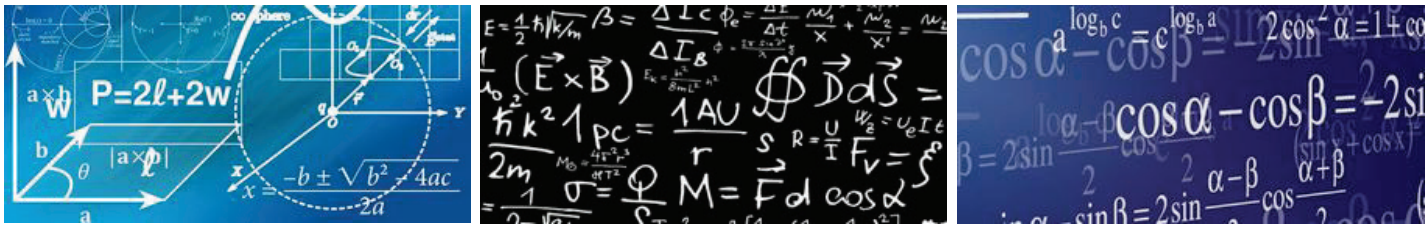

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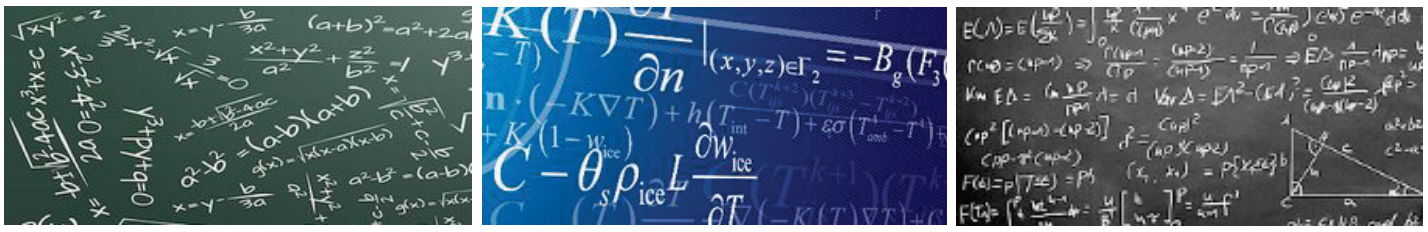

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Original Paper

Measuring the economic convergence by the OLS method. The European case

Martin Mariš*

Slovak University of Agriculture in Nitra, Faculty of European Studies and Regional Development, Department of Regional and Rural Development, Nitra, Slovak Republic

ABSTRACT

Rural regions within the European Union, in despite of the urbanization process and long term urban migration patterns, represent a significant part of the territory and portion of labor stock. Regional policy has been in place since 1957 (Treaty of Rome) however, it has not been enough effective in order to mitigating the regional inequalities across its member states, despite significant investment spent on employment and growth. Regional inequalities evenly widened due to the entrance of new states of Central and Eastern Europe in 2004 and 2007. Paper is focused on measuring the process of economic convergence, exclusive among the predominantly rural regions within the member states of EU in time period 2003-2013. For the purpose of measuring the convergence process, we opted for a beta-convergence approach via using of cross-sectional linear regression analysis. The next focus is given on the examining of the sigma-convergence, which is tested by the standard deviation of real GDP per capita. Results have shown up statistically significant economic convergence between the rural regions in selected time period. Furthermore, lower standard deviation in regional inequalities between the rural regions in selected time period also has been recorded. Thus, continuing economic convergence process among the member states of EU we cannot rule out.

KEYWORDS: economic convergence, rural regions, income inequality, beta-convergence, sigma-convergence

JEL CLASSIFICATION: D20, D40, M10

INTRODUCTION

Predominantly rural regions in the EU represent 52 % of the territory and 23 % of the population. In 2010 they generated 16 % of GVA and 21 % of the employment in total. However, in some aspects, there are significant differences between the EU-15 an EU-12 state, or so called “old member” and “new member” states. For instance, the share of predominantly rural regions in the territory is quite similar (50 % counts for EU-15 and 57 % counts for EU-12, respectively). However the share of predominantly rural regions in terms of

* Corresponding author: Martin Mariš, Slovak University of Agriculture in Nitra, Faculty of European Studies and Regional Development, Department of Regional and Rural Development, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic, e-mail:martin.maris@uniag.sk

population, GVA and employment is significantly higher in the EU-12 the in the EU-15: in the EU-12; 40 % of the population live in predominantly rural regions (18 % in the EU-15), they produce 29 % of the total GVA (14 %, in the EU-15) and account for 36 % of total employment (17 % in the EU-15) [4].

Within the European Union, predominantly rural regions often belong to social-economically disadvantaged. This phenomena had evenly its historical roots in the past, in the era of feudalism which had been dominating in most of the European countries.

In an overwhelmingly rural society, in which the productivity of agriculture was comparatively low, the vast majority of people were peasants and farmers. Often the farmers paid one-half or more of their output as rent for protection [10]. Thus, the countryside has been always tightly connected with the agriculture, extracting the ores and lumber, breeding and grazing the livestock.

The transition during the late 18th and early 19th centuries from Merchant capitalism to industrial capitalism as the dominant mode of production is conventionally ascribed to the Industrial Revolution. Prior to 1800, living standards in the world economy were roughly constant over the very long run: per capita wage income, output and consumption did not grow. Modern industrial economies, on the other hand, enjoy unprecedented and seemingly endless growth in living standards [6].

Industrialization process was the main driver of the urbanization which had been carrying the seeds of the economic inequality and income gap, between the urban and rural areas which is steadily rising.

In terms of economic conditions, one of the strongest findings is that current inequality is highly dependent on previous inequality [8]. If we measure the GDP as an annual flow of incomes (wages, rents, interests, dividends and profits) to the holders of production factors, we can equalize the income per head as a GDP per head.

In general, income inequality may arise due to a) changes affecting the labor supply (immigration, part-time labor, institutional changes related to minimal wage, unionism, etc. ; b) changes affecting the labor demand such a capital market liberalization, outsourcing, technological change, etc. [1].

Until the crisis in 2008, disparities between regional economies in the EU were shrinking. For instance, in 2000 average GDP per head in the most developed 20 % of the regions was about 3.5 times higher than that in the least developed 20 %. By 2008, the difference had narrowed to 2.8 times. However, the crisis seems to have brought this tendency to an end and between 2008 and 2011, regional disparities widened. In some regions, GDP per head in real terms (i.e. at constant prices) declined considerably, as, for instance, in Közep-Dunántúl (Hungary) or in Estonia, where it fell by 15 % between 2008–2009. Between 2008–2009, real GDP per head also fell in more developed countries such as Finland, Sweden and Italy. Regional disparities also widened significantly, between 2000–2011, in Bulgaria and Romania, Greece and in some regions of United Kingdom [5].

EU eastward enlargement brings about the obligation for EU policy to deal with a considerably increased range of income disparities within the EU. Considering the community ´s objective to enhance economic and social cohesion (Arcticle 2 of the Treaty on

European Union), this represents a challenging task. Cohesion policy, the second[1] largest item in the EU budget, has to be adjusted to this change in the scale of disparities. With respect to EU policy, which aims at regional equity, absolute convergence is the appropriate concept to be used. However, considering the variety of regions in Europe, including large structural differences, conditional convergence might be more realistic [9].

MATERIAL AND METHODS

Convergence between economies, which can be countries or regions, is defined as the tendency for the levels of per capita income, or levels of per product (productivity), to equalize over time which will happen only if a catching-up process takes place. One theory, which tries to explain above mentioned topic is „neo-classical theory" of convergence, which argues that due to diminishing returns to reproducible capital, poor countries or regions with low capital/labor ratios have a higher marginal productivity of capital, and therefore, will grow faster than richer ones, give the same level of saving investment. In this context, the tendency for disparities do decline over time is explained by the fact that factor costs are lower and profit opportunities are higher in poor regions compared to richer regions. Therefore, low income regions will tend to grow faster and will catch-up the leading ones. In the long run, income differences and growth rates will be equalized across regions [2].

The beginnings of studying convergence can be seen as studying absolute convergence, which can be defined as a process in which economies with lower capital per worker grow faster than economies with higher capital per worker. In contrast, if we measure convergence among more homogenous samples with the same institutional parameters we speak of conditional convergence. Absolute or conditional convergence can be verified by β-convergence and σ-convergence.

Methodology to study β-convergence comes from original Baumol study of real convergence between economies [3]. For the purpose of the paper the Baumol equation, we modify as follows:

$$\frac{1}{T} log\left(\frac{y_{i,T}}{y_{i,0}}\right) = \alpha + \beta log\left(y_{i,0}\right) + \varepsilon_i \quad (1)$$

where T is the end of the time period , y_t is GDP per capita at the end of time period (2013), t_0 is the initial time period, y_{t_0} is GDP per head at the beginning of time period (2003), α is level constant, β is slope parameter and ε is statistical error.

The concept of σ-convergence also comes from neoclassical growth theory. The σ-convergence is defined as lowering of variance of real GDP per capita logarithm among economies in time. Sigma convergence is then described as catching up effect. If the variance or real GDP per capita logarithm is denoted as σ_t^2 in group of countries in time t then σ-convergence among t and $t+1$ means:

$$\sigma_t^2 > \sigma_{t+1}^2 \quad (2)$$

[1] Note: Cohesion policy in current programming period 2014–2020 became the first largest policy of the EU

The sample data include GDP per capita in current prices, calculated in euro for all predominantly rural regions within the countries of EU for two time periods 2003 and 2013, respectively.

Practical side of the model we evaluate via using the coefficient of determination, R^2, based on residual analysis [7]:

$$R^2 = 1 - \frac{\sum_{i=1}^{n} e_i^2}{\sum_{n=1}^{n} (y_i - \bar{y})^2} \tag{3}$$

where e_i^2 means the residual sums of squares, as a difference between observed and estimated values.

The statistical significance of the model we submit to test of the associated hypothesis, whereby as a ground we use table data of Fisher distribution with k and $(n-k-1)$ degrees of freedom. If, the computed value is greater than the critical value of Fisher distribution (based on chosen significance level α), we fail to reject the alternative hypothesis.

$$F = \frac{\frac{R^2}{k}}{\frac{1-R^2}{n-k-1}} \tag{4}$$

Finally, we apply Durbin-Watson test in order to rule out possible autocorrelation between the random errors

$$d = \frac{\sum_{t=2}^{n} (e_t - e_{t-1})^2}{\sum_{t=1}^{n} e_t^2} \tag{5}$$

If

$$d_L < d < 4 - d_U \tag{6}$$

where d_L means lower bound interval and d_U means upper bound interval. We accept zero hypothesis, there is an absence of the autocorrelation.

RESULTS AND DISCUSSION

Primary we would like to summarize basic descriptive statistics about the sample in order to examine its position and the variability. Furthermore, we can observe deviations in selected parameters between the selected time periods 2003 – 2013, respectively.

From the Tab. 1, we can see minor changes in examining parameters between observed time periods. Based on parameters (mean, median, stdandard deviation, kurtosis, skewness) we can conclude that the situation had been evolving a slightly better.

Cross-sectional regression is not drawn by an effort to find model which could predict future development of the convergence process. The goal is to find out whether among EU economies is the convergence process present or there are more divergence tendencies.

