expenditures of municipalities (in mil. €). Source: Ministry of Finance of the Slovak Republic, own processing

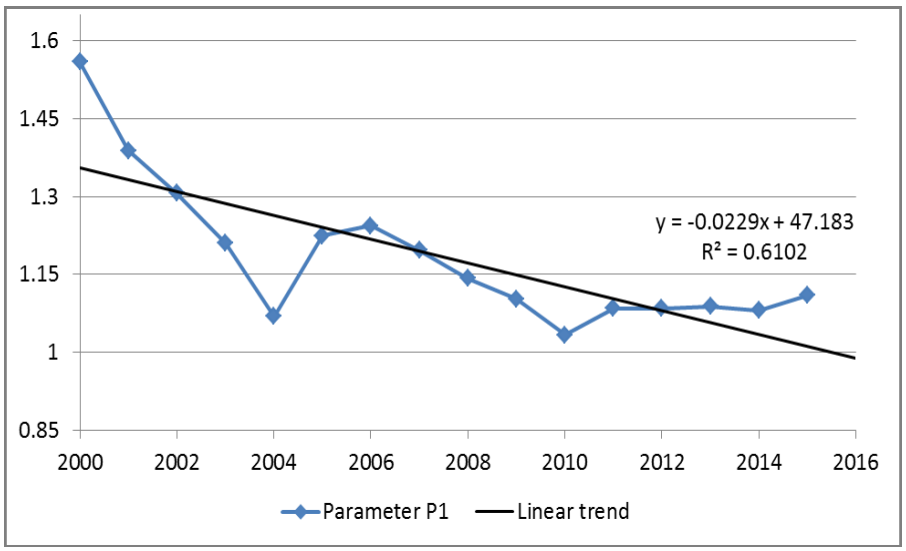

Figure 2 Trend line and prediction for parameter P1. Source: Ministry of Finance of the Slovak Republic, own processing

Based on current incomes and current expenditures of municipalities, we can evaluate the development of parameter P1. During the analyzed period from 2000 to 2015 the parameter P1 achieved the value greater than 1 (Figure 2). Thus, the financial situation of municipalities was good and they operated with the current budget surplus. It is evident that the linear trend for data was decreasing, so current expenditures (denominator of parameter) were increased in comparison to current incomes of municipalities.

The next financial parameter is based on non-tax revenues and total revenues. The non-tax revenues of the municipalities consist mainly of revenues from ownership and business with the property of municipalities. Municipalities receive funding primarily from rental property.

Although between 2000 and 2003 the non-tax revenues were increasing every year, the total revenues grew faster than non-tax revenues. The change has occurred in 2004, when the decrease of non-tax revenues for municipalities was 181 million € in the comparison with the previous year. In the following period 2005 to 2012 there are no significant changes of non-tax revenues. In the both cases the linear trends are increasing, so this model assumes the growing total current incomes of municipalities as well as non-tax revenues of municipalities (Figure 3).

