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Using the DEMATEL Method to Identify Impediments to the Process of Determining Compensation for Expropriated Properties

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Abstract: Laws governing the expropriation of real properties for public and socially useful purposes are in force in most countries. The problem of determining fair compensation for expropriated land is a very current one and has already been the subject of research. However, it deals mainly with the method of determining the value of the property without analyzing the procedure itself, and its weakest points in particular. The research objective is to develop a methodology to identify those factors that impede the entire process the most and should be eliminated in the first place. For this purpose, the authors firstly analyzed the procedure for determining compensation for expropriated real properties in Poland and identified factors that may adversely affect this process. Then, the decision support methods were reviewed. Due to the maturity, flexibility, and comprehensively verified quality, the DEMATEL method was used to achieve the research objective. This method allows for the efficient identification of all cause–effect relationships as well as key factors even in the case of very complex systems. Since the DEMATEL method is based on expert knowledge, the authors prepared a questionnaire and asked 16 experts—representatives of public administration at various levels, judges, and property appraisers—to assess the effect of individual factors on each other on a five-point scale. Finally, they analyzed the nature of the factors disturbing the course of the process of determining compensation for expropriated real properties. Thanks to the original multilevel application of the DEMATEL method, which took into account expert knowledge about the complex relationships between the factors, the authors demonstrated that in Poland the key roles in hindering the compensation determination process play two factors: the undetermined legal status and incomplete identification of real estate constituents. The proposed methodology is a universal one and may also be applied for the assessment of other administrative proceedings as well as various factors that determine them.

Keywords: property; expropriation; compensation; DEMATEL method

Citation: Kwartnik-Pruc, A.; Ginda, G.; Trembecka, A. Using the DEMATEL Method to Identify Impediments to the Process of Determining Compensation for Expropriated Properties. *Land* **2022**, *11*, 693. https://doi.org/10.3390/land11050693

Academic Editor: Liz Alden Wily

Received: 19 March 2022
Accepted: 3 May 2022
Published: 6 May 2022

1. Introduction

The institution of the expropriation of real properties for public purposes is in force in most countries. The problem of determining a fair level of compensation for expropriated land is a very current one and has already been the subject of research. It deals mainly with the method of determining the real estate value [1–4], the socioeconomic consequences [5,6], the assessment of the correctness of including the frequently complex legal status of real estate in the valuation [7–9], and factors contributing to the feeling of injustice expressed by expropriated owners [10–12]. The research presented in this paper, however, fills in a gap in existing research by focusing on the real estate expropriation procedure. The research objective is to develop a methodology for the identification of those factors that impede the entire process the most and should be eliminated in the first place.

Many authors point to the fact that compensation for expropriated real estate should correspond to its market value [13,14], though this is not always the same as fair compensation [6,15,16]. In postcommunist countries, these include forced land seizures performed by the state in the past without due compensation [17,18]. Another reason is that the interests of the expropriated are not fully taken into account. On the other hand, in countries where the state has abused its position in the past, as in postcommunist countries, expropriations are currently carried out in a complicated, multistage procedure (Figure 1).

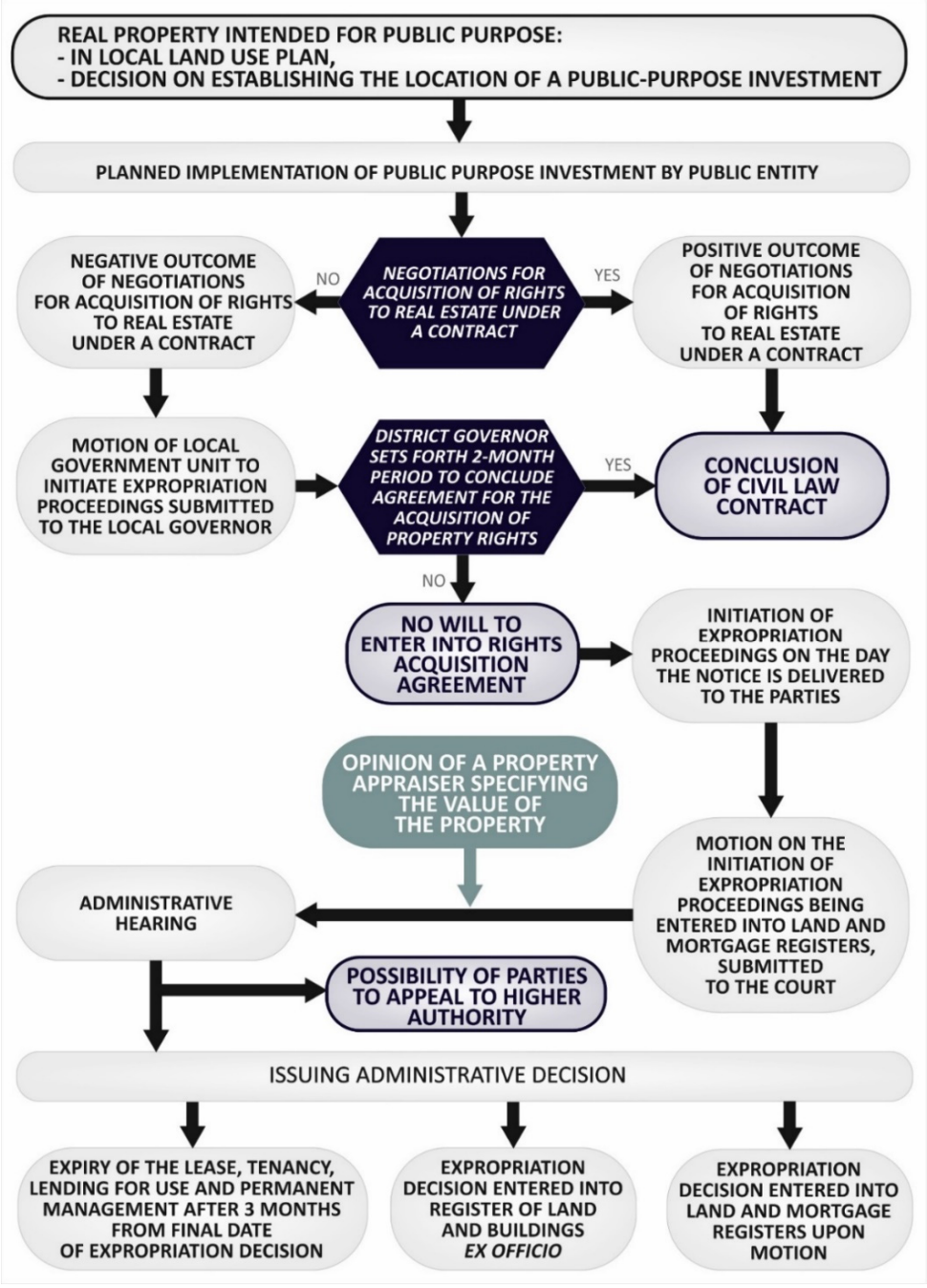

Figure 1. Real estate expropriation procedure in force in Poland. Source [19].

