Risks Caused by Information Asymmetry in Construction Projects: A Systematic Literature Review

Ivić, Ivona; Cerić, Anita

sustainability

Article

Risks Caused by Information Asymmetry in Construction Projects: A Systematic Literature Review

Ivona Ivić * and Anita Cerić

Faculty of Civil Engineering, University of Zagreb, 10000 Zagreb, Croatia; anita@grad.hr
* Correspondence: iivic@grad.hr

Abstract: The construction industry has a great impact on the environment and, more than ever, bears responsibility for achieving global sustainability goals. Despite the increasing technological development in the industry, information asymmetry between construction project participants affects communication and causes risks that have the potential to seriously harm project goals. The main objective of this systematic review is to collect and analyze existing scientific papers to summarize knowledge on the risks influenced by information asymmetry in construction projects. The established PRISMA 2020 methodology was used to collect and analyze papers from the two largest databases of scientific literature, Web of Science and Scopus. The coding rules were set up to evaluate the 94 articles that were assessed as eligible. Furthermore, the content analysis was applied with a set of coding rules and with the help of the software Mendeley. This study finds that research on risks caused by information asymmetry is still new, limited and not well connected with theoretical concepts. The most common methods used by researchers are simulation and case study. With a thematic analysis of current knowledge, this study provides a synthesis of identified risks, consequences and mitigation measures, as well as directions for future research.

Keywords: information asymmetry; adverse selection; moral hazard; hold-up; risk management; systematic review; knowledge gap

check for updates

Citation: Ivić, I.; Cerić, A. Risks Caused by Information Asymmetry in Construction Projects: A Systematic Literature Review. *Sustainability* **2023**, *15*, 9979. https://doi.org/10.3390/su15139979

Academic Editors: Ivan Marović and Georgios Aretoulis

Received: 26 May 2023
Revised: 16 June 2023
Accepted: 21 June 2023
Published: 23 June 2023

1. Introduction

Global construction output in 2020 was USD 10.7 trillion and is expected to grow by 42% between 2020 and 2030 to reach USD 15.2 trillion [1]. It is also considered to be a global engine for economic growth and recovery from COVID-19 [1]. Due to its expansion, in 2020, construction was responsible for 37% of total global energy-related CO_2 emissions [2]. Taking into account the worldwide concerns of climate change and global warming, construction will undoubtedly bear a great responsibility for achieving global sustainability goals in the future [3]. Nevertheless, there is an issue that could affect the realization of such plans. Construction projects often face difficulties in achieving their goals [4], despite increasing technological development in the industry. Some of the reasons include the fact that risks and uncertainties are present in construction much more than in other industries [5] and because not enough attention is paid to the sociological aspects of the project.

The relations between the participants of the construction project can be described by the principal–agent theory. The principal–agent theory describes a relationship in which one party (principal) engages another party (agent) to perform a task on their behalf [6]. According to the principal–agent theory, there is an asymmetry of information between the principal and the agent. Information asymmetry represents a situation in which the participants sometimes do not share information with other parties for personal interests [7]. The first research on the topic of information asymmetry was carried out by the Nobel laureate in economics, Akerlof, in the famous scientific paper The Market for Lemons in 1970 [8]. Since then, in addition to economics, the study and application of information asymmetry and the principal–agent theory have been present in other scientific disciplines, including construction. In construction projects, the main roles are played by the client, the contractor and their project managers. In addition to them, there are also designers, subcontractors and other stakeholders of the construction project. The simplest principal–agent model in construction presents the client as the principal and the contractor as the agent who needs to build a certain building for the client [9].

Different characteristics of principal–agent relationships, such as information asymmetry, different risk attitudes and the desire to maximize one's own benefit, often lead to opportunistic behavior of project participants [10]. Within the principal–agent theory, there are several agency problems, which take the form of 'hidden characteristics', 'hidden action' and 'hidden information', as well as 'hidden intention' [11]. Risks that may appear in such cases occur under the influence of information asymmetry among project participants. These risks can seriously threaten the achievement of project goals if they are not managed adequately [12].

The problem of hidden characteristics exists even before the contract is signed between the principal and the agent (ex ante). The problem exists because the agent's characteristics, such as the quality of performance or resource availability, are not visible to the principal ex ante [13]. This situation results in the selection of an unsuitable partner, the so-called adverse selection [13,14].

The problems of hidden action and hidden information occur after the contract between the principal and agent is signed and reflects the efforts of the agent [11]. Both arise from the principal's inability to control (hidden action) and assess (hidden information) the agent's actions while performing the work [15]. The principal is, therefore, aware of the performance result of the agent but cannot assess if the effort was maximum or not. If an agent decides to exploit this information asymmetry, this situation is called a moral hazard. Moral hazard is connected with a number of possible risks for the performance of the project.

The most challenging problem, hidden intention, describes the situation in which the real intentions of the agent are revealed to the principal after the conclusion of the contract [11]. In that case, the opportunistic behavior of the agent is visible to the principal, but they have limited negotiation power because they have already invested resources in the relationship. Thus, the principal is held-up in an undesirable relationship [15].

There is also an important connection between construction, information asymmetry and sustainability. The community, as an important stakeholder, wants a safe and clean environment [16]. On the other side, there is a construction company's ethical behavior. Contractors may act opportunistically regarding information on the environmental impact of their products, processes and waste [16]. If we look at the community as a buyer and contractor as a seller of construction products (for example, buildings), there is potential for information asymmetry problems. Contractors may take advantage of information asymmetry to achieve higher profits or charge unreasonably high prices for low-quality work in sustainable practices. This can result in community dissatisfaction, low trust, low willingness to pay and potential legal problems in the future [16]. In that regard, new research has begun on the topic of firms reporting their environmental, social and governance (ESG) performance to reduce information asymmetry between them and consumers [17].

Principal–agent theory and information asymmetry often appear in recent research in construction [18]; however, the management of risks caused by information asymmetry is insufficiently represented, both in the scientific literature and in the practice of construction project management. The purpose of risk management is to increase the probability that project goals will be achieved [19]. Therefore, the risk management process is one of the most important processes in project management. Many scientific publications have described the process of risk management. The basic three steps of this process have remained the same for years: risk identification, risk analysis and risk response [20,21].

Risk identification is the step that includes recognition and description of all risks that could affect the project's objectives. According to ISO [22], risk is "the effect of uncertainty on objectives". The effect represents any deviation from the expected. The objectives can have different aspects (such as financial, health and safety and environmental goals) and levels (such as strategic, organization-wide, project, product and process), depending on the area under consideration [22]. There are two different types of risks, depending on their nature, that demand a different approach in their identification. Risks that arise from an event are easier to identify with the recognition of the source of the risk, the event and its effect [5]. Risks not preceded by any specific event include variability and ambiguity risks [23] (p. 398). Variability risks are related to the uncertainty that exists about some key characteristics of a planned event or activity or decision (for example, expected productivity varies above or below the target). Ambiguity risks are related to the uncertainty that exists about what might happen in the future, where imperfect knowledge could have implications for project objectives.

Risk analysis is carried out in order to describe the impact of identified risks in as much detail as possible. Risk is a two-dimensional combination of consequences (of some activity) and associated uncertainties (about what the consequences of that activity will be) [24] (p. 624). Therefore, risk analysis includes an assessment of the probability of risk occurrence and the strength of its consequences, which together represent its impact on the project's objectives. After a risk analysis has been carried out, sufficient data is usually obtained to help make decisions about mitigation measures. Risk response involves making informed decisions about which risks should be given more attention and which should be ignored [25].

As for risks that are caused by information asymmetry among project participants, research in construction mainly deals with mitigation strategies. Thus, some of the main recognized strategies in recent research include the following: incentives for agents [10,26–30]; control and monitoring of the agent [10]; optimization of rewards and agent performance [31]; building trust among the project participants [9]; risk sharing between principal and agent [32,33]; and the use of information technologies such as building information modeling (BIM) and blockchain [7,34,35]. However, the previous steps of risk management are not equally represented. One of the studies that includes risk identification refers to the recognition of the main behavioral risk factors in construction projects in China [12]. However, the behavior of participants is not the only factor that influences information asymmetry problems. Others need to be considered as well.

With a brief review of the existing literature on this subject, it can be seen that more research is needed, especially in the area of risk identification, to enrich the field and improve the performance of construction projects. This review aims to summarize knowledge on risks influenced by information asymmetry in construction projects and find research gaps to provide future research directions in this field. The main research objectives are (1) to recognize key studies that contributed to the topic of information asymmetry in construction projects; (2) to summarize what is currently known about risks caused by information asymmetry in construction projects; and (3) to highlight future research opportunities.

The remainder of the paper is organized as follows. In Section 2, the details of the methodology used in this study are presented. In Section 3, the main results of the systematic review are presented, along with the descriptive and thematic content analysis. Finally, Section 4 provides a discussion of the results, identifies research gaps, gives recommendations for future research and concludes the paper.

2. Methodology

The aim of this study is to synthesize and analyze research on the subject of risks that are influenced by the information asymmetry between construction project participants. A systematic literature review was selected to provide the readers with the synthesis and analysis of the scientific literature on the subject and to present a starting point for future research. The established PRISMA 2020 methodology was employed to select and analyze the papers that dealt with risks influenced by information asymmetry in construction projects. PRISMA is an abbreviation for "preferred reporting items for systematic reviews and meta-analyses". It enables systematic reviews with clearly formulated questions, using systematic and explicit methods to identify, select and critically appraise relevant research and to collect and analyze data from the studies that are included in the review [36]. The methodology of this study, presented in Figure 1, consists of four phases explained below.

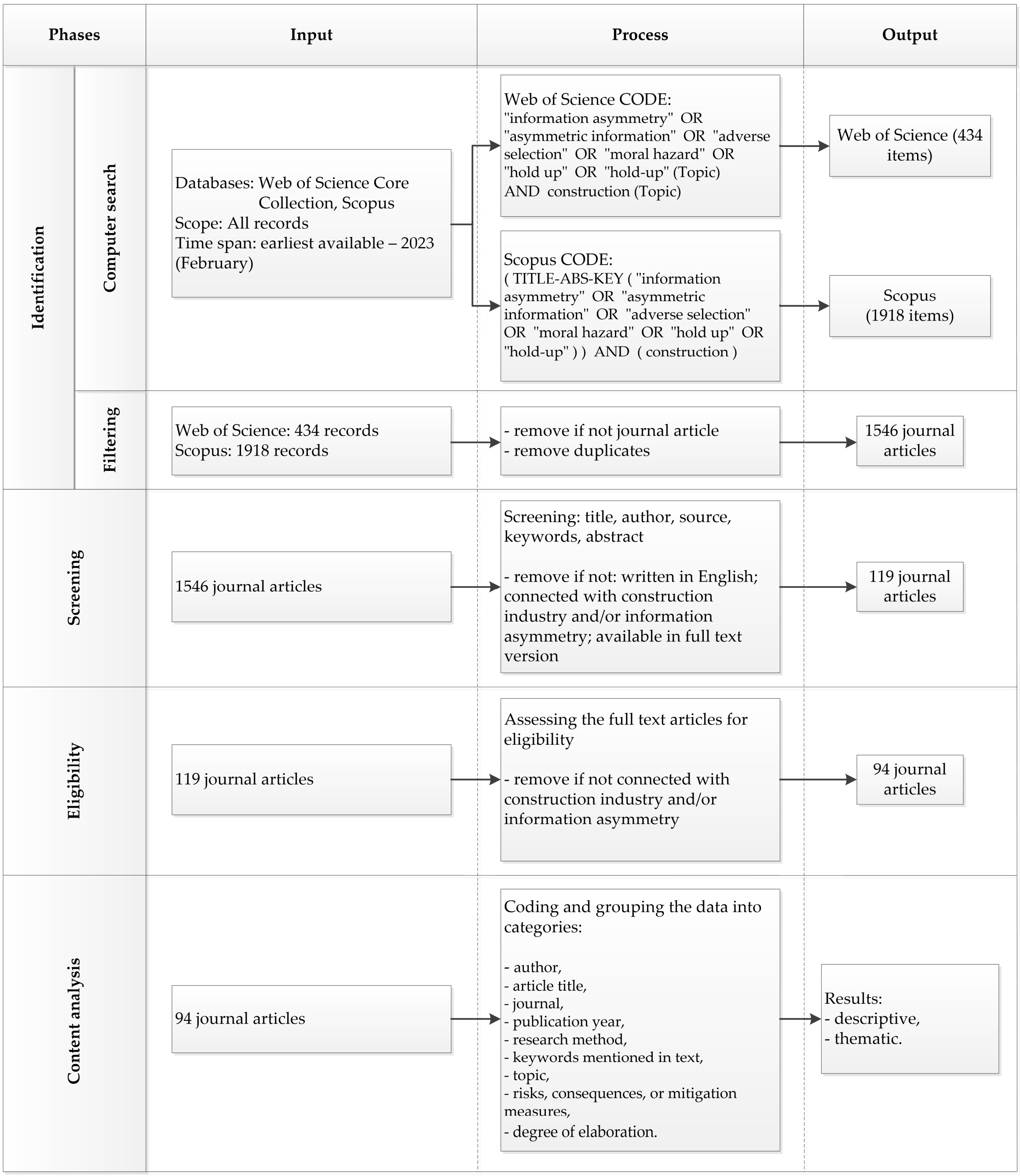

Figure 1. Research methodology.

