THE EFFECT OF GEOINFORMATION USAGE ON THE REGIONAL ECONOMIC DEVELOPMENT

by

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Abstract

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The state's borders are not just signs of the territorial integrity, but also serve as spatial limitation of the country's development. That is why most developed countries aim to ensure most efficient management of their resources throughout all the geography, not just in large metropolises. Due to limited space, the government attempts to encourage prosperity in less developed regions and ensure balanced development of living conditions for the inhabitants of any area. Proper regional planning includes, among others, economic ties mapping, analyzing multiregional data, modeling the regional imbalances, and therefore ensuring the policy initiatives' attachment to clear, transparent and renewable indicators. This research presents the estimation of the effect of geoinformation usage on the regional growth and explains the relations of social and economic parameters with the GRP per capita growth in a sample of 24 regions of Ukraine for the 2010-2019 period.

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This study was nourished by the fruitful KSE environment that surrounded its members with motivation, eager to ask questions and competitiveness to provide best suitable answers.

I express my deepest gratitude to Volodymyr Vakhitov for supervising the preparation of the thesis and sharing knowledge, experience and motivation.

I express gratitude to PMAP project for structuring territorial planning data and providing the overview of the integration of new plans in Ukrainian regions.

The joined work of Ministry of territorial and community development and Centre of economic recovery has provided Ukraine with clear framework of regional development. This work followed the strategical national views on how to approach the development of balanced economic and social conditions for each citizen regardless of his or her location.

LIST OF ABBREVIATIONS

GRP. Gross Regional Product.

NES. National Economic Strategy 2030.

SSRD. State Strategy for Regional Development 2027.

GIS. Geographical Information Systems.

SSSU. State Statistics Service of Ukraine.

RHDI. Regional Human Development Index.

PMAP. Open Spatial Planning Platform.

Minregion. Ministry of Territorial and Community Development

Chapter 1

INTRODUCTION

For the last couple of years, Ukraine changed into a decentralized state with more responsibilities passed to communities' self-management. That pulls the need for effective and continuous territorial management work in Kyiv and the whole state. The central government needs to play the fair distributor of state funds, supporting the nation's widely adopted strategy, while regions and territorial communities are to gather, analyze and report the local socio-economic data for further coordination both on the local and global levels. As the growth of the national economy is the result of the united growth of small communities in it, government should ensure the institutional capacity of any municipality and its integration into a national strategic framework.

To get a glance of the Ukrainian state of affairs compared to the international community it is useful to look at the Index of Regional Disparities**,** that is used to estimate the regional development imbalance in international practice of OECD. It is calculated by the ratio of the average GRP per capita, which accounts for 20% of the richest population and 20% of the poorest population, respectively. Due to poorly developed skills of identifying competitive growth points and their effective use, this ratio is 3.7 in Ukraine. That is almost twice as low in the neighboring countries: 1.9 in Slovenia, 2.3 in Lithuania, and 2.5 in Estonia (see Figure 1). Dnipropetrovsk, Poltava regions, and Kyiv city have the highest level of GRP per capita due to the density of production, research and innovation facilities registration and intense export activities. Kyiv, Kharkiv and Poltava regions produce high-valued services, while Dnipropetrovsk possesses export resources. GRP per capita in 10 regions of Ukraine is below the 75% of the average level of GRP in Ukraine, which indicates the need to introduce development incentives in these areas.

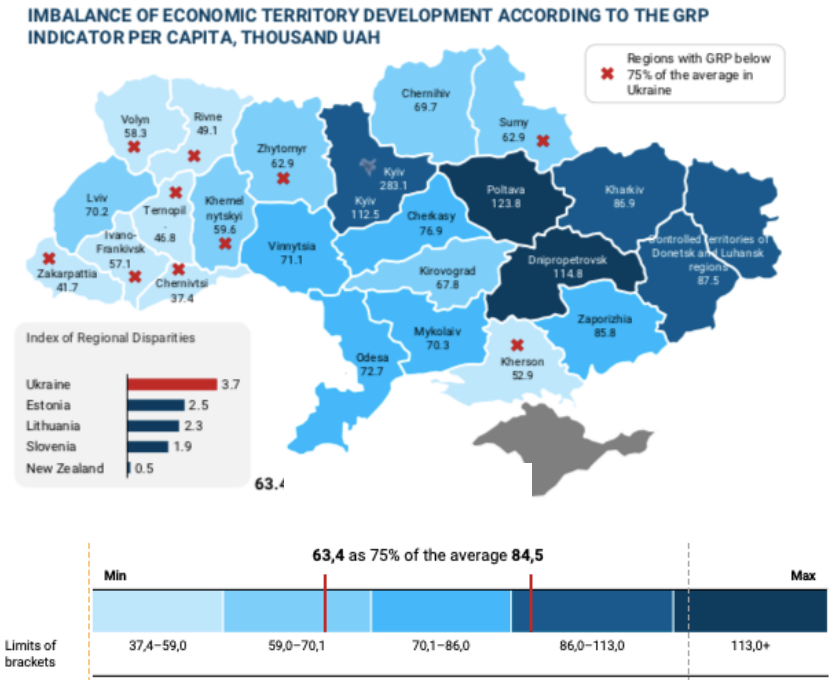

Figure 1. Imbalances of economic territory development in terms of GRP per capita.

Source: SSSU and author's calculations.

Considering the set of social development parameters, presented by the distribution of the RHDI level, other leaders are presented on Figure 2.