Such a complicated procedure may in some cases lead to a delay or resignation from the implementation of a public-purpose investment. For example, one street in Krakow (Poland) has been blocked for a period of over two years (Figure 2) due to the lengthy appeal proceedings against the expropriation decision. Similar situations may result from

complicated administrative procedures, the expectations of expropriated owners, and the appraisal reports not being accepted either by the authorities or expropriated entities. Owners of expropriated real estate are often interested in replacement properties, which in many cases is not possible to implement.

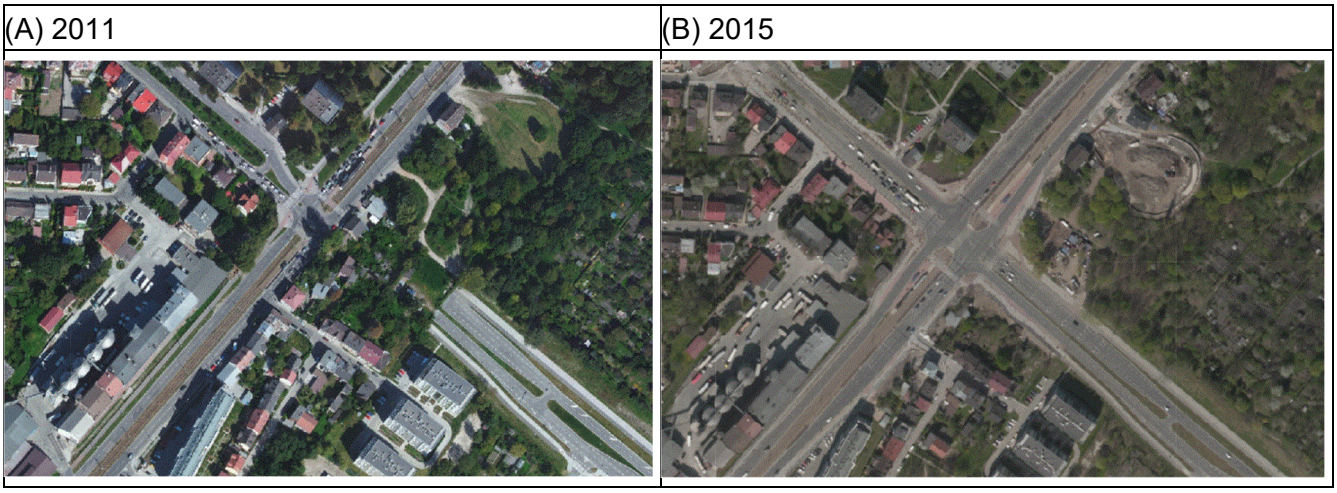

Figure 2. Example illustrating the effect of lengthy expropriation proceedings on the implementation of public purpose investment. Source: www.geoportal.gov.pl—accessed on 10 January 2022.

In the process of expropriation, it is important to balance the rights and obligations of both parties—that is, the public entity and the property owner. It should not be the case that the state abuses its rights by lowering the amount of compensation or delaying its payment. On the other hand, the owner of the property needed for the implementation of the public purpose investment should not be able to block it for a long period of time when it is known that sooner or later the investment must be implemented for the benefit of the public. Various factors may delay the expropriation or result in incorrectly calculated compensation, e.g., faulty valuation, improper administrative handling, or complaints filed by former owners. This will vary depending on the legal regulations of a given country and applied procedures. In Poland, due to the complicated expropriation procedure, there is a great number of these factors. Therefore, the research objective of this study was to develop a methodology identifying the factors that most impede the process of determining the amount of compensation. For this purpose, a detailed analysis of the Polish procedure for determining compensation for expropriated real estate was performed [20] and the available literature was analyzed.

This allowed for the identification of eight factors that could impede the process of determining the amount of compensation for expropriated real properties.

Then, the decision support methods were reviewed. Due to the maturity, flexibility, and comprehensively verified quality, the Decision Making Trial and Evaluation Laboratory (DEMATEL) method was selected to achieve the research objective. This method allows for the efficient identification of all cause–effect relationships as well as key factors even in the case of very complex systems. It has already proven to be useful in the real estate industry. For example, Wu and Guo [21] used it to identify the determinants of real estate prices. Lee [22] dealt with the problem of selecting the location for real estate brokerage services. In this study, DEMATEL was skillfully coupled with multiattribute decision analysis methods. The work [23] was devoted to the evaluation of the innovative abilities of companies in the industry, while Adegoke et al. [24] took up the issue of identifying the key determinants of the adoption of virtual reality technology in the practice of real estate agencies. DEMATEL also turned out to be an interesting tool for marketing analysis, as Ullah et al. [25] used it to recognize the perceptions of real estate website users.

Since the DEMATEL method is based on expert knowledge, the authors prepared a questionnaire and asked 16 experts—representatives of public administration at various levels, judges, and property appraisers—to assess the effect of individual factors on each other on a five-point scale.

Finally, they analysed the nature of the factors disturbing the course of the process of determining compensation for expropriated real properties. The use of expert knowledge and the DEMATEL method allowed for the identification of those factors resulting from the difficulties encountered, the identification of those factors that were their cause, and prioritizing factors adversely affecting the process of determining compensation for expropriated real estate.

The remaining part of the paper is structured as follows. The second section is devoted to literature review. Both the expropriation and DEMATEL related problematics are considered with this regard. Several topics are addressed in the third section. The topics include specific expropriation issues, the methodology for the identification of key factors and detailed DEMATEL technique procedure. Input results are also discussed there. The fourth section deals with the presentation of obtained DEMATEL analysis results. The outcomes of the analysis are discussed in the fifth section. The last section is devoted to final conclusions and plans for future research.

2. Literature Review

The literature review is divided into four subsections. The first subsection provides a broad overview of the literature thematically related to real estate expropriation. The second subsection regards the use of the DEMATEL method in real estate research. In the third subsection, the authors studied the factors affecting the process of determining compensation for expropriated real estate. The last one covers the gap analysis and research highlights.

2.1. Issues That Are the Subject of the Research on Real Estate Expropriation

Expropriation as a method of land acquisition for public investment purposes is implemented in numerous countries. Due to the compulsory nature of the acquisition of ownership rights to real estate by public entities, this process has been the subject of research worldwide.