In the first phase, named identification, a comprehensive exploratory desktop search was performed. The computer search was conducted on two large databases of scientific literature, namely "Web of Science Core Collection" and "Scopus". The time span which these databases cover is very extensive and was searched in its entirety. The Web of Science Core Collection database contains records from 1955, and Scopus also covers research published before 1960. The computer search included the keywords “information asymmetry”, “asymmetric information”, “adverse selection”, “moral hazard”, “hold-up” and “construction”. They were jointly searched for in the paper titles, keywords and abstracts. After the computer search of two databases, the records were joined in the reference management software Mendeley. All the subsequent phases were conducted in Mendeley, which enabled the objectivity of the analysis and careful management of retrieved records [37]. In the sub-phase filtering, with the help of Mendeley and reading of the records’ titles, all the duplicates and papers which were not published in scientific journals were removed. Through phase 1, a total of 1546 journal articles were collected. To avoid subjectivity, the subsequent phases were conducted in two stages by two researchers. First, one researcher performed the screening, eligibility assessment and content analysis. Second, the other researcher carefully reviewed the whole process. There were not any disagreements because they were mitigated with regular discussions between the two researchers and continuous cooperation using the software Mendeley.

In phase 2, thorough screening was necessary to exclude the articles which were not associated with the research topic, written in English or available in full-text version. This resulted in the exclusion of 1437 items. The main reason why so many retrieved articles were not associated with the subject in question is that every record in the Web of Science database also contains the so-called “keywords plus”, which are automatically generated from the titles of the cited articles. Consequently, a number of the retrieved articles did not actually contain the searched keywords in their text or were not focused on the research topic. Therefore, these items were removed manually during the screening phase. In most of those articles, the keyword “construction” was not associated with construction projects but used as the verb “construction”, meaning “the act or result of putting different things together” [38]. Furthermore, five of the papers were not available in full-text versions. The authors of those papers were contacted; however, they could not provide the full-text version. After reading the abstracts, it was concluded that the non-availability of the concerned papers would not affect the results of this review significantly.

In phase 3, the full-text versions of the 119 shortlisted journal articles were assessed for eligibility. The assessment included 119 articles concerning any aspect of the construction industry and with a notion of information asymmetry somewhere in the text. However, the final eligibility criterion was that information asymmetry is mentioned in the context of construction project risks. To determine that connection, the full-text articles were carefully read. If the paper’s content did not provide any valuable conclusion on the connection between project risks with information asymmetry, it was excluded from the final list.

Finally, in phase 4, the contents of 94 eligible papers were considered for content analysis. The content analysis was appropriate for this study because it could be used to determine the major facets of a set of data by counting the number of times that an activity happened or a topic was described [39]. To provide transparency and objectivity during the coding process, the coding rules were set as a highly reliable method for the descriptive and thematic analysis of the papers [40]. The coding rules (Table 1) were developed iteratively and applied in Mendeley. The first iteration included all the codes presented in Table 1 and the majority of definitions. However, the definition of research methods used in retrieved articles evolved throughout the analysis of articles. As the new method was detected, it was added to Table 1.

A descriptive content analysis was conducted to categorize and count the identified contents, namely: source attributes (research journal and author/s), publication chronology and research methods used by the researchers.

For the thematic content analysis, the focus was on the identification of research topics and findings; the number of interconnections between searched keywords; the risks, consequences and mitigation measures explicitly stated in the articles; and the degree of the theoretical contribution of each retrieved paper to the topic of risks influenced by information asymmetry.

Table 1. Coding rules for content analysis of the study (adapted from [41]).

Code	Definition of Code
Descriptive	
Author	List of authors
Article title	Title of the article
Journal	Scientific journal in which the article was published
Year	Year of publication of the article in the source journal
Research method	Case study, conceptual analysis, conceptual modelling, content analysis, focus group, framework development, interview, multi-attribute utility theory, network analysis, questionnaire survey, simulation, systematic literature review, text mining
Thematic	
Topic	Research objectives and/or questions explicitly stated in the article
Keywords mentioned in text	The number of interconnections between keywords "information asymmetry", "adverse selection", "moral hazard" and "hold-up" in articles
Risks, consequences, or mitigation measures	Risks, consequences or mitigation measures explicitly stated in the article that were influenced by information asymmetry
Degree of elaboration	Level I—concept enrichment; Level II—concept application; Level III—terminology application

To systematically assess the theoretical contribution of the retrieved papers to the research topic, they were organized into three categories. Thus, the theoretical contribution of an article on the topic of information asymmetry could be described as high for Level I, moderate for Level II and low for Level III. A similar categorization was previously used by Littau et al. [42] for assessing the qualitative contribution level of the retrieved papers. In this review, Level III is assigned to the articles which simply mention the keywords without investigating the concept further. Level II is assigned to the articles in which the concept of information asymmetry is explained and applied to any construction project context. Finally, Level I is assigned to the articles in which information asymmetry is discussed and developed further or enriched by new models or concepts. In this relation, Level III could also be described as terminology application, Level II as concept application and Level I as concept enrichment. Only one level was assigned to each article.

3. Results

The results of the content analysis are presented in the following two subsections. In the results, 94 eligible articles are included. These are the articles that met all the selection criteria described in the Section 2. Descriptive results include the distribution of retrieved articles in different journals and through the years, as well as the frequency of research methods used by the authors. The remaining two descriptive metrics coded in the content analysis, the authors and titles of the articles, are represented in Appendix A. Thus, descriptive results describe the context of the current research. Thematic results show the remaining three coding metrics. First, the degree of elaboration on information asymmetry in retrieved articles is presented. Second, the interconnections between searched keywords are shown. Finally, the usage of basic risk management terms in the current research on information asymmetry in construction projects is analyzed.

3.1. Descriptive Results

3.1.1. Leading Journals

The 94 eligible articles were published in 51 different journals, meaning that the topic is widely spread. Nevertheless, one-third (33 per cent) of the articles are published in the leading four journals: Sustainability (9 articles), Engineering, Construction and Architectural Management (8 articles), International Journal of Project Management (7 articles), and Journal of Construction Engineering and Management (7 articles). The frequency of eligible articles in journals is shown in Figure 2. According to the leading journals, the topic is widely applied in the fields of sustainable development, project management and construction management.

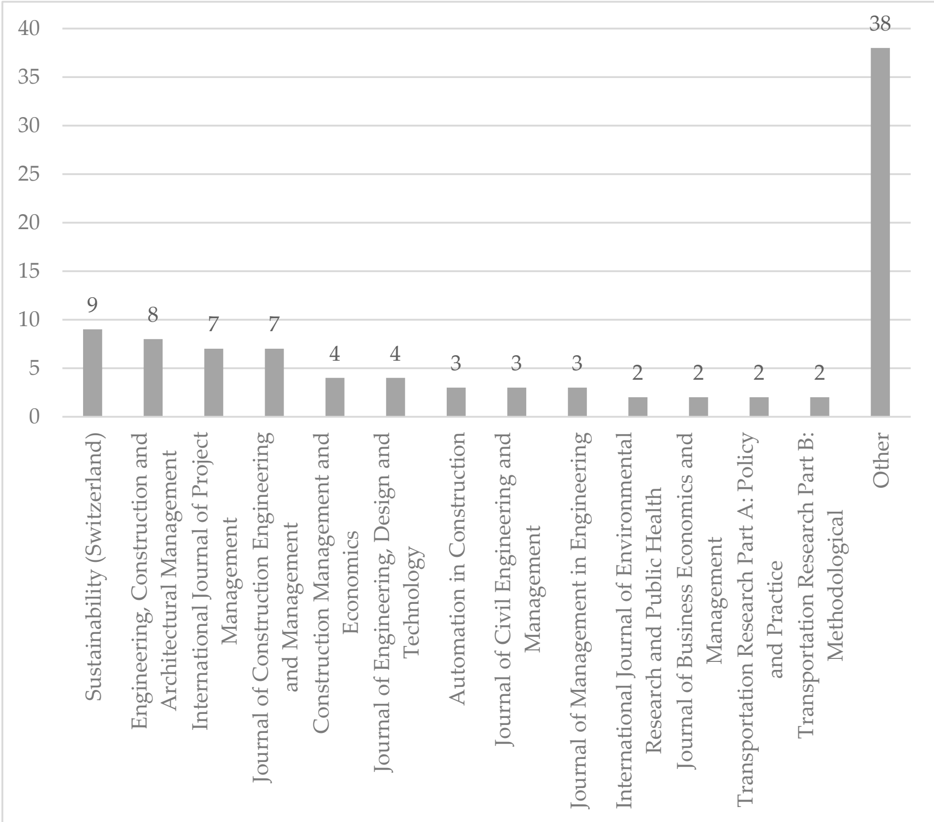

Figure 2. Frequency of eligible articles in journals.

3.1.2. Year-Wise Distribution

The year-wise distribution of 94 retrieved articles is shown in Figure 3. Before 1991, there was no mention of information asymmetry or associated terms in articles dealing with construction projects. Information asymmetry appeared in scientific research in the 1970s (see [8]) in the field of behavioral economics. It was part of the New Institutional Economy approach, which significantly changed how the field viewed the market. So, according to this literature review, the term did not appear in construction research until 20 years later, when the first two articles were published by Rosenfeld and Geltner [43] and Ward et al. [44]. Both studies were conceptual. The topics that were studied included the incentive contracts between the client and the contractor [43] and the risk attitude of contractors with implications on adverse selection and moral hazard [44]. In the 1990s, only two more articles dealt with the consequences of information asymmetry on technological development in the case of large construction projects [45,46]. In the period from 2000 to 2010, 14 more articles were published, but only after 2011 would the real development of the research in question start. In the following 12 years, a considerable number of 76 articles were published, with a significant enrichment of the topic.

3.1.3. Research Methods

Figure 4 shows the frequency of research methods used in retrieved studies. Researchers used 13 different methods in their studies. Both quantitative and qualitative methods (in approximately 50-50 ratio) were used. Of the 94 retrieved articles, 19 studies used multiple methods. In most cases, it was a combination of the quantitative and qualitative approaches (the so-called mixed-method approach). The most common method used is simulation. It is applied in 44 different studies. The simulation method includes the development of a mathematical model of some real phenomenon and a simulation of scenarios that could happen in nature, which is usually advocated by computers. In retrieved articles, agent-based models are prevailing, with game theory being the most common underlying approach. The method is especially appropriate for research on information asymmetry because of the theoretical foundations in principal–agent theory and the possibility of considering the principal–agent relationship through agent-based models. The second most common method used in retrieved articles is case study research. Case studies are used in 24 different articles. This body of literature provides a better understanding of the topic through real-world examples of information asymmetry in construction projects. Other popular methods include questionnaire surveys and interviews and conceptual analysis and modelling. Questionnaire surveys and interviews involve opinions from construction project participants. Furthermore, the aim of conceptual analysis and modelling is to better understand the terms and repercussions of information asymmetry between the construction project participants. It is worth noting that conceptual research is equally used in earlier and later years of the topic development, independently or in combination with other methods.