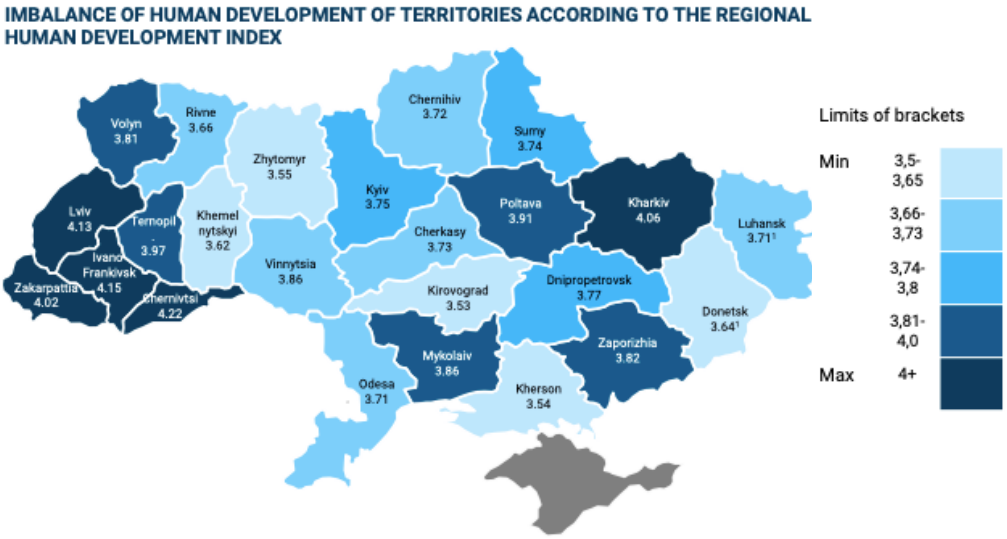

Figure 2. Imbalances of social development in terms of RHDI.

Source: SSSU and author's calculations.

Effective territorial governance is aimed at the increase of citizens' well-being within each territory unit. Meantime, people always choose to live in a comfortable environment with developing economic activity, while escaping locations where they cannot define and develop ones' potential. In order to assess the national socio-economic balance, it is useful to monitor the dynamics of regional migration flows. As a result of the distribution of economic activity and social welfare parameters presented above, population migrates accordingly (see Figure 3).

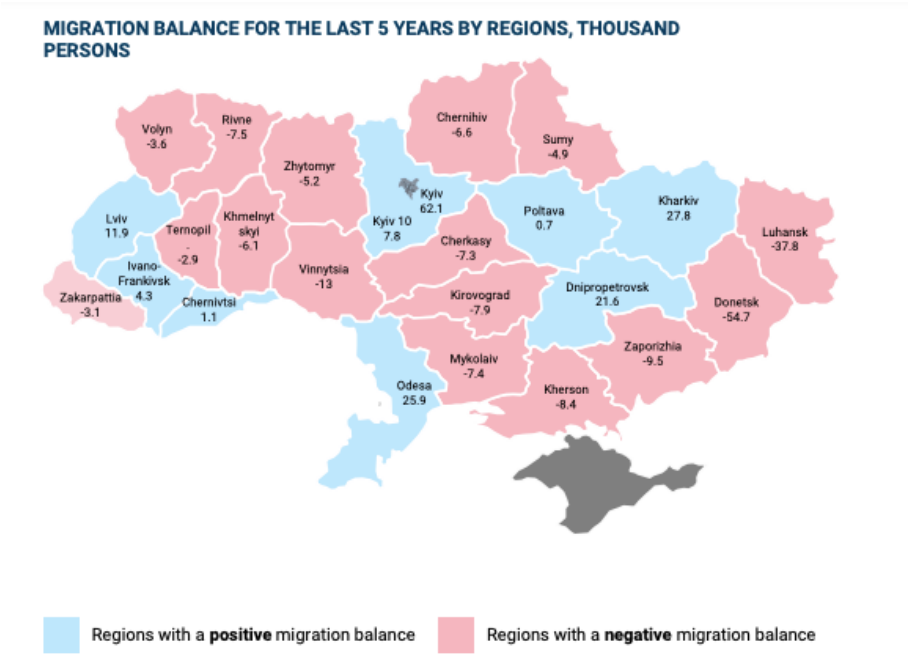

Figure 3. Regional migration flows.

Source: SSSU and author's calculations.

Most Ukrainian regions have experienced an outflow of workforce over the last 5 years, especially depopulating rural areas. This impedes their sustainable development, increases imbalances between regions, creates inequality in demand for resources, and agglomerates population in cities and regions with unsuitable for such a large population infrastructure. A positive 5-years dynamics is recorder in the regions with higher GRP per capita, as Kyiv, Odesa, Poltava, Lviv, Kharkiv and Dnipropetrovsk.

In order to overcome those challenges and to guarantee the balanced growth of all the territories and communities in Ukraine SSRD and NES propose to provide regional economic and human development by focusing on three main components: efficient regional development planning, efficient financing of

regional development and increase of the institutional capacity of local communities (see Figure 4). The research is focused on the last one and on the general approach of explaining the regional growth.