Special attention is focused on the problem of determining the appropriate compensation for expropriated land. The methods of real estate valuation are analyzed [1,11], but so are the influence of various factors on property value [26–28]. The assessment of the correctness of including the frequently complex legal status of real estate in the valuation is a problem as well [9,29]. The researchers also highlight the socioeconomic consequences of the compensation process. This compensation should correspond to the market value of the property, which is not always the same as fair compensation [13,14]. In [7], the authors focus on the problem of insufficient inclusion of customary property rights common in African countries in compensation for expropriated real estate. In [10], attention is drawn to the limitations of property rights to real estate designated for public purposes in local plans before the actual expropriation takes place. The publication [5] discusses the problem of insufficient compensation for farmers for land expropriated for the mining industry in China and the related problems. The problem presented in [8] is expropriation for the purposes of urbanization of agricultural land and insufficient compensation not taking into account an increase in inflation, which results in compensation at the level of 37% of the value of current crops. Similarly, [30] emphasizes that the compensation procedure in Nigeria does not follow international standards, which results in insufficient compensation being paid for the land seized. Many authors acknowledge that the determined amount of compensation is inadequate to the losses suffered by property owners [6,16,31]. They point to unfavorable socioeconomic effects, including landlessness, poverty, and increased tension in relationships between the state and the community [12,32,33]. In [32] it was found that the compensation received did not take into account all the losses incurred. The

author, based on the analysis of proceedings and interviews with former owners, identified the issues that are of key importance for improving the perception of the expropriation process by landowners: "ethical behaviour by the acquirers; representativeness of the affected landowners; quality information throughout the process; accountability of acquirers; neutral review of objections; unbiased determination of compensation; and inexpensive conflict resolutions". Similar comments are made in [11], where the expropriation procedure was analyzed in terms of social justice. In [12], the author points out that the expropriation and compensation procedures must be transparent and predictable. Otherwise, it may result in unwanted negative conflicts. In [33], the authors acknowledge that compulsory acquisition has an "essential element of injustice (in the form of compulsion to sell) that cannot be avoided by a good process or a just compensation fee". Another problem is delays in paying compensation, which has a very negative effect on the situation that former owners find themselves in [10,11,30].

2.2. The Use of the DEMATEL Method in Research on Real Estate

It turns out, according to the Scopus bibliographic scientific database, that there are a dozen or so DEMATEL-related publications which actually deal with real estate problems. Several interests in the technique have been articulated with regard to the real estate industry. The first one deals with research directed towards the estimation of the state of the real estate market [34,35], and real estate price in particular [21,36]. The second one applies to the management of real estate enterprises: real estate brokerage agency services location selection [22], real estate innovation capabilities assessment [23], the adoption of new tools for real estate agency practice [24,37], and marketing service research for real estate agencies [25]. The third one addresses problems of urban development: combating blight, remediation, and social impacts [38–42]; urban regeneration [43–47]; and urban resilience and sustainability [48–52]. The fourth one deals with the assessment of real estate objects [53–55] and management (of historical buildings, in particular) [56,57]. Note that although there are quite a few real estate and DEMATEL-related publications, almost all of them come from just the last few years. It seems, therefore, that real-estate-based research interest only started very recently; hence, this technique has created a lot of interest among members of the real estate profession.

2.3. Identification of Factors Affecting the Process of Determining Compensation for Expropriated Properties

Due to the need to identify factors affecting the process of determining compensation for expropriated properties, both the procedure and the literature related to the process of determining such compensation, both in Polish and in English, were analyzed in detail.

The analyzed publications identified problems concerning the effect of the undetermined legal status of real properties on the process of determining compensation [58,59], guidelines on unifying the procedure for determining compensation [60,61], or determining compensation for real estate with established limited property rights [62]. The subject of the study was also the effect of incorrectly determined compensation on the timeliness of public investments [63,64]. Incorrectly determined compensation discourages owners from property disposal for public purposes [63] and result in appeals to higher administrative authorities and courts [65]. Another problem is the heterogeneity of the interpretation of the provisions concerning the determination of the value of expropriated property [19,66]. The method of selecting publications containing information on the procedure for determining compensation for expropriated real estate that is implemented in Poland and the detailed results of the analysis are presented in Section 3.1.

2.4. Gap Analysis and Research Highlights

From the literature review above, many studies focus on the analysis of the method of determining the real estate value, socioeconomic consequences, and factors contributing to

the feeling of injustice expressed by expropriated owners. However, the presented studies did not focus on the compensation determination procedure itself.

The DEMATEL method has already been used to evaluate a variety of real estate processes. To the best of our knowledge, there has been no research report on its application in the identification of factors affecting the process of determining compensation for expropriated properties and their assessment. Poland is a good area for research because the procedure is very complicated. Its implementation is difficult and, as shown by examples from practice, it prolongs or even blocks public investments.

To fill this gap, our study proposes optimizing the process of determining compensation for expropriated real estate. It is important and, as demonstrated by the analysis of the publications presented above, there are no studies yet that have focused on the analysis of the procedure itself in order to optimize it. This prompted the authors to deal with this specific research problem. The proposed methodology is a universal one and may also be applied to the assessment of other administrative proceedings as well as various factors that determine them.

3. Materials and Methods

3.1. Identification of Factors Affecting the Process of Determining Compensation for Expropriated Properties

In order to identify factors adversely affecting the process of determining compensation for expropriated properties in Poland, the procedure for determining compensation for expropriated properties as well as the thematically related literature were analyzed in detail.

Following [67,68], the Scopus, Web of Science, and Polish BazTech databases were reviewed by searching for publications in international databases using the following keywords: expropriation, compensation, and Poland, because it is the procedure used in Poland that is the subject of the analysis. Figure 3 illustrates the method for selecting publications containing information on the procedure for determining compensation for expropriated real estate.

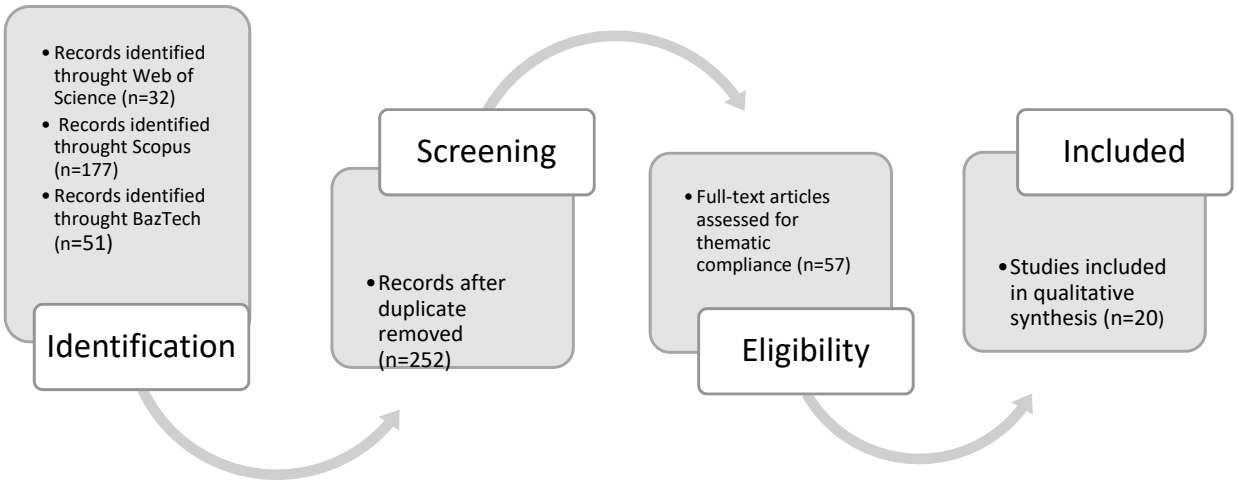

Figure 3. The method for selecting publications containing information on the procedure for determining compensation for expropriated real estate implemented in Poland.

