Developing the Digital Economy and Society Index (DESI) at local level - "DESI local"

Urban Agenda for the EU Partnership on Digital Transition

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Tallinn, June 2021

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1 Introduction

The aim of the research is to analyse methods and data sources for calculating DESI indicators on local administrative unit level. The research concerns mainly the human capital dimension of the DESI.

The following four indicators were selected for analyses and testing:

1. Frequent internet users – persons whose frequency of Internet access is at least once a week.
2. Communication skills above basic – persons who can perform at least two tasks from the following list:
    - Sending/receiving emails.
    - Participating in social networks.
    - Telephoning/video calls over the internet.
    - Uploading self-created content to any website to be shared.
3. Banking – persons who used the Internet to use online banking.
4. Shopping – persons who ordered goods or services online.

2 Administrative division of Estonia

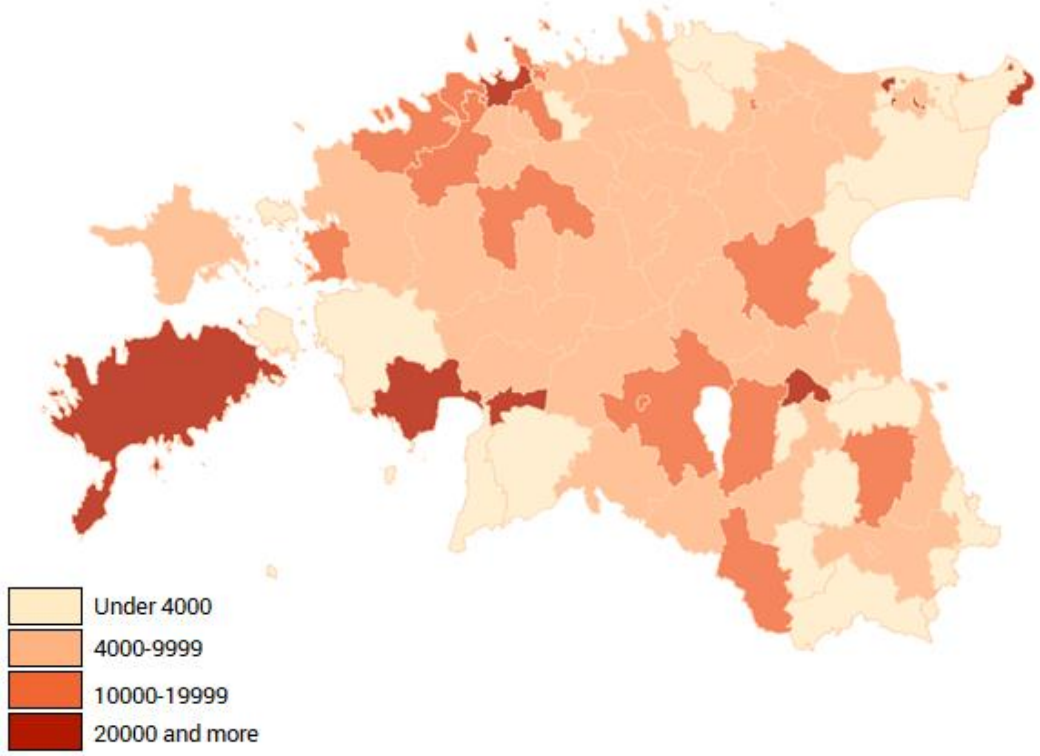
Administrative units of Estonia's territory are 15 counties and 79 municipalities (local administrative units, also known as LAU). There are two types of municipalities: rural municipalities, and cities with municipality status. The territory of Estonia is divided into counties. The county is divided into cities and rural municipalities. Counties form five NUTS 3 regions. See Annex 1 for more details.

Population size of municipalities vary from 100 to 330000. The table below shows that the population of the most of municipalities is under 10000 persons. Consequently, the sample size in the most of municipalities is too small for reliable estimates.

Table 1 Population aged 15-74 by municipality, 1 January 2020

Population size group	Number of municipalities	Population aged 15-64		
		Minimum	Median	Maximum
Under 4000 inhabitants	20	115	3423.5	3939
4000-9999 inhabitants	42	4002	5928	9985
10000-19999 inhabitants	11	10148	11680	16188
20000 and more inhabitants	6	23201	38677.5	329595

Figure 1 Local administrative units by the numbers of inhabitants



3 Data sources for local DESI

3.1 Information technology in households

Information technology of households is a sample survey with annual effective sample size around 4000 respondents. The sample size is proportional with population size, which means that a sample size in smaller municipalities is far too small for reliable direct estimates. Table 2 shows that over 60 municipalities have a sample size less than 50.

Table 2 Number of respondents by municipalities, 2018-2020

Reference period	Number of respondents grouped	Number of municipalities	Number of respondents		
			Minimum	Median	Maximum
2018	0-19 respondents	23	0	13,5	19
	20-49 respondents	39	20	30	49
	50-99 respondents	11	51	55	82
	over 100 respondents	6	118	163	1304
2019	0-19 respondents	25	0	13,5	18
	20-49 respondents	36	20	26,5	49
	50-99 respondents	12	50	60	73
	over 100 respondents	6	107	154	1196
2020	0-19 respondents	28	1	13	19
	20-49 respondents	34	20	30	49
	50-99 respondents	11	50	58	65
	over 100 respondents	6	116	143	1166

This sample size enables a calculation of reliable estimates for some larger or medium-sized municipalities. The accuracy or sampling error of survey estimates is measured by the coefficient of variation (CV). Table 3 shows the minimum, mean, and maximum values of CV-s of four indicators in the group of municipalities. Estimates based on 20-49 respondents have mostly CV between 10-20%. The accuracy measure might increase up to 50% if the sample size decreases under 20.

The CV up to 5% can be considered as high-quality estimates and CV between 5-10% shows satisfying quality. Accuracy is higher for Frequent Internet user indicator and lower for shopping indicator.

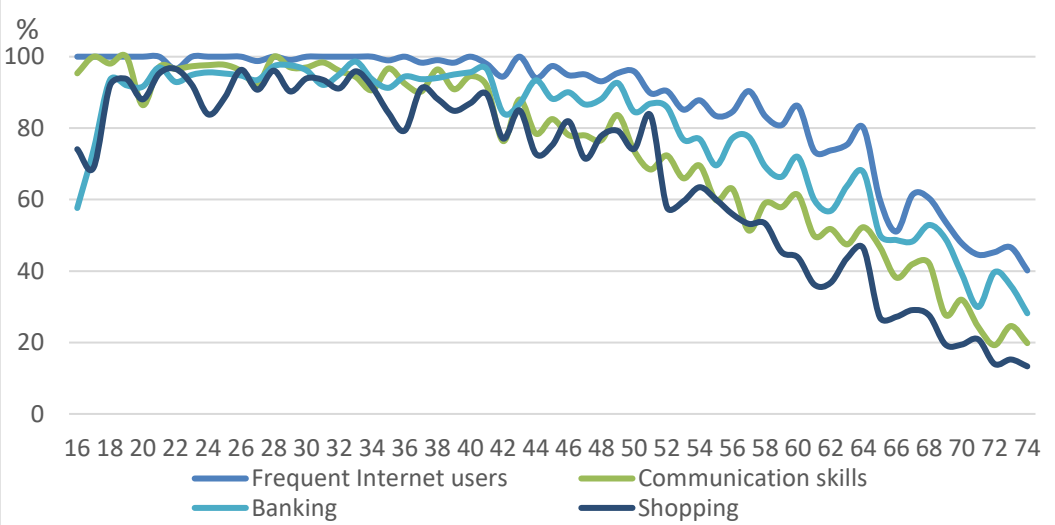
Table 3 Accuracy of DESI components by the number of respondents

Municipality	Number of respondents	Coefficient of variation of indicator, %				
			Frequent Internet users	Communication skills above basic	Shopping	Banking
Very small	1-19	Minimum	3.7	7.7	11.0	9.4
		Mean	12.8	17.6	23.8	18.6
		Maximum	26.8	34.4	57.6	48.0
Small	20-49	Minimum	2.6	5.8	6.6	3.4
		Mean	6.9	12.3	13.1	9.5
		Maximum	12.6	19.6	20.9	19.4
Medium	50-65	Minimum	1.9	4.0	5.8	2.3
		Mean	5.0	8.0	9.6	6.2
		Maximum	6.4	10.0	11.8	7.6
Narva	116		6.4	8.9	11.8	7.3
Pärnu	119		2.8	4.9	6.1	4.7
Saaremaa	119		3.1	6.1	5.6	3.9
Hiiumaa	167		2.6	4.7	5.0	3.0
Tartu	265		1.7	2.9	3.3	2.3
Tallinn	1166		0.8	1.3	1.7	1.3

Small area estimation methods combine survey estimates and auxiliary data from registers. For finding suitable auxiliary information, the data analysis was performed using descriptive statistics and generalized linear models. The aim is to find the set of auxiliary variables that is available for all persons in population and can explain the survey variables.

The strong auxiliary variable for all indicators is age (see table below). Starting from age 40-45 the value of all indicators starts to decrease linearly.

Figure 2 DESI components by age, 2020



Indicators depend also on the activity status and educational attainment, slightly on the gender, but not on the urban-rural place of residence (**Error! Reference source not found.**see table below).