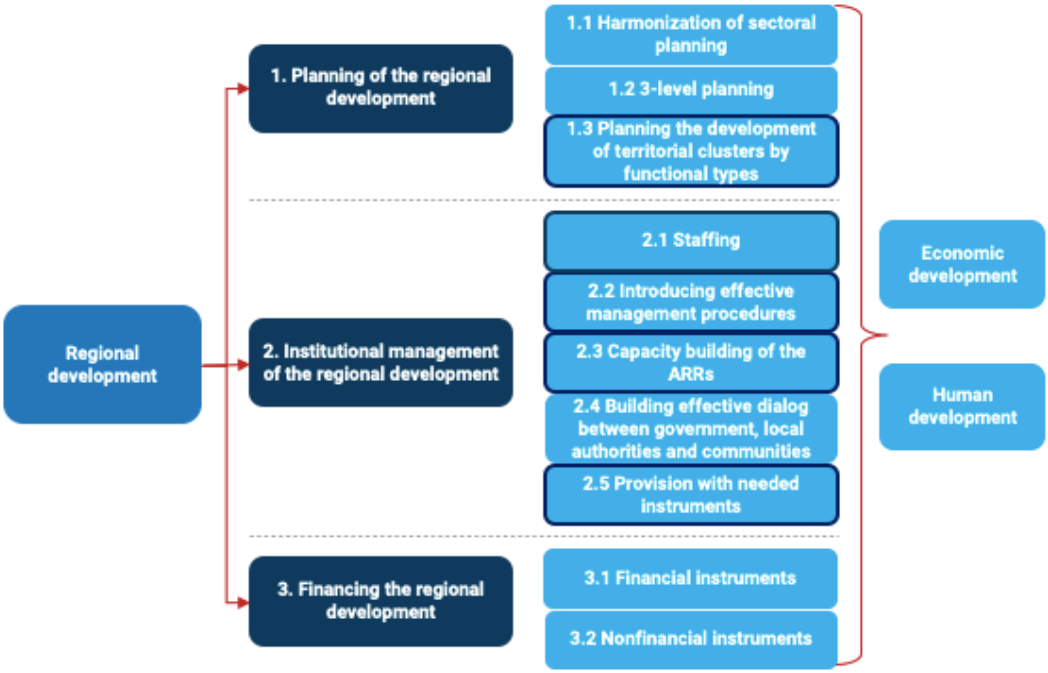

Figure 4. Regional development structure according to NES and SSRD.

Source: SSRD.

The institutional capacity can be explained by multiple variables and depends on various parameters. International Labor Organization (ILO 2013) together with most prominent policy makers around the world emphasizes that community's institutional capacity depends highly on data sufficiency, as the one is able to efficiently plan activities only in the known environment. With this said, we can state that it is crucial for communities to obtain, analyze and present all available data to the internal and external stakeholders to monitor infrastructure resilience, ecological sustainability, socio-economic paraments of living conditions and to attract investments.

The amount of accessible social-economic data is planned and gathered by SSSU, while communities are solely responsible ones to gather and analyze their geographical data. The newly passed law (Verhovna Rada 2020), discusses the environment of geographical information systems (GIS) in Ukraine and provides the legal infrastructure for its development, its legislature will be implemented in 2021. Some of the communities have already started to use GIS, but most geographical resources are still invisible or the information on them is outdated, as the majority of communities possess basic general plans of the territory dated 1917-1950 or do not have one at all.

The usage of GIS and monitoring of the geographical resources provides the base to ensure the institutional capacity of the community to attract the production factors and therefore provide resources for the economic growth. The research will try to explain the regional growth and answer the question: Is the integration of new general territory plans into community management associated with the regional economic growth?

Chapter 2

LITERATURE REVIEW

The issue of the balanced regional development troubles governments of the planet for the lifetime of the civilization from Greek metropolis up to modern continental economic unions. In 1975 Edwin von Böventer published Regional Growth Theory in Urban Studies, where he covered various theories of regional development, explaining the main principles of regional growth. The work of professor Böventer was followed in 2008 by his colleague from Glasgow university, Richard Harris, who systematized the works on regional growth models into his work: Models of Regional Growth: Past, Present, and Future.

In order to implement the research on regional development and understand the fundamentals of value generation in the regions, we need to be acquainted with classical growth models and the notion of β-convergence. Professor Harris discusses multiple models in his work. First, he presents a neoclassical growth model that shows the growth determinants from the supply-side by applying a homogenous Cobb-Douglas aggregate production function with a constant returns-to-scale. With new researchers diving into this model, they have added new estimation techniques to address an issue of not existing steady-state value, as not all the regions converge with the same pattern, following different equilibrium growth rates. Second, Harris presents Kaldorian models that operate under increasing returns, including virtuous circles between productivity growth and output, resulting in Verdoorn and other relationships. Further on, New Trade Theory (NTT) models focus on clusterization in order to face cost reduction on scale and transportation. Those models are based on regional exports of the goods that tend to have a big domestic market. The New Economic Geography (NEG) modelling approach is widening the NTT with geographical parameters and therefore, previously exogenous home market effect

becomes endogenous, because of the labor mobility and higher mobility of firms with the high level of intermediate demand. Based on those works, the density of economic activity is used in the model to explain the regional growth, unfortunately more complex analysis of the proposed interregional relations and special lags are not used in the research and should serve as the basis for following works.

After understanding basic concepts of regional growth models and assuming that the goal of regional policies is to effectively balance all the regions, we look at the empirical studies that analyze the convergence and various determinates of the regional development. An example of the regional imbalances' analysis, using U.S. county data (3,058 observations) and 41 conditioning variables to study growth and convergence (Higgins and Levy 2006) have proven the exciting patterns of convergence among states, showing that the speed of convergence decreases with the growth increase. The research provides arguments to use the differences of GRP in per capita terms instead of numerical values of the GRP.

