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Interregional Flows for the Czech Economy

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Abstract

The paper brings both the methodology and data on the construction of regional flows in the interregional model. We focus on the comparison of the entropy method and the commonly used gravity method. The entropy method is based on minimizing import distances at the determined rate of entropy of the interregional flows of intermediaries. The gravity method is used in its standard form with an additional factor for adjusting the warehouses, and its parameters are estimated for physical flows. The resulting estimates are then applied on the regional input-output tables and are used to construct a standard Leontief interregional model. To analyse the difference between the two models, we use a graphical representation. Furthermore, we assess the percentage deviation of the average Leontief multiplier in the regional submatrices. We proved that, although the interregional output flows appear different and the relative structure of Leontief matrix is different, the resulting impacts on the regions do not fundamentally differ.

Keywords

Regional Input-Output tables, Input-Output analysis, entropy theory, gravity method

JEL code

C67, R13, E21

INTRODUCTION

Regional Input-Output tables provide the detailed information about regional economy. We have published regional Input-Output Tables for the Czech Republic (2011, 2013) and the methodology, see Sixta and Vltavská (2016). Even if these tables include significant amount of data, their linkages and arrangements into interregional model describing also the product flows between the regions, multiply the usefulness for the users. The crucial point lies in the methods for the arrangements these regional matrices into a one Sigle matrix. Both the entropy method and the gravity method were devised for uses different from those for interregional flow estimation. Given their number of uses, these two methods for regional flow estimation can be considered the main methods for interregional output flow estimation. The gravity method is based on Newton's law of gravitation, where the force of attraction between two objects is proportional to the product of their masses and inversely proportional to the square of the distance between them (all multiplied by the gravitational constant). The application for estimating output flows between cities from the 18th century (Banzhaf, 2000; Kurz and Salvadori, 2000a and 2000b) can be considered

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the first economic use of the gravity method. In the input-output (I-O) analysis, this method was not applied until the 1970s by Leontief and Strout (1963) and Theil (1967), independently of each other. Since then, the gravity method has been used in the I-O analysis and data estimation for flows between regions and/or states themselves in many applications. For example, it has been used to construct multinational I-O tables where data sources are not sufficient – such as in the FIGARO project (Rueda-Cantuche and Rémond Tiedrez, 2016) or world Input-Output tables (Foster and Stehrer, 2010). In the decades following its introduction, the gravity method methodology acquired different forms of gravity equation estimation, especially with regard to the added data sources and the information contained therein (Anderson and van Wincoop, 2003). The main problem of gravity method estimation is that it is necessary to know the output flows in order to make it possible to calibrate the gravity method, which, however, directly thwarts its use. For this reason, some authors choose unit parameter values of the gravity method (e.g. Kieslichová, 2016). However, as shown by other authors, this leads to the degradation of this method to calibration from the inverse distance method (Šafr and Sixta, 2017). The solution of this estimate appears to be the use of alternative data sources available. Some authors use data flows between regions (or states) for other countries to for calibrate the parameters (or their estimation), and then apply these coefficients to the state being examined. This can be used, because the dynamics of relationships are determined by the parameters of variables, but the setting of flow levels is determined by the gravitational constant that can be established exogenously, based on the total level of flows in the economy (or between states). For these reasons, we have decided to use an alternative approach (Šafr and Sixta, 2017), estimating the parameters from the physical output flows in the economy, which will bring the real parameters closer to the territory of the Czech Republic that we examined.

The entropy theory was developed by Edwin T. Jaynes (1922–1998), who first used this method for studying the information theory in statistical mechanics (Jaynes, 1957). The theory is based on Bayesian statistics. However, compared to Bayes theorem, which is used to calculate probability, entropy maximization leads to the "assignment" of the probability of a priori distribution (Jaynes, 1988). The technique has been applied both in technical sciences and economics. In Input-Output analysis, A. G. Wilson can be considered the pioneer of this theory in estimating interregional flows (Wilson, 1970). The application of these methods has been subsequently dealt with by many authors. As a comprehensive view, Sargento's work can be mentioned, dealing with both the numerical optimization of this problem and the possible general solution of the optimization problem (Sargento, 2009). In general, there are two main approaches based on entropy. The principle of the first one is to maximize entropy under the conditions of meeting the sum of exports and imports between regions. In fact, it is the maximum possible distribution (decay) of output flows in the flow matrix, assuming the sum of columns and rows (export and import consistency between regions). The second option of applying this method (used in this article) is to minimize the import distance, assuming the sum of exports and imports and the exogenously determined entropy rate of the entries in the output flow matrix.

1 METHODOLOGY

1.1 Interregional I-O model

This article uses a standard interregional Input-Output model. Based on its construction, this model is considered to be a model "with full information" (Oosterhaven and Hewings, 2014) or Isard's standard model (Isard, 1951). In the view of the I-O model, this model is a model that considers full mutual interconnection of regions, facilitating also to analyse the retrospective impacts on individual regions (type III model according to Lenzen et al., 2004). The core of the I-O analysis is I-O tables (IOTs) and, for regional application, it is regional Input-Output tables (RIOTs). Regional Input-Output tables show the economy structure from the perspective of products and aggregates in regional categorization. This table can be illustrated by the following simplified form – see Figure 1.

Figure 1 Simplified interregional Input-Output table

			Region						Hous. Cons.			Gov. cons.			i_i^{pr}			export	product
	Region	Region	1		2		3		1	2	3	1	2	3	1	2	3		-
		Products	1	2	1	2	1	2	-	-	-	-	-	-	-	-	-		-
Region	1	1	z_{11}^{11}	z_{12}^{11}	z_{11}^{12}	z_{12}^{12}	z_{11}^{13}	z_{12}^{13}	c_1^{11}	c_1^{12}	c_1^{13}	g_1^{11}	g_1^{12}	g_1^{13}	i_1^{11}	i_1^{12}	i_1^{13}	e_1^1	x_1^1
		2	z_{21}^{11}	z_{22}^{11}	z_{21}^{12}	z_{22}^{12}	z_{21}^{13}	z_{22}^{13}	c_2^{11}	c_2^{12}	c_2^{13}	g_2^{11}	g_2^{12}	g_2^{13}	i_2^{11}	i_2^{12}	i_2^{13}	e_2^1	x_2^1
	2	1	z_{11}^{21}	z_{12}^{21}	z_{11}^{22}	z_{12}^{22}	z_{11}^{23}	z_{12}^{23}	c_1^{21}	c_1^{22}	c_1^{23}	g_1^{21}	g_1^{22}	g_1^{23}	i_1^{21}	i_1^{22}	i_1^{23}	e_1^2	x_1^2
		2	z_{21}^{21}	z_{22}^{21}	z_{21}^{22}	z_{22}^{22}	z_{21}^{23}	z_{22}^{23}	c_2^{21}	c_2^{22}	c_2^{23}	g_2^{21}	g_2^{22}	g_2^{23}	i_2^{21}	i_2^{22}	i_2^{23}	e_2^2	x_2^2
	3	1	z_{11}^{31}	z_{12}^{31}	z_{11}^{32}	z_{12}^{32}	z_{11}^{33}	z_{12}^{33}	c_1^{31}	c_1^{32}	c_1^{33}	g_1^{31}	g_1^{32}	g_1^{33}	i_1^{31}	i_1^{32}	i_1^{33}	e_1^3	x_1^3
		2	z_{21}^{31}	z_{22}^{31}	z_{21}^{32}	z_{22}^{32}	z_{21}^{33}	z_{22}^{33}	c_2^{31}	c_2^{32}	c_2^{33}	g_2^{31}	g_2^{32}	g_2^{33}	i_2^{31}	i_2^{32}	i_2^{33}	e_2^3	x_2^3
			l_1^1	l_2^1	l_1^2	l_2^2	l_1^3	l_2^3											
	Value	added	n_1^1	n_2^1	n_1^2	n_2^2	n_1^3	n_2^3											
		Import	m_1^1	m_2^1	m_1^2	m_2^2	m_1^3	m_2^3											
		x_i^p	x_1^1	x_2^1	x_1^2	x_2^2	x_1^3	x_2^3											

Source: Author's work based on Miller and Blair (2009)

Generally, input-output tables are made in two variant – in the industries classification (NACE) or in product classification (CPA). Input-output model can be than interpreted in both – as industries or as products. The interpretation depends on the source data. Where variable z_{ij}^{pr} represents the intermediate use flow of product i from region p to region r to produce good j. c_i^{pr} represents the output flow to household consumption, and it is product i from region p to household consumption in region r. g_i^{pr} represents to the output flow to government consumption, and it is product i from region p to consumption in region r. By analogy, i_i^{pr} represents the output flow to investment, and it is product i from region p to region r. Exports are represented by e_i^p, and it is exports from region p in product i. Variables l_j^r and n_j^r represent the variables of gross value added (GVA) for product j, produced in connection with product creation in region r (e.g. wages, profits ...etc). The last variable is the imports of the product (abroad) m_j^r – from region r (product j). The total number of region is P which is same as R. The number of products (or industries) is n (and it is i as well as j same). The total output can then be represented as x_i^p. The following relationships apply to this table from the use perspective:

$$\sum_{r=1}^{R}\left(\sum_{j=1}^{n}\left(z_{ij}^{pr}\right)+c_i^{pr}+g_i^{pr}+i_i^{pr}\right)+e_i^p=x_i^p\,, \tag{1}$$

and from the resource perspective:

$$\sum_{p=1}^{P}\sum_{i=1}^{n}\left(z_{ij}^{pr}\right)+l_j^r+g_j^r+m_j^r=x_j^r\,, \tag{2}$$

total use can be represented as:

$$\sum_{r=1}^{R}c_i^{pr}+\sum_{r=1}^{R}g_i^{pr}+\sum_{r=1}^{R}i_i^{pr}+e_i^p=f_i^p\,. \tag{3}$$

The Input-Output analysis is based on the matrix describing the ratio between intermediate use inputs and outputs of individual industries; the total matrix (composed of regional submatrices) can be represented as matrix A^T composed of submatrices:

$$\mathbf{A}^{\mathrm{T}} = \begin{bmatrix} \mathbf{A}^{11} & \mathbf{A}^{1r} & \mathbf{A}^{1R} \\ \mathbf{A}^{p1} & \mathbf{A}^{pr} & \mathbf{A}^{pR} \\ \mathbf{A}^{P1} & \mathbf{A}^{Pr} & \mathbf{A}^{PR} \end{bmatrix}, \text{where } \mathbf{A}^{pr} = (a_{ij}^{rp})_{nn}, \tag{4}$$

for $r, p = 1, 2.....P$, $(P=R)$, and, therefore, the size of A^{T} is $(Rn) \times (Rn)$.

The individual entries of matrices A^{pr} can then be defined as:

$$\text{matrix: } a_{ij}^{pr} = \frac{z_{ij}^{pr}}{x_j^r}. \tag{5}$$

Technical coefficients represent the parameters of Leontief production function. This function is known as the fixed proportions production function. This production function represents extreme case of production function without any elasticity of substitution of inputs.

It can be shown (e.g. Šafr, 2016a) that regional coefficients must be a disaggregation of national coefficients ($\mathbf{A}^{\mathbf{N}}$ – national technical coefficients, $\mathbf{x}^{\mathbf{N}}$ – national output vector):

$$\left[\sum_{p=1}^{P}\sum_{r=1}^{R}\mathbf{A}^{pr}\, diag\,(\mathbf{x}^{r})\right] diag\,((\mathbf{x}^{\mathrm{N}})^{-1}) = \mathbf{A}^{\mathrm{N}}. \tag{6}$$

Then, both in the classic I-O model and in the interregional I-O model, the following is true:

$$(\mathbf{I} - \mathbf{A}^{\mathrm{T}})^{-1}\mathbf{f}^{\mathrm{T}} = \mathbf{x}^{\mathrm{T}}, \tag{7}$$

where the $(\mathbf{I} - \mathbf{A}^{T})^{-1}$ is Leontief inverse, known as **L**. This directly shows the overall impact of total end use on total output in the economy. The elements of matrix **L** is interpreted as a derivative of total product by final use – the chance of total product caused by chance of final use. In the case of the three regions in question, this equation can be broken down into individual output vectors and submatrices of technical coefficients and vectors of use:

$$\begin{aligned} \mathbf{f}^{1} &= +(\mathbf{I} - \mathbf{A}^{11})\mathbf{x}^{1} - \mathbf{A}^{12}\mathbf{x}^{2} - \mathbf{A}^{13}\mathbf{x}^{3}, \\ \mathbf{f}^{2} &= -\mathbf{A}^{21}\mathbf{x}^{1} + (\mathbf{I} - \mathbf{A}^{22})\mathbf{x}^{2} - \mathbf{A}^{23}\mathbf{x}^{3}, \\ \mathbf{f}^{3} &= -\mathbf{A}^{31}\mathbf{x}^{1} - \mathbf{A}^{32}\mathbf{x}^{2} + (\mathbf{I} - \mathbf{A}^{33})\mathbf{x}^{3}. \end{aligned} \tag{8}$$

By solving this system of regional I-O equations, the solution for each region separately can then be gained, i.e. the following equation can be gained::

$$\mathbf{x}^{1} = \mathbf{J}^{-1}\mathbf{f}^{1} - \mathbf{J}^{-1}\mathbf{O}\mathbf{f}^{2} - \mathbf{J}^{-1}\mathbf{G}\mathbf{f}^{3}, \tag{9}$$

where element J^{-1} shows the impact effect of multiplying the increase in the end use of the first region on the total output of the first region, $\mathrm{J}^{-1}\mathrm{O}$ shows the effect of increasing the end use of the second region on the total output of the first region, and $\mathrm{J}^{-1}\mathrm{G}$ represents the effect of increasing the end use in the third region on the output of the first region. It can be said that these submatrices are submatrices of the Leontief total matrix. Their values are as follows:

$$\mathbf{J} = [\mathbf{I} - \mathbf{A}^{11} - \mathbf{A}^{12}\mathbf{E} - \mathbf{A}^{13}\,(\mathbf{I} - \mathbf{A}^{33})^{-1}\,\mathbf{A}^{31} - \mathbf{A}^{13}\,(\mathbf{I} - \mathbf{A}^{33})^{-1}\,\mathbf{A}^{32}\mathbf{E}], \tag{10}$$

where we simplified a part of the calculation using submatrix **E**:

$$\mathbf{E} = [\mathbf{R}^{-1}\mathbf{A}^{32}\,(\mathbf{I} - \mathbf{A}^{33})^{-1}\,\mathbf{A}^{31} + \mathbf{R}^{-1}\mathbf{A}^{21}]\,, \tag{11}$$

whose simplification removes matrix **R**:

$$\mathbf{R} = [\mathbf{I} - \mathbf{A}^{22} - \mathbf{A}^{23}\,(\mathbf{I} - \mathbf{A}^{33})^{-1}\mathbf{A}^{32}]\,. \tag{12}$$

Matrix **O** can be calculated as follows:

$$\mathbf{O} = [\mathbf{A}^{12}\mathbf{R}^{-1} + \mathbf{A}^{13}\,(\mathbf{I} - \mathbf{A}^{33})^{-1}\mathbf{A}^{32}\mathbf{R}^{-1}]\,, \tag{13}$$

and matrix **G** as follows:

$$\mathbf{G} = [\mathbf{A}^{12}\mathbf{R}^{-1}\mathbf{A}^{23}\,(\mathbf{I} - \mathbf{A}^{33})^{-1} + \mathbf{A}^{13}\,(\mathbf{I} - \mathbf{A}^{33})^{-1} + \mathbf{A}^{13}\,(\mathbf{I} - \mathbf{A}^{33})^{-1}\,\mathbf{A}^{32}\mathbf{R}^{-1}\mathbf{A}^{23}\,(\mathbf{I} - \mathbf{A}^{33})^{-1}]\,. \tag{14}$$

This is how we expressed the impact of total use in individual regions on the total increase in the output in the first region. Increase for the output of the second region and the third region can be expressed analogously. Its reasoning makes it an analogous equation as presented by Oosterhaven and Hewings (2014) or Miller and Blair (2009),[3] but for three regions, not two, in this case. This change is particularly important when one region is analysed in the context of all other regions and foreign countries – which can be simplified into 3 regions of the interregional I-O model.

The resultant equation (Formula 9) provided same results as the total Leontief inverse. The advantage of this approach lies in analytical use – due that these equations (Formulas 9–14) allows to analyse the channel of the change of total use. For example, it allows you to separate secondary effects of the chance of total use in region 1 caused by chance of final use in region 1 from other regions – which is not possible to take from total Leontief inverse matrix or from the submatrices of this matrix.

1.2 Interregional flows

Estimation of interregional output flows is based on the assumption that total exports and imports are known in individual regions. This can then be represented separately for each product as a flow matrix for product *i* as follows:

$$\boldsymbol{U}_i = (u_i^{p,r})_{P\times P}\,. \tag{15}$$

However, these are total output flows, i.e. not only to intermediate use, but also to end use, hence:

$$u_i^{pr} = \sum_{j=1}^{n} z_{ij}^{pr} + f_i^{pr}\,. \tag{16}$$

And, in the retrospective reconstruction, it will be necessary to estimate z_{ij}^{pr}, f_i^{pr} retrospectively, which can be conducted from the import table, assuming that international imports have the same structure of use and intermediate use as interregional imports to individual regions.

1.2.1 Entropy approach

This method is based on the assumption that the values of output flows between regions represent a microstate. Each unit of this output flow represents an individual movement (state). The total volume

[3] Miller and Blair (2009) describe this equation only from the perspective of the increase in the output of the industry, abstracting from elements **JO** and **JG**.

of flows in the matrix representation is the macro state of the system (identical to matrix $\mathbf{u}_i$). By using combinatorics, the total number of combinations of individual movements of output flows can be determined. If we assume that we know the matrix of output flows ($\mathbf{u}_i$), the total possible number of microstate combinations can be represented as function wfor interregional flows:

$$w(\boldsymbol{u}_i) = \frac{\sum_{p=1}^{P} \sum_{r=1}^{R} u_i^{pr}}{\prod_{p=1}^{P} \prod_{r=1}^{R} u_i^{pr}!}. \tag{17}$$

Entropy maximization as defined by Jaynes (1957) consists in the maximization of $w_p(\mathbf{u}_i)$, which expresses the number of possible combinations of microstates. Batten (1982) also points to other possible definitions and solutions of the maximization entropy equation (or, rather, uncertainty) of output flows that can be used for maximization. Stirling's approximation can lead us to the model defined by Batten and Boyce (1986),[4] where we minimize the import distance of individual output flows, assuming a predetermined entropy rate:

$$\begin{aligned}
&\min_{u_i^{pr}} f_i = \sum_{p=1}^{P} \sum_{r=1}^{R} \delta_i^{pr} u_i^{pr}, \\
&-\sum_{p=1}^{P} \sum_{r=1}^{R} (u_i^{pr} \ln u_i^{pr} - u_i^{pr}) \geq \phi_i \ ,^{5} \\
&v_i^p = \sum_{r=1}^{R} u_i^{pr}, \\
&d_i^r = \sum_{p=1}^{P} u_i^{pr}, \\
&u_i^{pr} \geq 0 \text{ for } p \neq r, \\
&u_i^{pr} = 0 \text{ for } p = r,
\end{aligned} \tag{18}$$

where δ_i^{pr} is the distance between region p and region r. Parameter ϕ_i is the rate of exogenously determined entropy for product i. v_i^p is the known total regional exports of product i from region p. d_i^r is the known regional total imports of product i to region r. The first equation in the limitation shows us an approximate entropy rate that must be greater than or equal to the predetermined entropy rate (ϕ_i). The parameter of entropy (which is in boundaries) is key variable which affect the final distribution of flows in economy. If this boundary is omitted, result of minimization is same as minimal distance. The maximum of this parameter (ϕ_i) is proportional distribution (calculated by the way of unconditional probability). The true size of this parameter is generally unknown. One way how to calculate it consists in using transport tables in different classification/or aggregation. These tables should be rescaled to the same size as is the estimated tables.

The only unsolved problem in estimating interregional output flows remains the problem of how to determine the entropy rate for individual products. In my case, we started from the structure of output flows in physical representation. Thus, this data shows the volume of exports and imports based on individual NST product classifications in natural representation – tonnes, kilograms, etc.

1.2.2 Gravity approach

As we mentioned in the introduction above, the gravity method is based on Newton's law of gravitation. In the case of I-O tables, it is assumed that the export/import rate (force) of two regions (objects) is directly

[4] The detailed procedure and other different model variants are shown by Batten (1982) and Sargento (2009).

[5] If the flow value is zero, then the expression ($u_i^{pr} \ln u_i^{pr} - u_i^{pr}$) is considered to be zero.

proportional to the product of the total output of the regions in question and indirectly proportional to their distance. The standard gravity model can then be presented as follows:

$$u_i^{pr} = G_i \frac{(x_i^p)^{\alpha_i} (x_i^r)^{\beta_i}}{(\delta^{pr})^{\omega_i}}, \tag{19}$$

where G_i is the total export/import level of product i in the economy between regions α_i and β_i then represent the elasticity (of the importing region and the exporting region) for product i. As with the entropy approach, variable δ^{pr} is the distance between region p and region r, and constant ω_i is the degree of distance decay between regions. In the case of international trade, this equation is supplemented by other variables that affect how much the countries in question cooperate with each other. However, this cannot be applied to the case of one country with a single fiscal and monetary framework. The estimation of individual parameters can be gained either by calibration or, using regression, by logarithmizing to the following expression:

$$\log(u_i^{pr}) = \log(G_i) + \alpha_i \log(x_i^p) + \beta_i \log(x_i^r) - \omega_i \log(\delta^{pr}). \tag{20}$$

As mentioned in the introduction above, in order to use the gravity model, it is necessary to know the model parameters that must be estimated from the output flows between regions. With regard to the availability of this data, we use the output flows between regions in natural representation. However, this data may be used under the following conditions:

1. It is assumed that the individual CPA and NST classifications have homogeneous outputs.
2. It is possible to approximate the CPA by means of the NST classification.
3. The values of products do not vary in individual regions and product flows.
4. These are net output flows (not quasi-transit).

Although these are strong conditions, we assume that conditions 1–3 have been met. However, the problem is condition 4, which is not met in our data as it is published, containing all flows in the economy (and thus also to stock). Another reason for adjusting the gravity equation can be found in the fact that we know the total volumes of exports and imports to individual regions. For this reason, we used the adjusted gravity form of the equation (for more information, see Šafr and Sixta, 2017):

$$u_i^{pr} = G_i \frac{(x_i^p)^{\alpha_i} (x_i^r)^{\beta_i}}{(\delta^{pr})^{\omega_i}} \left(\frac{l^{\psi_i^p}}{l^{\xi_i^r}}\right), \tag{21}$$

where variables $l_p^{\psi i} l_r^{\xi i}$ represent stock inventories in individual regions, ξ_i^r represents the effect of stock inventories in demanding region, ψ_i^p represents the effect of stock of inventories in supplying region. Unfortunately, this data is not directly available and, for this reason, we approximated stock using the number of workers in warehouses as in the original article by Šafr and Sixta (2017).

The most used way how to obtain these parameters (α_i, β_i, ω^{pr}, ψ_i^p, ξ_i^r) is to estimate them by regression method (Shepherd, 2013). Due to fact that the flows between regions have to be estimated, the approximation is generally used – the parameters are estimated on the basis of different data sources such as another states or different classification (our case).

2 DATA

The main data source for the estimation of interregional flows is regional I-O tables prepared at the Department of Economic Statistics of the University of Economics (KEST, 2017), as well as the national accounts of the Czech Statistical Office (2017). Imports and exports are estimated by the model based on structure of Use. Regional estimates are made separately from international ones (Vltavská and Sixta, 2017). Another important source is the employment data provided by Trexima (2017) on the number of workers

in warehouses, as well as data on exports and imports between regions in physical representation, and in a different classification from the Ministry of Transport (MD ČR, 2017). Parameters ϕ_i was estimated from NTS classification.

With regard to the NST and CPA classification mismatch, we used the following approximation of parameter estimates – see Table 1.

Table 1 NST proxy structures pro CPA products

NST	CPA
NST **01**	CZ-CPA **01–03**
NST **02**	CZ-CPA **05–06**
NST **03**	CZ-CPA **07–09, 41–42**
NST **04**	CZ-CPA **10–12**
NST **05**	CZ-CPA **13–15**
NST **06**	CZ-CPA **16–18, 58–63**
NST **07**	CZ-CPA **19**
NST **08**	CZ-CPA **20–22**
NST **09**	CZ-CPA **23**
NST **10**	CZ-CPA **24–25**
NST **11**	CZ-CPA **26–28**
NST **12**	CZ-CPA **29–30, 45–47**
NST **13**	CZ-CPA **31–33**
NST **14**	CZ-CPA **36–39**
NST **15**	CZ-CPA **49–53**
NST **18**	CZ-CPA **64–99**

Source: Author´s work

3 RESULTS

We applied the above two methods to data to gain interregional flow structures. Subsequently, we retrospectively estimated flows to intermediate use between the regions to individual products. Considering the magnitude of these results (1 148 × 1 148 matrix), we aggregated these structures, presenting them in the diagrams describing the volume of exports and imports between regions – see Figures 2 and 3.

The same figure can be shown for Gravity approach.

The results show that the entropy method achieves more extreme values compared to the gravity method. The entropy rate in Entropy method is about 3% higher than in model without entropy in constraints. The entropy rate in Entropy Method is then much closer to Newton model than to minimal distance approach. This is due to the minimization of import distances, which is limited by the degree of entropy of matrix entries. We can see the strongest relationship has Prague region in both method. This is caused by the constrain which comes from RIOTs. These two matrices can be compared by criteria. The WAD criterion is usually used to assess the difference between two intermediate use matrices[6] in the I-O analysis:

$$Err^{\mathrm{WAD}} = \frac{\sum_{j=1}^{n}\sum_{i=1}^{n} m_{ij}\left|m_{ij} - q_{ij}\right|}{\sum_{j=1}^{n}\sum_{i=1}^{n}\left(m_{ij} + q_{ij}\right)} \times 100\,, \qquad (22)$$

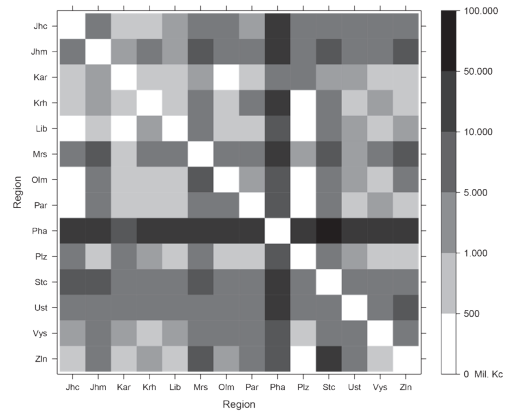
or MAPE:

$$Err^{\mathrm{MAPE}} = \frac{1}{n^2}\sum_{j=1}^{n}\sum_{i=1}^{n}\frac{\left|m_{ij} - q_{ij}\right|}{\left|m_{ij}\right|} \times 100\,. \qquad (23)$$

The problem with these criteria (as well as others, such as WAPE, SWAD, etc.) is that they require a reference matrix through which the force of the entry change is weighed. However, these two estimates are completely independent of each other, and no matrix is the starting point here. This then leads to the situation that the intermediate use matrix entries can be zero in one case and non-zero in the second case; however, the aforementioned criteria can lead to distorted results. For this reason, we constructed the MWAD criterion for this application:

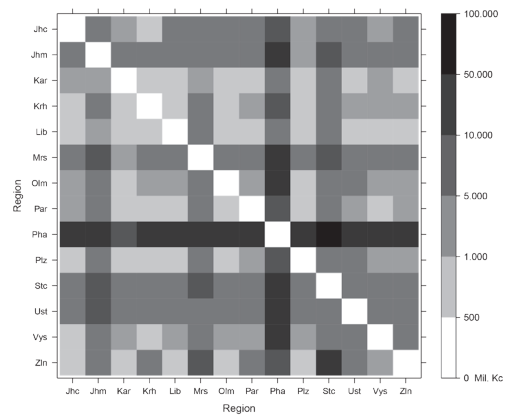
$$Err^{\mathrm{MWAD}} = \frac{\sum_{j=1}^{n}\sum_{i=1}^{n}\frac{m_{ij} + q_{ij}}{2}\left|m_{ij} - q_{ij}\right|}{\sum_{j=1}^{n}\sum_{i=1}^{n}\left(m_{ij}\right)} \times 100\,. \qquad (24)$$

Figure 2 Entropy approach: exports and imports between regions



Source: Author's work

Figure 3 Gravity approach: exports and imports between regions



Source: Author's work

They show that the difference between them is 0.223 and, according to RMSE (* 100), it is 0.428. Thus, it appears that compared to other methods (as published in Šafr and Sixta, 2017), these two methods do not lead to extremely different results. Table 2 shows the MWAD criterion structure for differences between regions (taking products) in the economy.