Figure 3 Users of e-commerce by gender, education, and activity status

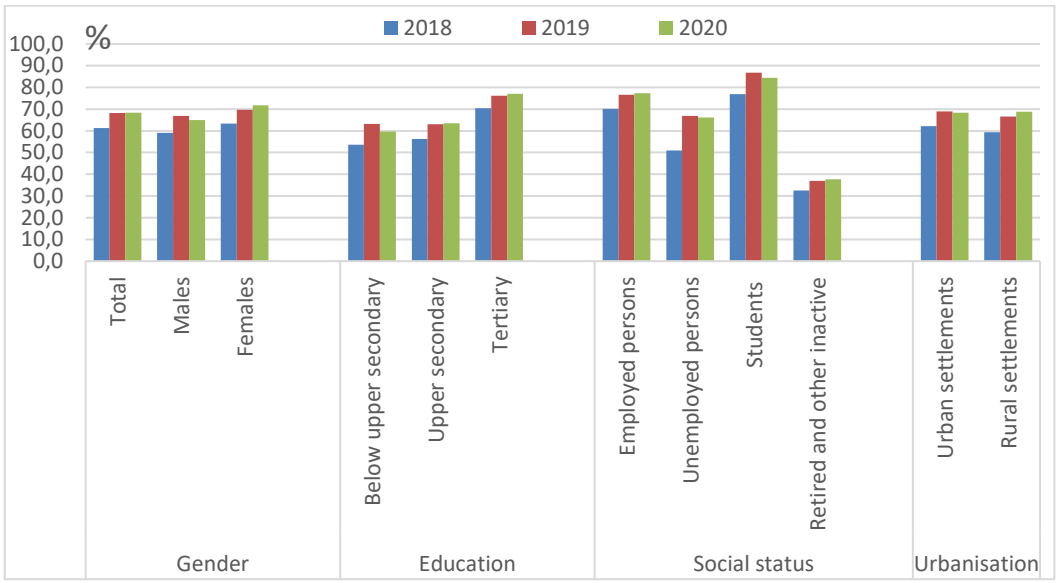


Table 4 Methodology information of the survey[1]

Country: Estonia	**Year: 2020**
Title: ICT usage in households	
Organisation running the survey: Statistics Estonia	
Survey period: 01 April – 30 June 2020	Sampling and statistical methodology: The list of permanent residents of Estonia based on the 2011 Population and Housing Census and the Population Register are used as sampling frame. Frame includes persons who have moved abroad. A probability sampling design is used, with one sampling stage and an explicit stratification (by place of residence). The sampling method is the systematic sampling with equal probabilities with stratification effect. The related auxiliary variables for stratification are address components. The frame is sorted by address components. The sampling unit is the individual. One individual in the household is interviewed.
Reference period: First quarter of 2020 / the year 2020	
Collection method: Stand-alone survey, voluntary. Web-based survey (CAWI): 23.9%; telephone interviews (CATI): 76.1%.	
Population covered: 16 to 74.	
Population size: Households: 536 600 Individuals: 970 900	
Net Sample size: Households: 4 010 Individuals: 4 010	
Overall response rate: Households. 62.5%, Individuals: 62.5%	
Main methodological differences compared to previous survey(s): Since 2014, the "ICT usage in households" survey is stand-alone survey. In earlier	

[1] https://circabc.europa.eu/sd/a/b929a881-22fd-4333-bdb0-8793eb1a33aa/isoc_sdds_hh_ee_2020.htm

years it was embedded in the Estonian Labour Force Survey (ELFS) in the 2nd quarter. Since 2014, the survey type is CAWI and CATI. In earlier years face-to-face computer assisted (CAPI) interviews were used. Since 2014, only one person (reference person) in the household is interviewed. In earlier years all members aged 15-74 in the reference person's household were interviewed. In 2015, the questionnaire and software were improved to be more suitable for CAWI and CATI. Since 2016, no major changes. Since 2017, Country of birth, Country of citizenship and Educational level (according to ISCED 2011) is linked from the population database (based on the 2011 Population and Housing Census and registers).	

3.2 Community Survey on ICT usage and e-commerce in Enterprises

The sample design of the survey does not take into account regional breakdown. Table 5 illustrates how the survey population and respondents are concentrated in large municipalities. Nine municipalities have not any enterprise belonging to the survey population and 10 municipalities are missing in the survey. A detailed description of the methodology is in Table 6. ICT activities are highly concentrated into large centres. Therefore, it is complicated to estimate local indicators concerning enterprises.

Table 5 Frame and respondents of Community survey on ICT usage and e-commerce in Enterprises, 2020

County	Municipality	Enterprises 1+ employed		Enterprises 10+ employed		Respondents of the survey	
		Number	%	Number	%	Number	%
Harju	Tallinn city	46447	48,3	3119	46,2	1356	46,0
Tartu	Tartu city	6676	6,9	561	8,3	221	7,5
Pärnu	Pärnu city	3359	3,5	245	3,6	111	3,8
Harju	Rae rural municipality	2203	2,3	239	3,5	114	3,9
Saare	Saaremaa rural municipality	1752	1,8	120	1,8	61	2,1
Harju	Saue rural municipality	1712	1,8	117	1,7	54	1,8
Harju	Viimsi rural municipality	2193	2,3	95	1,4	30	1,0
Harju	Saku rural municipality	933	1,0	84	1,2	38	1,3
Tartu	Kambja rural municipality	1002	1,0	81	1,2	27	0,9

County	Municipality	Enterprises 1+ employed		Enterprises 10+ employed		Respondents of the survey	
		Number	%	Number	%	Number	%
Ida-Viru	Jõhvi rural municipality	607	0,6	78	1,2	26	0,9
Harju	Harku rural municipality	1437	1,5	66	1,0	30	1,0
Ida-Viru	Kohtla-Järve city	728	0,8	64	0,9	36	1,2
Other municipalities							
	Total	20176	28,1	1299	27,8	586	28,6
	Mean	342,0		22,0		9,9	
	Q1	208		12		5	
	Q3	467		28		13	
Covered municipalities		**71**		**69**		**68**	

Table 6 Methodology information of the survey[2]

Country: Estonia	Year: 2020
Title: ICT usage in households	
Organisation running the survey: Statistics Estonia	
Survey period: 01 April – 30 June 2020	Sampling and statistical methodology: The list of permanent residents of Estonia based on the 2011 Population and Housing Census and the Population Register are used as sampling frame. Frame includes persons who have moved abroad. A probability sampling design is used, with one sampling stage and an explicit stratification (by place of residence). The sampling method is the systematic sampling with equal probabilities with stratification effect. The related auxiliary variables for stratification are address components. The frame is sorted by address components. The sampling unit is the individual. One individual in the household is interviewed.
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[2] https://circabc.europa.eu/sd/a/b929a881-22fd-4333-bdb0-8793eb1a33aa/isoc_sdds_hh_ee_2020.htm

3.3 Statistical population register

The Statistical population register is the base of official population statistics. The Statistical population register includes the list of residents of Estonia in the beginning of the reference year with following variables that were used as auxiliary variables for modelling DESI components: gender, age, place of residence, educational attainment, and activity status.

The list of residents is determined by residency index developed in Statistics Estonia for increasing the quality of population statistics (Tiit, Maasing 2016).

The highest study programme completed in the formal education system (i.e. in institutions of general, vocational or higher education) determines educational attainment of people. An uncompleted study programme does not raise the level of education. The level of education received in a foreign country was determined in the same manner as the level of education acquired in Estonia. The highest level of education attained was computed based on the data of the 2011 Population Census, the Estonian Education Information System, and the Population Register.

The methodology for calculating activity status cased on the administrative register is developed for register-based census (Muusikus, Lehto 2018). All residents over 15 years old are classified as employed, unemployed, pensioners and students, or other.

3.4 Employment register

The Employment register is sub-register of the Register of taxable persons[3]. The Employment register was established in 2014. The chief processor of the register is the Tax and Customs Board.

All natural and legal persons providing the work are required to register their employment. An employer is a resident or non-resident legal person in Estonia, Estonian state authority or a local government authority, a natural person, or a self-employed person who concludes an agreement which forms the basis for working or who appoints a person performing the work to office.

Employment of all-natural persons through whose working a tax liability will be created in Estonia, irrespective of the form of a contract, must be recorded in the Employment register.

The following data is registered in the Employment register: name of a person performing work and the personal identification code, the registry code of work provider, the date of commencement of employment, the type of employment, the occupation and the address of workplace, the initial and final dates of and the reason for the suspension of employment, initial and final dates of the termination of employment.

The occupation and the address of workplace are registered since 2019, which enables the use of this data as auxiliary information for modelling DESI components and as the alternative data source for some indicators.

[3] Taxation Act https://www.riigiteataja.ee/en/eli/ee/523012015008/consolide/current

3.5 Auxiliary data for small area estimators

As the result of data analysis and taking into account availability of register variables, it was decided to use the following set of auxiliary variables for small area estimation:

Gender_M
- 1 – person is male
- 0 – person is female

Age_15-24
- 1 – person was between 15-24 years old
- 0 – person was not 15-24 years old

Age_25-34
- 1 – person was between 25-34 years old
- 0 – person was not 25-34 years old

Age_35-44
- 1 – person was between 35-44 years old
- 0 – person was not 35-44 years old

Age_45-54
- 1 – person was between 45-54 years old
- 0 – person was not 45-54 years old

Age_55-64
- 1 – person was between 55-64 years old
- 0 – person was not 55-64 years old

Age_65-74
- 1 – person was between 65-74 years old
- 0 – person was not 65-74 years old

Tertiary_education
- 1 – person has tertiary education
- 0 – person has lower education

Employed
- 1 – person was employed
- 0 – person was not employed

White_collar
- 1 – person was employed with white-collar occupation
- 0 – person was employed with blue-collar occupation

Pensioner
- 1 – person was old-age pensioner who is not working
- 0 – person was not pensioner

Disabled
- 1 – person was disabled or not capable for a work
- 0 – person was not disabled

Table 7 Pearson correlation coefficient of DESI components and auxiliary information

	Indicator			
	Frequent internet users	**Communication skills**	**Shopping**	**Banking**
Male	-0.00362	-0.08087	-0.04325	-0.03476
Age (years)	-0.41793	-0.50001	-0.48358	-0.36978
Tertiary education	0.16242	0.13542	0.16596	0.16569
Employed	0.29862	0.21889	0.25110	0.29965
White-collar occupation	0.24787	0.23309	0.29363	0.24889
Old-age pension	-0.42236	-0.35643	-0.36202	-0.36243
Disabled or incapacity for work	-0.23183	-0.19801	-0.23179	-0.22802

The strongest negative correlation between DESI components and register variables are with age and pensioner activity status. Employment status and tertiary education are positively correlated with survey variables.