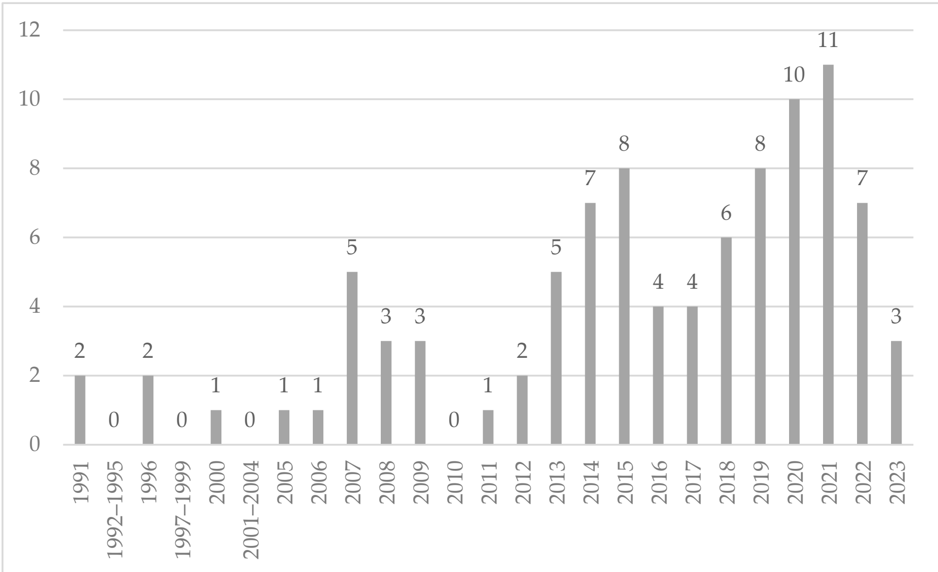

Figure 3. Year-wise distribution of eligible articles.

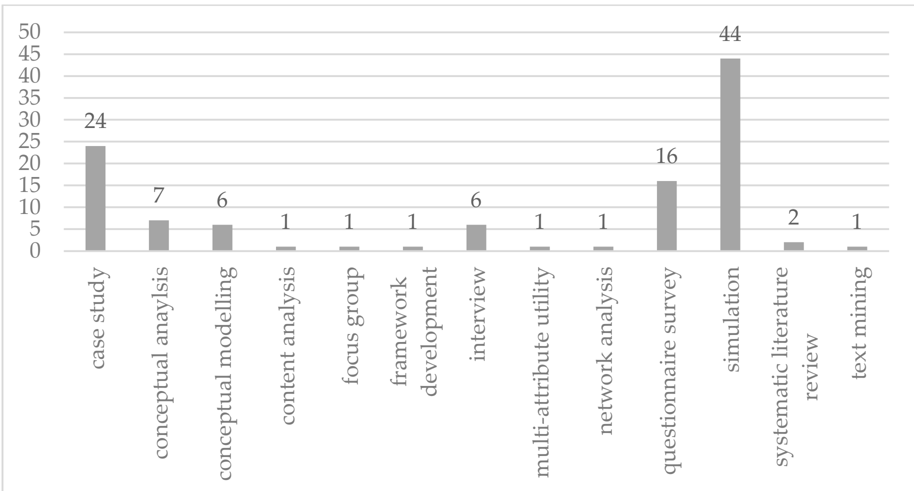

Figure 4. Frequency of research methods used in eligible articles.

3.2. Thematic Results

3.2.1. Key Studies

The first research objective was to recognize key studies according to their qualitative contribution level to the topic of information asymmetry in construction projects. This was enabled by categorizing the eligible articles into three levels. Level III is assigned to the articles which simply mention the keywords without investigating the concept further. Level II is assigned to the articles in which the concept of information asymmetry is explained and applied to any construction project context. Finally, Level I is assigned to the articles in which information asymmetry is discussed and developed further or enriched by new models or concepts. In this relation, Level III could also be described as terminology application, Level II as concept application and Level I as concept enrichment. Only one level was assigned to each article. The categorization of each article is presented in Appendix A. Figure 5 shows that, from the retrieved 94 articles, 43 articles, or 46 per cent, represent the information asymmetry concept enrichment (Level I), 30 articles, or 32 per cent, represent the concept application (Level II), and 21 articles, or 22 per cent, only apply the information asymmetry terminology (Level III).

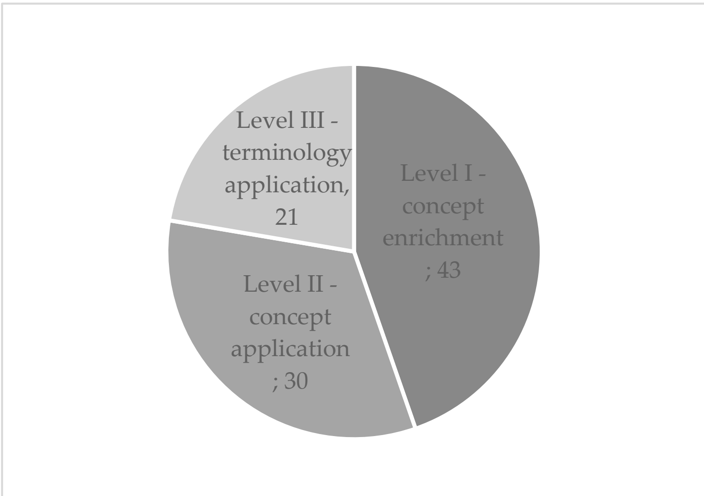

Figure 5. Theoretical contribution of eligible articles.

The majority of retrieved articles, Level I articles, brought new insights, frameworks, models, etc. These articles especially contributed to the topic development in construction research. The first Level I article was published by Lützkendorf and Speer in 2005 [47], about information asymmetry in housing and commercial property markets. They used the conceptual modelling method to conduct the research. The connection with construction is borderline in the part where they propose a building information system as a solution to the information asymmetry between the buyers and suppliers. The real development of the topic started after 2007. Since then, the majority of authors have been using case studies, questionnaire surveys and simulation methods to enrich the concepts in question.

Early case studies were presented by Chang and Ive [48,49] and Chang [50], who were dealing with hold-up problems in the Channel Tunnel Rail Link project. Then, Liu et al. [51] investigated the moral hazard and adverse selection in the case of construction tendering after the Wenchuan earthquake. Other cases included the investigation of information asymmetry in energy efficiency retrofits [52], the hold-up problem in the Taiwan High-Speed Railroad project [53] and different PPP projects [54,55]. Finally, there was also the investigation of possible mitigation measures for information asymmetry problems. These measures include BIM [34], incentive contracts [56,57] and enhancing calculus-based trust between the client and vendor [58].

Simulation is the most common method used in Level I articles. The first article that used simulation was [53]. They developed different scenarios explaining the hold-up problem based on a game theory model of a case study example. The simulation was combined with case studies in three other articles [50,55,56]. Furthermore, the simulation method is used to design optimal incentive contracts [30,59–65]. It is also used to explore the impact of other incentive mechanisms, such as cooperation and reputation [66,67]. Furthermore, simulation is used to explore the behavior of agents in a pre-contract [68,69] or post-contract process [29,32,70–72]. Finally, the authors use simulation to investigate the impact of different mitigation strategies on the probability of opportunistic behavior between participants [73,74].

Articles that used questionnaire surveys and interviews can be divided into two thematic groups. The first group explored the causes and effects of information asymmetry problems in construction projects [75–78]. The other group investigated the strategies for minimization of information asymmetry in construction projects [79–81].

Other methods were also used to enrich the concept of information asymmetry in construction projects. The two conceptual analyses by Schieg [82] and Xiang et al. [12] explored the strategies for mitigating information asymmetry. In 2020, Giraudet [83] used a systematic literature review to contribute to the knowledge about information asymmetry implications in energy efficiency retrofit contracting and financing. Furthermore, in 2021, a framework was developed by Cerić [7] for the implementation of blockchain technology in construction projects as a mitigation measure for information asymmetry problems between construction project participants.

Articles that are marked as Level II did not further develop the topic of information asymmetry but only applied the concept while enriching some other topic. In 50 per cent of these studies, authors employed the simulation method. These articles mostly used game models under information asymmetry between participants. The earliest research on information asymmetry in construction projects can be located in the Level II group (see [43,45,46,84]). The concept of information asymmetry was applied in research on the following: risk-sharing ratios between the client and contractor [85,86], affordability of new technologies and [10,45,46,87,88]; general contractor behavior in cases of subcontracting [84,89]; causes of cost overruns and low profitability [90–93]; inter-organizational trust asymmetry behavior in construction projects [94]; opportunistic behavior of agents in construction projects [95–98]; bid calculations for construction projects [99]; different types of contracts and incentive mechanisms [43,100–103]; implementation of BIM in construction projects [104,105], procurement process [106]; supervision strategies of clients [107]; and effectiveness of safety monitoring in the construction industry [108].

The remaining articles marked as Level III only used the terminology connected with information asymmetry somewhere in the text without any further elaboration on the concept. The topics investigated in these articles were diverse, and included the following: the analysis of work choices of contractors [109]; dynamic contract terms in projects [110]; network analysis of keywords in articles [18]; cost overruns of large construction projects [111]; risk identification and analysis on a company level [112]; decision support system for housing condition assessment, refurbishment and contractor selection [113–115]; communication performance challenges in PPP projects [116]; optimization of social procurement policy outcomes [117]; effect of contract completeness on contractors' opportunistic behavior [118]; allocation of risks in construction projects [44,119]; minimization of transaction costs in building energy efficiency [120]; blockchain in smart contracts and supply chain management [35]; contractors' risk attitudes [121]; improvement of the quality of projects [122,123]; environmental responsibility behavior in megaprojects [124]; safety supervision for prefabricated building construction [125]; and opportunistic behavior of private companies in a PPP project [126].

3.2.2. Risks Caused by Information Asymmetry in Construction Projects

To summarize what is currently known about risks caused by information asymmetry in construction projects, the analysis of interconnections between keywords, as well as coding of the explicitly stated risks, consequences and mitigation measures, was performed. First, the full-text articles were searched for the keywords "information asymmetry", "asymmetric information", "adverse selection", "moral hazard" and "hold-up". The goal was to find the most common interconnections between the keywords and to find out what is the most researched keyword in the construction field. Table 2 contains the searched keywords and the number of articles in which each of the keywords was found. The number in brackets indicates articles in which the keyword or the combination of keywords was mentioned independently of other keywords. For example, ''information asymmetry" was mentioned in 88 articles; in 68 of them, it was mentioned in combination with some other keyword from the search; and in 20 articles, it was mentioned alone. The most common information asymmetry in construction research is moral hazard, mentioned in 63 of 94 articles. Furthermore, the most common combination of keywords included the mentioning of information asymmetry and moral hazard in the same article (in 58 instances). The least common information asymmetry is hold-up, mentioned only in seventeen articles, eight of which are in combination with adverse selection and nine in combination with moral hazard. Generally, the interconnectedness of searched keywords is low because all four keywords were mentioned only in seven articles.

Table 2. Interconnections between keywords.

	Information Asymmetry	Adverse Selection	Moral Hazard	Hold-up
Information asymmetry	88 (20)	37 (3)	58 (24)	14 (7)
Adverse selection		39 (0)	35 (0)	8 (1)
Moral hazard			63 (2)	9 (2)
Hold-up				17 (0)

Furthermore, content analysis enabled the capturing of explicitly stated risks, consequences and mitigation measures in retrieved articles. If an article gave at least one statement on risks, their consequences and/or mitigation measures, this was marked with a plus sign in the table in Appendix A. From the retrieved 94 articles, 66 contain statements related to mitigation measures for risks caused by information asymmetry, 56 contain statements that can be interpreted as risks caused by information asymmetry and 44 contain explicitly stated risk consequences. All three terms related to risks caused by information asymmetry are stated in 35 articles, which represent the bulk of the knowledge on this topic.

Risks that arise before the contract between the principal and the agent is signed fall into the category of adverse selection. Due to the lack of information on agents' characteristics during the tendering process, it is impossible to distinguish the good agents for the execution of the project from the bad ones. Risk arises if the principal cannot verify the qualifications of the agent. The main reasons could be poor signaling value of the guarantees or certificates, lack of public information about the agents (reputation) or the agent has misrepresented their qualifications [12,34,43,52,74–78,83]. In the construction tendering process, agents often dump prices due to fierce competition and the desire to win contracts [51,59,69,91,96]. This can lead to a situation in which the quality agents drop out of the market while only those of lower quality remain. Other risks that fall into the same category include the inappropriate behavior of the principal or the agent and tacit agreements with other project participants [75,76], the lack of transparency in the evaluation of bids [12,75], unauthorized subcontracting of agents and reduced liability of subcontractors [65,76] and the lack of long-term cooperation between the participant and the agent [108]. The lack of long-term cooperation is characterized by the lack of information about the future behavior of the partners in the project (lack of trust in the relationship) [108].

