Methodology For Infrastructure Development Assesment

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Abstract. **In this paper has been proposed the importance of infrastructure and ulr. Theories of interconnected infrastructure have been studied. In order to determine the scale and strength of the synergistic effect, the connections in the infrastructure networks are classified. The types of interrelationships that create the synergy and the synergy effect have been identified. The SYNEFIA methodology was used to identify synergistic effects resulting from problems in production infrastructure. The synergistic impact of emerging problems in the manufacturing sector of the Republic of Uzbekistan was assessed on the basis of the SYNEFIA methodology.**

Keywords: Infrastructure, synergy, infrastructure structure, SYNEFIA methodology, infrastructure facilities, production, synergetic impact.

I. INTRODUCTION

Industrial infrastructure is a complex system, the failure of which (in whole or in part) has a significant impact on national interests, including the basic needs of the country's economy and population. The production infrastructure is also a specific system, representing the key elements in the organization of production and their interrelationships. The system consists of certain parts, and failure of one of the parts will affect the whole system. For the study of production infrastructure, it is important to develop a systematic approach based on cross-sectoral assessment and the study of the relationships between individual infrastructure networks.

II. LITERATURE REVIEW

The development of any country's economy requires the balanced development of infrastructure. However, a wide range of anthropogenic and natural hazards that constantly interact with infrastructure around the world poses a threat. [1] Not only large but also small threats can adversely affect the failure and balanced development of an infrastructure component or function. While such effects may not seem likely, failure to assess the effects can make them unsolvable in their outcome problems. Such impacts can often lead to economic losses, an increase in the poverty rate of the population, and an impact on the economic development of the affected area.[10]

The importance of protecting infrastructure networks was first emphasized in 1995 by the United States. In the following years, measures to protect infrastructure were initiated by other countries, including Canada in 1998 and the United Kingdom, Sweden and Switzerland in 1999. [2]

At the EU level, the term infrastructure is defined in two main documents. The first is the European Program for Infrastructure Protection, published by the European Commission in 2005, the Green Book. [3] The second is the Council's directive on the identification and identification of European infrastructure and the need to increase their protection, published in 2008 as a continuation of the Green Book. [4] The Council's directive states that "Infrastructure is an asset, system or part thereof that is essential to the vital social functions, health, safety, economic or social well-being of persons in the member states of the Union and leads to their destruction or destruction." The directive leaves the responsibility for protecting infrastructure to national authorities.

Infrastructure is complex. Infrastructure in many countries includes certain sectors, such as energy and transport, as well as their connections, as well as systems with a clear hierarchy. [5] Currently, two main methodological approaches to infrastructure risk assessment can be identified. The first is a sectoral approach, in which each sector has its own methods of risk assessment, and the second is a systematic approach, in which the assessment of interconnected networks of individual infrastructure networks. However, such assessments are not appropriate because the study emphasizes the need to increase the reliability and accuracy of simulation tools to model the effects of infrastructure failures. [6] [7] [8] In the research of P. Trucco et al., A prospective approach that takes into account synergistic effects based on dynamic functional modeling [9] has been proposed. However, it does not support modeling and simulation of synergistic effects.

In general, certain infrastructure problems can not only lead to serious disruption of the network or the entire infrastructure system, but it can also affect national interests such as security, the economy and basic human needs. [13]

Predicting and subsequently minimizing the consequences of problems on entire infrastructure is an important component of infrastructure protection research.

Problems in a particular infrastructure system cause two types of effects. Adverse effects on an important system of the first type of infrastructure are manifested in the force of interaction when the failure of one infrastructure sector causes the failure of another sector or its elements. The second type has a negative impact on the national interests outside the system, in particular on society, including security, the economy, and basic human needs. [14]

In both cases, the effects are structurally direct or indirect. The impact of a particular sector on another industry or community is considered direct or indirect. In contrast, indirect effects occur through the infrastructure sector, whether or not they affect another sector or society as a whole. Indirect effects can be secondary (through one sector) or multi-structured (through multiple sectors).

Other important features of the effect are its intensity and duration. The intensity of the impact depends on the scale of the failure in the sector (i.e., how it affects other sectors and the degree of interdependence of the sectors. [15] If the links are weak, the synergy effect is low and the impact on other sectors is only partial. , a combination of direct and indirect effects) and if they occur in real time, then the effect is synergistic.