4 Small area estimation

Four estimators are tested in the present research: Direct, GREG, Synthetic and EBLUP (EURAREA, 2004).

Direct estimator of area *d*:

$$\hat{\bar{Y}}_d^{\text{DIRECT}} = \frac{1}{\hat{N}_d}\sum_{i\in s_d} w_{id}\, y_{id} \qquad \text{where} \quad \hat{N}_d = \sum_{i\in s_d} w_{id}$$

y_{id} is the surveyed variable of person *i* in the area *d* and N_d is the population size of the area *d*.

GREG estimator:

$$\hat{\bar{Y}}_d^{\text{GREG}} = \bar{\mathbf{X}}_d\hat{\boldsymbol{\beta}} + \frac{1}{\hat{N}_d}\sum_{i\in s_d} w_{id}\left(y_{id} - \mathbf{x}_{id}^T\hat{\boldsymbol{\beta}}\right)$$

where $\bar{\mathbf{X}}_d = (\bar{X}_{d,1},\ldots,\bar{X}_{d,p})^T$ is the vector of auxiliary data and $\hat{\beta}$ is the least squares regression estimate assuming a standard linear model.

Regression Synthetic estimator based on a two-level model with individual data:

$$y_{id} = x_{id}^T\beta + u_d + e_{id}$$

$$u_d \sim iid\ N(0,\sigma_u^2), \quad e_{id} \sim iid\ N(0,\sigma_e^2)$$

Estimator: $\hat{\bar{Y}}_d^{SYNTHA} = \bar{\mathbf{X}}_d^T\hat{\boldsymbol{\beta}}$ with $\bar{X}_{.d} = (\bar{X}_{.d,1},\ldots,\bar{X}_{.d,p})^T$

Empirical best linear unbiased predictor EBLUP

$$\hat{\bar{Y}}_d^{EBLUPA} = \bar{\mathbf{X}}_d^T\hat{\beta} + \gamma_d\left(\bar{y}_d - \bar{\mathbf{x}}_d^T\hat{\beta}\right)$$

where:

$$\gamma_d = \frac{\hat{\sigma}_u^2}{\hat{\sigma}_u^2 + \hat{\sigma}_e^2/n_d}$$

R-package *JoSAE* and *lme* was used for small area estimation. The model for estimating DESI components is based on linear regression models with mixed effects. The regression coefficients are computed by maximum likelihood – Restricted Maximum Likelihood (REML). Package JoSAE calculates three small area estimators: GREG (general regression estimator), Synthetic and EBLUP (empirical best unbiased predictor). The Direct estimator (simple sample mean) was calculated for comparison.

Significant auxiliary variables were selected for each indicator. Regression coefficient with the *t*- and *p*-values are presented in the following table. The strongest auxiliary variables were age groups and disability. The results of small area estimation (EBLUP) are presented on the maps in Figure 4 to Figure 7. The results are logical: more skilled persons live in large cities and surrounding areas.

Table 8 Parameter estimates of the REML model

	Value	Standard error	t-value	p-value
Frequent internet users				
(Intercept)	0.629	0.023	27.600	0.000
gender_M	-0.027	0.009	-2.928	0.003
educat_tertiaryN	0.076	0.010	7.314	0.000
age_group_1524	0.357	0.023	15.173	0.000
age_group_2534	0.295	0.021	14.372	0.000
age_group_3544	0.280	0.020	13.886	0.000
age_group_4554	0.244	0.020	12.206	0.000
age_group_5564	0.157	0.019	8.415	0.000
white_collar	0.030	0.012	2.493	0.013
pensioner	-0.160	0.023	-7.015	0.000
employed	0.048	0.014	3.439	0.001
disability	-0.127	0.013	-9.509	0.000
Communication skills above basic				
(Intercept)	0.421	0.024	17.276	0.000
gender_M	-0.074	0.012	-6.228	0.000
educat_tertiaryN	0.097	0.013	7.243	0.000
age_group_1524	0.567	0.029	19.611	0.000
age_group_2534	0.484	0.026	18.444	0.000
age_group_3544	0.421	0.026	16.345	0.000
age_group_4554	0.287	0.026	11.198	0.000
age_group_5564	0.137	0.024	5.705	0.000
white_collar	0.092	0.014	6.457	0.000
pensioner	-0.144	0.025	-5.674	0.000
disability	-0.122	0.017	-7.152	0.000
Banking				
(Intercept)	0.503	0.028	18.211	0.000
gender_M	-0.044	0.011	-3.888	0.000
educat_tertiaryN	0.086	0.013	6.748	0.000
age_group_1524	0.362	0.029	12.508	0.000
age_group_2534	0.358	0.025	14.162	0.000
age_group_3544	0.327	0.025	13.190	0.000
age_group_4554	0.291	0.025	11.788	0.000
age_group_5564	0.142	0.023	6.173	0.000
white_collar	0.045	0.015	3.107	0.002
pensioner	-0.102	0.028	-3.622	0.000

	Value	Standard error	t-value	p-value
employed	0.089	0.017	5.187	0.000
disability	-0.172	0.016	-10.479	0.000
Shopping				
(Intercept)	0.222	0.019	11.924	0.000
gender_M	-0.077	0.012	-6.189	0.000
educat_tertiaryN	0.088	0.014	6.298	0.000
age_group_1524	0.645	0.025	26.192	0.000
age_group_2534	0.612	0.022	27.320	0.000
age_group_3544	0.531	0.022	24.307	0.000
age_group_4554	0.424	0.022	19.504	0.000
age_group_5564	0.210	0.021	9.983	0.000
white_collar	0.122	0.016	7.661	0.000
employed	0.056	0.016	3.475	0.001
disability	-0.129	0.018	-7.185	0.000

Figure 4 EBLUP estimator of the frequent internet users indicator by municipality, 2020

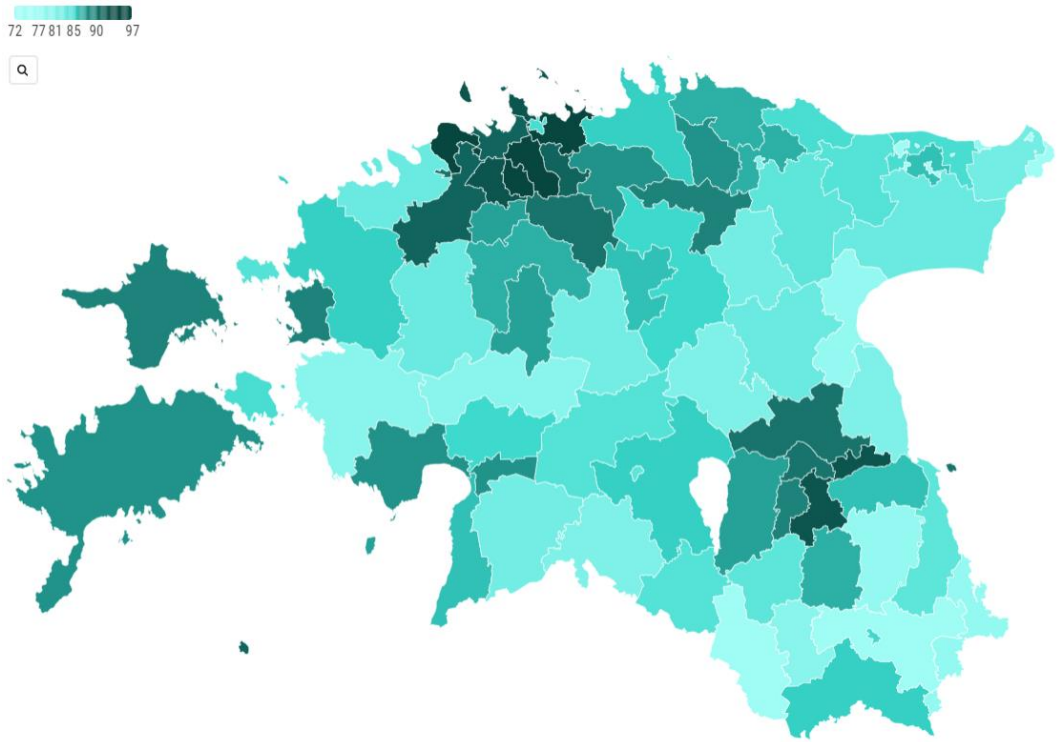


Figure 5 EBLUP estimator of the communication skills above basic indicator by municipality, 2020