Mathematically, the estimate of a regression model of cross-section data for the rural regions of EU countries can be written as follows:

$$\frac{1}{T} log\left(\frac{GDP_{i,T}}{GDP_{i,0}}\right) = \alpha + \beta log\left(GDP_{i,0}\right) + \varepsilon_i \quad (7)$$

Tab.1 Summary of the descriptive statistics between the time periods 2003-2013

Mean	14321	Mean	18427
Standard Error	2095	Standard Error	2305
Median	13413	Median	14114
Standard Deviation	10265	Standard Deviation	11292
Sample Variance	105360324	Sample Variance	127513202
Kurtosis	-1.3721	Kurtosis	-1.34397
Skewness	0.2907	Skewness	0.3948
Range	30282	Range	34189
Minimum	1819	Minimum	3957
Maximum	32101	Maximum	38146
Sum	343699	Sum	442251
Count	24	Count	24

From the Tab. 2, we can observe that estimated β-coefficient has a negative slope, thus we can see moderately positive convergence among rural regions of EU countries. We can conclude, that among the observing EU countries in chosen time frame, a positive convergence process we cannot rule out. According to the theory initially poorer regions have tended to grow faster that countries initially richer and converge to the common state.

Tab. 2 Summary of β-convergence model

α	$\widetilde{\beta}$	R^2	F	d
3.057	-0.2927	0.758	34.61	1.652

Additionally, coefficient of determination R^2 gain 0.758, which can be assessed as sufficient. The total quality of the model is significant, for F = 34.61 we found table value 5.72 (α = 0.05), so $F > F_{(2,22)}$. Durbin-Watson statistics gain $1.224 < 1.652 < 4 - 1.553$, for $k = 2$ and $n = 25;\ \alpha = 0.05$, thus possible autocorrelation we can rule out.

Finally, we take σ-convergence test where we computed $\sigma_{2003} = 0.94$ and $\sigma_{2013} = 0.68$, respectively. Since $\sigma_{2003} > \sigma_{2013}$, became to lowering of the variance of the real GDP capita logarithm among rural regions in time.

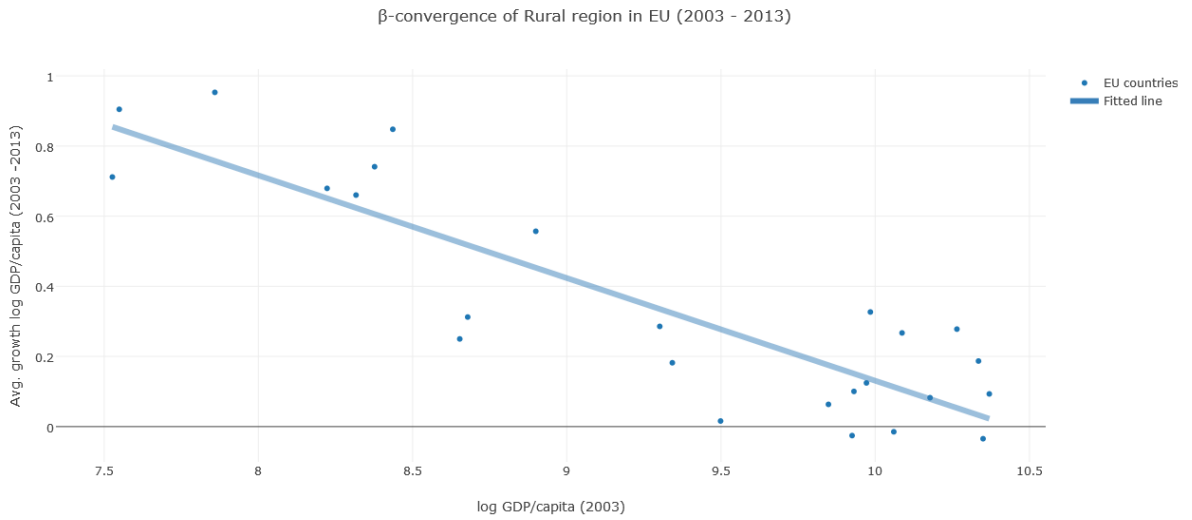

Fig. 1 β-convergence in rural regions of EU countries 2003–2013
Source: Author

CONCLUSIONS

The aim of the paper was to evaluate the dynamics of evolution of regional disparities among the rural regions between the so called "old" and "new" member states of the EU in terms of economic convergence. For this purpose, the concept of beta – and sigma-convergence were adopted. In the reference period 2003 – 2013 beta-convergence between the rural regions of EU countries can be confirmed. Furthermore, also sigma-convergence has been recorded.

It means that initially poorer rural regions, mainly from new member states of EU showed a higher average rate of economic growth that initially richer states. The total variance in income per capita in explored time period also decreased, thus the variance in incomes also converges to common state.

Generally, rural regions in EU countries belong to most undeveloped. The main obstacles to development are relatively sparsely populated territory, low market volume, lack of investments, inferior infrastructure and other factors. Endogenous resources of the territory play the crucial role in bringing the region on the development path. Heavily subsidized agriculture in the frame of CAP of EU, might be one of the factor of common convergence of rural regions to common state.

The future policy implications might be based on stimulating the endogenous potential of the countryside, which is traditional view. Investments in education, preserving natural potential

and renewing the cultural heritage of countryside in the long run might be the path for economic growth and employment creation of rural citizens.

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Original Paper

Propositional calculus in teaching mathematical subjects

Vladimír Matušek[1*], Eva Matušeková[2]

[1] Slovak University of Agriculture, Faculty of Economics and Management, Department of Mathematics, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic
[2] Slovak University of Agriculture, Faculty of Economics and Management, Department of Languages, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic

ABSTRACT

In the paper we try to point out the most common logical mistakes in mathematical thinking made students at the Slovak University of Agriculture in Nitra. The mistakes analysis was developed on the basis of students' tests. The students involved into the research are going to take their A-levels in Maths. The tasks in the tests were aimed at the use of an elementary logic – negations, general and existential quantifier in the curriculum of Mathematics at secondary schools and at universities. We tested our main hypothesis, that the evolvement of mathematical knowledge into other parts of mathematics will improve a quality of students' knowledge. 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. Pedagogical experiment was carried out in two groups – the experimental and the control one.

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

JEL CLASSIFICATION: C02, C11, I21

INTRODUCTION

Education for skills development must be based not only on efforts of teachers, but also on activities of students. We will focus on teaching mathematical logic and its importance in technical disciplines. Teaching mathematics, in general, contributes to the development of not only mathematical, but also logical thinking. Today, elementary mathematical knowledge and the insights into opportunities it brings 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 is still a priority, we talk about an increasing competence of both, students and modern math teachers. Quality requirements of a mathematical education are still very topical. Mathematical knowledge

[*] Corresponding author: Vladimír Matušek, Slovak University of Agriculture, Faculty of Economics and Management, Department of Mathematics, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic
E-mail: vladimir.matusek@uniag.sk

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.
Propositional logic may be studied through a formal system in which formulas of a formal language may be interpreted to represent propositions. A system of inference rules and axioms allows certain formulas to be derived. These derived formulas are called theorems and may be interpreted to be true propositions [2].

MATERIAL AND METHODS

Mathematical logic is a part of mathematics that occurs in all other parts of mathematics. There remains a question of what should be a proportion of propositional logics in mathematics compared with the other parts of mathematics. There is a discussion about how to teach students to correctly understand the terminology and its implications, as only in the context of terms we can talk about mathematical sentences. The aim is for students to understand definitions and sentences properly, be able to use them in their further studies or in solving mathematical or engineering problems. The aim is to choose such a method of teaching that will clearly show students different terms (concepts) so they will be able to combine them into sentences that are correct. This method should contribute to a more efficient learning of mathematical knowledge [1].

To determine the level of students' knowledge of mathematical logic, we have decided to carry out a research, in which participated students of the Faculty of Engineering (FE) of the Slovak University of Agriculture (SUA) in Nitra. In order to increase mathematical competences of students, we have set these research objectives:

- to check the level of students' knowledge of selected mathematical topics focused on mathematical knowledge,
- to compare the level of knowledge in tasks with the focus on mathematical knowledge between the two different groups of students in the subject Mathematics 1 taught at the FE SUA in Nitra,
- to analyse mistakes and procedural errors in handling individual tasks in tests.

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 knowledge into other parts of mathematics will improve a quality of students' knowledge.
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 (involving propositional logic into selected parts of mathematics) compared to the control one. 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 objects of the observation were students. 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
Research time: Winter term 2015/2016
Content targeting test: The test included four tasks. For each correct answer a student gets one point, for each incorrect answer zero points.

Example 1 Find out the truth value of the statement:

a) Let $a, b \in R$. If $a = b$, then $a^2 = b^2$.

b) Let $a, b \in R$. If $a^2 = b^2$, then $a = b$.

c) Let $a \in R - \{0\}$. If $a^2 > 0$, then $a > 0$.

d) Let $a \in R - \{0\}$. If $a > 0$, then $a^2 > 0$.

Example 2 Write negation of a statement:

(a) Statement p_1: "If I get A in Mathematics, I will buy an ice cream."

(b) Statement p_2: "No student took part in the competition."

(c) Statement p_3: $\forall x \in R: x \leq x^2$

(d) Statement p_4: $\forall x \in R \; \exists y \in R: x \leq y$

Example 3 Decide the veracity of general and existential statements:

a) $\forall x \in R: x \leq x^2$,

b) $\forall x \in R \exists y \in R: x \geq y$,

c) $\forall x \in R: \sqrt{x^2} = x$,

d) $\forall x \in R: (x-3)^2 \geq 0$.

Example 4 Find out which phrases of divisibility by 6 are true:

a) "If the number is divisible by two or three, then at the same time it is divisible by six."
b) "If the number is divisible by six, then at the same time it is divisible by twelve."
c) "If the number is divisible by three, then it is not divisible by six."
d) "If the number is divisible by six, then it is not divisible by two or three."

RESULTS AND DISCUSSION

The results, we 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. 84 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 40 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 Table 1.

Tab.1 Gained points in the test (control group)

Task No.	1	2	3	4	**Total**
100 % of points	160	160	160	160	**640**
Gained points	112	83	91	51	**337**
Success rate in %	70	52	57	32	**52.6**

The above table shows that the lowest average success rate was achieved in the task No. 4 – to check the veracity of statements regarding divisibility by number 6. The poor knowledge can be seen in the task No.2 – negations. The highest level of knowledge was found in the task No. 1 – find out the true value of the statement.

The experimental group

There were 44 students in the experimental group. Students of this group were working on tasks aimed at applying mathematical logic 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.

Tab. 2 Gained points in the test (experimental group)

Task No.	1	2	3	4	**Total**
100% of points	176	176	176	176	**704**
Gained points	138	122	103	66	**429**
Success rate in %	78	69	59	38	**60.9**

When we compare both groups, it is clear that in the experimental group the total success rate increased by 8.3 %. The table 2 shows that the lowest average success rate was reached in the task 4 considering the sets of numbers. The highest level of knowledge was recorded in the task number 1 and 2. Evaluation of success rate in individual tasks in both, the experimental and the control group is shown in the Fig. 1.

Testing equality of variances

In statistics, an F-test for the null hypothesis that 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. Let's assume that samples are realizations of random selections from the normal distribution $N(\mu_1,\sigma_1^2)$ a $N(\mu_2,\sigma_2^2)$ 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).

