The Ontology of the Region

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Abstract

In the paper, the conceptual apparatus (the ontology OntoReg) is presented for designing the Knowledge Based System (KBS). An original methodology of designing an applied ontology has been developed on the basis of the concept of Roman Ingarden's individual object as well as the concept of Rudolf Carnap's constructional systems (Aufbau). According to the procedure of creating an applied ontology, the original ontology of the region (OntoReg) has been developed, with particular emphasis on the characteristics of the region with the distinction of properties at three levels of the constructional system. At the first level, absolutely own properties, acquired properties and externally conditioned properties are distinguished. At the second level, positive states of objects (potentials of the region: geographical potential, social potential, innovative potential, institutional potential) and negative states of objects (risk of implementing the regional development strategy: project implementation risk, environmental risk, institutional risk, public health and safety risk) are defined. At the third level, the indicators of the respective types of potential and risk are considered. The relative characteristics of the comparative assessment between the indicator values for a given potential/risk and a reference value established in scientific research are determined. Determining the relative properties constitutes new knowledge generated due to the ontology constructed.

Keywords: the ontology of the region (OntoReg), methodology of designing an applied ontology, Carnap's constructional systems (Aufbau), Ingarden's individual object theory

Introduction

In the paper, the problem of describing a region in terms of regional development policy is analyzed. This policy is carried out by national and international administrative bodies as well as governmental and municipal agencies. In Poland, regional policy is pursued by the Ministry of Funds and Regional Policy,[1] which implements the strategy for responsible development (SRD).[2] The strategy is a key document of the Polish state in the area of medium and long-term economic policy until 2030. The SRD strategy is related to the strategy of the European Union, which adopted the Cohesion Policy[3] with a budget of EUR 392 billion[4] for 2021–2027. The European Regional Development Fund was established under this fund. According to the 1996 Declaration of the Assembly of European Regions on regionalism in Europe, a region is a territorial body of public law, established directly below the national level and endowed with political self-government.[5]

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1. See: https://www.gov.pl/web/fundusze-regiony (accessed 2022-03-09).
2. See: "Informacje o Strategii na rzecz Odpowiedzialnego Rozwoju." https://www.gov.pl/web/fundusze-regiony /informacje-o-strategii-na-rzecz-odpowiedzialnego-rozwoju (accessed 2022-03-09).
3. See: The European Regional Development Fund (ERDF). https://ec.europa.eu/regional_policy/pl/funding /erdf (accessed 2022-03-10).
4. As in American usage, a thousand million.
5. See: the "Declaration on Regionalism" adopted by the Assembly of European Regions in 1996. https://www .europeansources.info/record/declaration-on-regionalism-in-europe/.

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In the literature on the theory of regional development (Dawkins 2003), a number of different definitions of a region are presented. Nijkamp (2016) provided the following definitions of regions, introducing the new concept of "resourceful regions":

- regions as a work platform
- regions as spearheads of polarization and agglomeration
- industrial districts
- growth poles and growth centers
- industrial complexes
- industrial clusters
- proximity centers
- the concept of „resourceful regions"

The author of this paper defines the region as follows: a region is a part of a geographical territory with cultural and technical infrastructure and inhabitants which is included in an administrative unit of a state, marked in the national and international statistical classification. This unit carries out projects under national and international programs and funds in accordance with the adopted regional development strategy. The strategy has set goals and planned values of the established indicators. Each of the projects has established project goals and planned values of the project indicators. The administrative unit determines the policy monitoring system. As a result of scientific research, the region has a unique characteristic, which is a set of properties and their attributes as well as designated indicators and their values. The characteristics of the region include institutions defined in terms of institutional economy (Staniek 2017).

The terminology of the above definition is included in the taxonomy presented in figure 1. This taxonomy is generated in the Protege editor of OWL (Ontology Web Language). A region considered from a material point of view is a geographic territory with fixed boundaries together with natural, housing, financial, and human resources as well as infrastructure. The infrastructure consists of technical and cultural infrastructure. The taxonomy of the region's material resources is presented in figure 2.

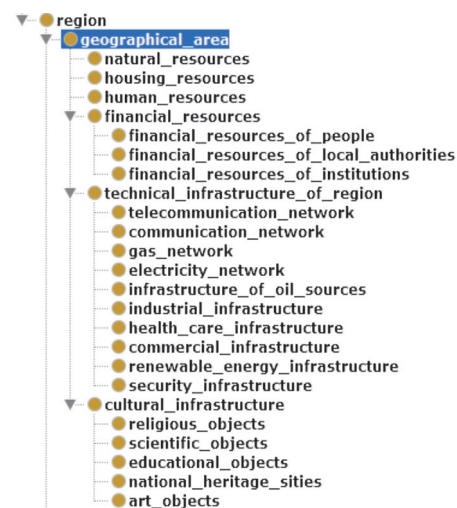**Figure 1.** A class diagram of the ontology of the region (part 1)

