Complementarity of Communication and Coordination in Ensuring Effectiveness of Emergency Management Networks

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Abstract: Inter-organizational communication, coordination, and network effectiveness have long been of great interest. However, the level of their complexity and situational dependencies still create challenges for researchers and public managers. It is usually assumed that inter-organizational communication leads to inter-organizational coordination, but little is known how these processes interact and complement each other. This article aims at identifying relationships linking these processes and analyzing their impact on effectiveness of emergency management networks. Achieving the goal of the article based on the survey questionnaire conducted with 83 experts. The results were analyzed using the principal components analysis (PCA), correlation analysis, hierarchical clustering, and partial least-square path modeling (PLS-PM). The analyses conducted allow for identifying the dimensions of the research processes, and relationships linking them. This was the basis for building the research models testing how relationships between inter-organizational communication and coordination influence the effectiveness of emergency management networks. Comparing analyzed models points to complementarity, parallelism, and the possibility of a non-sequential course of inter-organizational communication and coordination.

Keywords: inter-organizational communication; inter-organizational coordination; network effectiveness; emergency management networks

1. Introduction

Inter-organizational communication and coordination have long been of great interest in both theoretical research and the practice of public organizations [1–4]. Communication is used to explain the specificity of events, exchange of views, and obtain information on the actions necessary to be taken both within and between organizations [4–6]. Properly conducted communication processes increase the stability of relationships, commitment, and trust of individual organizations in the implementation of joint ventures, and also contribute to building common standards [4,7]. In turn, the importance of coordination results from the growing complexity in the implementation of public tasks, as well as the need to cooperate in networks created by units from various sectors [8–10]. The need for these units to adapt to each other in both organizational and social matters, and the constant changes taking place in the operating conditions, pose difficult tasks for public administration decision-makers [9,11–13]. Undoubtedly, proper communication and coordination of activities in each undertaking are key determinants of the success of public networks, and the problems related to the implementation of these processes have still not been resolved. Previous scientific research in this field focuses on their course [14–18], mechanisms [19–22], and effects [23–25]. Interest in these processes has also increased significantly in governance networks [26–29]. However, research on what mechanisms constitute effective communication, coordination, and network effectiveness is relatively rarely undertaken [5,10,30].

Emergency management is a particularly representative research area in respect to inter-organizational communication, coordination, and network effectiveness, as it creates...
benchmark conditions for understanding these processes [2,3]. In practice, disruptions in communication and a lack of access to necessary information in emergencies often cause problems in communication and coordination, and consequently affect the effectiveness of the network [12,28,31–33].

Previous studies include inter-organizational communication mainly as one of the key inter-organizational coordination sub-processes, the basis for the effectiveness of projects undertaken in this field. According to T.W. Malone and K. Crowston [22], communication is one of the processes underlying coordination. In the area of emergency management, R. Chen et al. [34] and E. Gardet and C. Mothe [35] write that communication is one of the basic coordination mechanisms. In addition, L.K. Comfort [2] and E.C. Martin et al. [33] argue that coordination in dynamic conditions is based on effective communication. In the theory of relational coordination of J.H. Gittel [36], communication and relationships are the foundation of this coordination. However, little is known if and how coordination affects communication, and whether these processes interact with each other, which can ultimately stimulate coordination processes and effectiveness of networks [23,37,38]. Only few publications relate to the issue of researching the bilateral relationship between communication and coordination [18,26]. The above research gap is the reason for seeking answers to the following research questions:

1. What relationships connect inter-organizational communication, inter-organizational coordination, and effectiveness of emergency management networks?
2. How can the dimensions of inter-organizational communication and coordination affect effectiveness of emergency management networks?

The research in this article begin with the presentation of the specifics of emergency management, and the need for a network approach to activities undertaken in this field. Identification of the mechanisms of inter-organizational communication, inter-organizational coordination, and effectiveness of emergency management networks is the result of literature review. The analyses of these mechanisms based on the Exploratory Factor Analysis (EFA) and the PLS-SEM method. These methods allowed for the establishment of the dimensions of inter-organizational communication and inter-organizational coordination in emergency management networks, analysis of the relationship between these dimensions and building a model mapping the relationship between inter-organizational communication and coordination in the area studied. This was the basis for identifying new characteristics of the processes analyzed, the relationships between them, and formulating theoretical and practical conclusions.

2. Theoretical Background

2.1. Emergency Management Network

According to the United Nations Office for Disaster Risk Reduction [39] (p. 13), emergency management is ‘the organization and management of resources and responsibilities for addressing all aspects of emergencies, in particular preparedness, response and initial recovery steps’. Boin and Hart [40] (p. 357) state that emergency management applies to both fires and natural disasters, as well as a full range of other threats that may paralyze society’s life (e.g., pandemics, technical infrastructure failures, terrorist attacks, and outbreaks of mass violence). It includes activities undertaken before the emergence of a threat (mitigation and preparedness phases), during the threat (response), and after the threat is surmounted (recovery) [27,34,41].