[6] We consider two matrices: **M** and **G** with elements: m_{ij}, resp. g_{ij}.

Table 2 MWAD criterion between Entropy and Gravity approach

REGION	JHC	JHM	KAR	KRH	LIB	MRS	OLM
MWAD	0.35	1.27	0.05	0.24	0.10	1.50	0.13
REGION	PAR	PHA	PLZ	STC	UST	VYS	ZLN
MWAD	0.16	4.67	0.26	4.68	0.29	0.51	0.78

Source: Author´s work

What is interesting about these results is the fact that the results for the Prague Region and the Central Bohemian Region show the most significant differences. On the contrary, the Karlovy Vary Region and the Liberec Region show the most significant similarities.

The biggest difference can be seen at the level of individual products. For the case of CZ-CPA 1 ("Products of agriculture, hunting and related services"), we have calculated the flow matrices by both methods. These matrices are summarized in Tables 3 and 4. The readers can see that the Entropy approach is providing more extreme results and lot of relationships estimated as zero. These results will provide totally different structure of multiplication in interregional Input-Output models.

Table 3 CZ-CPA 1: Imports and Exports between regions (Entropy approach)

	Jhc	Jhm	Kar	Krh	Lib	Mrs	Olm	Par	Pha	Plz	Stc	Ust	Vys	Zln
Jhc	0	53	3	1	11	70	1	0	2811	0	168	387	41	95
Jhm	2	0	0	0	0	337	21	0	1348	0	5	9	23	1146
Kar	0	0	0	0	4	13	0	0	0	0	2	9	1	4
Krh	4	4	0	0	27	84	10	0	1905	0	58	133	2	1
Lib	0	0	0	0	0	12	1	0	51	0	19	24	0	1
Mrs	0	12	0	1	2	0	27	0	3	0	7	0	0	169
Olm	0	35	0	1	7	208	0	0	421	0	10	8	0	94
Par	0	43	25	27	137	832	24	0	615	0	71	271	37	14
Pha	0	2	1	0	0	6	0	0	0	0	13	22	0	1
Plz	44	14	261	3	63	56	4	0	1587	0	126	194	19	41
Stc	2	6	20	2	52	13	1	0	2443	0	0	117	3	3
Ust	1	2	15	0	1	12	0	0	93	0	5	0	1	2
Vys	51	160	100	6	116	864	45	0	2457	0	239	457	0	296
Zln	0	2	0	0	0	8	1	0	47	0	0	0	0	0

Source: Author´s work

Table 4 CZ-CPA 1: Imports and Exports between regions (Newton approach)

	Jhc	Jhm	Kar	Krh	Lib	Mrs	Olm	Par	Pha	Plz	Stc	Ust	Vys	Zln
Jhc	0	60	67	7	66	401	22	0	2185	0	129	259	26	296
Jhm	16	0	54	6	53	324	18	0	1764	0	104	209	21	239
Kar	0	1	0	0	1	5	0	0	25	0	1	3	0	3
Krh	12	37	41	0	40	245	14	0	1333	0	79	158	16	180
Lib	1	2	2	0	0	13	1	0	69	0	4	8	1	9
Mrs	1	4	5	1	5	0	2	0	152	0	9	18	2	21
Olm	4	14	15	2	15	91	0	0	496	0	29	59	6	67
Par	13	40	44	5	43	263	15	0	1432	0	85	170	17	194
Pha	1	2	2	0	2	14	1	0	0	0	4	9	1	10
Plz	13	42	46	5	46	276	15	0	1503	0	89	178	18	203
Stc	15	45	50	5	49	299	17	0	1637	0	0	193	19	220
Ust	1	2	3	0	3	16	1	0	89	0	5	0	1	12
Vys	27	84	94	10	93	561	31	0	3057	0	181	363	0	414
Zln	0	1	1	0	1	7	0	0	38	0	2	5	0	0

Source: Author´s work

3.1 Analytical impact

Interregional flow estimation is based on total export and import volumes between regions. For this reason, the total shocks for the economy calculated using the interregional model are the same, but the *shock structures are different*. Therefore, we focused on Formula (9) and decomposition of Leontief matrix (matrix **L**). Subsequently, we expressed the average value of the multiplication in the region in question due to the increase in the end use in the examined region and compared these results between the volumes of the method. Table 5 summarizes the submatrices of the Leontief Inverse matrix (**L**) of this calculation.

Table 5 Percentage difference of submatrices of interregional Leontief matrix

	Jhc	Jhm	Kar	Krh	Lib	Mrs	Olm	Par	Pha	Plz	Stc	Ust	Vys	Zln
Jhc	100%	88%	68%	88%	67%	60%	106%	64%	120%	154%	89%	128%	173%	98%
Jhm	65%	100%	55%	74%	70%	105%	139%	133%	92%	182%	77%	59%	141%	191%
Kar	72%	69%	100%	75%	99%	121%	53%	71%	104%	253%	61%	241%	56%	69%
Krh	54%	67%	82%	100%	85%	143%	49%	181%	108%	49%	107%	62%	136%	35%

Table 5 (continuation)

	Jhc	Jhm	Kar	Krh	Lib	Mrs	Olm	Par	Pha	Plz	Stc	Ust	Vys	Zln
Lib	59%	41%	53%	202%	100%	93%	57%	84%	112%	54%	106%	197%	50%	154%
Mrs	97%	142%	78%	134%	99%	100%	202%	94%	80%	50%	116%	77%	46%	175%
Olm	31%	184%	60%	34%	58%	257%	100%	119%	58%	47%	50%	83%	52%	296%
Par	39%	96%	92%	124%	91%	168%	216%	100%	89%	44%	100%	63%	129%	64%
Pha	108%	95%	94%	105%	102%	95%	93%	99%	100%	89%	107%	110%	104%	89%
Plz	223%	42%	711%	151%	55%	80%	50%	82%	113%	100%	81%	68%	39%	52%
Stc	127%	107%	77%	52%	135%	88%	57%	98%	108%	145%	100%	92%	109%	54%
Ust	68%	43%	137%	128%	138%	61%	79%	84%	127%	119%	83%	100%	99%	100%
Vys	124%	200%	96%	95%	95%	98%	132%	134%	86%	60%	95%	72%	100%	104%
Zln	54%	285%	93%	49%	43%	138%	257%	105%	78%	80%	86%	56%	41%	100%

Source: Author´s work

Thus, if we interpret the relationship between the South Moravian Region and the South Bohemian Region (second row, first column), i.e. 65%, this value states that the entropy-based calculation approach will cause that the average increase in the output of the average product of the South Bohemian Region is 65% lower than in the calculation using the gravity model. From the row perspective (i.e. multiplication for the region in the row caused by the increase in end use in the region in the column), the Karlovy Vary Region (average 128%) and the Moravian-Silesian Region (114%) are the most overvalued compared to the gravity model, with the South Bohemian Region (average 87%) and Liberec Region (88%) being the most undervalued.

These results appear to be crucial, although the absolute values according to the graphs do not seem to be very varied. For this reason, we further focused on the decomposition of Leontief multiplication in the relative structure. For each region, we calculated the multiplier structure of the average Leontief multiplier for the region in question, and then we entered this data for all regions in the web diagram. The following set of 14 images illustrates the results of this calculation.

Figure 4 Structure of average multiplication out of the region (without Prague)

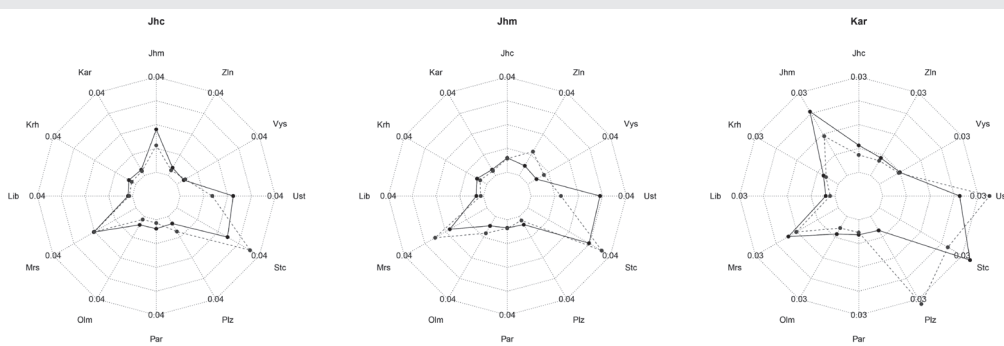
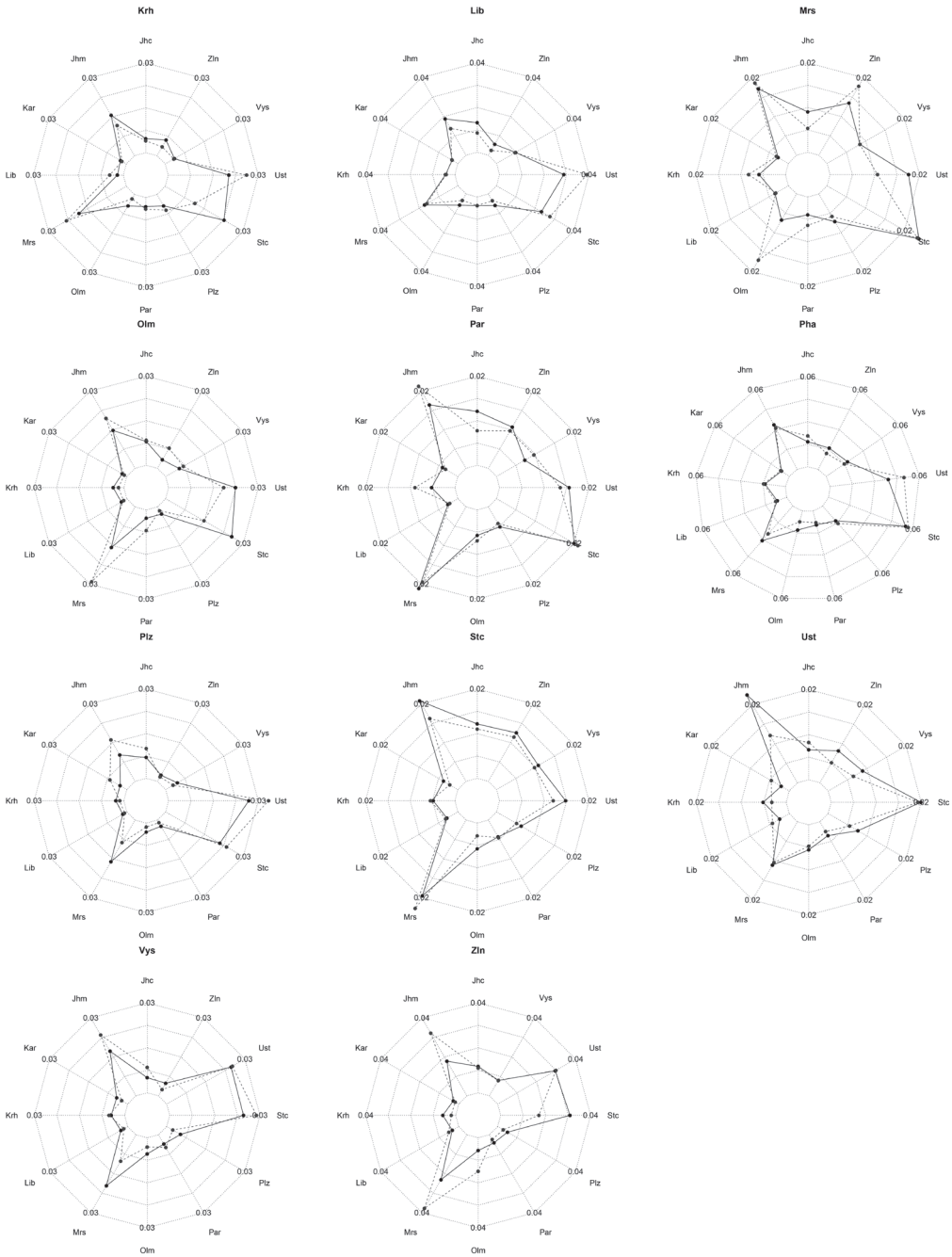


Figure 4 (continuation)



Note: The hatched line represents the entropy approach, and the black line represents the gravity approach.
Source: Author's work

The results clearly show that the considerable (up to 700%) difference is not significant in size, with very small shares in the Leontief total multiplier. This means that, from the size perspective, these are not the major differences in multiplication. The only major differences can be found in the South Bohemian Region, Karlovy Vary Region and Prague Region.

CONCLUSION

Input-output analysis is a powerful tool for modelling of a wide range of effects. Such models are often used on the level of total economy but they can be used on the level of regional economy, as well. The availability of regional input-output tables for the Czech Republic (KEST, 2017) allowed us to focus on interregional model. It means that it emphases the importance of the method used for modelling of interregional flows (in the case of Czech Republic for year 2013). Gravity method is commonly used but we show that entropy can be use as well. The selection of the correct method may be fundamental.

The results showed that despite the fact that the results in absolute values graphically do not show fundamental differences between regions, differences can be measured across individual regions from the perspective of multiplication process of the particular product in interregional model. With regard to the construction of the model, impacts on the entire economy are the same, but their structure differs significantly (retrospective multiplication to other regions). At first glance, the relative share of the Leontief matrices revealed fundamental differences, but the web diagram showed that this difference is not as fundamental in terms of the volume of multiplication between these methods. Therefore, it can be assumed that, if these two methods are used, the results of the impacts on individual regions will be very similar, except for the South Bohemian Region, Karlovy Vary Region and Prague Region, as mentioned above.

The results described in the paper can be used for further modelling and/or impact assessment analysis for the Czech Republic or they can serve as a guidance for those who are trying to construct interregional model for different country. We proved that interregional model can be constructed for smaller country, as well. We illustrate that the elements of Leontief matrix can be dependent on the method selected and can influence the forecasts of gross value added and employment across both regions and products. This has to be considered when conducting similar research and therefore we recommend to use at least two mentioned approaches.

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APPENDIX

Table A1 Estimates of parameters (Estimates and their 95% bounds)

Coefficient	Lower bound	Estimate	Upper bound
α_i	0.065	0.068	0.071
β_i	–0.013	–0.010	–0.007
ω^{pr}	1.057	1.068	1.079
ψ_i^p	0.595	0.602	0.609
ξ_i^r	–0.758	–0.749	–0.740

Source: Author's work

Table A2 Czech regions – Abbreviations and their full names

Abbreviation	Full name
Jhc	South Bohemian Region
Jhm	South Moravian Region
Kar	Karlovy Vary Region
Krh	Hradec Králové Region
Lib	Liberec Region
Mrs	Moravian-Silesian Region
Olm	Olomouc Region
Par	Pardubice Region
Pha	Prague
Plz	Plzeň Region
Stc	Central Bohemian
Ust	Ústí nad Labem Region
Vys	Vysočina Region
Zln	Zlín Region

Physical Supply and Use Tables: the Most Comprehensive Way for Reporting Waste Flows

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Abstract

Material flow analysis is a useful tool to measure resource use and mitigate the related problems. In order to increase its analytical potential, it is advisable to construct physical input-output tables. (PIOT). PIOT, defined by SEEA (UN et al., 2014), are based on two basic building stones: physical supply tables and physical use tables (PSUT). Besides other information, PSUT include data on waste and secondary materials. We collected waste and secondary material data for the Czech Republic, 2014, and incorporated them into various PSUT Tables. We argue that PSUT are a useful tool for organizing and depicting these data in a clear and comprehensive way. We constructed a Sankey diagram based on PSUT which provides some important insights into waste and secondary material flows in the Czech Republic. These insights can be used in reports assessing waste flows in the Czech Republic and for further shaping and updating of waste policies. We therefore think that our argument on usefulness of PSUT for organizing data on waste and secondary materials proved valid.

Keywords

System of environmental-economic accounting (SEEA), physical supply and use tables (PSUT), solid waste, secondary materials, Czech Republic

JEL code

Q56

INTRODUCTION

Sustainable consumption and production aims at "doing more and better with less," increasing net welfare gains from economic activities by reducing resource use, degradation and pollution along the whole lifecycle, while increasing quality of life (UN, 2017). In order to measure resource use and to mitigate the related problems, material flow analysis has been conceived (Eurostat, 2001; OECD, 2008). To increase analytical potential of this tool, it is advisable to construct physical input-output tables (PIOT). Data from PIOT can be used to analyse physical flows, considering the economic activities and structural changes that lie behind these flows, to analyse technological change, material substitution and to assess the effectiveness of policies targeting at sustainable consumption and production.

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The implementation of PIOT is a labour-intensive task involving many data entries. This is the reason why it has only been compiled for a few countries so far including Denmark (Mulalic, 2007), Finland (Mäenpää, 2004), Germany (Stahmer et al., 1997), Italy (Nebbia, 2000), New Zealand (McDonald and Patterson, 2006), Spain (Gasco et al., 2005), the Netherlands (Hoekstra and van den Bergh, 2006) and the EU (Giljum and Hubacek, 2004). Moreover, as no standardized approach for PIOT compilation was available until 2014, the above studies use different approaches and the resulting PIOTs thus have different formats and are not fully comparable.

The procedures for compilation of PIOT have been currently standardised in the System of Environmental-Economic Accounting (SEEA) (UN et al., 2014). PIOT are based on two basic building stones: physical supply tables and physical use tables (PSUT). While physical supply tables set out the flows relating to the production, generation, and supply of natural inputs, products and residuals by different economic units or the environment, the physical use tables set out the flows relating to the consumption and use of natural inputs, products and residuals by different economic units or the environment. The structure of PSUT is shown in Figure 1.

Figure 1 Structure of physical supply and use tables (PSUT)

Supply table

	Production; Generation of residuals		Accumulation	Flows from the rest of the world	Flows from the environment	Total
	Production; Generation of residuals by industries	Generation of residuals by households	Industries			
Natural inputs					A. Flows from the environment	Total supply of natural inputs
Products	C. Output			D. Imports of products		Total supply of products
Residuals	I1. Residuals generated by industry I2. Residuals generated following treatment	J. Residuals generated by households	K1. Residuals from scrapping and demolition of produced assets K2. Emissions from controlled landfill sites	L. Residuals received from the rest of the world	M. Residuals recovered from the environment	Total supply of residuals
Total supply						

Use table

	Intermediate consumption of products; Use of natural inputs; Collection of residuals	Final consumption	Accumulation	Flows to the rest of the world	Flows to the environment	Total
	Industries	Households	Industries			
Natural inputs	B1. Extraction of natural inputs used in production B2. Extraction of natural resource residuals					Total use of natural inputs

Figure 1 (continuation)

Products	E. Intermediate consumption	F. Household final consumption	G. Gross capital formation (including fixed assets and inventories)	H. Exports of products		Total use of products
Residuals	N. Collection and treatment of residuals		O. Accumulation of waste in controlled landfill sites	P. Residuals sent to the rest of the world	Q1. Direct residual flows from industry and households Q2. Residual flows following treatment	Total use of residuals
Total use						

Source: UN et al. (2014)

The compilation of PSUT can be understood as an extension of and addition to the compilation of supply and use tables and input-output tables in monetary units. These are commonly compiled at statistical offices, including the Czech Statistical Office. The PSUT tables in monetary units for the Czech Republic are regularly published at: <*http://apl.czso.cz/pll/rocenka/rocenka.indexnu*> (Czech Statistical Office, 2017a).

Reporting of residuals, including solid waste and also secondary materials produced from waste, is an important part of PSUT. We argue that PSUT are a useful tool for organizing and depicting these data in a clear and comprehensive way. Waste and secondary material data are covered by many tables. Table I shows production of waste by particular industries and production of waste which is intended for final disposal after treatment while Table J shows production of waste by households. Table K1 quantifies wastes from scraping and demolition of physical capital.

Tables L and P shows imports and exports of waste and Table M shows amount of waste recovered from the environment. Table N shows collection of waste and Table Q quantifies the flow of waste to the environment after treatment. Table C shows the production of recycled secondary materials for use in the economy. Finally, Tables E, F and G show the consumption of secondary materials by industries, households and for gross fixed capital formation while Tables D and H show imports and exports of secondary materials. As waste is approached from both the supply and use perspective and the direct and after treatment flows perspective, PSUT can be considered as the most comprehensive way for reporting waste flows.

The PSUT has been compiled for the Czech Republic for 2014 (Kovanda, 2018). This article shows how various data on solid waste have been integrated into PSUT. It also tries to show in a clear and comprehensive way the production of waste and use of secondary materials in the Czech Republic from the viewpoints of sectoral contribution and all other perspectives the PSUT can offer.

1 INTEGRATION OF WASTE DATA INTO PARTICULAR PSUT TABLES

1.1 Tables I and J

Table I shows production of waste by particular industries and production of waste which is intended for final disposal after treatment while Table J shows production of waste by households. Both tables do not include waste identified as unused domestic extraction[2] which is not considered a waste flow according

[2] Unused domestic extraction refers to materials extracted or otherwise moved on a nation's territory on purpose and by means of technology which are not fit or intended for use. Examples are soil excavated during construction or overburden from mining (Eurostat, 2001).

to the material flow analysis and PSUT methodologies (Eurostat, 2001; UN et al., 2014). Table I does not further comprise production of waste from demolition of buildings, transport infrastructures and other physical capital which is included in table K1. The amounts of waste in Tables I and J were based on data published by the Czech Statistical Office (Czech Statistical Office, 2015a). Some data needed for the calculations such as unused domestic extraction and demolition waste were provided by Eurostat (2017) and at request by the Czech Statistical Office employees (Czech Statistical Office, 2015b).

Table I and J Production of waste by particular industries and households and production of waste which is intended for final disposal after treatment (thousand tonnes), Czech Republic, 2014

NACE	01–03	05–09	10–36	37–39	41–43	45–47	49–53	55–99	Households
Production of waste	63	97	4 418	1 744	200	702	22	242	3 261
Production of waste which is intended for final disposal after treatment				5 697					

Source: Czech Statistical Office (2015ab), Eurostat (2017)

1.2 Table K1

Table K1 quantifies wastes from scraping and demolition of physical capital. This data was available from the Czech and Eurostat waste statistics (Czech Statistical Office, 2015b; Eurostat, 2017). Total volume of wastes from scraping and demolition of physical capital amounted to 4 597 thousand tonnes of which 4 518 thousand tonnes originated from demolished buildings and transport infrastructures and 79 thousand tonnes originated from other physical capital such as machinery.

1.3 Tables L, P and M

Tables L and P shows imports and exports of waste and Table M shows amount of waste recovered from the environment. Data on imports and exports of waste was provided by the Czech Statistical Office (Czech Statistical Office, 2015a). Table M was set equal to zero, as no waste is recovered from the environment in the Czech Republic. Total amount of waste imported to the Czech Republic equaled to 1 584 thousand tonnes while total export equaled to 2 945 thousand tonnes in 2014.

1.4 Table N

Table N shows collection of waste. The data are based on waste generated by enterprises and waste from municipalities under assumption that this waste is collected and further treated by NACE 38. Once again the amounts were reduced by waste identified as unused domestic extraction. Data for Table N was provided by the Czech Statistical Office (Czech Statistical Office, 2015ab).

Table N Collection of waste (thousand tonnes), Czech Republic, 2014

N1	Waste from enterprises	12 083
N1.1	Waste resulting from exploration, mining, quarrying, physical and chemical treatment of minerals	95
N1.2	Waste from agricultural, horticultural, aquaculture, forestry, hunting and fishing, food preparation and processing	206
N1.3	Waste from wood processing and production of panels and furniture, pulp, paper and cardboard	189

Table N (continuation)

N1.4	Waste from the leather, fur and textile industries	78
N1.5	Waste from petroleum refining, natural gas purification and pyrolytic treatment of coal	14
N1.6	Waste from inorganic chemical processes	14
N1.7	Waste from organic chemical processes	106
N1.8	Waste from the manufacture, formulation, supply and use of coating (paints, varnishes and vitreous enamels), adhesive, sealants and printing inks	39
N1.9	Waste from the photographic industry	1
N1.10	Waste from thermal processes	1 769
N1.11	Waste from chemical surface treatment and coating of metals and other materials; non-ferrous hydrometallurgy	76
N1.12	Waste from shaping and physical and mechanical surface treatment of metals and plastics	608
N1.13	Oil waste and waste of liquid fuels (except edible oils, 05 and 12)	121
N1.14	Waste organic solvents, refrigerants and propellants (except 07 and 08)	3
N1.15	Waste packaging; absorbents, wiping cloths, filter materials and protective clothing not otherwise specified	690
N1.16	Waste not otherwise specified in the list	431
N1.17	Construction and demolition waste	4 517
N1.18	Waste from human or animal health care and/or related research (except kitchen and restaurant wastes not arising from immediate health care)	32
N1.19	Waste from waste management facilities, off-site waste water treatment plants and the preparation of water intended for human consumption and water for industrial use	2 212
N1.20	Municipal waste from enterprises	881
N2	Waste from municipalities	3 553

Source: Czech Statistical Office (2015ab)

1.5 Table Q

Table Q quantifies the flow of waste to the environment after treatment, i.e. incineration and recycling, which can be identified with disposed waste (mostly landfilling). Total amount of disposed waste, without unused domestic extraction, equalled to 5 697 thousand tonnes in the Czech Republic in 2014 (Czech Statistical Office, 2015b).

1.6 Table C

Table C shows the production of secondary materials for use in the economy broken down by particular industries. The table was compiled with the use of two data sources: production of particular types of secondary materials such as secondary materials from metals, textiles or construction materials in tonnes (Czech Statistical Office, 2015a) and production of particular types of secondary materials in monetary units (Czech Statistical Office, 2015c). The data in tonnes was taken as a basis for Table C and was attributed to particular industries using monetary production of secondary materials under the assumption of homogenous prices of secondary materials. Table C shows the result of this attribution for industries which generated any secondary materials.

Table C Production of secondary materials by industries (thousand tonnes), Czech Republic, 2014

	Production of secondary materials (SM)										
NACE	13	16	17	22	24	25	28	31	32	35	38
SM from precious metals	0	0	0	0	0	0	0	0	0	0	47
SM from ferrous metals	0	0	0	0	10	1	0	0.4	0.1	0	3 172
SM from copper	0	0	0	0	0	0	0	0	0	0	30
SM from nickel	0	0	0	0	0	0	0	0	0	0	0
SM from aluminum	0	0	0	0	0	0	0	0	0	0	112
SM from other metals, glass and rubber	0	0	0	0	0	0	0	0	0	0	492
SM from paper	0	0	0.3	0	0	0	0	0	0	0	709
SM from plastic	0	0	0	0	0	0	0	0	0	0	354
SM from tires	0	0	0	2	0	0	0	0	0	0	13
SM from textile	1	0	0	0	0	0	0	0	0	0	1
SM from wood	0	11	0	0	0	0	0	0	0	0	167
SM from construction materials	0	0	0	0	0	0	127	0	0	0	3 471
SM from thermal processes	0	0	0	0	0	0	0	0	0	9 934	0
Other SM	0	0	0	0	0	0	1	0	0	0	97
Total SM	1	11	0.3	2	10	1	128	0.4	0.1	9 934	8 665

Source: Czech Statistical Office (2015ab)

1.7 Tables E, F and G

Tables E, F and G show the consumption of secondary materials by industries, households and for gross fixed capital formation. Data on consumption, household final consumption and gross capital formation were not available in physical units at all. The attribution of produced and imported secondary materials (sum of Tables C and D) to industries, households and accumulation was therefore based on relationships in the monetary use tables (Czech Statistical Office, 2017a) under the assumption of homogenous prices of secondary materials.

Tables E, F and G Consumption of secondary materials by industries, households and for gross fixed capital formation (thousand tonnes), Czech Republic, 2014

NACE	01–03	05–09	10–36	37–39	41–43	45–47	49–53	55–99	Households	Gross fixed capital formation
Secondary materials	65	52	9 900	5 357	338	518	79	1 022	2 364	–942

Source: Czech Statistical Office (2015ac), Czech Statistical Office (2017ab)

1.8 Tables D and H

Tables D and H show imports and exports of secondary materials. Data for these tables were provided by the foreign trade statistics of the Czech Statistical Office (Czech Statistical Office, 2017b). Total amount of secondary materials imported to the Czech Republic equaled to 90 tonnes while total export equaled to 61 tonnes in 2014.