As to determinants, multiple researches had different approaches to state what exactly increases or decreases regional growth. Among multiple variables used in the regression of regional and clustered Russian economy growth study (Timofeev 2014) the following showed significance: oil extraction, juridical bureaucracy, and inequality of own revenue in clustered regions. The regression of regional economic growth by quantile (Crespo-Cuaresma et al. 2011) has showed positive significance level of education and mobility factors. While regressing regional per capita income on cultural environment with quantity of theaters and libraries, their annual visitors by respective population, number of granted patents based on the residence of inventor, members of workforce, travel time between regions on train/plane and via roads (Fornahl et al. 2009), Human Capital has the most influence among Cultural Capital and Infrastructure Capital. By regressing the regional growth on Innovation, Investment, Population

growth, Infrastructure level, Lower secondary education coverage, Technological readiness and Business sophistication in two spatial regimes (core – central EU states and periphery – Western and Eastern states) (Annoni et al. 2016) it was found that location matters, as being surrounded by regions with higher growth positively effects own growth, and that human capital is the most significant factor, influencing regional growth in all the spatial regimes. Therefore, it is clear that human development variables are to be introduced in any regional growth modeling. Education as human capital provides the positive determination effect on growth in Italian regions (Di Liberto 2001). Having South of the country being less economically developed, the research provides a proof of contribution to growth with the elimination of illiteracy in 60s in the southern regions. The paper also discusses that different levels of education show different returns, and that Italy is still not at a sustainable economy development level to observe positive return from higher educational levels' development. That is why my work firstly includes RHDI as a more complex variable to include not only education but also other human capital variables and also the set of variables that RHDI consists of to show their individual effect.

Researching the sources of Economic Growth in EU and Poland (Błaz˙ejowski et al. 2019) the authors regressed the average growth rate of GDP 2002–2013 on Total investment (% of GDP)*;* Gross national savings (% of GDP); Military expenditure (% of GDP); Population; Rate of natural increase; Infant mortality rate; Area of countries; Population per square mile; Natural logarithm of GDP per capita in 2002; General government revenue (% of GDP); Current account balance (% of GDP); Gross fixed capital formation (% of GDP); General government final consumption expenditure. (% of GDP); Shares of agriculture, hunting, forestry, and fisheries (% of GDP); Unemployment rate; Homicide rate; Stock of immigrants (% of population); Years of schooling for females and males and expenditures on education in various spatial regimes. With the analysis of

NUTS 2 and 3 levels in EU they have once again proven that initially lower level of economic development provides higher dynamics of economic growth in future and have shown the highly significance of the Gross fixed capital formation and Gross national savings variable. By modeling the Ukrainian regional growth (Ryadno and Berkut 2017), using OLS regression of regional GDP on Capital investments per person; Volume of sold industrial products (goods, services) per capita; Financial results of enterprises before taxation; Retail turnover; Foreign direct investment (equity) per capita; Distribution of total costs by areas of innovation; Export coverage ratio of imports; Migratory increase (decrease) in population; Average monthly nominal wages of employees; The share of the population with per capita equivalent total income per month is below the subsistence level and Employment rate, the significance was shown in Migration dynamics and in Sold industrial products per capita. Therefore, I included capital investment per capita and the percentage of urban population into the data to explain the regional growth.

The Smart-City approach for community development (Neirotti and De Marco 2014) emphasizes the need of data sufficiency for smart technologies implementation in urban areas for it to serve as a tool to increase the level of life and what does influence this process. That supports the idea to regress the geographical data sufficiency on regional growth.

A threshold analysis and quantile regression of the African regional economic growth aligned with the growth of tourism receipts (Sahni et al. 2020) shows that policy designing for tourism development should consider waning of the marginal benefit of tourism on growth beyond certain levels, even though tourism receipts serve an important role in economic growth at any level. This research shows that even if thesis states the positive significance of the "new plans" variable, its effect should be further monitored with a threshold analysis.

The future works analyzing the impact geographical data sufficiency on regional growth should follow the robustness analysis by the Bayesian model averaging (BMA) on the class of quantile regression models (Crespo-Cuaresma et al. 2009).

The newly passed Law on the infrastructure development for geoinformation defines sets of data that are to be gathered and presented by all 3 level of governance, they all present numerous possibilities to reduce unnecessary costs, increase productivity, adaptability and resilience of the territorial management by formation of clearly readable analytical materials. Following activities can be implemented, using geoinformation discussed by Law 554-IX 2020 in community, territorial, sectoral and country management:

- Modeling engineering and public works;
- Mosquito spread inspection;
- Operational field tracking screen;
- Requests for public services;
- Tracking the cleanliness of the streets;
- Inspection of hatches and sewerage;
- Management and analysis of land information;
- Energy consumption;
- Situational awareness during mass events;
- Modeling and assessment of ecological condition;
- Influenza epidemics and coverage by networks of medical institutions;
- Number of drug distribution cases;
- Budgeting for public safety;
- Pest spread;
- Water catchment vulnerabilities;
- Monitoring of air pollution;

- Water quality and pollution and many more.

Overall, the literature findings suggest regressing the GRP in per capita terms, using human capital variables, economic density, volume of investments, urban population as regressors. Institutional capacity in terms of data sufficiency is proposed to be added to the mentioned list by my research. Also, the literature provides multiple instruments for future deeper analysis of my findings in this work.