Emergency management is an intentional activity carried out by authorities at all levels of state organization, involving specialized organizations, inspections, guards, and the public. These include [41,42]: local government units, emergency and rescue units, non-governmental organizations, research and development units, society, and media. Together, they form an emergency management network oriented toward helping people, protecting the environment, and saving property. The foundation of these networks, however, are blue lights organizations—police, state fire service, and emergency medical services [43,44]. Other entities support their activities, in accordance with the situational conditions.
Emergency management networks are one example of public networks, which are non-hierarchical interdependent structures involving three or more autonomous organizations or parts of them and oriented towards achieving a common goal [45–47]. They are dynamic in nature, constantly evolving, and the results they can achieve depend on their structural and behavioral specificity [48,49]. Relationships linking organizations in public networks are multifaceted. Because of them, public networks can meet social needs to a greater extent, develop the potential of individual organizations, as well as introduce changes and innovative solutions [50,51]. They cover various forms of inter-organizational relations (e.g., partnerships, coalitions, federations, alliances), however, the most common ones include 4C, that is [25,33,52]:

- Communication—transfer of information between organizations;
- Cooperation—voluntary, unstructured, and short-term relationships that do not require adjusting individual actions;
- Coordination—a permanent and formalized form of relationship consisting of mutual adaptation of organizations and connecting their interdependent elements of activity;
- Collaboration—a long-term relationship with a high level of mutual interdependence, which requires changes in the way individual organizations operate.

Communication is the most casual form of relationships, not creating the need to pool resources or goals. The increase in the intensity of relations is visible in cooperation, which manifests itself through mutual interaction and the pursuit of common tasks. Coordination consists of harmonizing the activities of many entities on the basis of formal and informal relations. Meanwhile, collaboration requires changes to the way organizations operate in a network, sharing power, pooling resources, and as a result, a high level of trust and commitment. It is associated with a high risk of failure of joint actions [48,52,53].

In emergency management, the necessity of a network approach stems from the specificity and complexity of undertaken actions and the scope of joint activities results from applicable legal regulations, individual arrangements, and built inter-organizational relationships. Network connections already appear during the planning and preparation of activities, which include the scope of training, procedures, and division of responsibility [54]. On a daily basis, when performing routine activities, individual emergency management organizations conduct their statutory tasks based on applicable policies and procedures. In the principal scope, the implementation of these tasks does not require joint actions with other organizations, but only the implementation of activities in accordance with a given specialization. In practice, even the implementation of basic tasks often takes place as part of inter-organizational relationships [27,55]. These relationships are characterized by varying intensity, degree of mutual adaptation, and risk of achieving common goals. However, the results of many studies indicate that, above all, problems in the processes of inter-organizational communication and coordination limit effectiveness of emergency management networks [14,27].

2.2. Inter-Organizational Communication in Emergency Management Networks

Inter-organizational communication in the basic sense consists of the multilateral transmission of information between entities. It is a key element of collective action [3,5,33,37,56]. In emergency management networks, inter-organizational communication is the foundation of the organization’s ability to make decisions and take actions adequate to changing and uncertain operating conditions [4,6]. P. Palttala and M. Vos [57] (p. 39) define it as ‘sending and receiving messages which explain the specific event, identify its probable consequences and outcomes, and provide specific harm-reducing information to affected communities in an honest, candid, prompt, accurate, and complete manner’. It aims at leveling the differences between individual units and focuses on common, unifying features but not on the dividing factors [2,7,58]. Its mechanisms include the creation of common meanings among individuals, groups, and units, and the interoperability of systems used by individual organizations [2,31–33].
The appropriate level of communication strengthens inter-organizational collaboration and is its driving force [28,36]. It is used to clarify the situation, understand the actions taken so far, and share knowledge and information about resources held. As a result, it creates the basis for the effectiveness of responding to emerging threats [31,32,58].

Although the organizations participating in emergency management are aware of the need to exchange information, they are often limited to obtaining information without paying attention to sharing it with others [32]. Hence, mechanisms such as communication frequency, constant contact during action realization, and continuity of vertical communication throughout all emergency management process can ensure the quality of information necessary to develop a common picture of the situation and joint action [3,28,59]. Consulting action plans and consensus skills may also be helpful in this respect [2,33,60]. They constitute mechanisms that ensure the efficiency of joint actions (Table 1).

Table 1. Mechanisms of inter-organizational communication.

| No. | Mechanism of Inter-Organizational Communication                                      | Source                        |
|-----|-------------------------------------------------------------------------------------|-------------------------------|
| 1   | Communication frequency during emergency management process                          | [18,28,33,36]                |
| 2   | Maintaining of constant contact during action realization                            | [2,3,59]                     |
| 3   | Information sharing during action realization                                        | [3,19,25,32]                 |
| 4   | Formalization of communication channels                                              | [18,32,59]                   |
| 5   | Communication informality                                                            | [3,19,25,36]                 |
| 6   | Up-to-datedness of transferred information                                           | [21,28,33,35,60]             |
| 7   | Precision of transferred information                                                 | [28,35,60]                   |
| 8   | Ability to reach an agreement                                                        | [33,60]                      |
| 9   | Capabilities to develop common solutions                                             | [2,22,33]                    |
| 10  | Consulting action plans with other organizations                                      | [2,33,35,60]                 |
| 11  | Existence of a common communication ground (e.g., compatible ICTs)                    | [2,3,33,31,32,59]            |
| 12  | Advantage of horizontal communication over vertical communication                      | [25,36,59,60]                |
| 13  | Continuity of vertical communication throughout the entire emergency management process | [3,31,60]                    |