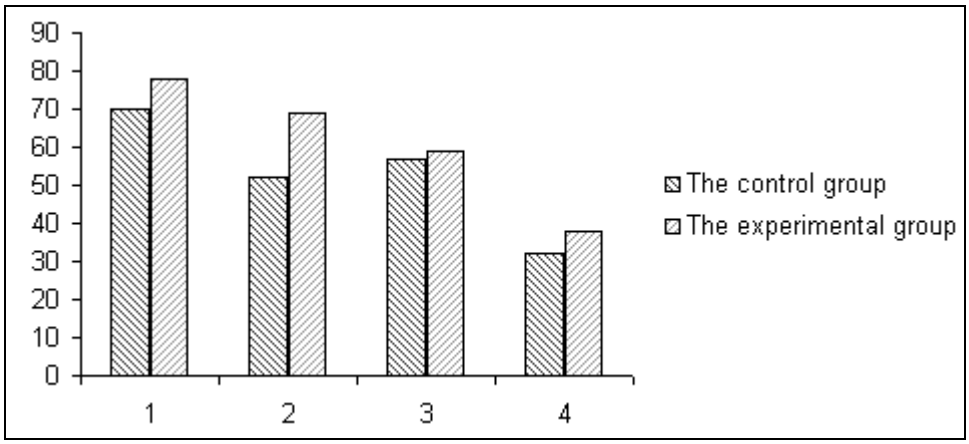

Fig. 1 Evaluation of success rate in individual tasks

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

Tab. 3 *F*-Test for Equality of Two Variances

	The control group	The experimental group
Mean	8.425	9.75
Variance	7.789103	4.052325581
Observations	40	44
F	1.922131	
P(F<=f) one-tail	0.019006103	
F Critical one-tail	1.852992982	

The F-test table brings $F = 1.922131$, the critical value where the level of significance is 0,025 and a test of significance is 1.852992982, i.e., $F > Fkrit(1)$; and therefore the equality of variances is rejected.

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.

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 -2.474039997. A critical value for statistical significance is 2.015367. 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.

Tab. 4 t-Test: Two Sample Assuming Unequal Variances

	Control group	Experimental group
Mean	8.425	9.75
Variance	7.789103	4.052325581
Observations	4004029	44
t Stat	- 2.474039997	
P(T<=t) one-tail	0.007893522	
t Critical one-tail	2,015367	
P(T<=t) (2)	0.015787044	
t krit (2)	2.290638629	

By statistical evaluation we have found out that the involvement of elementary logics 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 from false arguments that students reported as reasons for incorrect solution. Mentioned errors can be eliminated by using negations in other areas of teaching mathematics (the theory of numbers, functions, sequences) and not only in teaching mathematical logic. The table 2 shows that students, who studied propositional logics, reached much better results in two parts of the task.

CONCLUSIONS

The research results pointed out the weaknesses that were caused by the preference of the studied thematic unit. As a consequence, there was no time left to practice the use of mathematical knowledge during lessons. In our opinion, teaching negations does not entail a loss of time, because mathematical terms are related. By saying a negation, or a reverse sentence to the original one, we can get other terms related to the given term or a sentence, the veracity of which can be considered. The above mentioned deficiency was caused by the fact that students did not understand terms and principals of a mathematical logic. One possibility of how to eliminate these weaknesses is to follow correct and incorrect ways of thinking of students and to include mathematical logic into selected areas of mathematics.

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Original Paper

Preferences in students' educational styles

Miriam Pietriková[1*], Radomíra Hornyák Gregáňová[2], Monika Orlíková[3]

[1] Slovak University of Agriculture in Nitra, Faculty of Economics and Management, Department of Statistics and Operations Research, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic
[2] Slovak University of Agriculture in Nitra, Faculty of Economics and Management, Department of Mathematics, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic
[3] University of Ss. Cyril and Methodius, Faculty of Social Sciences, Department of Social Services and Counselling, Bučianska 4/A, 917 01 Trnava, Slovak Republic

ABSTRACT

Objective of the research was to verify the existence of dominant students' educational style in the English language learning in the selected city in Slovakia. The theme of educational styles and students' education is quite current and therefore it became the subject of survey. The article deals with the creation of integrated review on the prevailing educational styles among students in English lessons in selected Slovak schools. The basic survey's aim was to determine whether there exists a dominant educational style in learning of the English language in selected schools. In connection with the abovementioned aim, the existence of differences between preferred educational styles of all students, as well as of students in accordance with the type of attended school or according to the age has been found as well. The following 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.

KEYWORDS: educational style, English language, students, secondary schools, questionnaire, survey

JEL CLASSIFICATION: I 21, C12

INTRODUCTION

Students in lower levels of educations should adopt the required education strategy so their education was the most effective. Currently it is not only about adopting the knowledge but as well as the creation and utilization of general abilities and concrete and effective techniques used for learning which can be transferred to the outside of educational environment. The whole process is called as the educational style which is individual for each student. The issue of educational styles is the subject of several discussions and opinions on it are not unified, vice versa they are inconsistent; sometimes even contradictory [9]. Identification of preferred

[*] Corresponding author: Miriam Pietriková, Slovak University of Agriculture, Faculty of Economics and Management, Department of Statistics and Operations Research, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic, e-mail: miriam.pietrikova@uniag.sk

educational styles of teachers manage to reveal effective and ineffective models of students' behaviour in the educational process, can help a teacher in the consideration process of reconciliation level between his styles, teaching styles and students' learning styles. In the year 2004 Coffield identified more than 70 models of educational styles what reflects the fact that this issue is intensively observed mainly abroad [2]. According to Tandlichová [8] the teachers of foreign languages should pay more attention to a student, his/her personal features and abilities. She emphasizes that it is crucial to take into account the differences between sexes which are not only combined with the physical differences but as well as differences related to the learning process. In connection with the before mentioned statement Blaško [1] takes the line that with respect for dominant intelligence students' types better results are achieved not only in the area of knowledge and skills.

Educational styles can be divided in accordance with the prevailing intelligence types. Gardner [3] understands the intelligence as the ability to solve problems and create products which can be considered as valuable in one or several cultures. In his theory so called theory of multiple intelligences or shortly MI theory he adduced evidence of minimum seven intelligence types which occur in all cultures. In accordance with the prevailing intelligence types the following educational types are mentioned:

- Linguistic (language, speech, verbal) educational style (Linguistic),
- Logical – mathematical educational style (Logical),
- Space visual educational style (Visual),
- Musical educational style (Musical),
- Interpersonal educational style (Interpersonal),
- Intrapersonal educational style (Intrapersonal),
- Natural educational style (Natural),
- Existential educational style (spiritual; Physical).

The basic survey aim was to find out whether there exists the dominant educational style in the learning of English language in the selected schools. In connection with the before mentioned task the existence of differences among preferred educational styles was determined for all students but as well as the students pursuant to the type of attended school, resp. pursuant to the age.

MATERIAL AND METHODS

The survey was conducted by means of a questionnaire method. In order to acquire the result we selected the standardized MI questionnaire for finding the educational styles in accordance with the prevailing intelligence types. The questionnaire was translated to the Slovak language and adjusted by Ivan Turek [9]. The questionnaire was anonymous, with the cover letter as its part which addressed the students, contained basic instructions for filling in the questionnaire and appeal to open and conscientious attitude when answering the questions.

The current trend at universities is to offer to students the study programs with the subjects taught in English. If the teacher knows the preferred learning styles of students, it can affect the education process and learning outcomes [5], [6].

The method of descriptive statistics and verification of hypotheses validity was used for the survey results assessment. The existence of statistically significant relations between obtained assessments was verified by means of χ^2 -test. Statistically verifiable existence of difference in

the assessment was reviewed on the base of significance of testing characteristic (*p*-value), what presents the error probability which we will commit if we reject H0 tested hypothesis even in fact it is valid. In case the *p*-value of testing characteristic is lower than 0.05, the null hypothesis about the equality of observed features is rejected and the difference in values of statistical feature is considered as statistically significant [7].

In our case we have statistical samples of range *n* and we examine the statistical features – the first observed feature A is the preferred educational style and the second observed feature B is the type of attended secondary school, students' age or respondents' sex.

We verified the following null hypothesis H0: the statistically verifiable dependence does not exist between observed features A and B. On the contrary of alternative hypothesis H1: the statistically verifiable dependence exists between observed features A and B.

The statistics χ^2 is used as a testing criterion and is presented by the following ratio:

$$\chi^2 = \sum_{i=1}^{m}\sum_{j=1}^{r}\frac{\left(a_i \cdot b_j - \left(a_i \cdot b_j\right)_0\right)^2}{\left(a_i \cdot b_j\right)_0},$$

where a_i, b_j are number of students in analyzed category. The testing statistics χ^2 has the χ^2 - division with the number of variance levels $(m-1)\cdot(r-1)$ under the validity of testing hypothesis H0. The testing hypothesis H0 is rejected on the significance level α, if the value of testing criterion χ^2 exceeds the critical value $\chi^2_{\alpha;(m-1)\cdot(r-1)}$. The critical value χ^2, respectively KH can be found in the table of critical values [4].

The applying of χ^2 goodness of fit test finds out that there exists the dependence between the compared features; therefore it is suitable to determine the intensity of such dependence. Several measures were defined for the determination of dependence intensity between categorical features out of which the mostly used are Pearson's contingency coefficients. Pearson's coefficient of square contingency is defined as follows:

$$C = \sqrt{\frac{\chi^2}{n+\chi^2}}$$

Disadvantage of such a constructed coefficient is that the maximum coefficient value is strongly influenced by the size of pivot table. This feature is removed in the following so called Adjusted Pearson's contingency coefficient:

$$C_{adj} = \frac{C}{\min\left\{\sqrt{1-\frac{1}{r}};\sqrt{1-\frac{1}{m}}\right\}}$$

This adjusted coefficient takes valued from the interval $<0,1>$ for a pivot table of optional size and values are mutually comparable.

Cramer's contingency coefficient is the most frequently used for the assessment of dependence strength of pivot table of any size, defined as follows:

$$V = \sqrt{\frac{\chi^2}{n \cdot h}},$$

where h is the minimum from numbers (the number of rows $r - 1$) and (the number of columns $m - 1$); n is number of students [7]. The program Microsoft Excel 2013 was used for the realization of calculations and determination of critical values.

RESULTS AND DISCUSSION

The survey was realized in the classes of four different secondary schools in the city Nitra and 113 students participated in the survey, in the structure presented in the Table 1. Based on the following the number of girls and boys is approximately the same in the second classes. The girls prevail in the third class of octennial gymnasium and business academy and furthermore the average age is higher, what according to Tadlichová (2009, p.12) should cause that the preferred educational style differentiate as in the second classes of Parovské gymnasium and Golianove gymnasium.

