Ontology-Based Intelligent Decision Support Expert System for Economic Growth Management in the Territorial Entities of the Russian Federation

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Abstract: The territorial economy is a complex system with many interrelated factors. Ontology-based modeling allows formalizing knowledge about these interconnections and taking into account the unique characteristics and needs of different territories, which contributes to more effective management and the development of strategies adapted to specific conditions. Ontology-based expert systems can analyze large volumes of data and provide recommendations based on rules and logic, which significantly improves the quality of decision making, which is especially important in managing economic growth, where many factors must be taken into account. This paper presents a description of a territorial management ontology-based model of a decision support expert system at the regional level that is designed for managing economic growth of the territories of the Russian Federation.

1 INTRODUCTION

Managing economic growth in the process of strategic planning of the Russian Federation territories socio-economic development is a complex task that requires a systematic approach and coordination of efforts on various levels of the government, the business community and the public [10]. The process of strategic planning of the Russian Federation territories socio-economic development is closely linked to the civil society and government relationships that arises in the process of implementing the powers of territorial development entities. These relations between central and local executive authorities, local government, business entities and public organizations play a key role in the formation and implementation of development strategies.

The following aspects link the process of strategic planning with the civil society and government relationship systems:

1. Participation of all concerned parties: it is important that all participants of the civil society and government relationship system are involved in the strategic planning process. They can make their proposals, discuss strategic priorities and coordinate actions to achieve common development goals.

2. Decision-making and coordination: central and local executive authorities, local governments, business entities and public organizations should together make decisions on the strategic development of territories. Coordination of actions and development of common approaches help to avoid contradictions and ensure the effective implementation of strategies.

3. Resources and responsibility: The strategic planning process requires identifying and allocating resources for the implementation of development strategies. Different levels of government and other participants must be accountable for their responsibilities and contribution to the achievement of the set goals.

4. Monitoring and evaluation: The civil society and government relationship system should also ensure monitoring and evaluation of the results of the development strategies implementation. This allows for adjusting to the situation, adapting strategies to

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changing conditions and ensuring accountability to society.

Thus, the civil society and government relationship system plays an important role in the successful implementation of strategic planning for the social and economic development of territories, ensuring the coordination of actions, the efficient use of resources and the achievement of economic growth of these entities.

The experience of implementing public administration functions has shown that optimization of public administration requires non-traditional approaches based on a modern methodological base that takes into account the self-organization potential of social and territorial systems, the influence of globalization, digitalization, regionalization of public life on the decentralization of public authority, strengthening the role of information, knowledge, humanitarian values, trust and social capital phenomena, informal components of interaction between government entities and society as intangible development resources. One of the tools for optimizing the implementation of public administration functions is an ontology-based intelligent decision support expert system for economic growth management in the territorial entities of the Russian Federation. It allows accumulating data on social and economic indicators, investment projects, resource potential and other factors influencing the development of regions. The expert system will analyze current trends, predict the consequences of various management decisions and develop recommendations to improve the efficiency of economic policy at the level of the constituent entities of the Russian Federation. Applying such an expert system will contribute to a more justified distribution of budget funds, improve the investment climate and stimulate sustainable development of the territories of the Russian Federation.

2 MATERIALS AND METHODS

In the core of territorial management there is a clear jurisdictions delineation of territorial entities at all levels. The functions of the main territorial entities do not intersect, but complement each other. At the same time, there is a stronger centralized influence on the social and economic activities of the regions, which ensures the implementation of national regional policy. This circumstances can be extremely useful in the context the Russian Federation, where the main problem of territorial management is the lack of a clear distribution of functions and powers of territorial authorities.

General approaches to the territorial governance systems analysis and its reform potential are described in the works of Babintsev V., Shapovalova Zh. [1], Batyreva N. [2], Bakhlov I., [3], Malinovskaya G. [6], Miroshnikov S. [7] and others. According to Federal Law No. 131-FZ of October 6, 2003 "On general principles of local self-government in the Russian Federation", a municipal entity is an urban or rural settlement, municipal district, urban district or inner-city area in a federal city [11].

From a systems perspective the municipal entity (hereinafter referred to as ME) management system is:

- probabilistic, since its state can be predicted at any given moment in time only with a certain degree of probability;
- dynamic, since it changes over time;
- large, since it contains heterogeneous elements and subsystems;
- open, since there is a possibility of interaction of subsystems with each other and the external environment.