The aim was to identify factors that had a negative effect on the process of determining compensation for expropriated real estate in Poland. The table below (Table 1) demonstrates the identified factors, with reasons and references to the source.

Table 1. Identified barriers to the process of determining compensation for expropriated real estate in Poland.

Factor	Reasons	References
Undetermined legal status of expropriated real estate	The problem of undetermined legal status of properties expropriated ex officio identified as the basic one that hinders and delays the process of compensation for expropriation.	Trembecka [59] Ministerstwo [69] Kwartnik, Kolińska, Trembecka [59]
Incorrectly determined compensation	Incorrectly determined compensation causes problems with the promptness of public investments. It also results in owners' reluctance to sell their land for public purposes.	Hełdak et al. [63] Zyga [64] Woś [65]
Lengthy compensation proceedings	Problem occurrence at the stage of determining the legal status of expropriated land directly affects the time of its implementation.	Walacik [70] Hełdak et al. [63]
Incomplete identification of real estate constituents (building structures, plants, limited property rights)	Compensation should apply not only to the value of the real estate itself but also to buildings and other structures (including trees and other plants) on its premises.	Wolanin [60] Wrześniak [61] Brucko-Stępkowski [62]
Incorrect real estate survey prepared by property appraiser	Despite the fact that the value of expropriated real estate was estimated by property appraisers in accordance with the applicable methodology and professional standards, there were cases of underestimation of their values or lack of revaluation in the examined area.	Źróbek [71] Jaworski J, Prusaczyk A., Tułodziecki A., Wolanin [72] Strzelczyk [73] Stanek [74]
Contestation of the amount of compensation and appeal to higher administrative authorities and courts	Undetermined compensation and its nonpayment are caused by: owners contesting the amount of compensation and appealing against compensation decisions to second instance. It may be due to failure to take land use into account in the valuation or such elements as costs and fees related to the purchase of a new property.	Trembecka [29] Hełdak et al. [63] Woś [65]
Inconsistent interpretation of regulations on real estate appraisal	Indicating the validity of introducing precise legal regulations concerning the procedure in compensation cases, aimed at eliminating inconsistent interpretation as well as divergent lines of administrative court jurisdiction.	Trembecka [58] Trembecka [66] Źróbek S, Źróbek R., [75] Stanek [74]
Incorrect administrative handling (staff not prepared in terms of content and numbers)	Efficiency of administration is expressed by the degree of utilization of the existing possibilities regarding the optimal performance of tasks under given conditions. Gradual improvement of the quality and availability of sources of information on real estate requires the use of advanced analytical instruments in real estate appraisal. Possibilities resulting from the use of modern and advanced solutions supporting the real estate appraisal process require knowledge of these methods.	Dobrowolski [76] Kotrasiński, Nurek [77] Dolewka [78]

3.2. The Identification of Key Factors Methodology

There are very different techniques available which are capable of supporting the solution to the problem. Both statistical and econometric analyses can be applied in this regard. The availability of numerical data is nevertheless necessary to enable their use. Direct measurements of physical entities and questionnaire-based research are often used to provide necessary data. The possible complex interdependence of factors and their intangible character often result in a need for the application of more versatile and flexible

techniques to solve key factor identification problems. This is why cause–effect chain and intangibility-aware identification techniques may prove particularly helpful in this regard. Matrice d'Impacts Croisés, Multiplication Apliquée à un Classement—Matrix-based Multiplication Applied to a Classification—MICMAC [79], Interpretative Structural Modeling–ISM [80], and DEMATEL [81] exemplify such techniques. The techniques are over 40 years old. They nevertheless still remain very popular thanks to their inevitable merits [82–84]. They all rely on the opinion of experts about the direct influence of factors on other factors. The opinions provide the users with a mechanism necessary to assess the direct impact of factors by means of specific ordinal scales. Matrix calculations are then applied to derive information about the total influence of factors. The techniques differ in the form of the provided results. The application of the DEMATEL technique also provides users with more sophisticated tools for the comprehensive analysis of complete structures of direct, indirect, and total influence in comparison with MICMAC and ISM. It also delivers numerous tools for advanced analysis, e.g., the detailed analysis of the total influence formation process, the diverse interactions between the factors, and the influence of experts' perceptions [85]. This is why the DEMATEL technique was finally applied to deal with the problem discussed in the paper.

3.3. The DEMATEL Technique

The technique is named after the research project—Decision Making Trial and Evaluation Laboratory—it was developed for. The project was implemented by Emilio Fontela and Andre Gabus at the Batelle Geneva Research Centre, aka Batelle Research Institute, Geneva, Switzerland, back in the early 1970s. It was devoted to identifying the structure of the main problems of the contemporary world and their perception by the representatives of diverse cultural, social, economic, political, religious, etc., circles from all over the world [81,86].

Initial interest in the practical application of the technique was shown in the 1980s in the Far East. Far East users were also responsible for the second, evidently more vigorous, wave of interest in the utilization of DEMATEL. The technique spread to be used in diverse new areas. The second half of the first decade of the twenty-first century brought a meaningful turn in DEMATEL-based research as the number of dedicated publications started to grow rapidly. The community of DEMATEL-technique users also started to become more and more geographically dispersed then. For example, according to the Scopus scientific bibliographic database, only one or two dedicated publications appeared annually, and since 2006 the number of publications has grown constantly year after year. In 2020, the Scopus database registered over 500 dedicated publications out of over 2600 dedicated publications in general. Additionally, the authors of the DEMATEL-technique-related publications represent all continents, although authors from the Far East still prevail.

The popularity of DEMATEL-technique-related publications is also largely influenced by the fact that it has mainly developed in the course of its actual applications. Thus, it underwent diverse improvements that made it an acknowledged, universal tool for the identification of cause–effect chain components under imperfect information. Hence, the major interest in the technique results from its actual enhancements rather than the actual field of application.

DEMATEL application flexibility made it a welcome tool to solve various problems arising in diverse fields. The problems often differ very much from the original purpose served by the technique. The growing popularity of the technique led not only to specific interests in its application [87] and to the adoption of a notion of stochastic influence [88]; it also resulted in numerous efforts to enhance it so that it was strictly adopted for actual user needs and a specific direct-influence assessment application [89]. The merits of the DEMATEL technique were also fully utilized when it was combined with other tools to enhance them [90] or when used to directly enhance the internal mechanisms of other tools [91]. Cases of practical application also provide a kind of a training ground for numerous proposals for the enhancements of the DEMATEL-technique internals. The most

popular enhancement deals with the application of a specific number of ordered direct-influence scale levels. The other notable enhancements cover the adequate expression of direct influence [92], the reliability of calculation procedures [93], the presentation of essential outcomes [94], and the ranking capability [95]. For the detailed discussion of DEMATEL's merits and its application potential the reader may consult dedicated surveys, e.g., [96].