Figure 2. A class diagram of the ontology of the region (part 2)

1 The characteristics of the region in scientific research

In this section, the characteristics of the region in scientific research will be presented, the results of which were presented in the papers published in *Barometr Regionalny*. The characteristics of

the region consist of a feature which is a certain distinguished property of a region from the point of view (aspect) of a specific explanatory theory. This feature is quantified through an appropriately defined indicator according to statistical methods. An indicator is an integrated measure of a set of variables (attributes) that significantly distinguish a given feature. The values of the indicators are a ranking number that relates directly to the highest or lowest value in the adopted ranking scale (this number may be expressed as a percentage) or the position number in the ranking. Below, we present the characteristics of two regions (Lubelskie Voivodship and Podkarpackie Voivodship) in the following order: property — list of attributes (variables) — values of ranking numbers (positions in the ranking), reference value (maximum or minimum value in the ranking).

- property: the standard of living is a multidimensional phenomenon, determined not only by the value of material resources and their consumption but also by the level of health, the quality of the natural environment and the level of education and safety (Kowerski and Bielak 2019)
  - attributes (variables):
    - consumption of gas in households per year per capita (m^3)
    - doctors authorized per 10,000 population
    - suicides per 10,000 population
    - passenger cars per 1,000 population
    - life expectancy of males (years)
  - a value of the indicator — position in the ranking from 1 (max) to 16 (min):
    - Lubelskie: 10 (in the year 2016)
    - Podkarpackie: 8 (2016)
- property: agricultural potential (Foryś and Cymerman 2018)
  - attributes (variables):
    - geodesic areas
    - agricultural land
    - demographic variables
    - population income
    - agricultural production
    - ecology
    - infrastructure
  - a value of the indicator — SDM (synthetic development measures, a number from the interval [0, 1], where 0 — the highest development potential, and 1 — the lowest development potential):
    - Lubelskie: 0.479 (2015)
    - Podkarpackie: 0.447 (2015)
      (the ranking leader — Łódzkie: 0.376)
- property: region innovation potential (Bernat and Jasek 2018)
  the aggregated indicator: Millennium Index
  - attributes (variables):
    - labor productivity
    - value added rate
    - R&D expenditures
    - higher education
    - employed in R&D
    - number of patents
  - a value of the indicator — a number from the interval [0, 100]:
    - Lubelskie: 60 (2018)
    - Podkarpackie: 55 (2018)
      (the ranking leader — Mazowieckie: 9)
- property: quality of life (Bielak and Kowerski 2018)
  - attributes (variables):
    - average monthly disposable income per capita
    - expressways and highways per 10,000 km^2 (km)

     ◦ consumption of gas in households per year per capita (m^3)
     ◦ doctors authorized per 10,000 population
     ◦ gross domestic product per capita, Poland = 100
     ◦ suicides per 10,000 population
     ◦ unemployment rate—on the LFS basis (%)
     ◦ infant deaths per 1,000 live births
     ◦ life expectancy of females (years)
     ◦ life expectancy of males (years)
   – a value of the indicator—a number from the interval [0, 1]:
     ◦ Lubelskie: 0.482 (2016)
     ◦ Podkarpackie: 0.505 (2016)
     (the ranking leader—Mazowieckie: 0.761)

- property: economic development (Majka and Jankowska 2017)
  indictor: synthetic indicator of economic development of Polish voivodships
  - attributes (variables)
    - GDP per capita (PLN)
    - share of gross added value generated in the agriculture section of the Polish Registry of Business (PKD) of 2007 in the overall gross value added (%)
    - share of gross added value generated in the industry and civil construction sections of the Polish Registry of Business (PKD) of 2007 in the overall gross value added (%)
    - share of gross added value generated in the services section of the Polish Registry of Business (PKD) of 2007 in the overall gross value added (%)
    - generation of electrical energy per capita (MWh)
    - highways and expressways per 100 km^2 (km)
    - wheat yields (dt/ha)[6]
    - percentage of population in retirement age
    - percentage of innovative enterprises in the service sector
    - percentage of employed persons in the agriculture sector
    - percentage of people employed in the service sector
    - percentage of registered unemployment (%)
    - share of monthly expenditures on food and non-alcoholic beverages in overall expenditures per capita (%)
    - infant mortality per 1,000 live births
    - number of medical doctors per 10,000 residents
    - number of hospital beds per 10,000 residents
    - number of students per 10,000 residents
  - the value z_i of economic development indicator is a number from the interval [0, 1]:
    - Lubelskie: 0.163 (2014)
    - Podkarpackie: 0.091 (2014)
    (the ranking leader—Mazowieckie: 0.509)
- property: innovation and entrepreneurship of the region (Klosa and Widera 2017)
  - attributes (variables):
    - percentage of people aged 30-34 with higher education (%)
    - share of public expenditure on R&D in GDP (%)
    - share of enterprises' expenditure on R&D in GDP (%) (only for SMEs)
    - SME expenditure on innovation other than R&D (% of turnover on innovation)
    - share of SMEs introducing innovations in the total number of SMEs (%)
    - share of SMEs cooperating in the field of innovation in the total number of SMEs (%)
    - number of patent applications to PCT per 1 million inhabitants
  - a value of the indicator—measure of Hellwig's development pattern, a number from the interval [0, 1]:

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   6. [dt—decitonne = 100 kg—Ed.]