All these characteristics simultaneously demonstrate the complexity and proclaim the necessity to build a municipal governance integrated system. As indicated in the works of Shirokov A. [12], local government bodies, having the status of a government body and an economic entity, have two main management functions:

- regulation of relations between municipal entity territories with the help of legal acts
- direct production of goods and services necessary for the population.

The elements of the municipal governance system include:

- population;
- territory;
- local government bodies;
- bodies of territorial self-government;
- municipal property;
- municipal budget;
- civil engineering and social infrastructure.

The management subjects of the ME system are local government bodies. The main goal of municipal management is to improve the quality of life of the ME residents. In terms of the information approach, local government is necessary to improve the quality of management decisions at the regional and state levels by providing more reliable, adequate, prompt and complete information on the economic and political state and dynamics of development of

municipalities, as well as decisions taken by local authorities.

As a result, we can come to the conclusion that the main elements of the system are: planning and forecasting activities, organizational and management structure, as well as methods and tools (means) of the mechanism enabling the management the regional development. The overall effectiveness of the regional management system depends, first of all, on how quickly and adequately all its elements reflect the functions, powers and capabilities of the management system, do not contradict or duplicate each other, and also fully correspond to the goals of the comprehensive social and economic development of the region.

In the last decade, while implementing new methods of representing and processing information at the intersection of system analysis, logic, applied linguistics, artificial intelligence, applied data analysis, theory and technologies of automated data banks, researchers conducted studies on content ontologies and conceptual specifications (schemes). The development and implementation of such technologies links the organization of a knowledge system about various subject areas and methods of targeted use of this knowledge. Analytical work aimed at identifying and combining relevant information, logical and functional aspects of the system in the corresponding content ontology can be defined as ontological system analysis (or, simply, ontological analysis) [4]. Ontological analysis is aimed at studying and interpreting systemic connections in complex objects using methods and means of computer modeling.

Recently, the use of ontologies for modeling subject areas of automated information systems has become increasingly widespread [5, 8]. Most often, this approach is used for intelligent systems, in particular, those designed to operate on the Internet. This is due to the fact that the ontological model allows the development of a metadata model, which significantly improves the use of the system by a wide range of users in terms of interoperability.

The ontology-based model of the territorial administration system should reflect the taxonomy of administrative units, the allocation of rights, duties and powers of regional and local administrations, the correlation of assessment metrics and management tasks, so that it would be possible to build semantic maps based on this ontology and using inference machines. An example of such a semantic map could be an assessment of the effectiveness of regional and local authorities.

The main source of knowledge in the subject area consists of regulatory and legal documents. Numerous legal sources sometimes contradict each other regarding the definition of terms. The main problem in constructing an ontology is the redundancy, ambiguity and contradictory nature of the input terminological data. The ontology base of the state territorial administration system in Russian Federation consists of the provisions of regulatory legal acts of two levels:

- general regulatory legal acts, which, along with other issues, are the organizational and institutional foundation of the territorial administration in the Russian Federation;
- special regulatory legal acts, that directly regulate aspects of the activities of state and local authorities.

The first group includes the Constitution of the Russian Federation, the Federal Law of the Russian Federation "General Principles of the Organization of Legislative (Representative) and Executive Bodies of State of the Entities of the Russian Federation", the Federal Law "On general principles of local self-government in the Russian Federation", the Charters (Constitutional laws) of the subjects of the Russian Federation.

The second group includes:

- statutory and regulatory enactments that regulate the economy of the subjects of the Russian Federation;
- federal constitutional laws and federal laws regulating individual economic issues, including the economic development of the regions;
- decrees of the President of the Russian Federation regulating particularly important national public issues that stand out among legal acts of the Russian Federation;
- decrees and orders of the Government of the Russian Federation, that fully and efficiently regulate economic and financial relations;
- departmental regulatory acts (for example, obligations to ensure public health protection in the regions of the Russian Federation within the powers of regional executive authorities are determined by acts of the Ministry of Health of the Russian Federation);
- regional and municipal regulatory legal documents.

3 RESULTS AND DISCUSSION

The initial task of implementing expert systems in the activities of state and municipal management

structures in Russian Federation can be formulated as a search for a semantic model that is corresponds to the characteristics of the state territorial management system, which allows for the consistent storage of information on the practice and results of the implementation of the powers of regional authorities and local self-government.

The process of constructing an ontology is divided into a series of subprocesses. At the first stage, the task is to identify the main classes of entities and determine their definitions in natural language. The second stage is to construct concept classification trees based on taxonomic relations (relationship "Class-Subclass").