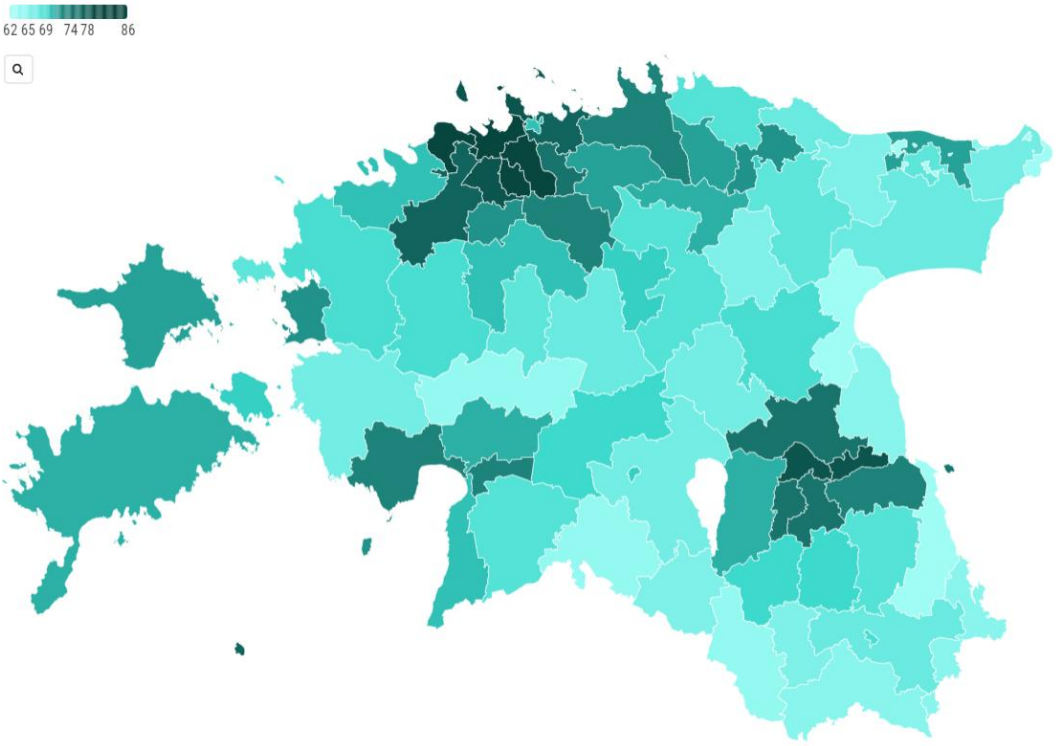


Figure 6 EBLUP estimator of the banking indicator by municipality, 2020

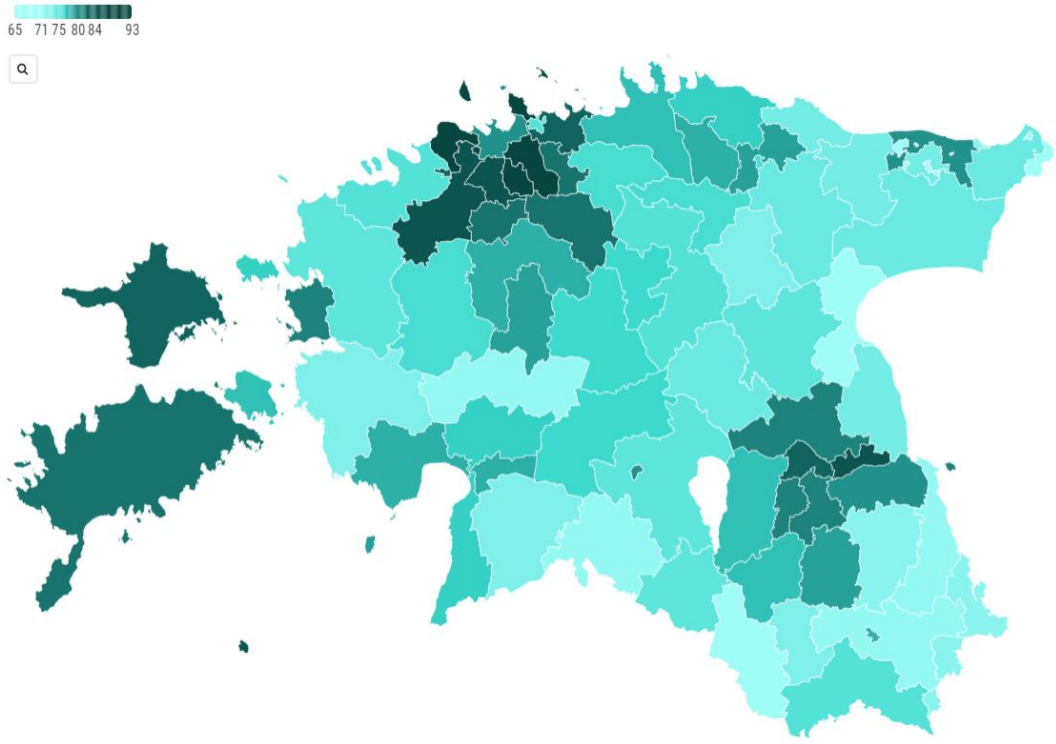
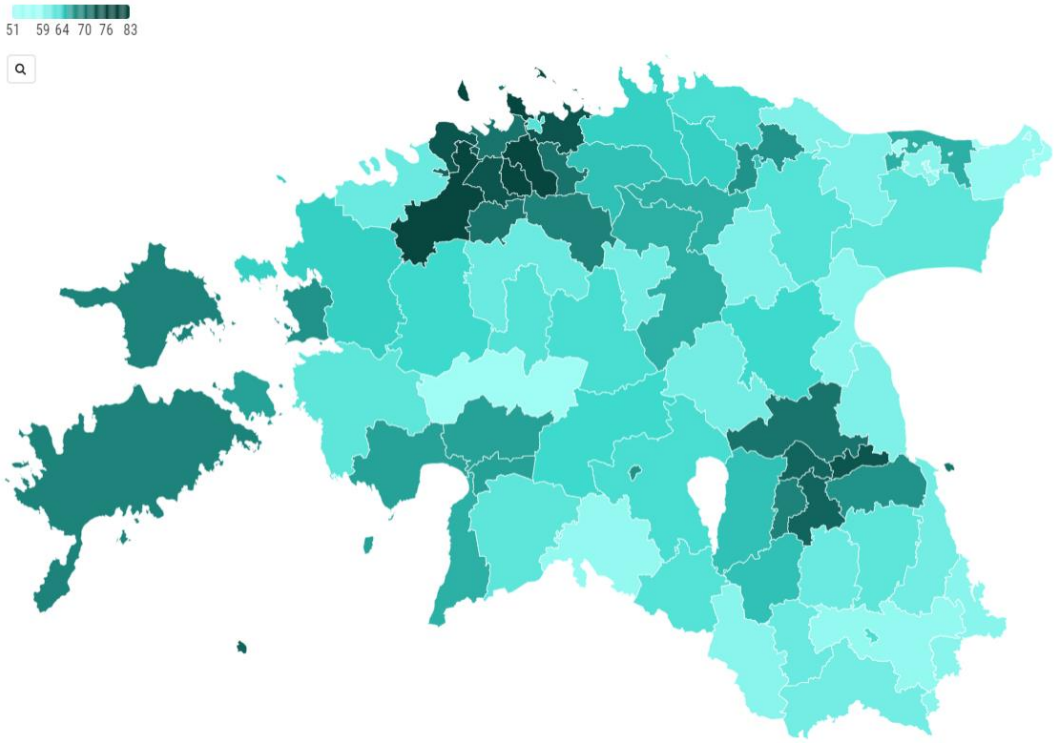


Figure 7 EBLUP estimator of the shopping indicator by municipality



5 Simulation study

Simulation study is the main method for testing new methodology. The aim of a simulation study is to simulate repeatedly and as close as possible the real situation with all survey steps: population frame, sample selection, and estimation. Repeated sampling procedure allows for estimating the performance of new estimators close to real-life situation. Artificial population includes both auxiliary and survey variables, which enables the comparison of the estimated mean from each sample to real population mean and calculate bias and variability of estimates.

5.1 Artificial population and sample selection

The artificial population was generated for the simulation study. The base of population were all residents of Estonia aged 15-74 as of 1 January 2020 form statistical population register linked with Employment register and disability information. This frame was linked on personal level with ICT survey data from 2018-2020. All persons were grouped according to gender, 10-year age group, education, activity status and disability. Survey data was imputed for every person in the population by selecting randomly donors from the same group with known survey data. The table below presents the groups and group sizes for generating artificial population. The population size was 970166 persons, the number of unique respondents of ICT survey form 2018-2020 was 12150.

The correlations between study variables and auxiliary variables in the artificial population were similar to correlations in the ICT survey.

Artificial population was used for the simulation study. The population frame was sorted by county and municipality, and samples with size 4000 persons were selected by systematic sampling. The sampling design was similar to the real survey design. All possible 246 samples were selected with starting point from the 1st person to the 246th person. The population mean of auxiliary variables by municipality was calculated and used for calculating small area estimates for municipalities (see Annex 1). Four indicators were estimated from every sample for 78 municipalities. One municipality was excluded due to missing sample.