⬦ Lubelskie: 0.318 (2014)
⬦ Podkarpackie: 0.346 (2014)
(the ranking leader — Dolnośląskie: 0.384)
• property: regional development level (Klóska et al. 2020).
  – attributes (variables):
  Social Dimension
  ⬦ infant deaths per 1,000 live births
  ⬦ relative at-risk-of-poverty rate (%)
  ⬦ number of university students per 10,000 inhabitants
  ⬦ registered unemployment rate (%)
  ⬦ fatalities in road accidents per 100,000 inhabitants
  ⬦ water consumption for the purposes of national economy and total population per 10,000 inhabitants (hm^3)[7]
  Economic Dimension
  ⬦ GDP per capita (PLN, current prices)
  ⬦ share of business entities outlays in total outlays on R&D activity (%)
  ⬦ number of newly registered entities of the national economy in the private sector per 10,000 inhabitants
  ⬦ porkers per 1,000 people
  ⬦ total capital expenditure per capita (PLN, current prices)
  Environmental Dimension
  ⬦ percentage of population using wastewater treatment plants (%)
  ⬦ level of forestation (%)
  ⬦ recycling of packaging waste (%)
  ⬦ share of devastated and degraded land requiring rehabilitation in total area (%)
  ⬦ share of recovered waste (excluding municipal waste) in the amount of waste produced
  ⬦ during the year (%)
  ⬦ share of electricity production from renewable sources in total electricity production (%)
  ⬦ electricity consumption per 1 million PLN of GDP (GWh)
  – the integrated indicator — SDM (synthetic development measure):
  ⬦ Podkarpackie: 48 (2018), ranking position: 6
  ⬦ Lubelskie: 32 (2018), ranking position: 15
  (the ranking leader — Mazowieckie: 61, ranking position: 1)

2 The methodology of designing an applied ontology

The ontologies are used to represent knowledge in KBS (Knowledge Based System) systems. In paper (Garbacz and Trypuz 2012), the systematization of applied ontologies is presented. There is a problem of constructing a conceptual apparatus that can synthetically represent such a complex system as a region. An appropriately defined ontology of the region (in the OWL — Ontology Web Language) will be an essential part of the KBS system, the purpose of which will be to generate a synthetic measure of assessment of the region's potential and risk of economic activity. This new knowledge may be the basis for recommending investment locations, as well as introducing changes to the regional development policy.

In philosophy, the problem of representing the world (real, unreal, possible, impossible) is included in the theory of object (Stróżewski 2006). The concept of an object is the designation of anything that can become an act of representation or designation of everything that can be judged.

In his work *The Logical Structure of the World*, Rudolf Carnap (1967) presented a method of creating a constructional system of objects. This constructional system (Aufbau)[8] consists in building a chain of definitions of concepts. The constructional system is a system that includes all

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7. [hm — hectometer = 100 meters — Ed.]
8. [Original title of Carnap's work, published in 1928, was: *Der Logische Aufbau der Welt* — Ed.]

concepts (or objects) of science not as a system of divisions but as a system of deductions (family tree). Each concept is constituted of the previous concepts of the system. Objects of each tier are constituted by objects of the lower tiers. Concept construction is a general rule for transforming propositions for any concept.

Carnap distinguishes the following objects: physical, mental and cultural. For each object of study, it is possible to provide a description within its domain, which is determined solely by giving the structure. An object description is an unambiguous characteristic according to which the alleged object can be unequivocally recognized. The structure contains a description of the relations between objects. The following types of relations are distinguished: psychophysical relation, expression, manifestation, and documentation. A characteristic feature of Carnap's method is the assumption regarding the definition of basic objects. The basic object is one from which all the others are constituted. The collection of basic objects (notions) creates the conceptual base of a given constructional system. The diagrams in the Protege editor presented in figure 1 and figure 2 constitute the basis for the concept: the region.