In accordance with the purpose of the study, the authors established a taxonomy of terms of territorial-administrative division of Russia and identified basic relations between terms.

According to federal legislation, state territorial administration bodies are present in all administrative-territorial units that form the basic relations between the terms:

1. Subject of the Russian Federation
2. Municipal entity
3. Urban district
4. Municipal district
5. Urban settlement
6. Rural settlement

According to the Web Ontology Language (hereinafter OWL), classes are interpreted as sets of individuals, so the default ontology contains the “Thing” class; this is a class representing a set containing all objects of the subject area. All created classes are subclasses of “Thing” [9].

The classes “Municipal District” and “Urban District”, “Urban Settlement” and “Rural Settlement” are disjoint, so that any given object cannot be an instance of more than one of these classes. For this purpose, each class is defined with the property “Disjoint With”.

To record significant relationships between terms, the authors highlighted the main connections between them and graphically displayed them using binary relations. The relations of the type “consists of” and “is part of” are used as basic relations for territorial units. Thus, the class “Subject of the Russian Federation” includes the subclass “Municipal Entity”, which includes “Urban District” and “Municipal District”, the latter in turn has the subclasses “Urban settlement” and “Rural settlement”.

In this study, such subclasses of “Municipal Entity” as “Urban district with intraurban division”, “Intraurban district”, “Intraurban territory”, “Intrasettlement territory” are deliberately not selected, since these specific types of settlements are not independent subjects of legal relations for the local authorities, except for the cases where this is established by a separate federal law.

To specify subjects of territorial administration, the classes "Regional executive authority" and "Concil" were added into the model. The connection between them and the corresponding classes "Subject of the Russian Federation" and "Municipal Entity" is functional, which allows us to specify only one value for the selected individuals. The semantics of the connection can be defined as "is a subject of concil".

Semantic relations for storing information about the activities of regional executive bodies and local governments are implemented through their own classes.

Thus the corresponding federal law defined for concils a finite set of individuals for classes describing their activities:

1. Local matters (issues with essential services for the population, the solution of which corresponds to the management and material and financial capabilities of local governments).

2. Powers of the concil (responsibilities for solving local issues).

3. Rights of the concil (formal norms protected by the state determining the mode of behaviour of local governments as a subject endowed with powers).

The above specified classes are also disjoint, so that any individual cannot be an instance of more than one of these classes.

Between the class “Concil” and its subclasses, the semantics of the relations are defined as “acts on the basis of” (for powers of the concil), “is assigned” (for the rights of concil) and “has obligations” (for local issues).

For a similar description of the activities of regional executive authorities, due to the lack of such a normative consolidation on the elements of powers implementation, it is necessary to adopt a methodological procedural approach to the analysis of the economic mechanism. The economic mechanism distinguishes the following units as elements: goals and means, methods and forms of management, as well as the results and criteria for the transformation of economic relations, which are reflected in its internal structure in accordance with its natural quality and functions for the implementation of the original relations.

Thus, the basic concepts for describing the activities of regional authorities in the model are:

1. Function as a set of administrative actions to implement state powers to manage a separate area of the regional social and economic system based on

decisions, regulations, and laws adopted by federal and regional representative authorities.

2. Target as a state of the areas of the regional social and economic system determined by qualitative and quantitative parameters.

3. Method as a process that includes a set of actions by regional executive authorities aimed at achieving the goal.

4. Tool as specific levers and activities by means of which the methods of managing the regional social and economic system are implemented (tariffs, rates, subsidies, etc.)

The following functional relationships are established between the specified concepts: "The regional executive authority" "has obligations" to perform a "Functions", for each of which the "Goal", "Method" and "Tool" of implementation can be determined. To assess the effectiveness of territorial management systems, the "Indicator" class is introduced into the model, which is associated with the classes "Local Issues", "Powers of the Concil" and "Function" through the "Assess" relationship. The resulting scheme of classes and relationships is presented in Figure 1.