Chapter 3

DATA AND METHODOLOGY

This chapter consists of two parts: 1) Description of data, and 2) Methodology used to examine the main hypotheses.

3.1 Data description

In this thesis I follow mentioned in the literature review approach on explaining the regional growth by regressing three categories of variables on the GRP per capita growth of 25 Ukrainian regions (24 oblasts and Kyiv City) for the period of 10 years (2010-2019). SSSU and PMAP project of the Minregion are the sources of the data.

GRP is hard to determine because of its complexity, however we can associate its growth with various parameters by analyzing historical panel data. I have constructed a dataset, consisted of 250 observations of the social-economic parameters of the regional growth with 5 groups of parameters, following the NES 2030 approach: 1) Dependent variable: 1.1) GRP per capita (RGDPcap); 1.2) Growth of GRP per capita (DifRGDPcap); 2) Economic activity parameters: 2.1) Enterprises density per 10000 of population (Enterdenst); 2.2) Capital investment per capita (CapInvst); 2.3) Growth of portion of building value added in GRP (Growthoftheportion); 2.4) Regional level of unemployment (Unemployment); 3) Parameters of institutional capacity: 3.1) Percentage of updated territorial plans in the region (NewPlans); 3.2) The weighted on the population number of staff working in R&D (Researchers); 4) Human development parameters: 4.1) Regional Human Development Index (RHDI); 4.2) Availability of doctors per 10000 of population (Doctors); 4.3) Number of crimes weighted on population (Childmort); 4.4) Availability of living conditions

in m2 per population (Livingconditions); 4.5) Child under 5 mortality rate per population (Childmort); 4.6) Percentage of kids covered by the primary education (Primaryedu); 5) Additional regional characteristics: 5.1) Percentage of urban population (Urbanpop).

The yearly data, provided by the SSSU in thousands of UAH, was adjusted per average yearly exchange rate of USD and per USD inflation during the period of 2010-2019 in order to provide a consistent base for the research. The same approach was used towards all variables in national currency.

To properly analyze the data I have used visual inspection, graphical illustrations of data distributions and description function in R (see Table 1).

Table 1. Data description of the research object and key variable.

Variable	Mean	Std. Error	Min	Max	Median
GRPpc growth,%	0.030	0.189	-0.614	0.400	0.054
GRPpc, mln.USD	2, 764.00	1, 812.29	493.498	13, 692.36	2, 327.49
NewPlans,%	8.928	17.993	0.00	91.800	4.100

As it is shows in the table, maximum value of the NewPlans variable is more than 10 times higher than the mean value. Because of Lviv and Zakarpatya regions observations the sd value is twice higher than the mean one. After cleaning the dataset, the mean value reached 4.998 and the standard deviation decreased to 4.728. I have discarded the observation for Lviv and Zakarpatya regions, as they have disproportionally introduced most of their updated territorial plans in 2011 and did not follow with this activity since, while others followed the same pattern

of the updating process in 2010, 2011 and 2014-2015 (see Figure 5). As to the object of the research, growth of GRP per capita as a more consistent variable is chosen to be the main regressor.

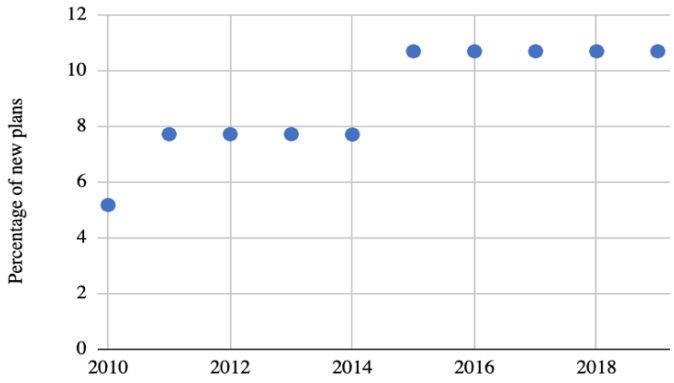

Figure 5. Average percentage of updated plans per each year.

Source: PMAP.

Further observation and analysis of the gathered data showed the presence of endogeneity in some of proposed by literature variables, so it was needed to discard CapInvst and RHDI. The amount of capital investment into the region correlates gravely with the GRP, additionally the process of GRP calculation includes the analysis of investment flows. As to RHDI, one of its components describes the economic development of people in the region, explained by average salary deviation and GRP per capita.

Table 2. Explanatory variables and expected signs.

Variable	Description	Expected effect
NewPlans	Percentage of updated plans	Positive significant
Researchers	Number of staff working in R&D per 10000 population	Positive significant
Urbanpop	Percentage of urban population	Positive significant
Primaryedu	Percentage of primary education coverage	Positive significant
Doctors	Availability of doctors per population	Positive significant
Crimes	Number of crimes per population	Negative significant
Livingconditions	Availability of living conditions m2 per population	Positive significant
Childmort	Children died under 5 per year per population	Negative significant
Macroregions	Dummy: 6 regions	Ambiguous
Enterdenst	Number of enterprises per 10000	Positive significant
Growthoftheportion	The increase of the building added value	Positive significant
Unemployment	Level of regional unemployment, %	Negative significant

There are several issues with RHDI calculation in Ukraine, one of them is that the architecture of components has been changed in 2017, reducing the number of 6 components' parameters from 33 to 8. Additionally, Chernivtsi and Zakarpatya regions, having one of the lowest GRP per capita and employment rates in the country, demonstrate the highest levels of RHDI, proving the inconsistency of this variable when explaining the well-being of the region. All

of the above-mentioned arguments support the idea to discard this variable from the model. However, understanding that the absence of human development parameters in the model does not follow neither economic logic nor literature, the separate multi-sectoral 6 components of the RHDI will be used instead of the index, those include security, health care, living conditions, education and mortality rate parameters.