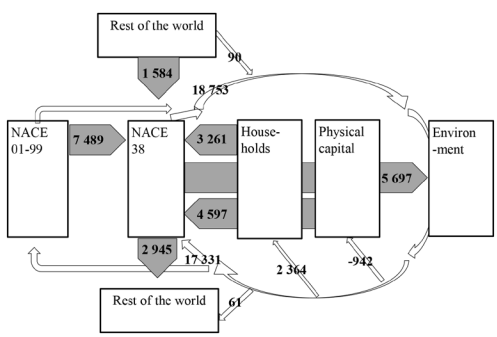
2 OVERALL PICTURE OF WASTE AND SECONDARY MATERIAL PRODUCTION AND USE IN THE CZECH REPUBLIC

Major reason for incorporating waste data into physical supply and use tables is to provide a complete and comprehensive picture of waste and secondary material flows in a country.

In the Czech Republic, 2014, industries produced 7 489 thousand tonnes with largest flow coming from the manufacturing industries (NACE 10-36, 4 418 thousand tonnes). Households contributed by 3 261 thousand tonnes. Another 4 597 thousand tonnes was added from demolishing of buildings, transport infrastructures and decommissioning of other physical capital. Production of waste intended for final disposal after treatment was 5 697 thousand tonnes. The amount of waste imported to the Czech Republic equaled to 1 584 thousand tonnes, the amount of waste exported was 2 945 thousand tonnes and no waste was recovered from the environment. Total amount of waste collected for treatment, i.e. produced waste from industries, households, physical scraping of physical capital plus imported waste, minus exported waste and plus balance of waste taken from stock, was equal to 15 636 thousand tonnes. Total amount of waste heading to the environment which can be identified with disposed waste (and production of waste intended for final disposal after treatment) was 5 697 thousand tonnes.

Total amount of produced secondary materials was 18 753 thousand tonnes with most secondary materials coming from electricity, gas, steam and air conditioning supply (NACE 35, 9 934 thousand tonnes). The reason why total volume of produced secondary materials is higher than the difference between total production of waste (Tables I, J, K1) and production of waste intended for final disposal after treatment is that some secondary materials such as ashes from electricity-related coal burning do not enter the waste system and statistics according to the Czech legislation, but are directly declared as secondary materials when they leave industries. Additionally to the domestic production, 90 tonnes of secondary materials was imported from abroad. Regarding the consumption of secondary materials, 17 331 thousand tonnes was consumed by industries, mostly by manufacturing industries (NACE 10-36, 9 900 thousand tonnes), 2 364 thousand tonnes was consumed by households and –942 thousand tonnes was used for gross fixed capital formation. Moreover, 61 tonnes of secondary materials was exported in 2014.

Figure 2 Scheme of waste and secondary material flows (thousand tonnes, import and export of secondary materials in tonnes), Czech Republic, 2014



Note: Waste flows are depicted by grey arrows, secondary material flows by white arrows.

Source: Czech Statistical Office (2015abc), Eurostat (2017), Czech Statistical Office (2017ab)

The scheme of waste and secondary material flows in the Czech Republic in 2014 is shown in Figure 2.

An important insight obvious from Figure 2 is that production of secondary materials for use in the economy is somewhat larger than the sum of waste produced by NACE 01-37, 39-99, households and from demolition of physical capital (18 754 thousand tonnes vs. 16 934 thousand tonnes). This is favourable news from the viewpoint of transition to circular economy (Commission to the European Parliament et al., 2015). Other insights include that production of waste by households is almost the half of waste production by NACE 01-37, 39-99 or that relatively significant amount of waste is exported and thus cannot be recycled for use in the economy.

CONCLUSION

The article describes how physical supply and use tables defined by SEEA can be used for organizing and depicting data on waste and secondary material flows. We argued that PSUT are a useful tool. We showed how waste and secondary material data are incorporated in various PSUT tables and on an example of the Czech Republic we illustrated how these data can be depicted in a clear and comprehensive Sankey diagram. An important feature of this depiction is that it integrates data on waste and secondary materials and indicates their ratios. This provides an information on how far the Czech Republic is on its transition to circular economy. Such insights can be used in reports assessing waste flows in the Czech Republic such as the Report on the Environment of the Czech Republic (CENIA, 2017). It can also be used for shaping and updating of waste policies including Waste Management Plan of the Czech Republic (Government of the Czech Republic, 2014) and broader environmental policies such as State Environmental Policy (Ministry of the Environment, 2016) in order to further strengthen the capacity of the Czech Republic to implement circular economy. We therefore think that our argument on usefulness of PSUT for organizing data on waste and secondary materials proved valid.

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A Statistical Analysis of Productivity and Compensation of Labor in the EU

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Abstract

The presented paper first discusses possible hypotheses on the relationship between compensation and labor productivity, arguing equiproportionality between the two cannot be considered a viable economic hypothesis. The main part of the analysis focuses on the EU countries, presenting a detailed view of the developments in the past twenty years from the point of view of both nominal and real unit labor costs. It shows that the relationship between compensation and labor productivity varies greatly among the economies and no general conclusions may be drawn. In case of the Czech Republic the estimates show that responsiveness of compensation to productivity is relatively high as compared with the EU panel and the growth of compensation surpasses the growth of productivity in both nominal and real terms as compared with the EU or Germany as a benchmark.

Keywords

Compensation, labor productivity, statistical analysis, unit labor costs

JEL code

F00, J24, J31

INTRODUCTION

Recently there has been a rather great deal of popular discussion on the issue of development of productivity and compensation of labor in the Czech economy in relation with the rest of the EU, especially Germany. It is a rather heated topic in the USA as well. Naturally, this economic question is of significant interest to the general public, which is why it is, for the most part, covered in less formal discussions and analyses outside the scientific journals. Compensation of labor is understood throughout this paper in accordance with the system of national accounts ESA 2010, Eurostat (2013), as the total remuneration, in cash or in kind, which is paid by employers to employees in return of work. It consists of both wages and social contributions paid by employers.

The presented paper aims at bringing in some evidence on this issue from the perspective of the EU economy and with a special focus on the Czech economy in its last section using a formal statistical analysis. The form of the analysis is well positioned in the theoretical economic framework, which is presented together with findings in other relevant literature directly after this introduction. Given this starting point, the next section presents information on how the various measures were constructed and which data was used. The third section shows the result for the whole EU economy. While the approach is based on theoretical reasoning, the aim of this section is not an estimation of an economic model but rather economic analysis of the presented data. The fourth section focuses on the Czech economy,

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especially giving some estimates of the responsiveness of compensation of employees to productivity in comparison with the EU. The key results are summarized in the last section of the paper.

1 ECONOMIC THEORY AND EMPIRICAL ASSESSEMENT OF THE RECENT SITUATION

The standard starting point of all the analyses on the relationship between productivity and compensation is that compensation should somehow correspond to productivity. However, to reach defensible conclusions, it must be argued precisely what nature this correspondence actually may and, on the other hand, may not represent.

In absolute terms, compensation reflects productivity equiproportionally only under the conditions of perfect competition, more precisely it is the equality between wage rate and marginal productivity of labor, a theoretical abstraction out of touch with the real world. A distinction between the short run and the long run is unnecessary in this case as the same conditions of perfect competition imply swift adjustments to changes in economic conditions. It is readily verifiable, e.g. Gravelle and Reese (1992), that when monopoly power of any strength is present the level of compensation ceases to be determined solely by productivity. No other market imperfections, more below, are necessary for this result to occur. Thus, to investigate the relationship between compensation and productivity, the idea of compensation being equiproportional to (labor) productivity must be abandoned right at the beginning because it is not an implication of any economic theory which might attempt at describing economic reality.

A good reference to the complexities of the relationship between compensation and productivity is D'Auria et al (2010), who, in their description of the production function methodology of potential output estimates, lay out the theoretical framework for the estimate of structural unemployment, which rests on a mixture of all the key theoretical approaches to labor market modeling, and closely follows the exposition of Mortensen and Pissarides (1999). From the point of view of labor supply it may be reasonably expected that the compensation is determined by reservation wage, labor productivity, unemployment rate, and bargaining power. The demand side of the model shows that the sole determinant of wages is labor productivity. The exact meaning of the reservation wage depends on the theoretical approach. From the point of view of the neoclassical theory it is derived from the utility of leisure, while in the search model, see Pissarides (2000), it is related to alternative income in form of unemployment benefits or the value of household non-market production. The role of labor productivity is also closely linked to the search theory while it is absent in neoclassical view of the labor market, which in its typical presentation rests on the assumptions of perfect competition. This more complex view of the labor market clearly shows that labor productivity is only one of potentially many determinants of compensation and, thus, there is much more than just the fact of monopoly power which precludes any meaningful analysis of compensation and productivity based on the idea of equiproportionality between the two.

Reviewing some relevant empirical findings, Pessoa and Reenen (2013) practically refuse the hypothesis of decoupling of compensation from labor productivity in the USA and in the UK when average figures are considered. Nevertheless, they point to sharp increases in income inequality since the 1970s. They state that the top 1% of the US households receive 19% of income while in the UK it is 15%.

Schwellnus et al (2017) analyze the OECD countries from a similar perspective as Pessoa and Reenen (2013) did in case of the USA and the UK. They show that between 1995 and 2013 the ratio of median wage to average wage declined in the OECD by app. 2%. In the Czech Republic the decline reached approximately 4%, similarly to Poland, and, on the other hand, a significantly lower decline in comparison with Hungary and the USA, where it amounted to a little over 8%. The share of labor in GDP (gross domestic product) decreased slightly in the OECD between 1995 and 2014. In the Czech Republic the share of labor increased by app. 3% especially due to an increase of labor share in services (non-market services were excluded from this analysis), which was very similar to the development in Slovakia, while in Poland and Hungary there were declines in the labor shares, much more significant in Poland,

and in both economies especially because of decreases in labor shares in manufacturing. They conclude that on average there has been decoupling of wages from labor productivity in the OECD countries, however, they refute the idea that it might be solely due to the effects of globalization and technological change. Based on the analysis, they claim that local policies have played a significant role in the process.

Nikulin (2015), focusing on Central and Eastern European countries, shows that there is a strong relationship between the evolution of wages and labor productivity in the Czech Republic, Estonia and Hungary and a somewhat weaker one in case of Slovakia and Slovenia. He also shows that in the Czech Republic, Slovakia and Slovenia wages increased more rapidly than labor productivity.

Galgóczi (2017) argues that generally the Central and Eastern European countries saw some under proportional increases in wages as compared to increases in labor productivity and claims that higher increases in wages would not harm the competitiveness of these economies.

This is a point which deserves a clearer exposition because it is closely related to the interpretation of the data on labor productivity as well as unit labor costs. Myant (2016) argues that the standard interpretation of unit labor costs, due to labor productivity, and its implications for competitiveness are inherently incorrect given the measurement problems. The key problems are related to how the prices of final output are estimated especially in case of non-market output of government and non-profit institutions and production in multinational companies. National accounts, see Eurostat (2013), resort to costs method in case of public services, whose result is dependent on the wage level of the particular country, and in many cases of the domestic production within multinational firms the prices are set in relation to comparable products produced in the economy. In both cases the relatively lower price and wage level of less developed economies automatically translates into estimates of lower productivity. In case of production within multinational firms, internal pricing policy which might deliberately undervalue the final output of production within a particular economy also plays a role. These facts greatly complicate comparison of absolute levels of compensation and productivity. Myant (2016) also contests the usual interpretation of unit labor costs, a ratio of average compensation (wage) to average productivity, as a measure of competitiveness. Such a typical analysis may be found for example in the relatively recent annual analysis by EC (2017). Beside the problems just mentioned above, the argument rests on the comparison of wages in the mother economy, typically much more developed, with much lower wages in the economy to which the multinational firms moved some parts of their production. Compared with the reallocation costs, unit labor costs would have to increase really significantly to pose any threat to competitiveness of the less developer economies.

2 METHODOLOGY AND DATA

The analysis presented in the following sections focuses on both levels of and relative changes in labor productivity, compensation and unit labor costs as both views offer answers to different questions. As it was discussed above the hypothesis of equiproportionality between compensation and productivity has no economic merit, however, international comparison of the relation between the two casts some light on the question whether or not compensation to relative to productivity in some countries may be considered as lower or higher given a benchmark, which then serves as a starting point to pose the question why. Such a question in turn may only be answered by explicit economic modeling, which, however, should not rest on a uniform approach or panel analysis, which implicitly assumes the same structure and behavior of the labor markets of the countries in questions. Given this part of the analysis is focused on the whole EU, this paper does not aim at answering the question why in the sense of rigorous economic modeling.

As it is crucial to show in which countries the compensation might be considered as relatively low or high given their labor productivity relative to a benchmark, leaving out dynamics of the two would render the final picture incomplete. For example, in case the compensation in one country is found as relatively

low given its labor productivity, the responsiveness of compensation to productivity then indicates, beside other factors, how probable it is that such a state will prolong into the long run.

The data used in the analysis was retrieved from the Eurostat database and runs from 1995 until 2017. There is a risk of misleading information towards the end of the sample because the data from national accounts is subject to revisions, however, for the purpose of the methods used in the analysis the data is included because of the need of sufficient length of the data series. These were data series on: purchasing power parity in terms of gross domestic product (PPPGDP) and final consumption expenditure of households (PPPC), gross value added in nominal (GVAN) and real (GVAR) terms, deflator of final consumption expenditure of households (DEFC), compensation of employees (COM), total employment (TEMP) and employees (EMP). Total employment and employees are measured in persons. Given the annual frequency of the data little difference in values of the resulting variables, nominal and real unit labor costs, was expected when using hours instead of persons. This was verified by directly comparing the variables based on persons and hours. Only data based on persons is presented below.

Compensation of employees as well as gross value added were expressed in purchasing power standard (PPS) using purchasing power parities: purchasing power parities at the level of GDP were used for gross value added conversion because purchasing power parities for gross value added are not generally published and purchasing power parities at the level of household consumption were used for the conversion of compensation of employees into purchasing power standard. Both nominal and real compensation and productivities are expressed in PPS.

Average compensation in PPS ($ACOMP^{PPS}$) was calculated as a ratio of nominal compensation of employees to number of employees:

$$ACOMP^{PPS} = \frac{COM/PPP_C}{EMP}. \tag{1}$$

Labor productivity in PPS (LP^{PPS}) was calculated as nominal gross value added relative to total employment:

$$LP^{PPS} = \frac{GVA_N/PPP_{GDP}}{TEMP}. \tag{2}$$

Unit labor costs in PPS (ULC^{PPS}) were calculated as a ratio of average compensation and productivity:

$$ULC^{PPS} = ACOMP^{PPS}/LP^{PPS}. \tag{3}$$

Both nominal and real unit labor costs are used in the analysis. To calculate real unit labor costs ($RULC^{PPS}$), nominal compensation of employees were deflated by deflator of household consumption and real gross value added was used to compute productivity:

$$RULC^{PPS} = \frac{\frac{COM}{DEF_C} * \frac{1}{PPP_C}}{EMP} \Big/ \frac{GVA_R * \frac{1}{PPP_{GDP}}}{TEMP}. \tag{4}$$

This means that the issues of compensation and labor productivity are analyzed from the point of view of employees.

The benchmark in the following section is the average of the EU while in the section focused on the Czech Republic, for the purpose of comparison, Germany is also used as a benchmark.

3 THE EU PERSPECTIVE

The first look at the data is dedicated to nominal and real unit labor costs, Table 1 and Table 2, respectively, of the European economies. The benchmark used is EU28 and the selected years are

1995, 2005, 2010, and 2017. The sample of the countries is not the same: Bulgaria (BG), Malta (MT) and Romania (RO) do not enter into the analysis of real unit labor costs because in cases of Bulgaria and Romania there are inconsistencies between nominal values, their real counterparts and deflators in the beginning of the sample, which was apparent from the analysis of contributions to changes in real unit labor costs, which is presented further below. In case of Malta data on real gross value added as well as deflator of gross value added are missing completely.

Table 1 Students enrolled in undergraduate studies at higher vocational

	BE	**BG**	**CZ**	**DK**	**DE**	**EE**	**IE**
1995	105	75	69	98	105	86	86
2005	106	77	82	101	99	81	84
2010	105	78	82	100	99	87	81
2017	107	109	86	98	103	98	53
	EL	**ES**	**FR**	**HR**	**IT**	**CY**	**LV**
1995	78	97	99	96	89	86	76
2005	93	101	102	109	92	98	76
2010	95	96	102	107	96	96	79
2017	90	95	106	97	92	93	94
	LT	**LU**	**HU**	**MT**	**NL**	**AT**	**PL**
1995	72	87	97	91	109	104	
2005	83	96	97	85	106	99	83
2010	75	93	87	85	106	101	87
2017	87	91	90	84	103	101	90
	PT	**RO**	**SI**	**SK**	**FI**	**SE**	**UK**
1995	99	85	115	71	92	83	84
2005	106	94	105	73	93	90	98
2010	96	85	113	73	99	91	102
2017	92	83	108	81	100	92	101

Notes: Countries: Belgium (BE), Bulgaria (BG), Czech Republic (CZ), Denmark (DK), Germany (DE), Estonia (EE), Ireland (IE), Greece (EL), Spain (ES), France (FR), Croatia (HR), Italy (IT), Cyprus (CY), Latvia (LV), Lithuania (LT), Luxembourg (LU), Hungary (HU), Malta (MT), Netherlands (NL), Austria (AT), Poland (PL), Portugal (PT), Romania (RO), Slovenia (SI), Slovakia (SK), Finland (FI), Sweden (SE), United Kingdom (UK).
Source: Own computation, data source: Eurostat

What can be assumed given this data is that when an economy experienced significantly different developments of nominal or real compensation given the development of productivity then significant

changes in nominal or real unit labor costs should be observed. Three crucial economic reasons for such changes may be readily established: (a) the catching up process of less developed economies linked to the preparations for EU entry and to the period after the actual entrance into the EU, (b) effects of strong economic expansion culminating in 2007, which translated into tighter labor markets leading to the possibility of higher compensation demands of employees, and (c) effects of strong economic downturn after 2008, which lead to not only far less tight labor markets but also to protracted periods of restrictive fiscal policy with both the factors resulting in the possibility of much slower compensation growth relative to productivity.

Table 2 Real Unit Labor Costs in Purchasing Power Standard (EU28 = 100)

	BE	**CZ**	**DK**	**DE**	**EE**	**IE**	**EL**
1995	109	68	93	114	76	76	77
2005	108	85	98	101	81	85	96
2010	105	82	100	99	87	81	95
2017	107	87	98	107	101	54	87
	ES	**FR**	**HR**	**IT**	**CY**	**LV**	**LT**
1995	95	96	88	88	85	79	68
2005	102	101	108	93	97	76	87
2010	96	102	107	96	96	79	75
2017	89	106	95	90	90	97	91
	LU	**HU**	**NL**	**AT**	**PL**	**PT**	**SI**
1995	78	100	107	107		97	115
2005	88	102	105	100	82	106	109
2010	93	87	106	101	87	96	113
2017	98	93	99	99	92	90	107
	SK	**FI**	**SE**	**UK**			
1995	78	95	81	80			
2005	78	94	89	99			
2010	73	99	91	102			
2017	77	102	96	98			

Notes: Countries: Belgium (BE), Czech Republic (CZ), Denmark (DK), Germany (DE), Estonia (EE), Ireland (IE), Greece (EL), Spain (ES), France (FR), Croatia (HR), Italy (IT), Cyprus (CY), Latvia (LV), Lithuania (LT), Luxembourg (LU), Hungary (HU), Netherlands (NL), Austria (AT), Poland (PL), Portugal (PT), Slovenia (SI), Slovakia (SK), Finland (FI), Sweden (SE), United Kingdom (UK).
Source: Own computation, data source: Eurostat

Table 3 presents the contributions of changes in compensation and productivity to changes in nominal and real unit labor costs; averages for the whole sample are given in the table. If we single out the last quartile of the set of average growth rates of nominal and real unit labor costs in absolute terms, we arrive at the following result: the countries which experienced the most significant changes in nominal unit labor costs were: Greece, the United Kingdom, Lithuania, Latvia, the Czech Republic, Bulgaria and Ireland. With the exception of Ireland, in which case there was a decline in nominal unit labor costs due to mild increase in compensation and large decrease in productivity, in all the other cases the nominal unit labor costs significantly increased: in Lithuania, Latvia, the Czech Republic and Bulgaria due to a more rapid increase in compensation relative to increase in productivity.

Table 3 Average Growth of (Real) Unit Labor Costs and Contributions

	ULC	Compensation	Productivity	RULC	Compensation	Productivity
BE	0.1	–0.2	0.3	–0.1	–0.4	0.2
BG	1.7	3.1	–1.4			
CZ	1.0	2.1	–1.1	1.1	1.1	0.1
DK	0.0	0.3	–0.3	0.2	0.2	0.0
DE	–0.1	–0.5	0.5	–0.3	–0.1	–0.1
EE	0.6	4.3	–3.7	1.3	0.9	0.4
IE	–2.2	0.2	–2.5	–1.5	0.3	–1.8
EL	0.7	–0.1	0.8	0.5	–0.7	1.3
ES	–0.1	–0.5	0.3	–0.3	–1.1	0.8
FR	0.3	0.1	0.3	0.5	0.5	0.0
HR	0.0	1.3	–1.3	0.4	0.1	0.3
IT	0.2	–0.9	1.0	0.1	–1.3	1.4
CY	0.3	0.0	0.3	0.3	–0.3	0.5
LV	0.9	4.1	–3.1	0.9	1.0	–0.1
LT	0.8	4.8	–3.9	1.3	3.2	–1.8
LU	0.2	–0.1	0.3	1.0	–0.2	1.2
HU	–0.4	0.8	–1.2	–0.3	–3.7	3.4
MT	–0.3	0.3	–0.7			
NL	–0.3	–0.4	0.1	–0.4	–0.6	0.2
AT	–0.1	–0.3	0.2	–0.4	–0.4	0.1
PL	–0.2	1.8	–2.0	–0.2	0.9	–1.1

Table 3 (continuation)

	ULC	Compensation	Productivity	RULC	Compensation	Productivity
PT	–0.4	–0.2	–0.1	–0.3	–0.9	0.5
RO	–0.1	4.3	–4.4			
SI	–0.3	0.7	–1.0	–0.3	–1.6	1.3
SK	0.6	2.8	–2.2	–0.1	0.8	–0.9
FI	0.4	0.2	0.2	0.4	0.1	0.3
SE	0.5	0.6	–0.1	0.8	0.9	–0.1
UK	0.8	0.6	0.2	1.0	0.4	0.6

Notes: Countries: Belgium (BE), Bulgaria (BG), Czech Republic (CZ), Denmark (DK), Germany (DE), Estonia (EE), Ireland (IE), Greece (EL), Spain (ES), France (FR), Croatia (HR), Italy (IT), Cyprus (CY), Latvia (LV), Lithuania (LT), Luxembourg (LU), Hungary (HU), Malta (MT), Netherlands (NL), Austria (AT), Poland (PL), Portugal (PT), Romania (RO), Slovenia (SI), Slovakia (SK), Finland (FI), Sweden (SE), United Kingdom (UK). The slight differences between unit labor costs growth and its contributions are due to rounding.
Source: Own computation, data source: Eurostat

From the point of view of real unit labor costs, the last quartile consists of the United Kingdom (and Latvia with a nearly the same figure), Luxembourg, the Czech Republic, Estonia, Lithuania and Ireland. With the exception of Ireland the changes were positive. Focusing on the less developed economies in this group, increases in real compensation surpassed increases in real productivity in Latvia and Lithuania, while growths in real compensation were accompanied by declines in real productivity in the Czech Republic and Estonia.

The question of significant changes in unit labor costs is further explored by unit root testing. Following Arltová a Fedorová (2016) and their results on the applicability of unit roots tests in the presence of relatively short time series, Dickey-Fuller GLS test and KPSS test are employed to detect countries which experienced nonstationary development of unit labor costs, which should be indicative of divergent evolutions of compensation and productivity. The results of the unit root testing are presented in Table 4.

Not surprisingly in various cases the results of the unit roots test give conflicting outcome. Thus, only those series which were considered nonstationary by both the test are considered to be exhibiting trend behavior, either stochastic or deterministic.

Based on these results Table 5 then presents categorization of the economies in question which exhibit trend behavior of unit labor costs, and, therefore, statistically significant divergences between the evolution of compensation and productivity. The categorization is done according to the behavior of unit labor costs, compensation and productivity.

As far as nominal unit labor costs are concerned, only Bulgaria, the Czech Republic and Hungary from the set of relatively young EU members experienced trend behavior and only in cases of Bulgaria and the Czech Republic it may be considered as a result of catching up process since in Hungary nominal unit labor costs decreased on average due to slower growth of compensation relative to productivity. The categorization of Greece, Portugal and Spain indicates the results of restrictive fiscal policies: in case of Portugal increase in productivity was even accompanied by decrease in compensation. The strong fiscal stance in these economies may be readily deduced from the development of structural balance of general government published by AMECO database. Comparing the development of the ratio of structural balance of general government to potential GDP, the ratio increased by 2.4 pp in Greece, 1.2 pp in Portugal and 0.9 pp in Spain between 2010 and 2015, which is indicative of strong fiscal restrictions; the average change in this ratio for the whole EU was 0.6 pp.

Table 4 Unit Root Tests

	Nominal ULC		Real ULC	
	DF-GLS	**KPSS**	**DF-GLS**	**KPSS**
BE	–2.35**	0.48**	–2.62**	0.25
BG	–0.26	0.53**		
CZ	–0.68	0.66**	–0.20	0.54**
DK	–2.44**	0.13	–2.36**	0.29
DE	–1.20	0.28	–2.22**	0.34
EE	–1.78*	0.48	–1.48	0.61**
IE	0.30	0.42*	0.25	0.29
EL	–1.32	0.46*	–1.46	0.31
ES	–1.22	0.44*	–0.53	0.42*
FR	–0.18	0.62**	–0.38	0.63**
HR	–1.31	0.30	–1.68*	0.20
IT	–1.61*	0.38*	–2.09**	0.28
CY	–1.43	0.38*	–1.63*	0.33
LV	–2.56**	0.33	–2.52**	0.35*
LT	–3.52***	0.06	–2.86***	0.22
LU	–2.08**	0.18	–0.70	0.67**
HU	–1.07	0.54**	–1.24	0.48**
MT	–1.92*	0.15		
NL	–1.23	0.60**	–0.09	0.54**
AT	–1.87*	0.24	–0.94	0.48**
PL	–1.85*	0.17	1.72	0.14
PT	–0.09	0.53**	–0.25	0.49**
RO	–2.09**	0.32		
SI	–1.73*	0.13	–1.42	0.36*
SK	–1.18	0.19	–1.44	0.48**
FI	–2.83***	0.55**	–2.39**	0.52**
SE	–1.39	0.62**	–1.01	0.66**
UK	–1.11	0.53**	–1.46	0.48**

Notes: Countries: Belgium (BE), Bulgaria (BG), Czech Republic (CZ), Denmark (DK), Germany (DE), Estonia (EE), Ireland (IE), Greece (EL), Spain (ES), France (FR), Croatia (HR), Italy (IT), Cyprus (CY), Latvia (LV), Lithuania (LT), Luxembourg (LU), Hungary (HU), Malta (MT), Netherlands (NL), Austria (AT), Poland (PL), Portugal (PT), Romania (RO), Slovenia (SI), Slovakia (SK), Finland (FI), Sweden (SE), United Kingdom (UK). Unit root test: DF-GLS (Dickey-Fuller GLS, null hypothesis = unit root), KPSS (Kwiathowski-Phillips-Schmidt-Shin, null hypothesis = stationarity), *, **, *** signifies rejection of the null at 1%, 5%, 10% significance level, respectively.

Source: Own estimates, data source: Eurostat

From the point of view of real unit labor costs, catching up process is observed in the Czech Republic and Estonia and Slovakia (real unit labor costs decreased on average but very slightly). While the effects of restrictive fiscal policy are still observable in Portugal and Spain where real compensation decreased more than real productivity, it is not seen in the data for Greece.