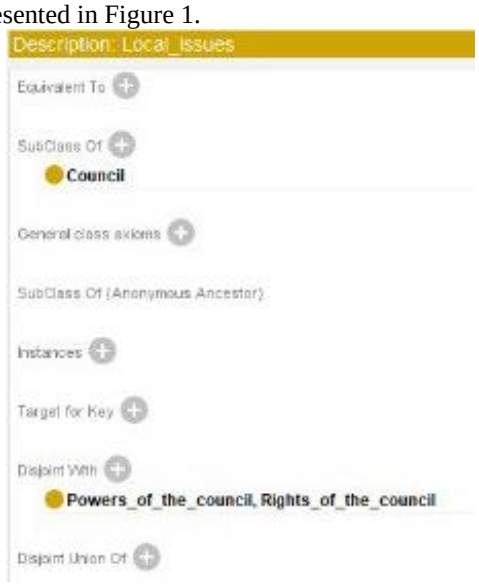

Figure 1: Visualization of the ontology of the territorial management system (compiled by the authors).

Formalized description of the subject area using ontology-based modeling ensures communication both between people and between programs. This ontology feature has led to significant research interest. Researchers consider both subject ontologies intended for solving specific applied problems and the creation of universal ontologies describing general concepts, that allow to construct concepts for particular subject ontologies.

To develop an ontological model of the territorial management system, the authors in this paper use the Protégé graphical editor. The first step in creating a new project in the Protégé system is to create Classes. Usually, classes correspond to objects or types of objects in a certain subject area. In our system, classes will include a system for assessing the effectiveness of territorial management at the regional level. Classes in Protégé are displayed as an inheritance hierarchy, which is located in the viewing area called the Class Browser on the left side of the classes tab. The properties of the classes currently selected in the navigator are displayed in the class editor on the right. The class hierarchy illustrating the structure of territorial management is shown in Figure 2.

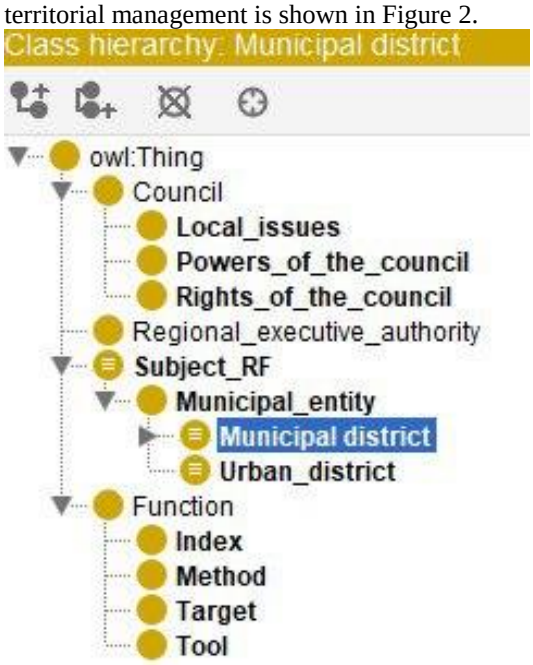

Figure 2: Class hierarchy (compiled by the author).

Each block of the executive authorities ontology contains both powers and documents, legal acts, statistics on the work of all local government bodies. Thus, the ontology together with a set of individual class instances forms a federal knowledge base, which is convenient to use for both individual local government bodies and municipal authorities. Then, the authors created Disjoint Classes and a Class expression editor (Fig. 3).

