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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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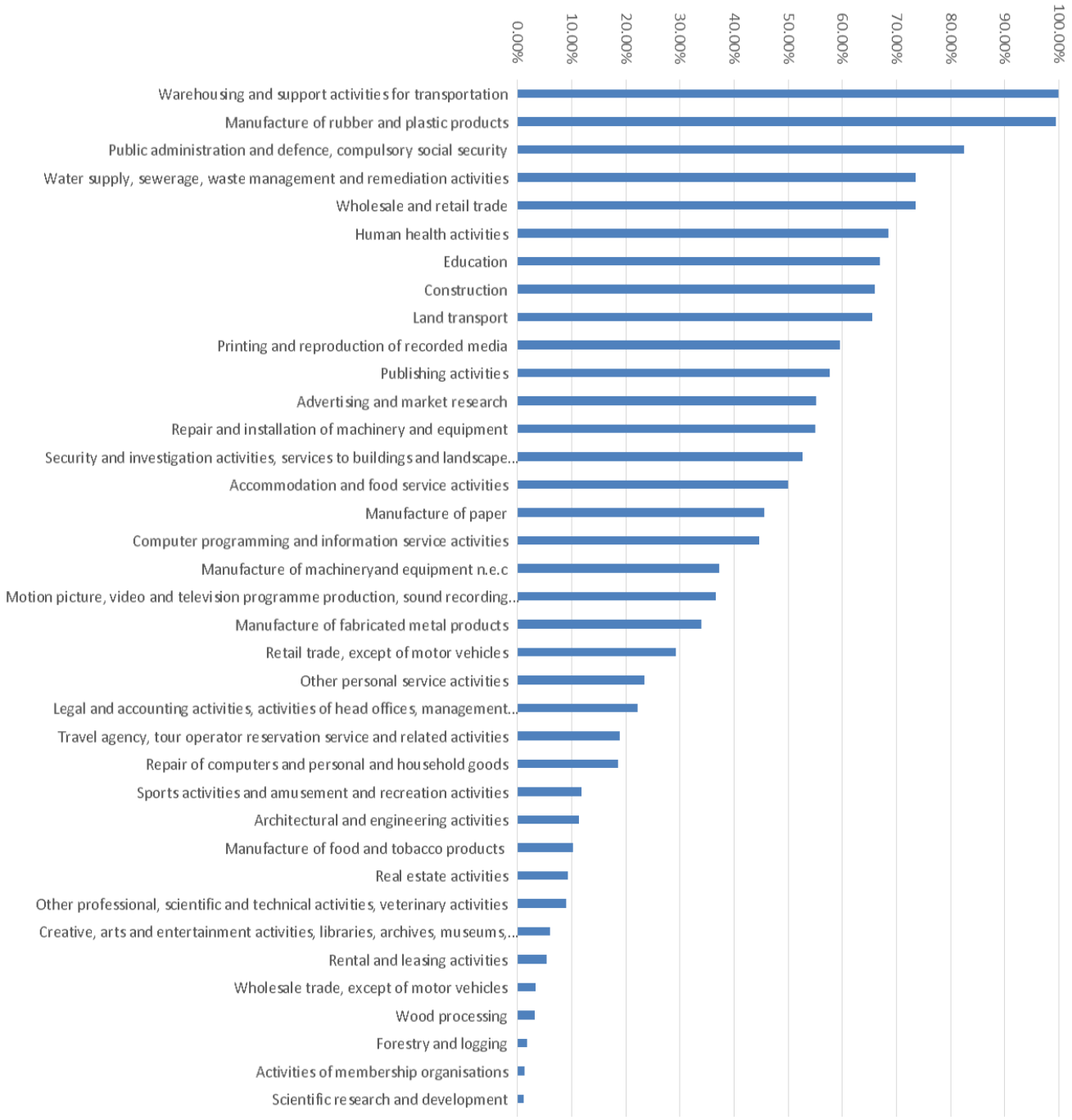

Figure 1 Share of local expenditures of Slovak University of Agriculture in Nitra according to sector in 2015