2.3. Inter-Organizational Coordination in Emergency Management Networks

Inter-organizational coordination describes the activities directed towards achieving a specific bundle of common goals of different organizations [9,13,21,26,28]. In traditional terms, it refers to the structure of the organization, hierarchy, control, procedures, as well as standardization of processes and results [61,62]. Pursuant to this approach, formal authority, division of tasks and responsibilities, and linking the functions performed are the base of the coordination effectiveness. In turn, the network approach to coordination concerns informal relations, level of tasks decentralization, and dispersion of these tasks [8,61–63]. This approach stems from the current conditions of implementation of activities, according to which no organization operates individually but in networks, and the coordination of joint activities goes beyond traditional, intra-organizational, hierarchical mechanisms. It is based on both organizational and relational mechanisms that result from the multifaceted nature of coordination [11,20,28,64]. In this approach, inter-organizational coordination is largely informal and depends on the specifics of the entities involved, and the conditions and dynamics of changes in the environment in which they operate.

For the purposes of this article, N. C. Roberts’ [19] (p. 677) definition of coordination was adopted which states that inter-organizational coordination is ‘synchronizing of system elements to forge a coherent, integrated whole. Thus, coordination is not understood in terms of its results but by the attempts to integrate and design system activity’. This definition makes it possible to address the complexity of emergency management networks by incorporating both the formalized principles of inter-organizational collaboration as well as the informal relationships existing in these networks.

Current research conducted in emergency management networks identifies different mechanisms for solving inter-organizational coordination problems. Firstly, inter-organizational coordination serves the achievement of common goals [12,20,28]. Hence,
the ability to combine individual organization goals and the ability to focus not only on one’s own tasks but also on the tasks of the entire network is the starting point for common task design. To achieve the shared goals in emergency management networks, a division of roles, and the resulting tasks between cooperating organizations is needed [8,37,61,62,65]. These two mechanisms constitute the basis for dealing with chaos, doubling, or discontinuity of activities. This involves a clear division of responsibilities in emergency management networks and establishing links between the activities implemented [61]. As pointed out by Okhuysen and Bechky [66] (p. 473) ‘the most straightforward way in which plans and rules coordinate is by explaining the actions that different parties have to take to complete a task’. Assuming the obligations of implementing joint actions forces organizations in emergency management networks provide also the right amount of resources to implement individual actions, share them with other units, as well as to mutual adjustment [33,61,67,68]. However, each emergency is unique, takes place in different conditions, place, and time, and poses a threat to other people. This creates the need to ensure flexibility. For this reason, creating the conditions for effective action alone will not be enough without proper leadership and decision making at the level of task forces [63,65,69]. The mechanisms of inter-organizational coordination create conditions for faster management and adaptation to existing operating conditions [20,67]. These include mechanisms presented in Table 2.

**Table 2. Mechanisms of inter-organizational coordination.**

| No. | Mechanism of Inter-Organizational Coordination | Source |
|-----|-----------------------------------------------|--------|
| 1   | Clear division of responsibilities            | [18,21,22,52,61,64,66] |
| 2   | Transparency of each organization’s roles      | [22,52,61,62,66] |
| 3   | Clarity of each organization’s tasks           | [18,52,61,62,65] |
| 4   | Capableness in achieving common goals          | [20,22,28,33,64,70] |
| 5   | Adapting resources to the needs                | [21,25,33,61,64,68] |
| 6   | Flexibility of joint actions                   | [24,67,68] |
| 7   | Fast flow of resources between organizations   | [21,22,61,66] |
| 8   | Formalization of procedures and rules          | [20,25,52,62,67] |
| 9   | Strong leadership during task realization      | [40,62,69] |
| 10  | Possibility to make decisions at task force level | [19,63,65,69] |
| 11  | Quickness of adaptation to the conditions of action | [18,67–69] |
| 12  | Reciprocal adaptation of the organization      | [2,18,21,22,25,33,61,66,67] |

2.4. Effectiveness of Emergency Management Networks

Network effectiveness is the result of actions taken by all organizations in the network on the grounds of collaboration [29,71–73]. This collaboration is based on applicable legal regulations, contracts, and agreements to ensure the implementation of specific public tasks in a given administrative area. According to Provan and Kenis [74] (p. 230), network effectiveness is ‘the attainment of positive network-level outcomes that could not normally be achieved by individual organizational participants acting independently’. More specifically, Turrini et al. [70] (p. 529) refer network effectiveness to ‘the effects, outcome, impacts, and benefits that are produced by the network as a whole and that can accrue to more than just the single member organizations in terms of increasing efficiency, client satisfaction, increased legitimacy, resource acquisition, and reduced costs’.

The effectiveness of emergency management networks is based on planning, preparing, and taking such actions that will not allow the emergence of threats, and if this is not possible-taking the right actions quickly [68,75–77]. According to Bodin and Nohrstedt [78] (p. 183), ‘responses to collective action problems such as natural disasters are most effective when orchestrated within collaborative governance networks supporting resource-sharing, development of joint solutions, and coordination to avoid duplication of work’. Nowell et al. [68] state that capacities of effective emergency management networks include: rapid adaptation, distributed information management, bilateral coordination, and emergent collective action. Individual entities should keep in mind the goals they
want to achieve together and adapt their activities to these goals. The effectiveness of emergency management networks refers therefore to the extent to which its common goals have been achieved [70, 74]. These networks can be called effective if they help achieve planned goals, increase opportunities for inter-organizational learning, self-organization, adaptation to existing operating conditions, and strengthen inter-organizational relationships [23, 29, 38, 70, 75, 79]. In general, effective emergency management networks could lead to such results as presented in Table 3.