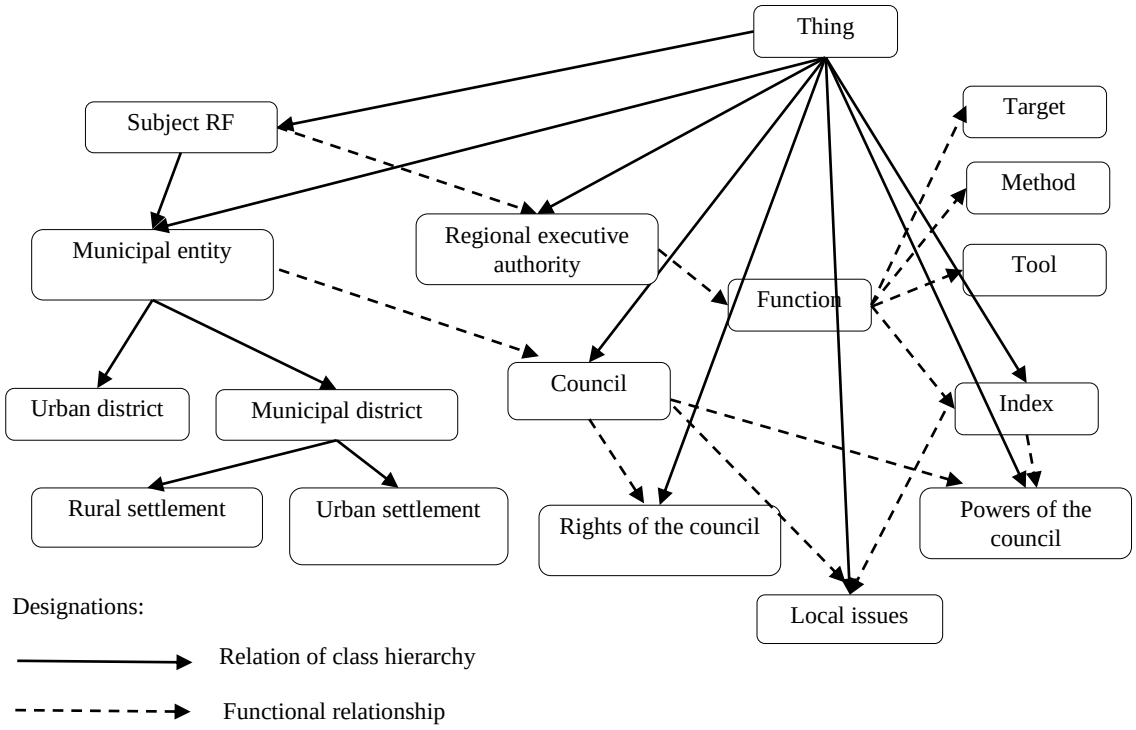

Figure 3: Disjoint Classes (compiled by the author).

Properties in OWL represent relationships. There are two main types of properties: object properties and data type properties (DataType). Object properties are relationships between two individuals. These are the object properties in the developed model:

- acts on the basis of;
- is assigned;
- has obligations;
- assess;
- is a subject of authority.

OWL classes are interpreted as sets whose elements are individuals. They are described using formal (mathematical) constructs that declare the requirements for class membership. Classes can be organized into a hierarchy of subclass-superclass relationships, also known as a taxonomy. Subclasses are specified units of (i.e. are subsets of) their superclass. An empty ontology contains one class named THING. The THING class is a class representing a set containing all objects in a subject area. For this reason, all classes are subclasses of THING. As an example, the description panel of the class “Urban District” is shown in Figure 4.

OWL has five predefined annotation properties that can be used to annotate classes (including anonymous classes such as constraints), properties, and individuals: OWL: versionInfo — this property is a string. RDFS:Label — a string. This property can be used to add a readable explanations for the names of elements such as classes, properties, and individuals in the ontology. RDFS:Label can also be used to provide multilingual names for ontology elements. RDFS:comment — a string. RDFS:seeAlso — has a URI value that can be used to refer to relevant resources. RDFS:isDefinedBy — has a URI reference value that can be used to reference the ontology defining the ontology of elements such as classes, properties, and individuals. Using queries (Figure 5), the constructed model was searched for subclasses of “Municipal District” using literal data. The query will return descendants of the class with the “Municipal District” label.

Figure 4: Class description panel “Urban district”.

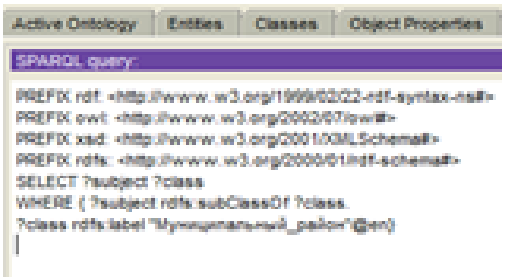

Figure 5: Creating a query using literal data (compiled by the author).

The resulting semantic model of territorial administration activities at the regional level is presented in Figure 6.