Tab. 1 Respondents' structure

School	Abbreviation	Class	Boys	Girls	Total	Age average
Párovské gymnasium	GP	II. OG	14	11	25	13.44 years
Golianove gymnasium	GG	II. SA	14	13	27	13.40 years
Gymnasium of St. Cyril and Metod	GCM	Sexta	12	20	32	15.36 years
Business Academy	OA	I.A	9	20	29	15.44 years
		Total	49	64	113	

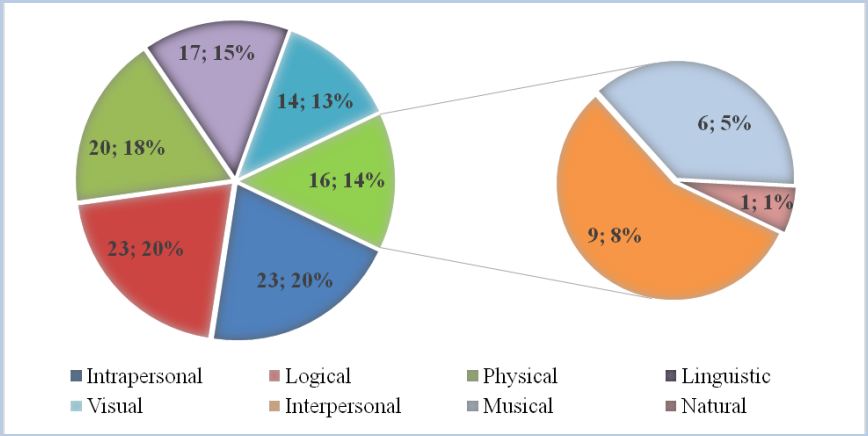

Fig. 1 Structure of students' educational styles of preferences

After the filling in the questionnaire the students were classified in groups according to preferred learning style. In the total sample of students just one student occurred (GCM), who

prefers the natural educational style. Similarly among the students of business academy even one student does not occur who would prefer musical educational style (Fig. 1).

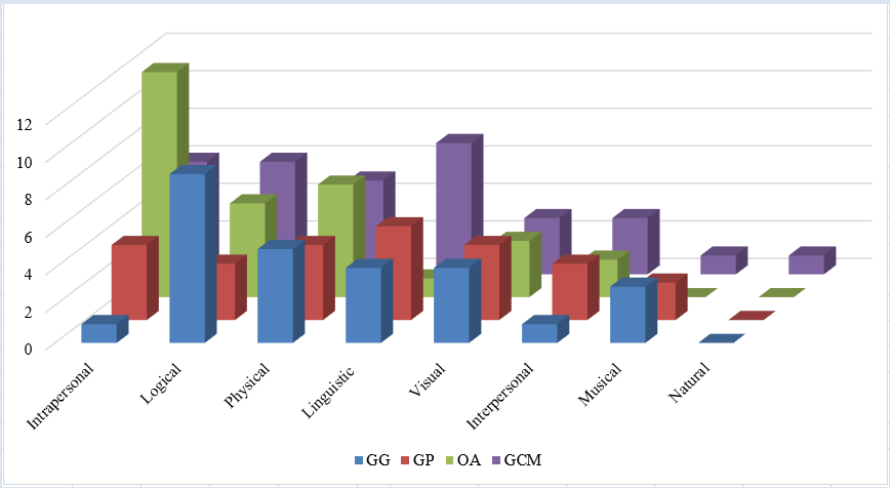

Fig. 2 Respondents' structure

When assessing the answers the compliance was found out for the most preferred educational styles when 23 students (20.35 %) submit logical or intrapersonal educational type (Tab. 1). For the second mentioned one is interesting its numerical superiority for the students of business academy. The third educational style is physical which dominates throughout 20 students (17.17 %). Further the verbal (Linguistic) educational style follows among 17 students (15.04 %) which dominates throughout the students of Gymnasium of St. Cyril and Metod (Fig. 2).

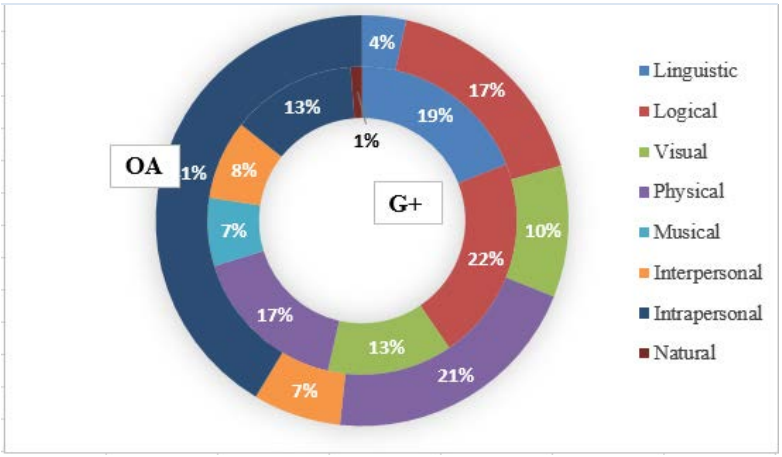

Fig. 3 Educational styles in accordance with the type of attended secondary school (SS)

If we compare the structure of students preferences in accordance with the type of attended secondary schools we find out that the students of special secondary school submit most frequently the dominance of intrapersonal educational style (41 % students) what is in

contrary with 13.10 % of gymnasium students. Vice versa the uniform dominance of some verified educational styles does not exist for gymnasium students (Fig. 3).

Based on the before mentioned we can assume the existence of statistically verifiable difference in the preferences of educational style for students of various types of secondary schools. However there exists the difference in the age of observed students (Table 1) we can accordingly assume the existence of differences in students' preferences.

We verified the validity of described hypotheses about the preference dependence of some above mentioned educational styles with some respondents' groups by the analysis of data acquired through the survey and following observation of interactions between students' answers. The results are presented in Table 2. This indicates that in four cases the existence of statistically verifiable influence of statistical feature B on the educational style was not confirmed. In three cases the existence of such influence was confirmed while in both cases when the sex was selected as the second feature so in case of girls the statistically verifiable dominant educational style exists. For girls differentiated in the age there is the preference of intrapersonal style which can be caused by the most numerous group of girls (12 persons) from the total observed sample the girls from business academy prefer the mentioned educational style. The values confirming the existence of dependence in the preference of educational style can be considered as marginal. The strength of such preference quantified by various dependence tightness levels can be considered as middle strong (Table 3).

Tab. 2 Verification of difference and dependence existence

	Acquired assessment	Value of testing statistics	
	***p*-value**	χ^2	$KH_{(0.05;n-1)}$
ES vs SS	0.0367	14.9468	14.0671
ES vs Age	0.1357	11.0670	
ES vs Sex	0.4813	6.5127	
ES vs SS (boys)	0.6131	4.4721	12.5916
ES vs age (boys)	0.8198	2.9122	
ES vs SS (girls)	0.0376	14.8760	14.0671
ES vs Age (girls)	0.0500	14.0668	

Tab. 3 Quantification of analysed dependence tightness

Tightness level of assessed dependence	Educational style vs.		
	SS	SS (girls)	Age (girls)
Pearson's contingency coefficient	0.3418	0.4343	0.4245
Adjusted Pearson's contingency coefficient	0.3654	0.4643	0.4538
Cramer's coefficient	0.3637	0.4821	0.4688

Similarly the middle strong dependence can be considered between the preferences of girls' educational style in accordance with the attended secondary school. Table 3 presents the existence of statistically middle strong dependence which is among all compared ones the least tight, viz. between preferred educational style and types of attended secondary school

CONCLUSIONS

The article deals with the existence of dominant educational styles in the learning of English language in the selected schools. Based on the statistical results and the graphical representation we conclude that 25 % (23 students) students preferred intrapersonal learning style. The interactions between students' answers were verified with the analysis of data acquired by the survey and further examination. The aim was to verify 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.

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Original Paper

Assessment of daylighting in the stable for dairy cattle by the computer program simulation Wdls 5.0

Milada Balková*

Slovak University of Agriculture in Nitra, Faculty of Engineering, Department of Building Equipment and Technology Safety, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic

ABSTRACT

The proper lighting in the stable is for the health, as well as for the usefulness of dairy cattle very important. In the stable we can assess the lighting by the measurement or by the simulation in an appropriate program. The advantage of simulation is that we are not dependent on the weather conditions, in which is daylighting variable. In this work we simulated the same two stables with different sizes of opening structures in the longitudinal walls. Using a computer program Wdls 5.0 we calculated the values of daylight factor. These values we compared in the selected profiles and rows by the tables and graphs. We have found that the opening of the side walls will improve the light conditions in the stable, but with such stable width do not affect the lighting in the middle of the stable. We can to improve conditions in a stable from overheating by change the technological arrangement and simultaneously we can design of such illuminating elements in skylight through which we achieve the smallest overheating of stable.

KEYWORDS: lighting simulation, program Wdls 5.0, stable, daylight factor

JEL CLASSIFICATION: C 63

INTRODUCTION

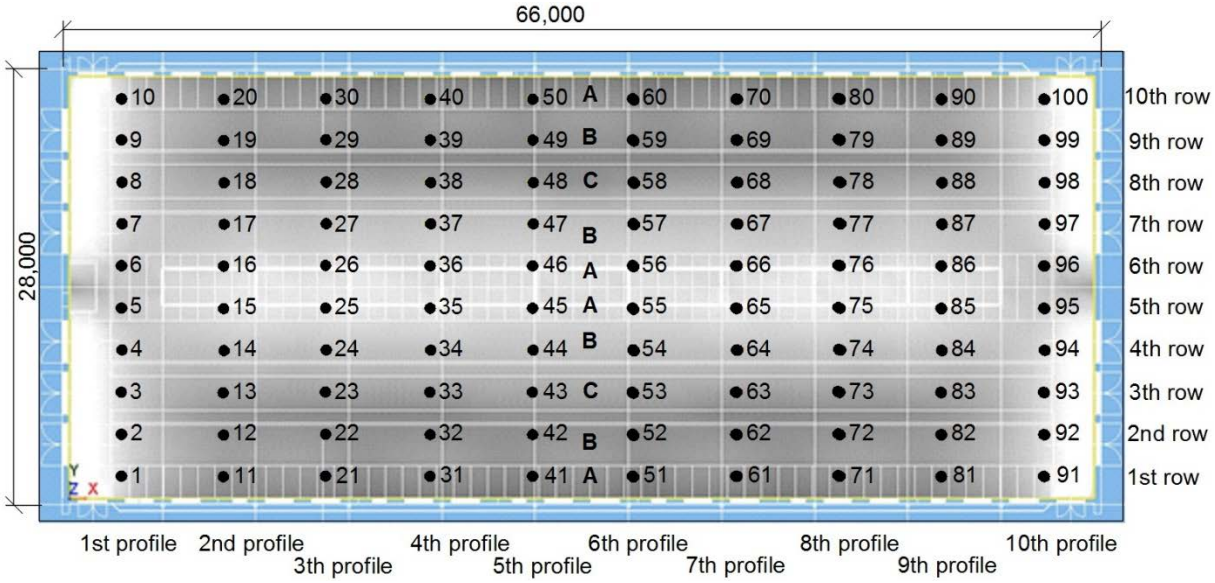
Light is an important factor of quality environment not only for humans, but also for animals. The light microclimate is an integral part of the environment [1]. It is therefore necessary to monitor in the stable not only microclimatic facilities of environment and air-containing gases, dust and micro-organisms, which are byproduct of the decomposition of animal excrements often due to imperfect metabolism of nutrients [4], as well as the light conditions. According to Chastain [1] 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 operation as ventilation, heating, or cooling.

* Corresponding author: Milada Balková, Slovak University of Agriculture in Nitra, Faculty of Engineering, Department of Building Equipment and Technology Safety, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic, e-mail: milada.balkova@uniag.sk

Assessment or design of daylighting in the stable we can do using simulation program Wdls 5.0, that combines a software for calculation of daylighting and new programming environment Building Design. The advantage of this program is, that we can simply model the rooms, buildings and barriers or we can use cooperation with AutoCAD, perhaps even we can use dxf ground plans.