Risks that arise after the contract is signed fall into the category of moral hazard or hold-up. In these cases, the agent changes their behavior after concluding the contract and hides this information from the principal. The principal has no insight into the agent's actions because of a lack of control mechanisms. In this group, the most commonly mentioned risk caused by information asymmetry in construction research is incomplete or flexible contracts. The risk refers to loosely defined rights and obligations of the principal and the agent, as well as the rewards and punishments for the agent [29,32,34,55,71,74,77,78,87,97,98,102,107]. If all the risk is assumed by the principal, the agent will not pay attention to their behavior and mistakes in the project because they feel "safe". In that case, it is easier for the agent to engage in risky behavior because the principal does not have a good control mechanism (the contract). Moreover, if rewards and penalties for the agent are not clearly defined, they can engage in risky behavior (with the aim of achieving financial gain) without being punished. The literature suggests that they will surely take advantage of this situation because of the psychological influence of the free option—it affects even those agents who are otherwise risk-averse [127]. Furthermore, an incomplete or flexible contract allows for renegotiation, which may arise due to unforeseen events or additional work. Changes after the contract is signed may cause either party to be held back in a relationship in which they have already invested some resources or effort [34,48,49,53–55,102].

Quality control at the construction site should be one of the principal's control mechanisms. In the case of inefficient or irregular quality control, the agent's actions are invisible to the principal [10,34,51,65,67,71,75,76,84]. The agent, therefore, has an incentive to behave opportunistically. Thus, the agent can install materials of lower quality, cut corners without being punished or pay less attention to safety measures at the construction site.

In construction projects, the information about the quantities and other characteristics of the project sometimes is not defined before the contract is signed. This information can be subsequently changed. This happens if, for example, the main project was not prepared earlier or the principal changes their mind about some details of the project. The principal does not have an adequate control mechanism for items that were not foreseen, so the agent's actions related to that work are less visible. Again, the agent has the opportunity to renegotiate the contract, which encourages them to behave opportunistically [12,43,54,57,58,75,76,99].

Sometimes, the risk arises from loosely defined communication protocols and reporting mechanisms [45–47,65,75,76,87,98], as well as the lack of visibility of participants' actions to the third party or court. If there is no evidence for their actions, opportunistic behavior is enabled [73,87,90,102,126]. The risk also arises if the principal is in a poor negotiating position in the event that the dispute is taken to court [49,90,102]. For example, the principal can be held up in a situation when they cannot abandon the project (the project is too important) and they cannot replace the agent (the cost of replacement would be larger than agreeing to the agent's terms in the renegotiation). The same can happen if the building is unique or has great socio-economic or political importance [54,82,84,92,102]. Asset or investment specificity is a term that describes the uniqueness of the work being performed (for example, a unique building that cannot be repurposed). Investing in such a project disables the repurposing of funds, which encourages the hold-up problem in which one party holds something against the other party in order to reach a favorable agreement through renegotiations. Usually, the contractor is in a more favorable position than the client who invests resources.

The risk also lies in a situation when there is significant pressure on the agent. The pressure can be in project cost, time and quality requirements, health, safety and environmental requirements, or in relationships with other participants. The agent hides their mistakes from the principal because of the pressure to finish the work they started and to fulfill the contractual obligations [56,98,124]. Moreover, if the agent is exposed to unpredictable events related to weather, environment, etc., this can affect their performance and cause them to exert less effort [29,80].

The lack of long-term cooperation and the lack of trust between the participants of the project are also seen as major risks for construction projects [44,58,66,96]. The lack of previous cooperation and trust between the participants can lead to misunderstanding in communication or hiding information due to pressure or fear of the actions of the other party. Both parties are overly cautious, leading to increased costs. The risk also refers to the lack of future cooperation between the principal and the agent [55,108]. The agent has an incentive to act opportunistically if they know that their actions will not affect future cooperation with the principal. Finally, the agent can also engage in opportunistic behavior because of moral designment. They justify their own immoral or opportunistic behavior because (1) they are in an environment (company or market) that behaves in the same way or (2) individuals often try to reduce responsibility for their actions and transfer it to others (for example, the contractor claims that he did something for the benefit of the project and not for his own profit) [29,64,65,73,87,93,98,124].

The consequences of the risks caused by information symmetry in construction projects are well recognized in the existing literature. These consequences include failure to achieve project objectives, poor relationships and collaboration between project participants, and, in the long term, a decline in industrial productivity. Consequences on project objectives are related to project cost [34,74,77,78,91,96,99], schedule [48,56,96], quality [51,59,64–66,85,126], profitability [47,60,65,74,77,78,126], building usability [83] and the effects of new technology and innovation [10,45,46,71,80]. These risks also hinder future collaboration between the project participants [85], produce disputes [48–50] and endanger honest cooperation and communication between the participants [30,65,74,77,78,93,97]. In the long term, risks caused by information asymmetry negatively influence industrial productivity [43]. Competent contractors earn less [69] or do not bid in competitive tender processes [74,77,78]. Buyers are not willing to pay for project results [52]. Furthermore, companies included in such projects have increased transaction costs [50–58,74,77,78,84].

The majority of retrieved studies mention one or more mitigation measures for risks caused by information asymmetry. Before the contract is signed, the client should employ strategies that would help to recognize the characteristics of agents, the so-called screening. This includes the investigation of agents [59,81,89], verification of bidding offers (compared to the market or probabilistic calculations) [30,45,46,75,81], or asking for guarantees from agents [48,71,75,81], advanced payments [29], or bank insurance [55]. Agents can also signal their characteristics with certificates [52] and advertising [52,75]. They can also calculate the optimal bid to prevent dumping [69]. When choosing agents, clients should pay attention to their organizational culture [79,82,122], reputation [43,47,50,52,64,79,82,102] as well as partnering and long-term relations [75,84,85].

Mitigation measures with the largest frequency in the literature are related to contract design and control. These measures include a definition of incentives for agents. For example, agents are incentivized to honestly report their expenses [68,128] and other important information [96] to finish the work as planned [10,29,30,34,45,46,56,58,60,62,67,70,71,73,79,81,82,88,108], to recover after unforeseen events [56] and to adapt to different project circumstances [61,63,95]. The contract should also include the following: objective criteria for its enforceability [48,49,90], clear intentions of both parties [10,79,82,108], fair risk-sharing [32,86,91,96,101], mechanisms for cost adjustment according to the market situation [59], quality standards, technical specifications and performance specifications [43] and protective measures (guarantees), such as, for example, minimum rates of return, minimum income and maximum cost limits [102]. The agent could receive rewards for finishing the work earlier and with the requested quality [48] and for ensuring savings [58,85,105]. However, the agent could be punished if they fail to finish the project within the planned budget and deadline [48,58,70,73,85,105,108,126]. Also, the project should have a proper reporting system and monitoring of contract execution [12,34,58,59,81], as well as an agent performance evaluation system [29]. Authors often speak of this type of contract as optimal [12,57,59,64,65,86,93,99–101,103].

Effective quality control is very important to mitigate risks connected with information asymmetry during construction [10,45,46,51,64,65,71–73,97]. Besides adequate control, from the very beginning of the project, participants should cooperate and share the information and rewards [66,80,81]. Communication between participants should be transparent and responsible [81,102], credible [102], honest [12] and more informal [34]. Also, trust between the participants should be built and preserved throughout the project [34,52,58,79,82,102]. The principal should provide intrinsic rewards for the agent that includes trust, reputation enhancement, discretion, autonomy, accountability, job satisfaction, stability and goal alignment [58,65,67,126]. Finally, transparent information management can be enabled with different information systems [7,79,82,83], building information management—BIM [34,35,80,104], blockchain [35], project management platform [75,108], open accounting [85,99] and benchmark systems [91].

4. Discussion and Conclusions

Using a systematic literature review and content analysis, this study enabled a synthesis of the existing research on risks caused by the information asymmetry between construction project participants. The results of year-wise distribution (see Figure 3) have shown that the majority of retrieved articles were published in the recent 12 years, indicating the timeliness of the topic. The first articles appeared in the 1990s, which is not surprising because information asymmetry as a concept in behavioral economics has only existed since the 1970s. Although the principal–agent relationship is evident in construction projects, especially between the client and the contractor, the concept of information asymmetry was applied to construction research 20 years after its appearance in the scientific world. Even after that, it still took about 20 years for research on this topic to start on a larger scale. This confirms the statement that the construction industry is slow to change and innovate [129], not only in the technological context but in social, economic and other contexts, too.

According to the leading journals' analyses (Section 3.1.1), the topic is predominantly applied in the fields of project management and construction management. With *Sustainability* being the leading journal (see Figure 2), it seems that the topic of information asymmetry can affect the sustainable development of construction projects. Previous research considered the impact of information asymmetry on the environmental needs of the community as an important stakeholder of construction projects [16]. Also, there is a development in firms reporting their environmental, social and governance (ESG) performance to reduce information asymmetry between them and consumers [17]. Nevertheless, this idea needs further development since only nine articles were found in this field.

The 50-50 ratio in quantitative and qualitative methods applied in the retrieved articles indicates that the topic is well covered (see Section 3.1.3). Moreover, with thematic analysis, this study showed that most of the research that deals with this topic in construction is fruitful and enriches the concept (see Section 3.2.1 and Figure 5). Nevertheless, the prevalence of simulation as a research method (see Figure 4) and the relatively small number of studies that used interviews or questionnaires indicates that the research lacks the dimension of industry experts' opinion. While simulations can offer valuable insights, they are based on assumptions and simplifications of the real world. Simulation models may not fully capture the complexity of actual construction projects and the interactions between project participants. Industry experts possess valuable knowledge and insights gained from their practical experience, and their perspectives can provide a more holistic understanding of the topic [130].

The analysis of interconnections between the searched keywords revealed that the most researched keyword is ''information asymmetry" and the most researched information asymmetry problem is ''moral hazard" (see Table 2). The keywords are often mentioned independently of other connected concepts, meaning that the topic is frequently investigated without real theoretical foundations. This has confirmed the findings of previous research by Cerić and Ivić [18]. Hold-up is the least researched phenomenon, mentioned only in 17 articles. This means that future research should focus more on hold-ups in construction projects, especially because situations where one party is held up in an undesirable position after already investing resources often happen in construction projects.

Coding of risks, their consequences and mitigation measures explicitly stated in retrieved articles enabled the synthesis of current knowledge on risks caused by information asymmetry in construction projects (see this in more detail in Section 3.2.2). The majority of retrieved articles dealt with mitigation measures but also mentioned risks and possible consequences somewhere in the text. So, content analysis proved valuable in providing the list of possible risks, their consequences and mitigation measures stated in the existing literature. These lists are valuable for future researchers who want to further develop any of the specific topics in the construction context. Research on the usability of mitigation measures in different contexts and their impact on project success could be especially valuable. Besides developing the topics independently, there is a need for more comprehensive research on connections between risks, their consequences and possible mitigation measures. Currently, the topics are scattered and loosely connected. Special attention should be paid to the process of identification and analysis of these risks to provide a comprehensive picture for industry practitioners. Finally, a framework or model for managing risks caused by information asymmetry in construction projects would be of great value for practitioners that are now experiencing issues described in Section 3.2.2.

To summarize, the key findings of this article indicate that the research on the topic of information asymmetry in construction projects

- Is still new;
- Is rarely using real theoretical foundations and interconnections between the associated keywords;
- Is lacking the dimension of industry experts' opinions;
- Is mostly dealing with mitigation measures for information asymmetry;
- Is rich in examples of risks caused by information asymmetry;
- Is rich in examples of mitigation measures for risks caused by information asymmetry;
- Can help in reducing the negative effects of information asymmetry between construction stakeholders, including failure in achieving project objectives, poor relationships and collaboration between project participants and, in the long term, the decline in industrial productivity and low willingness to pay for construction products;
- Has a great potential for promoting sustainability in the built environment.

The findings of this research can be used by industry practitioners who are managing construction projects. They could use the lists of potential risks caused by information asymmetry as a part of the risk identification process in their projects. Furthermore, they are encouraged to recognize the potential consequences of these risks and to analyze them with respect to the project goals. With the summary of mitigation measures described in the current literature, this article provides a body of information for project managers to help them mitigate the concerning risks.

A better understanding of risks caused by information asymmetry in construction projects has several positive implications for the construction industry. Understanding information asymmetry could improve processes and outcomes of construction projects, increase trust among project stakeholders and enhance efficiency and innovation. The findings of this research show that information asymmetry can be a source of risk in construction projects. With the lists of risks, potential consequences and mitigation measures described in this article, the identification and management of risks can be enhanced. This can help prevent or minimize potential project delays, cost overruns, disputes, legal issues between project stakeholders and, in the long term, the decline in industrial productivity and the low willingness to pay for construction products.