Source: Authors

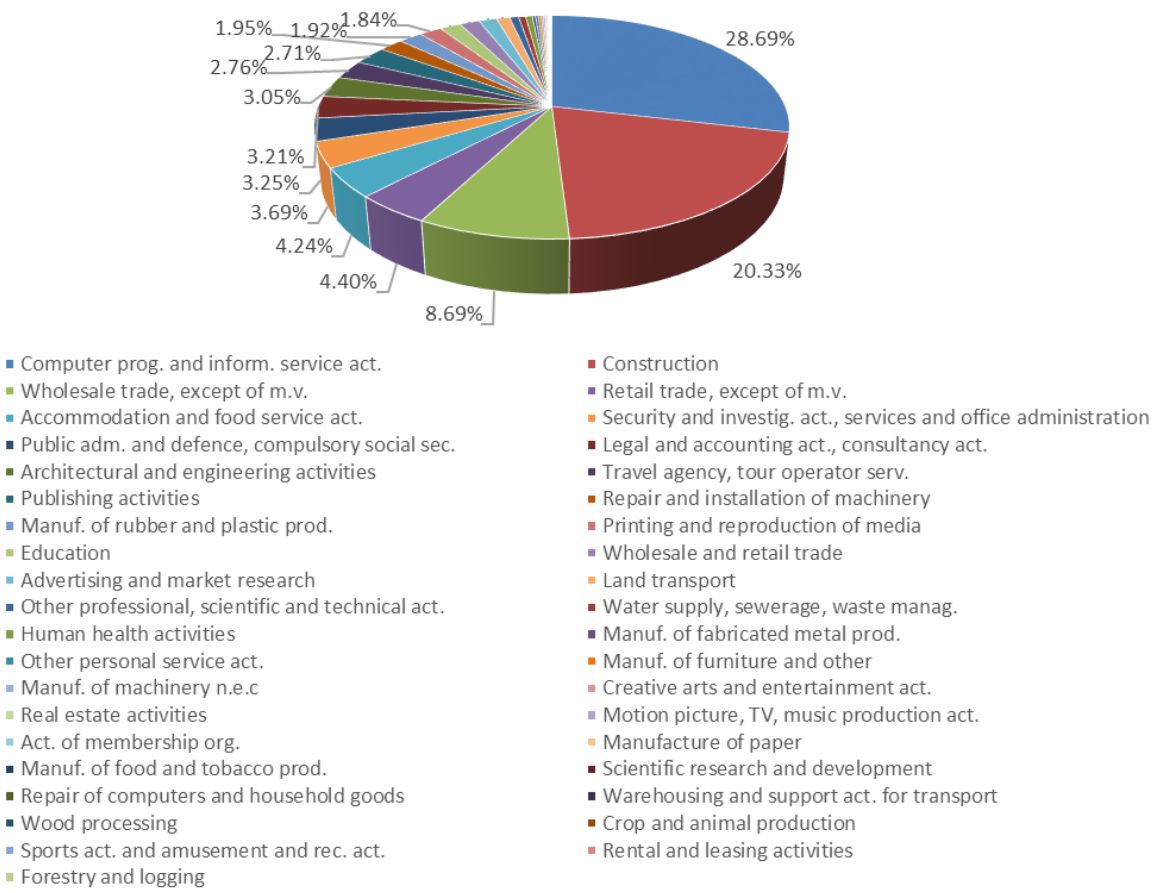

Figure 2 Sectoral composition of SUA in Nitra expenditures in Nitra City in 2015

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.

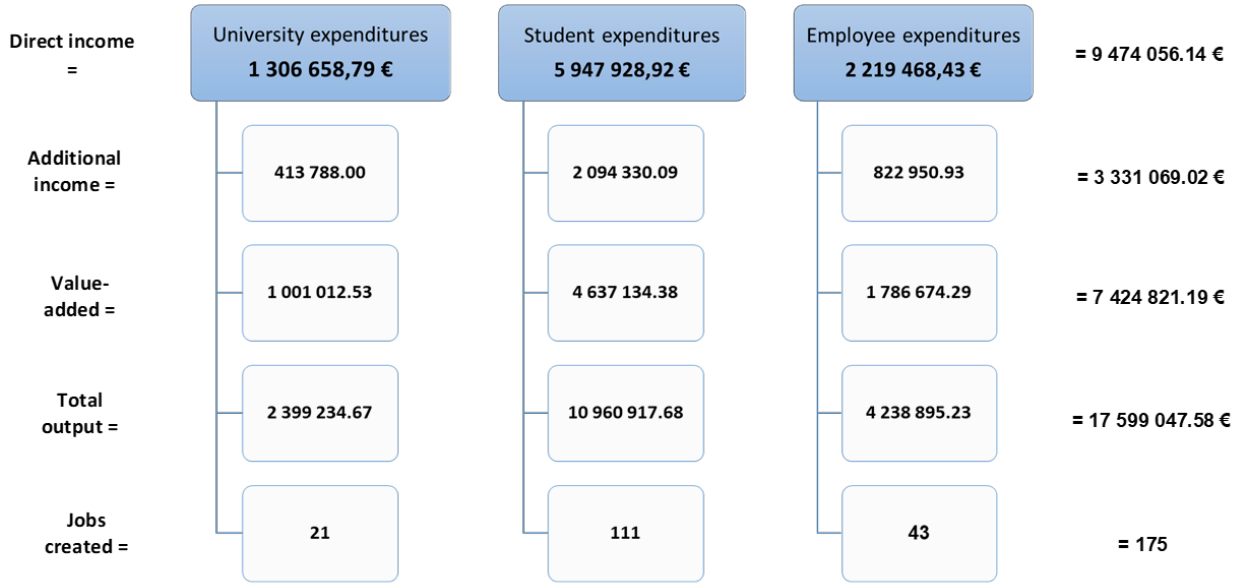

Figure 3 Total direct and multiplier effect of Slovak University of Agriculture in Nitra on local economy in 2015
Source: Authors

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).

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