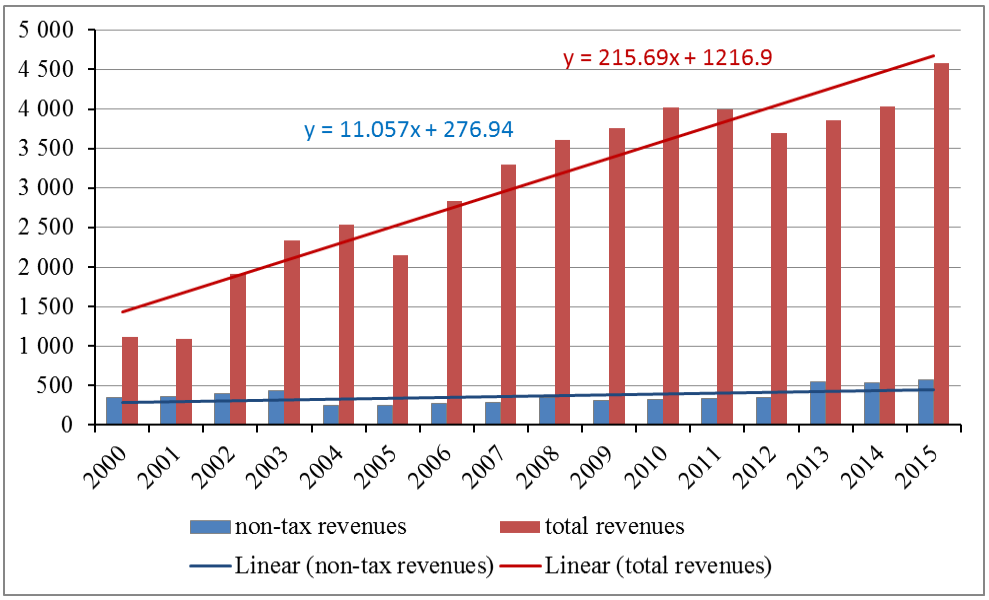

Figure 3 Development of non-tax revenues and total revenues of municipalities (in mil. €).
Source: Ministry of Finance of the Slovak Republic, own processing

We applied the tool of MS Excel to estimate the future value for the parameter P2. Based on results displayed on Figure 4 we can conclude that the linear trend of data was decreasing. We suppose that in the next period the value of the parameter P2 will decline.

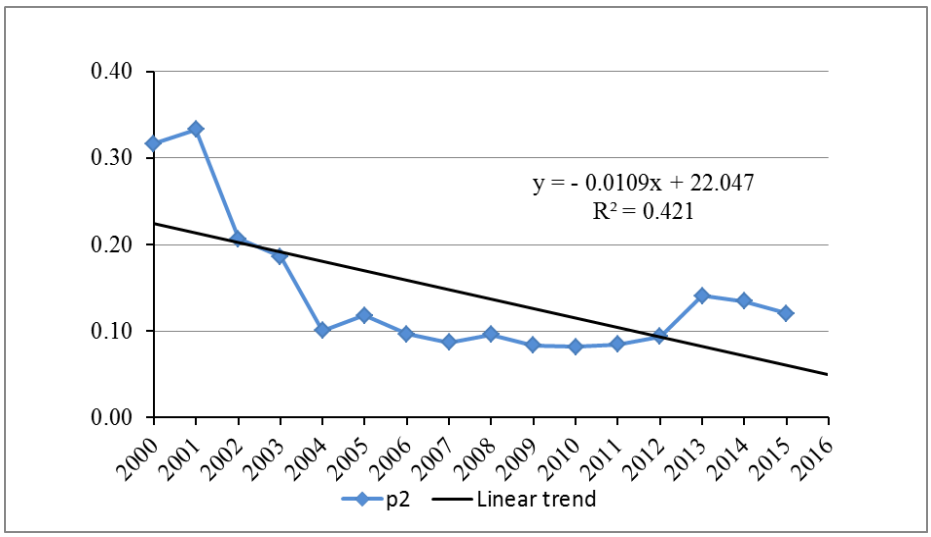

Figure 4 Trend line and prediction for parameter P2. Source: Ministry of Finance of the Slovak Republic, own processing

The municipalities are using the capital budget for its investment activities. They get capital incomes through capital transfers and subsidies, which they receive from the state budget or from the EU funds. The increasing of capital expenditures shows, that the municipalities develop and evaluate their property. The largest amount of capital expenditures was spent in 2010. In year 2010 the increase in the use of capital expenditures represented 245 million € in comparison with the previous year. The second largest amount of capital expenditures of municipalities was observed in 2015. The total expenditures showed an increasing trend except years 2001, 2005 and 2012 (Figure 5).