Table 5 Categorization of Countries

Increase of Nominal Unit Labor Costs				**Decrease of Nominal Unit Labor Costs**			
		Productivity				**Productivity**	
		Increase	**Decrease**			**Increase**	**Decrease**
Compensation	**Increase**	BG, CZ, SE	FR, UK, CY	**Compensation**	**Increase**	HU, IE	
	Decrease		EL		**Decrease**	PT	NT, ES
Increase of Real Unit Labor Costs				**Decrease of Real Unit Labor Costs**			
		Productivity				**Productivity**	
		Increase	**Decrease**			**Increase**	**Decrease**
Compensation	**Increase**	FR, SE	CZ, EE, UK	**Compensation**	**Increase**	SK	
	Decrease		LU		**Decrease**		HU, NT, AT, PT, ES, SI

Notes: Countries: Bulgaria (BG), Czech Republic (CZ), Estonia (EE), Ireland (IE), Greece (EL), Spain (ES), France (FR), Cyprus (CY, Luxembourg (LU), Hungary (HU), Austria (AT), Portugal (PT), Slovenia (SI), Slovakia (SK), Sweden (SE), United Kingdom (UK).
Source: Own computation, data source: Eurostat

4 PERSPECTIVE OF THE CZECH REPUBLIC

The development of unit labor costs, both nominal and real, which was presented in the previous section is in case of the Czech economy more or less the same whether the benchmark used is EU28 or Germany. However, especially for the purpose of common discussion when the development of purchasing power of households is frequently compared with Germany, the data is explicitly stated in Table 6.

Over the course of the sample the average growth of the nominal unit labor costs was 1.0% in case EU28 as a benchmark and 1.1% in case of Germany as a benchmark. Looking at the real unit labor costs, the average growths reached 1.1% and 1.4%, respectively.

Table 6 Comparison of Unit Labor Costs in PPS of the Czech Republic with EU28 and DE as benchmarks

	Nominal Unit Labor Costs		**Real Unit Labor Costs**	
	EU28 = 100	**DE = 100**	**EU28 = 100**	**DE = 100**
1995	69	65	68	59
1996	73	69	74	64
1997	75	71	77	68
1998	74	70	77	68

Table 6 (continuation)

	Nominal Unit Labor Costs		Real Unit Labor Costs	
	EU28 = 100	DE = 100	EU28 = 100	DE = 100
1999	74	70	77	69
2000	74	70	77	69
2001	75	73	79	73
2002	78	76	82	76
2003	79	78	84	81
2004	80	81	85	83
2005	82	82	85	84
2006	81	83	85	85
2007	82	85	85	88
2008	81	83	82	85
2009	80	80	81	81
2010	82	83	82	83
2011	82	83	82	82
2012	84	83	83	81
2013	84	83	83	80
2014	83	81	84	80
2015	83	81	85	79
2016	84	82	85	80
2017	86	83	87	81

Source: Own computation, data source: Eurostat

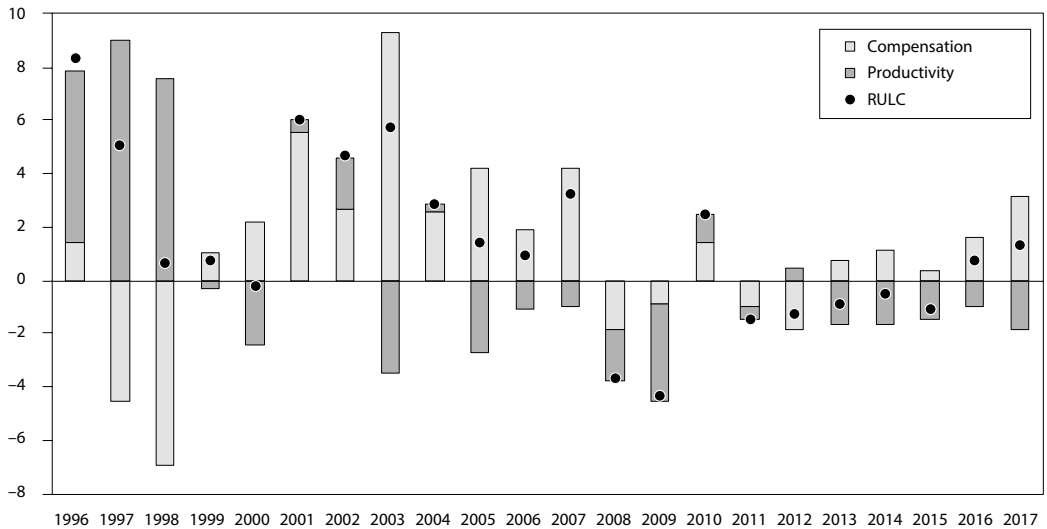
Focusing now on real unit labor costs, it is interesting to look at the structure of their growth, Germany is used as a benchmark. Over the whole sample the growth of the real unit labor costs of 1.4% came from a growth of real compensation of 1.2% and a decline in productivity of 0.2%. More detailed picture is presented in Figure 1. The data is presented in such a way so that the sum of contributions of compensation and productivity directly gives the growth of real unit labor cost, for example, the contribution of compensation in 2006 was 2.0 pp and that of productivity –1.0 pp so that the growth of real unit labor costs was 1.0% and, at the same time, the growth of productivity was 1.0%.

The results show that the real compensation in the Czech Republic has converged to the level in Germany, expressed in PPS, and given the sample, from 49% in 1995 to 64% in 2017 while productivity started at 83% and reached 79% in 2017. The development of productivity is significantly influenced

by its profound decline between 1995 and 1996. However, starting from 1996 the message stays the same: the real unit labor costs increased by 1.1% with contributions of compensation and productivity at 1.2 pp and –0.1 pp, respectively.

Not only does the data show that real compensation has converged to the level of Germany but also that their responsiveness to changes in productivity may be relatively significant.

Figure 1 Contributions of Compensation and Productivity to RULC Growth in the Czech Republic with Germany as a benchmark



Note: RULC: real unit labor costs.
Source: Own computation, data source: Eurostat

A closer look at this question shows that real compensation does indeed respond to productivity quite strongly in the Czech Republic as compared with the whole cross-section of EU28 economies (Bulgaria, Germany, Malta, Poland, Romania were excluded: Germany was a benchmark and the data for Poland starts in 2000, which was not a problem in the previous analysis, however, it would significantly reduce the sample here).

The question of the responsiveness of real compensation to productivity was examined by means of dynamic ordinary least squares with one lag and one lead to account for possible feedbacks between the two variables, constant was also introduced in the relationship, however, their estimates are not reported in Table 7 as they have no specific interpretation in this case. In both cases their estimates were not statistically significant.

The stationarity of the data was tested by DF-GLS and KPSS unit root tests in case of the Czech Republic and it was already indicated in the previous section that they were found nonstationary. In case of the panel, the Levin-Lin-Chu test of the common unit root process was used with the statistic at –0.85 for compensation and –1.12 for productivity, confirming common unit root process in both the cases.

Given the estimates of the panel, the results show that real compensation responds positively to productivity and the relationship is highly statistically significant. In case of the Czech Republic the relationship between real compensation and productivity is much stronger than the EU average. Cointegrating relationship was confirmed by the Hansen test as it is shown in Table 7. In both cases

Table 7 Cointegration

Panel (DOLS), cross-sections	23	**Czech Republic (DOLS)**	
Observations	19	Observations	19
dependent variable		*dependent variable*	
compensation		compensation	
independent variable		*independent variable*	
productivity	0.34***	productivity	0.81***
Residuals		*Residuals*	
Autocorrelation at 1st lag	0.24	Autocorrelation at 1st lag	0.29
Partial Autocorrelation at 1st lag	0.24	Partial Autocorrelation at 1st lag	0.29
Jarque-Bera	0.30	Jarque-Bera	0.41
		Hansen Cointegration Test	0.06

Notes: Autocorrelation of residuals stated, tested with Q-statistic under the null of no autocorrelation, normality of residuals tested by Jarque-Bera under the null of normality, LC statistic for Hansen cointegration test given under the null of cointegration, significance of estimated values of independent variable given under the null of their estimates being zero, *, **, *** signifies rejection of the null at 1%, 5%, 10% significance level, respectively.
Source: Own estimates, data source: Eurostat

the residuals may be considered normal and without autocorrelation. These results are in line with the research of Nikulin (2015), which has already been referred to above.

CONCLUSION

The paper presented some stylized facts on the development of compensation and productivity in the EU. To properly handle the issue it refuted right in the beginning the popular belief that compensation should be somehow directly aligned with productivity. Such a hypothesis may only be based on the restrictive assumptions of perfect competition and thus has no empirical merit in the real world. To econometrically evaluate the relationship between compensation and productivity a full-fledged labor market model would need to be constructed and estimated. However, it still would not give an answer to the question whether or not compensation is high or low relative to productivity but rather whether is high or low relative to all the set of variables. Also it must be taken into account that no uniform model might be used for the set of countries examined in this paper because, for example, as far as unemployment benefits are concerned, certainly one of the determinants of compensation, as shown in the theoretical part of the paper, there are countries with a very short or no history of unemployment benefits.

The approach employed in the paper rested on direct comparison of the data on compensation and productivity, both in nominal and real terms, expressed in PPS with the aim to identify countries with trend developments of unit labor costs and thus divergences between the evolutions of compensation and productivity. This was carried out with the use of unit root testing and subsequent categorization of the economies. The analysis showed that about half of the sample experienced divergences in the evolutions of compensation and productivity which may be put down to, especially, catching up process of some of the less developed economies and the effects of severe fiscal restrictions after 2010.

The last section focused on the Czech Republic with the aim to answer the question of responsiveness of compensation to productivity. Using dynamic OLS and comparing the results for the Czech Republic with the whole panel, the outcome showed that the responsiveness of compensation to productivity is relatively high. This goes hand in hand with the finding that, over the course of the sample, compensation increased significantly more than productivity both in nominal and real terms and both with EU28 and Germany as benchmarks.

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The Influence of Public Support on University-Industry-Government Collaboration: the Case of the Czech Republic, Slovakia, Hungary and Romania

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Abstract

European, national governments and regional authorities, in recent times, are actively encouraging technology transfer from universities to industries as a fulfilment of the well embraced "third mission" of universities. To pursue this, governments have mediated this process by enacting and enforcing legislative instruments and efficiently appropriating research outcomes by providing public funding support structures to aid universities in their research commercialization efforts. The paper aims to examine various public funding schemes available for firm's innovation collaborations and how they influence firm's cooperation. Using data from the Eurostat's Community Innovation Survey (2012–2014) and the binary logistic regression model, we found that funding from the central government was a significant determinant influencing firm's collaborations with universities, other enterprises in the enterprises group and with government research centres. Conversely, funding from local authorities and the EU was largely insignificant in influencing firm's collaborations with other enterprises and the government. Practical policy recommendations will be also provided to strengthen firm's collaboration.

Keywords

Public funding, government, university, firms, collaboration, innovation

JEL code

H5, H7, 030

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INTRODUCTION

Funding of research and development activities as part of supportive public policies for research gradually gained fame after the end of the second world war as an established means of boosting regional innovation and growth. Fueled by the linear model innovation, the years following the 20th century, in the European Union witnessed the portion of real gross domestic product apportioned for expanding the foundation of scientific and technological purposes for both private and public entities increasing although stagnated sometimes, it never significantly reduced (David, Hall and Toole, 1999). However, for universities, government support has appeared to have diminished recently (Beaudry and Allaoui, 2012) even as governments in their new-found role, commercialized one sector or collaboratively conducted basic research to generate a stable flow of income to supplement research funds for the academia.

Furthermore, this principle has been furthered on by activists of the new growth theory and has established a strong connection with long run economic growth and endogenous forces such as human capital, knowledge spill-over from interactions of regional players and information technology. Chiefly hinged on the reliance of knowledge as an asset with no diminishing return, it is believed that the creation of interactive relationship between firms and institutions that provide human capital, i.e. universities, coupled with the support of funding institution activates knowledge sharing and transfer among these players, generating new and innovative ideas when merged with current knowledge and consequently boosting productivity and growth in knowledge-based economy.

In an effort to assess the relevance of public support, Schneider and Veugelers (2010) attempted to discover the public policy measures that had been implemented across the European Union to support Young Innovative Companies (YIC's) and found newness, smallness and high R&D (research and development) intensity of such firms made them highly innovative with access to finance very crucial. Falk (2007) also surveyed 1 200 Austrian firms to identify the degree of need of public funds and concluded that increased innovation inputs do not necessarily lead to more innovation output and, in a similar way, behavioral changes which he termed as constituting only of intermediate results should be economically justifiable either at the micro or macro-level. Other researches have focused on the design and impact of public policy measures oriented at boosting technology transfer activities and university–industry relations, specifically those that hinged on official processes such as licensing, trademarks, patenting and generation of spin-offs (Goldfarb and Henrekson, 2003; Mustar and Wright, 2010). However, they were criticized as focusing only on single country experience (Kochenkova, Grimaldi and Munari, 2016).

Considering the relevance of collaborative research among enterprises (Stejskal, Meričková and Prokop, 2016), among universities (Bozeman and Slade, 2013), inter-sector scientific collaboration (Lakitan, Hidayat and Herlinda, 2012) the synergetic effects of collaboration and widespread essence of knowledge spillover arising (Acs and Audretsch, 2010) and its essence widely entrenched courtesy of the New growth theories, the goal of this research is to assess the impact of public funds – local, national and supranational – on collaborative research of enterprises, universities and public organizations among selected Eastern European countries.

The remainder of the paper is structured as follows: the next sections deal with the progressive views of public policy support to research, the third sections touches the methodology of conducting the research on the selected countries, fourth section provides details of the discussion on the results acquired and the final part concludes the paper.

1 REVIEW OF LITERATURE

The public sector plays quite important role in providing support to regional players. Public support consists of a myriad of activities performed on behalf of the government such as the catalyst, facilitator and advocate of business ideas, regulation of institutional and organizational activities via legislation and policy structuring, financing public and private R&D activities and even creatively planning the preferred

urban structure of cities at the local level (Herliana, 2015). However, public funding as it is relatively the most obvious and tangible form of public support will be mainly focused on.

Public funding of research and regional innovation attempts have made a critical part of most national and regional innovation support schemes especially in the CEEC, i.e. Central and Eastern European Countries (Radosevic and Lepori, 2009). Their regulatory capacity and financial prowess have eased off the difficulty in sourcing funds for regional players whilst maintaining transparency and accountability in a regional innovation system even as it also complements private funding (Un and Montoro-Sanchez, 2010). Impact of funding for regional players has revealed mixed reactions from various researchers. Lundvall (2010) researched on the National systems of Innovation and various interventions of the public sector in regional innovation systems. Dodgson et al. (2011), in his research, also talked of the public sector as financial contributor to private firms and concurred with Fehr, Rosenborg and Wiegard (2012) on the need for capital funding that are tailored for small and medium sized enterprises. This, he believed, will allow innovative new firms to introduce socially useful products to their market niches.

Research on sources of innovation of manufacturing sectors in Slovakia and Hungary revealed that in as much as firms can acquire knowledge for innovation internally or via cooperation, Slovak firms derived their innovation from in-house activities and other sources such as scientific journals and conferences while Hungarian firms relied on market sources such as cooperation with clients or customers from the private sector for their innovation as well as from scientific journals (Odei and Stejskal, 2018) researched on sources of innovation between Slavic Schakenraad (2013) demonstrated a positive relationship between the formation of technology partnerships and firm-level innovation. His findings also supported the findings of Guellec and Van Pottelsberghe de la Potterie (2002) whose research also revealed a positive correlation between R&D in government labs, universities and market sector total factor productivity growth in 16 OECD countries whilst controlling for other factors. The admonishing of the role of public sector as an active financier in the regional indigenous and exogenous network as well as research of Coccia (2012) concurred to the positive effects of public financial support, underlines the irreplaceable need of public funds to support regional research initiatives even as it is argued to accentuate the evidence of failures of the market. (Lundvall, 2010; Edquist, 2010).

The assimilation of industrial and political interest into that of academia heralded new pathways of collaborative research and equally blurred the traditional role the public sector and the other helices (Benner and Sandstrom, 2000). Although the public sector is now even involved in redirecting academic work oriented to commercial usage (Benner and Sandstrom, 2000) in generating economic growth in the knowledge economy, it possesses a comparably higher capacity in assisting with funding for locally initiated and international collaboration whilst also ensuring better coordination of actors in networks (Lepori, 2011). Firm collaboration has been proven to have extensive impact on firm growth, innovation and regional productivity (Audretsch and Feldman, 2004; Zang, Shu and Malter, 2010; Odei, 2017). Wennberg, Wiklund and Wright (2011) compared university and industry spin offs finding that performance of corporate spin offs in terms of sales growth and survival is higher than university spin offs, but not for employment growth further adding up to the essence of knowledge overflow from sector-wide cooperation. Whilst industrial collaboration with university is adjudged to inject more practical and realistic expectations into the theoretical knowledge imparted, there is also the fear that such alliance could rather affect the research output of universities (Feller, 2005; Garvey, 2014). Consequently, if such perceivably detrimental alliances are continuously viewed as inimical to the diffusion and open access of knowledge, it may risk changing the perspective of policy makers that seeks to favour collaborative alliance to rather opt for the short-term pros of industrial research rather than the more informative findings from collaborative research (Dosi et al., 2006).

In the CEEC, funding patterns changed in the last two decades owing more to economic restructuring and two systemic changes: opening of previously closed research systems and the introduction

of the principle of quality (Radosevic and Lepori, 2009). Institutional uncertainty including disrupted production, technology and trade linkages hindered funding in the early 90's, however, incremental institutional changes in the early 2000's coupled with an increasing international assistance, accession plans into the EU despite a reducing public funding, did boost the growth and has continued up till now. GERD/GDP increased with the injection of EU structural funds among CEEC, especially in the Czech Republic and Estonia (Radosevic and Lepori, 2009). Currently, the introduction of Horizon 2020 EU funding program for research and development and prior ones have added to the comprehensiveness of funds for transnational research, industrial and entrepreneurial support, not just to academia and firms but also to the local and regional authorities. As funds from the public sector have a higher potential of ensuring effectiveness due to their control capacity and reliability, it becomes curious to assess their tendency to influence firms to research collaboratively with regional players even as it is proven to have multiplier effects on regional productivity.

Regarding the impact of the public funds on these regional players, Kang and Park (2012) assessed small- and medium-sized biotechnology enterprises (SMEs) in South Korea for the impact of governmental support on output and found direct and indirect influence of governmental support on the innovation output of SME's in biotechnology. Guo, Guo and Yang (2016) also found firms performing significantly better technologically and in commercializing outputs compared with other firms. Bruneel, D'este and Salter (2010) drew data from a large-scale survey and public records to research on the barriers of university-industry collaboration in UK. Results revealed that collaborative research lowers orientation-related barriers and that higher levels of trust reduced barriers of universities orientation and to the transactions involved in working with partners of these universities. Aside financial incentives, incubation support in the form of science parks, entrepreneurial support, venture capital has a positive influence on universities spin off activities (Odei and Stejskal, 2018); Teodorescu and Andrei (2011) also researched on cooperation of Eastern European countries regarding scientific literature and found international cooperation in science and social sciences becoming more frequent and extensive, playing far greater role today in the production of scientific knowledge in these countries. Tochkov and Nenovsky (2011) researched on efficiency of public funds in the educational system in Bulgaria and revealed inefficiencies in public schools compared with private schools. Ebersberger (2005) also researched on impact of public funding on innovation efforts of Finnish firms focusing on input and output additionality. He concluded that on average, public funding increases private innovation efforts of firms that received the funding, in both nominal and real terms. Public funding was also found, average, to increase the innovation output of funded firms but ultimately this sort of funding was considered to be most efficient when meant to stimulate collaborative innovation activities.

However, in as much as several scholarly researches on these countries have been conducted, most of them have focused on their growth over the past decades (Radosevic and Lepori, 2009; Kozak, Bornmann and Leydesdorff, 2015). There has not been an extensive assessment of the exclusive impact of funds from a defined public sector on collaboration in CEEC in a triple helix context: enterprises, universities and public institutions. It is sought to assess the impact of respective public funds ranging from the local, national and European Union perspective on collaboration of firm's collaborative research with enterprises, universities and public sectors in selected Central and Eastern European countries. This research intends to prompt the various inquests and checks on the dissemination of funds, their defined usage versus actual usage to improve accountability and ensure effectiveness of funds if the contrary is proved. The objective is to identify the impact of Local, National and supranational funds on collaborative scientific research involving universities, industries and the government (Public). Based on findings which revealed firms as initiators of cooperation (Goet et al., 2017) and knowledge capabilities increases with bigger public funding (Aschoff, 2010; De Blasio, Fantino and Pellegrini, 2015), we establish the hypothesis that:

H1a: *Local public funding has a significant influence on affecting firm collaboration with other firms.*
H1b: *Local public funding significantly influences firm collaboration with universities.*

Un and Montoro-Sanchez (2010) also asserts due to the control prowess of the public sector and the consistent transparency and accountability checks at the regional and National level, firms are forced to align such funds even more with the intended purposes. Hence the following hypothesis:

H1c: *Local public funding does not influence firm collaboration with government research firms.*
H2a: *National funding does influence cooperation of firms with other firms.*
H2b: *National funding significantly affects firm collaboration with universities.*
H2c: *National funding does influence firm cooperation with government research institutes.*

As Bronzini and Iachini (2014) suppose that business usually prefer to invest in cooperation with internally generated funds and may even acquire other knowledge in national and international markets, we further hypothesise that:

H3a: *European Funds are not significant in instigating firm cooperation with other firms.*
H3b: *European funds do not influence firms to cooperate with universities.*
H3c: *Funds acquired at the European level does not influence firm cooperation with government research centers.*

2 METHODOLOGY AND SOURCES OF DATA

Data for the empirical analysis was taken from the Eurostat's Community Innovation Survey (CIS) conducted between 2012 and 2014. In the Community Innovation Survey, firms are asked to indicate their sources of funding and partners they collaborate with. Many studies have used the CIS data to study firm level innovation, public support and firm's collaborations (Prokop et al., 2017; Archibugi and Filippetti, 2018).

Given the binary character of the dependent variable (firm's collaborations with other entities) the logistic regression model was used. The goal of logistic regression model is to examine the best fitting model to describe the relationship between the dichotomous dependent variable and a set of independent variables (Harrell, 2015). The logistic regression is often used if the independent variables contain a mixture of both continuous and categorical variables (Dayton, 1992; Hosmer and Lemeshow, 2000,). In our study, the probability of a dichotomous outcome (e.g. cooperation or non-cooperation) is related to a set of explanatory variables (financial determinants of R&D, see Table 1). The reduced form of the binomial logistic modem can be expressed as:

$$Co\_op = \beta 0 + \beta 1 FUNLOC + \beta 2 FUNMGT + \beta 3\ FUNEU + \varepsilon\ , \quad (1)$$

where Co_op represents firms' cooperation, β_0 is the intercept term, β_1, β_2, and β_3 are the coefficients associated with explanatory variables of local funding (FUNLOC), national funding (FUNMGT) and funding from the European Union (FUNEU) and ε is the error term. A positive intercept means that baring all independent variables, there is still a likely probability of occurrence of the event and the higher the figure, the higher the likeliness; a negative one however, explains that baring all interference of the independent variable, there is an unlikely probability of occurrence of the event. The more negative it is, the more unlikely it is to occur. A positive beta coefficient means that the log of odds increases as the corresponding independent variable increases. Negative beta coefficient, on the other hand, denotes an unlikely occurrence of the event as the independent variable increases. Three dependent and independent

variables were selected for this research. The independent variables were mainly financial variables classified by their source: namely local, national and European Union funding provided to support research activities research activities of enterprises, universities and government research centres. These have been duly explained in Table 1.

Table 1 Variables used in the model

Independent Variables	FUNLOC, FUNGMT, FUNEU
Dependent variables	CO11, CO61, CO71

Note: FUNLOC – Funding from local government, FUNGMT – Funding from National state, FUNEU – Funding from the European Union, CO11 – Firms collaboration with other firms, CO61 – Firms' collaboration with Universities, CO71 – Firms' collaboration with government research institutes.
Source: Author's own compilation

3 RESULTS AND ANALYSIS

The focus of this paper is to analyse how public support influences firm's collaboration. Probability of three main sources of funding and how they influence firm's collaborations within the enterprise group, with universities and with government research centers was analyzed. The results are shown in Table 2.

Table 2 Effect of funding on firms' collaboration within the enterprise group

Country	**Romania**	**Czech Republic**	**Hungary**	**Slovakia**
	β (p value)	**β (p value)**	**β (p value)**	**β (p value)**
	Tjur r^2–0.06	**Tjur r^2–0.16**	**Tjur r^2–0.20**	**Tjur r^2–0.76**
Constant	–3.158	–2.439	–2,122	–2.491
FUNLOC	0.305 (0.694)	0.072 (0.834)	–0.188 (0.765)	**1.537 (0.093)** *
FUNGMT	**0.895 (0.051)** *	**0.323 (0.048)** **	0.175 (0.400)	**1.402 (0.003)** ***
FUNEU	–0.408 (0.474)	**–0.448 (0.011)** **	0.161 (0.404)	0.176 (0.696)
Number of observations	7 662	5 449	5 152	2 888

Note: *** significant at p< 0.01, ** significant at p< 0.05, * significant at p< 0.10.
Source: Own calculation

From Table 2 it can be evidenced that funding from local or regional governments influenced firm's collaborations with other firms in the enterprise group. This was statistically significant and positively influenced firm's collaborations in Slovakia thereby fulfilling *H1a*. This meant that Slovak firms that received local funding were more likely to collaborate with other enterprises in the group. Slovak firms cooperating receiving local funds are highly likely to increase with increased local funding. In countries like the Czech Republic, Romania and Hungary, local funding did not influence firm's collaborations effectively rejecting *H1a*. Contrastingly, in Table 3, in all the remaining countries, local funding from regional authorities did not influence the likelihood of firm's collaborations with universities effectively rejecting *H1b* for all countries. Table 4 has also demonstrated that local funding statistically influenced firm's collaboration with government research institutions in the Czech Republic and showed a high probability of occurrence of cooperation proved by a positive coefficient. It was also statistically insignificant

in determining firm's collaboration in the remaining countries, hence *H1c* was rejected in the Czech Republic and accepted in other countries. The result is similar to the findings of other studies (Levén et al., 2014; Maietta, 2015; Acosta et al., 2015).

Public funding from the central government was also a significant source of funding for manufacturing firms in the countries under study. Table 2 shows that central government funding influenced firm's collaborations with other firms in the enterprise group in Romania, the Czech Republic and Slovakia and the odds of cooperation within enterprises in these countries were highly likely. Considering their co-efficient, Slovakia would be even more likely to have more cooperation with other enterprises compared to the Czech Republic and Romania when central government funding is supplied. Per contra, central government funding was not statistically significant in Hungary effectively ensuring that *H2a* was accepted in all countries except Hungary.

In Table 3, public funding from the National level was positive and statistically significant in influencing firm's collaborations with their local universities. Implying that manufacturing firms in these countries were highly likely to collaborate with universities for their sources of knowledge and innovations increased. This effectively accepted *H2b* in all countries assessed. Although in all countries under study, public funding proved to be significant, it was highly significant and more likely in Slovakia as can be seen with the highest coefficient in Table 3 (1.864).

Lastly, public funding from central government was also statistically significant in influencing firm's collaborations with government research centers. This meant that apart from universities, public research centers were the preferred choice of collaborative partner for manufacturing firms and firms receiving public funding were highly probable to collaborate with public research institutions. This was also statistically significant for all countries effectively. The study also corroborates the findings of (Aschoff, 2010; Goel et al., 2017).

Table 3 Funding influence on firm's collaboration with universities

Country	Romania	Czech Republic	Hungary	Slovakia
	β (p value)	**β (p value)**	**β (p value)**	**β (p value)**
	Tjur r^2–0.06	**Tjur r^2–0.60**	**Tjur r^2–0.5**	**Tjur r^2–0.82**
Constant	–2.906	–2.220	–1.422	–2.104
FUNLOC	0.828 (0.101)	0.406 (0.202)	–0.172 (0.695)	1.064 (0.255)
FUNGMT	**0.928(0.009)** ***	**1.601 (0.000)** ***	**0.757 (0.000)** ***	**1.864(0.000)** ***
FUNEU	**0.705 (0.043)** **	**0.679 (0.000)** ***	0.204 (0.161)	**1.157(0.000)** ***
Number of observations	7 662	5 449	5 152	2 888

Note: *** significant at p< 0.01, ** significant at p< 0.05, * significant at p< 0.10.
Source: Own calculation

Funding from the European Union has also been instrumental in supporting firm's collaboration with other entities. The results in Tables 2, 3 and 4 have shown that firms receiving EU funding showed a strong significance to cooperation and a high likelihood of collaborating with local universities in Romania, the Czech Republic and Slovakia evidenced by their coefficient. This rejected *H3b* for all countries but Hungary. Conversely, EU funding was not significant in supporting firm's collaboration with other firms in Hungary, Romania and Slovakia affirming *H3a* in these countries except for the Czech Republic.