The term “synergy” is derived from the Greek word “syn-ergazomai”, which means cooperation or joint action. Dictionary.com [16] defines synergy as “the interaction of elements that, when combined, produce an overall effect that is greater than the sum of the individual elements, contributions, and so on”. In the medical sciences, synergy is defined as the joint action of two or more muscles, nerves, or the like. In the fields of biochemistry and pharmacology, synergy is considered as a joint action of two or more drugs. Synergism in business management is the potential and ability to be more successful or effective as a result of the merger of individual organizations or groups.

The term synergy is used in many different forms in many areas of human activity, but it is rarely used in relation to infrastructure. [17] Research on synergy in the field of infrastructure was first studied in 2001 by Rinaldi et al. [18]. This research was the basis for the formation of classical theories of synergetic effects in the field of infrastructure. In online business dictionaries [19], a synergistic effect is defined as “an effect that occurs between two or more agents, objects, factors, or substances that is greater than the sum of their individual effects”.

In the studies of A. Nieuwenhuijs and others [20], several functions have been identified to express the effects at t1 and t2 and between t3 and t4. In particular, power outages have a social impact that occurs during t0 due to the effects of an emergency (e.g., wind). The failure of the drinking water sector is the result of a contraction in time t1, which leads to an increase in the social impact to 3. The maximum effect that results from the failure of two sectors occurs at time t2. In the time interval [t1, t3] there is a synergy of impact of the energy and drinking water sectors on society (i.e., level III synergy), which may lead to a synergistic effect that increases the overall impact. When the energy sector recovers at time t3, synergy and synergistic effects cease. Restoration of the drinking water sector will take up to t4 time. However, synergistic effects, as well as overall social impact, may increase or decrease due to the simultaneous impact of the failure of two or more elements / sectors in the infrastructure.

The synergetic effect is the opposite side of the synergetic effect, which is represented symbolically or in form. In physiology and medicine, this effect is described as "the opposite effect of substances such as drugs that reduce the effectiveness of at least one of them when taken together." [21] In the event of a major event or catastrophe, social and psychological impacts can have a series of impacts on the infrastructure, and disruptions related to common causes may be of minor importance.

III. METHODOLOGY

The study uses the SYNEFIA methodology to identify synergistic effects that occur as a result of problems in production infrastructure. The theoretical basis of the methodology is applied to the concept of symmetric operational impact, in particular, in determining the importance of interconnected networks, sub-sectors or elements of the production infrastructure.

In this case, the importance of small production infrastructure networks is directly proportional to the activity and passivity of other industries.

The SYNEFIA methodology consists of five stages:

1. Identification of production infrastructure networks.
2. Analysis of the correlation of industrial infrastructure networks.
3. Determining the importance of industries of production infrastructure.
4. Impact assessment.
5. Determine the synergistic effect.

A list of all infrastructure sectors to be evaluated at the stage of identifying the production infrastructure networks of the geographical region will be compiled. This phase also determines the maximum number of infrastructures to be considered in the region. Inventory should cover infrastructure networks more fully. Infrastructure networks vary significantly in regions that vary in geographical features. [22] For example, according to the annex to the Council of Europe Directive 2008, [23] only small sectors have been identified for the energy and transport sectors. Thus, it is necessary to form a list of small main production sectors for a geographical region, country or group of countries.

In the second stage, the interactions between the sub-sectors of the infrastructure system are assessed. It is recommended to use the KARS method [12] in this study. It is mainly used for quantitative analysis of risks based on risk correlation. The KARS method is a method of analysis that consists of components such as connecting, analyzing, and setting limits. [13]

The next step is to determine the interconnectedness of the infrastructure networks. Correlations are evaluated using pairwise comparisons that compare the importance of the two subsectors selected. A sub-sector that is more important than each pair is selected. Table 2 shows the correlation results.[14]

In the third stage, the activity and passivity hidden in each sector of the production infrastructure are identified. In particular, the KASi activity coefficient of the Si network represents the full potential of the Si network for the failure of other networks. It is calculated as follows:

$$K_A S_i = \frac{\sum_{i=1}^{n} A_i}{n-1} \qquad (1)$$

here,

A_i S_i in the entire production infrastructure network is the sum of the activities of the small infrastructure network;

n - number of small networks.

The $K_P S_i$ passivity coefficient of the S_i production infrastructure network represents the potential (strength) that can lead to the failure of the S_i sub-sector of other sub-sectors. It is calculated as follows:

$$K_P S_i = \frac{\sum_{i=1}^{n} P_i}{n-1} \qquad (2)$$

P_i is the sum of the passivity of the S_i sub-infrastructure network in the entire production infrastructure network;

n - is the number of production infrastructure networks.