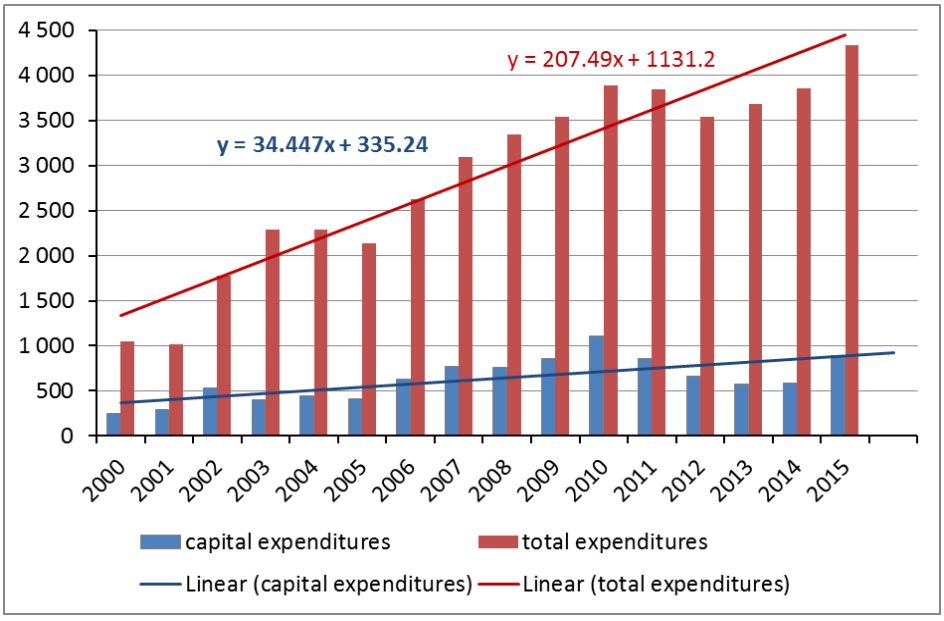

Figure 5 Development of capital expenditures and total expenditures of the municipalities (in mil. €). Source: Ministry of Finance of the Slovak Republic, own processing

The parameter P3 gives the ratio of capital expenditures and total expenditures of municipalities. During the analyzed period the values of this parameter had the fluctuating character (Figure 6).

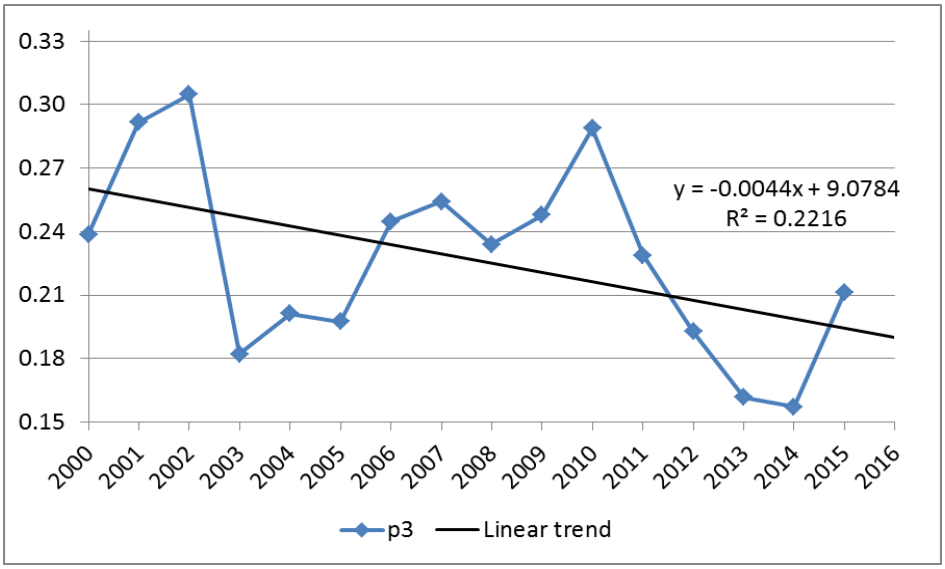

Figure 6 Trend line and prediction for parameter P3. Source: Ministry of Finance of the Slovak Republic, own processing

Based on the calculated values of individual indicators, it can be created a matrix [13] in which a given row represents vector of financial parameters of a particular municipality. This matrix is suitable as a tool for the assessment of the creditworthiness of municipalities via the neural network and the function of quick - propagation.

CONCLUSIONS

In the paper we presented the application of selected financial indicators to the assessment of the financial performance of the municipalities in the Slovak Republic. There were evaluated data about municipal financial resources in the period 2005 – 2015 with prediction for a short period. The calculated data can be included in the database and used in the process of assessment the creditworthiness of municipalities in the Slovak Republic. The usage of quantitative tools results in the classification of the municipality into the corresponding category. It gives to municipalities the opportunity to compare each other and provides a basis for rating of the financial efficiency of municipalities.

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