In order to define the base of concepts (objects), it is convenient to use certain patterns. A number of such patterns have been developed in philosophy. One of them is the pattern (form) of an individual object presented by the Polish philosopher Roman Ingarden (Ingarden 1987). This pattern is formed by the following concepts:

- individual object — the individual object has matter, form and mode of being; from the material point of view, the object is determined by its constitutive nature; from a formal point of view, the object represents the subject; from an existential point of view, there is a mode of being for the object
- subject — the subject is a certain aspect (point of view) to which specific features (properties) are assigned
- property — a notion determining an object
- types of properties — relative features, externally conditioned properties, acquired properties, absolutely own properties of an individual object
- relative feature — a notion determining an object due to its relationship to another object
- externally conditioned property — a notion determining an object due to the impact of other objects
- acquired property — a property determining an object treated with a factor whose effect has ceased
- absolutely own property — a property of an object which is not caused by external factors
- material equipment of property — the resources that a given property determines or from which it emerges
- constitutive nature of individual object — matter (content) that defines the object as a whole
- state of object — a judgment about an object; it is the result of the assignment of a property to an object
- types of states of object — a positive state of an object and a negative state of an object; positive state of object includes judgments about what an object is; negative state of object includes judgments about what an object is not
- relation — multi-item state of object; it is the assignment of a property to a relationship between two or more objects
- types of mode of being of an object:
  - self-contained — it is completely immanently defined
  - non-self-contained — it is not self-contained
  - primary — it has its reason for being
  - derivative — it can only exist if it is produced by another object
  - self-sufficient — it is capable of being a separate unity
  - independent — it is independent and it does not have to coexist with anything else that is independent
  - dependent — it is self-sufficient and not independent
  - not self-sufficient — it is not self-sufficient

Using the theories presented above, we present an original methodology for designing applied ontology.

Step 1. Adoption of the assumptions of the constructional system

1.1. Determining the domain of the object. It is a field of science or a field of knowledge or their separate scope

1.2. Defining the constitutive nature of the object by defining the unique material basis (content) of the object

1.3. Determining the mode of being of an object in terms of independence, dependence, derivation, and self-existence

Step 2. Adoption of the conceptual bases of the 1st level

2.1. Determining the subject (aspect) according to which the features (properties) will be defined; this aspect can be a specific explanatory theory that is formulated to explain specific phenomena of a given domain

2.2. Setting features (properties):
– absolutely own properties of the object
– acquired properties
– externally conditioned properties

Step 3. Adoption of the conceptual bases of the 2nd level

3.1. Establishing the positive states of the object; assigning relative properties for which quantitative indicators will be given to the analyzed object; the positive states of the object are the relative properties assigned to it according to a fixed aspect (explanatory theory) and referring to explaining what an object is (analysis of advantages and potential)

3.2. Establishing the negative states of the object; the negative states of the object are the relative properties assigned to it according to a fixed aspect (explanatory theory) and referring to explaining what an object is not (analysis of defects and risk)

Step 4. Adoption of the conceptual bases of the 3rd level—determining the quantitative indicators for individual states of the object

Step 5. The level of scientific research that will result in establishing the relation between the analyzed object and the reference system; the aim of the research is to establish numerical values for the indicators of the states of the object; the reference values of indicators are determined, which may be maximum values, average values, or minimum values in the studied group of objects

Step 6. Determining assessments of the relation between the analyzed object and the reference system; this relation is the new knowledge established in the designed constructional system; these assessments are relative properties (features); they are regarded as comparative assessments of the value of indicator A for a given object against the reference value B of this indicator; we adopt the 9-point scale of the Analytic Hierarchy Process (AHP) method (Saaty 2001):

9—total (extreme) advantage of A
7—very large advantage of A
5—large advantage of A
3—small advantage of A
1—comparable values
1/3—small advantage of B
1/5—large advantage of B
1/7—very large advantage of B
1/9—total (extreme)advantage of B
2, 4, 6, 8—intermediate values for compromising comparisons between 1, 3, 5, 7, 9

The diagram of the classes of the constructional system (Aufbau) for the concept: the object for which the structure is adopted according to Roman Ingarden's formal ontology is shown in figure 3.
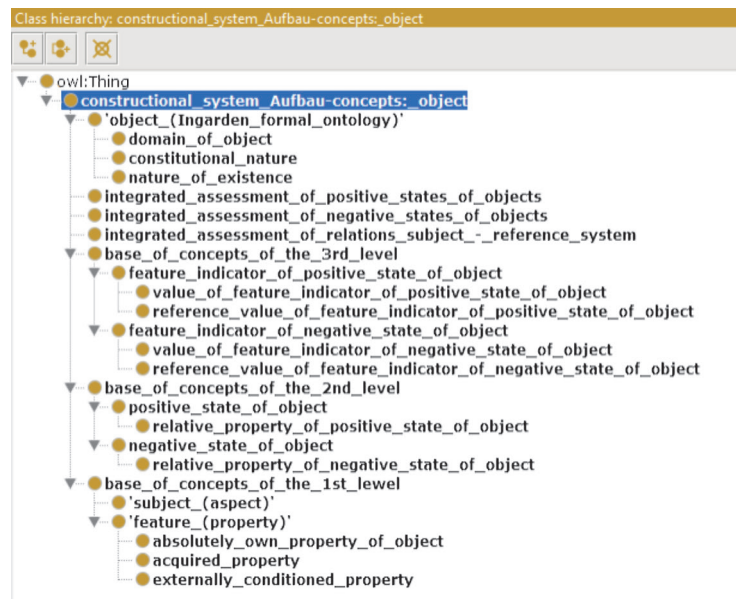
Figure 3. The diagram of the classes of the constructional system (Aufbau) for the concept: object in the Protege editor