In the next stage, the importance of infrastructure networks is segmented. It draws a graph of the interconnectedness of each sector based on the activity and passivity coefficients and is divided into four segments: In terms of importance, the I-segment includes infrastructure networks with the highest level of impact and dependence (core). Segments II and III represent infrastructure networks with the highest level of connectivity (secondary importance). In segment IV, there are sub-sectors with the lowest level of impact and dependence (tertiary importance).[15]

To divide into segments, the values of P1 and P2 are set using the Pareto principle, which helps to determine that 80% of the infrastructure networks are located in Segment I (the most important infrastructure subnets). The parameter P1 of the row $K_A S_i$- is calculated as follows:

$$P_1 = K_{A\,max} - \frac{K_{a\,max} - K_{a\,mix}}{100} * 80 \qquad (3)$$

$K_{a\,max}$ the maximum value of the activity coefficient;

$K_{a\,mix}$ the mnimum value of the activity coefficient.

The parameter P_2 of the row $K_P S_i$ is calculated as follows:

$$P_2 = K_{P\,max} - \frac{K_{p\,max} - K_{p\,mix}}{100} * 80 \qquad (4)$$

$K_{p\,max}$ maximum value of the passivity coefficient;

$K_{p\,mix}$ the minimum value of the passivity coefficient.

Thus, small networks with high levels of impact and dependence are considered more important. The importance of the S_i sub-sector R_i is expressed as follows:

$$S_i = K_A S_i + K_p S_i \qquad (5)$$

where S_i is the sub-activity coefficient $K_p S_i$ of the production infrastructure network and $K_p S_i$ passivity coefficient of the S_i infrastructure networks;

The fourth stage is to determine the strength of the interaction of each production infrastructure network. Impact is how the impact of a problem on a particular production infrastructure affects the overall infrastructure system. Note that the results at this stage and the next stage are expressed as percentages. Thus, the percentage S_i of the total impact of the C_i production infrastructure network is calculated as follows:

$$C_i = \frac{R_i}{\sum_{n-1}^{n} R_i} * 100 \qquad (6)$$

R_i - S_i the importance of a particular infrastructure network;

n - number of small networks.

The fifth and final step of the SYNEFIA methodology is to identify synergistic effects. In particular, problems in two or more manufacturing infrastructure networks are common synergistic effects on other industries. It is assumed that the synergistic effects are due to the lack of resilience of the infrastructure to the impact of the event, which results in cumulative effects.[16]

The degree of synergistic impact, for example, S1 and S2 represent situations that occur simultaneously in the production infrastructure. The degree of synergistic effect occurs as a result of the simultaneous failure of the S2 and S3 infrastructure networks (e.g., problems in the power grid, air transport failure), which is caused by the failure of the S2 sub-sector. These effects are all calculated as the sum of the synergistic effects that result from the failure of interconnected production infrastructure. For example, if the impact of a power grid failure is 5%, then the impact on other sub-sectors (e.g., information and communication systems and road transport) will also be 5%. This value increases the impact of the affected sub-sector on society, representing a synergistic effect.

Based on the above, the effect of the synergistic effect on total production as a result of simultaneous failure of certain connected industries in the production infrastructure of Si and Sj is explained by $C_{j;i}$:

$$C_{j;i} = \frac{C_j * C_i}{100} \qquad (7)$$

C_j – sector - the main problem is the observed network impact;

C_i – and the overall impact of the existing networks on the problem that occurred in the network where the interruption was observed;

After identifying synergistic effects, the overall impact (percentage) of the infrastructure system on society is expressed as follows:

$$C_Y = \sum_{i=1}^{n} C_i + \sum_{i=1}^{n} C_{j;i} \qquad (8)$$

$C_Y -$ the percentage of total synegetic effects that occur under the influence of networks where disruption is observed.

IV. CONCLUSIONS

According to the results of the study, infrastructure is the sectors of social importance and their relationships that are important for the continuous provision of national security, economy and basic social needs of the country. Certain interruptions always occur in infrastructure systems. At this time, it has always been a problem to calculate the total losses and the financial losses caused by a problem in this network. The proposed methodological approach has the potential to be used to calculate the overall synergistic impact of a problem on a particular infrastructure network and to predict total losses.

Determining synergistic effects due to problems in production infrastructure is of great importance in decision-making within the country and the industry to protect infrastructure. The presented SYNEFIA methodology provides not only production infrastructure, but also the ability to calculate the impact of social infrastructure on the country's economy.

The application of this methodology to the production infrastructure of the Republic of Uzbekistan demonstrates its intuitive attractiveness and usefulness and provides opportunities for use in the management of industrial sectors.

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