The universal methodology of the technique is capable of deriving information about the overall structure, the total influence of all the considered factors, and also information about the direct influence of one factor on other factors. The notion of influence corresponds with the distinct nature of the problem considered. Hence, the considered influence may deal with any kind of action of factors, e.g., economical, societal, environmental, military, etc. To make use of imperfect information about direct influence, the opinions of experts are applied in DEMATEL. The opinions are based on the application of a multilevel scale of judgements about the direct influence of factors on one another. Hence, pairwise comparisons are used to derive the complete picture of the direct influence of distinct factors. In the original setting, the direct-influence scale consisted of the following five levels:

0—no direct influence,
1—a noticeable influence,
2—big influence,
3—very big influence,
4—extreme influence

of the i-th consecutive factor on the j-th consecutive factor (i, j = 1, 2 . . . , n), out of n factors.

Note that any number of scale levels is usually acceptable nowadays, as it deems to result from the specific research context. However, the application of the five levels of the direct-influence scale adhere well to general psychological rules for making meaningful pairwise judgements easier [97]. According to the general DEMATEL rule, no direct influence by itself is considered in the case of any factor.

A complete set of direct influence judgements is put into a quadratic n-by-n matrix called the direct influence matrix. The consecutive rows and columns of the matrix are devoted to consecutive factors. The matrix component located in the i-th consecutive row and the j-th consecutive column corresponds with the judgement for the direct influence of the i-th consecutive factor on the j-th consecutive factor. Each engaged expert delivers such a matrix on its own. The matrix provided by the k-th consecutive expert, out of K experts, is denoted by X(k). Judgements are then aggregated to form the average direct influence matrix X*. The simple unweighted average is usually applied in this regard:

$$X^* = \frac{1}{K} \sum_{k=1}^{K} X(k). \quad (1)$$

It is nevertheless also possible to include the difference in credibility of expert opinions due to their different quality. The weighted average may provide the necessary means for aggregating the opinions of experts in such cases.

X* then undergoes a special transformation to become the normalized direct influence matrix X:

$$X = \frac{X^*}{\lambda}. \quad (2)$$

where: λ is the scaling factor which ensures that:

$$\lim_{p \to \infty} X^p = \varnothing, \quad (3)$$

where: ∅ denotes a quadratic null matrix which is compatible with the X matrix.

In other words, the scaling factor λ allows the successful transformation of the average direct influence matrix into the form, and a sequence of consecutive powers is convergent to the null quadratic n-by-n matrix ∅. The transformation is necessary to express the indirect

influence of factors which result from the transmission of influence through intermediate factors by the following sum of consecutive X matrix powers:

$$\Delta X = \sum_{p=2}^{\infty} X^p, \tag{4}$$

and, finally, by the components of the following matrix:

$$\Delta X = X^2(I - X)^{-1}, \tag{5}$$

where: I is the n-by-n quadratic identity matrix.

The application of the scaling factor λ value equal to the largest row-wise sum of X* matrix components is usually sufficient to obtain the X matrix with property given by Equation (3).

The total influence, which includes both the direct and indirect influences, is expressed by the n-by-n quadratic matrix of total influence T:

$$T = X + \Delta X. \tag{6}$$

The property in Equation (3) results in the following expression for T:

$$\Delta X = X(I - X)^{-1}. \tag{7}$$

Matrix T component t_{ij} expresses total influence of the i-th consecutive factor on the j-th consecutive factor. Note that matrix components which correspond with the same factor, i.e., t_{ij}, can now be nonzero. This is because total factor influence also covers the indirect influence of a factor via the influence of other factors.

The exploration of information about total influence results in two indices which allow factors to be classified. The first index is called the prominence (or the position). It is denoted for the i-th consecutive factor as s_i^+. It is used to express, for a given factor, the strength of influence links with other factors. It is given by the addition of sums of the T-matrix components which make up the i-th consecutive row and the i-th consecutive column of the matrix:

$$s_i^+ = \sum_{j=1}^{n} t_{ij} + \sum_{j=1}^{n} t_{ji}. \tag{8}$$

The second index (s_i^-) is called the relation. This indicates the actual—causal or effective—role of the i-th consecutive factor. Note that its value may be both positive and negative. The former value provides evidence that a factor is a cause indeed, while the latter value expresses the effective role of a factor. The higher the absolute value of the index for a given factor is, the clearer the cause or effect it is, respectively. The value of the index is given by the difference between the adequate row-wise sums and columnwise sums:

$$s_i^- = \sum_{j=1}^{n} t_{ij} - \sum_{j=1}^{n} t_{ji}. \tag{9}$$

To facilitate the classification of factors they are expressed by points in a two-dimensional prominence-relation diagram. The diagram is interpreted in a well-known magical quadrantwise manner. Hence, the plane of the diagram is divided into four quarters according to the values of prominence and relation indices. Points of causal factors occupy two top quarters. The factors are the most important because their improvement may influence the improvement of other factors that are influenced by them. The points of least important effect factors—that is, the factors that are least involved in the total influence of factors (lower prominence values and negative relation values)—reside in the bottom left quarter.

Note that both the direct influence X and indirect influence ΔX of factors may also be analyzed in the same way that the total influence of factors are. The following formulae

may be applied to express the prominence and relation with regard to direct influence Equations (10) and (11) and with regard to indirect influence Equations (12) and (13):

$$s_i^+(\text{dir}) = \sum_{j=1}^{n} x_{ij} + \sum_{j=1}^{n} x_{ji}, \tag{10}$$

$$s_i^-(\text{dir}) = \sum_{j=1}^{n} x_{ij} - \sum_{j=1}^{n} x_{ji}, \tag{11}$$

$$s_i^+(\text{ind}) = \sum_{j=1}^{n} \Delta x_{ij} + \sum_{j=1}^{n} \Delta x_{ji}, \tag{12}$$

$$s_i^-(\text{ind}) = \sum_{j=1}^{n} \Delta x_{ij} - \sum_{j=1}^{n} \Delta x_{ji}. \tag{13}$$

The DEMATEL technique is most often applied for the identification of the factors' role and the identification of key factors, as in the case of this paper. The original methodology of the technique nevertheless offers more possibilities for its application, which are yet to be fully utilized [86].

Note that some enhancements were proposed to directly deal with imperfect information about direct-factor influence while trying to enhance DEMATEL. However, their direct use seems to be controversial. This is because they seem to unnecessarily duplicate inherent mechanisms for expressing the representation of imperfect information by means of the ordinal direct-influence scale [98]. This is why the application of the technique in this paper is based on a traditional way of expressing such information by means of the original casual five-level direct-influence scale from 0 to 4.

3.4. Input Data

The factors selected earlier based on the literature (n = 8) impeding the outcomes of real property valuation in case of property expropriation were used. The factors were coded by symbols A1 through A8. The meaning of the factors is presented in Table 2.