Table 9 Population groups for generating artificial population

Age group	Tertiary education	Employed	White Collar	Pension	Disabled	Population, 1 January 2021		Respondents 2018-2020	
						Male	Female	Male	Female
15-24	-	-	Yes	-	-	5919	8064	66	94
15-24	-	-	No	-	-	58032	52767	488	423
25-34	-	Yes	Yes	-	-	31116	36749	395	481
25-34	-	Yes	No	-	Yes	2484	1745	34	21
25-34	-	Yes	No	-	No	38785	21844	413	254
25-34	-	No	No	-	Yes	3104	2360	17	21
25-34	-	No	No	-	No	19344	23079	123	224
35-44	Yes	Yes	Yes	-	-	17437	30375	274	469
35-44	Yes	No	Yes	-	-	13627	10469	171	157
35-44	Yes	Yes	No	-	-	8421	7842	93	116
35-44	Yes	No	No	-	-	3923	8170	38	94
35-44	No	No	No	-	Yes	7090	5374	65	50
35-44	No	No	No	-	No	44416	26338	467	273
45-54	Yes	Yes	Yes	-	-	12472	28341	187	434
45-54	Yes	No	Yes	-	-	10238	9780	145	144
45-54	Yes	Yes	No	-	-	9758	11399	110	152
45-54	Yes	No	No	-	-	4112	4629	31	59
45-54	No	Yes	No	-	Yes	4731	4883	77	69
45-54	No	Yes	No	-	No	28310	19415	375	250
45-54	No	No	No	-	Yes	5747	3875	61	55
45-54	No	No	No	-	No	10859	4308	89	40
55-64	Yes	Yes	Yes	-	-	10215	23183	153	396
55-64	No	Yes	Yes	-	-	4835	7835	84	142
55-64	Yes	Yes	No	-	-	11697	12998	159	179
55-64	Yes	No	No	-	-	7659	8432	86	79
55-64	No	Yes	No	-	-	26098	24183	386	366
55-64	No	No	No	-	-	18271	15204	203	216
65-74	Yes	-	Yes	No	-	3589	7243	59	107
65-74	No	-	Yes	No	-	1161	2553	23	44
65-74	Yes	-	No	Yes	-	11736	19546	178	281
65-74	Yes	-	No	No	-	4921	5435	67	71
65-74	No	-	No	Yes	Yes	7657	11539	110	173
65-74	No	-	No	Yes	No	17267	26830	243	461
65-74	No	-	No	No	Yes	1172	1526	14	22
65-74	No	-	No	No	No	7520	8130	114	135

5.2 Simulation results

R-package *JoSAE* and *lme* was used for small area estimation. Use of packages *lme* and *JoSAE*:
Summary (fit.lme <- lme(Shopping ~ gender_M + educat_tertiary + age_group_1524 + age_group_2534 + age_group_3544 + age_group_4554 + age_group_5564 + white_collar + pensioner + employed + disabled, data=sample1, random=~1|domain.ID))
result_Shopping <- eblup.mse.f.wrap(domain.data = pop_mean_data, lme.obj = fit.lme)

Results of the simulation study are illustrated in the figures below. The first figure shows single estimates obtained for one very small municipality. It can be seen that variability of Direct and GREG estimators is very large. Estimates vary from 0.4 to 0.95. It is clear that Direct and GREG are not suitable estimation methods for small municipalities. Synthetic and EBLUP estimates are all close to true value (0.67). These estimates vary between 0.64 and 0.70.

Figure 8 Estimated communication skills indicator over 246 samples in small municipality (sample size = 14)

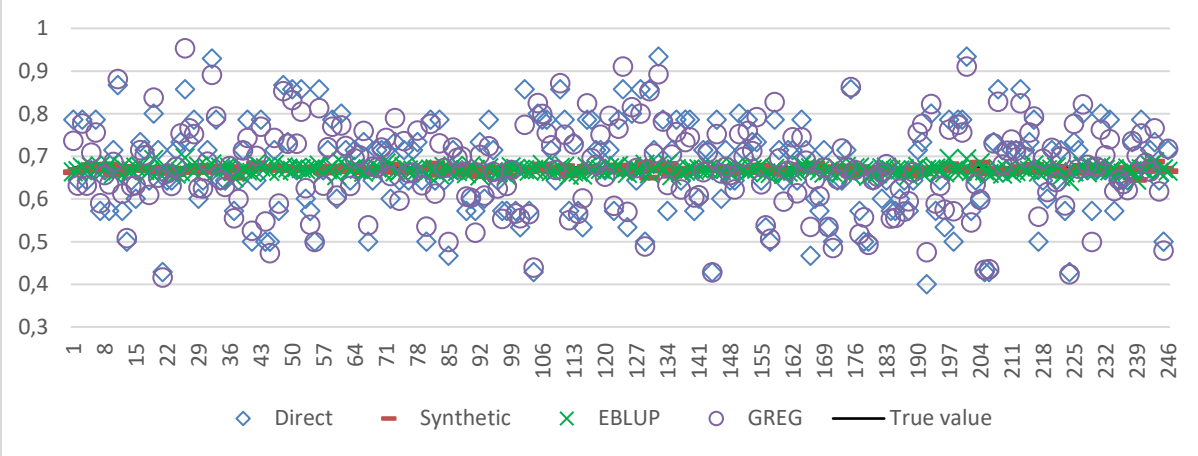
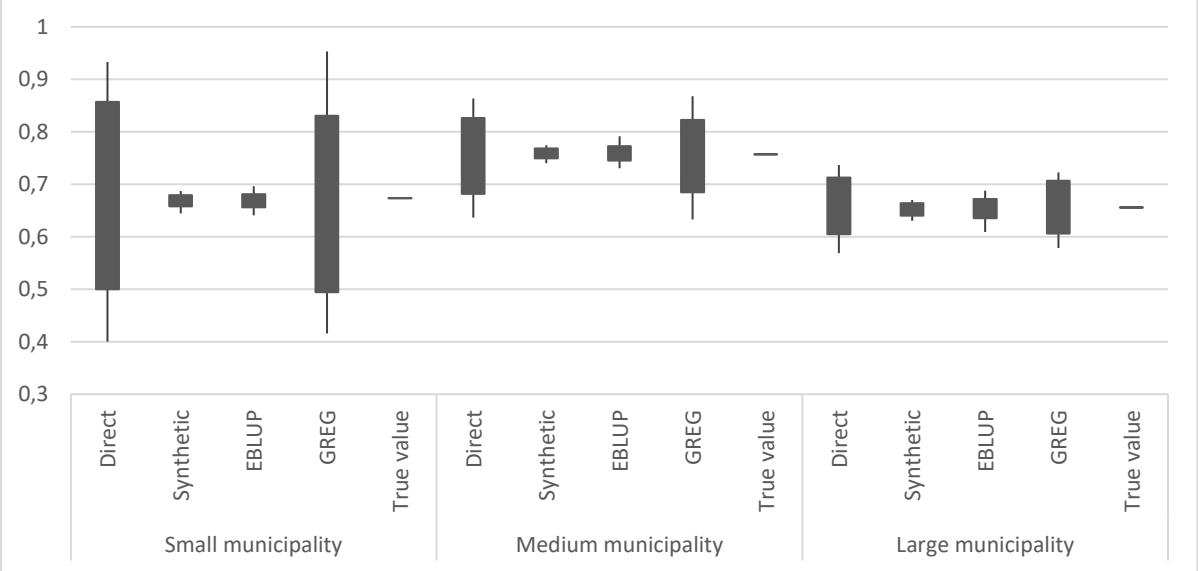


Figure 9 Performance of the small area estimators in three selected municipalities



Three municipalities of different sizes are compared in the figure above. Lines show the minimum and maximum of estimated value, box covers values between 5 and 95 percentiles. Sample sizes of small, medium, and large municipalities are 14, 66, and 166 respectively. Direct and GREG estimators perform quite well for large municipality. For small and medium municipalities, the EBLUP and Synthetic estimators outperform GREG and Direct estimators.

The performance of estimators was compared by calculating average absolute relative bias (AARB) and average relative root mean squared error (ARRMSE) of SAE-s in over 246 simulations and the group of municipalities. Known population mean of survey variables were the base of calculation bias.

Table 10 Performance of small area estimates

Sample size	Nr. municipalities	Average Absolute relative bias. %				Average relative root mean squared error. %			
		Direct Est.*	GREG Est.*	Synthetic Est.*	EBLUP Est.*	Direct Est.*	GREG Est.*	Synthetic Est.*	EBLUP Est.*
Frequent Internet users									
1-19	33	0.330	0.266	0.705	0.681	10.701	9.887	0.999	1.096
20-39	27	0.170	0.162	0.376	0.360	6.629	6.330	0.746	0.959
40-89	12	0.130	0.119	0.357	0.319	4.755	4.478	0.690	0.926
90 and more	6	0.069	0.056	0.258	0.242	2.632	2.531	0.676	0.988
Communication skills above basic									
1-19	33	0.611	0.537	1.003	0.992	17.517	16.483	1.488	1.636
20-39	27	0.325	0.328	0.568	0.552	10.911	10.414	1.158	1.426
40-89	12	0.208	0.188	0.393	0.361	7.802	7.456	0.980	1.282
90 and more	6	0.154	0.137	0.324	0.283	4.218	4.057	0.941	1.356
Shopping									
1-19	33	0.684	0.582	1.052	1.034	20.752	19.308	1.615	1.735
20-39	27	0.343	0.364	0.521	0.513	12.463	11.973	1.273	1.505
40-89	12	0.233	0.277	0.443	0.426	9.016	8.609	1.141	1.414
90 and more	6	0.159	0.161	0.383	0.369	4.963	4.831	1.179	1.628
Banking									
1-19	33	0.455	0.366	0.881	0.869	14.418	13.604	1.245	1.356
20-39	27	0.234	0.244	0.424	0.414	8.878	8.529	0.898	1.108
40-89	12	0.166	0.157	0.367	0.341	6.615	6.311	0.843	1.121
90 and more	6	0.158	0.146	0.332	0.279	3.569	3.480	0.810	1.184

*Est. = Estimator

Direct and GREG are unbiased estimators and consequently the AARB of GREG is the smallest compared to other estimators for almost all cases. The bias increases slightly when sample size decreases. Average bias of Synthetic and EBLUP is about two times larger than the average bias of GREG, except for large municipalities where the difference is higher. At the same time, the error of GREG estimates measured by ARRMSE increases four to five times for small municipalities compared to larger ones. It gives an indication that the GREG is not a reliable estimator for smaller municipalities. The variability of Synthetic and EBLUP estimators do not depend on the sample size.