Table 3. Mechanisms of network effectiveness.

| No. | Mechanism of Network Effectiveness                          | Source          |
|-----|-------------------------------------------------------------|-----------------|
| 1   | Increasing the adaptability of the organization in the network to take actions adequate to current conditions [70, 75, 76, 80] |
| 2   | Increasing the capability to conduct actions [75, 76]     |
| 3   | Increasing the speed of action [65, 76]                     |
| 4   | Applying a proper action strategy [38, 65]                  |
| 5   | Achieving common goals [38, 70, 72]                        |
| 6   | Increasing the quality of actions [75, 76]                  |
| 7   | Increasing the innovativeness of implemented actions [70, 72] |
| 8   | Increasing flexibility of actions [65, 80]                  |

3. Methods

3.1. Literature Review

The aim of this article is seeking answers to the following research questions:

1. What relationships connect inter-organizational communication, inter-organizational coordination, and effectiveness of emergency management networks?
2. How can the dimensions of inter-organizational communication and coordination affect effectiveness of emergency management networks?

To achieve this goal, an initial literature review was first conducted. On this basis, keywords were adopted that were used in the systematic review of the literature [81, 82]. These were the following phrases: “emergency management”, “disaster management”, “communicat*”, “coordinat*”, “network”. In the first step of a systematic literature review, a pairwise search of adopted phrases was performed in the Scopus and Web of Science databases. These databases were selected because they contain works of high scientific value that are subjected to a rigorous peer-review process [83]. The search was carried out in titles, abstracts, and keywords, in articles, conference publications, and chapters in collective works, with no time limit. The obtained results were additionally reduced to the areas of business, management, public administration, and social science. Such search conditions have been intentionally adopted to redefine the number of publications, as the subject of inter-organizational coordination and communication in emergency management is significant and therefore popular. These studies were aimed at identifying key publications, and additionally, their large number could lead to a distraction to side issues. The search process led to 2178 records, which were analyzed for duplicate items, screened, and qualified on the basis of abstract analysis. 26 items were selected from the entire set of identified publications, and some of them were consistent with those identified during the initial literature review. In the inclusion phase, 6 more previously identified publications were added to the selected items. As a result, 32 publications were the basis for identifying the mechanisms of inter-organizational communication, coordination, and network effectiveness in emergency management networks. They formed the basis for questionnaire development and are included in Tables 1–3 in the Theoretical background section.

3.2. Research Process and Questionnaire

The analysis of the relationship between inter-organizational communication, coordination, and effectiveness of emergency management networks base on the results of a survey questionnaire conducted in June 2016 with experts dealing with the problems
of emergency management networks. Empirical research has been carried out in Poland, where, like in most countries, it is common that public administration authorities at all levels of the state organization (local, regional, and central) are responsible for conducting emergency management activities. In Poland, the tasks and scope of activities implemented in emergency management are regulated by the Constitution of the Republic of Poland and the Act of Emergency Management. These regulations are consistent with EU treaties, directives, and conventions.

Representatives of blue lights organizations, officials from local governments, and universities’ researchers from all over Poland took part in the research. Representatives of the first two groups were elected and delegated by local authorities, heads of provincial police and state fire departments as well as directors of emergency medical services on the basis of their experience and knowledge, which proved their position as experts. Scholars were selected based on the analysis of scientific achievements. The most known and publishing in the field of emergency management universities’ researchers were invited to the research.

The research was conducted during two seminars aimed at discussing problems and expectations in the field of collaborative emergency management. These seminars were organized as part of the emergency management research project carried out by the Silesian University of Technology. In the process of their preparation, discussions were conducted with the commanders of the polices and the fire brigades, the directors of the ambulance services, as well as with government decision-makers. These units declared their willingness to participate in the research. Almost 180 experts attended both seminars, but only 97 of them agreed to complete the survey. This survey was conducted personally, in a paper version. The analyses were based on 83 correctly filled out questionnaires. Representatives of blue lights organizations (36.1% of the surveyed population), officials dealing with the issue of emergency management from the position of local governance (34.9%), and researchers from universities (29%) participated in the studies. The mechanisms of inter-organizational communication, coordination, and network effectiveness identified throughout the literature review and presented in Tables 1–3 were included in the research. Together with the survey’s questions prepared for research, they are presented in Table 4. Answers to the questionnaire were on the 5-point Likert scale. Prior to the main studies, the questions in the survey were discussed with representatives of blue light organizations and local government.