Additionally, through inspection of GPD per capita growth, it was found out that years 2014-2016 demonstrate extreme decrease of the economic activities, as it is the time of the shock caused by war, so in order to smooth the dataset those years were discard from the model.

In order to weight for regional clusters and include special relations of economic activity, the dummy variable "Macroregions" was include, uniting 6 macro regions of Ukraine: Western, Carpathian, Central, Azov-Black Sea Coast, Central-Eastern, Northern.

After the data preparation process, the table of expected effects of the explanatory variables was formed (see Table 2).

3.2 Methodology

To estimate the effect of social-economic parameters on the regional growth firstly the fixed effect model will be used, following the formula:

$$\begin{aligned}(Y_{it}) = {} & B_0 + B_1X_{1,it} + B_2X_{2,it} + B_3X_{3,it} + \\ & B_4X_{4,it} + B_5X_{5,it} + B_6X_{6,it} + B_7X_{7,it} + B_8X_{8,it} + \\ & B_9X_{9,it} + B_{10}X_{10,it} + B_{11}X_{11,it} + u_{it},\end{aligned} \quad (1)$$

Where (Y_{it}) stands for of the growth of GRP per capita for a region i = 1,..., n, in a year t = 2010,…, 2019; i, B_0 stands for an intercept; $X_{1,it}$ stands for

"Macroregions"; $X_{2,it}$ stands for "NewPlans"; $X_{3,it}$ stands for "Urbanpop"; $X_{4,it}$ stands for "Primaryedu"; $X_{5,it}$ stands for "Doctors"; $X_{6,it}$ stands for "Crimes"; $X_{7,it}$ stands for "Livingconditions" ; $X_{8,it}$ stands for "Childmort"; $X_{9,it}$ stands for "Enterdenst"; $X_{10,it}$ stands for "Researchers" ; $X_{11,it}$ stands for "Growthoftheportion"; $X_{12,it}$ stands for "Unemployment" and u_{it} stands for the error.

Two regressions of Fixed and Random models are analyzed, using the R-studio, being followed with Durbin-Wu-Hausman test to define the most consistent one.

The endogeneity problem is expected and present in the key variable NewPlans, as the integration of new territorial plans is stimulating the economic activity, but the increase of economic activity itself stimulates the development of new plans and their updating process. To avoid endogeneity the 2SLS model is used, introducing the instrumental variable to the model, as a combination of three variables: 1) Difference in building sector value added portion of GRP to the model; 2) The density of population in urban areas; 3) Amount of staff working in R&D in the region per 10000 of population.

To construct the instrumental variable, I followed the economic logic of needed components to implement the initiative of geoinformation updating demand factor and technological availability. Demand is caused by building activity increase, as creation of the territorial plans has an immediate effect on the building possibilities in the region, moreover, the absence of the territorial plan in the community does not allow any building activity. Another demand factor is presented as the density of population in urban areas, as urbanization expands the geographical limits of the central communities, which provokes the need to reorganize the territory. The technological availability is presented by the quantity of professional staff that can implement the demand-caused initiative. The

validation of the instrumental usage is based on the first stage linear regression model's consistency and level of its explanation. The following formula is used:

$$(Y_{it}) = A_0 + A_1 X_{1,it} + A_2 X_{2,it} + A_3 X_{3,it} + u_{it} \qquad (2)$$

Where (Y_{it}) stands for "NewPlans"; A_0 stands for an intercept; $X_{1,it}$ stands for "Researchers"; $X_{2,it}$ stands for "Growthoftheportion"; $X_{3,it}$ stands for "Urbanpop" and u_{it} stands for the error.

The valid level of explanation, presented by R^2 at minimum value of 0.25, serves as an argument to use the set of instrumental variables in the second stage of 2SLS model, using following formula:

$$\begin{aligned}(Y_{it}) = {} & K_0 + K_1 X_{1,it} + K_2 X_{2,it} + K_3 X_{3,it} + K_4 X_{4,it} + K_5 X_{5,it} + \\ & K_6 X_{6,it} + K X_{7,it} + K_8 X_{8,it} + u_{it1} \,|. \sim K_2 X_{2,it} + A_1 X_{9,it} + \\ & A_2 X_{10,it} + A_3 X_{11,it} + u_{it2}\end{aligned} \qquad (3)$$

Where (Y_{it}) stands for of the growth of GRP per capita for a region i = 1,..., n, in a year t = 2010,…, 2019; i, K_0 stands for an intercept; $X_{1,it}$ stands for "Macroregions"; $X_{2,it}$ stands for "NewPlans"; $X_{3,it}$ stands for "Primaryedu"; $X_{4,it}$ stands for "Doctors"; $X_{5,it}$ stands for "Crimes"; $X_{6,it}$ stands for "Living conditions" ; $X_{7,it}$ stands for "Childmort"; $X_{8,it}$ stands for "Enterdenst"; $X_{9,it}$ stands for "Researches"; $X_{10,it}$ stands for "Growthoftheportion"; $X_{11,it}$ stands for "Urbanpop"; u_{it1} stands for the error and u_{it2} stands for the error of first stage model.