Therefore, the simulation study shows that the Synthetic and EBLUP estimators are reliable estimation methods for local DESI components for small and medium municipalities. The choice between GREG and EBLUP for large municipalities depends on if one prefers unbiased estimator where it is reliable or to use the same method for all areas for better comparability.

6 Alternative data sources

6.1 Employment register

Employment register includes information about occupation which allows the calculation of the following indicators:

- Persons employed with ICT Specialist Skills
- Enterprises employing ICT specialists

The table below presents the number of persons with main job with ICT specialists' skills by occupation. The share of persons employed with ICT skills is 4.7% from all employed persons with registered occupation. This result is below the same indicator estimated from LFS (6.0% in 2019, 6.5% in 2020).

There might be several reasons for different results:

1. Registration of occupation is not required for all types of employment. Self-employed persons and employers are also not registered in Employment register. LFS covers the occupation of all employed persons.
2. An employer declares occupation information in Employment register, but in LFS each person reports his/her occupation himself/herself. Comparison of LFS and register occupation data showed differences for 1/3 of the cases.
3. Register data is for a one-time moment, while LFS estimates are annual averages.

Table 11 Persons employed with ICT skills in Employment register, 1 January 2021.

Occupation group				Number of persons
I. ICT MANAGERS, PROFESSIONALS AND ASSOCIATE PROFESSIONALS				21314
	133	ICT Service managers		2013
25	Information and communications technology professionals			14511
	251	Software and multimedia developers and analysts		11809
		2511	Systems analysts	2641
		2512	Software developers	6508
		2513	Web and multimedia developers	431
		2514	Application programmers	830
		2519	Software and multimedia developers and analysts not elsewhere classified	1399
	252	Database specialists and systems administrators		2702
		2521	Database designers and administrators	697
		2522	Systems administrators	1388
		2523	Computer network professionals	195
		2529	Database and network professionals not elsewhere classified	422
35	Information and communications technicians			4790
	351	ICT operations and user support technicians		3836
		3511	ICT operations technicians	312
		3512	ICT user support technicians	2290
		3513	Computer network and systems technicians	962

Occupation group				Number of persons
		3514	Web technicians	272
	352	Communications technicians		954
		3521	Broadcasting and audio-visual technicians	607
		3522	Telecommunications engineering technicians	347
II. OTHER UNIT GROUPS THAT PRIMARILY INVOLVE THE PRODUCTION OF ICT GOODS AND SERVICES				5475
		2152	Electronic engineers	700
		2153	Telecommunication engineers	433
		2166	Graphic and multimedia designers	1367
		2356	Information technology trainers	62
		2434	ICT sales professionals	555
		3114	Electronics engineering technicians	570
	742	Electronics and Telecommunications Installers and Repairers		1788
		7421	Electronics mechanics and servicers	1113
		7422	ICT installers and servicers	675

The register data enables the calculation of an indicator for municipalities and compare municipalities according to the level of indicator. The table below presents municipalities where the share of ICT specialists is above average. Workplaces of ICT specialists are concentrated in the two large cities and one neighbouring rural municipality. Persons live in the same cities or in rural municipalities surrounding the cities. The complete table of indicators can be found in Annex 2.

Table 12 Share of ICT specialists by place of residence and location of workplace, 1 January 2021

County	Municipality	Share of ICT specialists. %
Estonia		4,7
Place of residence		
Harju	Kiili rural municipality	7.6
Harju	Rae rural municipality	7.4
Harju	Tallinn city	7.4
Harju	Harku rural municipality	6.8
Harju	Viimsi rural municipality	6.6
Harju	Saku rural municipality	6.5
Harju	Saue rural municipality	5.8
Tartu	Tartu city	5.6
Tartu	Kambja rural municipality	5.0
Saare	Muhu rural municipality	4.8
Harju	Raasiku rural municipality	4.8
Tartu	Luunja rural municipality	4.8
Tartu	Tartu rural municipality	4.7
Harju	Keila city	4.7
Location of the workplace		
Harju	Tallinn city	8.2
Tartu	Tartu city	6.2
Tartu	Tartu rural municipality	5.5

The same occupations were used for estimating the enterprise level indicator. Differently, all jobs with registered occupation were taken into account. If an enterprise employed at least one ICT specialist then the enterprise was classified as employing ICT specialists. If the enterprise had local units in several municipalities, then every local unit was counted. There were 18.8% enterprises or local units with 10+ employed persons that employed ICT specialists. This is close to the value of the indicator based on the survey – 16.7% in 2020. The share among all enterprises was 7.5%. Municipalities above average are presented in the table below. Data for other municipalities is given in Annex 2.

Table 13 Share of enterprises employing ICT specialists.

County	Municipality	Share of enterprises, which employ ICT specialists %
Harju	Tallinn city	11,0
Tartu	Tartu city	9,6
Harju	Loksa city	7,8
Harju	Rae rural municipality	7,7

6.2 Big data and other alternative sources

Components of the DESI are closely related to the development and current situation of the IT infrastructure. The strategy aims to provide all residents with internet access above 30 Mbps and to achieve at least a 60% rate of household subscriptions with a speed of above 100 Mbps.[4] The information about the high-speed broadband is collected and published by Consumer Protection and Technical Regulatory Authority[5]. Use of the information about the availability and speed of internet connections helps to improve the local DESI estimates.

There is a significant increase of mobile Internet usage during recent years. Mobile operators collect the anonymous information about mobile Internet usage by region. For example, Telia analysed mobile Internet usage before and immediately after the lockdown in March 2020 and published changes by region[6]. This information would be a good source of auxiliary data for SAE model, because SAE models can include both individual and area level auxiliary data.

[4] https://digital-strategy.ec.europa.eu/en/policies/desi-estonia
[5] https://www.netikaart.ee/tsaApp/
[6] https://www.ituudised.ee/uudised/2020/03/26/kaart-naitab-kus-on-mobiilse-interneti-kasutus-enim-kasvanud

7 Conclusions

The DESI components are based on the sample survey. Sample sizes in local units are too small for reliable estimates. There are two solutions for local DESI:

1. To increase sample size for small local units;
2. To apply statistical modelling or alternative data sources.

The first solution is easier to explain to data users. General and local indicators are consistent. On the other hand, the solution is costly, because interviewing is the most expensive data collection method. An increased sample size may also influence response rates.

The second solution requires availability of the comprehensive administrative register data and a possibility to link register and survey data. Developing and implementing the methodology for the first time is time consuming. Later, the models need to be updated over some years.

The data analysis and simulation study demonstrated that DESI human capital components could be well explained by demographic and socio-economic variables available for all population. Four selected DESI components were analysed and tested in simulation study. Correlation analysis indicated that other DESI components could be estimated at local level using similar SAE models.

Based on the study, I can recommend to prefer small area estimation methods for local DESI if administrative register data or/and some alternative data sources are available for statistical purposes. An increase of sample size is a second option in case of poor register data.

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ANNEX 1 Population aged 15-74, 1 January 2020

Municipality			Share of total population												
Code	Name	Type	Population 15-64	Male	Age 15-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65-74	Tertiary education	Employed	Blue-collar	Old age pension	Disabled
Northern Estonia															
Harju county															
0141	Anija	R	4597	0.520	0.121	0.164	0.170	0.191	0.207	0.146	0.271	0.665	0.239	0.129	0.131
0198	Harku	R	10757	0.504	0.125	0.150	0.255	0.224	0.151	0.095	0.464	0.725	0.431	0.067	0.064
0245	Jõelähtme	R	4832	0.529	0.109	0.170	0.217	0.211	0.179	0.114	0.351	0.723	0.358	0.081	0.083
0296	Keila	C	7096	0.481	0.138	0.191	0.219	0.173	0.160	0.119	0.366	0.719	0.339	0.086	0.085
0305	Kiili	R	4002	0.513	0.143	0.173	0.268	0.211	0.122	0.083	0.426	0.733	0.431	0.057	0.068
0338	Kose	R	5131	0.515	0.131	0.202	0.193	0.183	0.167	0.124	0.274	0.696	0.281	0.096	0.109
0353	Kuusalu	R	4703	0.523	0.125	0.159	0.190	0.182	0.202	0.142	0.319	0.660	0.289	0.117	0.107
0424	Loksa	C	1960	0.532	0.103	0.109	0.162	0.179	0.237	0.211	0.314	0.574	0.137	0.196	0.147
0431	Lääne-Harju	R	9433	0.508	0.121	0.144	0.185	0.208	0.193	0.148	0.285	0.654	0.218	0.121	0.132
0446	Maardu	C	12128	0.497	0.107	0.145	0.182	0.173	0.230	0.164	0.319	0.648	0.200	0.129	0.133
0651	Raasiku	R	3587	0.517	0.131	0.189	0.226	0.182	0.148	0.123	0.295	0.708	0.326	0.093	0.091
0653	Rae	R	13931	0.515	0.107	0.228	0.339	0.156	0.098	0.071	0.453	0.731	0.455	0.048	0.051
0719	Saku	R	7318	0.507	0.138	0.175	0.251	0.198	0.133	0.105	0.401	0.731	0.414	0.071	0.065
0726	Saue	R	16188	0.509	0.128	0.184	0.242	0.192	0.142	0.112	0.391	0.706	0.384	0.082	0.080
0784	Tallinn	C	329595	0.463	0.128	0.216	0.205	0.163	0.156	0.132	0.457	0.680	0.348	0.095	0.092
0890	Viimsi	R	14504	0.490	0.135	0.157	0.260	0.210	0.131	0.107	0.521	0.711	0.458	0.074	0.049
Central Estonia															
Järva county															
0255	Järva	R	6617	0.538	0.135	0.165	0.162	0.173	0.204	0.160	0.204	0.617	0.188	0.136	0.178
0567	Paide	R	7672	0.492	0.126	0.171	0.162	0.182	0.195	0.165	0.260	0.643	0.236	0.134	0.164
0834	Türi	R	7994	0.511	0.125	0.158	0.146	0.189	0.209	0.174	0.222	0.607	0.198	0.146	0.169
Lääne-Viru county															
0191	Haljala	R	3292	0.547	0.111	0.170	0.153	0.197	0.201	0.167	0.293	0.655	0.253	0.139	0.128
0272	Kadrina	R	3569	0.525	0.136	0.186	0.175	0.177	0.184	0.141	0.254	0.643	0.201	0.122	0.142
0663	Rakvere	C	4171	0.517	0.138	0.167	0.188	0.185	0.182	0.140	0.244	0.642	0.212	0.120	0.143
0661	Rakvere	R	10979	0.465	0.131	0.172	0.167	0.191	0.187	0.153	0.314	0.635	0.263	0.130	0.144
0792	Tapa	R	7879	0.505	0.148	0.147	0.162	0.184	0.196	0.163	0.234	0.592	0.162	0.136	0.189
0901	Vinni	R	5091	0.528	0.124	0.180	0.153	0.190	0.208	0.145	0.236	0.607	0.192	0.141	0.163
0903	Viru-Nigula	R	4179	0.516	0.129	0.129	0.153	0.195	0.219	0.174	0.232	0.609	0.168	0.159	0.195
0928	Väike-Maarja	R	4235	0.527	0.134	0.172	0.144	0.184	0.207	0.159	0.218	0.604	0.178	0.146	0.172