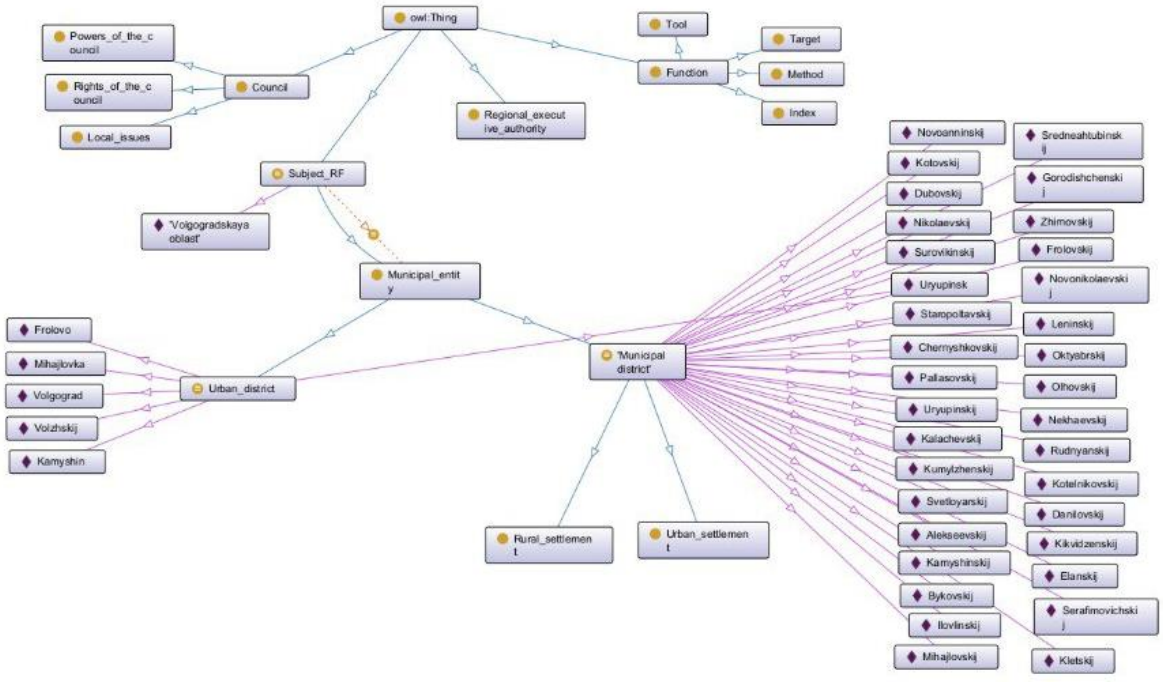

Figure 6: Semantic model of territorial administration activities at the regional level (compiled by the author).

This scheme allows to visually represent both the rights and powers of local government bodies, and to see the connection between the functions and instruments of local government bodies and municipalities, which allows to better study the entire management structure. Each block of the created ontology carries both powers and documents, legal acts, statistics on the work of territorial management systems. Thus, the ontology together with a set of individual class instances forms a federal knowledge base, which is convenient to use both for individual local government bodies and for municipal authorities. As a tool for describing knowledge, ontologies should be of interest to all specialists who face the problem of representing and using knowledge in their practice.

4 DISCUSSIONS

Ontology-based modeling is an important tool for improving the efficiency of economic growth management in the territories of the Russian Federation, allowing for more informed and strategic based decisions. Ontologies help to combine data from various sources and ensure their compatibility, which is a prerequisite for analyzing and monitoring economic indicators at the regional level. Ontological models can also be easily adapted to changes in the economic environment or legislation, so both internal and external factors that can influence the system are considered and the system remains up to date. In order to ensure effective management of economic growth in the territories of the Russian Federation, it is necessary to improve the system of civil society and government relationship that arise in the process of implementing the powers of territorial development entities: central and local executive authorities, local governments, business entities and public organizations. The experience of implementing administrative reform in the Russian Federation has shown that the corresponding optimization requires non-traditional approaches based on a modern methodological base that takes into account the self-organization potential of social and territorial systems, the influence of globalization, digitalization, regionalization of public life on the decentralization of public authority, strengthening the role of information, knowledge, humanitarian values, trust and social capital phenomena, informal components of interaction between government entities and society as intangible development resources. The effectiveness of government bodies in managing economic growth lies in monitoring the quality of activities of state institutions, as well as a modern system for assessing the activities of local governments. Ontology-based modeling is an important tool for managing the economic growth of the territories of Russian Federation, which allows making more informed and strategy based decisions. The use of such systems can help identify new opportunities for economic growth and innovative solutions, which is especially important in the context of global competition.

5 CONCLUSION

As a result of the conducted research, the authors designed an administrative ontology of the system for assessing the effectiveness of territorial administration at the regional level; the ontology contributes to a clear understanding of the delineation of functions and powers of the entire structure of the municipal administration system. The developed ontology will allow for prompt and error-free information search of the necessary management methods and tools, and will allow to determine the relationship with the available information on their effectiveness of regional and local authorities. The data scheme obtained on the basis of the OWL model is used as an information base in the expert decision support system for managing the economic growth of the territories of the Russian Federation, which is being developed by the authors.

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