3 The ontology of the region

In this section, we present the original ontology of the OntoReg region according to the methodology discussed in the previous section, which is based on Carnap's and Ingarden's ontological conceptions. The region is represented by the characteristic of the region which is defined by the following concepts:

- regional development (domain) — an interdisciplinary field that uses methodologies developed in such disciplines of social sciences as economics and finance, socio-economic geography and spatial management, security sciences, social communication and media sciences, politics and administration sciences, management and quality sciences, legal sciences, sociological sciences, pedagogy, and psychology
- regional development strategy (constitutive nature) — the basic artifact (strategic document) developed by the Ministry of Development Funds and Regional Policy and approved by the government of the Republic of Poland, used to implement its regional policy; currently, it is the "National Strategy for Regional Development 2030"[9]
- establishing the region (mode of being) — a set of general features referring to the legal acts creating the organizational and administrative framework of the region
- dependence — the functioning of the region depends on the financial resources allocated to the implementation of state and local administration tasks and projects resulting from the adopted regional policy; the funds are transferred on the basis of the state budget and the budget of the European Union cohesion policy[10]
- self-existence — the authorities of the region conduct their own regional policy on the basis of the regional development strategy adopted by the voivodship assembly (for example, in the Podkarpackie Voivodship, the following strategy was adopted: "Strategy for the Development and Marketing Communication of Tourism in the Podkarpackie Voivodship for the Years 2020–2025")[11]

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9. See: "Krajowa Strategia Rozwoju Regionalnego 2030." https://www.gov.pl/web/fundusze-regiony/krajowa-strategia-rozwoju-regionalnego.

10. See: "Cohesion Policy 2021-2027." https://ec.europa.eu/regional_policy/en/2021_2027/.

11. See: "Strategia rozwoju i komunikacji marketingowej turystyki województwa podkarpackiego na lata 2020–2025." prepared by H. Gonera (project director) with M. Pilarczyk, P. Brzeska, C. Molski, J. Reczek, K. Zieliński, and P. Zmyślony. Załącznik do Uchwały Nr 167/3530/20 Zarządu Województwa Podkarpackiego w Rzeszowie z dnia 16 czerwca 2020 r. https://www.podkarpackie.pl/images/TURYSTYKA/dokumenty_2021/Strategia_Rozwoju_Komunikacji_Marketingowej_Turystyki_woj_Podkarpackiego_PDF_892_MB.pdf.

- primacy — regions in Poland are administered in accordance with the Act on Local Government[12]
- independence — the region is governed by elected bodies: the voivodship parliament and the voivodship board

The base of concepts of the 1st level
- aspect — this is the point of view adopted to identify the features of the region; it may be the theory of regional development; in this paper the classification of the theory of regional development was adopted from Nowak (2011):
  - theories of the region as a place of export specialization — theory of economic base, new theory of trade, theory of exogenous development, theory of the production cycle
  - theories of the region as a "source of growing revenues" — new growth theory, growth poles theory, new economic geography, agglomeration economics
  - theories of the region as a "knowledge center": "learning" regions, regional innovation systems, cluster theory, new institutional economics

In the literature, theories of regional development are defined in various combinations. The following theories are distinguished in *Handbook of Regional Growth and Development Theories* (Capello and Nijkamp 2009):

1. The neoclassical growth theory is focused on the analysis of the regional GDP gross product, interregional market, employee migration, capital flow and technology transfer.
2. The endogenous growth theory is focused on the analysis of technological changes, human capital, effect of scale, return on investment, development of the R&D sector, and development of public services.
3. Post-Fordism and "radical" theories are aimed at analyzing the geographical concentration of small and medium-sized companies (new industrial districts).
4. The social capital theory assumes that social capital stimulates economic growth.
5. New economic geography models (NEG) assumes that the creation of new companies and the labor market results in lower transport costs and the occurrence of the effect of scale.
6. Evolutionary economic geography (EEG) assumes that regions should develop on the basis of the development of agglomerations in order to increase their competences and knowledge.
7. Demand-driven export competition models — this theory assumes export specialization of the region.
8. Innovative milieus and "learning" regions — this theory assumes creating a cluster of high technology companies.

- absolutely own properties — these are the features that characterize the geography of the region, natural resources, and inhabitants; for example, a region:
  - has inhabitants,
  - has working-age inhabitants,
  - has natural resources prepared for operation,
  - has NATURA 2000 protected areas,
  - has a national park, or
  - has a landscape park.
- acquired properties — these are the features resulting from the creation of resources that have arisen as a result of implemented projects; for example, a region:
  - has a university,
  - has a higher vocational school,
  - has the headquarters of a national corporation,
  - has the headquarters of an international corporation,
  - has an international commercial network,
  - has a business incubator,

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12. See: Ustawa z dnia 5 czerwca 1998 r. o samorządzie województwa. Dz. U. z 1998 r. Nr 91 poz. 576.