Municipality			Share of total population												
Rapla county															
0293	Kehtna	R	4006	0.520	0.132	0.172	0.154	0.191	0.199	0.152	0.204	0.630	0.195	0.129	0.150
0317	Kohila	R	5324	0.530	0.128	0.179	0.227	0.188	0.152	0.126	0.274	0.673	0.274	0.102	0.094
0503	Märjamaa	R	5592	0.533	0.129	0.164	0.159	0.195	0.184	0.169	0.220	0.634	0.196	0.137	0.151
0668	Rapla	R	9626	0.508	0.131	0.168	0.174	0.186	0.191	0.149	0.257	0.656	0.254	0.121	0.126
Northeastern Estonia															
Ida-Viru county															
0130	Alutaguse	R	3507	0.539	0.127	0.139	0.153	0.214	0.209	0.158	0.301	0.589	0.198	0.151	0.230
0251	Jõhvi	R	8863	0.518	0.105	0.153	0.174	0.184	0.212	0.171	0.379	0.581	0.237	0.154	0.247
0321	Kohtla-Järve	C	25190	0.472	0.109	0.136	0.162	0.168	0.234	0.191	0.318	0.564	0.162	0.183	0.316
0442	Lüganuse	R	6269	0.500	0.114	0.125	0.149	0.181	0.228	0.203	0.256	0.571	0.168	0.186	0.257
0511	Narva	C	41008	0.467	0.111	0.132	0.164	0.186	0.219	0.189	0.326	0.529	0.157	0.194	0.254
0514	Narva-Jõesuu	R	3520	0.528	0.105	0.120	0.166	0.180	0.244	0.185	0.378	0.545	0.224	0.173	0.263
0735	Sillamäe	C	9524	0.474	0.103	0.119	0.158	0.171	0.255	0.193	0.364	0.564	0.183	0.194	0.288
0803	Toila	R	3541	0.506	0.131	0.135	0.168	0.190	0.216	0.160	0.361	0.644	0.297	0.140	0.189
Western Estonia															
Hiiu county															
0205	Hiiumaa	R	7371	0.533	0.115	0.176	0.150	0.194	0.201	0.166	0.291	0.661	0.267	0.141	0.110
Lääne county															
0184	Haapsalu	R	9552	0.477	0.121	0.157	0.156	0.187	0.202	0.178	0.297	0.640	0.247	0.141	0.129
0441	Lääne-Nigula	R	3654	0.516	0.146	0.233	0.222	0.190	0.132	0.076	0.348	0.715	0.349	0.060	0.131
0907	Vormsi	R	326	0.623	0.055	0.104	0.248	0.221	0.187	0.184	0.359	0.687	0.307	0.153	0.098
Pärnu county															
0214	Häädemeeste	R	3621	0.530	0.143	0.173	0.158	0.204	0.182	0.140	0.233	0.598	0.207	0.128	0.137
0303	Kihnu	R	559	0.531	0.109	0.204	0.157	0.222	0.197	0.111	0.272	0.662	0.243	0.107	0.143
0430	Lääneranna	R	5225	0.543	0.113	0.185	0.152	0.185	0.207	0.159	0.219	0.633	0.207	0.141	0.142
0638	Põhja-Pärnumaa	R	5803	0.531	0.136	0.179	0.145	0.184	0.204	0.152	0.222	0.606	0.176	0.137	0.174
0624	Pärnu	R	6053	0.521	0.125	0.169	0.152	0.175	0.216	0.163	0.193	0.618	0.171	0.146	0.204
0712	Saarde	R	3356	0.535	0.133	0.171	0.139	0.189	0.214	0.154	0.229	0.599	0.172	0.145	0.170
0809	Tori	R	8744	0.514	0.134	0.185	0.180	0.188	0.174	0.139	0.241	0.644	0.213	0.116	0.154
Saare county															
0478	Muhu	R	1434	0.563	0.084	0.182	0.163	0.214	0.192	0.165	0.342	0.651	0.273	0.130	0.130
0689	Ruhnu	R	115	0.504	0.096	0.165	0.200	0.270	0.174	0.096	0.461	0.696	0.443	0.078	0.070
0714	Saaremaa	R	23201	0.512	0.118	0.184	0.159	0.197	0.193	0.148	0.276	0.650	0.242	0.122	0.155
Southern Estonia															
Jõgeva county															
0247	Jõgeva	R	9985	0.502	0.141	0.174	0.146	0.183	0.187	0.170	0.251	0.604	0.203	0.141	0.256
0486	Mustvee	R	4035	0.543	0.115	0.147	0.144	0.208	0.215	0.171	0.240	0.559	0.169	0.168	0.360
0618	Põltsamaa	R	10148	0.514	0.133	0.170	0.163	0.184	0.197	0.154	0.264	0.609	0.207	0.131	0.284
Põlva county															
0284	Kanepi	R	3491	0.550	0.122	0.175	0.167	0.193	0.190	0.154	0.252	0.621	0.208	0.136	0.241
0622	Põlva	R	36347	0.474	0.129	0.173	0.180	0.188	0.180	0.150	0.302	0.645	0.255	0.120	0.145
0708	Räpina	R	4716	0.535	0.119	0.166	0.149	0.188	0.226	0.151	0.235	0.580	0.171	0.141	0.358
Tartu county															
0171	Elva	R	10496	0.519	0.139	0.179	0.172	0.181	0.183	0.147	0.269	0.620	0.234	0.123	0.238

Municipality			Share of total population												
0283	Kambja	R	8192	0.519	0.139	0.209	0.240	0.182	0.145	0.085	0.383	0.718	0.375	0.065	0.138
0291	Kastre	R	3934	0.531	0.130	0.206	0.184	0.190	0.176	0.113	0.274	0.658	0.259	0.098	0.184
0432	Luunja	R	3939	0.544	0.128	0.149	0.146	0.193	0.217	0.167	0.202	0.596	0.179	0.149	0.174
0528	Nõo	R	3127	0.519	0.155	0.195	0.193	0.177	0.162	0.119	0.325	0.686	0.294	0.088	0.169
0586	Peipsiääre	R	4072	0.550	0.134	0.159	0.146	0.198	0.202	0.161	0.231	0.576	0.163	0.153	0.296
0793	Tartu	C	68702	0.459	0.150	0.203	0.197	0.175	0.152	0.124	0.429	0.649	0.332	0.090	0.167
0796	Tartu	R	8110	0.527	0.135	0.207	0.213	0.187	0.151	0.106	0.322	0.682	0.306	0.091	0.156
Valga county															
0557	Otepää	R	4752	0.532	0.132	0.179	0.154	0.208	0.187	0.141	0.277	0.636	0.229	0.119	0.199
0824	Tõrva	R	4499	0.522	0.130	0.178	0.142	0.185	0.205	0.160	0.247	0.591	0.192	0.145	0.251
0855	Valga	R	11680	0.504	0.142	0.150	0.156	0.193	0.197	0.162	0.236	0.545	0.161	0.145	0.270
Viljandi county															
0480	Mulgi	R	5568	0.534	0.124	0.169	0.147	0.168	0.224	0.168	0.220	0.572	0.165	0.154	0.255
0615	Põhja-Sakala	R	7073	0.515	0.138	0.180	0.138	0.186	0.200	0.158	0.228	0.612	0.200	0.138	0.228
0897	Viljandi	C	12279	0.458	0.130	0.181	0.160	0.179	0.179	0.171	0.306	0.646	0.272	0.126	0.161
0899	Viljandi	R	10395	0.532	0.136	0.170	0.158	0.186	0.187	0.162	0.218	0.599	0.181	0.139	0.212
Võru county															
0142	Antsla	R	3275	0.542	0.140	0.163	0.144	0.190	0.211	0.151	0.203	0.577	0.147	0.144	0.245
0698	Rõuge	R	4067	0.567	0.123	0.177	0.154	0.187	0.205	0.155	0.252	0.583	0.198	0.143	0.271
0732	Setomaa	R	2453	0.569	0.100	0.180	0.151	0.190	0.224	0.156	0.244	0.572	0.194	0.141	0.323
0919	Võru	C	8116	0.534	0.145	0.176	0.157	0.190	0.193	0.138	0.237	0.597	0.191	0.125	0.247
0917	Võru	R	8441	0.461	0.130	0.176	0.155	0.193	0.184	0.161	0.281	0.613	0.219	0.127	0.241