Similarly, EU funding influenced firm's collaborations with universities in all the countries under study but Hungary. Hungarian firms that received EU funding did not show any significant influence on cooperation and were not likely to collaborate within the enterprise group or with universities. Lastly, the results have also shown that EU funding influenced firm's collaborations with government research centers only in Romania, but it was not significant in influencing the probability of firm's collaboration with government research centers in Hungary, the Czech Republic and Slovakia. This confirmed *H3c* in all countries except Romania. The results are similar to the findings of Rõigas et al. (2018). They found out that firms receiving funding support from the EU are more likely to cooperate with universities. While firms in new EU member states such as Hungary receiving funds from the EU were not likely to collaborate with universities.

However, in Tables 2, 3 and 4, the negative intercept recorded for all countries receiving local funding, national and European funding shows the unlikely probability of cooperation happening without the interference local, national or European Union funding going further to entrench the credence of funding for cooperation.

Table 4 Funding influence on collaborations with Government

Country	Romania	Czech Republic	Hungary	Slovakia
	β (p value)	**β (p value)**	**β (p value)**	**β (p value)**
	Tjur r^2–0.25	**Tjur r^2–0.25**	**Tjur r^2–0.50**	**Tjur r^2–0.58**
Constant	–2.736	–3.342	–2.664	–2.885
FUNLOC	0.392 (0.438)	**0.895(0.004)** ***	0.153 (0.787)	0.796 (0.502)
FUNGMT	**2.245 (0.00)** ***	**1.920(0.000)** ***	**0.710 (0.001)** ***	**1.885 (0.000)** ***
FUNEU	**0.899 (0.003)** ***	0.359 (0.163)	0.299 (0.162)	0.591 (0.187)
Number of observations	7 662	5 449	5 152	2 888

Note: *** significant at p< 0.01, ** significant at p< 0.05, * significant at p< 0.10.
Source: Own calculation

CONCLUSIONS

The focus of this paper is to examine the influence of public support on firm's collaborations. Hence, it was sought to provide an empirical insight into how public funding supports collaboration among firms, universities and government research centers. Financial support from central governments and the EU can increase the probability of firms' collaboration with other entities because it can help overcome the obstacle of shortage of finance that hinders them from partnering other institutions for knowledge sharing and innovation. Data from the Eurostat Community Innovation Survey (2012–2014) and the binary logistics model was used whilst funding from local or regional authorities, central government and the EU were used as the explanatory variables.

Three different models were used to assess how funding influenced firm's collaboration within the firms, universities and with government research institutions. The analysis conducted affirmed *H1a* in Slovakia and rejected it for all other countries assessed. *H1b* was rejected in all countries assessed and *H1c* was rejected in the Czech Republic but, however, accepted in all other countries. *H2a* was accepted in all countries except Hungary whilst *H2b* and *H2c* were accepted in all countries assessed. *H3a* was also accepted in all other countries except the Czech Republic,

H3b was rejected among all countries considered except for Hungary and *H3c* was also confirmed in all countries but Romania.

The results strongly support the pivotal role played by central government funding in firm's collaborations. Firms receiving funding from the local government were more likely to cooperate with other firms only in Slovakia, however, local funding only strongly influenced firm's collaborations with government research centers in the Czech Republic. Firms receiving funding from their central government were also found to be more likely to collaborate with other enterprises in the enterprise group, with universities and with government research centers. Among all the funding sources considered for this paper, it is worth noting that central government funding was largely identified as most significant source for collaboration with all entities considered. Lastly, firms receiving EU funding were found to be more likely to collaborate with universities, this was particularly true for Romania, the Czech Republic and Slovakia. It was also a significant source of funding for firms that collaborated with government research centers in Romania.

Policy recommendations are therefore provided on how various funding sources can be used to increase firm's collaborations with other triple helix entities. Funding from local authorities is currently not a reliable source for firms aiming to cooperate with other entities probably because these authorities do not have huge funds to allocate to managing firm's collaboration. Local authorities can therefore strengthen their funding for industries by providing other non-financial benefits such as tax reliefs and other sweetener policies for firms aiming to cooperate for innovation purposes. Secondly, governmental support measures should focus more on promoting the efficient use of EU funding schemes for firm's cooperation with universities, other enterprises with the group and with government research centers.

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Public Finance, the Public Sector and the General Government Sector

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Abstract

The aim of this paper is to bring a contribution to the clarification of the terms such as public finance, public sector or government which are widely used in economic analysis or in public finance management. In the Czech environment, those terms are understood differently across statistical, legislative or accounting domains. The paper illustrates a nuanced understanding currently existing. Apart from the illustrations of varying use, the content of terms in question and their mutual relation are explained and analysed from the point of view of a relevant statistical methodology. The paper concludes offering a more robust content of the term "public finance" in relation to the statistical data which are generally used as an illustration of public finance development.

Keywords

Public finance, public sector, government sector

JEL code

E02, E60

INTRODUCTION

The aim of this paper is to bring a contribution to the clarification of the terms widely used in economic analysis and in public finance management. Here, we are referring to the terms such as public finance ("veřejné finance"), public institutions ("veřejné instituce"), public sector ("veřejný sektor") on the one hand, and the government sector ("vládní sektor") or government finance ("vládní finance") on the other hand. Although an apprehension and an application of those terms in the Czech economic literature and national legislation is often arbitrary, from the statistical point of view they represent different stages of aggregation, clearly separated, and providing users with different kind of information. Given the above, we consider it highly necessary to clarify the meaning of those statistical concepts.

Not least, disparate views on which entities aggregates concerned actually represent may hamper discussions on public finance performance as well as its analysis and public finance management. So-called Maastricht criteria might serve a perfect example. By signing the Maastricht treaty, the Czech Republic is obliged to stick to the fiscal rules requiring to maintain government ("vládní") deficit under 3 percent of GDP and debt not more than 60 percent of GDP.[3] Quantification of relevant figures is closely linked

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[3] For the sake of our discussion, we can ignore an exceptions from this rule.

to the treatment of public/government finance and to the national accounts´ delimitation of public/government sector managing public/government financial means. Although "the Maastricht criteria" are commonly presented as public finance indicators, they do not fit the definitions of the public sector in national accounts.

Making a difference between both concepts is of key importance not only for the public finance management, but also for theoretical considerations and empirical research on how public/government finance affects economic performance and business cycle, on the range of redistribution through political mechanism or even on inflationary/deflationary pressures originating in the public sphere. Methodology of statistical data underlying empirical research in this area goes mostly unnoticed by researchers. This purely methodological paper is meant to at least partly fill this gap. This need is further highlighted by the evolution which the methodology has gone through lately. Recent trend manifested itself in an expansion of the government sector taking gradually still larger share within the public sector´s sphere.

1 TERMINOLOGY IN USE

Historically, authors did not make much difference between the terms such as state, government or public; they were rather considered synonymous. For example, aiming to calculate the national income, economists and statisticians like William Petty, Gregory King or Adam Smith used the term "public finance" ("veřejné finance") referring to the budget of central authority. Similar holds true for Keynes, who approached the impact of government on the economy in terms of cash flow (revenue and expenditure) of the state.[4] In his famous book "Macroeconomics", Mankiw (1992), when discussing the government deficit and debts, also refers to the state rather than any other (public) entity (p. 337).

P. A. Samuelson and W. D. Nordhaus (1991) addressed such a too narrow understanding to public finance. When discussing the performance of public finance, Samuelson and Nordhaus identified that term not only with the state budget and the state debt, but they also paid attention to various budget deficits at other levels of government. In the section on government debt,[5] borrowed funds are discussed in relation to budget deficits defined as government or public debt ("vládní, či veřejný dluh").

Let us take a look at the Czech economic literature. In widely-used textbook on public finance, Hamernikova and Maaytova (2010) define public finance as "economic relations and operations carried out between institutions of public administration and other institutions in economic system".[6] According to this definition, "public finance" would statistically cover only institutions classified in the branch of public administration. In other words, institutions falling in the area of social security, public defence and the like would fall outside the definition of public finance or the public sector.

Inadequacy of similar views is further highlighted by the fact that statistical treatment is steadily getting wider. The definition of public finance, as of today, captures wide array of institutions managing tax revenues, public property or institutions engaged in information technologies (the Czech Television, the Czech Radio), culture (the National Theatre or the National Museum), education (grammar schools, high school or public universities), healthcare (especially public hospitals) or even financial business (the Czech Export Bank or the Czech-Moravian Guarantee and Development Bank). Recent trends thus reveal a need to understand public finance in a much broader sense.

In another well-known Czech economic book (Holman, 2016), public finance is defined as the state budget together with budgets of municipalities (p. 598).[7] After mentioning this, the size of the public sector is illustrated by the share of total expenditures of the general government sector, as defined in ESA2010, on GDP. Then, the aggregate on the total government expenditures is further referred

[4] Auerbach, Kotlikoff, Leibfritz (1999).
[5] Samuelson and Nordhaus (1991, pp. 383–417).
[6] Authors´ translation from the Czech original.
[7] Authors´ translation from the Czech original.

to as "public expenditures". Narrow definition of the public sector is thus accompanied by illustration with data representing much wider concept than original definition set out in the book. Similarly in Spevacek (2012), the development of so-called public finance is demonstrated by the use of data describing the general government sector as defined in national accounts.

The discrepancy between terminology and the real content of illustrative data can be hardly overlooked. For the sake of complexity, we should mention that lack of consensus between economists on the definition of public finance (and related terms) is recognized by public finance economists themselves (Hamernikova-Kubatova, 1999, p. 18). At this stage, we can only reiterate that it is not an ambition of this paper to provide exhaustive definitions, but to describe the relations between relevant concepts, their mutual relations and to show a certain kind of leeway with which they are used.

To do so, let us move on to the Czech national legislation. Act No. 23/2017 Coll. regulating the Rules of Budgetary Responsibility lays down, with reference to the EU legislation, rules for public institutions in the public institution sector (par. 1) which take care of sound public finance (par. 2).[8] This act represents implementation of the Council Directive 2011/85/EU on requirements for budgetary frameworks of the Member States. Still, the definition stated in the act is not straightforward.

Paragraph 3 of the Act defines "public institutions in the public sector" which is, however, not defined in the Directive. The Act No. 23/2017 Coll. uses the term "institution of the general government sector" only for so-called "other economy unit" (par. 3, clause "m"), which meets characteristics of the institution classified in the general government sector. However, it is not entirely obvious from the wording of the Act whether the term "the general government sector" and "the public sector" are considered identical, i.e. synonymous, or not.

Further, two separate parts devoted to the public budgets are contained in the State Final Account of the Czech Republic. Concretely, we are referring to the part B (Economic development and public budgets) and part F (Economic report on other public budget components and on funds of the state budgetary organisation). It can be drawn on the text that only the state budget, the National fund, the former National Property Fund, extrabudgetary funds, public social security and local authorities (municipalities, regions, etc.) are considered parts of the public finance. The term "public budgets" thus encompasses only units using budgetary system (data on cash basis).

At the same time, the text in the part B draws the reader´s attention to the fact that the text presents data on the public finance as defined in the international standard Government Financial Statistics 2014 (GFS2014). It is worth mentioning in this respect, that both GFS2014 and the previous GFS2001 are harmonised with the manual ESA2010 (and ESA1995 respectively) in the basic concepts. This implies that all these systems present data covering the economic behaviour of units classified in the general government sector and on the accrual basis.

As in the previous cases, the conception in the State Final Account constitutes rather narrow definition of the public finance in comparison to other accounting systems discussed below and statistical models. To sum up, the term "public finance" is not firmly defined in the Czech legislation. Furthermore, the Act No. 89/1995 Coll. on the State Statistical Service further contributes to certain confusion in the use of terminology. In paragraph 9 on the use of administrative data, the Act states that the Czech Statistical Office can use individual data of public institutions classified, for statistical purposes, in the public sector. It further indicates, that this relates to quantification of deficit and debt on both quarterly and annual basis in line with the requirements of the European Community. In fact, this provision relates to the institutions treated as part of the general government sector which are generally referred to as government institutions.

Recently, we can also come across the term "a consolidated group of the state".[9] This concept captures a group of units specifically designed for the sake of consolidation of the state. Technically, it consists

[8] The interpretation from the Act No. 23/2017 Coll. is translated by the authors.

[9] The final data on the consolidation of the State are published on the website of the Ministry of Finance.

of a group of units classified in the general government sector representing the state and state enterprises which might be classified not only in the same sector as these "core" institutions, but also in the sectors of non-financial and financial corporations. This implies that this concept stands somewhere between other consolidated levels of public institutions such as the general government or the public sector.

2 DELIMITATION OF PUBLIC AND GOVERNMENT INSTITUTIONS IN INTERNATIONAL DOCUMENTS

The Council Directive 2011/85/EU mentioned above is entirely based on the concepts stipulated in the national accounts´ methodology, i.e. the general government sector in the first place. Data depicting the behaviour of the general government are taken as basis for monitoring of public finance. The following quotation is illustrative in this respect: *"To be effective in promoting budgetary discipline and the sustainability of public finance, budgetary frameworks should comprehensively cover public finances. For this reason, operations of those general government bodies and funds which do not form part of the regular budgets at sub-sector level and that have an immediate or medium-term impact on Member States' budgetary positions should be given particular consideration*" (section 25 of the Directive 2001/85/EU). From this perspective, financial means going through the general government accounts can be thus understood as public finance.

This treatment leaves open a question whether or not also financial resources of governmentally controlled corporations shall be treated as part of public finance.[10] This kind of units are referred to as public corporations taking various legal forms like state enterprises, public joint-stock companies (e.g. public transport companies) or public limited liability company (e.g. technical services). They often remain classified outside the general government sector; they do not thus add to "public finance" as derived from the generally accepted definitions.

Here we come to the one of the potential sources of certain leeway in use of the terms in the Czech environment. In the Czech translation of the Council Regulation (EC) No. 479/2009,[11] the English term "government" ("vládní") is translated into Czech as "public" ("veřejný"). Consequently, the term "public" ("veřejný") is generally used for a narrower statistical concept of "government" (vládní"), while a broader statistical concept of "public sector" defined in the ESA2010 does not actually have a Czech equivalent. As a result, the term "public" ("veřejný") is somewhat confusingly used to describe both the general government and the public sector.

Looking at other European legislative acts, we realize that the term "public" ("veřejný") has been too serving as an equivalent of the general government sector ("vládní"). The following acts can be mentioned as examples – Commission Regulation (EC) No. 264/2000 of 3rd February 2000 on the implementation of Council Regulation (EC) No. 2223/96 with respect to short-term public finance statistics, or the Government Finance Statistics 2001 and 2014 drawn up by the International Monetary Fund.

At the end of this section, let us briefly mention how the public sector, or public finance respectively, is treated in the international accounting standard for the public sector (hereinafter IPSAS). In IPSAS, the public sector covers also so-called government business enterprises (hereinafter GBE) running their business on the profit-seeking basis. Delimitation of the public sector in IPSAS is thus very similar to that in the national accounts´ methodology. However, the latter further draw a line between public enterprises operating on the market and non-market basis whereas only the latter is part of the consolidated group (the general government sector). It is just this different approach to consolidation which makes a key difference between IPSAS and ESA (Dabiccio, 2015).

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[10] This view if pursued e.g. in the Fiscal Monitor published by the International Monetary Fund (2018).

[11] On the on the application of the Protocol on the excessive deficit procedure annexed to the Treaty establishing the European Community.

3 PUBLIC SECTOR AND GENERAL GOVERNMENT SECTOR

As we have tried to show above, the statistical concepts shape the general understanding to the scope of public finance and public sector. In this section, we will thus more clearly define these groups of institutional units as defined in the national accounts´ manuals.[12] The public sector covers the general government sector as well as non-financial and financial (quasi-)corporations. This implies two important aspects. First, particular group of publicly controlled institutional units is left out of the government sector as they supposedly operate on the market basis. Second, it is the concept of control which determines the scope of the public sector.

The notion of control consists in the ability of government institution *"to determine the general policy or programme of that entity"* (par. 20.18, ESA2010). It is worth recalling that the public sector is not a part of the core sector accounts nor has a code number in the code list of institutional sector. The actual content of the public sector is graphically illustrated by Table 1.

Table 1 The public sector and its constituents

General government sector				Public corporations		
					Public financial institutions	
Central government (S.1311)	State government* (S.1312)	Local government (S.1313)	Social Security Funds (S.1314)	Public non-financial corporations (S.11001)	Central bank (S.121)	Other public financial corporations (S.12001)

Note: * not relevant for the Czech Republic.
Source: Own processing

Aggregates for the public sector in the Czech Republic are regularly published by the CZSO in the form of the satellite accounts which is methodologically compatible with national accounts´ definitions. Moreover, the final aggregates are presented on the consolidated basis, i.e. internal flows within the consolidated entities are eliminated.[13] Final balance of the public sector is referred to as "public surplus/deficit", debt of the public sector than as "public debt". Debt is thus defined in line with the methodology ESA as sum of debt instruments (deposits and currency, debt securities and loans) on the asset side of the balance sheet. Nevertheless, its valuation at market prices makes an important difference compared to the definition of debt in the EDP statistics.

As Table 1 further demonstrates, the general government sector constitutes only that part of the public sector capturing on those public institutional units operating on the non-market basis. To specify in greater detail, ESA defines this group of units *"which are non-market producers whose output is intended for individual and collective consumption, and are financed by compulsory payments made by units belonging to other sectors, and institutional units principally engaged in the redistribution of national income and wealth"* (par. 2.111, ESA2010). Furthermore, the government sector includes all public corporations and quasi-corporations which are not entitled to act independently from government institutions, public institutions predominantly financed from government institutions or public units in liquidation.

To illustrate both entities numerically, the public sector consisted of 19 216 economic units at the end of 2017. The general government sector itself counted 18 042 economic subjects of different legal forms whereas 617 were included in the central government, 17 414 in the local government and 11 units were

[12] The position of national accounts data is dominant in this area; we thus consider as logical and even necessary to departure our discussion from the structural approach of the system of national accounts.

[13] The purpose of consolidation is not to inflate the share of revenues and expenditures in terms of GDP (O´Connor, Weisman, Wickens, 2004).

classified in the social security funds. All in all, the general government sector does not cover 1 143 public non-financial corporations running their business on the market basis as defined in the methodology and 7 public financial corporations.

It shall be mentioned that the determination of market behaviour remains an open question in the methodology. Currently, the manuals enumerate a number of criteria to be applied in this respect. As the treatment of market behaviour constitutes a key moment in the definition of the government sector and implicitly "public finance", let us make a few more remarks on this issue. First, although we are dealing with the macroeconomic statistics, an assessment of market behaviour of a particular unit is made at the level of institutional unit. The very first step is to decide whether a particular public producer does meet the criteria to be an independent institutional unit, as it is defined in the paragraph 2.12 ESA2010.

If a unit is recognized as institutional unit, other criteria shall be applied. The first group is related to qualitative aspects of the operation. It concerns of existing institutional environment in which a given activity is carried out. The methodology requires compilers to check the existence of private competitors, economic advantage of public producer due to regulation, granted guarantees on the value of assets or debts, and the like. If those qualitative characteristics are not met, a unit shall be classified in the government sector. If not, then compilers have to proceed to check so-called quantitative criteria. Quantitative criteria focus on the share of own revenues on the production costs. It simply states that revenues from non-government institutions including subsidies provided equally to all producers engaged in similar activities shall exceed 50 percent so that public unit can be considered as market public producer classified outside the government sector.

By application of the rules mentioned above, the methodology of national accounts, contrary to the rules stated in IPSAS, divides the public sector into market and non-market parts. This also causes conceptual and quantitative difference between final balance and debt of the public sector and the government sector. The non-market part serves a basis for the public finance management as is the case of EDP statistics. However, then we run into trouble how to interpret the public sector in its entirety, or rather how to reconcile these concepts with the term "public finance", i.e. whether it should be attributed to the public sector or the government sector, as is currently the case.

4 TOWARD ROBUST DEFINITION

To sum up the discussion above, we can illustrate nuanced approaches by Table 2.

Table 2 The treatment of public sector in statistical system, accounting and legislation

	System of national accounts	National legislation and economic texts	IPSAS
State	Part of the central government sub-sector	Central budgetary institutions	
Government institutions	General government sector	Public institutions	
Public institutions	Public institutions		Public institutions

Source: Own processing

From the methodological point of view, it is worth mentioning that the proportional share of ownership is not reflected in national accounts´ sector classification. This is not the case of IPSAS where a unit is consolidated within the public sector according to the share. In other words, if the share exceeds 50 percent then a public producer is included in the national accounts´ public sector in its entirety. If not, a unit is again wholly classified in the subsector of domestically or foreign controlled corporations.

In the consolidation of the state mentioned above, similarly to IPSAS, units controlled by the state are consolidated up to the share of the state.

It can be drawn on Table 2 that the public sector is treated in different way as to the coverage of institutional units. Aggregates of national accounts represent the broadest concept compared to those applied in legislative or economic texts. Evidently, the national accounts´ concept is closer to the system IPSAS. After all, ESA or MGDD are in many aspects inspired by the concept of IPSAS, chiefly in the definition of control. However, the main difference is the reflection of share ownership as described in the previous paragraph.

CONCLUSION

Application of the term "public finance" in national legislation and economic texts is highly fragmented giving impression that different statistical output bears the same explanatory power or that it describes economic behaviour of the same segment of economy. This might lead not only to mistaken decisions but also confusions in discussions of economists when it comes to sustainability of public finance or the adoption of economic policy measures.

It is thus highly desirable to establish more robust definitions in this area and not least to find more appropriate Czech equivalents of English terms. For doing so, mutual cooperation of translators, economists and lawyers would be very valuable. In our text, we have tried to show how the treatment and understanding differ across domains like macroeconomic models, accounting systems or legislation.

To conclude, in our view, as public finance or public budgets shall be strictly understood financial resources, i.e. revenues and expenditures, managed by government institutions classified in the general government sector in national accounts. Identification of the term "public finance" or "public budgets" with the public sector in national account, let alone with the state budget or the state debt, would make current inconsistencies in understanding persist.

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Supporting the Compilation of Quality Reports

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Abstract

During the last years, the quality unit of Destatis made valuable experiences at national and international level with the compilation of quality reports concerning the following questions: Which concepts of the quality reports are typically posing problems for the subject matter units? How can existing guidelines be improved (in wording and form) in order to better support the compilation of quality reports?

Based on the experiences made by Destatis, the aim of the paper is to present which additional support could be provided to the compilers of quality reports – besides the already existing ESS or national guidelines for quality reports: a) A checklist for quality reports based on the guidelines for quality reporting and b) extensions and further specifications on the content of the guidelines for quality reporting and c) provision of standard texts for designated concepts.[2]

Keywords

Quality report, ESQRS, ESMS, metadata, guidelines, checklist, standard text

JEL code

L15

INTRODUCTION

Quality reports play an important role in describing the quality of statistical outputs as well as the methods and definitions used. Their aim is to enable the users of statistics to interpret and use the statistical products correctly by providing meaningful and complete content. However, the compilation of quality reports is not trivial for the subject matter units. Therefore, the paper focuses on the question, how can the compilers of quality reports get the best support in compiling quality reports?

Quality reports are subject to European and national standards described in the respective detailed European and national guidelines for quality reporting. When working closely with these guidelines in various contexts, Destatis made valuables experiences and identified possible improvements in content and form of the European and national guidelines for user and producer oriented quality reports. On this basis, Destatis developed additional support for the compilation of quality reports:

- a checklist for quality reports based on the guidelines,
- extensions and further specifications on the content of the guidelines and
- standard texts for a number of concepts.

The aim of the paper is to present these supporting tools, which could also be of help to other National Statistical Institutes of the European Statistical System. Additionally, the objective of the paper is to be helpful for the preparations of the new ESS Handbook on Quality and Metadata Reporting.

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[2] This article represents the author's contribution at the *European Conference on Quality in Official Statistics* (Q2018) in June 2018 in Krakow, Poland.

1 DESTATIS' EXPERIENCES

Destatis is working with European and national guidelines for user and producer oriented quality reports in various contexts. During the last years, the quality unit of Destatis made valuable experiences at national and international level with the compilation of quality reports.

Destatis has been publishing user oriented quality reports for almost all statistics since 2005. These are subject to European and national standards regarding their content, structure and update frequency, which are described in detailed European and/or national guidelines. However, the quality of the content of the national quality reports is heterogeneous and in some cases the guidelines for quality reports need more specification and clarification.

In various training courses dealing with national quality reports, which correspond to a great extent to European ESMS quality reports, the quality unit learned, which concepts, terms and formulations of the European as well as the national guidelines for quality reports are hard to understand or ambiguous for the statistical units as compilers of quality reports.

In the framework of the second round of the ESS Peer Review, which took place from 2013 to 2015, it was recommended, that the quality of the content of the German national quality reports should be reviewed by the responsible quality unit and that, where necessary, quality reports have to be improved in cooperation with the specialised units. In 2015 and 2016 the top 100 user oriented quality reports (in terms of users' demand) have been centrally reviewed by the quality unit regarding the content and structure. Again, the quality unit of Destatis gained important insights about which guidelines for user oriented quality reporting need to be further concretised and which quality reporting concepts are typically posing problems for the subject matter units.

Furthermore, Destatis observed that working with the guidelines put down in a running text is not always easy to handle. So, the form of the guidelines was changed and they were put in form of a checklist in order to support the quality unit during the review process of the top 100 national quality reports. Then the idea came up of providing the checklist not only to the review team but also to the statistical units themselves in order to be able to check on all important aspects to be covered by their quality report.

During the Twinning Project "Support to the State Statistical Committee in Harmonisation of the National Statistics System of the Republic of Azerbaijan in line with European standards"[3] with the State Statistical Committee (SSC) of the Republic of Azerbaijan, two expert missions about "improving quality reporting" have been conducted in 2017. In this context, five ESQRS[4] quality reports and therefore also the corresponding European ESQRS guidelines have been discussed intensively – thanks to the open and fruitful discussions with the colleagues from the SSC and with the support of the Bulgarian National Statistical Institute as our junior partner. Conducting the missions, both the Destatis' quality unit and the colleagues from the SSC learned which guidelines for producer oriented quality reports could benefit from further explanations to help statistical units to compile their quality reports.

The experiences made and insights collected concerning possible improvements of the various European and national guidelines for user or producer oriented quality reports helped Destatis to further develop supporting tools to improve and ease up their use. These supporting tools are presented in the following sections.

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[3] The Twinning Project "Support to the State Statistical Committee in Harmonisation of the National Statistics System of the Republic of Azerbaijan in line with European standards" was funded by the European Union and was conducted from 2015–2017 with the State Statistical Committee (SSC) of the Republic of Azerbaijan in consortium with the National Statistical Institute of the Republic of Bulgaria as junior partner. The overall objective of the current project is the improvement of quality, availability and compliance of official statistics of Azerbaijan with European standards in key domains.

[4] ESQRS stands for ESS Standard for Quality Reports Structure, which is a more detailed quality reporting structure addressing primarily the producers of statistics and focussing more on the statistical process side.

2 CHECKLIST FOR QUALITY REPORTS

Firstly, Destatis' quality unit developed a checklist for the national user oriented quality reports. Secondly, a similar checklist has been worked out with the colleagues from the SSC of Azerbaijan for their ESQRS quality reports. This paper concentrates on the checklist prepared together with the SSC (which has been reworked in some points for the purpose of this paper), as it is the most current version and at this time more advanced than the DESTATIS checklist[5]. Therefore the ESQRS numeration of concepts is used in this paper.

2.1 Tabular structure of the checklist

A tabular structure was chosen for the checklist. Oftentimes the guidelines for one concept have been split into two or more items, which are put into separate rows in order to distinguish independent items (see Table 1, 2.4 "Statistical concepts and definitions"). Sometimes the guidelines didn't need to be split up (see Table 1, 2.9 "Base period").

Table 1 Tabular structure of the checklist

Concept number	Concept name	Guidelines for quality reporting
2	Statistical presentation	
2.4	Statistical concepts and definitions	Describe in short the main statistical variables provided. The definition and types of variables provided should be listed.
		Provideany Information on discrepancies from the ESS / international standards.
2.9	Base period	The period of time used as a base of an index should be described (e.g. base year 2000).

Notice: The original checklist has two additional columns "check if guideline is fulfilled" and "check if guideline is applicable". For reasons of clarity, the two additional rows are left out in this table, but they can be seen in Table 4.
Source: Own construction

2.2 Two options to check

The checklist provides two options to check: a) if the guideline is applicable and b) if the guideline is fulfilled. That means, the checklist distinguishes between items, which are "not fulfilled" and items, which are "not applicable" by the subject matter units.

Option "not applicable"
"Not applicable" means that the concept (as a whole) is not applicable for the specific statistic.

For example, if surveys don't calculate indexes, then the concept 2.9 on "base period" is not applicable. Or: if surveys are exhaustive, then the concept 6.2 on "sampling error" is not applicable (see Table 2, column "check if guideline is applicable").