The results of Fixed Effect and 2SLS are presented in the next Chapters and serve as fundament for further interpretation, hypothesis validation and policy recommendations.

Chapter 4

ESTIMATION RESULTS

This chapter discusses the results of the estimations of the effect of social-economic and institutional parameters on the regional growth.

The first run regression is an analysis of the effect of all the explanatory variables on the GRP per capita growth using the Fixed effect model. The results are presented in the Table 3.

After running the regression using Random effect model and comparing its consistency with the Fixed effect one, using test it I should interpret a Fixed effect model. The results of the test are presented in Table 4.

As seen from Table 3, the proposed variables explain the growth of GRP per capita with R-squared = 0,4, that indicates that there is a relation between them.

The entrepreneurship density is significant as expected, however there was an assumption that it should have a positive effect on the GRP per capita growth. The findings suggest looking at the density of enterprises not from the perspective of quantity, but to consider productivity of their activity. Following that logic, the richer regions in terms of GRP per capita tend to increase the productivity of enterprises, merge them, form more complex institutions, rather than have a disperse small business activity as the regions with lower value added per capita.

Table 3. Estimation results of Fixed effect model (dependent variable: GRP per capita growth)

Variable	Estimate	Std. Error	Pr(>|t|) and Wald test
Entrepreneurship density	-0.003	0.00103	0.001988 **
NewPlans	0.00472	0.00518	0.363820
Urban population	-0.0169	0.02153	0.432359
Primary education coverage	-0.0064	0.00318	0.044663 *
Child mortality	0.0034	0.00623	0.584085
Unemployment	0.0300	0.00892	0.001079 **
Researchers	0.00056	0.00037	0.136004
Living conditions	0.00298	0.01330	0.822680
Crimes	0.0016	0.00051	0.002168 **
Doctors	0.0114	0.00571	0.049108 *
Observations		132	
R-Squared		0.4088	

Source: author's calculations.

Note: "-" $p < 1$, "*" $p < 0.05$, "**" $p < 0.01$, "***" $p < 0.001$.

The significance of the effect of primary education coverage on the regional economic growth is aligned with expectations, however the negative sign of the relationship rejects the hypothesis that richer regions tend to have better developed educational infrastructure. Thus, it shows that economic environment

with faster growth suffers overconcentration of population, especially young families, and it is more challenging to develop public service providing networks. Literature suggests that a pivot point from the fast growth into a balanced one happens when people have fulfilled undervalued potential of the territory and society through effective resource management. That period allows less wealthy economies to catch up by growing faster, following the idea of convergence.

Table 4. The Durbin-Wu-Hausman test results.

Comparison of the fixed and random effect specification	
Chi-square distribution	43.343
Degrees of freedom	10
P-value	4.318e-06
Alternative hypothesis	One model is inconsistent

Source: author's calculations.

In the meantime, the effect of the availability of doctors per population is significant and positive. Those results completely follow the assumption, however, due to the endogeneity issue, it is not correct to interpret the estimates, as the increase of the presence of medical personnel represents an increase of high value-added segment of the economy. Even though the variable is highly associated with regional growth, indicating that richer regions tend to have better developed medical environments and thus living conditions, the variable is not used on the following steps of the research.

The estimate of the effect of the number of crimes per population on regional growth is positive and significant, indicating that more crimes happen in the faster developing economy.

Number of children under 5 dying per year, percentage of urban population, number of staff working in R&D and the availability of living conditions per person are insignificant variables under this specification of the model.

Level of regional unemployment has a positive significant estimate that can be explained by some misspecification of the model or by the Philips curve relation, assuming the high level of correlation between inflation and growth.

The sign of the key variable is positive, that supports the hypothesis of positive relation of the introduction of new territory plans and the regional growth. However, there is still a need for improvement of the model due to endogeneity of this variable.

Table 5. Estimation results of first stage of 2SLS model (dv: NewPlans).

Variable	Estimate	Std. Error	Pr(>|t|) and Wald test
Urban population	1.3379202	0.3372102	0.0001316 ***
Researchers	0.0092929	0.0064363	0.1517106
Growthoftheportion	1.9143365	0.8610597	0.0283023 *
Observations		132	
R-Squared		0.26588	

Source: author's calculations.

Note: "-" $p < 1$, "*" $p < 0.05$, "**" $p < 0.01$, "***" $p < 0.001$.

To analyze the more proper effect of the introduction of new territory plans on regional growth through 2SLS model, the first stage regression was of the depended variable NewPlans was run. The results are presented in Table 5.

Analyzing the findings, presented in Table 5, it is possible to use that set of variables as the instrumental variable for "NewPlans" to avoid the existing endogeneity. Almost all the variables show significance except the quantity of staff working in R&D per 100 000 people. Still, this variable does explain the geoinformation usage from the point of view of resources needed for its implementation. The results of the next step of introducing the instrumental variable into the 2SLS model are presented in Table 6.

Table 6. Estimation results of the second stage of 2SLS model (dv:DifRGDPcap).