ANNEX 2 Estimated values of selected indicators by municipality, 2020

Municipality				EBLUP estimator, %				Share of ICT specialists, %		Share of enterprises with ICT specialists, %
Code	Name	Type	Population 15-74	Frequent Internet users	Communication skills	Banking	Shopping	by the place of residence	by the location of workplace	
Northern Estonia										
Harju county										
0141	Anija	R	4597	87.9	71.5	76.5	64.5	2.3	0.8	3.9
0198	Harku	R	10757	96.6	80.9	88.1	76.1	6.8	1.5	6.5
0245	Jõelähtme	R	4832	93.4	77.4	83.7	73.1	4.1	0.6	3.8
0296	Keila	C	7096	89.8	76.2	83.9	72.5	4.7	1.6	5.1
0305	Kiili	R	4002	94.6	80.4	88.6	77.0	7.6	1.8	6.0
0338	Kose	R	5131	89.9	73.9	81.9	69.4	3.3	2.2	2.8
0353	Kuusalu	R	4703	85.2	72.6	78.0	64.1	3.3	1.0	4.4
0424	Loksa	C	1960	80.7	63.6	73.4	59.0	1.2	0.8	7.8
0431	Lääne-Harju	R	9433	83.2	70.0	75.9	61.3	2.2	0.9	3.9
0446	Maardu	C	12128	84.7	69.7	76.1	62.3	2.4	0.7	3.8
0651	Raasiku	R	3587	90.1	75.8	81.5	70.9	4.8	1.0	3.1
0653	Rae	R	13931	97.2	86.2	92.9	82.8	7.4	2.5	7.7
0719	Saku	R	7318	91.3	78.8	85.5	74.4	6.5	3.1	6.6
0726	Saue	R	16188	90.4	77.7	86.0	76.6	5.8	1.6	5.1
0784	Tallinn	C	3E+05	90.5	79.1	79.9	70.7	7.4	8.2	11.0
0890	Viimsi	R	14504	92.9	78.8	86.4	77.2	6.6	2.0	6.1
Central Estonia										
Järva county										
0255	Järva	R	6617	84.8	68.7	76.1	65.1	1.8	0.5	2.9
0567	Paide	R	7672	85.8	69.2	76.8	60.7	2.5	1.2	5.6
0834	Türi	R	7994	82.7	66.8	76.7	62.9	1.8	0.9	2.9
Lääne-Viru county										
0191	Haljala	R	3292	85.8	68.5	77.0	63.1	2.1	0.5	1.3
0272	Kadrina	R	3569	87.5	71.6	78.4	64.5	2.1	0.6	1.5
0663	Rakvere	C	4171	81.4	69.5	76.5	64.8	2.4	1.7	4.8
0661	Rakvere	R	10979	86.4	71.8	79.0	67.9	1.7	0.6	1.7
0792	Tapa	R	7879	89.6	70.9	76.5	65.6	1.7	1.0	3.2
0901	Vinni	R	5091	83.5	68.0	75.4	62.3	1.5	0.9	2.0
0903	Viru-Nigula	R	4179	84.5	67.0	74.4	59.4	0.8	0.6	4.4
0928	Väike-Maarja	R	4235	81.5	65.9	73.9	59.5	1.7	0.5	1.7
Rapla county										
0293	Kehtna	R	4006	87.4	67.7	78.9	62.7	2.1	0.6	2.7
0317	Kohila	R	5324	86.7	72.2	81.7	71.5	4.7	1.7	3.9
0503	Märjamaa	R	5592	83.3	68.9	76.4	63.6	2.4	0.7	2.8

Municipality				EBLUP estimator, %				Share of ICT specialists, %		Share of enterprises with ICT specialists, %
Code	Name	Type	Population 15-74	Frequent Internet users	Communication skills	Banking	Shopping	by the place of residence	by the location of workplace	
0668	Rapla	R	9626	86.3	70.1	78.2	61.9	2.9	0.9	3.7
Northeastern Estonia										
Ida-Viru county										
0130	Alutaguse	R	3507	82.9	67.3	75.4	62.2	1.9	0.5	3.2
0251	Jõhvi	R	8863	85.6	67.7	74.1	59.4	2.2	2.7	5.2
0321	Kohtla-Järve	C	25190	74.6	62.4	65.0	55.4	1.8	1.7	3.8
0442	Lüganuse	R	6269	84.5	65.8	74.4	59.7	1.7	1.0	3.8
0511	Narva	C	41008	72.5	61.6	68.2	50.5	1.8	1.7	5.9
0514	Narva-Jõesuu	R	3520	82.6	66.8	74.6	59.0	1.4	0.7	4.8
0735	Sillamäe	C	9524	77.6	65.1	72.3	55.1	1.8	1.9	7.1
0803	Toila	R	3541	84.8	71.0	79.0	65.7	2.6	0.6	4.2
Western Estonia										
Hiiu county										
0205	Hiiumaa	R	7371	89.2	71.1	82.9	68.6	4.2	1.8	6.5
Lääne county										
0184	Haapsalu	R	9552	87.9	71.8	80.2	67.0	2.5	1.3	5.0
0441	Lääne-Nigula	R	3654	85.1	69.0	75.9	64.2	2.1	0.7	2.9
0907	Vormsi	R	326	84.1	68.2	76.9	64.0	2.7	..	..
Pärnu county										
0214	Häädemeeste	R	3621	85.4	69.9	77.0	65.2	1.7	0.3	1.6
0303	Kihnu	R	559	87.4	72.1	78.9	66.8	1.4	0.0	0.0
0430	Lääneranna	R	5225	79.2	66.7	73.9	62.2	1.9	0.7	2.4
0638	Põhja-Pärnumaa	R	5803	79.0	63.9	72.3	58.6	1.7	0.7	2.8
0624	Pärnu	R	6053	87.8	72.7	78.1	65.8	2.3	1.6	4.5
0712	Saarde	R	3356	82.2	68.6	73.8	62.0	2.3	0.9	4.5
0809	Tori	R	8744	84.9	70.7	76.8	66.6	1.9	1.0	4.1
Saare county										
0478	Muhu	R	1434	84.7	69.7	77.2	66.2	4.8	1.0	3.2
0689	Ruhnu	R	115	90.8	76.9	84.5	72.8	4.3	0.0	0.0
0714	Saaremaa	R	23201	87.8	70.9	81.8	70.0	2.8	1.8	5.6
Southern Estonia										
Jõgeva county										
47	Jõgeva	R	9985	83.1	68.8	75.5	63.9	2.3	0.6	3.3
0486	Mustvee	R	4035	77.5	61.9	70.1	59.2	1.5	0.5	1.6
0618	Põltsamaa	R	10148	81.1	66.6	75.1	61.0	1.5	0.3	1.2
Põlva county										
0284	Kanepi	R	3491	86.6	69.2	78.7	61.4	2.8	0.7	3.0
0622	Põlva	R	36347	78.5	68.2	73.0	62.2	2.4	0.7	2.6
0708	Räpina	R	4716	83.6	62.7	71.6	60.2	1.8	1.2	6.4
Tartu county										
0171	Elva	R	10496	87.5	70.8	77.6	64.9	3.2	2.7	4.3
0283	Kambja	R	8192	91.2	74.7	81.3	71.7	5.0	1.6	5.9

Municipality				EBLUP estimator, %				Share of ICT specialists, %		Share of enterprises with ICT specialists, %
Code	Name	Type	Population 15-74	Frequent Internet users	Communication skills	Banking	Shopping	by the place of residence	by the location of workplace	
0291	Kastre	R	3934	85.6	73.2	79.5	67.1	3.1	..	..
0432	Luunja	R	3939	92.1	79.0	84.7	73.2	4.8	1.0	6.6
0528	Nõo	R	3127	88.4	74.6	80.7	68.0	3.6	1.7	7.1
0586	Peipsiääre	R	4072	81.5	64.8	74.2	59.5	1.6	0.5	1.9
0793	Tartu	C	68702	89.7	77.7	82.8	72.2	5.6	6.2	9.6
0796	Tartu	R	8110	89.8	75.8	80.4	71.0	4.7	5.5	3.7
Valga county										
0557	Otepää	R	4752	83.9	69.1	77.3	64.7	2.9	0.9	2.9
0824	Tõrva	R	4499	84.4	65.4	75.4	62.3	2.2	0.3	1.1
0855	Valga	R	11680	76.9	63.0	71.1	59.3	1.6	0.9	2.8
Viljandi county										
0480	Mulgi	R	5568	81.4	64.1	71.4	59.1	1.5	0.5	2.6
0615	Põhja-Sakala	R	7073	84.4	69.2	76.5	63.3	1.8	0.7	2.4
0897	Viljandi	C	12279	83.6	69.4	79.1	67.0	2.5	1.8	4.9
0899	Viljandi	R	10395	85.4	66.4	75.6	63.3	2.0	0.5	2.1
Võru county										
0142	Antsla	R	3275	80.7	65.4	73.4	61.1	1.3	0.6	3.6
0698	Rõuge	R	4067	85.2	64.9	76.1	60.3	3.1	0.8	2.1
0732	Setomaa	R	2453	78.4	64.5	72.8	59.2	2.5	..	..
0919	Võru	C	8116	85.0	69.0	78.2	62.8	2.2	1.2	4.6
0917	Võru	R	8441	75.5	67.3	72.0	58.8	2.0	0.7	3.1