MATERIAL AND METHODS

Using a computer program to daylighting calculation Wdls 5.0 we simulated two stables. Dimensions of stables were 66 m x 28 m. To the program environment Building Design we have then downloaded from dxf ground plan. Stables had the same dimensions and layout. The same dimensions were also barn doors in the front walls of stables. In the roof construction was a skylight, whose dimensions were 54 m x 2.4 m. The difference was in the longitudinal walls of the stables. The first stable had in the longitudinal walls windows with dimensions 900 x 900 mm and height of parapet 1,600 mm. The second stable had demolished the side walls. In the bottom of walls was installed parapet with a height 830 mm. In the side walls of the stable were situated pillars. To the program we entered parameters of particular openings and environment cleanliness. Before we started to count, we have added system of assessed points (Fig. 1). Height of reference surface, in which are calculated values of daylight factor, were 0.5 m about the ground. This is height, which is used for big sort of animals. Daylighting we assessed by daylight factor (D), which is expressed in percentage. The resulting values were compared with the standard [6] according to the minimum value of daylight factor (D_{min}) for dairy cattle should be 1.0 %.



● 1 – number of measuring point
A – cubicle, **B** – manure passage, **C** – feed passage

Fig. 1 Plan of the assessed object and measuring points

RESULTS AND DISCUSSION

After entering all values into the program we started the calculation of the daylight factor. In the area of the stables were 100 points, which were evenly distributed in the whole building. In the transverse direction was the stable divided into ten profiles, in the longitudinal direction was divided into ten rows (Fig. 1). In Figure 2 and 4a is a graphical representation of the daylight in the stable with the windows in the longitudinal walls. In Figure 3 and 4b is a graphical representation of the daylight in the stable with opened side walls. In Table 2 are calculated values of daylight factor in both stables in the first and fifth profile. The first profile is located near the opened barn doors, that affect the lighting in the stable. In this profile is appropriate lighting at all points. The small differences in the values of daylight factor are only the longitudinal walls. The fifth profile is located approximately in the middle of the stable. The biggest difference in lighting between stables is in cubicles that are near the longitudinal walls. In the manure passages, which are located near the longitudinal walls, in the stable with windows, is insufficient lighting. Under the skylight, which is situated in the middle of the stable is the biggest lighting. Lighting values are in both cases approximately the same. In this section is not influence of lighting from openings in longitudinal walls. We can it see in the model rows (Table 2). The first row is in cubicles, situated in the longitudinal walls. Here we can see the biggest impact of the size of opened structures. In cubicles situated under the skylight is difference in the values of daylight factor minimal. The difference in lighting between the stables we can see in the graphs, which are in Figures 5 to 9.

Tab. 1 Values of daylight factor (D) in the 1st and 5th profile

The serial number of point	Measurement point 1st profile	D, %; 1st profile		Measurement point 5th profile	D, %; 5th profile	
		Stable with windows	Stable with opened side walls		Stable with windows	Stable with opened side walls
1	1	3.1	4.3	41	1.4	3.6
2	2	2.5	2.7	42	0.8	1.2
3	3	2.3	2.4	43	1.1	1.3
4	4	2.4	2.4	44	2.2	2.3
5	5	1.8	1.9	45	3.5	3.5
6	6	1.8	1.9	46	3.7	3.8
7	7	2.4	2.4	47	2.2	2.3
8	8	2.3	2.4	48	0.7	0.9
9	9	2.5	2.7	49	0.8	1.2
10	10	3.1	4.3	50	1	3.6

The stable with windows and the stable with opened side walls

Tab. 2 Values of daylight factor (D) in the 1st, 3th and 5th row

The serial number of point	Measurement point 1st row	D, %; 1st row		Measurement point 3th row	D, %; 3th row		Measurement point 5th row	D, %; 5th row	
		Stable with windows	Stable with opened side walls		Stable with windows	Stable with opened side walls		Stable with windows	Stable with opened side walls
1	1	3.1	4.3	3	2.3	2.4	5	1.8	1.9
2	11	1.2	3.8	13	0.8	1	15	4.2	4.3
3	21	1.9	3.6	23	0.7	0.9	25	4.6	4.7
4	31	1.9	3.4	33	0.7	0.9	35	4.5	4.6
5	41	1.4	3.6	43	1.1	1.3	45	3.5	3.5
6	51	1.0	3.6	53	1.1	1.3	55	3.5	3.5
7	61	1.9	3.4	63	0.7	0.9	65	4.5	4.5
8	71	1.9	3.6	73	0.7	0.9	75	4.6	4.7
9	81	1.5	3.8	83	0.8	1.0	85	4.2	4.3
10	91	3.1	4.3	93	2.3	2.4	95	1.8	1.9

The stable with windows and the stable with opened side walls

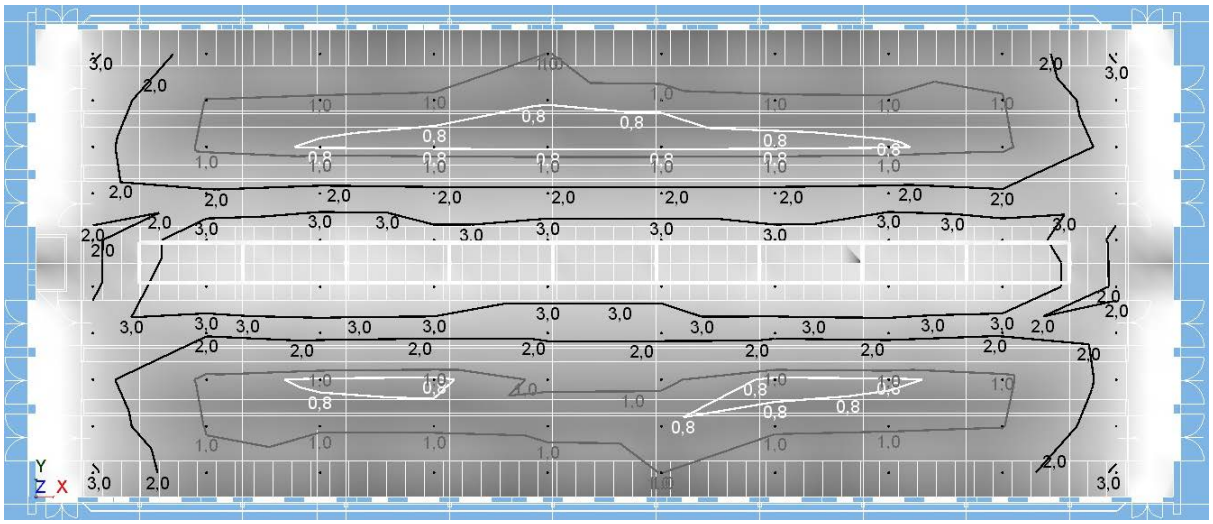


Fig. 2 The graphic presentation of daylighting in the stable with windows

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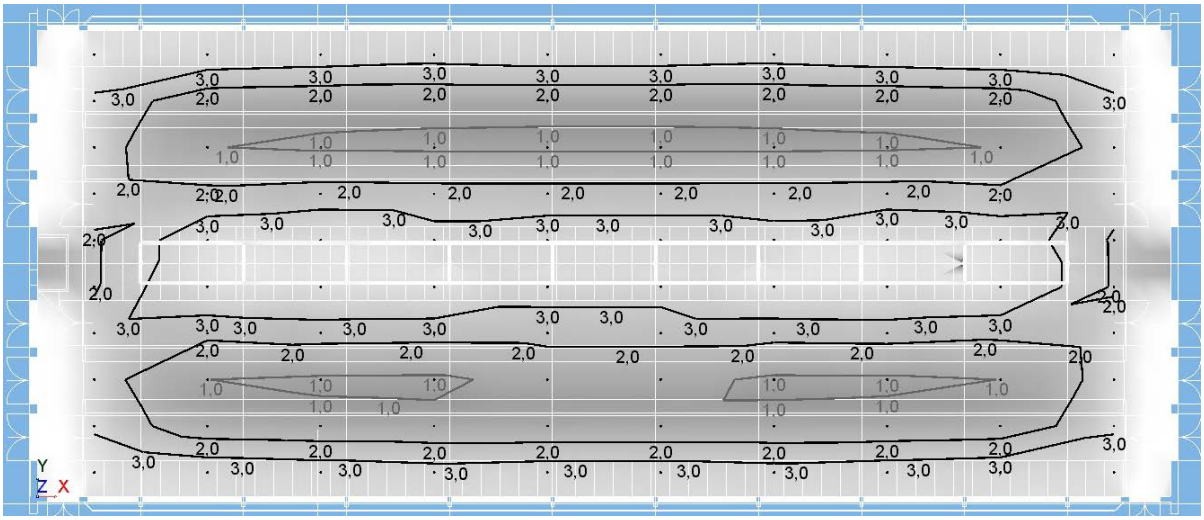
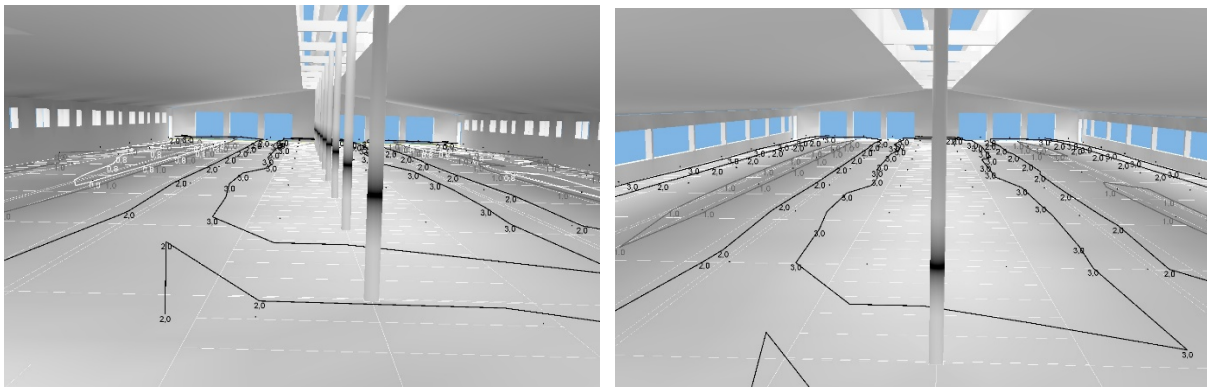