Variable	Estimate	Std. Error	Pr(>|t|) and Wald test
Entrepreneurship density	-0.00260257	0.00110382	0.018384 *
NewPlans	0.01717334	0.01833250	0.405545
Primary education coverage	-0.00541673	0.00356693	0.128864 .
Child mortality	0.02167406	0.00925658	0.019208 *
Living conditions	0.01518012	0.01114510	0.173184
Crime density	0.00214400	0.00063509	0.0007357 ***
Unemployment	0.03029571	0.01134474	0.007575 **
Observations		132	
R-Squared		0.29921	

Source: author's calculations.

Note: "-" $p < 1$, "*" $p < 0.05$, "**" $p < 0.01$, "***" $p < 0.001$.

After running of multiple combination of regressions there is a finding that NewPlans variable becomes significant with the estimation effect equals 0.029739***** only under the specifications that have R-Squared value not more than 0.12128, that makes the findings statistically insignificant.

Table 7. Comparison of the estimation results of different models (dv: DifRGDPcap).

Variable	Fixed effect	2SLS
Entrepreneurship density	-0.003 **	-0.00260257 *
NewPlans	0.00472	0.01717334
Primary education coverage	-0.0064 *	-0.00541673 .
Child mortality	0.0034	0.02167406 *
Living conditions	0.00298	0.01518012
Crime density	0.0016 **	0.00214400 ***
Living conditions	0.0114 *	-
Researchers	0.00056	IV
Unemployment	0.0300 **	0.03029571 **
Urban population	-0.0169	IV
Observations	132	
R-Squared	0.4088	0.29921

Source: author's calculations.

Note: "-" $p < 1$, "*" $p < 0.05$, "**" $p < 0.01$, "***" $p < 0.001$.

Nevertheless, under all the analyzed specifications key variable "NewPlans" has a positive sign, describing the positive relations of geoinformation usage on the regional growth. It indicates that regions with faster growth have higher institutional capacity in terms of data and planning instruments sufficiency. The consistency of the estimation results of the effect of other social-economic variables on the GRP per capita growth can be analyzed through comparing the outcomes of different models with different specifications presented in Table 7.

According to the Table 7, we can observe that estimate of entrepreneurship density effect on the regional growth is consistent in its sign, significance and value. That allows to state that holding everything else constant, at the present level of entrepreneurship productivity level in Ukraine, the 1% of decrease of entrepreneurship density is associated with 0,003% increase of GRP per capita.

Estimate of the effect of primary education is also consistent in its sign, significance and value, supporting the mentioned above interpretation. Number of children dying per year per population has a stable positive sign, that is most probably associated with the higher birth rate in the region. The estimate of availability of living conditions is insignificant, but its stable positivity reflects the finding that fast growing regions tend to have higher squared meter sufficiency.

Number of crimes per population is consistent in its sign, significance and value, indicating that fast economic growth is not followed by higher security guarantees, at contrary the overconcentration of human activity in the environment of poor resources provokes more crimes.

Unemployment is very consistent in its sign, significance and value that indicates a need for further research to estimate the regional unemployment to inflation ratio and define where are Ukrainian regions placed on the Philips curve.

Chapter 5

CONCLUSIONS AND POLICY RECOMENDATIONS

This study presents analysis of the effect of geoinformation usage on the regional economic growth and describes the relationship between some regional socio-economic parameters and the growth of Regional Gross Product per capita in 25 Ukrainian regions during the period of 2010-2019.

The goal of the study was to analyze social, economic and institutional parameters of the regional development and define whether the initiatives proposed by national strategical documents are associated with regional growth. Latest question occurs under most nourishing environment for regional development in last decades. Ukraine is establishing a new, optimal and effective system to manage existing resources throughout 26 regional economies. This process has started with the Decentralization reform, with passing down the responsibilities form centralized Kyiv to territorial communities, their regional, functional and resourceful clusters, and reached now the stage of the focus of national policy, represented by National Economic Strategy 2030 and State Strategy for Regional Development 2027.

Strategic documents view the regional development through increase of the quality of regional policy planning, increase of the institutional capacity of territorial management system of all levels, and design of an effective framework of the financing of regional development.

The study presents relevant literature on the regional growth modeling, assessment of the effect of institution development, and the description of geoinformation usage.

In order to answer research questions, the model was constructed explaining the regional growth with a set of variables describing social development, economic development and institutional capacity of the territorial managers. Institutional

capacity variables were presented by Newplans (percentage of the communities that have an updated territorial plan), Researchers (quantity of R&D staff in the region per population) and Urbanpop (density of population).

Geographical data sufficiency in terms of the introduction of the updated territorial plans is indeed positively associated with the economic growth of the region. The findings do not provide proof of significance due to the complexity of a dependent variable, however the there is a noticeable connection between them under various model specification.

The analysis of the effect of other social-economic parameters on the regional growth has stressed the importance to introduce geoinformation analysis into the monitoring of following aspect of the regional development by Minregion and sectoral governmental bodies:

- monitoring of the entrepreneurship productivity level distribution should serve as a tool to plan location of the regional business support centers by the Ministry of Economics and Ministry of Digital Transformation;
- monitoring of the primary education coverage via geoinformational instruments aligned with demographic development allows to effectively plan educational infrastructure;
- analysis of the availability of doctors via regions and regional clusters with higher child mortality allows to properly plan the need of professional migration of doctors and planning of the needed infrastructure;
- understanding the presence of higher crime rates in more economically active region stresses the fact that public security measures are lagging behind economic stimuluses;
- the assessment of those paraments and their geoinformational visualization should serve as a tool for State Fund of Regional

Development to focus on priority project for each region and functional type of the territory.

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