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NLP AND SNA FOR UNDERSTANDING RENEGOTIATIONS OF TOLL ROAD PPPs AMID THE COVID-19 PANDEMIC

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The Covid-19 pandemic has directly impacted Public-Private Partnership (PPP) projects worldwide. As a result of these impacts, many of the projects were renegotiated to assure favorable conditions for either the public, private, or both parties. Based on this context, this study seeks to unravel contractual mechanisms implemented or modified within the context of renegotiation processes caused by the Covid-19 pandemic in Colombia's PPP toll road projects. Thus, this research aims to determine the impacts of the pandemic and the contractual strategies implemented in different renegotiation processes of PPP toll road projects. The mechanisms were analyzed at individual and cluster levels by implementing natural language processing (NLP) and social network analysis (SNA) procedures. These methodologies facilitated the analysis of multiple contractual mechanisms to identify the different impacts and common strategies between renegotiation processes. This research determined the main drivers and strategies to mitigate the effects of the Covid-19 pandemic on Colombia's PPP projects, providing a methodology to enable contractual and renegotiation analysis. Overall, the renegotiation processes revealed that the pandemic had an economic and time-related impact, with differences between processes based on the renegotiation initiator or project phase at which the process arises.

Keywords: Contractual mechanisms, Force majeure, Contractual strategies, Construction management.

1 INTRODUCTION AND BACKGROUND

Renegotiations are considered a mechanism to deal with uncertainty in Public-Private Partnership (PPP) contracts (Biziorek *et al.* 2023, Cruz *et al.* 2015, Castelblanco *et al.* 2022b, Xiong *et al.* 2022). In this way, the unpredictability of the Covid-19 pandemic and its mitigation measures generated multiple renegotiations in PPPs seeking more favorable conditions (Castelblanco *et al.* 2022a). Despite scholars having studied renegotiation processes (Marcellino *et al.* 2023), the impacts of the Covid-19 pandemic on PPP toll road projects still need to be studied from a PPP program perspective (Castelblanco and Guevara 2022). To fill this gap, this paper uses Content analysis (CA), Natural Language Processing (NLP), and Social Network Analysis (SNA) as complementary methodologies to provide a holistic comprehension of the contractual mechanisms

implemented or affected by Covid-19 renegotiations from different perspectives. Individually, it is possible to study the aim of each mechanism, while by clusters, mechanisms give a qualitative and quantitative understanding of the diversity and importance of the contractual mechanisms implemented or affected in the different renegotiation processes. This enables an understanding of the impacts that a force majeure event can generate on multiple levels: the PPP projects, the public sector, and users. Moreover, this framework provides a first approach to the automation of renegotiation analysis to reduce its subjectivity, which is a priority in this type of research (Salama and El-Gohary 2016).

2 RESEARCH METHODOLOGY

The purpose of this framework is to provide a holistic understanding of the implications of Covid-19 on toll road projects. To do so, first, information collection and content analysis were conducted. As a result, 13 renegotiation processes related to Covid-19 were identified in the 29 projects of the Colombian PPP road program. Each process is identified with the nomenclature T1, T2, ..., T13. Processes T1 and T2 are general processes and were applied to different projects. The T1 process is an event liability waiver, and the T2 process compensates concessionaires for the effects generated on their income. Processes T5 and T6 are liability exemption events. Finally, processes T3, T4, T7, T8, T9, T10, T11, T12, and T13 are contractual modifications.

For each process, several items were identified, including the initiator of the process, the project phase when the process arises (Guasch *et al.* 2014, The World Bank Group 2022), and context information about Covid-19 impacts. The main keywords of each mechanism were then identified for categorization with Natural Language Processing. This group of words is known as a lexicon (Lee *et al.* 2019, Wang *et al.* 2022).

Second, information preparation and NLP were applied to summarize and categorize the contractual mechanisms (Padhy *et al.* 2021, ul Hassan and Le 2022). Information preparation consisted of arranging the processes in an appropriate format to be able to apply the NLP method. This method has 6 main steps: tokenization, stopword removal, lemmatization, POS Tagging, named entity recognition, and chunking. This allows for the development of contractual mechanism categorization. The categories used are: compensation (C), delay (D), extension (E), extra work costs (EW), further interpretation (FI), and negotiation (N), which were identified and adapted to the risk distribution mechanisms described by Dewulf and Garvin (2019). Furthermore, two additional categories were defined: modification (M) and project or process-Specific Issue (S). The modification category is related to statements that imply the modification of contractual mechanisms of previous renegotiation processes or even the concession contract. On the other hand, the project or process-specific issue category refers to statements related to the aspects to be validated in the contract. For example, statements for future Covid-19 events' liability waivers or changes in risk allocation schemes. Thus, categorization entails searching for similarities between the summary of the mechanisms and the words in the lexicon that correspond to each of the described categories.