A short notice in the quality report, why sampling errors or the base period aren't applicable (keyword "exhaustive statistics" or "no indexes calculated"), makes it easier to understand for users, why this concept isn't relevant and why it isn't filled out by the statistical unit.

[5] The "DESTATIS-checklist" provides only the option to check, whether the guideline is fulfilled and is only for the user oriented DESTATIS quality reports, whereas the "SSC-checklist" additionally provides the option to check and therefore to differentiate, whether a guideline is applicable for the specific statistic or not. Additionally, the "SSC-checklist" is for the more detailed producer oriented ESQRS quality reports. In the future, the findings obtained when elaborating the "SSC-checklist" will be reflected in the "DESTATIS-checklist".

Option "not fulfilled"

"Not fulfilled" means that the statistical unit did not provide the specific content asked for. However the concept is applicable and should have been filled out with corresponding content. A checkbox is provided for each item of the concept.

> For example, a subject matter unit does not fill in the concept 2.4 on "statistical concepts and definitions", however this concept is always applicable and has to be filled by every subject matter statistic (see Table 2, column "check if guideline is fulfilled").

Crosshatched concepts in the column "check if guideline is fullfilled"

Sometimes the guidelines only have an introductory purpose, therefore the cells in the column "check if guideline is fulfilled" have been crosshatched and no checkbox is given.

> For example, the first item of the concept 6.1 "accuracy overall" has only an introductory purpose and has therefore been crosshatched and no checkbox is provided (see Table 2, column "check if guideline is fulfilled").

Crosshatched concepts in the column "check if guideline is applicable"

For some concepts the cells in the column "check if guideline is applicable" are shaded grey and no checkbox is given (see Table 2, concept 2.4, column "check if guideline is applicable"). That means those guidelines are applicable for every statistical unit, no matter what. No option is given to state, that those concepts are not applicable for the statistical unit.

> This is for example the case in concept 2.4 "statistical concepts and definitions". That means, the guidelines concerning the statistical concepts and definitions are applicable for every statistical unit, no matter what. Obviously, each statistics has to provide to the user of quality reports an explanation of the statistical concepts and definitions used.
>
> Further examples, where no checkbox is provided and the cells are shaded grey:
>
> - Concepts concerning all aspects on contact details.
> - Concepts concerning most of the aspects to be covered of the "statistical presentation" (like data description, statistical concepts and definitions, statistical units, statistical population, reference area, time coverage,…).
> - Concepts concerning most of the aspects to be covered of the "statistical processing" (like source data, frequency of data collection, data validation,…).
> - Concepts concerning all aspects to be covered of "quality management".
> - …

Aim of the checklist

The checklist gives a better overview, which different aspects are to be covered for each concept. A specific guideline for a concept of the quality report could contain more than one aspect, which the compiler has to cover in his quality report. The checklist helps the statistical units in covering all important aspects of the concept.

Moreover, the checklist also helps for example in the framework of a review process (done by the statistical unit itself or centrally by a quality unit) to check whether important aspects are covered by the quality report.

Table 2 Option "not fulfilled" and crosshatched concepts

Concept number	Concept name	Guidelines for quality reporting	Check if guideline is applicable	Check if guideline is fulfilled
2	Statistical presentation			
2.4	Statistical concepts and definitions	Describe in short the main statistical variables provided. The definition and types of variables provided should be listed,		☐
		together with any Information on discrepancies from the ESS/ international standards.		☐
2.9	Base period	The period of time used as a base of an index should be described (e.g. base year 2000).	☐	☐
6	Accuracy and reliability			
6.1	Accuracy overall	Summarize the most important aspects concerning the sub-concepts 6.2 to 6.6.		
		Describe the main sources of sampling and non-sampling error in the statistical outputs		☐
		and provide a summary assessment of all errors with special focus on their impact on key estimates. The bias assessment can be in quantitative or qualitative terms, or both. It should reflect the producer's best current understanding		☐
		including actions taken to reduce bias.		☐
6.2	Sampling error	Clearly state if sampling error is not relevant.	☐	☐
		If probability sampling is used,	☐	☐
		the range of variation over time, among key variables, of the ESS A1 indicator "Sampling error – indicators" (Eurostat, 2014a, p. 5). is reported (relative standard error or coefficient of variation and / or confidence intervals for key variables).	☐	☐
		A short interpretation on the impact of the sampling errors on the quality of the survey results is included.	☐	☐
		It should be also stated if adjustments for non-response, misclassifications and other uncertainty sources such as outlier treatment are included.	☐	☐
		The calculation of sampling error could be also affected by imputation. This should be noted unless special methods have been applied to deal with this.	☐	☐
		If non-probability sampling is used,	☐	☐
		the responsible for the statistical domain should provide estimates of the accuracy in qualitative terms, a motivation for the invoked model for this estimation, and brief discussion of sampling bias.	☐	☐

Source: Own construction

2.3 Extensions and further specifications of the content of the guidelines

Further extensions and specifications of the content of the guidelines on quality reports have been made, where necessary. Important definitions and terms as well as some shorthand examples have been provided with the aim to better clarify the content of the guidelines for quality reports. Those extensions and specifications have been included in the checklist itself.

In the following two examples of the SSC's checklist two exemplary extensions und specifications are shown:

Example 1

> "Identification and general assessment of the main sources of measurement error should be reported." (Eurostat, 2014b, p. 36)

In order to help the statistical units in compiling quality reports, an explanation of the term "measurement errors" has been included directly into the checklist (see text in italic):

> "Identification and general assessment of the main sources of measurement error should be reported. *Explanation: Measurement errors refer to errors in survey responses arising from the respondent (respondent confusion, ignorance, carelessness or dishonesty) or the questionnaire (error attributable to the wording of the questions in the questionnaire, the order or context in which the questions are presented) or the method of data collection (poor or inadequate training of interviewers, expectations regarding respondents' responses or deliberate errors)."*

Example 2
Furthermore, in concept 6.3.2 "measurement error" further specifications are given, when a description of actions to prevent measurement errors is asked from the compilers of quality reports. Some shorthand examples have been provided to better clarify the content of the guideline (see text in italic).

> "Describe actions taken to prevent measurement errors *(e.g. questionnaire design and testing, interviewer trainings, interviewer surveillance)."*

2.4 Provision of standard texts

Finally, a number of concepts have been identified, for which a standard text could be provided (for example by the quality unit).

Please note, that the standard text might cover only some parts, items or aspects of the guideline for the respective quality report concept, but it can also cover the whole guideline for the relevant concept.

Concepts suitable for standard texts:
1.1 Contact organization,
1.5 Contact mail address,
2.2 Classification system,
3.3 Data collection,
4.1 Quality assurance,
6.5 Data revision – policy,
9.4 Microdata access,
9.5 Other (data dissemination means),
11.1 Confidentialiy – policy,
11.2 Confidentiality – data treatment.

Example 3
In the following example of the SSC's checklist an exemplary standard text is shown.

In concept 6.5 "data revision – policy" the ESQRS guidelines state:

"A revision should follow standard, well-established and transparent procedures that are described here or accessible via links from here. […] Describe the general revision policy adopted for the organisation and the data disseminated. […]" (Eurostat, 2014b, p. 37)

This concept is very well suited for a standard text as a description of the general revision policy adopted for the whole organisation is demanded. This standard text (which is written for the Statistical Offices of the Federation and the Länder) could be provided for example by the quality unit.

An example for a standard text for the concept 6.5 "data revision – policy" could be as follows:
"The general revisions policy of the Statistical Offices of the Federation and the Länder describes the revision procedures which apply to all statistical domains in a transparent and comprehensible manner so as to increase the trust in official statistics and further enhance the usability of statistics.

The general revision policy of DESTATIS is available online: www.destatis.de >> methods >> quality >> General Revisions Policy of the Statistical offices of the Federation and the Länder.

The general revisions policy is supplemented by the revision calendar of the Federal Statistical Office, which is available online (only in German language): www.destatis.de >> Methoden >> Qualität >> Revisionskalender.

The revision calendar provides an overview of which sets of statistics are subject to revision and describes the respective revisions cycle by means of a standardised structure."

Please note, if the statistical unit carries out revisions and apply domain specific revision procedures, then additionally to the standard text, the specific revision procedures should be described as well.

Advantages of using standard texts

Statistical units as compilers of quality reports could refer to well formulated standard texts. When standard procedures and rules are the same throughout the whole NSI, the respective descriptions should not have to be compiled by each statistical unit again and again. By using standard texts not only is the quality of those concepts assured, but it also saves time for the statistical units.

CONCLUSION

All those supporting tools helped the Azerbaijani colleagues from the SSC as well as DESTATIS to increase the usability of the guidelines and to clarify them.

- The checklist helps the compiler and the reviewer to get a better overview which different aspects are to be covered by a concept. This helps in not forgetting important aspects and to be better able to check whether important aspects are covered or not.
- Extensions and further specifications on the content and the provision of some shorthand examples make the guidelines clearer and are therefore easier to understand for the compilers (and the reviewers as well).
- Compilers are provided with standard texts (e.g. on revisions), which are well formulated. This is more comfortable for the compilers, saves time and therefore increases the acceptance of the obligation to compile quality reports.

This additional support could also be of help to other National Statistical Institutes of the European Statistical System. Additionally, the idea of clarifying the guidelines as well as the provision of a checklist and of standard texts could be considered for the new ESS Handbook on Quality and Metadata Reporting.

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Technological Innovations in the Census of Agriculture

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Abstract

Unparalleled changes in technology such as remote sensing, mobile devices (e.g. tablets, smartphones), Web questionnaires, online dissemination of results (e.g. infographics, social media) as well as electronic data archiving and anonymization of micro-data, are increasingly transforming the way countries conduct agricultural censuses and sample surveys. Their use facilitate both data collection and data dissemination by enhancing reliability, timeliness, readability and comprehensibility of census results. This is discussed in Volume 2 of the new FAO guidelines on the World Programme for Census of Agriculture 2020 (WCA 2020) and summarized in this paper. [2]

Keywords

World Programme for the Census of Agriculture 2020 (WCA 2020), international guidelines

JEL code

C10

INTRODUCTION

FAO is the leading United Nations agency for providing technical guidelines and support to member countries for the conduct of national censuses of agriculture. In 2015, FAO published its latest decennial census programme *World Programme for the Census of Agriculture 2020 (WCA 2020), Volume 1 "Programme, concepts and definitions"* (FAO, 2015). This was the tenth decennial programme and presents de-facto international standard that provides the methodological basis for the implementation of national agricultural censuses in the 2016–2025 decade.

To complement Volume 1, FAO prepared *Volume 2 "Operational Guidelines"* of the WCA 2020 (FAO, 2018). Volume 2 is a revised and updated edition of *"Conducting Agricultural Censuses and Surveys"* (FAO, 1996). It supplements the new census programme by providing practical guidance to national census practitioners on the main stages involved in the preparation and implementation of the census of agriculture. The 49th session of the United Nations Statistical Commission (UNSC, New York, March 2018) encouraged member countries to use Volume 2 as a reference for the implementation of the 2020 round of censuses of agriculture.

The revision was opportune not only in view of the new census programme and methodology but also in view of the substantial changes witnessed in the census technological environment over the last two decades. Fast technological developments are shaping the way agricultural censuses and sample surveys are planned and implemented in this millennium. This paper discusses some of the innovations in these operations introduced by the use of recent technology.

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[2] This article is based on contribution at the *IAOS* conference in September 2018 in Paris, France.

1 INFORMATION TECHNOLOGY IN THE AGRICULTURAL CENSUS

Census agencies have seen considerable developments and changes in the statistical methodology and technology environment at the turn of the century. These include an increasing use of administrative sources to meet the growing data needs and phenomenal advances in technological tools at relatively lower costs facilitating census and survey operations.

Volume 2 of the WCA 2020 guidelines acknowledges these developments and emphasizes the use of information technology (IT) on various stages of census implementation, such as:

- Planning of fieldwork (e.g. digital frame construction and geo-referencing).
- Data collection and processing (e.g. use of tablets and online questionnaires).
- Combined census (e.g. using data from administrative sources in combination with collection of field data).
- Data archiving (digital preservation of microdata for wider use or reuse of data over the long term).
- Data dissemination (e.g. interactive outputs and web-based data (dynamic tables, infographics, thematic maps, access to anonymised micro-data).

The next sections discuss these uses in more detail.

2 INFORMATION TECHNOLOGY SUPPORT TO CENSUS FIELDWORK

Technologies can be used in agricultural censuses and sample surveys to support fieldwork both for planning and facilitating field operations. These technologies include Remote Sensing (RS), aerial/ortophotos, Geographic Information System (GIS) and Global Positioning System (GPS) (Global Strategy, 2015).

RS and aerial photos are useful for monitoring land cover/land use, cartography and area frame construction, support censuses/surveys fieldwork, crop area estimation and crop yield forecasting/monitoring. RS imagery is used to update land use maps by photo-interpretation and automatic classification of the various land uses. Stratification can be carried out using the total crop area classified by RS (e.g. agricultural land and other, irrigated and rainfed crops, and permanent and temporary crops). In the census of agriculture, RS and aerial photos are used for census cartography and frame building. Area frames can be built using several types of sampling units (e.g. segments, points, transects) together with related sampling techniques. Figure 1 shows a segment with a number of plots used in an agricultural survey in Rwanda.The Census of Agriculture 2016 of Morocco and the Census of Agriculture 2015 of Colombia, also provide good examples of use of RS images and ortophotos for conducting agricultural census. The Global Strategy (2018) provides country examples on frames building using these technologies.

Satellite images and aerial photos also support field work by helping enumerators optimize their displacements and facilitate localization of holdings and fields. These tools allow enumerators to navigate from holding to holding within an enumeration area and differentiate a household from a holding or from an enterprise holding. This minimizes the likelihood of enumerator going to incorrect units. In this manner, enumerators can plan their best route, which overall maximizes the efficiency of logistics and reduces data collection time. Used as paper prints or on a mobile device, imagery will also minimize the obvious declaration and measurement errors improving data quality.

RS and aerial photography can also be used for area estimation in sample surveys. However, the use of these tools for measuring areas of fields in agricultural censuses is limited by the fact that data are collected from agricultural holdings. With technological advances, high-resolution aerial photographs and ortophotos are becoming less costly but still requiring substantial resources to ensure that up-to-date photos are available at the time of the enumerator's visit.

GIS is used for storing and combining different information layers, which may be required to build an area sampling frame, select a sample and compute expansion factors, as well as information generated while conducting a survey. The layers in a GIS may include boundaries of administrative areas,

Figure 1 A segment (outer boundary) with plots (inner boundaries) in Rwanda

Source: FAO (2018)

boundaries of plots and water points coming from administrative registers and could be in the form of points, lines, polygons or nearly-continuous surfaces ("rasters" or pixels). Tools in a GIS environment are used to manipulate and operate these layers in order to identify the most suitable area sampling frame for a specific survey. A wide range of GIS software tools exist and some packages are free of charge and most are open source. These include GRASS (Geographic Resources Analysis Support System), QGIS (Quantum GIS) and Arc-GIS.

GPS provides support to field activities such as: geo-referencing plots or holdings; locating the known coordinates of holdings; building frames; or measuring area of plots or a landscape patch. The measurement of area of plots is mainly used in agricultural sample surveys.

3 INFORMATION TECHNOLOGY IN CENSUS DATA COLLECTION AND PROCESSING

In the last couple of decades, there has been an increased use of electronic questionnaires for data collection, in particular in computer-assisted personal interviewing (CAPI), computer-assisted self-interviewing/web-interviewing (CASI/CAWI) and computer-assisted telephone interviewing (CATI). The use of these methods has resulted in significant reductions of processing time and improvement in the reliability and timeliness of census results. When these methods are used, traditional activities related to monitoring questionnaires, data entry, part of the computer editing and coding, and transmission of questionnaires

are undertaken during the enumeration. This results in significant efficiencies and drastically reduces the time lag between data collection and data analysis.

CAPI involves face-to-face interviews using mobile devices such as tablets or smartphones. Unlike paper questionnaires, CAPI electronic questionnaires allow a drop-down menu for answering, pre-programmed automatic jumps in the questions and consistency checking during the interview. The technology allows direct data transmission to field and central offices. When equipped with in-built GPS, CAPI can be also used for geo-referencing holdings, measuring plots, optimizing logistics and supporting enumerators, and for collecting and compiling paradata (e.g. current location, date and time of interview, duration, completion, approval, etc.) for effective monitoring of fieldwork progress. Figure 2 illustrates the daily performance of enumerators in an enumeration area.

Figure 2 Monitoring fieldwork in real time

Interviews completed on 1/2/2015

TEAMS	ENUMERATORS	INTERVIEWS
Team A	Interviewer 1	3
Team A	Interviewer 2	2
Team A	Interviewer 3	3
Team B	Interviewer 4	1
Team B	Interviewer 5	1
Team B	Interviewer 6	2
Team C	Interviewer 7	2
Team C	Interviewer 8	2
Team C	Interviewer 9	3
Team D	Interviewer 10	0
Team D	Interviewer 11	2
Team D	Interviewer 12	3

Source: FAO (2018)

The CASI/CAWI method requires sending a notice to respondents with instructions on how to access the online questionnaires with their secure access code, phone number to call for help and how to complete it online. Respondents can complete the questionnaire over a number of sessions before submission. This method reduces burdens as some respondents prefer to fill-up the questionnaires at a convenient time for them and at their own pace. In Canada, 11% of the agricultural holders opted for CAWI in the 2011 census of agriculture. This percentage went up to 55% in the 2016 census of agriculture and is expected to reach 70% in 2021. Similar trends are seen in other countries.

The CATI method requires interviewers to contact respondents by phone and entering the data into electronic questionnaires. A notice letter is mailed in advance to help respondents to prepare prior to the phone interviews.

Table 1 lists some advantages and disadvantages of electronic questionnaires in CAPI and CASI/CAWI methods.

Table 2 shows countries that have used CAPI and CASI/CAWI in agricultural censuses since 2006. The use of these methods in agricultural sample surveys are not included in the table.

Table 1 Advantages and disadvantages of electronic questionnaires

Pros	
In CAPI	**In CASI/CAWI**
1. Eliminates printing and distribution costs	1. Low cost
2. Easy to manage in the field	2. Easy to implement
3. Editing checks and jumps are automatic	3. Editing checks and jumps are automatic
4. Allows smoother and faster interviews	4. Fast processing
5. Allows the use of multiple questionnaires according to the answers received	5. Allows the use of different languages
5. Allows quick links to maps, satellite imagery and GPS to help enumerators do the fieldwork	6. Allows the drop-down menus
6. Allows applying supplementary questionnaires to selected sample holdings	
6. Can easily switch languages	
7. Allows drop-down menus	
Cons	
In CAPI	**In CASI/CAWI**
1. Requires field testing in the most difficult conditions and a good training programme	1. Works well with educated respondents (computer/web literate)
2. High fixed cost, but devices cost can be shared with other surveys	2. Respondents need to be in some way trained to respond rightly
3. Special skills needed for programming the devices	3. Security required to avoid hacking and protect confidentiality
4. Requires good Internet or satellite connectivity	4. Requires good Internet or satellite connectivity
5. Vulnerability to weather, batteries and access to power for charging	

Source: FAO (2018)

Table 2 Countries using electronic questionnaires in agricultural censuses since 2006

CAPI	Argentina (2008), Brazil (2006), Colombia (2013/2014), Cote d'Ivoire (2014/2015), Equatorial Guinea (2015), Cape Verde (2014/2015), France (2010), French Guyana (2010), Iran (Islamic Republic of) (2014), Jordan (2007), Malta (2010), Martinique (2010), Mexico (2007), Morocco (2016), Mozambique (2009/2010), Namibia (2013/2014), Thailand (2013), Venezuela (Bolivarian Republic of) (2008)
CASI/CAWI, CATI, CAPI combined	Australia (2010/2011), Austria (2010), Brazil (2017), Canada (2011), Estonia (2010), Finland (2010), Iceland (2010), Italy (2010), Latvia (2010), Lithuania (2010), Mexico* (2017), Poland (2010), Slovenia (2010), Spain (2009/2010), Sweden (2010), the Netherlands (2010), United States of America (2012)

Note: * Mexico (2017) pilot census.
Source: FAO (2018)

In practice, however, countries use a combination of data collections methods. For instance, CASI/CAWI might be applied in large holdings of the non-household sector while CAPI or paper questionnaires might be used in small holdings in the household sector. The increasing use of technology in data collection operations results in significant efficiencies and drastically shorthens the time prior to data analysis. However, the use of the methods above discussed depends on the country's information and communication technology capacity (ICT). CAPI, for instance, should be first tested in small-scale operations such as sample surveys before it is used in large operations such as the agricultural census. There have been cases where countries underestimated the time needed to master the method and allocated inadequate sessions for testing and training with unwanted results.

4 INFORMATION TECHNOLOGY SUPPORT FOR COMBINED CENSUS

A growing number of statistical offices, particularly in countries with more developed national statistical systems, are moving towards increasing use of data from administrative sources in the statistical data production process. This has been driven by increasing demand for data at a low administrative or geographical level more frequently and pressures to reduce census costs and burden on respondents. As a result, some countries have been implementing combined censuses of agriculture, that is using data from administrative sources in combination with field data collection to generate data items required for the census of agriculture.

Therefore, the improvement in administrative registers in many countries and tremendous revolution in technology are inducing methodological developments in conducting the census of agriculture. The use of registers may involve one or more administrative registers, with each register providing part of the required variables or data for all or a subset of the target population. Thus, a common identifier is of crucial importance for record linkage between the various databases.

In addition to institutional and legal preconditions, the implementation of a combined census requires well-developed administrative systems, adequate IT infrastructures and skills, and the use of special software for data transfer and data matching. Examples of combined agricultural census are found mainly in Europe, in countries such as Denmark, Finland, Norway, Sweden, Estonia, Latvia, Lithuania, Austria, Hungary and the Netherlands (UNECE, 2018).

5 INFORMATION TECHNOLOGY FOR DATA ARCHIVING

Census data archiving is used to digitally preserve microdata. It enables wider use or reuse of data, time series and other types of historical analysis, and helps justify the high cost of the census. Evidence shows that this valuable data can be destroyed unintentionally by natural disasters, fires, power failures, programming errors, theft or sabotage. The new technological environment provides conditions for proper archiving of census microdata and other census material such as technical documentation, IT programs, etc. using appropriate technical tools.

Unlike physical materials, digital data must be actively maintained over time (to ensure reuse) and documented. This includes guarding against hardware and software obsolescence, such as outmoded floppy disks and unreadable file formats, so that digital material is accessible and independently understandable over the long term.

Fortunately, digital preservation standards make it possible now for census offices to manage digital data over the long term. One major standard is the Open Archival Information System (OAIS) Reference Model, which became an ISO International Standard in 2003 (CCSDS, 2012; DPC, 2014). The OAIS Reference Model defines the roles, functions of and information necessary for managing digital material over the long term and making it accessible to interested users.

6 INFORMATION TECHNOLOGY FOR ONLINE DISSEMINATION OF RESULTS

Remarkable developments in ICT is allowing innovative and user-friendly methods of dissemination and access of census results. Methods include providing access to summarized data, including macro-databases, using interactive Web products (e.g. dynamic tables, data visualization, interactive infographics and thematic GIS maps), social media and by providing safe access to (anonymized) microdata files, including metadata, for more in-depth analysis.

The use of interactive outputs and web-based data as well as access to anonymised micro-data has enhanced accessibility, clarity and interpretability of census results. Novel and user-friendly dissemination tools support informed-decision making, unleash the analytical creativity of users and elevate the value of census data for agricultural policy purposes, research and business, in addition to the usual statistical uses.

The advantages of online dissemination are found primarily in terms of speed, flexibility, cost and accessibility of the results. Information can be static or dynamic. Most users accessing the census website

seek for data in static format, as it is faster to download. Specialized users prefer to run data extraction on online databases as a dynamic way of accessing the census information.

Advanced interactive Web products are growing in popularity. Interactive products allow for complex maps and visualizations, various cross-tabulations and other customized data queries. Making a census database available online along with integrated searching, tabulating, graphing, mapping and analysis capabilities is an important way to improve the effectiveness of census data dissemination. Security measures, including passwords and callback procedures, are required to prevent unauthorized access to data.

Social media has become another tool for disseminating census results, other information and marketing statistical products. Interacting with followers and users on these platforms provides the census agency with an opportunity to disseminate information, build relationships with established and new users, and engage the public on a regular basis. Free mobile phone applications can be used to make census results and data releases available anywhere at anytime.

CONCLUSIONS

The increasing availability of digital and mobile computing tools for data capture at affordable prices, such as smartphones or tablets, geo-positioning tools like handheld GPS devices, and more precise and cheaper RS images now provide new and cost-effective alternatives to traditional methods of collecting, centralizing and processing census data.

Technology is evolving fast and there may be technologies that will be available in the next decade that are either unknown or not yet affordable now. The extent of the use and benefits of new technology depend largely on the national ICT infrastructure. Some countries might be unable to fully benefit from ICTs because of poor connectivity, high cost of access and lack of necessary skills. Other countries could leapfrog their way into the use of recent technology, but adequate time for testing and training before its adoption should not be underestimated. Census and survey managers should consider the trade-off between the safety of proven systems and the benefits of using new technology.

Fast-evolving technologies have a potential to attain substantial efficiencies in census and surveys operations and offer governments an unprecedented opportunity to achieve sustainable development and improve the well-being of their citizens.

Wider and user-friendly access to census and survey data has acquired greater importance for their contribution to monitoring the Sustainable Development Goals (SDGs) and informing in national and regional policy decisions. Data use will grow exponentially in the next decade and will offer the ability to systematically analyze and act in real time in solving more complex sectoral problems, creating more competitive advantage and making better informed decisions in a tightly connected world.

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Hundred Years of the Czech Statistics

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Abstract

After a brief information about the history of statistics in the Czech lands during the Austria-Hungarian monarchy the paper aims to specify basic features of statistics outlined during the World War I by Dobroslav Krejčí, a representative of the Statistical Office in the Bohemian Kingdom.

Dobroslav Krejčí and Karel Engliš processed the above features and included them into the law regulating the organization of statistical service adopted after the birth of the republic in 1919. It summarizes basic principles of statistical act including specification of statistical bodies and informs also about the role and activities of the "Statistical State Council" and "State Statistical Office", i.e. institutions specified by respective governmental provisions. The attention is paid also to the beginnings of activities of the statistical office and implementation of respective hundred years' old statistical principles at present.

Keywords

Beginnings of Statistics, Dobroslav Krejčí, Act No. 49/1919, establishment of the SSO

JEL code

B20, B30, Z00

Birth of an independent Czech, i.e. Czechoslovak state in 1918 entailed also a gradual establishment of individual state bodies and institutions.

The same applied to the state statistics. This was naturally linked to the existing bodies within the extinct Austrian – Hungarian empire. Especially in Bohemia there existed a statistical institution since the end of 1856 called the **Central Committee on Statistics of Agriculture and Forestry** and qualified by historians of statistics as the first state organized statistics in the Czech lands. An imminent predecessor of a statistical institution in an independent republic was the **Land Statistical Office of Bohemian Kingdom**, founded by the Czech Assembly in March 1897, both in terms of institution and personalities. The office consisted of the two following bodies: the Land Statistical Commission, as consultative and decision-making unit and the Land Statistical Office as an executive unit. This principle of two bodies was subsequently implemented in the organization of statistics in various modifications up to present day.

We should mention at least briefly the preceding institutions in other parts of the country. In Moravia, which was the margraviate with autonomy and an independent land assembly, there was the Land Statistical Office of the Margraviate of Moravia located in Brno and established even four years earlier. Similarly, in Silesian Dukedom in 1898 the Land Statistical Office was established in Opava, however, in view of prevailing German community it acted in purely German environs. It should be noted, that a significant activity was recorded especially for the statistical office in Bohemia. Let us mention

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the situation in Slovakia, in order to have a complete picture. Given the direct integration of Slovakia into Hungary, statistical service at its territory was performed by the Royal Hungarian Central Statistical Office in Budapest existing in Hungary since 1871.

Let us go back to the land office of Bohemian Kingdom which formed the platform for the future Czech statistics.

As early as during the World War I a number of representatives of public and professional life in Bohemia paid attention to the future structure of public life and general government after the war end, including statistics. Statistics was perceived under these circumstances as one of the important elements characterising the level of administrative independence of a certain territorial unit, i.e., as a precondition of functioning of future independent state. As early as in 1915, Dobroslav Krejčí, a long time representative of the Land Statistical Office of Bohemian Kingdom, raised the issue of including statistics into these plans. He delivered his lecture dealing with future organization of statistical work at the end of the year 1915 in the Czech National Economic Society. For wider public the lecture was published in 1916 in the first issue of the journal called Obzor národohospodářský under the title "Our Statistics after the War". Let us remind here, along with numerous principles which now constitute a natural part of statistics performance, three fundamental requirements for the future development of statistics which Krejčí formulated.