   – has a technology park,
   – has a highway, or
   – has an airport.
- externally conditioned properties — these are the features resulting from the creation of resources by external economic agents or state or international institutions; for example, a region:
   – has a special economic zone, or
   – has a NATO military base.

The base of the concepts of the 2nd level

- the potential of the region (positive state of objects) — it is the possibility of using human, financial and material resources as well as institutions (formal, informal, institutions-organizations) while implementing effective contracts (with low transaction costs) in order to improve the quality of life of the inhabitants; types of the potential of the region:
   – geographic potential — this is the possibility of using natural attractions (landscape parks, nature monuments, river basins, natural routes, geothermal springs and mineral waters, etc.) as well as cultural and religious monuments and objects for the development of tourism, the creation of enterprises for recreation and biological regeneration, catering services and hotels
   – social potential — this is an opportunity to develop human resources in the region thanks to the educational infrastructure, public health infrastructure, telecommunications infrastructure, municipal infrastructure, information and administrative infrastructure, etc.
   – innovation potential — this is the possibility of using specialized human resources, regional science infrastructure (laboratories, design studios of universities and research institutes, libraries and knowledge repositories) and institutions-organizations supporting innovation (incubators, technology parks) to adopt innovative solutions (patents, design utilities, scientific articles and solutions at various levels of TRL technological readiness)
   – institutional potential — it is constituted by the existing and "hidden" opportunities and motivations for effective solving of economic problems by individual entities within a given system of institutions; this potential is determined by the method and form of managing and solving specific problems — project management, the functioning of institutions-organizations, the quality of law or the trust of individuals and social groups in other entities of the institutional system (Staniek 2017).
- risk of the implementation of the regional development strategy (negative state of objects) — this is the probability of loss or an increase in costs in the implementation of the projects of the regional development strategy, resulting from the anticipated threats; types of the risk:
   – risk of project implementation — this is a risk posed by an increase in project costs resulting from the following threats: unfavorable PLN/EUR exchange rate, price increase, changes in the supply markets in semi-finished products and raw materials, changes in the supply chain, loss of employees, changes in insurance, wage pressure, extension of the duration of project stages, breach of contracts, technological errors, design errors, errors in the organization of work, etc.
   – ecological risk — this is a risk posed by an increase in operating costs resulting from the following threats: an increase in pollution removal costs, an increase in the fees for exceeding the emission standards for gases and chemical pollutants, an increase in the prices of claims settlement, etc.
   – institutional risk — this is a risk posed by an increase in the costs of services resulting from the following threats: introduction of an embargo on imported goods, introduction of unfavorable international regulations, errors in the interpretation of legal regulations, the occurrence of opportunistic behavior, corruption, etc.
   – public health and safety risk — this is a risk posed by an increased probability of the following events: epidemiological events, an increase in occupational and civilization diseases, an increase in criminal cases, theft, etc., protection of people and property in the event of armed conflicts and natural disasters, etc.

The base of the concepts of the 3rd level
- geographic potential indicators (tourist potential) (Ozimek, Gralak, and Pomianek 2019):
  - Baretje-Defert index—tourist development of the area; definition: the number of tourist accommodation places per 100 permanent inhabitants of the region:
    ◦ Lubelskie: 1.3 (in the year 2018)
    ◦ Podkarpackie: 1.6 (2018)
    (reference value: 8.1, Zachodniopomorskie)
    ◦ relative property of the geographic potential—Podkarpackie and Lubelskie: very large advantage of B
  - Defert index—tourist congestion in the area; definition: the number of tourists using accommodation per 1 km² of the region:
    ◦ Lubelskie: 4 (2018)
    ◦ Podkarpackie: 7 (2018)
    (reference value: 34, Małopolskie)
    ◦ relative property of geographic potential—Lubelskie: very large advantage of B
    ◦ relative property of geographic potential—Podkarpackie: very large advantage of B
  - Scheider index—the intensity of tourist traffic; definition: the number of overnight stays per 100 permanent residents of the area:
    ◦ Lubelskie: 0.5 (2018)
    ◦ Podkarpackie: 0.8 (2018)
    (reference value: 9.9, Małopolskie)
    ◦ relative property of geographic potential—Lubelskie and Podkarpackie: very large advantage of B
  - Chorwat index—tourist traffic load; definition: number of nights spent per 100 permanent residents of the area:
    ◦ Lubelskie: 108 (2018)
    ◦ Podkarpackie: 166 (2018)
    (reference value: 891, Zachodniopomorskie)
    ◦ relative property of geographic potential—Podkarpackie and Lubelskie: very large advantage of B
- social potential indicator:
  - the European Union Regional Social Progress Index (ESP);[13] definition—the index is an integrated measure of 50 factors of social progress in three dimensions: basic human needs (nutrition and basic medical care, water and sanitation, shelter, personal safety), foundations of well-being (access to basic knowledge, access to information and communication, health and wellness, ecosystem sustainability), and opportunities (personal rights, personal freedom and choice, tolerance and inclusion, access to advanced education)
    ◦ Lubelskie: 61.1 (2020)
    ◦ Podkarpackie: 60.3 (2020)
    (reference value: 63.9, average of EU regions)[14]
    ◦ relative property of social potential—Podkarpackie and Lubelskie: small advantage of B
- innovation potential indicators:
  - degree of implementation of solutions for industry 4.0 (Sokołowski and Markowska 2021); definition: the indicator characterizes the adaptation of enterprises to the requirements of the fourth industrial revolution in the following areas: the use of ERP software, the use of "cloud computing," the use of solutions in the field of the Internet of Things, the analysis of large amounts of data, the use of technologies using artificial intelligence, the employment of new highly qualified specialists, the use of production individualization solutions, production of machines and devices for Industry 4.0; this indicator is also determined in international studies for NUTS 2 regions (Honti, Czvetkó, and Abonyi 2020):