Fig. 3 The graphic presentation of daylighting in the stable with opened side walls



a) Stall with windows b) Stall with opened side walls

Fig. 4 Daylighting by looking into the interior of the stable

Fig. 5 Values of daylight factor in 1st profile

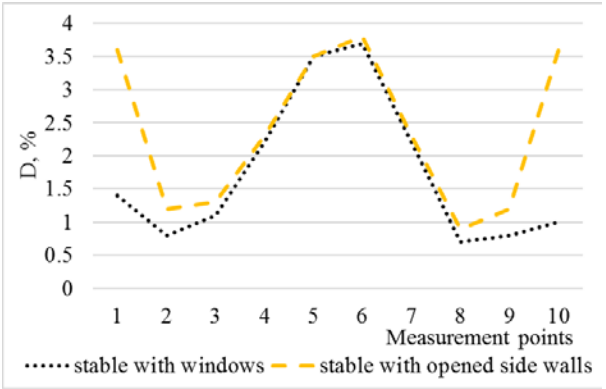


Fig. 6 Values of daylight factor in 5th profile

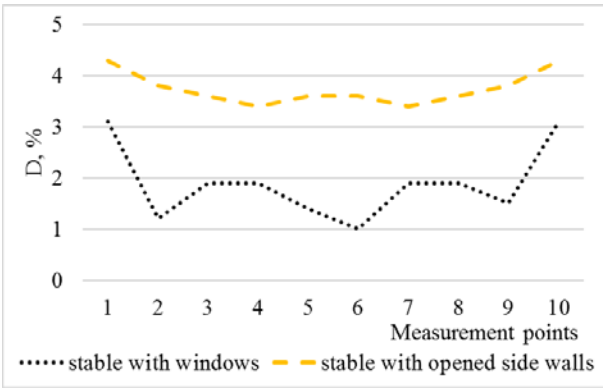


Fig. 7 Values of daylight factor in 1st row

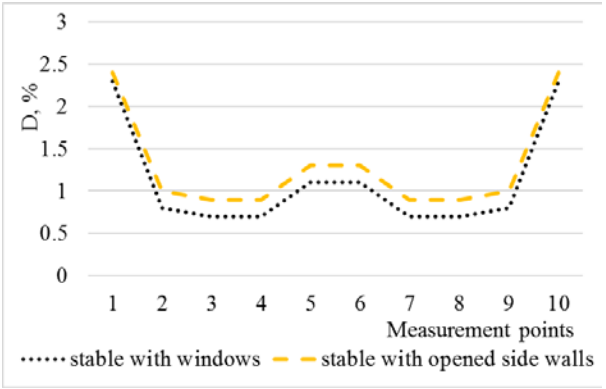


Fig. 8 Values of daylight factor in 3th row

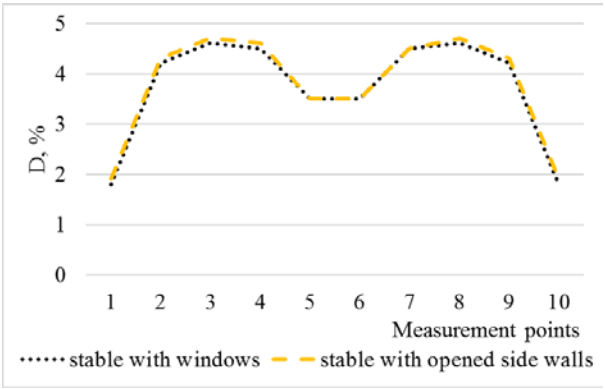


Fig. 9 Values of daylight factor in 5th row

Dairy cows need plenty of daylight. Studies have shown that exposing cows to supplemental light during the short days of autumn and winter can increase milk production by about 5-16 % [2]. In the case, where were the side walls opened, light has improved mainly in cubicles, that had been placed in the side walls. Light has improved partly also in manure passage. On cubicles that were situated under the skylight, the demolished side walls had almost no influence. Lighting under skylight was in both cases sufficient. The disadvantage is that comb skylight lighting improved, but in the summer pose a risk of increased heat load of animals [5]. The way as possible to prevent overheating of the stable is the use of such illuminating elements, that reflect the sunrays. Window glazing with better thermal insulation properties have in many cases reduced transmittance of solar radiation [3]. Another possible solution to improve the lighting is artificial lighting. It is important especially in winter. A suitable solution would be adding a light sensor device to the lighting system which would switch on the system automatically if the lighting levels get worse [7].

CONCLUSIONS

The work deals with the assessment of stables for dairy cattle by the simulation in computer program Wdls 5.0., which after entering of necessary data directly calculates values of daylight factor. Into this program we simulated two the same stables with different sizes of

opened structures in the longitudinal walls. After the extension of these openings in the stable the lighting conditions improved. Part of stables, which was situated under skylight was not by this change affected. Here is more of problem with overheating of stable under skylight. Conditions for animals with cubicles directly under the skylight we can improve in two methods. One method is change the technological arrangement of stable so, that the cubicles under the skylight was not situated. The second method, which is simpler, is design of such illuminating elements in skylight through which we achieve the smallest overheating of stable.

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Original Paper

Application of linear programming

Alexandra Filová*, Veronika Hrdá

Slovak University of Agriculture in Nitra, Faculty of Economics and Management, Department of Management, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic

ABSTRACT

Object of the interest of the given paper is the area of linear programming and its application in economic practice. It is possible to find basic characteristics, definitions, possibilities of records as well as description of selected task solution of linear programming in the paper. The authors focused on solution of a certain issue and therefore showed overall approach within solution of this kind of issues we come across each day in economic practice. The main goal of the paper is application of steps and algorithms focused on solution of issues connected with minimalization of costs created within purchase of materials used in a production company.

KEYWORDS: linear programming, nutrition issue, graphical solution

JEL CLASSIFICATION: C610, A20

INTRODUCTION

Theory of mathematical programming as Brezina et al. state [1] "was elaborated in accordance with task solution of effective exploitation of bounded disposable resources necessary for reaching the given goals". Moreover, the authors state that "each task of mathematical programming is constructed with the aim to display some economic situation in which we try to find the best possible solution within specific bounded prerequisites". Numeric optimization methods are a part of various quantitative economic investigations, whereas many of them can be expressed by linear functions. Linear programming as a part of operational research has significantly rich history and nowadays represents scientific discipline of which the issues, tasks and questions are described in a great details. A linear programming (sometimes known as linear optimization) problem may be defined as the problem of maximizing or minimizing a linear function subject to linear constraints. The constraints may be equalities or inequalities. Simplistically, linear programming is the

* Corresponding author: Alexandra Filová. Slovak University of Agriculture in Nitra, Faculty of Economics and Management, Department of Management, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic.
E-mail: alexandra.filova@uniag.sk

optimization of an outcome based on some set of constraints using a linear mathematical model.

MATERIAL AND METHODS

According to Fábry [2] basically we distinguish three basic forms of linear programming tasks (LP)[1].

I. General form of LP tasks, it is a task to find points $\boldsymbol{x} \in R^n$, in which the linear form of n variables reaches:

$$f(\boldsymbol{x}) = \boldsymbol{c}^T.\boldsymbol{x} = \sum_{j=1}^{n} c_j.x_j = c_1.x_1 + c_2.x_2 + \cdots + c_n.x_n \qquad (1a)$$

maximum, resp. minimum in set $S \subset R^n$ of all the points $\boldsymbol{x} = (x_1, x_2, \ldots, x_n)^T$ suitable for equalities and inequalities in the form:

$$\begin{aligned} &\sum_{j=1}^{n} a_{ij}.x_j \leq b_i && i = 1,2,\ldots,p \\ &\sum_{j=1}^{n} a_{ij}.x_j = b_i && i = p+1, p+2, \ldots, m \\ &x_j \geq 0 && j = 1,2,\ldots,n \end{aligned} \qquad (1b)$$

Note:

1. For values b_i, where $i = 1,2,\ldots,m$ from (1b) there are no limitations. These can reach positive, negative and zero values.
2. Objective function $f(\boldsymbol{x})$ is not identically equal zero, i.e. exists $c_j \neq 0$, where $1 \leq j \leq n$.
3. There are cases when general formulation does not include the condition of non-negativity for all the variables x_j, where $j = 1,2,\ldots,n$.

II. Canonical form of LP tasks representing general form (1) which can be formulated as follows: To find points $\boldsymbol{x} \in R^{n+p}$, in which the linear form of $n+p$ variables reaches:

$$f(\boldsymbol{x}) = \boldsymbol{c}^T.\boldsymbol{x} = \sum_{j=1}^{n} c_j.x_j + \sum_{j=n+1}^{p} 0.x_j = c_1.x_1 + c_2.x_2 + \cdots + c_n.x_n + 0.x_{n+1} \cdot 0.x_{n+2} + \cdots + 0.x_{n+p} \qquad (2a)$$

maximum, resp. minimum in set $S \subset R^{n+p}$ of all points $\boldsymbol{x} = \left(x_1, x_2, \ldots, x_{n+p}\right)^T$ having a form of equalities:

$$\begin{aligned} &\sum_{j=1}^{n} a_{ij}.x_j + \sum_{j=1}^{p} \delta_{ij} x_{n+j} = b_i && i = 1,2,\ldots,p \\ &\sum_{j=1}^{n} a_{ij}.x_j = b_i && i = p+1, p+2, \ldots, m \\ &x_j \geq 0 && j = 1,2,\ldots,n+p \end{aligned} \qquad (2b)$$

Note:

1. δ_{ij} is indication of so called Kronecker delta[2].
2. Newly given variables x_{n+j}, where $j = 1,2,\ldots,p$ are called additional variables.
3. Canonical task (2) about maximum can be equivalently converted to a task about minimum by changing objective function $f(\boldsymbol{x}) = \sum_{j=1}^{n} c_j.x_j$ to $f(-\boldsymbol{x}) = \sum_{j=1}^{n} -c_j.x_j$.

[1] All these three types of LP are tasks are equivalent meaning that by simple modifications it is possible to convert them.

[2] Enables more economical record. Stated: $\delta_{ij} = 1$ for $i = j$ and $\delta_{ij} = 0$ for $i \neq j$.

III. Standardized form of LP tasks defining general form (1) can be formulated as follows: To find points $\boldsymbol{x} \in R^n$, in which linear form of n variables reaches:

$$f(\boldsymbol{x}) = \boldsymbol{c}^T.\boldsymbol{x} = \sum_{j=1}^{n} c_j.x_j = c_1.x_1 + c_2.x_2 + \cdots + c_n.x_n \qquad (3a)$$

maximum, resp. minimum in set $S \subset R^n$ of all points $\boldsymbol{x} = (x_1, x_2, \ldots, x_n)^T$ suitable for inequalities in form:

$$\begin{aligned} &\sum_{j=1}^{n} a_{ij}.x_j \leq b_i && i = 1,2,\ldots,m \\ &\sum_{j=1}^{n} a_{ij}.x_j \geq b_i && i = 1,2,\ldots,m \\ &x_j \geq 0 && j = 1,2,\ldots,n \end{aligned} \qquad (3b)$$

One of the possible methods used for solution of LP tasks is a graphical method which, as Klvaňa [3] states, is valuable especially because it is graphic.

Fig. 1. Algorithm of graphical method of LP task solution for two variables x_1 and x_2

Step I.	Coordinative axis x is indicated as x_1 and coordinative axis y is indicated as x_2
Step II.	We draw set of possible solutions S by displaying all the half-planes suitable inequalities and all the straight lines suitable for equalities in limited conditions (1b). Set of suitable solutions is intersection of all the half-planes and straight lines. If this intersection is not empty it is therefore convex polyedric set in plane.
Step III.	We display objective function in graph (1a). The easiest images are contour lines called as well isolines which create a set of parallels.
Step IV.	We find point or points from the set of possible solutions (if they exist) in which objective function reaches required extreme.

Source: authors elaboration based on [4]

In spite of the fact that optional LP task can be interpreted geometrically there are limitations for graphic solution and representation of these tasks.

1. Set of possible solutions S is a part of maximally three-dimensional space R^3. LP task can be given in general form (1).
2. Dimension n of space R^n, in which the task is solved, can be more than 3, although LP task must be given in canonical form (2) and must be stated $n - m = l$, where $l = 1,2,3$.

Specific procedure of using graphical method for LP tasks solution which consists of four steps is given in the Fig. 1. It shows a case for two variables x_j, where $j = 1,2$, solution of which can be drawn in double-dimensional graph, i.e. in a plane.

RESULTS AND DISCUSSION

In many cases, significantly easy tasks which have only basic elements in common with the real models are solved as model tasks. The main reason for this simplification is the fact that real system contains many elements which are not substantial for theoretical examples and models are so complicated that the substance of the solved issue is not often clear.
In the following part we give an example with its possible solution.