The most important and until then non existing in Austrian statistics was, according to Dobroslav Krejčí, the need for statistics with a firm legal basis regulating its activities. This should be reached by proposing and approval of Statistics Act anchoring especially a **reporting duty for statistical entities**. This duty was not a regular principle at that time, not even in more developed countries than Austria and in the monarchy itself there existed only for a few most important statistical surveys, such as the population census. Otherwise, the statistical surveys were organised on voluntary basis. Needless to say that this is clear to any statistician. As a matter of interest let us mention a fitting and apt characteristics of the above duty given by Dobroslav Krejčí – *"thus, the statistics will cease to be a pack of voluntarily provided, i.e., as a rule, incomplete and hardly controlled data*".

The other proposed requirement was the issue of systematic organization of statistical work. This referred to a firm **working plan of statistical works**, chiefly statistical surveys including all other related links to this plan. He had in mind e.g. allocation of tasks to individual statistical bodies including proper facilities for their performance. According to him, the plan should determine *"what is to be statistically surveyed, in which order, the scope of survey as well as methods used."*

To date still current requirement formulated by Dobroslav Krejčí was his third axiom for operation of statistics – to inform by all means the wide public of the **need for and usefulness of proper statistics**. Even this requirement in the light of later often used statement, mostly incorrectly assigned to an anonymous author: *"I do not believe any statistics which I failed to fix myself"* is still needy and perhaps today even more important. As for the two preceding requirements it may be stated that both have always been anchored in statistical act amendments, including the one which is in force now. Specifically, it refers to the reporting duty and also to annual unified plan of statistical surveys.

It should be noted that Dobroslav Krejčí was not the first who proposed the reporting duty on our territory. The first one was Karel Engliš, who had been working at the beginning of the 20th century for four years with Dobroslav Krejčí at the Land Statistical Office. Five years later when he acted as an extraordinary professor of national economy including statistics at the Technical University in Brno, he helped to organize statistical service in Moravia (Moravia was then Margraviate of Moravia, like the Bohemian Kingdom, one of Austro-Hungarian lands). Based on his initiative the Land Moravian Chair adopted by the end of 1914 the act setting out the reporting duty for all surveys conducted by self-administrative units, i.e. only for a certain part of administrative bodies and not for physical persons. However, the fact is that in view of war events the act did not record any significant response neither was widely applied.

At the end of the war Dobroslav Krejčí reverted to his proposal concerning the performance of the Czech statistics which he changed to reach a concrete wording of statistical draft act. Not in vain is Dobroslav Krejčí percieved as the "father of Czech statistics" considering his concept of state statistics anchored in respective law on statistics in the new independent state born in 1918.

After the birth of an independent republic his draft act was taken by the above mentioned Karel Engliš. As a deputy of the Revolutionary National Assembly he revised it and, compared to the original draft, he made it shorter and more transparent. Subsequently, he pushed it forward for discussion in social-political committee of the National Assembly. It was him, who on 28 January 1919 presented the report of the respective committee along with the draft act. After his presentation of the draft when no remarks were raised, the draft act was approved. It came that after almost three months upon the date when the republic was born, the act on statistics was adopted. Having been signed by the president of the republic, Tomáš Garrigue Masaryk, and Antonín Švehla, prime-minister, by proxy, the act was promulgated in the Collection of Laws and Ordinances. Thereby, it became effective as the **Act No. 29 (28th January 1919) on Organization of the Statistical Service**. Intentional brevity of the act anticipated its detailed specification in two ordinances. These were adopted later, in November 1919 as Governmental Ordinance No. 634/1919 Coll., on composition, competences and operation of the Statistical State Council (Statute of the Statistical State Council) and governmental ordinance No. 635/1919 Coll., on composition and operation of the State Statistical Office (Statute of the State Statistical Office). It suggests an apparent split mentioned already in the Land Office into the advisory, decision-making and executive units.

Let us summarise now basic principles which were codified by the above legal provisions especially compared to the previous situation in Austria-Hungary:

a) statistical surveying was concentrated into one place in the country – central statistical office,

b) the scope of statistical data required from respondents was determined by the Statistical Council composed of a representative sample of representatives of state administration, universities, professional chambers and others including the public,

c) duty to provide the information to statistical institutions was stipulated for both the population, and also for all associations, co-operatives and profit-raising institutions of all kinds,

d) individual data protection was regulated including provision stating that the statistical data obtained may be used for statistical purposes only,

e) non-observance of the duty to provide data shall be punished,

f) all who collect and process data for statistical purposes are subject to confidentiality in respect of "matters discovered during surveying if they concern private aspects" including specification of relevant sanctions for non-observance,

g) administrative offices and municipalities are obliged to "support!" statistical office in performance of its tasks and obey the instructions resulting from the Statistical Council's resolution, and finally

h) statistics was proclaimed as autonomous and independent activity which cannot be subject to any departmental body and so, at that time, it was directly subordinated to the Prime-Minister.

The above described process of building statistics in the new state was not so problem-free and peaceful. Setting aside proclamations on the importance of statistics, i.e., processing of statistical data for the operation of legislation and administration in the new state, it became obvious that a 10 months' delay between very brief law and specifying conditions of practical operation formulated in ordinances, will make the performance of statistical service uneasy. This situation was aggravated also by a long time vacant post of the president of the office (president František Weyr was appointed at the beginning of 1920) and by problems accompanying practical running of the office (the draft amendment of the Act No. 49/1919 reducing the original wide independence of the office and proposing its subordination to the Ministry of Internal Affairs was finally withdrew and not presented). From the beginning of the establishment of the statistical office its location was a handicap. The office operated gradually in different

buildings, often not suitable for its purpose. Organisational problems were due also to the fact, that the office was not at one place but in many buildings rented in different Prague locations. This is attested to the number of its employees. While the Land Statistical Office at the end of 1919, i.e., before the war, employed 220 persons, two years later, in 1921, when its establishment was practically completed, the office staff increased up to 804 persons. Let us remark that this problem did not exist only in the first twenty years of its existence but it survived until 2004 when the office moved, after 85 years, to a new modern building in Prague – Strašnice. Let us add that before the office had been located for several decades in provisional buildings in Prague – Karlín and, as a paradox, the end of its existence was caused by a natural disaster – a 1000-year flood when water from the Vltava river flooded the above buildings up to the first floor.

An interesting fact is that all three persons contributing to creation of the Czech statistics were important representatives of public and political life of a new republic. At the beginning they met in the Land Statistical Office where they worked together. Dobroslav Krejčí after he had left the field of statistics acted as university professor at Masaryk's University in Brno and occupied the post of the a rector before his death in 1936. Karel Engliš was also university professor and the first rector in the new established Masaryk's University in Brno. During the existence of the first republic he was several times minister of finance and, by the end of the 1930s, he was also the National Bank governor. The career of František Weyr was very similar. In addition to being a deputy in the first Revolutionary National Assembly (together with Karel Engliš) he performed for 9 years the post of the first president of the State Statistical Office, he was university professor, professor at a secondary school, dean and rector at the Masaryk's university in Brno.

The above stated principles of the first law on statistics including detailed specifications of ordinances were included, most in form of certain amendments, in statistical laws effective for the whole period of hundred years without respect to changing social relations (e.g. period of building socialism), different period provisions or other ways of organization and structure of statistical bodies. To be concrete, it referred to principles of statistical work and provision of statistical service as defined in presented Act No.49/1919 and related governmental regulations. The last amendment to the Statistics Act (if partial amendments are not considered) dates back to 1995 and was adopted almost a quarter century ago. Changes which took place at that time, e.g. functioning of independent Czech Republic and its general government and mainly turbulent development of IT (let us remind only, at random, e.g. administrative data and its data base or currently distributed data, i.e. scanner data) require new legal regulation concerning the operation of the whole state statistics. Roughly after a hundred years, principles which were effective for that period (including most probably the issues of reporting duty or statistical surveys plan) will be most likely substantially modified and updated, but from a completely new aspect.

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Statistical Literacy and Education in the State Statistical Office of the Republic of Macedonia

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Abstract

In modern knowledge-driven society, the knowing how to use statistical information is a necessary skill to citizens. The State Statistical Office of the Republic of Macedonia recognizes the importance of the proper use of statistical data. According to its Strategy, the State Statistical Office will work on improving statistical literacy, and the specific sub-program: Improving statistical literacy is defined.

This paper will describe the actions taken by the State Statistical Office to promote the statistical culture in the country. In addition, a description will be given of the unique postgraduate studies in "Statistical Methods for Business and Economics".[2]

Keywords

Postgraduate studies, statistical literacy, SSO strategy

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INTRODUCTION

The use of statistical information became a crucial need for citizens in their professional and private activities and it is of essential importance for their active participation in the society. The complexity of the world where we live shows that it is almost impossible to comment some economic or social event without the use of statistics.

In the last decade, the statistical knowledge was concentrated only to specialized groups (like researchers), who were the most frequent users of statistics; nowadays, its use is widely present in everyday life. However, the lack of knowledge in statistics, including its interpretation and use of statistical information is still existent.

Statistical Offices are responsible not only for producing, disseminating and analyzing statistical information, but also for ensuring that this information is well understood by the users. This paper outlines the activities taken by the State Statistical Office to improve statistical literacy since 2007.

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[2] This article is based on contribution at the conference *Q2018* in June 2018 in Krakow, Poland.

1 WHAT IS STATISTICAL LITERACY

There are several approaches concerning the meaning of statistical literacy.

Statistical literacy, as a concept, includes the ability to read and interpret statistical data in daily and other media (newspapers, Internet, television channels, etc.) and includes the same data shown through, for example, graphs, tables, statements, statistical surveys and studies (UNECE, 2012).

Statistical literacy is the ability to understand and use statistics and it includes different skills linked together, such as:

- ability to understand/interpret statistical information,
- ability to use statistical information,
- ability to be critical towards statistical information,
- ability to communicate making use of statistical information (Ribeiro, 2013).

2 LEGAL AND STRATEGIC FRAMEWORKS OF STATISTICAL LITERACY IN THE REPUBLIC OF MACEDONIA

The Law on State Statistics regulates official statistics in the Republic of Macedonia. In Article 8, the promotion of statistical literacy is stated as one of the main duties of the State Statistical Office.

The empowerment of the main duty of the State Statistical Office is included in the Strategy of the State Statistical Office. The mission of the SSO states: The State Statistical Office produces and disseminates official statistical data on the Macedonian economy and society as a basis for the process of decision making based on relevant information.

For the period 2017–2019, several priorities are defined for implementation of statistical objectives. One of them is "Strengthening the cooperation and communication with users". Under this priority, several objectives are defined:

- simplifying the access to statistical data,
- modernizing the manner of disseminating statistical data,
- increasing the amount of published data and providing data with longer time series,
- measuring user satisfaction.

In order to facilitate the access to statistical data, different dissemination products are developed and statistical users are provided with tools to decipher the specific language of statistics.

3 STATISTICS IN PRIMARY AND SECONDARY SCHOOLS

Integrating statistical concepts and reasoning from primary school through to secondary school should develop a nation of critical thinkers and capable consumers of information that would ultimately benefit social progress – future government and business leaders.

Statistical literacy is more than numeracy. It includes the ability to read and communicate the meaning of data. This quality makes people literate as opposed to just numerate. The weakness in quantitative skills is summarized under the term statistical innumeracy. In particular, among the younger generations there is an increasing need to understand quantitative data and facts.

The process of developing statistical reasoning must involve both students and teachers. For students, it is essential to build capabilities when they supplement what they have heard and read on statistics and to actually produce statistics. For teachers, it is of crucial importance to have not only theoretical background in statistics, but also to be able to interpret statistical information. Therefore, statistical organizations must involve teacher educators and address the professional development of teachers.

In the Republic of Macedonia, children start to learn the basic elements of statistics in the upper grades of primary schools in the syllabus for geography and mathematics. Elementary topics such as the gathering and organization of data, measures of central tendency and basic probability calculation are

taught at primary and secondary schools in the subject mathematics. The reading and interpretation of official statistical data is included in lectures of geography.

The State Statistical Office cannot be satisfied with this situation and actions for change must be undertaken. The institution must put efforts to influence the importance of continuity of learning and building statistical skills and knowledge progressively, rather than learning concepts in isolation and out of real-world context. There is a need to design a curriculum on statistics for primary and secondary schools, which provides a rich and diverse means of incorporating the authentic and contextual teaching of statistical concepts.

In order to improve statistical literacy, several activities were organized in the past years. So, in 2016, a caravan for "Statistical Lectures" was organized in two rounds in secondary schools, with visits to four gymnasiums in Skopje and two secondary schools of economics in Skopje in the first round, and visits to 8 secondary schools/gymnasiums around the country. Around 50-60 pupils visited each lecture on statistics. Each year, groups of pupils from the secondary schools of economics in Bitola and Skopje visit the SSO.

4 UNIVERSITY-LEVEL EDUCATION IN STATISTICS

At university level, statistics is an element of different studies. In the last decade, the reform of tertiary education in the country was marked with the European Credit Transfer and Accumulation System (ECTS) and introduction of the Bologna Process, which means statistics to be part in minor fields of study.

Young people, in particular, must be helped to overcome their reluctance to deal with this subject and become critical and responsible users of statistics. The co-operation with educational institutions is an important issue for the development of the statistical system, both for reinforcement of the technical capacity for the production of official statistics and for the promotion of statistical literacy.

In the last decade, the Macedonian tertiary educational system was rapidly changed and one of the big changes was the foundation of many new state and private universities. In accordance with the Law on Higher Education, in the Republic of Macedonia, there are 20 higher education institutions of which 16 are universities. There are 6 state universities.

In order to obtain information about studying statistics in tertiary education, a short questionnaire was sent to all universities and faculties. The main point of the study was to get information about syllabus on statistics. In the survey were included 138 faculties and higher educational organisations. On the basis of the results gained from 69 faculties, statistics as a subject is taught at: Faculties of Economics, Faculties of IT and Computer Sciences, Faculties of Medicine/Veterinary Sciences.

At most of the faculties, statistics is taught in the third/fourth semester or in the sixth/seventh semester.

Table 1 Students enrolled in undergraduate studies at higher vocational

	Mode of study	Total		
		Total	Male	Females
TOTAL	total	56 941	25 272	31 669
	full-time	50 701	22 543	28 158
PUBLIC FACULTIES	total	48 087	20 141	27 946
	full-time	43 440	18 343	25 097
Faculty of Natural Sciences and Mathematics, Skopje	total	1 209	377	832
	full-time	1 161	359	802
Theoretical mathematics	total	23	9	14
	full-time	22	8	14

Table 1 (continuation)

	Mode of study	Total		
		Total	Male	Females
Mathematics - informatics applied	total	4	2	2
	full-time	4	2	2
Faculty of Computer Science and Engineering - Skopje	total	52	40	12
	full-time	52	40	12
State University of Tetovo, Faculty of Natural Sciences and Mathematics	total	1 003	383	620
	full-time	991	379	612
Faculty of Mechanical Engineering, Skopje	total	1 156	758	398
	full-time	1 156	758	398
Faculty of Technology and Metallurgy, Skopje	total	202	66	136
	full-time	202	66	136
Faculty of Agricultural Sciences and Food, Skopje	total	41	23	18
	full-time	37	21	16
Faculty of Computer Science and Engineering, Skopje	total	3 005	1 997	1 008
	full-time	3 005	1 997	1 008
Faculty of Technical Engineering, Bitola	total	544	361	183
	full-time	513	334	179
Faculty of Biotechnical Sciences - Bitola	total	153	70	83
	full-time	134	54	80
Faculty of Information and Communication Technologies, Bitola	total	546	378	168
	full-time	544	377	167
Faculty of Informatics, Shtip	total	406	274	132
	full-time	354	235	119
Faculty of Agriculture, Shtip	total	11	8	3
	full-time	7	6	1
Faculty of Electrical Engineering, Radovish	total	168	132	36
	full-time	122	89	33
University of Information Science and Technology - Ohrid, Faculty of Computer Science and Engineering	total	151	111	40
		151	111	40
University of Information Science and Technology - Ohrid, Faculty of Computer Networks and Security	total	56	42	14
	full-time	56	42	14
University of Information Science and Technology - Ohrid, Faculty of Information Systems, Visualisation, Multimedia and Animation	total	77	47	30
	full-time	77	47	30
University of Information Science and Technology - Ohrid, Faculty of Information and Communication Sciences	total	22	12	10
	full-time	22	12	10
Faculty of Applied Sciences, State University of Tetovo	total	473	347	126
	full-time	473	347	126

Table 1 (continuation)

	Mode of study	Total		
		Total	Male	Females
Faculty of Food Technology and Food, State University of Tetovo	total	98	64	34
	full-time	98	64	34
Faculty of Medicine, Skopje	total	2 587	685	1 902
	full-time	2 366	636	1 730
Faculty of Dentistry, Skopje	total	606	182	424
	full-time	606	182	424
Faculty of Medicine - State University, Tetovo	total	1 462	492	970
	full-time	1 268	449	819
Faculty of Technology and Metallurgy, Skopje	total	227	62	165
	full-time	227	62	165
Faculty of Veterinary Medicine - Skopje	total	136	65	71
	full-time	136	65	71
Faculty of Economics, Skopje	total	3 547	1 351	2 196
	full-time	3 179	1 185	1 994
Faculty of Philosophy, Skopje	total	2 254	566	1 688
	full-time	1 925	471	1 454
Faculty of Pedagogy, Skopje	total	873	151	722
	full-time	675	121	554
Faculty of Pedagogy, Bitola	total	134	21	113
	full-time	110	17	93
Faculty of Economics, Prilep	total	754	300	454
	full-time	731	288	443
Faculty of Economics, Shtip	total	769	271	498
	full-time	604	220	384
Faculty of Applied Sciences - State University of Tetovo	total	5	3	2
	full-time	5	3	2
Faculty of Economics - State University of Tetovo	total	468	249	219
		433	229	204
Faculty of Business Administration - State University of Tetovo	total	329	174	155
		329	174	155
PRIVATE HIGHER VOCATIONAL SCHOOLS	total	234	154	80
	full-time	123	79	44
Business Academy Smilevski, Skopje	total	234	154	80
	full-time	123	79	44
International Slavic University "G.R. Derzhavin" - Faculty of Information Technology	total	36	33	3
		20	17	3

Table 1 (continuation)

	Mode of study	Total		
		Total	Male	Females
International Balkan University - Faculty of Engineering	total	356	263	93
	full-time	356	263	93
SEE - Faculty of Business and Economics	total	469	228	241
	full-time	412	192	220
SEE - Faculty of Public Administration and Political Sciences	total	362	247	115
	full-time	286	196	90
International Balkan University - Faculty of Humanities and Social Sciences	total	200	88	112
	full-time	200	88	112
International Slavic University "G.R. Derzhavin" - Faculty of Economics and Organisation of Enterprises	total	86	55	31
	full-time	41	26	15
International Slavic University "G.R. Derzhavin" - Faculty of Psychology	total	81	18	63
	full-time	62	12	50
International Slavic University "G.R. Derzhavin" - Faculty of Safety Engineering	total	78	61	17
		41	33	8

Source: State Statistical Office of Macedonia

Studies on statistics can be divided in three classes: descriptive statistics, probability statistics and sampling and biostatistics, and correspond with the following faculties: Faculty of Economics, Public Administration, Faculty of ICT and Computer Sciences and Faculty of Medicine/Veterinary Sciences. Only two respondents mentioned that in addition to the theoretical lectures, students also learn specific software: R-software and Libri.

The students of the Faculty of Medicine learn so-called biostatistics, which cover descriptive statistics and vital and demographic statistics with practical examples.

Faculties where statistics is taught as probability statistics include lectures on analysis of time series, too.

Very often, the classes with descriptive statistics include lectures on the basics of official statistics, such as data collection, data tabulation and interpretation of statistical tables.

The State Statistical Office is willing to improve this situation and Memoranda of co-operation with public and private universities were signed in the last years.

Furthermore, statisticians gave lectures on different topics of official statistics to students in the premises of the SSO or in the premises of faculties.

5 POSTGRADUATE STUDIES IN STATISTICAL METHODS FOR BUSINESS AND ECONOMICS

Under the TEMPUS program, the consortium composed of the Faculty of Economics at the University "Ss Cyril and Methodius", University Roma III, Rome Italy, University Carlos III, Madrid Spain and the State Statistical Office of the Republic of Macedonia launched postgraduate studies in statistical methods for business and economics, in the academic year 2007/2008. The studies were organized in the premises of the Faculty of Economics where, for the needs of the studies, special laboratories and a library with relevant books were equipped. The lectures were given in English language by professors from the Universities, participants in the Project, and statistical data for the work of students were provided by the State Statistical Office.

The studies were organized in three semesters (plus one semester for preparation of master's thesis) and the following exams were included:

- Multivariate statistical methods,
- Theoretical econometrics,
- Mathematical statistics,
- Computational statistics,
- Simulation methods,
- Advanced econometrics,
- Time series analysis,
- Statistical quality control,
- Econometrics for finance.

During the studies, the students gained theoretical knowledge in different subjects for economic and statistical analysis as well skills to work in several software packages: E-View, R-software, SAS software, MATLAB and Statistics for quality.

After the end of the TEMPUS project, the postgraduate studies were embedded in the regular Program for postgraduate studies at the Faculty of Economics in Skopje. Up to 2017, 35 students finished these studies and 9 students graduated in 2009 during the lifetime of the Project.

These studies are unique for several reasons:

- for the first time in the country studies are organized which offer comprehensive knowledge for quantitative economic research,
- the students gained solid theoretical knowledge of economic analysis, skills to use different software and analytical skills for proper use and interpretation of statistical data in daily work,
- the State Statistical Office and other organizations associated with statistics (ministries, central bank, research institutes, consultants, etc.) could recruit qualified staff for statistics from the labor market.

6 TRAINING PROGRAMS FOR EMPLOYEES IN OFFICIAL STATISTICS

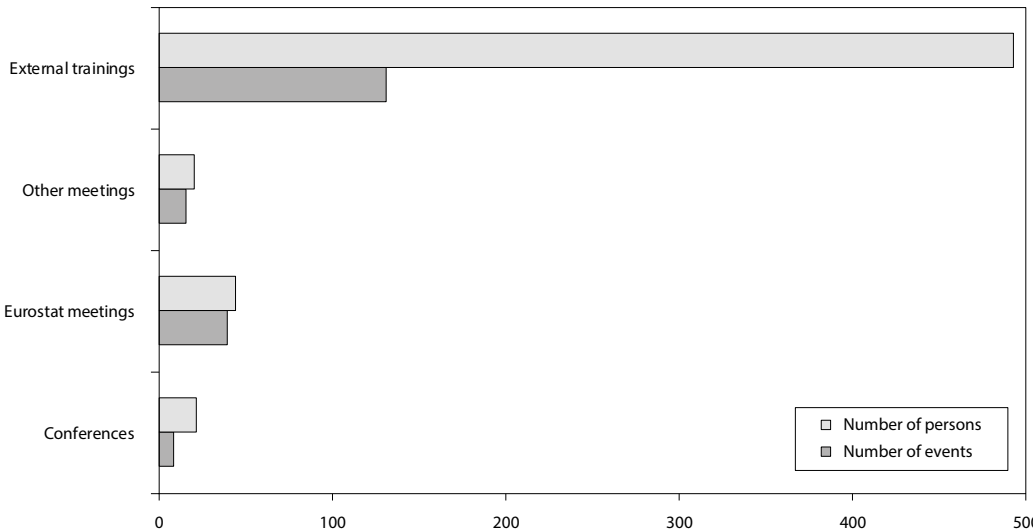
The State Statistical Office of the Republic of Macedonia was one of the first state institutions that started the process for joining the European standards after proclaiming state independence in 1991. The first contacts with the international community were established in 1993. The management of the SSO has recognized that for the production of high-quality data on the Macedonian economy and society in accordance with European standards, it is necessary for the staff to have an adequate level of statistical knowledge.

In this context, the attendance at TES/ESTP courses was very beneficial for young and middle-level staff for training in methodologies, statistical production and statistical-mathematical methods.

In the last three years, more than 254 persons attended 20 EMOS Webinars on different topics.

The area that requires special attention in the statistical organizations is the development of knowledge transfer models. Bearing in mind that it is not possible for all employees to receive the same quantity of required knowledge, it is necessary that the institutions develop systems for exchange of experiences, within the institution, between certain numbers of persons who have similar professional engagements. The State Statistical Office noticed the benefits of this model and five years ago introduced the in-house training courses. The staff that attended training in statistical methodologies organized training for their colleagues. In addition, many colleagues gave informative lectures on different topics (like introduction of ESA 2010, metadata, PC AXIS, quality issues) to inform staff about the content, importance and influence of novelties in the daily work of the institution. The relevance of the topic for daily work was one criteria for selection of training persons. Also, this training was used before start up some new activitiy. For example, before introducing PC AXIS software for WEB publishing, SSO experts on PC AXIS have organised trainings for all statisticians. These trainings were organised as Workshops with duration

Figure 1 Participation of SSO staff on different kinds of trainings, 2017



Source: State Statistical Office of Macedonia

of 2 days, where statisticians gained information how to use PC AXIS, practical work with data tables and tutorial for PC AXIS which is available on SSO INTRANET site. Trinings on topics like metadata, quality, writing Press releases, were intended for young statisticians and they lasted a couple of hours. All these trainings are organised within SSO premises-classroms, equipped with computers, projectors and other relevant euipment.

7 STATISTICAL LITERACY AS AN ASPECT OF MEDIA LITERACY

The media have a versatile role related to national statistical institutes. First, the media are interested in the activities of NSIs as public organizations. Second, the media are important redistributors of statistical information. Third, the media are large-scale users of statistical information – NSIs output is a raw material, i.e. input to media production processes and activities. Statisticians are well aware of how the media can sometimes misinterpret statistical data (UNECE, 2008). Numerous misunderstandings and misinterpretations of statistical data can be observed in media reports, in daily newspaper articles and in direct contact with the users (UNECE, 2012).

Indeed, to understand the meaning of a text, journalists need to be able to do more than the reading of statistical information; they need to understand the concepts and methodologies used in its preparation. NSIs must improve statistical thinking and train journalists how to "read" the data. An important objective to all statistical agencies should be to promote statistical literacy of the media workers (UNECE, 2008).

The State Statistical Office has a long tradition in the communication with media. In the past, journalists were one of the regular user groups and the co-operation was twofold: journalists informed about the data and activities in the SSO and SSO staff assisted in proper interpretation of data. Many journalists confirmed that when they had no idea for the day, they came to the SSO library and the article was finished in an hour. Besides, the SSO regularly organized info sessions for journalists before crucial methodological changes or before conducting Censuses.

However, the digitalization and appearance of social media has changed completely the media sector in the country. The number of newspapers and informative radio and TV stations has decreased dramatically in the last years.

These changes refer to "consumption" of statistics by journalists. The SSO is aware of this situation and several actions are undertaken:

- improving the visualization of the SSO web site with infographics on specific topics,
- strengthening the co-operation with different information agencies,
- strengthening the co-operation with Faculties/Studies of Journalism and informing the future journalists about statistics,
- active participation of the SSO in different social media.

CONCLUSIONS

The main message of statistical offices: their reliability based on quality data and transparent methods should be conveyed through an effective communication strategy thus building a specific brand. The SSO should resort to measures to increase statistical literacy and by being transparent. This is of strategic importance for increasing the appreciation of official statistics, leading users to perceive the statistical office as trustworthy.

Effective user engagement should be a continuous dialogue, not just a series of one-off consultations.

Besides traditional areas, there are emerging needs that need to be illuminated by statistics. In this sense, the presence in social media cannot be limited only to posting statistical data on own social media platform. The SSO needs to make an extensive analysis of what is being said about them in social media and react when needed. It is necessary to respond to what is being said in the different platforms, show that they are listening and handle important issues in the platforms where the users are active, i.e. by going to their meeting place. SSO responsible staff must talk with the network and spread the statistical office brand.

The SSO must develop a strategy how to generate awareness and interest in national statistics and their practical application to everyday life. The actions to increase the statistical literacy in education should be the starting points for improving statistical literacy.

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Policies, Technology, and Quality Returns from the World Development Indicators

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Abstract

The World Bank's World Development Indicators are the primary collection of development statistics including economic, social, and environment indicators compiled from recognized international sources. It presents the most current and accurate global development data available, and includes relevant national, regional and global aggregated estimates for the purposes of analytics and policy making in international development arena.