Table 2. The meaning of factors and their denotations.

Factor	Meaning
A1	Undetermined legal status of expropriated real estate
A2	Incorrectly determined compensation
A3	Lengthy compensation proceedings
A4	Incomplete identification of real estate constituents
A5	Incorrect real estate survey prepared by property appraiser
A6	Contestation of the amount of compensation and appeal to higher administrative authorities and courts
A7	Inconsistent interpretation of regulations on real estate appraisal
A8	Incorrect administrative handling

Then, a 56-question questionnaire was prepared, in which respondents were asked to assess, on a five-point scale, the impact of each of the eight factors on each other.

A group of K = 16 experts were asked to complete the questionnaire. The experts represented the following fields and expertise:

- An administrative employee carrying out the procedure in the first instance authority, entitled to issue decisions on compensation;
- An administrative employee carrying out the procedure in the second instance authority, considering owners' appeals against compensation decisions;
- Judge of the provincial administrative court, specialist in public real estate law;

- Property appraiser with a state license in property valuation granted by the minister after conducting the qualification procedure.

Expert opinions were used to compose the structure of the direct influence of factors. The five-level direct influence scale was applied in this regard. The opinions are presented in tables contained in Supplementary Material. The components resulting in the average direct influence matrix X* that were derived by means of Equation (1) application are presented in Table 3.

Table 3. Average direct influence matrix X* components.

	A1	A2	A3	A4	A5	A6	A7	A8
A1	0.0000	1.6875	2.9375	1.1250	1.0000	2.0625	0.6250	1.8125
A2	0.0625	0.0000	3.3750	0.0625	0.0000	3.5000	2.3750	2.3750
A3	0.8125	0.8750	0.0000	0.6250	0.7500	1.9375	1.0000	1.6875
A4	0.6250	2.0625	1.8750	0.0000	1.9375	2.8125	2.0000	1.5625
A5	0.0000	3.7500	3.6250	0.1250	0.0000	3.7500	2.1875	2.4375
A6	0.6875	1.3750	3.5625	1.7500	0.5000	0.0000	0.8750	1.7500
A7	0.1250	3.3125	2.9375	2.3750	2.9375	3.0625	0.0000	2.4375
A8	0.8125	2.7500	3.3750	1.6875	1.5000	2.6250	2.0000	0.0000

4. Results

This section is devoted to the presentation of results of multiple-stage DEMATEL application for the identification of the key factors for abnormalities in the process of real estate valuation for expropriation purposes.

4.1. The Analysis for the Full Factors Set Case

The application of the DEMATEL technique was implemented through a universal, open-source spreadsheet software; *R system for statistical computing* version 3.5.1 (2 July 2018, R Core Team, Vienna, Austria), codename *Feather Spray* was applied to make the actual calculations. The software is available for instant download at https://www.r-project.org (accessed on 1 April 2022). *R Studio*© IDE, version 1.3.1093, available at: https://www.rstudio.com (accessed on 1 April 2022), was applied to control the calculations. Additionally, 64-bit MS Windows 10 OS and *Lenovo*™ *ideapad*™ *700* notebook with *Intel*® *Core*™ *i7-6700HQ* CPU and 16 GB RAM provided the necessary means for running the software. The source code for the calculations is available from the authors upon request.

The results of calculations for the full set of eight factors are presented in several figures. Matrix X is obtained by means of Equation (1). Figure 4 deals with cases of direct influence. The prominence and the relation indices were obtained by means of Equations (10) and (11), respectively. Figure 5 was obtained for the case of indirect-influence-related indices—Equations (12) and (13). Finally, results for the total influence case are presented in Figure 6, where the prominence and the relation indices result from Equations (8) and (9), respectively.

All three Figures present a pretty uniform qualitative picture of the character of factors, regardless of whether we consider only the direct, indirect, or total influence. The strongly positive relation index values for four factors: A1, A5, A4, and A7 confirm their causal role. The casual role of these four factors testifies to their possible function as key factors which impede the determination of compensation for expropriated properties. Strongly negative relation index values for three factors, namely A3, A6, and—to a slightly lesser extent—A2, unveil that they comprise evident effects of the influence of causal factors. That is, they seem to appear under the presence of identified causers only. A slightly positive value of the relation-index value for the remaining factor A8 testifies to its rather indistinct character. Hence, it can be treated neither as the actual cause nor the actual effect. On the other hand, it can be concluded, based on the prominence values of factors, that the majority of them are strongly connected with each other in the sense of influencing other factors and being influenced by other factors. In fact, only one factor, namely A1, exercises rather slight interference with other factors.

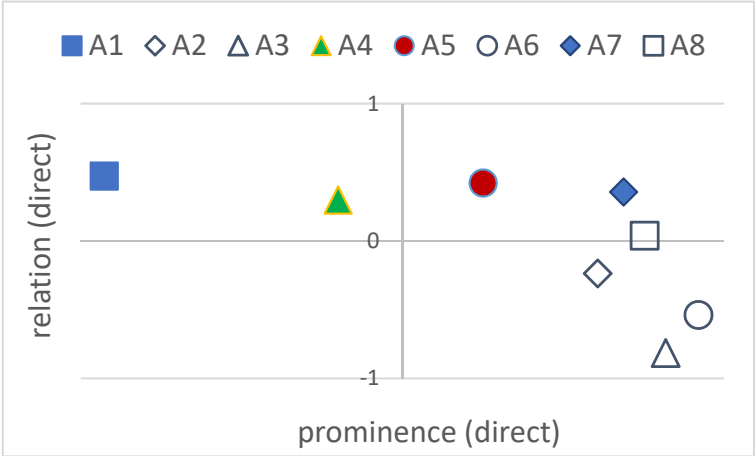

Figure 4. Results for full set of factors; the direct influence X case.

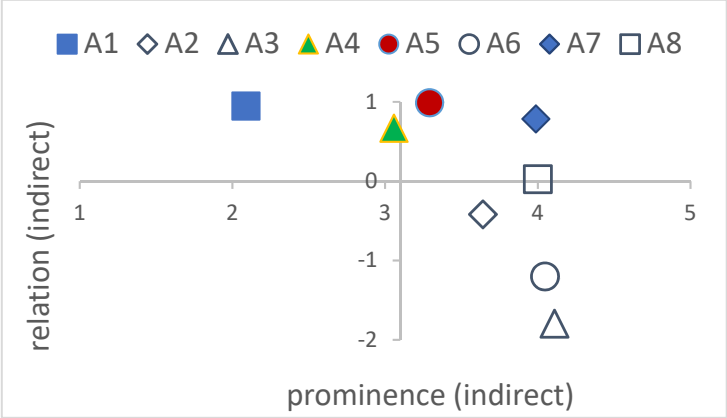

Figure 5. Results for the full set of factors; the indirect influence ΔX case.