Task
A company produces forage mixture which contains 2 components Z_1 and Z_2. Forage mixture should contain at least 48 units of L_1 substance and 60 units of L_2 substance. Component Z_1 contains 8 units of L_1 substance and 20 units of L_2 substance and component Z_2 contains 16 units of L_1 substance and 10 units of L_2 substance. These components are stocked by the company in a warehouse with capacity of 24 m^2 whereas Z_1 takes 2 m^2 and Z_2 takes 3 m^2. Moreover the company has got an order for a sale of Z_2 component in the amount of 9 units. The price for which the company purchases the Z_1 component is 20 euro and Z_2 component is 12 euro.
The aim of the task:
The management of the company wants to know in what amount they should purchase Z_1 and Z_2 components so that the overall costs for the company are minimum.
Creation of mathematical model:

Tab. 1 Table of an example about nutrition issue

	$Z_1(x_1)$	$Z_2(x_2)$	Limitation
Price (euro)	20	12	MIN
L_1 (units)	8	16	48
L_2 (units)	20	10	60
Warehouse (m^2)	2	3	24
Sale (units)	5	9	-

The situation that emerged in the company can be clearly written in a table (see table 1) which significantly simplifies orientation in the given issue. Consequently we set a mathematical model of LP task in general form whereas inequalities of limited conditions can be indicated by the letters of alphabet. x_1 variable represents the amount of Z_1 component purchased by the company and x_2 variable represents purchased amount of Z_2 component.

Objective function:

$$f(x) = 20x_1 + 12x_2 \qquad f(x) \rightarrow minimum \qquad (4)$$

Limited conditions:

$$08x_1 + 16x_2 \geq 48 \quad (5a) \qquad x_1 \geq 0 \quad (5d)$$
$$20x_1 + 10x_2 \geq 60 \quad (5b) \qquad x_2 \geq 9 \quad (5e)$$
$$02x_1 + 03x_2 \leq 24 \quad (5c)$$

Solution of the task by graphical method:

To solve the given nutrition task we use geometrical method and algorithm which is given in the previous part. Specific solution is shown in the Fig. 2. According to the fact that x_1 and x_2 variables can reach negative values, the set of possible solutions S is always given in the first quadrant.

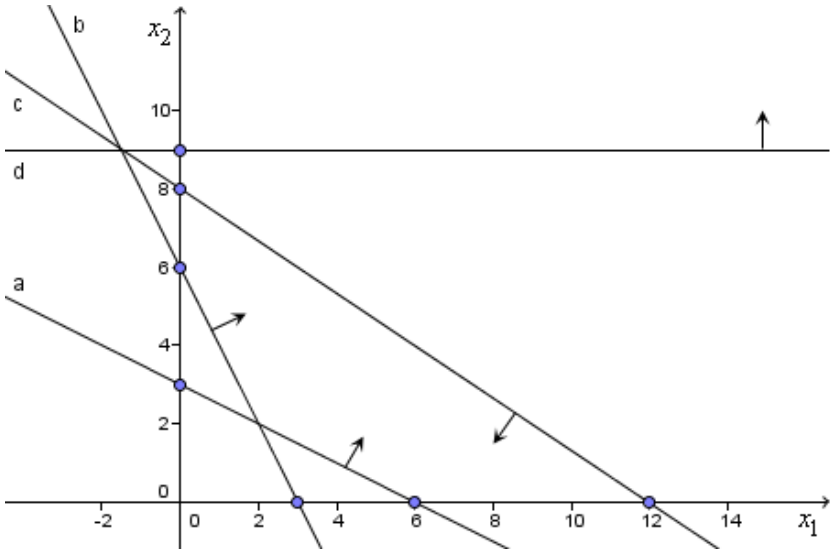

Fig. 2 Geometrical solution of the nutrition task

The Fig. 2 shows that such LP task does not have a solution because the intersection of all half-planes, i.e. a set of possible solutions S is an empty set. In other words, a set of limited conditions of the LP task is not consistent.

In such case the company has more possibilities how to solve the given task. They could for example not to accept the order for a sale of Z_2 component in the amount of 9 units or sell smaller amount. Another alternative could be increasing of stock capacity and so forth.

Solution of modified task by graphical method:

In this case we voted for the first out of above mentioned possibilities as a solution, i.e. the company denies the sale of Z_2 component. It means that from the mathematical model of the original task about nutrition issue, inequality $x_2 \geq 9$ is omitted and we add the second condition of non-negativity $x_2 \geq 0$.

Graphical solution of modified task is shown in the Fig. 3 which shows a set of possible solutions S given in light blue color. It creates a pentagon with its points A, B, C, D and E. Each point[3] of this set is a solution of the given LP task.

[3] Contains all the point on the edges, boarders and internal set of possible solutions S.

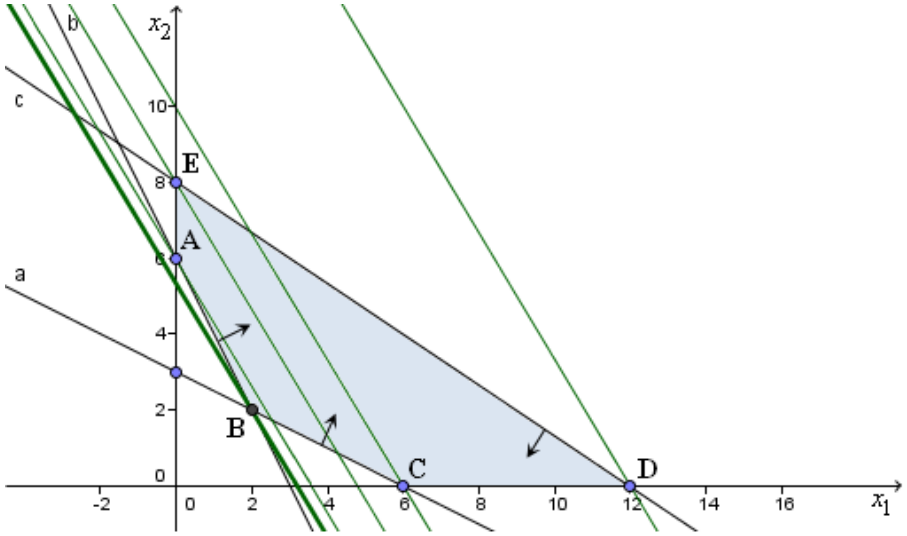

Fig. 3 Geometric solution of modified nutrition task

To look for extreme in objective function is essential only on the edges of possible set S. Therefore table 2 shows values of objective function for these five edges. Table 2 as well as Fig. 3 show that minimum value is reached by objective function on the edge B, i.e. in a point where set of possible solutions S are touched by isoline in the smallest value (in the Fig. 3 we can see line in green color).

Tab 2 Values of objective function on the edges of possible set of tasks

Point	Coordinates of point	Value of objective function in the given point	
A	[0.6]	$20.0 + 12.6 = 72$	⇐ Point in which objective function reaches minimum value
B	**[2.2]**	$20.2 + 12.2 = 64$	
C	[6.0]	$20.6 + 12.0 = 120$	
D	[12.0]	$20.12 + 12.0 = 240$	
E	[0.8]	$20.0 + 12.8 = 96$	

From the above mentioned findings we can state that within given limitations it is more advantageous for the company to purchase optimally 2 units of Z_1 component and 2 units of Z_2 components with overall costs 64 euro.

CONCLUSIONS

As we already mentioned linear programming is a part of operational research known as well as managerial science. Their meaning is to provide managers with exact quantitative solutions for decision-making they come across in everyday economic practice. Specific goal of the

given paper was the area of linear programming, which is a part of above mentioned managerial science or operational research and it is one of the branches of applied mathematics. This goal was up to some level fulfilled but for the shortage of space in the given paper we did not provide detailed information and many findings of linear programming were intentionally omitted.

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Original paper

Evaluation of consumers' purchase behavior by means of mathematical and statistical methods

Dana Országhová[1*], Dagmar Kozelová[2], Peter Chládok[2]

[1] Slovak University of Agriculture, Faculty of Economics and Management, Department of Mathematics, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic
[2] Slovak University of Agriculture, Faculty of Biotechnology and Food Sciences, Department of Food Hygiene and Safety, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic

ABSTRACT

The objective of this paper was the identification and evaluation of the purchase preferences of the Slovak consumers of small fruits and berries. The evaluation of the consumers' purchase behavior was carried out by methods of mathematical statistics. Data collection for the identification of main preferences in the purchase and consumption of small fruits was conducted by the questionnaire survey. We applied methods of statistical hypotheses testing and finding out dependencies between the determined characters. The existence of a statistically significant relationship was verified by χ^2- test. Calculations were performed by tools of MS Excel, 2013. The statistical hypotheses testing showed that in the process of the purchase of small fruits there is no statistically significant relationship between the gender of respondents and the country of origin of fruits. Similarly, we found out that there is no statistically significant relationship between the respondent's age and the country of origin of small fruits.

KEYWORDS: statistical dependence, χ^2-test, questionnaire survey, purchase behavior, small fruits

JEL CLASSIFICATION: K45, M10, M65

INTRODUCTION

In this paper we deal with the consumers behavior in the purchase of small fruits and berries. The main objective of this contribution is to evaluate data of the exploratory survey, which is concerning the consumers purchase behavior, by appropriate statistical methods. On the basis of obtained answers of the respondents – consumers we want to find out what kinds of small fruits and berries Slovak consumers usually eat, what are the motives of their purchase and whether it is important the information about the country of the product origin.

[*] Corresponding author: Dana Országhová, Slovak University of Agriculture, Faculty of Economics and Management, Department of Mathematics, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic
E-mail: dana.orszaghova@uniag.sk

Various methods of mathematical statistics are used to the evaluation of the purchasing behavior of consumers. Vietoris et al. [8] applied the hierarchical multiple factor analysis (HMFA) to the evaluation of the marketing exploration of the consumers' preferences. Detection of dietary habits and preferences of consumers is the objective of different investigation and research projects [4]. Gluten-free products are intended for people with celiac disease and they are very important for them. As Nagyová et al. in [7] report, the most important criterion in the purchase of gluten free products is their quality (51.54 % of respondents). Healthy lifestyle, good diet and purchase of organic products are also reflected in consumer preferences as significant factors.

Fruit is an indispensable component of the human food for its high content of vitamins, enzymes, minerals, fiber and other healthful substances. Matošková et al. in [6] report that on the Slovak market the fruit is consumed in the fresh form and also in the form of various products of the food industry. They found out that in the period 2002 - 2011 it has changed the share of the import of the fresh fruit to Slovakia in relation to the domestic consumption (from 41 % in 2002 to 80.5 % in 2011) and in the relation to the domestic production (from 62.3 % in 2002 to 191.7 % in 2011). It follows that in the last year of the observed decade the volume of the fruit import was almost twice the size in the comparison with the domestic production.

MATERIAL AND METHODS

The behavior of consumers during the purchase of small fruits was analyzed from the input data obtained by the questionnaire survey. The survey was conducted from the October 2012 to the January 2013, and we obtained answers of 300 respondents. The characteristic of the respondents by the gender was as follows: 58 % of women and 42 % men. Distribution of the research sample according to the economic activity: 48 % of students, 36 % employed, 6 % unemployed and 9 % pensioners. Distribution into groups according to the age: 49 % of respondents under 25 years, 21 % of respondents from 26 to 40 years, 19 % of respondents from 41 to 55 years and 11 % of respondents over 56 years. The structure of respondents by the education: 5 % with primary education, 56 % with secondary education and 39 % with university education.