**Table 4.** Mechanisms of inter-organizational communication, coordination, and network effectiveness adopted in the research.

| Mechanism                                      | Question in the Survey *                                                                 | Code |
|-----------------------------------------------|------------------------------------------------------------------------------------------|------|
| **Communication**                             | **Communication frequency during emergency management process**                         | com1 |
|                                               | Organizations in emergency management networks communicate with each other on a daily basis |      |
| **Maintaining of constant contact during action realization** | During the realization of joint actions organizations in emergency management networks are in constant contact with each other | com2 |
| **Information sharing during action realization** | During the realization of joint actions organizations in emergency management networks always share the information they possess | com3 |
| **Formalization of communication channels**    | Transferring of information in emergency management networks is based on formal communication channels | com4 |
| **Communication informality**                 | The nature of communication in emergency management networks is informal                | com5 |
| **Up-to-datedness of transferred information** | Information in emergency management networks is always transferred on time               | com6 |
Table 4. Cont.

| Mechanism                                      | Question in the Survey *                                  | Code  |
|------------------------------------------------|----------------------------------------------------------|-------|
| Precision of transferred information           | Information transferred in emergency management networks is always precise | com7  |
| Ability to reach an agreement                  | Organizations in emergency management networks are always able to reach an agreement | com8  |
| Capabilities to develop common solutions       | Inter-organizational meetings enable to agree solutions to problems connected with the realization of joint actions | com9  |
| Consulting action plans with other organizations | Organizations in emergency management networks consult together their own action plans with other organizations of this system | com10 |
| Existence of a common communication ground (e.g., compatible ICTs) | Organizations in emergency management networks have a developed common language, which facilitates their communication | com11 |
| Advantage of horizontal communication over vertical communication | Horizontal (inter-organizational) communication dominates in emergency management networks | com12 |
| Continuity of vertical communication throughout the entire emergency management process | The nature of vertical communication in emergency management networks is continuous | com13 |

**Coordination**

| Mechanism                                      | Question in the Survey *                                  | Code  |
|------------------------------------------------|----------------------------------------------------------|-------|
| Clear division of responsibilities            | In the realization of joint actions in emergency management networks it is always known, which organization is leading in a given situation | coord1 |
| Transparency of each organization’s roles      | The roles of each organization in emergency management networks are transparent | coord2 |
| Clarity of each organization’s tasks           | The responsibilities of each organization in emergency management networks are clear | coord3 |
| Capableness in achieving common goals          | The tasks of each unit in emergency management networks during joint actions are effectively realized | coord4 |
| Adapting resources to the needs                | The flow of resources during realization of actions in emergency management networks is suitable | coord5 |
| Flexibility of joint actions                   | The realization of joint actions in emergency management networks is characterized by flexibility | coord6 |
| Fast flow of resources between organizations   | The needs of each unit in the scope of action realization are replenished on an ongoing basis | coord7 |
| Formalization of procedures and rules          | The realization of joint actions in emergency management networks is based on formal procedures and rules | coord8 |
| Strong leadership during task realization      | The realization of joint actions in emergency management networks is coordinated by one person who is responsible for the course of commonly realized endeavours | coord9 |
| Possibility to make decisions at task force level | Joint actions in emergency management networks are conducted in task forces and the decisions are made at the level of these forces | coord10 |
| Quickness of adaptation to the conditions of action | Organizations in emergency management networks adapt their activities to the situational conditions | coord11 |
| Reciprocal adaptation of the organization      | It is a norm in emergency management networks to organize common meetings, exercises, and training | coord12 |
Table 4. Cont.

| Mechanism                                                                 | Question in the Survey *                                                                 | Code |
|---------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|------|
| **Network effectiveness**                                                 |                                                                                             |      |
| Increasing the adaptability of the organization in the network to take actions adequate to current conditions | Conducting activities in emergency management networks based on inter-organizational collaboration enables to undertake actions appropriate for a given situation | ne1  |
| Increasing the capability to conduct actions                              | Conducting activities in emergency management networks based on inter-organizational collaboration enables to realize the planned actions easier | ne2  |
| Increasing the speed of action                                            | Conducting activities in emergency management networks based on inter-organizational collaboration enables to realize the planned actions quicker | ne3  |
| Applying a proper action strategy                                         | Conducting activities in emergency management networks based on inter-organizational collaboration enables to realize the planned actions in an appropriate way | ne4  |
| Achieving common goals                                                   | Conducting activities in emergency management networks based on inter-organizational collaboration enables to achieve the assumed goals | ne5  |
| Increasing the quality of actions                                         | Conducting activities in emergency management networks based on inter-organizational collaboration enables to increase the quality of jointly realized actions | ne6  |
| Increasing the innovativeness of implemented actions                      | Conducting activities in emergency management networks based on inter-organizational collaboration increases possibilities of implementing the new methods of actions | ne7  |
| Increasing flexibility of actions                                         | Conducting activities in emergency management networks based on inter-organizational collaboration increases the flexibility of actions | ne8  |

* answers were given on a 5-point Likert scale.

After the survey conducting, the results were coded, and a database containing the collected empirical material was prepared, which was then analyzed using the adopted research methods.

3.3. Method of Analysis

The search for answers to research questions based on explorative studies using the principal components analysis (PCA), correlation analysis, hierarchical clustering, and partial least-square path modeling (PLS-PM). PCA was used to identify the dimensions of communication, coordination, and network effectiveness. Correlation analysis and hierarchical clustering were used to identify groups closely related to the previously identified dimensions. The results of this analysis were used to develop the structure of the model of the relationship between the identified variables. In the last stage, PLS-PM was used to identify the strength of dependence and verify the reliability of the received constructs.