The limitations of this study include the literature sampling criteria used. In literature reviews, it is possible to choose leading journals in the selected field as a sample [42,131] or to use common computer search engines and established literature databases [132,133]. As this literature review aimed to retrieve the majority of the articles that deal with information asymmetry in construction projects and not necessarily in a specific research field (such as construction management, project management, engineering, etc.), this study adopted the latter approach. Another important limitation is that, due to resource and time constraints, other databases of scientific literature were not included in the search. The decision to use Web of Science and Scopus was made because these are the two most extensive databases in construction management research. With this decision, the majority of journal papers related to the subject in question were included, but not all. Furthermore, this study included only journal articles, thereby excluding conference papers, books, chapters and other types of publications. As a result of this decision, certain relevant publications may not have been included in this review. In addition, the keyword search has its limitations because some articles may have studied the topic without explicitly stating the searched keywords in their title, abstract or keywords. Furthermore, the number of 94 analyzed articles is not adequate to arrive at generalized conclusions; however, they are valuable in providing guidelines for future researchers.

Summarizing all the discussed areas, directions for future research on risks caused by information asymmetry in construction projects are given below. Future research should

- Use interviews, questionnaire studies and other methods involving industry expert opinions;
- Provide more insight into the connection between information asymmetry risks and sustainable development of construction projects;
- Focus on hold-up risks connected with renegotiations and changes in construction projects;
- Consider the interconnections between adverse selection, moral hazard and hold-up in construction projects, with special emphasis on hold-up and its connections with adverse selection and moral hazard;
- Focus on the usability of possible mitigation measures for risks caused by information asymmetry and their impact on a project's success;
- Further identify risks caused by information asymmetry;
- Explore the methods and possibilities for the analysis of risks caused by information asymmetry;
- Develop frameworks and models for comprehensive management of risks caused by information asymmetry, involving all the steps of the risk management process.

The findings of this study and proposed directions for future research are valuable for researchers dealing with construction projects or dealing with information asymmetry in other fields. The findings of this study are relevant in the field of construction management but also enrich economic theory with a list of possible risks, consequences and mitigation measures connected to information asymmetry in construction. Understanding the risks that can arise from information asymmetry in construction can contribute to the smoother implementation of sustainable practices in construction. It can also have much broader positive outcomes, including increased trust between the construction industry and communities. It could benefit all stakeholders involved and help foster a more transparent and successful construction industry. Finally, researchers are strongly encouraged to embark on research on risks caused by information asymmetry to further enrich project management, risk management and other related fields.

Author Contributions: Conceptualization, A.C. and I.I.; methodology, A.C. and I.I.; software, I.I.; formal analysis, I.I.; writing—original draft preparation, I.I.; writing—review and editing, A.C. and I.I.; visualization, I.I.; supervision, A.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data available on request due to restrictions.

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

Appendix A

Ref.	Author/s	Year	Article Title	Journal	Risk	Risk Consequence	Risk Mitigation Measures	Degree of Elaboration
[69]	Ahmed et al.	2016	Construction bidding and the winner's curse: Game theory approach	*Journal of Construction Engineering and Management*	+	+	+	Level I—Concept Enrichment
[85]	Badenfelt	2008	The selection of sharing ratios in target cost contracts	*Engineering, Construction and Architectural Management*	-	+	+	Level II—Concept Application
[109]	Bröchner	2008	Construction contractors integrating into facilities management	*Facilities*	-	-	-	Level III—Terminology Application
[91]	Cantarelli et al.	2013	Explaining cost overruns of large-scale transportation infrastructure projects using a signalling game	*Transportmetrica A: Transport Science*	+	+	+	Level II—Concept Application
[128]	Cao and Wang	2014	Contractor–subcontractor relationships with the implementation of emerging interorganizational technologies: Roles of cross-project learning and pre-contractual opportunism	*International Journal of Construction Education and Research*	-	-	+	Level II—Concept Application
[110]	Carmichael and Karantonis	2015	Construction contracts with conversion capability: A way forward	*Journal of Financial Management of Property and Construction*	-	-	-	Level III—Terminology Application
[79]	Cerić	2014	Strategies for minimizing information asymmetries in construction projects: Project managers' perceptions	*Journal of Business Economics and Management*	-	-	+	Level I—Concept Enrichment
[18]	Cerić and Ivić	2021	Network analysis of interconnections between theoretical concepts associated with principal-agent theory concerning construction projects	*Organization, Technology and Management in Construction*	-	-	-	Level III—Terminology Application
[7]	Cerić	2021	Reducing information asymmetry and building trust in projects using blockchain technology	*Građevinar*	-	-	+	Level I—Concept Enrichment
[50]	Chang	2013	Understanding the hold-up problem in the management of megaprojects: The case of the Channel Tunnel Rail Link project	*International Journal of Project Management*	+	+	+	Level I—Concept Enrichment
[48]	Chang and Ive	2007	Reversal of bargaining power in construction projects: Meaning, existence and implications	*Construction Management and Economics*	+	+	+	Level I—Concept Enrichment
[49]	Chang and Ive	2007	The hold-up problem in the management of construction projects: A case study of the Channel Tunnel	*International Journal of Project Management*	+	+	+	Level I—Concept Enrichment
[53]	Chen et al.	2012	The analysis of BOT strategies based on game theory—Case study on Taiwan's high speed railway project	*Journal of Civil Engineering and Management*	+	+	-	Level I—Concept Enrichment
[30]	Chen and Li	2021	Incentive contracts for green building production with asymmetric information	*International Journal of Production Research*	-	+	+	Level I—Concept Enrichment
[88]	Cheng and Zheng	2022	Incentive Compensation Mechanism for the infrastructure construction of electric vehicle battery swapping station under asymmetric information	*Sustainability (Switzerland)*	+	-	+	Level II—Concept Application
[73]	Du et al.	2019	Exploring the moral hazard evolutionary mechanism for BIM implementation in an integrated project team	*Sustainability (Switzerland)*	+	-	+	Level I—Concept Enrichment
[89]	Fernández-Solís et al.	2015	General contractor's project of projects—a meta-project: understanding the new paradigm and its implications through the lens of entropy	*Architectural Engineering and Design Management*	+	+	+	Level II—Concept Application
[52]	Feser and Runst	2016	Energy efficiency consultants as change agents? Examining the reasons for EECs' limited success	*Energy Policy*	+	+	+	Level I—Concept Enrichment
[111]	Flyvbjerg et al.	2018	Five things you should know about cost overrun	*Transportation Research Part A: Policy and Practice*	+	+	-	Level III—Terminology Application

Ref.	Author/s	Year	Article Title	Journal	Risk	Risk Consequence	Risk Mitigation Measures	Degree of Elaboration
[34]	Forsythe et al.	2015	How far can BIM reduce information asymmetry in the Australian construction context?	*Project Management Journal*	+	+	+	Level I—Concept Enrichment
[83]	Giraudet	2020	Energy efficiency as a credence good: A review of informational barriers to energy savings in the building sector	*Energy Economics*	+	+	+	Level I—Concept Enrichment
[84]	González-Díaz et al.	2000	Causes of subcontracting: Evidence from panel data on construction firms	*Journal of Economic Behavior and Organization*	+	+	+	Level II—Concept Application
[93]	Guo et al.	2023	The influence of effort level on profit distribution strategies in IPD projects	*Engineering, Construction and Architectural Management*	+	+	+	Level II—Concept Application
[60]	Hajjej et al.	2017	Optimal contract with moral hazard for Public Private Partnerships	*Stochastics*	+	+	+	Level I—Concept Enrichment
[64]	Han et al.	2022	Dynamic incentive mechanism for large-scale projects based on the reputation effects	*Sage Open*	+	+	+	Level I—Concept Enrichment
[54]	Ho et al.	2015	Opportunism-focused transaction cost analysis of public-private partnerships	*Journal of Management in Engineering*	+	+	+	Level I—Concept Enrichment
[90]	Ive and Chang	2007	The principle of inconsistent trinity in the selection of procurement systems	*Construction Management and Economics*	+	+	+	Level II—Concept Application
[112]	Jallan and Ashuri	2020	Text mining of the securities and exchange commission financial filings of publicly traded construction firms using deep learning to identify and assess risk	*Journal of Construction Engineering and Management*	-	-	-	Level III—Terminology Application
[114]	Juan et al.	2009	GA-based decision support system for housing condition assessment and refurbishment strategies	*Automation in Construction*	-	-	-	Level III—Terminology Application
[115]	Juan et al.	2009	Housing refurbishment contractors selection based on a hybrid fuzzy-QFD approach	*Automation in Construction*	-	-	-	Level III—Terminology Application
[113]	Juan	2009	A hybrid approach using data envelopment analysis and case-based reasoning for housing refurbishment contractors selection and performance improvement	*Expert Systems with Applications*	-	-	-	Level III—Terminology Application
[116]	Kwofie et al.	2019	Communication performance challenges in PPP projects: cases of Ghana and South Africa	*Built Environment Project and Asset Management*	-	-	-	Level III—Terminology Application
[45]	Lampel et al.	1996	Impact of owner involvement on innovation in large projects: Lessons from power plants construction	*International Business Review*	+	+	+	Level II—Concept Application
[46]	Lampel et al.	1996	Information asymmetries and technological innovation in large engineering construction projects	*R & D Management*	+	+	+	Level II—Concept Application
[56]	Lewis and Bajari	2014	Moral hazard, incentive contracts, and risk: Evidence from procurement	*Review of Economic Studies*	+	+	+	Level I—Concept Enrichment
[67]	Li et al.	2020	Dynamic reputation incentive mechanism for urban water environment treatment PPP projects	*Journal of Construction Engineering and Management*	+	+	+	Level I—Concept Enrichment
[94]	Li et al.	2021	Influencing factors on inter-organizational trust asymmetry behavior in construction projects: Evidence from China	*Engineering, Construction and Architectural Management*	-	-	-	Level II—Concept Application
[97]	Li and Ning	2022	Mitigating opportunistic behaviors in consulting projects: evidence from the outsourced architectural and engineering design	*Journal of Construction Engineering and Management*	+	+	+	Level II—Concept Application
[61]	Liang et al.	2019	Optimizing incentive policy of energy-efficiency retrofit in public buildings: A principal-agent model	*Sustainability (Switzerland)*	-	-	+	Level I—Concept Enrichment
[51]	Liu et al.	2011	Moral hazard and adverse selection in Chinese construction tender market A case of Wenchuan earthquake	*Disaster Prevention and Management*	+	+	+	Level I—Concept Enrichment
[10]	Liu and Ma	2020	Study on incentive and supervision mechanisms of technological innovation in megaprojects based on the principal-agent theory	*Engineering, Construction and Architectural Management*	+	+	+	Level II—Concept Application
[98]	Liu et al.	2022	Multidimensional drivers: exploring contractor rule violations in the construction industry	*Engineering, Construction and Architectural Management*	+	-	-	Level II—Concept Application