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13. See: European Social Progress Index. https://ec.europa.eu/regional_policy/en/information/maps/social_progress/, https://ec.europa.eu/regional_policy/sources/information/maps/methodological_note_eu_spi.pdf.
14. See: https://ec.europa.eu/regional_policy/sources/docgener/work/spi2020_scorecards.pdf.

     ◦ Lubelskie: 28 (15th place in the 2020 ranking)
     ◦ Podkarpackie: 41 (11th place)
      (reference value: 72, Opolskie, 1st place)
     ◦ relative property of innovation potential for Podkarpackie: large advantage of B
     ◦ relative property of innovation potential for Lubelskie: very large advantage of B
   – Millennium 2000 index;[15] definition: it is an index for assessing the innovation potential of Polish regions on the basis of five criteria: labor efficiency, expenditure on the R&D sector, post-secondary education, people working in the R&D sector, and the number of patents:
     ◦ Lubelskie: 53 (8th place in the ranking 2020)
     ◦ Podkarpackie: 47 (10th place)
      (reference value: 99, Mazowieckie, 1st place)
     ◦ relative property of innovation potential — Lubelskie and Podkarpackie: very large advantage of B

• institutional potential indicator:
   – European Regional Competitiveness Index (RCI);[16] definition: the index has been measuring the major factors of competitiveness over the past ten years for all the NUTS 2 level regions across the European Union; using more than 70 comparable indicators, the index measures the ability of a region to offer an attractive and sustainable environment for firms and residents to live and work; users can easily see where their region stands on such aspects as governance, infrastructure, including the digital networks, health, human capital, labor market, and innovation:
     ◦ Lubelskie: −0.68, score (0–100): 34.66 (rank 209/268)
     ◦ Podkarpackie: −0.67, score (0–100): 34.95 (rank 208/268)
      (reference value: Warsaw capital city: 0.23, score (0–100): 68.30 (rank 105/268))
     ◦ relative property of institutional potential — Lubelskie and Podkarpackie: very large advantage of B

• ecological risk indicators:
   – total household carbon footprint (MtCO$_2$e) (Ivanova et al. 2017) — carbon footprint (CF) is the total sum of greenhouse gas emissions (carbon dioxide, methane, nitrous oxide, greenhouse gases) caused directly in the region concerned
     ◦ Lubelskie and Podkarpackie: 15–20 MtCO$_2$e
      (reference range: 5–10 MtCO$_2$e, Podlaskie)
     ◦ reference value of ecological risk — Lubelskie and Podkarpackie: small advantage of B
   – average household carbon footprint (tCO$_2$e/cap) — CO$_2$ emissions per capita
     ◦ Lubelskie and Podkarpackie: 8.0–9.3 tCO$_2$e
      (reference value: 8.0–9.3 tCO$_2$e, Podlaskie, Warmińsko-Mazurskie)
     ◦ reference value of ecological risk — Lubelskie and Podkarpackie: index values comparable to the reference value

• public health care and security risk indicators:
   – life satisfaction index[17] — it is an aggregated indicator containing the following components: the income of households, the indicator of the relatively high income of households in %, the living conditions in households, the quality of the natural environment in the place of residence, satisfaction with green areas, the sense of security in the place of residence, satisfaction with the place of residence, trust in neighbors and strangers, trust in local authorities, the police and the Roman Catholic Church, the attitude towards religion:

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15. See: "Indeks Millennium 2020. Potencjał Innowacyjności Regionów". Millenium Bank report by G. Maliszewski, M. Gromada, and M. Nasiłowska. https://www.bankmillennium.pl/documents/10184/28780471/Millenium_201027_Raport_index2020.pdf

16. See: European Regional Competitiveness Index. https://ec.europa.eu/regional_policy/en/information/maps/regional_competitiveness/.