The use of PLS-PM requires additional commentary. Current research presents numerous examples of using this method for confirmatory analysis, i.e., testing a pre-adopted model [84–86], confirmatory analysis, i.e., testing a pre-adopted model [87] or prediction [88]. It is being subjected to debate about which situations are more or less appropriate for using PLS-PM There is criticism of this approach and even the rejection of some of the sense of this type of analysis [89]. Although some studies show that PLS-PM models are even recommended in some situations [90]. However, there is consensus that PLS-PM models can be used in exploratory research, involving the search for the best possible model reflecting the relationships between variables, when the current knowledge about the studied phenomenon is limited [91–93]. As Hair et al. [94] (p. 5) suggests, researchers
should choose PLS-PM ‘when the research objective is to better understand increasing complexity by exploring theoretical extensions of established theories (exploratory research for theory development)’ and ‘when the structural model is complex and includes many constructs, indicators and/or model relationships’. This is the case here, which is why the choice of PLS-PM seems appropriate.

The following rules for model evaluation were used in the analyses:

1. **The assessment of the measurement model:**
   - Internal consistency reliability should be higher than 0.70, however in exploratory research 0.60 is also acceptable [94,95];
   - Indicator loadings should be higher than 0.70 [94,95];
   - The average variance extracted (AVE) should be higher than 0.50 [94,95];
   - Discriminant validity: the ratio of the correlations for each pair of the heterotrait-monotrait (HTMT) variables should be below 0.90 [94,95].

2. **The evaluation of the structural model:**
   - R² values of 0.75, 0.50, or 0.25 for endogenous latent variables in the structural model can be described as substantial, moderate, or weak, respectively [94,95];
   - Critical t-values for a two-tailed bootstrapping test are 1.65 (significance level = 10 percent), 1.96 (significance level = 5 percent), and 2.58 (significance level = 1 percent) [95].

3. **Model comparisons:**
   - Select the model that minimizes the value in Bayesian Information Criterion (BIC) compared to the other models in the set [94,96].

The analyzes presented in this article have been prepared based on the R programming language [97,98].

4. **Results**

4.1. **Identification of Variable Dimensions**

In the first step, for each of the mechanisms considered, Exploratory Factor Analysis (EFA) was carried out using PCA with Varimax rotation to identify their dimensions. The number of components was selected on the basis of the Kaiser criterion, i.e., those components whose eigenvalue was greater than 1 were selected [99].

In the case of inter-organizational communication, the Kaiser criterion identified 4 components, explaining a total of 64% of the variance. Indicators with the highest factor loadings were assigned to these dimensions, and only those indicators with loadings > 0.5 were selected. At this stage indicator 1 was rejected as its loading did not reach the required threshold on any of the components. The fourth component consisted of only two negatively correlated indicators coord4 and coord5, and it was omitted in further analysis. Finally, the following three dimensions were obtained, explaining a total of 55% of the variance:

- **COM1-**communication capacity, which is formed by: up-to-date nature of transferred information (com6), precision of transferred information (com7), ability to reach an agreement (com8), and consulting action plans with other organizations (com10);
- **COM2-**communication coherence, which includes: maintaining of constant contact during action realization (com2), information sharing during action realization (com3), and capabilities to develop of common solutions (com9);
- **COM3-**fluency of vertical communication include: existence of a common communication ground (e.g., compatible ICTs) (com11), advantage of horizontal communication over vertical communication (com12), and continuity of vertical communication throughout the entire emergency management process (com13).

In the case of inter-organizational coordination on the basis of the Kaiser criterion three components were selected, explaining a total of 65% of the variability. The coord12
indicator was rejected due to the value of the factor loading below 0.5. The three identified dimensions were the following:

- **COORD1**: organizational adjustment, which refers to: a clear division of responsibilities (coord1), transparency of each organization’s roles (coord2), clarity of each organization’s tasks (coord3), adapting resources to the needs (coord5), and fast flow of resources between organizations (coord7);
- **COORD2**: steering of activities, which is formed by: formalization of procedures and rules (coord8), strong leadership during task realization (coord9), and possibility to make decisions on task force level (coord10);
- **COORD3**: organizational integrity including such mechanisms as: capableness in achieving common goals (coord4), flexibility of joint actions (coord6), and quickness of adaptation to the conditions of action (coord11).

In the case of network effectiveness, one component was selected, explaining a total of 69% of the variance. All indicators assigned to it had factor loadings above 0.5.

### 4.2. Correlation Analysis and Hierarchical Clustering

In the next step, it was necessary to examine the relations between the identified dimensions. The means, standard deviations, and Pearson’s linear correlation coefficients were used for this purpose. They are presented in Table 5.

**Table 5.** Means, standard deviations, and correlations between identified dimensions.

| Dimension | Mean | Sd  | COM1 | COM2 | COM3 | COORD1 | COORD2 | COORD3 |
|-----------|------|-----|------|------|------|--------|--------|--------|
| COM1      | 3.64 | 0.64|      |      |      |        |        |        |
| COM2      | 4.19 | 0.51| 0.48 |      |      |        |        |        |
| COM3      | 3.69 | 0.53| 0.32 | 0.39 |      |        |        |        |
| COORD1    | 4.04 | 0.58| 0.58 | 0.41 | 0.29 |        |        |        |
| COORD2    | 4.00 | 0.70| 0.43 | 0.49 | 0.43 | 0.41   |        |        |
| COORD3    | 3.90 | 0.50| 0.45 | 0.52 | 0.22 | 0.63   | 0.43   |        |
| NE        | 4.27 | 0.50| 0.32 | 0.52 | 0.38 | 0.38   | 0.51   | 0.39   |

Based on Table 5, one can conclude that the correlations between the identified dimensions of the communication and coordination mechanisms are diverse and do not group within the dimensions of the same mechanisms. For example, the COM2 variable has a stronger relationship with the COORD3 variable than with the other variables that make up communication.