Ref.	Author/s	Year	Article Title	Journal	Risk	Risk Consequence	Risk Mitigation Measures	Degree of Elaboration
[87]	Liu et al.	2020	Exploring the factors triggering occupational ethics risk of technology transaction in chinese construction industry	*International Journal of Environmental Research and Public Health*	+	-	-	Level II—Concept Application
[117]	Loosemore et al.	2020	Optimising social procurement policy outcomes through cross-sector collaboration in the Australian construction industry	*Engineering, Construction and Architectural Management*	-	-	-	Level III—Terminology Application
[118]	Lu et al.	2016	Effect of contract completeness on contractors' opportunistic behavior and the moderating role of interdependence	*Journal of Construction Engineering and Management*	-	-	-	Level III—Terminology Application
[47]	Lützkendorf and Speer	2005	Alleviating asymmetric information in property markets: Building performance and product quality as signals for consumers	*Building Research and Information*	+	+	+	Level I—Concept Enrichment
[29]	Ma and Zhang	2014	Game analysis on moral hazard of construction project managers in China	*International Journal of Civil Engineering*	+	-	+	Level I—Concept Enrichment
[71]	Ma et al.	2018	Governing the moral hazard in China's sponge city projects: A managerial analysis of the construction in the non-public land	*Sustainability (Switzerland)*	+	+	+	Level I—Concept Enrichment
[80]	Marinho et al.	2021	Relational contracting and its combination with the BIM methodology in mitigating asymmetric information problems in construction projects	*Journal of Civil Engineering and Management*	+	-	+	Level I—Concept Enrichment
[119]	Medda	2007	A game theory approach for the allocation of risks in transport public private partnerships	*International Journal of Project Management*	-	-	-	Level III—Terminology Application
[99]	Missbauer and Hauber	2006	Bid calculation for construction projects: Regulations and incentive effects of unit price contracts	*European Journal of Operational Research*	+	+	+	Level II—Concept Application
[92]	Montrimas et al.	2021	Beyond the socio-economic impact of transport megaprojects	*Sustainability (Switzerland)*	+	+	-	Level II—Concept Application
[72]	Nie et al.	2020	Quality control of water conservancy construction projects considering contractor's credibility	*Journal of Coastal Research*	-	-	+	Level I—Concept Enrichment
[77]	Owusu-Manu et al.	2018	An empirical examination of moral hazards and adverse selection on PPP projects: A case study of Ghana	*Journal of Engineering, Design and Technology*	+	+	-	Level I—Concept Enrichment
[81]	Owusu-Manu et al.	2021	Exploring strategies to reduce moral hazard and adverse selection of Ghanaian public–private partnership (PPP) construction projects	*Journal of Engineering, Design and Technology*	-	-	+	Level I—Concept Enrichment
[74]	Owusu-Manu et al.	2021	Fuzzy synthetic evaluation of moral hazard and adverse selection of public private partnership projects	*International Journal of Construction Management*	+	+	-	Level I—Concept Enrichment
[78]	Owusu-Manu et al.	2018	Causal relationships of moral hazard and adverse selection of Ghanaian Public-Private-Partnership (PPP) construction projects	*Journal of Engineering, Design and Technology*	+	+	-	Level I—Concept Enrichment
[96]	Pesek et al.	2019	Information asymmetry on heavy civil projects: Deficiency identification by contractors and owners	*Journal of Management in Engineering*	+	+	+	Level II—Concept Application
[120]	Raji	2019	Conceptual model for minimization of transaction costs in building energy efficiency (BEE) for affordable housing delivery	*Malaysian Construction Research Journal*	-	-	-	Level III—Terminology Application
[43]	Rosenfeld and Geltner	1991	Cost-plus and incentive contracting: Some false benefits and inherent drawbacks	*Construction Management and Economics*	+	+	+	Level II—Concept Application
[82]	Schieg	2008	Strategies for avoiding asymmetric information in construction project management	*Journal of Business Economics and Management*	+	-	+	Level I—Concept Enrichment
[32]	Shi et al.	2021	Double moral hazard and risk-sharing in construction projects	*IEEE Transactions on Engineering Management*	+	+	+	Level I—Concept Enrichment
[103]	Shi et al.	2021	Optimal build-operate-transfer road contracts under information asymmetry and uncertainty	*Transportation Research Part B: Methodological*	-	-	+	Level II—Concept Application
[100]	Shi et al.	2016	Optimal choice of capacity, toll and government guarantee for build-operate-transfer roads under asymmetric cost information	*Transportation Research Part B: Methodological*	-	-	+	Level II—Concept Application

Ref.	Author/s	Year	Article Title	Journal	Risk	Risk Consequence	Risk Mitigation Measures	Degree of Elaboration
[35]	Singh and Prasath Kumar	2022	Smart contracts and supply chain management using blockchain	*Journal of Engineering Research (Kuwait)*	-	-	+	Level III—Terminology Application
[58]	Snippert et al.	2015	Barriers to realizing a stewardship relation between client and vendor: The Best Value approach	*Construction Management and Economics*	+	-	+	Level I—Concept Enrichment
[62]	Su et al.	2020	Incentive mechanism and subsidy design for construction and demolition waste recycling under information asymmetry with reciprocal behaviors	*International Journal of Environmental Research and Public Health*	-	-	+	Level I—Concept Enrichment
[104]	Sun and Wang	2015	The interaction between BIM's promotion and interest game under information asymmetry	*Journal of Industrial and Management Optimization*	-	-	+	Level II—Concept Application
[106]	Tao et al.	2021	Analysis on the procurement cost of construction supply chain based on evolutionary game theory	*Arabian Journal for Science and Engineering*	-	-	-	Level II—Concept Application
[121]	Taofeeq et al.	2020	Government policy as a key moderator to contractors' risk attitudes among Malaysian construction companies	*Journal of Engineering, Design and Technology*	-	-	-	Level III—Terminology Application
[55]	Tserng et al.	2014	Proactive measures of governmental debt guarantees to facilitate Public-Private Partnerships project	*Journal of Civil Engineering and Management*	+	-	+	Level I—Concept Enrichment
[86]	Wang et al.	2018	Analysis of the risk-sharing ratio in PPP projects based on government minimum revenue guarantees	*International Journal of Project Management*	-	-	+	Level II—Concept Application
[101]	Wang et al.	2019	Incentive game of investor speculation in PPP highway projects based on the government minimum revenue guarantee	*Transportation Research Part A: Policy and Practice*	-	-	+	Level II—Concept Application
[44]	Ward et al.	1991	On the allocation of risk in construction projects	*International Journal of Project Management*	+	-	-	Level III—Terminology Application
[122]	Warsame et al.	2013	How can clients improve the quality of transport infrastructure projects? The role of knowledge management and incentives	*Scientific World Journal*	-	-	+	Level III—Terminology Application
[95]	Wu	2017	A multi-objective trade-off model in sustainable construction projects	*Sustainability (Switzerland)*	-	-	+	Level II—Concept Application
[66]	Wu et al.	2017	Incentive model based on cooperative relationship in sustainable construction projects	*Sustainability (Switzerland)*	+	+	+	Level I—Concept Enrichment
[107]	Wu et al.	2014	Construction supervision mechanism for public projects in China: Progress goal-oriented perspective	*Journal of Management in Engineering*	+	-	+	Level II—Concept Application
[76]	Xiang et al.	2018	Critical behavioral risk factors among principal participants in the Chinese construction industry	*Sustainability (Switzerland)*	+	-	-	Level I—Concept Enrichment
[59]	Xiang and Wang	2014	Research on preventing moral hazard of construction project based on information asymmetries	*Open Construction and Building Technology Journal*	+	+	+	Level I—Concept Enrichment
[75]	Xiang et al.	2015	Research on the phenomenon of asymmetric information in construction projects—The case of China	*International Journal of Project Management*	+	+	+	Level I—Concept Enrichment
[12]	Xiang et al.	2012	Construction project risk management based on the view of asymmetric information	*Journal of Construction Engineering and Management*	+	-	+	Level I—Concept Enrichment
[124]	Xie et al.	2023	Explaining the alienation of megaproject environmental responsibility behavior: a fuzzy set qualitative comparative analysis study in China	*Engineering, Construction and Architectural Management*	+	-	-	Level III—Terminology Application
[102]	Xiong et al.	2019	Transaction hazards and governance mechanisms in public-private partnerships: A comparative study of two cases	*Public Performance and Management Review*	+	+	+	Level II—Concept Application
[108]	Xu et al.	2019	Collaborative information integration for construction safety monitoring	*Automation in Construction*	+	+	+	Level II—Concept Application
[65]	Xue et al.	2022	Design of social responsibility incentive contracts for stakeholders of megaprojects under information asymmetry	*Sustainability (Switzerland)*	+	+	+	Level I—Concept Enrichment
[63]	Yao et al.	2020	Optimal incentive contract with asymmetric cost information	*Journal of Construction Engineering and Management*	+	-	+	Level I—Concept Enrichment

Ref.	Author/s	Year	Article Title	Journal	Risk	Risk Consequence	Risk Mitigation Measures	Degree of Elaboration
[68]	Yiyong et al.	2013	Analysis of adverse selection for motivation mechanism in engineering project cost management	*Research Journal of Applied Sciences, Engineering and Technology*	-	-	+	Level I—Concept Enrichment
[123]	Zeng et al.	2007	Managing information flows for quality improvement of projects	*Measuring Business Excellence*	-	-	-	Level III—Terminology Application
[57]	Zhang et al.	2015	Study on the project supervision system based on the principal-agent theory	*Journal of Industrial Engineering and Management*	-	-	+	Level I—Concept Enrichment
[125]	Zhang et al.	2023	Evolutionary game of government safety supervision for prefabricated building construction using system dynamics	*Engineering, Construction and Architectural Management*	-	-	-	Level III—Terminology Application
[126]	Zhao et al.	2022	Evolutionary game analysis of opportunistic behavior of Sponge City PPP projects: a perceived value perspective	*Scientific reports*	+	+	+	Level III—Terminology Application
[70]	Zhao and Zhong	2013	Analysis of collusion between contractors and supervisors in constructions	*Journal of Southwest Jiaotong University*	-	-	+	Level I—Concept Enrichment
[105]	Zheng et al.	2017	Benefit sharing for BIM implementation: Tackling the moral hazard dilemma in inter-firm cooperation	*International Journal of Project Management*	-	+	+	Level II—Concept Application

References

1. Robinson, G.; Leonard, J.; Whittington, T. *Future of Construction: A Global Forecast for Construction to 2030*; Marsh & GuyCarpenter, Oxford Economics: London, UK, 2021.
2. UN Environment Programme (UNEP); Global Alliance for Buildings and Construction (GlobalABC). The Global Status Report for Buildings and Construction. Available online: https://globalabc.org/resources/publications/2021-global-status-report-buildings-and-construction (accessed on 23 May 2023).
3. Kiani Mavi, R.; Gengatharen, D.; Kiani Mavi, N.; Hughes, R.; Campbell, A.; Yates, R. Sustainability in Construction Projects: A Systematic Literature Review. *Sustainability* **2021**, *13*, 1932. [CrossRef]
4. Flyvbjerg, B. What you should know about megaprojects and why: An overview. *Proj. Manag. J.* **2014**, *45*, 6–19. [CrossRef]
5. Flanagan, R.; Norman, G. *Risk Management and Construction*; Blackwell Science: Oxford, UK, 1993.
6. Jäger, C. *The Principal-Agent Theory within the Context of Economic Sciences*; Herstellung und Verlag; Books on Demand GmbH: Norderstedt, Germany, 2008.
7. Cerić, A. Reducing information asymmetry and building trust in projects using blockchain technology. *Građevinar* **2021**, *73*, 967–978. [CrossRef]
8. Akerlof, G.A. The market for "lemons": Quality uncertainty and the market mechanism. *Q. J. Econ.* **1970**, *8*, 488–500. [CrossRef]
9. Cerić, A. *Trust in Construction Projects*; Routledge: Oxon, UK, 2016.
10. Liu, J.; Ma, G. Study on incentive and supervision mechanisms of technological innovation in megaprojects based on the principal-agent theory. *Eng. Constr. Archit. Manag.* **2020**, *28*, 1593–1614. [CrossRef]
11. Bernhold, T.; Wiesweg, N. Principal-agent theory: Perspectives and practices for effective workplace solutions. In *A Handbook of Management Theories and Models for Office Environments and Services*; Danivska, V., Appel-Meulenbroek, R., Eds.; Routledge: Oxon, UK, 2022; pp. 117–128.
12. Xiang, P.; Zhou, J.; Zhou, X.; Ye, K. Construction project risk management based on the view of asymmetric information. *J. Constr. Eng. M.* **2012**, *138*, 1303–1311. [CrossRef]
13. Ebers, M.; Gotsch, W. Institutionsökonomische Theorien der Organisation. In *Organisationstheorien*; Kieser, A., Ebers, M., Eds.; Kohlhammer: Stuttgart, Germany, 2006; pp. 247–308.
14. Eisenhardt, K.M. Agency theory: An assessment and review. *Acad. Manag. Rev.* **1989**, *14*, 57–74. [CrossRef]
15. Picot, A.; Dietl, H.; Franck, E. *Organisation—Eine ökonomische Perspektive*; Schäffer-Poeschel: Stuttgart, Germany, 1999.
16. Kulkarni, S.P. Environmental Ethics and Information Asymmetry among Organizational Stakeholders. *J. Bus. Ethics* **2000**, *27*, 215–228. [CrossRef]
17. Kim, J.W.; Park, C.K. Can ESG Performance Mitigate Information Asymmetry? Moderating Effect of Assurance Services. *Appl. Econ.* **2023**, *55*, 2993–3007. [CrossRef]
18. Cerić, A.; Ivić, I. Network analysis of interconnections between theoretical concepts associated with principal-agent theory concerning construction projects. *Organ. Technol. Manag. Constr.* **2021**, *13*, 2450–2464. [CrossRef]
19. Adelsberger, Z. Upravljanje Rizicima Prema ISO 31000: Temeljna Norma za sve ISO Sustave Upravljanja. Available online: http://www.hdkvaliteta.hr/file/articleDocument/documentFile/zdenko-adelsberger-upravljanje-rizicima-prema-iso-31000.pdf (accessed on 23 May 2023).
20. Crispin, G. The essence of risk identification in project risk management: An overview. *Int. J. Sci. Res.* **2020**, *9*, 973–978.