17. See: "Regionalne zróżnicowanie jakości życia w 2018 r. Wyniki badania spójności społecznej 2018." GUS 31.01.2019. https://stat.gov.pl/files/gfx/portalinformacyjny/pl/defaultaktualnosci/5486/31/1/1/regionalne_zroznicowanie_jakosci_zycia_w_polsce_w_2018_roku.pdf.

Figure 4. The diagram of the classes of the ontology of the region (OntoReg) in the Protege editor

◦ Podkarpackie: 81 (2018)
◦ Lubelskie: 76 (2018)
  (reference value: 88 (Wielkopolskie)
◦ relative value of public health care and security risk for Podkarpackie: small advantage of B
◦ relative value of public health care and security risk for Lubelskie: large advantage of B
• project implementation risk indicators:
  – cooperation quality index (Dudkiewicz and Makowski 2012); definition: the cooperation qual-
    ity index includes the following components: cooperation infrastructure, financing coopera-
    tion, supra-financial cooperation, knowledge and opinions of NGOs, NGO satisfaction, public
    availability of cooperation infrastructure
  ◦ Lubelskie: 5.57 (2012)
  ◦ Podkarpackie: 1.60 (2012)
    (reference value: 23.22, Warmińsko-Mazurskie)
  ◦ relative value of project implementation risk for Lubelskie: large advantage of B
  ◦ relative value of project implementation risk for Podkarpackie: large advantage of B
• institutional risk indicator:
  – institution quality index of Institute for Development (Zaucha 2014); definition: the indi-
    cator takes into account the following factors: the total value of projects co-financed from
    EU funds, the percentage of the region's area covered by valid spatial development plans,
    the detection of perpetrators of identified crimes, the number of preparatory proceedings in
    corruption cases, voter turnout in direct elections to the European Parliament
  ◦ Lubelskie: 0.427 (4th place in 2014)
  ◦ Podkarpackie: 0.243 (16th place)
    (reference value: 0.512 (Dolnośląskie)
  ◦ relative value of institutional risk for Lubelskie: large advantage of B
  ◦ relative value of institutional risk for Podkarpackie: a very large advantage of B

Figure 4 (on previous page) shows the structure of the classes of the ontology of the region in the
Protege editor. Figure 5 (below) shows the diagram of object properties of the ontology of the region
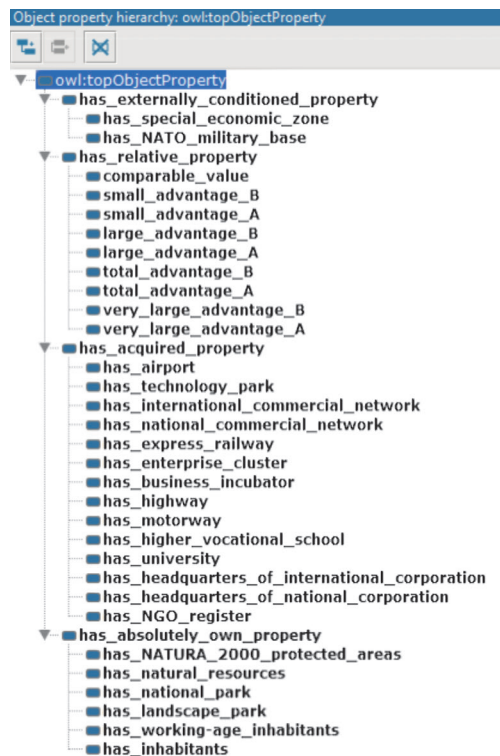(OntoReg) in the Protege editor.

Figure 5. The diagram of the classes of the ontology of the region (OntoReg) in the Protege editor

Conclusion

The presented ontology of the region (OntoReg) constitutes the structure of the knowledge base on Polish regions according to the NUTS 2 classification. A characteristic feature of the ontology is the characteristic of the region, which includes the region's features in three groups: in group I these are the region's absolute own properties of the region, acquired properties and externally conditioned properties; group II includes relative properties divided into two groups: characterizing the region's potential and the risk of implementing the regional development strategy; in group III, potential indicators and risk indicators were compiled. The indicators were selected on the basis of an extensive study of the literature on the subject. There is a great difficulty in selecting indicators for the regions covered by NUTS 2 statistics because in a number of scientific studies the indicator values are calculated for countries (NUTS 1) and are not decomposed into regions at a lower level. On the basis of a comparative analysis of the indicators of a given potential and risk (determined in scientific research), the relative property is calculated, which answers the question of whether a given type of potential or risk is above or below the reference value. The presented ontology system makes it possible to generate new knowledge about the region. According to the presented ontology, the Knowledge Based System (KBS) will be developed to generate aggregated knowledge about the region. This knowledge concerns the relationship between the assessment of the potential of a given region and the assessment of the risk of implementing a regional development strategy.

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