In order to group the identified variables, a hierarchical clustering analysis was performed. The grouping method was chosen using the Ward method, which creates groups minimizing intra-group variance, and a complement to one of the Pearson correlation value was chosen as the measure of distance [100]. The results of the analysis are presented in Figure 1. It can be noticed that there is a clear separation of two groups of variables: COM1, COORD1, and COORD3 as well as COORD2, COM2, and NE, with the variable COM3 being the link between them.
4.3. The PLS-PM Model

The hierarchical clustering results served as the basis for establishing the model’s structure. The resulting model is shown in Figure 2, along with the strength and significance of the impact of each variable. The $R^2$ value for endogenous latent variable NE was 0.375 which can be described as somewhere between moderate and week.

Evaluation of the PLS-PM model requires verifying several criteria [67]. The first is to check the indicators’ loadings to assess items’ reliability. The results are presented in Table 6. Only in the case of two items the recommended level of 0.7 was not reached, however, due to the information provided by these indicators, a decision was made to keep them. The values from Table 6 also show that the largest loading values are achieved for the respective variables.
The second criterion is the assessment of internal consistency reliability based on Composite Reliability and Cronbach’s alpha (alpha-C). Of all variables, only the COM3 variable does not meet the recommended alpha-C > 0.7 criterion (Table 7). However, due to the fact that alpha-C is considered a conservative measure and the CR value is in this case within the recommended range of 0.7–0.95, it can be considered that the criterion of internal consistency reliability is met. The next criterion is convergent validity, i.e., the assessment of the extent to which the construct explains the variability of the indicators assigned to it. In this case, the AVE coefficients for each variable are above 0.5, so this criterion is met. The next criterion is discriminant validity, i.e., verifying whether the variables are distinguishable from each other. In this case, it is recommended to calculate the ratio of the correlations for each pair of the heterotrait-monotrait (HTMT) variables—values below 0.9 indicate that the criterion has been met [94]. None of the calculated HTMT values (Table 7) exceed the limit value, thus it may be assumed that the discriminant validity criterion is also met.

For PLS-PM models, there is no global measure of model fit whose value would support the acceptance or rejection of a model. A certain hint in choosing a model can be its predictive value. As suggested by P. N. Sharma et al. [96] in the absence of additional data allowing for out-of-sample error comparison, this measure may be the Bayesian Information Criterion (BIC). In order to verify the predictive ability of the model, its BIC was compared with the same measure obtained on the basis of the sequential model, in which the dimensions of communication affect the dimensions of coordination and network effectiveness, and the dimensions of coordination affect network effectiveness (Figure 3).
Table 7. Consistency reliability, convergent validity, and discriminant validity (HTMT) measures.

| Dimension | alpha-C | CR   | AVE | R²   | COM1 | COM2 | COM3 | COORD1 | COORD2 | COORD3 |
|-----------|---------|------|-----|------|------|------|------|--------|--------|--------|
| COM1      | 0.82    | 0.88 | 0.67 | -    | 0.63 |      |      |        |        |        |
| COM2      | 0.72    | 0.85 | 0.65 | 0.36 | 0.47 | 0.59 |      |        |        |        |
| COM3      | 0.58    | 0.78 | 0.54 | 0.12 | 0.70 | 0.52 | 0.40 |        |        |        |
| COORD1    | 0.86    | 0.90 | 0.65 | 0.55 | 0.54 | 0.68 | 0.67 | 0.52   |        |        |
| COORD2    | 0.75    | 0.86 | 0.66 | 0.40 | 0.61 | 0.72 | 0.34 | 0.82   | 0.57   |        |
| COORD3    | 0.73    | 0.85 | 0.64 | 0.23 | 0.38 | 0.63 | 0.53 | 0.43   | 0.62   | 0.47   |
| NE        | 0.93    | 0.95 | 0.69 | 0.38 |      |      |      |        |        |        |

For PLS-PM models, there is no global measure of model fit whose value would support the acceptance or rejection of a model. A certain hint in choosing a model can be its predictive value. As suggested by P. N. Sharma et al. [96] in the absence of additional data allowing for out-of-sample error comparison, this measure may be the Bayesian Information Criterion (BIC). In order to verify the predictive ability of the model, its BIC was compared with the same measure obtained on the basis of the sequential model, in which the dimensions of communication affect the dimensions of coordination and network effectiveness, and the dimensions of coordination affect network effectiveness (Figure 3).

Figure 3. Model of sequential relationships between inter-organizational communication, coordination, and network effectiveness. The Bayesian Information Criterion (BIC) = −11.98. A clearly inferior BIC value for the first model indicates its better predictive capability.