21. Flanagan, R.; Kendell, A.; Norman, G.; Robinson, G.D. Life cycle costing and risk management. *Constr. Manag. Econ.* **1987**, *5*, S53–S71. [CrossRef]
22. *ISO 31073:2022*; Risk management—Vocabulary. ISO: Geneva, Switzerland, 2022.
23. Project Management Institute. *A Guide to the Project Management Body of Knowledge (PMBOK Guide)*, 6th ed.; Project Management Institute, Inc.: Newtown Square, PA, USA, 2017.
24. Aven, T. On how to define, understand and describe risk. *Reliab. Eng. Syst.* **2010**, *95*, 623–631. [CrossRef]
25. Thakur, A.I.; Khan, S.; Siddiqui, M.J. Risk Management and Life Cycle Costing of Infrastructure Project. *Int. J. Adv. Eng. Technol.* **2016**, *4*, 70–75.
26. Sha, K.X. Incentive strategies for construction project manager: A common agency perspective. *Constr. Manag. Econ.* **2019**, *37*, 461–471. [CrossRef]
27. Zeng, W.; Wang, H.; Li, H.; Zhou, H.T.; Wu, P.; Le, Y. Incentive mechanisms for supplier development in mega construction projects. *IEEE Trans. Eng. Manag.* **2019**, *66*, 252–265. [CrossRef]
28. Chang, C.Y. Principal-agent model of risk allocation in construction contracts and its critique. *J. Constr. Eng. M.* **2014**, *140*, 04013032. [CrossRef]
29. Ma, L.; Zhang, P. Game analysis on moral hazard of construction project managers in China. *Int. J. Civ. Eng.* **2014**, *12*, 429–438.
30. Chen, W.; Li, L. Incentive contracts for green building production with asymmetric information. *Int. J. Prod. Res.* **2021**, *59*, 1860–1874. [CrossRef]
31. Gomez, C.; Castiblanco, D.; Lozano, J.M.; Daza, C. An exact optimization approach to the principal-agent problem in infrastructure projects via PPPs. *Int. J. Constr. Manag.* **2020**, *20*, 679–689. [CrossRef]
32. Shi, L.; He, Y.J.; Onishi, M.; Kobayashi, K. Double moral hazard and risk-sharing in construction projects. *IEEE Trans. Eng. Manag.* **2021**, *68*, 1919–1929. [CrossRef]
33. Osipova, E. Establishing cooperative relationships and joint risk management in construction projects: Agency theory perspective. *J. Manag. Eng.* **2015**, *31*, 5014026. [CrossRef]
34. Forsythe, P.; Sankaran, S.; Biesenthal, C. How far can BIM reduce information asymmetry in the Australian construction context? *Proj. Manag. J.* **2015**, *46*, 75–87. [CrossRef]
35. Singh, A.K.; Prasath Kumar, V.R. Smart contracts and supply chain management using blockchain. *J. Eng. Res.* **2022**, *9*, 6092792. [CrossRef]
36. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ* **2021**, *372*, n71. [CrossRef]
37. Mendeley. Available online: https://www.mendeley.com/?interaction_required=true (accessed on 22 February 2023).
38. Cambridge University Press. Available online: https://dictionary.cambridge.org/dictionary/english/construction (accessed on 22 February 2023).
39. Fellows, R.; Liu, A. *Research Methods for Construction*, 3rd ed.; Blackwell Science: Oxford, UK, 2008.
40. Seuring, S.; Gold, S. Conducting content-analysis based literature reviews in supply chain management. *Supply Chain. Manag.* **2012**, *17*, 544–555. [CrossRef]
41. Laplume, A.O.; Sonpar, K.; Litz, R.A. Stakeholder theory: Reviewing a theory that moves us. *J. Manag.* **2008**, *34*, 1152–1189. [CrossRef]
42. Littau, P.; Jujagiri, N.J.; Gerald, A. 25 Years of Stakeholder Theory in Project Management Literature (1984–2009). *Proj. Manag. J.* **2010**, *41*, 17–29. [CrossRef]
43. Rosenfeld, Y.; Geltner, D. Cost-plus and incentive contracting: Some false benefits and inherent drawbacks. *Constr. Manag. Econ.* **1991**, *9*, 481–490. [CrossRef]
44. Ward, S.C.; Chapman, C.B.; Curtis, B. On the allocation of risk in construction projects. *Int. J. Proj. Manag.* **1991**, *9*, 140–147. [CrossRef]
45. Lampel, J.; Miller, R.; Floricel, S. Information asymmetries and technological innovation in large engineering construction projects. *R D Manag.* **1996**, *26*, 357–369. [CrossRef]
46. Lampel, J.; Miller, R.; Floricel, S. Impact of owner involvement on innovation in large projects: Lessons from power plants construction. *Int. Bus. Rev.* **1996**, *5*, 561–578. [CrossRef]
47. Lützkendorf, T.; Speer, T.M. Alleviating asymmetric information in property markets: Building performance and product quality as signals for consumers. *Build. Res. Inf.* **2005**, *33*, 182–195. [CrossRef]
48. Chang, C.-Y.; Ive, G. Reversal of bargaining power in construction projects: Meaning, existence and implications. *Constr. Manag. Econ.* **2007**, *25*, 845–855. [CrossRef]
49. Chang, C.-Y.; Ive, G. The hold-up problem in the management of construction projects: A case study of the Channel Tunnel. *Int. J. Proj. Manag.* **2007**, *25*, 394–404. [CrossRef]
50. Chang, C.-Y. Understanding the hold-up problem in the management of megaprojects: The case of the Channel Tunnel Rail Link project. *Int. J. Proj. Manag.* **2013**, *31*, 628–637. [CrossRef]
51. Liu, D.; Xu, W.; Li, H.; Zhang, W.; Wang, W. Moral hazard and adverse selection in Chinese construction tender market a case of Wenchuan earthquake. *Disaster Prev. Manag.* **2011**, *20*, 363–377. [CrossRef]

52. Feser, D.; Runst, P. Energy efficiency consultants as change agents? Examining the reasons for EECs' limited success. *Energy Policy* **2016**, *98*, 309–317. [CrossRef]
53. Chen, T.-C.; Lin, Y.-C.; Wang, L.-C. The analysis of BOT strategies based on game theory—Case study on Taiwan's high speed railway project. *J. Civ. Eng. Manag.* **2012**, *18*, 662–674. [CrossRef]
54. Ho, P.S.; Levitt, R.; Tsui, C.-W.; Hsu, Y. Opportunism-focused transaction cost analysis of public-private partnerships. *J. Manag. Eng.* **2015**, *31*, 04015007. [CrossRef]
55. Tserng, H.P.; Ho, S.-P.; Chou, J.-S.; Lin, C. Proactive measures of governmental debt guarantees to facilitate Public-Private Partnerships project. *J. Civ. Eng. Manag.* **2014**, *20*, 548–560. [CrossRef]
56. Lewis, G.; Bajari, P. Moral hazard, incentive contracts, and risk: Evidence from procurement. *Rev. Econ. Stud.* **2014**, *81*, 1201–1228. [CrossRef]
57. Zhang, R.; Zhou, Y.; Zhuang, H.; Zhu, X. Study on the project supervision system based on the principal-agent theory. *J. Ind. Eng. Manag.* **2015**, *8*, 491–508. [CrossRef]
58. Snippert, T.; Witteveen, W.; Boes, H.; Voordijk, H. Barriers to realizing a stewardship relation between client and vendor: The Best Value approach. *Constr. Manag. Econ.* **2015**, *33*, 569–586. [CrossRef]
59. Xiang, P.; Wang, J. Research on preventing moral hazard of construction project based on information asymmetries. *Open Constr. Build. Technol. J.* **2014**, *8*, 468–475. [CrossRef]
60. Hajjej, I.; Hillairet, C.; Mnif, M.; Pontier, M. Optimal contract with moral hazard for Public Private Partnerships. *Stochastics* **2017**, *89*, 1015–1038. [CrossRef]
61. Liang, X.; Shen, G.Q.; Guo, L. Optimizing incentive policy of energy-efficiency retrofit in public buildings: A principal-agent model. *Sustainability* **2019**, *11*, 3442. [CrossRef]
62. Su, P.; Peng, Y.; Hu, Q.; Tan, R. Incentive Mechanism and Subsidy Design for Construction and Demolition Waste Recycling under Information Asymmetry with Reciprocal Behaviors. *Int. J. Environ. Res. Public Health* **2020**, *17*, 4346. [CrossRef]
63. Yao, M.; Wang, F.; Chen, Z.; Ye, H. Optimal Incentive Contract with Asymmetric Cost Information. *J. Constr. Eng. Manag.* **2020**, *146*, 04020054. [CrossRef]
64. Han, H.; Shen, J.; Liu, B.; Han, H. Dynamic Incentive Mechanism for Large-scale Projects Based on the Reputation Effects. *SAGE Open* **2022**, *12*, 21582440221133280. [CrossRef]
65. Xue, F.; Chen, G.; Huang, S.; Xie, H. Design of Social Responsibility Incentive Contracts for Stakeholders of Megaprojects under Information Asymmetry. *Sustainability* **2022**, *14*, 1465. [CrossRef]
66. Wu, G.; Zuo, J.; Zhao, X. Incentive model based on cooperative relationship in Sustainable construction projects. *Sustainability* **2017**, *9*, 1191. [CrossRef]
67. Li, H.; Lv, L.; Zuo, J.; Su, L.; Wang, L.; Yuan, C. Dynamic Reputation Incentive Mechanism for Urban Water Environment Treatment PPP Projects. *J. Constr. Eng. Manag.* **2020**, *146*, 04020088. [CrossRef]
68. Yiyong, L.; Yousong, W.; Jingkuang, L. Analysis of adverse selection for motivation mechanism in engineering project cost management. *Res. J. Appl. Sci. Eng. Technol.* **2013**, *5*, 3777–3782. [CrossRef]
69. Ahmed, M.O.; El-adaway, I.H.; Coatney, K.T.; Eid, M.S. Construction Bidding and the Winner's Curse: Game Theory Approach. *J. Constr. Eng. Manag.* **2016**, *142*, 04015076. [CrossRef]
70. Zhao, L.; Zhong, S. Analysis of collusion between contractors and supervisors in constructions. *J. Southwest Jiaotong Univ.* **2013**, *48*, 1136–1141. [CrossRef]
71. Ma, T.; Wang, Z.; Ding, J. Governing the moral hazard in China's sponge city projects: A managerial analysis of the construction in the non-public land. *Sustainability* **2018**, *10*, 3018. [CrossRef]
72. Nie, X.; Wang, Y.; Wang, B. Quality Control of Water Conservancy Construction Projects Considering Contractor's Credibility. *J. Coast. Res.* **2020**, *104*, 410–414. [CrossRef]
73. Du, Y.; Zhou, H.; Yuan, Y.; Xue, H. Exploring the moral hazard evolutionary mechanism for BIM implementation in an integrated project team. *Sustainability* **2019**, *11*, 5719. [CrossRef]
74. Owusu-Manu, D.-G.; Kukah, A.S.K.; Edwards, D.J.; Ameyaw, E.E. Fuzzy synthetic evaluation of moral hazard and adverse selection of public private partnership projects. *Int. J. Constr. Manag.* **2023**, *23*, 1805–1814. [CrossRef]
75. Xiang, P.; Huo, X.; Shen, L. Research on the phenomenon of asymmetric information in construction projects—The case of China. *Int. J. Proj. Manag.* **2015**, *33*, 589–598. [CrossRef]
76. Xiang, P.; Jia, F.; Li, X. Critical behavioral risk factors among principal participants in the Chinese construction industry. *Sustainability* **2018**, *10*, 3158. [CrossRef]
77. Owusu-Manu, D.-G.; Edwards, D.J.; Kukah, A.S.; Parn, E.A.; El-Gohary, H.; Hosseini, M.R. An empirical examination of moral hazards and adverse selection on PPP projects: A case study of Ghana. *J. Eng. Des. Technol.* **2018**, *16*, 910–924. [CrossRef]
78. Owusu-Manu, D.-G.; Kukah, A.S.; Edwards, D.J.; Pärn, E.A.; El-Gohary, H.; Aigbavboa, C. Causal relationships of moral hazard and adverse selection of Ghanaian Public-Private-Partnership (PPP) construction projects. *J. Eng. Des. Technol.* **2018**, *16*, 439–460. [CrossRef]
79. Cerić, A. Strategies for minimizing information asymmetries in construction projects: Project managers' perceptions. *J. Bus. Econ. Manag.* **2014**, *15*, 424–440. [CrossRef]
80. Marinho, A.; Couto, J.; Teixeira, J. Relational contracting and its combination with the BIM methodology in mitigating asymmetric information problems in construction projects. *J. Civ. Eng. Manag.* **2021**, *27*, 217–229. [CrossRef]