From the methodological point of view in this paper there were used statistical methods for the measurement of the dependence, resp. associations of observed variables. We assessed the statistical significance of relations by means of χ^2-test. Calculations were carried out by means of MS Excel 2013.

As the first method we will use χ^2-test of independence [5] for the verification the hypothesis if the examined variables of the statistical sample are dependent or independent. We get the statistical sample of a range n and we will investigate two attributes signed X, Y which acquire more levels. The primary table for quantitative characteristics is a sequence of ordered pairs $[x, y]$ which are further sorted out into contingency table.

When examining the dependence between the attributes we verify the following hypotheses:
Null hypothesis: Attributes X and Y are independent.
Alternative hypothesis: Attributes X and Y are dependent.

The test criterion is expressed by formula:

$$\chi^2 = \sum_{i=1}^{r}\sum_{j=1}^{s}\frac{\left(a_i \cdot b_j - \left(a_i \cdot b_j\right)_0\right)^2}{\left(a_i \cdot b_j\right)_0},$$

where a_i, b_j are number of frequencies (in our case respondents) in analyzed category. Critical region is interval $W_\alpha = (\chi^2((r-1)(s-1));\infty)$, where $\chi^2((r-1)(s-1))$ is the critical value of χ^2 – probability distribution. We conclude: If $\chi^2 \in W_\alpha$, so the hypothesis H_0 is refused in favor of the alternative hypothesis; if $\chi^2 \notin W_\alpha$, so the hypothesis H_0 cannot be refused.

RESULTS AND DISCUSSION

We processed answers of conducted questionnaire survey and we identified the opinions and preferences of consumers in relation to the purchase and consumed of small fruits. The results show that strawberries (35 %) and raspberries (22 %) are the most consumed kinds of small fruits. Red currants (11 %), blackberry (10 %) and black currants (9 %) also belong to the often consumed kinds. A minor part of respondents chose gooseberries (6 %) and cranberries (6 %). Other kinds of small fruits accounted for 1 % share.

Suitable organoleptic properties (smell, taste and texture) are the reason for fruit consumption for 51 % of respondents. Part of 27 % of respondents buys small fruits grown organically and products thereof in bio quality. The quality of small fruits is important for 93 % of respondents. Within the examination of the other motifs of consumption of small fruits, we found that 48 % of respondents consume those for the high content of biologically active substances such as vitamins, polyphenols, organic acids and minerals [3].

In the survey the respondents were asked to answer this question:
In what form do you eat small fruits and berries?
In the Fig. 1 there is the graph of the responses (expressed in percentages).

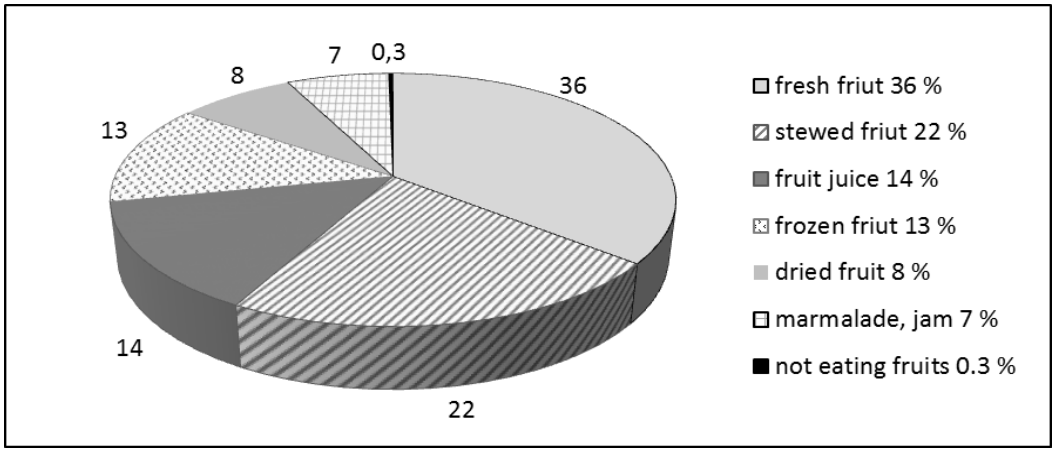

Fig. 1 The distribution of responses according to the form of the fruit consumption

The country of origin of the imported small fruits was studied in the next question:
Is the country of origin important for you when buying small fruits?

We can positively evaluate that 94 % of respondents prefer small fruits grown in Slovakia. The country of origin of fruits is important for 30 % of respondents when buying ones; sometimes it takes into account the 42 % of respondents, and is completely irrelevant for 28 % of respondents. The distribution of responses by the gender: the country of origin when buying small fruits is prefered by 32 % of women and it does not important for 23 % of women. This factor is important for 28 % of men when buying fruits; in reverse, the country of origin is not important for 34 % men. In percentage, the most respondents from women and men said that the country of origin (when buying small fruits) is important only sometimes: exactly 45 % of women and 38 % men. In the Fig. 2 there are graphically shown the answers of respondents in accordance to the gender.

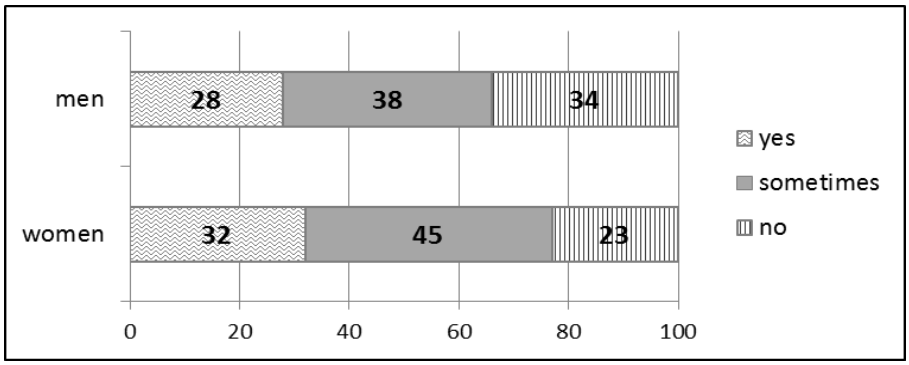

Fig. 2 The preference of respondents: the country of origin in relation to the gender
Expressed in percentages. Source: authors

The age of the respondents was the next classification criterion. When buying small fruits the country of origin is important: for 41 % of respondents aged 41-55 years, for 29 % of respondents under the age of 25 years, for 26 % of respondents aged 23-40 years and for 24 % of respondents older than 56 years. The country of origin has no significant influence on the purchasing decisions of small fruits for 35 % of respondents aged over 56 years, for 29 % of respondents under the age of 25 years, for 26 % of respondents aged 41-55 years and for 23 % of respondents aged 26-40 years. In the Fig. 3 the graph shows the answers of respondents according to their age.

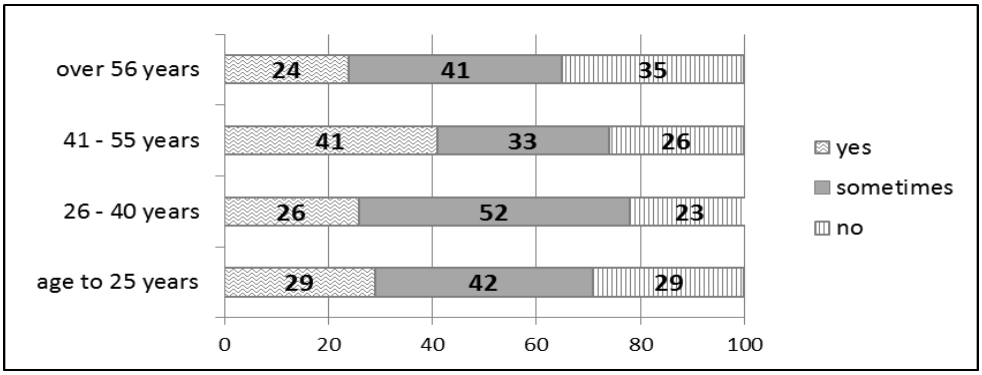

Fig. 3 Respondents preferences of the country of origin in relation to the age
Expressed in percentages. Source: authors

In the research part we tested two null hypotheses and we processed the obtained results.

The first hypothesis H_0: The country of origin of small fruits is not statistically significant factor in the purchase decision of the consumer in relation to the gender.

The second hypothesis H_0: The country of origin of small fruits is not statistically significant factor in the purchase decision of the consumer in relation to the age of the respondent.

In the Tab. 1 we summarized the results to the hypotheses testing.

Tab. 1 Results of the statistical evaluation of responses

Country/criterion	Country of origin/gender	Country of origin/age
Frequency	300	300
χ^2 characteristics	4.534	7.286
Critical value	5.991	12.592
Outcome	$\chi^2 \notin (5.991, \infty)$ H_0 not refused	$\chi^2 \notin (12.592, \infty)$ H_0 not refused
Dependence	no	no

Source: authors

The results to the first null hypothesis tested by χ^2-test:

- We have found that when buying small fruits there is no statistically significant relationship between the gender of a respondent and the importance of the country of origin of the fruits. The value of the test criterion is 4.534; therefore it is true $\chi^2 \notin (5.991, \infty)$. On the chosen level of significance ($\alpha = 0.05$) we cannot refuse the null hypothesis about the independence of observed characters. We found that there was no significant relationship between the gender of a respondent and the country of origin when buying small fruits.

The results to the second null hypothesis tested by χ^2-test:

- The results have proved that when buying small fruits there is no statistically significant relationship between the age of a respondent and the importance of the country of origin of the fruits. The value of the test criterion is 7.286; therefore it is true $\chi^2 \notin (12.592, \infty)$. On the chosen level of significance ($\alpha = 0.05$) we cannot refuse the null hypothesis about the independence of observed characters. Thus, the age of the respondent has no importance when deciding on purchasing fruit according to the country of origin.

These results also confirm the fact that foreign products are cheaper in the stores and the consumers are choosing products according to the price and then according to the country of origin. The consumers are the economic and want to maximize their own utility. At the same time, they are trying to determine the quality attributes of the selling products.

The health benefits of eating small fruits are confirmed by the research work of various authors. Habánová et al. [2] state that due to regular consumption of blueberries for three weeks, the total cholesterol level decreased slightly. Research shows that regular consumption of small fruits has a preventive effect against cardiovascular diseases [1], also reduces the risk of cancer, atherosclerosis and tumor diseases [9].

CONCLUSIONS

Consumers' purchase behavior is influenced by many internal and external factors. The objective of this contribution was to identify consumers' opinions and preferences in the purchase of small fruits and berries and assess the impact of the country of origin of small fruits in deciding of the consumer to buy them. In the research part we have tested two hypotheses by χ^2-test. The hypotheses were related to the preferences of consumers in the purchase and consumption of small fruits in relation to the gender and age of respondents. The research sample was composed of 300 respondents. The results of testing hypotheses did not prove the existence of the statistically significant relationship between observed attributes: the country of origin and the gender of a respondent; the country of origin and the age of a respondent.

The conducted survey on the sample of Slovak consumers and its evaluation show interesting and important facts about purchasing and consuming of small fruits and berries. These findings can be useful for both, the Slovak sellers of fruit and producers of small fruits. On the basis that there is no significant relationship between the respondent's gender and the country of origin of small fruit, as well as between the respondent's age and the country of origin of small fruit, it can be assumed that the consumers make decisions based on the price of fruit, or on other factors. This finding may be a topic for further investigation of the process of consumer decision-making.

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