5. Discussion and Implications

In this article, the dimensions of inter-organizational communication and coordination were identified, and the one-dimensionality of the network effectiveness variable was found. Then, correlation was analyzed, and hierarchical clustering was used to predetermine the relationship between the identified dimensions. On this basis, a model of complex relationships between inter-organizational communication, coordination, and network effectiveness was built. It was analyzed based on PLS-SEM structural equation modeling. Finally, the predictive abilities of the built model were compared with the predictive abilities of the model based on the sequential relationships between the variables studied. This approach allowed to analyze the relationship between inter-organizational communication and coordination processes, as well as to explore how the dimensions of these processes affect effectiveness of emergency management networks. This leads to the conclusion that the processes of communication and coordination in emergency management networks can interact and intertwine. Although in the literature dominates the view that communication is one of the determinants of coordination [20,21,26], the analyses carried out indicate, that the relationships between inter-organizational communi-
cation and coordination in an emergency management network are not always one-way relationships. These relationships can be bilateral, and coordination mechanisms affect communication processes. Moreover, communication processes significantly affect the network effectiveness, which is in line with the research of Turrini et al. [70] and Lucidarme et al. [72]. Bayesian Information Criterion (BIC) index also demonstrates a better predictive capability of the model of complex relationships and confirms our finding of mutual complementation of inter-organizational communication and coordination processes in emergency management networks.

Identified dimensions of inter-organizational communication and coordination and the relationships between them do not have to be sequential. The dimensions of inter-organizational communication tend to create a big picture of common actions and to develop a consensus. As Martin et al. [33] write, it is necessary to adapt to the institutional environment and situational conditions at the same time. In turn, the identified dimensions of inter-organizational coordination point to both the need to formalize the foundations of coordination (e.g., rules, tasks, roles) and the existence of strong informal relationships (e.g., informal standards, common values, and practices). However, the literature emphasizes the greater effectiveness of informal mechanisms over formal mechanisms [24,67]. Informal mechanisms combine individual perspectives for the implementation of activities and capabilities of individual organizations. Based on the results obtained as part of the PCA analysis, however, we assume that both types of mechanisms are complementary to each other and they are necessary in emergency management networks. This assumption results from the risk of failure of joint operations in dynamic and changing conditions [52,64], and formal mechanisms allow for the creation of a framework of inter-organizational communication and coordination. However, they are not sufficient, and they require the coexistence of informal relationships, such as inter-organizational trust and commitment, as well as the creation of common values and standards of action.

The main finding of this article is an indication that inter-organizational communication and coordination processes in emergency management networks can interact and intertwine, and their nature does not have to be sequential. It was established that although the dimensions of inter-organizational communication fulfill the role of initiator and integrator, the processes of inter-organizational communication and coordination complement each other, and develop in parallel. These complementarities generate the need for their complex development by managers of emergency management networks. Therefore, building effectiveness of these networks requires from managers using the necessary formal mechanisms of inter-organizational communication and coordination (e.g., division of tasks, setting rules) [52,61,64,66], and simultaneously paying particular attention to informal mechanisms (e.g., developing inter-organizational trust, informal contacts) [24,67]. They are responsible for building strong inter-organizational communication capacity and, at the same time, for developing the capacity for inter-organizational coordination, including organizational integration and adjustment.

The analyses carried out are not free from the limitations that point to future research. Firstly, the research was carried out only in Poland. Although Poland is a member of the European Union and the formal rules for implementing emergency management activities have been adapted to EU legal regulations, a different organizational culture, experience, values, and needs of individual entities exist in each state. These factors could affect inter-organizational communication and coordination processes in emergency management networks [64]. Secondly, the interactions of the processes studied may have a different nature in different contexts of public governance, and the findings presented in this article are based on the results obtain in emergency management networks. Therefore, it would be advisable to verify the developed model in other countries and in other contexts of public governance. The conducted tests and analyses, however, permit to make certain findings that can be verified in further research.
6. Conclusions

Ensuring the effectiveness of emergency management networks is extremely difficult. The nature, intensity, and location of each emergency are different, which forces taking different actions and engages different entities. During emergencies, the joint response is even more necessary, and it must be adapted to the situational conditions. For this reason, in each case, emergency management networks are of an individual nature, are deliberately organized and focused on solving specific problems. Inter-organizational communication and coordination are essential for this purpose.

In view of the above, this article is directed at searching for correlation between inter-organizational communication and coordination, as well as at identifying the impact of these processes on the effectiveness of emergency management networks. As a result of the analysis, significant findings were made, which could be classified in three areas: 1. Identifying of mechanisms and dimensions of inter-organizational communication, coordination, and network effectiveness in emergency management networks; 2. Determining relations linking the examined processes and revealing their bilateral nature; 3. Building the model of complex relationships between inter-organizational communication, coordination, and effectiveness of emergency management network and its comparison with the sequential model.

The identified dimensions of communication and coordination emphasize the need to create a common platform for perceiving and interpreting the situation, as well as the need for coherence and flexibility in communication and coordination. It was established that although the dimensions of communication fulfill the role of initiator and integrator, the processes of communication and coordination could be bilateral, complement and stimulate each other, and develop in parallel. As a consequence, the results obtained add a new knowledge to the theory of inter-organizational communication and coordination and also to the theory of emergency management. They can be useful for decision-makers to develop emergency management networks and to search for solutions in case of ineffectiveness of these networks. In the future, the obtained results could be verified in emergency management networks in other countries.

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