81. Owusu-Manu, D.-G.; Kukah, A.S.; Boateng, F.; Asumadu, G.; Edwards, D.J. Exploring strategies to reduce moral hazard and adverse selection of Ghanaian public–private partnership (PPP) construction projects. *J. Eng. Des. Technol.* **2021**, *19*, 358–372. [CrossRef]
82. Schieg, M. Strategies for avoiding asymmetric information in construction project management. *J. Bus. Econ. Manag.* **2008**, *9*, 47–51. [CrossRef]
83. Giraudet, L.-G. Energy efficiency as a credence good: A review of informational barriers to energy savings in the building sector. *Energy Econ.* **2020**, *87*, 104698. [CrossRef]
84. González-Díaz, M.; Arruñada, B.; Fernández, A. Causes of subcontracting: Evidence from panel data on construction firms. *J. Econ. Behav. Organ.* **2000**, *42*, 167–187. [CrossRef]
85. Badenfelt, U. The selection of sharing ratios in target cost contracts. *Eng. Constr. Archit. Manag.* **2008**, *15*, 54–65. [CrossRef]
86. Wang, Y.; Cui, P.; Liu, J. Analysis of the risk-sharing ratio in PPP projects based on government minimum revenue guarantees. *Int. J. Proj. Manag.* **2018**, *36*, 899–909. [CrossRef]
87. Liu, X.; Lin, S.; Liu, L.; Qian, F.; Zhang, K. Exploring the Factors Triggering Occupational Ethics Risk of Technology Transaction in Chinese Construction Industry. *Int. J. Environ. Res. Public Health* **2020**, *17*, 1175. [CrossRef] [PubMed]
88. Cheng, H.; Zheng, S. Incentive Compensation Mechanism for the Infrastructure Construction of Electric Vehicle Battery Swapping Station under Asymmetric Information. *Sustainability* **2022**, *14*, 7041. [CrossRef]
89. Fernández-Solís, J.L.; Rybkowski, Z.K.; Xiao, C.; Lü, X.; Chae, L.S. General contractor's project of projects—A meta-project: Understanding the new paradigm and its implications through the lens of entropy. *Archit. Eng. Des. Manag.* **2015**, *11*, 213–242. [CrossRef]
90. Ive, G.; Chang, C.-Y. The principle of inconsistent trinity in the selection of procurement systems. *Constr. Manag. Econ.* **2007**, *25*, 677–690. [CrossRef]
91. Cantarelli, C.C.; Chorus, C.G.; Cunningham, S.W. Explaining cost overruns of large-scale transportation infrastructure projects using a signalling game. *Transp. A Transp. Sci.* **2013**, *9*, 239–258. [CrossRef]
92. Montrimas, A.; Bruneckienė, J.; Gaidelys, V. Beyond the socio-economic impact of transport megaprojects. *Sustainability* **2021**, *13*, 8547. [CrossRef]
93. Guo, S.; Wang, J.; Xiong, H. The influence of effort level on profit distribution strategies in IPD projects. *Eng. Constr. Archit. Manag.* **2023**, *in press*. [CrossRef]
94. Li, Y.; He, N.; Li, H.; Liu, Z.; Qi, J. Influencing factors on inter-organizational trust asymmetry behavior in construction projects: Evidence from China. *Eng. Constr. Archit. Manag.* **2021**, *28*, 308–331. [CrossRef]
95. Wu, G. A multi-objective trade-off model in sustainable construction projects. *Sustainability* **2017**, *9*, 1929. [CrossRef]
96. Pesek, A.E.; Smithwick, J.B.; Saseendran, A.; Sullivan, K.T. Information Asymmetry on Heavy Civil Projects: Deficiency Identification by Contractors and Owners. *J. Manag. Eng.* **2019**, *35*, 04019008. [CrossRef]
97. Li, Y.; Ning, Y. Mitigating Opportunistic Behaviors in Consulting Projects: Evidence from the Outsourced Architectural and Engineering Design. *J. Constr. Eng. Manag.* **2022**, *148*, 04022044. [CrossRef]
98. Liu, J.; Wang, Y.; Wang, Z. Multidimensional drivers: Exploring contractor rule violations in the construction industry. *Eng. Constr. Archit. Manag.* **2023**, *30*, 1496–1518. [CrossRef]
99. Missbauer, H.; Hauber, W. Bid calculation for construction projects: Regulations and incentive effects of unit price contracts. *Eur. J. Oper. Res.* **2006**, *171*, 1005–1019. [CrossRef]
100. Shi, S.; Yin, Y.; Guo, X. Optimal choice of capacity, toll and government guarantee for build-operate-transfer roads under asymmetric cost information. *Transp. Res. Part B Methodol.* **2016**, *85*, 56–69. [CrossRef]
101. Wang, Y.; Gao, H.O.; Liu, J. Incentive game of investor speculation in PPP highway projects based on the government minimum revenue guarantee. *Transp. Res. Part A Policy Pract.* **2019**, *125*, 20–34. [CrossRef]
102. Xiong, W.; Chen, B.; Wang, H.; Zhu, D. Transaction Hazards and Governance Mechanisms in Public-Private Partnerships: A Comparative Study of Two Cases. *Public Perform. Manag. Rev.* **2019**, *42*, 1279–1304. [CrossRef]
103. Shi, S.; Yin, Y.; An, Q.; Chen, K. Optimal build-operate-transfer road contracts under information asymmetry and uncertainty. *Transp. Res. Part B Methodol.* **2021**, *152*, 65–86. [CrossRef]
104. Sun, J.; Wang, L. The interaction between BIM's promotion and interest game under information asymmetry. *J. Ind. Manag. Optim.* **2015**, *11*, 1301–1319. [CrossRef]
105. Zheng, L.; Lu, W.; Chen, K.; Chau, K.W.; Niu, Y. Benefit sharing for BIM implementation: Tackling the moral hazard dilemma in inter-firm cooperation. *Int. J. Proj. Manag.* **2017**, *35*, 393–405. [CrossRef]
106. Tao, Z.; Wang, B.; Shu, L. Analysis on the Procurement Cost of Construction Supply Chain based on Evolutionary Game Theory. *Arab. J. Sci. Eng.* **2021**, *46*, 1925–1940. [CrossRef]
107. Wu, Y.; Huang, Y.; Luo, W.; Li, C. Construction supervision mechanism for public projects in China: Progress goal-oriented perspective. *J. Manag. Eng.* **2014**, *30*, 205–213. [CrossRef]
108. Xu, Q.; Chong, H.-Y.; Liao, P.-C. Collaborative information integration for construction safety monitoring. *Autom. Constr.* **2019**, *102*, 120–134. [CrossRef]
109. Bröchner, J. Construction contractors integrating into facilities management. *Facilities* **2008**, *26*, 6–15. [CrossRef]
110. Carmichael, D.G.; Karantonis, J.P. Construction contracts with conversion capability: A way forward. *J. Financ. Manag. Prop. Constr.* **2015**, *20*, 132–146. [CrossRef]

111. Flyvbjerg, B.; Ansar, A.; Budzier, A.; Buhl, S.; Cantarelli, C.; Garbuio, M.; Glenting, C.; Skamris Holm, M.; Lovallo, D.; Lunn, D.; et al. Five things you should know about cost overrun. *Transp. Res. Part A Policy Pract.* **2018**, *118*, 174–190. [CrossRef]
112. Jallan, Y.; Ashuri, B. Text Mining of the Securities and Exchange Commission Financial Filings of Publicly Traded Construction Firms Using Deep Learning to Identify and Assess Risk. *J. Constr. Eng. Manag.* **2020**, *146*, 04020137. [CrossRef]
113. Juan, Y.-K. A hybrid approach using data envelopment analysis and case-based reasoning for housing refurbishment contractors selection and performance improvement. *Expert. Syst. Appl.* **2009**, *36*, 5702–5710. [CrossRef]
114. Juan, Y.-K.; Kim, J.H.; Roper, K.; Castro-Lacouture, D. GA-based decision support system for housing condition assessment and refurbishment strategies. *Autom. Constr.* **2009**, *18*, 394–401. [CrossRef]
115. Juan, Y.-K.; Perng, Y.-H.; Castro-Lacouture, D.; Lu, K.-S. Housing refurbishment contractors selection based on a hybrid fuzzy-QFD approach. *Autom. Constr.* **2009**, *18*, 139–144. [CrossRef]
116. Kwofie, T.E.; Ohis Aigbavboa, C.; Thwala, W.D. Communication performance challenges in PPP projects: Cases of Ghana and South Africa. *Built. Environ. Proj. Asset. Manag.* **2019**, *9*, 628–641. [CrossRef]
117. Loosemore, M.; Denny-Smith, G.; Barraket, J.; Keast, R.; Chamberlain, D.; Muir, K.; Powell, A.; Higgon, D.; Osborne, J. Optimising social procurement policy outcomes through cross-sector collaboration in the Australian construction industry. *Eng. Constr. Archit. Manag.* **2020**, *28*, 1908–1928. [CrossRef]
118. Lu, W.; Zhang, L.; Zhang, L. Effect of contract completeness on contractors' opportunistic behavior and the moderating role of interdependence. *J. Constr. Eng. Manag.* **2016**, *142*, 04016004. [CrossRef]
119. Medda, F. A game theory approach for the allocation of risks in transport public private partnerships. *Int. J. Proj. Manag.* **2007**, *25*, 213–218. [CrossRef]
120. Raji, A.U. Conceptual model for minimization of transaction costs in building energy efficiency (BEE) for affordable housing delivery. *Malays. Constr. Res. J.* **2019**, *8*, 107–122. [CrossRef]
121. Taofeeq, M.D.; Adeleke, A.Q.; Lee, C.-K. Government policy as a key moderator to contractors' risk attitudes among Malaysian construction companies. *J. Eng. Des. Technol.* **2020**, *18*, 1543–1569. [CrossRef]
122. Warsame, A.; Borg, L.; Lind, H. How Can Clients Improve the Quality of Transport Infrastructure Projects? The Role of Knowledge Management and Incentives. *Sci. World J.* **2013**, *2013*, 709423. [CrossRef]
123. Zeng, S.X.X.; Lou, G.X.; Tam, V.W.Y. Managing information flows for quality improvement of projects. *Meas. Bus. Excell.* **2007**, *11*, 30–40. [CrossRef]
124. Xie, L.; Xu, T.; Ju, T.; Xia, B. Explaining the alienation of megaproject environmental responsibility behavior: A fuzzy set qualitative comparative analysis study in China. *Eng. Constr. Archit. Manag.* **2023**, *in press*. [CrossRef]
125. Zhang, Y.; Yi, X.; Li, S.; Qiu, H. Evolutionary game of government safety supervision for prefabricated building construction using system dynamics. *Eng. Constr. Archit. Manag.* **2023**, *in press*. [CrossRef]
126. Zhao, H.; Liu, X.; Wang, Y. Evolutionary game analysis of opportunistic behavior of Sponge City PPP projects: A perceived value perspective. *Sci. Rep.* **2022**, *12*, 8798. [CrossRef] [PubMed]
127. Frunza, M.-C. Moral Hazard and Financial Crime. In *Introduction to the Theories and Varieties of Modern Crime in Financial Markets*; Frunza, M.-C., Ed.; Elsevier: Amsterdam, The Netherlands, 2016; pp. 33–42.
128. Cao, D.; Wang, G. Contractor–Subcontractor Relationships with the Implementation of Emerging Interorganizational Technologies: Roles of Cross-Project Learning and Pre-Contractual Opportunism. *Int. J. Constr. Educ. Res.* **2014**, *10*, 268–284. [CrossRef]
129. Borowska, K. The Slow Revolution—Five Technology Trends In Construction 2020, Forbes. Available online: https://www.forbes.com/sites/kasiaborowska/2020/11/19/the-slow-revolutionfive-technology-trends-in-construction-2020/?sh=34fb8171419a (accessed on 26 May 2023).
130. Poulson, D.; Ashby, M.; Richardson, S. *USERfit. A Practical Handbook on User-Centred Design for Assistive Technology*; TIDE EC-DG XIII, ECSC-ECEAEC: Brussels, Luxembourg, 1996.
131. Xia, N.; Zou, P.X.W.; Griffin, M.A.; Wang, X.; Zhong, R. Towards integrating construction risk management and stakeholder management: A systematic literature review and future research agendas. *Int. J. Proj. Manag.* **2018**, *36*, 701–715. [CrossRef]
132. Di Maddaloni, F.; Davis, K. The influence of local community stakeholders in megaprojects: Rethinking their inclusiveness to improve project performance. *Int. J. Proj. Manag.* **2017**, *35*, 1537–1556. [CrossRef]
133. Sabini, L.; Muzio, D.; Alderman, N. 25 years of 'sustainable projects'. What we know and what the literature says. *Int. J. Proj. Manag.* **2019**, *37*, 820–838. [CrossRef]