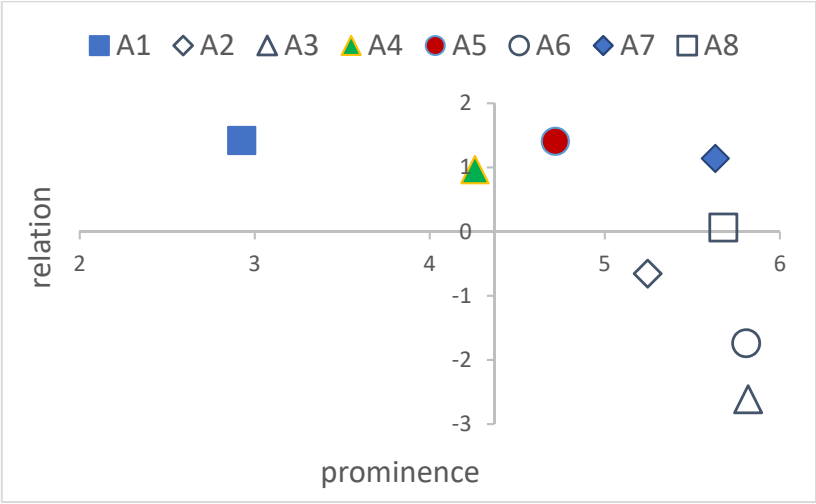

Figure 6. Results for the full set of factors; the total influence T case.

Note that the difference regarding the relation index value between the causal factors is very small. This is why it seems purposeful to analyze the influence of these four factors on each other to identify which of them are the actual key factors. The application of a specific, limited, and more detailed DEMATEL analysis was proposed in order to perform this. By the way, it seems that the concept of such multilevel usages of the technique were

not used in the past. The proposal may be even concerned as original and, therefore, vital enhancement of DEMATEL methodology.

4.2. Analysis of the Limited Factors Set Case

The second stage of the DEMATEL technique application was devoted to the set of four factors which proved to be the only evident causes in the full factor set case, namely: A1, A5, A4, and A7. The results of the calculations are presented in Figures 7–9. They correspond to the cases of direct, indirect, and total influence, respectively.

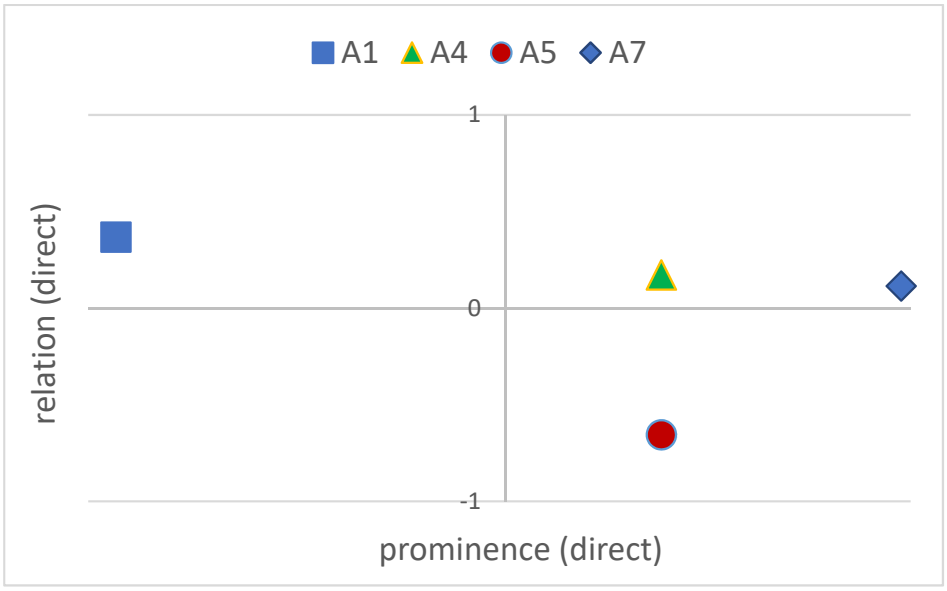

Figure 7. Results for the limited set of factors; the direct influence X case.

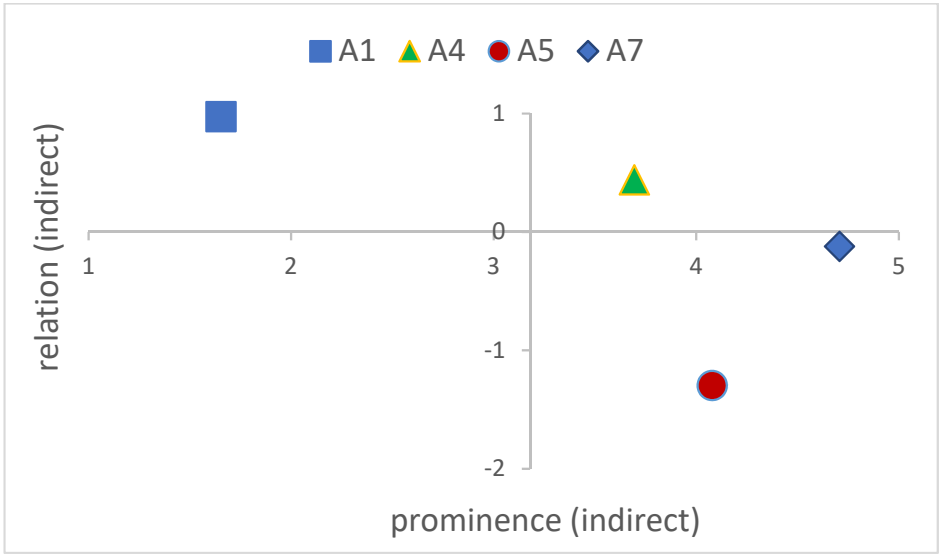

Figure 8. Results for the limited set of factors; the indirect influence ΔX case.

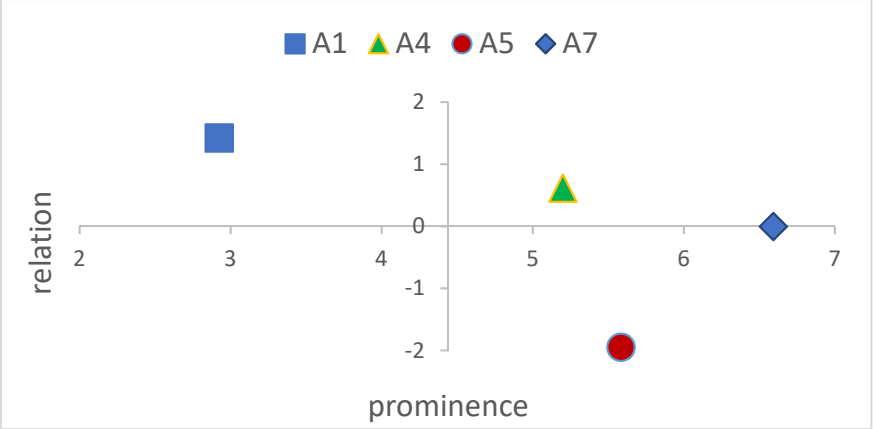

Figure 9. Results for the limited set of factors; the total influence T case.