In this paper, we review major policy decisions, key investments in technological platforms, and best practices in quality management around the reputation of the World Development Indicators. These findings are presented with the prospects of assessing how international statistical organizations model high demand statistical products, gather resources for their production, and establish subsequent quality control frameworks – including customer relations – needed for their sustainability.[3]

Keywords

Quality management, statistical products, international development, technology, customers' relations

JEL code

L15

INTRODUCTION – BACKGROUND

Quality in the World Development Indicators context is presented as a multidimensional concept: from the systems to the product through the process followed to collect, analyze, and disseminate data, the World Development Indicators puts significant efforts in developing the highest standards for this flagship publication. While assessing data quality as part of the product component, this paper presents different tools including software applications as inherent parts of the WDI production systems.

For the past forty years, the World Bank has made quality an integrated part of the dissemination of the World Development Indicators. It started as an annex of the 1978 World Development Report[4] with a couple of dozens of indicators on about 120 countries in its early editions.[5] Demand for data

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[3] This article is based on contribution at the conference *Q2018* in June 2018 in Krakow, Poland.
[4] The World Bank, World Development Report 1978–2017, Washington, D.C.

and other related information grew over time leading to the design of a database with a metadata component through the Stars[6] System.

In 1996,[7] the traditional annex to the World Development Report was replaced by an independent publication. In the Open Data era, the Bank first made its own development data available for free but moreover fostered the concept of Open Data and Open Government to its member countries with technical assistance where needed.[8]

The 2017 online edition covers over 1 500 indicators on more than 200 economies for over 80 years. The World Development Indicators is popular because of its convenience and credibility. It receives about 1.2 million unique visitors per month. The dissemination of WDI would not be possible without the day-to-day collaboration with national and international statistical agencies. The production unit strives constantly to improve the quality of data on a regular basis.

1 DATA QUALITY STANDARDS AND THE WORLD DEVELOPMENT INDICATORS

The World Development Indicators applies the IMF DQAF as a major international framework on data quality. The DQAF was first introduced at the Fifth Review of the Fund's Data Standards Initiatives and serves as an umbrella for several dataset-specific frameworks.[9]

The IMF's Data Quality Assessment Framework (DQAF) was developed as an assessment methodology that aims to provide structure and a common language for the assessment of development data quality. It facilitates dialogue with national statistical agencies and country authorities, as well as a more homogenous approach to assessing data quality.[10]

In addition to adhering to DQAF principles, the World Development Indicators documents its data compilation methodology as well as issues related to data quality and effectiveness in relevant sections of its *knowledge base*. This resource also presents a wealth of information related to how the World Bank classifies world economies, national currencies, how often WDI is updated, metadata coverage, and WDI related products.

The World Bank policies towards data in general and the World Development Indicators have evolved over time. The following section will provide a set of institutional reforms that shaped the WDI ecosystem and cumulated to the current corporate product.

2 WDI DISSEMINATION PROCESS: PRACTICES, METHODOLOGY, AND QUALITY

The World Bank Development Data Group collects data from internal departments, national statistical agencies, and international sources for dissemination in the World Development Indicators. Content experts are responsible for the collection of a subset of sector statistics. The data is first processed in satellite databases before it converges to a working environment. Once assessed for quality and relevant operations, the data is moved to a production database where it is stored and published to various outlets. This allows the production team to validate the data at relevant stages in the ingestion process. The following graph provides a snapshot of the WDI data management process.

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[5] The 1981 World Development Report also includes the World Development Indicators, a set of 25 tables of economic and social indicators for 124 countries.

[6] World Bank Socio-economic Time Series Access and Retrieval System (March & July 1990).

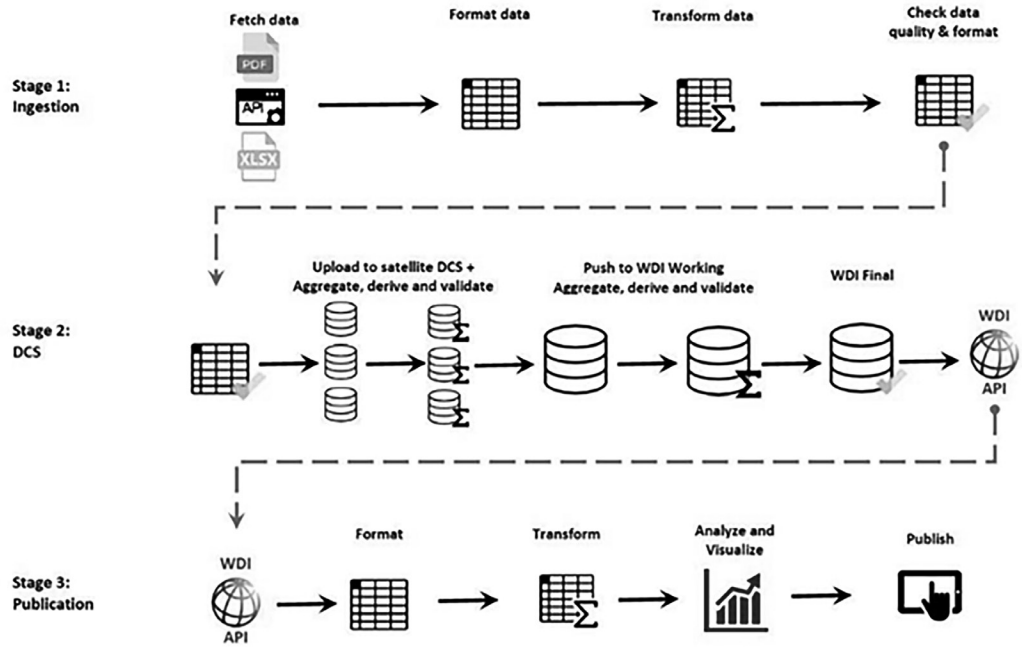
[7] World Bank, World Development Report 1996 – From Plan to Market, 1996.

[8] World Bank Group, World Bank Support for Open Data 2012–2017, June 2017.

[9] International Monetary Founds Data Quality Reference Site on the Dissemination Standards Bulletin Board.

[10] United Nations Statistics Division UNSTAT.

Figure 1 Description of WDI Work Flow



Source: Own construction, World Bank

In the following section, we to explore major principles governing official statistics and data quality in the international environment.

a) Principles governing statistical data quality

Through the World Development Indicators, the World Bank aims at providing high-quality data and data services by 1. establishing and maintaining the highest professional data standards, 2. supporting the improvement of national statistical systems, 3. actively participating in the international statistical community, and 4. developing and maintaining the tools to use data effectively through the quality principles of integrity, client focus, and fiscal responsibility.

These principles apply to all team members, regardless of terms of their employment, grade, line of business, or field of expertise. They are consistent with the Fundamental Principles of Official Statistics and the Principles Governing International Statistical Activities of the United Nations Statistical Division (UNSD).[11]

Moreover, in adherence to the Data Quality Assurance Framework, any indicator disseminated through the WDI output ought to be accurate, reliable, and accessible. Extensive metadata is provided to document methodology used to produce the indicator, limitations, as well as sources and revision policies.

b) Methods used to calculate aggregates for groups of countries

One of the key value added that make WDI unique in international development data arena is its well-maintained derivation and aggregation formulas and procedures that create new data out of what is

[11] Source: World Bank Data HelpDesk.

collected from sources. What are the methods and techniques used to calculate aggregates for country groups and categories?

In general, when indicators are ratios, aggregates are computed using weights corresponding to the denominator of the ratio. Other methods of aggregation used in the World Development Indicators are presented as follows:

- For group and world totals denoted in the indicator metadata as *gap-filled total*, missing data is imputed based on the relationship of the sum of available data to the total in the year of the previous estimate.
- For aggregates denoted in the indicator metadata as *sums*, missing values are not imputed. Sums are computed if less than a third of the observations in the series or a proxy for the series are missing in each year.
- For aggregates of ratios denoted as *weighted averages* of a ratios (using the value of the denominator or, in some cases, another indicator as a weight), the aggregate ratios are based on available data.
- For aggregates of ratios denoted as *unweighted averages*, the aggregate ratios are based on available data. Missing values are assumed to have the same average value as the available data.
- Aggregates denoted as *medians* in the indicator metadata are medians of the values shown in the table. No median aggregate value is shown if more than half the observations for countries with a population of more than one (1) million are missing.[12]
- When aggregating relevant indicators, one of the main requirements is to insure international comparability of national inputs. For instance, no aggregation shall be done for data in national currency. This must be converted to a common currency (e.g. USD) using exchange rate or purchasing power parities. In some cases, methodological adjustments are required before aggregation (e.g. Atlas method for Gross National Income).

3 TOOLS, SYSTEMS, AND INFORMATION TECHNOLOGY PLATFORM FOR QUALITY MANAGEMENT

In this chapter, we present various tools and techniques used to ensure quality data during collection, processing, and dissemination of World Development Indicators.

The World Bank **Data Collection System** is an in-house SQL system built to gather data from various sources for processing and dissemination purposes. The Data Collection System is organized into multiple databases. These are thematic (satellite) databases, one "work" or live database (WDI Working), and one dissemination database (WDI Final).

Each database has dedicated process(es) administered either by the satellite database owner or a central administrator. These processes are used to collect, view/edit, transfer, import/export, process (aggregate/derive), and publish the data. In addition to these functions, the central administrator is responsible for defining variables (countries, series, and time).

The WDI also leverages existing metadata standards to facilitate the data ingestion process. Select WDI structured data is collected using the **Statistical Data and Metadata eXchange** also known as **SDMX**. This platform stems from an international initiative aiming at standardizing and modernizing the mechanisms and processes for the exchange of statistical data and metadata among international organizations and their member countries. The World Bank is an official sponsor of the SDMX together with six other international organizations. The SDMX is used to collect official statistics in member countries of these organizations in different areas including agriculture, environment, social, economic, and financial statistics.[13]

[12] Source: World Bank Data HelpDesk.
[13] Source: Statistical Data and Metadata eXchange.

The Data Exchange works along other **specialized tools** to collect and prepare data for ingestion in the World Development Indicators. These tools include but are not limited to the External Debt Reporting System, the Joint External Debt Hub, and the International Comparison Program for purchasing power parities.[14] The World Bank Data Catalogue is an umbrella tool for the dissemination of various datasets including WDI and its interactive query tool known as DataBank. The main gateway to access WDI Data is the Open Data website for indicator level search, visualization, and extraction.

CONCLUSION – TOWARDS THE NEXT GENERATIONS OF THE WORLD DEVELOPMENT INDICATORS

While recognizing the importance of the World Development Indicators, with its high profile and exceptional exposure, it remains clear that this flagship product does not cover all the needs and/or every aspect of development data needs expressed by the users' community.

The team is leveraging recent technologies and data science techniques to automate the production of the World Development Indicators. It has recently migrated from its popular online data query tools to a mobile responsive web technology. What plans are foreseen for the next generation of the World Development Indicators?

On data quality side, the World Development Indicators processes focus mostly on ad-hoc data checking with abilities to perform select comparisons on a rather small subset of the whole database. Improving data quality in the World Development Indicators will require a comprehensive strategy with short, medium, and long-term perspectives.

In the *short term*, the team is working on plans to identify areas of concern and mitigate potential risks including data edit, sensitivity for identifying errors, and what discrepancies could be tolerated.

In the *medium term*, we are reducing the time needed to make the data available to users from when it is accessed at sources. We are leveraging on technology to improve the process while keeping the integrity of the data.

As indicated earlier, one of the greatest value added to original data received by the Bank through WDI is the aggregation of – and derivation from – select indicators. The team is working to determine the soundness of current methods and establish protocols for aggregation and indicators selection - which indicators to keep, which ones to drop, and what new indicators could be explored?

In the longer term, the data quality processes will consider expansion to two categories namely sub-national and high frequency time series.

Over the years, the World Bank operations have come across projects for which there was a need to disaggregate data within country boundaries. Multiple sectors were covered including environment, population and even economic activities. Some of the phenomenon being observed even have a time dimension making their structure a bit more complex than the current WDI records system.

Also, some areas of global development require data with frequencies higher than the annual data collected in WDI. Commodity prices, exchange rates, environmental measures (e.g. weather), and market indexes are crucial to knowledge about development matters, yet the current infrastructure of WDI is not covering those.

Moreover, other kinds of data are collected by the development community including the Bank and do not fit to any of these categories though they must be of equal importance. A significant amount of resources is devoted to collecting geospatial data, shapefiles, raster, maps as well as survey data of all kinds from single observations to big data and longitudinal datasets sometimes referred to as panel data, tracking the same sample at different points in time.

[14] Reference: World Bank Data Programs.

DISCLAIMER – ACKNOWLEDGEMENT

The findings, interpretations, and conclusions expressed in this work do not necessarily reflect the views of The World Bank, its Board of Executive Directors, or the governments they represent.

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International Conference *Applications of Mathematics and Statistics in Economy* (AMSE 2018)

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From 29th August to 2nd September 2018 the 21st year of International conference *Applications of Mathematics and Statistics in Economy* (21st AMSE) was held in the beautiful environs of historical town Kutna Hora. This year's conference was organized by the Department of Statistics and Probability and the Department of Economic Statistics of the Faculty of Informatics and Statistics of the University of Economics Prague. The conference was attended by more than 60 experts from the Czech Republic, Slovakia and Poland representing University of Economics, Prague, Matej Bel University, Banska Bystrica, Wroclaw University of Economics, Czech Statistical Office, Metropolitan University, Prague and Institute of Hospitality Management in Prague.

The conference dealing with the above subject was held for the 21st time. The characteristic feature of this traditional trilateral conference is the exchange of knowledge and experience, presentation of the latest results of research and discussion on new procedures and methods. Working meetings of representatives of co-operating work places and determination of future trends of scientific and pedagogic co-operation made a vital part of this event.

The programme of the conference was opened by the vice-president of the Czech Statistical Office, Jaroslav Sixta, with his lecture *The Recovery of the Input-Output Analysis in the Czech Republic*, in which he summarized the history of the use of input-output tables and showed new trends of research which are to be applied in the field of macro-economic, environmental and regional analyses. The participants of the conference discussed the issues in the following 10 sections: Macroeconomic issues, Regional analysis, Social economics issues, Multivariate statistical methods, Multivariate statistical methods, Insurance and demography, Time series analysis methods, Insurance market, Financial market, History of statistics. Since it is rather difficult to point out the most inter-esting contributions; allow me to mention only those papers of doctoral and post-doctoral students which I consider of high quality, interesting and innovative in terms of methodology.

In the section *Macroeconomic issues* most attention was paid to the contribution *Margins on Buying and Selling Transactions and Their Capturing in the System of National Accounts*, in which the authors (Kramulová, J., Vincenc, J., Houžvičková, H.) presented an original method of estimating and capturing of trade surcharge on transactions with securities, shares, investment fund shares and foreign currencies. Their approach was based on the fact that in the Czech Republic no reliable database on completed transactions exists. Their new methodology will, undoubtedly, serve an inspiration for other EU countries.

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In section Regional analysis contributions based on the use of the input-output analysis prevailed. K. Šafr in his contribution *Combination of Regional and World Input-Output Tables: A Czech Case of Territorial Export at Regional Level* presented methodology of estimating Czech territorial export at the regional level. It is a new approach responding to the fact that since 2008 the Czech Statistical Office has stopped publishing the territorial structure of Czech regional export and it is therefore useful to search for new model approaches.

Practical application of multivariate statistical methods (in section Multivariate statistical methods) was presented by Cibulková, J. and Šulc, Z. in the paper *A Case Study of Customer Segmentation with the Use of Hierarchical Cluster Analysis of Categorical Data*. Results of their analysis may help companies to aim their marketing strategy more effectively.

In section *Time series analysis methods* theoretical contribution *Comparison of Robust Moment Methods for Parameter Estimation in Autoregressive Process* (authors: Flimmel, S., Fojtík, J., Malá, I. and Procházka, J.) took interest because the authors presented several robust moment methods for parameter estimation in $AR(p)$ and compared them using a simulation study.

In section *Financial markets* Virdzek, T., Kubaška, P. and Cisková, P. presented in their paper *Portfolio Performance: An Active Approach to Weighting Assets in the Portfolio Versus a Naive Diversification* new approaches to assessment of the performance of active approach to weighting in the portfolio versus naive diversification. According to authors, an active approach is the approach to constructing an optimal portfolio based on the weighting of individual assets in the portfolio.

In traditional section dealing with *History of statistics* it is desirable to mention the contribution *Scientific and Publishing Activities of the Land Statistical Office in Bohemia*, where the authors (Závodský, P. a Šimpach O.) reminded this year's 120th anniversary of birth of the Land Statistical Office in Prague.

For a complete programme of AMSE 2018, including full texts of presented contributions see <*http://www.amse-conference.eu*> where the information on AMSE history and reference to previous years of this international conference is available.

Papers presented at the conference AMSE 2018 are published in the book of proceedings that has been send to Thomson Reuters to be considered for inclusion into the Conference Proceedings Citation Index (CPCI). The proceedings of the past four AMSE conferences (i.e. AMSE 2014, 2015, 2016, 2017) have been successfully indexed and are available in the Web of Science database.

Tradition of alternate conference holding (Slovakia – Poland – Czech Republic) continues and the 22nd year of the AMSE conference which is to be organized by the Department of Quantitative Methods of Matej Bel University, Banská Bystrica, will be held at the turn of August and September 2019 in Slovakia, in the mountains in Orava. For the future AMSE 2019 conference contributions reminding the 100th anniversary of the Czechoslovak state statistics are invited.

Mathematical Methods in Economics (MME 2018) International Conference

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Mathematical Methods in Economics (MME) conferences have a very long history and tradition.[3] They belong to most important scientific events organized in the Czech Republic in the field of operational research, econometrics, mathematical economics, and related research areas. In 2018, the 36th international conference *Mathematical Methods in Economics* 2018 was held in the city of Jindřichův Hradec on September 12–14. Except for the local organizer, which was the Faculty of Management, University of Economics, Prague, main organizers of MME conferences were the *Czech Society for Operations Research* (CSOR) and the *Czech Econometric Society*.

The total number of participants of this year's MME 2018 conference was more than 140 people coming from the Czech Republic, Spain, Finland, Poland, and Slovakia. The scientific programme started with a plenary session opened by the chair of the CSOR, Professor Miroslav Plevný. Then, the Dean of the Faculty of Management, Professor Vladislav Bína, welcomed all the participants in the campus of the Faculty of Management, and Lucie Váchová, head of Organising Committee, presented the main program and all facilities.

After these introductory talks, one regular invited plenary lecture was delivered. The lecture titled *Dreaming of Fair Democracy – Limitations of Collective Decision Making* was given by Professor Milan Vlach (Charles University, Prague, Czech Republic). After the plenary session, the programme of the conference was divided into 5 parallel sessions. The total number of presentations was more than 110. All accepted papers are published in the Proceedings of the MME 2018. They are submitted, as in the previous years, for indexing in the Web of Science.

It has been a long tradition that during MME conferences a competition of PhD students for the best paper takes place. This competition is organized and honoured by the CSOR. All papers submitted were peer-reviewed and the papers with positive referee reports were further evaluated by the Programme Committee. Eight best selected papers were presented at the conference in two special sessions and, finally, the evaluation committee decided about the winners. The best six papers have been awarded at conference dinner it the hall of Faculty of Management. The winner of the competition was Tomáš Rusý (Charles University, Prague, Czech Republic) with the paper *Optimal Loan Performance Management via Stochastic Programming*. The second place got Petra Tomanová (University of Economics, Prague, Czech Republic) with her paper *A semiparametric Approach to Modelling Time-Varying Quantiles*.

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[3] More at: <*https://mme2018.fm.vse.cz*>.

Ondřej Badura (Technical University of Ostrava, Czech Republic) placed third with his paper *Client Interest Rates and Household Behaviour: the Case of Czech Republic*. The remaining three honoured contributions were delivered by Tomasz Stachurski (University of Economics in Katowice, Poland), Petra Zýková (University of Economics, Prague, Czech Republic), and Jakub Houdek and Ondřej Sokol (University of Economics, Prague, Czech Republic).

Organization of the conference was excellent. All sessions including a conference banquet took place in a campus of the Faculty of Management that offers all necessary up-to-date facilities for this kind of events. Welcome evening took place in the nearby Museum of Photography and Modern Visual Media. An important part of all conferences is a social programme always offering many opportunities to discuss various problems in an informal environment. The organizers have prepared 4 options for a half-day tour: City tour in Jindřichův Hradec, a guided tour of the castle Červená Lhota, guided tour with beer tasting in Regent Brewery and Lookout tower U Jakuba. After the tour, the conference was officially finished by the conference banquet at which the winners of the PhD competition were awarded.

The annual meeting of the CSOR decided that the 37th MME conference will be organized in the city of České Budějovice by the Faculty of Economics, University of South Bohemia on September 11–13, 2019.

12th Year of the *International Days of Statistics and Economics* (MSED 2018)

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Jakub Danko[2] | *University of Economics, Prague, Czech Republic*

From 6th to 8th September 2018, a worldwide conference of the International Days of Statistics and Economics (MSED) took place at the University of Economics in Prague.[3] The conference belongs to traditional professional events; this year, the twelfth year of this event was held. The University of Economics, Prague (the Department of Statistics and Probability and the Department of Microeconomics) was the main organizer, as usual; and was helped by the Faculty of Economics, the Technical University of Košice, and Ton Duc Thang University, as co-organizers. The conference ranks among important statistical and economic conferences, which can be proved by the fact that Online Conference Proceedings were included in the Conference Proceedings Citation Index (CPCI), which has been integrated within the Web of Science, Clarivate Analytics since 2011. This year, 319 participants from various countries, such as Poland (59), Russian Federation (92), Slovakia (21), registered at the conference. Other participants came from Vietnam, Turkey, Lithuania, France, etc. Conference participants were, as usual, doctoral students and young scientists of various universities abroad. The aim of the conference was to present scientific papers and discuss current issues in the field of statistics, demography, economics, and human resources, including their mutual interconnection. Regarding statistical topics, the interest was traditionally focused on the cluster analysis, computational statistics, and statistical modeling. This year, a significant contribution by Mr. Marek Rojíček (President of the Czech Statistical Office) was presented. His lecture about the Recent Macroeconomic Development of the Czech Republic was accompanied by fruitful discussion about current economic topics. The second keynote speaker was Mrs. Eva Zamrazilová (head of the National Budgetary Council of the Czech Republic) with her contribution about the Independent fiscal watchdogs and their role in economic policy. This topic also opened an interesting discussion. Due to high erudition, speakers´ general knowledge and topicality of the contributions discussed, the lecture room was full. To conclude, we wish the conference be successful in the next year as well, because it is important that through this professional event deeper connections between important disciplines such as statistics and economics are established and the professional community realizes that the mutual cooperation is crucial to the entire system. We would also like to invite researchers, doctoral students and the wide professional public to the thirteenth International Days of Statistics and Economics, which will take place at the University of Economics, Prague from 5th to 7th September 2019.

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Modelling Smart Grids 2018: 4th International Interdisciplinary Workshop

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Already the 4th well-established interdisciplinary international workshop *Modelling Smart Grids 2018* took place in Prague during 20–22 September 2018. It was organized by the Charles University in Prague, Czech Technical University in Prague, Czech Academy of Sciences, Czech Statistical Office, Technical University in Liberec and the Czech Statistical Society. In total, 48 participants from 5 countries presented and discussed contributions covering a broad spectrum ranging from theoretical statistics, optimization, computer science, official statistics, energy economics, control theory, cloud solutions and advanced remote metering for smart grids. Foreign participants came from China, France, Poland and Slovakia. The idea behind the *Modelling Smart Grids* workshops has always been to bring together statisticians, experts in optimization, computer scientists, economists, technicians, managers from energy production and distribution sector to enable the exchange of ideas and to provide them with interdisciplinary insight into the changing field of energetics.

The workshop took place in three different places: the Czech Institute of Informatics, Robotics and Cybernetics (CIIRC), the Czech Statistical Office and historical building of the Czech Technical University in Prague. Five keynote lectures were delivered.

Professor Jean-Michel Poggi (University Paris Descartes and University Paris Sud) delivered lecture on forecasting electricity consumption of individual consumers by wavelets. Hynek Beran (CIIRC) broadly discussed challenges of the Czech energetics after 2022 connected with EU regulations reducing usage of coal, replacing nuclear power plants and adopting infrastructure to smart grids. Václav Rybáček and Miloslav Beránek presented their reflection of energy sector in macroeconomic (emission trading) and price statistics. Tomasz Piasecki (Huawei) gave an overview on advanced remote electricity metering telecommunication infrastructure. Jakub Kúdela (Microsoft CZ) focused on two topics: i) Application of machine learning for remote control and security monitoring of the power plants, ii) Cloud service to process sensor data of smart grids in the real time.

The important parts of the Energy Days workshop are panel discussions on strategic issues of energetics. This year it was focused on long term investment strategy on power-plants and based on three lectures. The first part was the keynote lecture of Hynek Beran. Then, Vladimír Vágner (Nuclear Physics Institute, Czech Academy of Sciences) focused on effects of putting nuclear reactors in Germany out of operation to the Czech power industry. Finally, Radek Lamich (ČEZ Distribution) presented a simulation study of renewal costs of the distribution networks based on simulations.

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Celebrations of the 50th Anniversary of the Slovak Statistical and Demographic Society

Hana Řezanková[1] | *University of Economics, Prague, Czech Republic*
Jitka Langhamrová[2] | *University of Economics, Prague, Czech Republic*

On 18–20 June 2018, ceremonial conference on the 50th anniversary of the Slovak Statistical and Demographic Society (SSDS) took place under the auspices of the President of the Slovak Republic. The conference was held at Papiernička near Častá municipality, a purpose built facility at the Chancellery of the National Council of the Slovak Republic. The conference was opened by Iveta Stankovičová, President of the Slovak Statistical and Demographic Society. Then, the participants of the Conference were greeted by Hana Řezanková, Vice President of the Czech Statistical Society, Jitka Langhamrová, President of the Czech Demographic Society and by Mr. Andrej Piovarči, head of the university education department of the Ministry of Education, Science, Research and Sport of the Slovak Republic. Peter Mach delivered greetings from Viktor Milata, President of the Council of Slovak Scientific Societies at the Slovak Academy of Sciences.

The first contribution providing the information on Bratislava self-governing region was presented by Silvia Szabová, head of the Statistical Office work place of the Slovak Republic in Bratislava. Her presentation was followed by papers aimed at history which were delivered by Prokop Závodský from the University of Economics, Prague (History of the Czechoslovak Statistical Society between the wars), Peter Mach (History of the Slovak Statistical and Demographic Society – 50 years since the establishment of the Society), František Bernadič, Vice President of the Statistical Office of the SR (25 years from the birth of an independent state statistics in the SR) and Branislav Bleha from Comenius University in Bratislava (Slovak demography after 1993). In the end of the introduction meritorious members of the Slovak Statistical and Demographic Society were awarded.

The programme of the second part of the first day was focused on statistics and demography education. Tomáš Želinský from the Technical University in Košice informed about the research on students' attitudes to statistics, Iveta Stankovičová from Comenius University presented her contribution on problems related the statistics teaching, needs for big data analysis and importance of data science. The following panel discussion on statistics and demography teaching in the Slovak Republic and the Czech Republic was opened by Hana Řezanková and Jitka Langhamrová from the University of Economics, Prague. The programme of the next two days included the following two conferences: "PES 2018" (Views on Slovak Economy) and "FERNSTAT 2018" (Finance, Economy and Statistics).

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Recent Publications and Events

New publications of the Czech Statistical Office

Analýza ekonomického vývoje v roce 2017 (Analysis of Economic Development in 2017). Prague: CZSO, 2018.
České zemědělství očima statistiky 1918–2017 (Czech Agriculture with the eyes of Statistics). Prague: CZSO, 2018.
Demographic Yearbook of the Czech Republic 2017. Prague: CZSO, 2018.
Rozvoj informační společnosti v České republice a zemích EU 2018 (Information Society Development in the Czech Republic and EU Countries 2018). Prague: CZSO, 2018.

Conferences

The ***62nd ISI World Statistics Congress*** will take place in **Kuala Lumpur, Malaysia, from 18th to 23rd August 2019.** More information available at: <*http://www.isi2019.org*>.

The ***22nd AMSE 2019 Conference*** will be held in **Nižná, Slovakia, from 28th August to 1st September 2019**. The conference is held under the auspices of the President of the Czech Statistical Office and of the President of the Statistical Office of the Slovak Republic and is dedicated to the 100th anniversary of statistics in Czechoslovakia (*https://www.czso.cz/csu/czso/history_of_czech_statistics_after_1918*). More information available at: <*http://www.amse-conference.eu*>.

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