There are only a few qualitative differences between the figures which present calculation results. The most noticeable difference deals with factor A7. It seems to be a slight cause under the direct influence of other factors. However, the indirect influence of other factors results in its final classification according to the relation index as a rather neutral factor. The remaining factors seem to perform consistently, regardless of whether direct, indirect, or total influence is considered. Two of them, namely A1 and A4, prove to be clear impediments for determining compensation for expropriated properties. The behavior of factor A5 is totally different from its behavior in the case of the analysis performed for the full set of factors, as it proves to be an evident effect, now. Note that the majority of factors show strong influential links with other factors except A1, again.

5. Discussion

The analysis of the procedure of determining compensation for expropriation purposes and the relevant literature allowed for the identification of factors that impede this process in Poland. According to the authors' knowledge, there is not any similar research on this matter available. In order to apply the presented methodology to other countries where the legal solutions may be different, it will be necessary to identify idiosyncratic factors influencing the process of determining compensation in a given country. This is why the considered problem was discussed only in a specifically Polish context.

Regarding factors specific for Poland, results of the DEMATEL-technique application reveal that there are four top-rated factors, out of eight factors in general, which may impede the process of determining compensation for expropriated real estate. The factors include:

1. Undetermined legal status of expropriated real estate (A1);
2. Incorrect real estate survey prepared by the property appraiser (A5);
3. Incomplete identification of real estate constituents (A4);
4. Inconsistent interpretation of regulations on real estate appraisal (A7).

Three other factors proved to be final effects in the following order of severity:

1. Lengthy compensation proceedings (A3);
2. Contestation of the amount of compensation and appeal to higher administrative authorities and courts (A6);
3. Incorrectly determined compensation (A2).

The remaining factor, A8 (Incorrect administrative handling), seems not to play any specific role with regard to causing abnormalities in the process of the valuation of real estate for expropriation.

Rather tiny differences between top-rated factors A1, A5, A4, and A7 with regard to their influence on other factors made more detailed analysis purposeful. However, DEMATEL was applied once again with this regard, instead of other methodologies. Additionally,

this fact fundamentally differentiates current research from common DEMATEL application in the course of real estate research [28,50,54–56].

The original second-level DEMATEL application with this regard provides the results that finally confirm that abnormalities in the valuation process of real estate for expropriation purposes are caused by two impediments, namely: undetermined legal status A1, and incomplete identification of real estate constituents A4. Hence, drawing particular attention to them may be especially helpful in hindering abnormalities in the real estate valuation process.

6. Conclusions

Expropriation of real estate for public and socially useful purposes is allowed in many countries. Although it is undoubtedly a process frequently justified by social needs, owners of expropriated properties have difficulty accepting the fact that the property has been taken from them and they contest the amount of compensation received. By analyzing the administrative procedures, it is possible to identify factors that may hinder expropriation or result in unfair compensation. For this purpose, a detailed analysis of the real estate expropriation procedure carried out in Poland and of the available literature was performed. This allowed for the identification of eight factors that could have an adverse effect on the process of determining compensation for expropriated real estate. Subsequently, expert opinions specifying the mutual influences of the factors were obtained.

The DEMATEL method was used to achieve the research goal. It allowed for the efficient identification of all cause–effect relationships and key factors, even in the case of complex processes.

The use of expert knowledge and the DEMATEL method allowed for the:

- Identification of the factors resulting from the difficulties encountered;
- Identification of the factors that are their cause;
- Prioritizing factors that adversely affect the process of determining compensation for expropriated real estate.

The conducted research allowed for the identification of the factors that impeded the process of determining compensation for expropriated real estate. These included: undetermined legal status, incorrect appraisal report, incorrect identification of real estate components, and inconsistent interpretation of regulations.

As a result of further analysis, it was found that two of the above-mentioned factors, i.e., undetermined legal status and incorrect identification of real estate components, had the most significant influence on irregularities in the process of determining compensation for expropriation.

The above-mentioned factors resulted in adverse effects in the compensation determination process, including prolonged proceedings, owners questioning the amount of compensation, and an incorrectly determined amount of compensation.

The conducted research is an implementation of the innovative idea conceived by the authors. The previous research has focused on the principles and methods of determining compensation without focusing on the hierarchy of importance of factors adversely affecting the course of the process. The research contained in this paper concentrated on the optimization of the compensation determination process by filling the existing gap. The results of the research may contribute to a discussion on the improvement of the compensation process by introducing appropriate regulations for administration bodies and property appraisers.

The research is hindered by different and diverse statuses of expropriated real properties. The undetermined legal status may relate to the denotation of the property and its geodetic data, rights, factual status, etc. Therefore, at a later stage, detailed studies could be carried out, e.g., in terms of key factors influencing the compensation determination process. It would be interesting to identify what specific situations are covered by the factors mentioned and to what extent they affect the compensation procedure. A

separate area of research could be an attempt to identify factors influencing the process of property valuation.

The conducted research implements the research objective and confirms that the selected DEMATEL method allows for the identification of factors that most disturb the process of determining compensation for expropriated real estate and should be eliminated in the first place. Moreover, the actual needs for data processing for the scientific problem, discussed in the paper, resulted in the original idea of a nested, multilevel application of the technique. Due to DEMATEL universality, the idea may also prove useful for other application areas of the technique as well, such as when there is a need for rapid reduction of data.

All in all, the proposed methodology is a universal one and may also be applied to the assessment of other administrative proceedings as well as various factors that determine them. Moreover, opinion-processing-related capabilities make provided methodology an interesting tool for educating professionals in the real estate industry.

There are also some opportunities for the enhancement of the methodology. The main reason for this is provided by the use of the DEMATEL technique itself. This is because it is capable of reliably processing a lot of data, and the use of a proposed multilevel way of using the technique would make this ability even stronger. This is why the expansion of the analysis by means of more data-opinions of experts in the field is recommended. The acquisition and appropriate preprocessing of mass data would nevertheless result in a need for the preparation and use of adequate software tools. Fortunately, the application of even a simple spreadsheet seems to accomplish this. On the other hand, DEMATEL also provides a number of specific tools for in-depth analysis of expert opinions [85]. Their application may prove beneficial, therefore, to assuring a conscious and reliable processing of expert opinions.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/land11050693/s1, Table S1: Experts' opinions on the influence of factors.

Author Contributions: Conceptualization, A.K.-P., A.T. and G.G.; methodology, G.G.; validation, G.G.; formal analysis, G.G.; investigation, A.K.-P. and A.T.; resources, A.K.-P. and A.T.; data curation, A.K.-P. and A.T.; writing—original draft preparation, A.K.-P., A.T. and G.G.; writing—review and editing, A.K.-P.; visualization, A.K.-P. and G.G.; project administration, A.K.-P. All authors have read and agreed to the published version of the manuscript.

Funding: This research was founded by research subsidies provided by the AGH University of Science and Technology no. 16.16.150.545 and no. 16.16.200.396.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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