Third, mapping was conducted for the two-mode networks of categorized mechanisms and renegotiation processes, followed by using social network analysis to obtain metrics. From the weighted degree centrality, it is possible to determine the number of processes in which a mechanism was implemented (Newman 2018, Castelblanco *et al.* 2021, Castelblanco *et al.* 2023, Castelblanco *et al.* 2024, Salazar *et al.* 2024), where the weight of the relationships is also considered. In contractual networks, the weight of the links will depend on the number of projects in which a particular process was implemented. On the other hand, it is possible to obtain metrics for the whole network. Density and transitivity cohesion metrics were analyzed in this study.

Density is a measure of a network's disconnection, providing insight into the diversity of mechanisms present in the network (Borgatti and Everett 1997). A perfect density indicates that all mechanisms were implemented in all processes present, whereas a low density suggests that mechanisms are uncommon between processes. On the other hand, transitivity reveals whether nodes are immersed in a group. Perfect transitivity occurs when all nodes in the network are connected. In contractual networks, transitivity is inversely proportional to the number of renegotiation processes present.

3 RESULTS AND DISCUSSION

The NLP method allowed the categorization of 88 different mechanisms in the 13 renegotiation processes (T1, T2, ... T13). Based on these results, the mechanisms and processes were mapped into two-mode networks. The number of mechanisms obtained by category is shown in Table 1.

Table 1. Number of mechanisms by category.

Category	Abbreviation	Number of mechanisms
Compensation	C	2
Delay	D	11
Extension	E	1
Extra work costs	EW	5
Further Interpretation	F	1
Modification	M	15
Negotiation	N	5
Project - Specific Issue	S	48

The main network revealed that there is a central cluster of processes (i.e., T1 and T2) along with their mechanisms. This is because both processes were implemented 27 and 26 times, respectively. For this reason, there is a significant difference in the importance of processes T1 and T2 over the other processes that were specific to one project and implemented only once. Moreover, centrality measures revealed that the general processes (T1 and T2) were approximately 27 times higher in weighted degree centrality than the other processes. The weighted degree for processes T1 and T2 was 2.95 and 2.15, respectively. Similarly, the results for the mechanisms confirmed the importance of these processes. This, considering that the most important mechanisms in the network based on the weighted degree centrality were those implemented in processes T1 and T2.

Processes T1 and T2 recognize the main effects of Covid-19 on the road projects of the Colombian PPP program. The T1 process refers to a liability exemption event where the main affected obligations were identified, influencing the different phases of the project life cycle. Consequently, contractual delay mechanisms were implemented to adjust the schedule (D1). Similarly, compensation mechanisms were included to compensate costs incurred during the period of affectation, known as idle costs (C2). On the other hand, the T2 process sought to recognize the economic effects of the concessionaires. Therefore, in this process, a compensation mechanism was implemented in response to the pandemic mitigation measures that affected the revenues of the concessionaires (C1). Both processes allow for a broad understanding of the economic and time impacts that the pandemic had on these PPP projects.

On the other hand, the main network indicates that there is a wide variety of contractual mechanisms. In the main network, it is possible to appreciate that contractual mechanisms are uncommon between renegotiation processes, generating a disconnected network with a high

presence of clusters. This is supported by a density of 0.109. Additionally, for the main network, a transitivity of 0.570 was obtained due to the significant diversity in the renegotiation processes implemented. This demonstrates that, even though the T1 and T2 processes made a general recognition of the impacts of the pandemic, a generic response to an event of the magnitude of Covid-19 is not possible.

CA enabled the identification of the processes initiated by the government, firms, or bilateral agreements. Similarly, it was possible to establish the project phases of each process. Pre-construction, construction, and operation phases were identified. In the networks initiated by the government and the firms, no compensation mechanisms were implemented, indicating the interests of each initiator. Contractual mechanisms revealed that the processes initiated by the firms tended to implement delay mechanisms or obtain liquidity through extra work cost mechanisms to meet obligations not contemplated in the general processes T1 and T2, where the obligations differ concerning the project stage. In contrast, the government-initiated processes demonstrated an interest in promoting economic reactivation, implementing mechanisms related to priority interventions or time adjustments in the collection of tolls for high-importance projects to compensate for the economic imbalance caused by the Covid-19 mitigation measures. Finally, the bilateral agreement processes demonstrate the intention of the parties to identify and respond to the economic and time impacts generated by the pandemic and their respective mitigation measures. It should be emphasized that processes T1 and T2 were initiated through a bilateral agreement, indicating a greater mutual interest in responding to the adversities presented by a force majeure event such as Covid-19.

CA disclosed that six out of eleven delay mechanisms related to environmental and property management were reported during the pre-construction phase and were given by the entities involved in these processes because they were unable to operate due to Covid-19. During the construction phase, the implementation of five extra work costs and three delay mechanisms revealed an impact on the liquidity to continue with project execution, schedule delays, or even delays in the process of relinquishing the concession contract. This, considering the suspension of the execution of projects and the isolations that prevented the concessionaires from fulfilling their obligations. Because road projects affect both the public sector and users, the impact on concessionaires was greater during the operation phase. Therefore, collecting tolls during times of crisis was opposite to the goals of economic reactivation. Thus, the renegotiations for the operation phase were associated with the income lost due to the measures implemented to promote economic reactivation. As a result, direct compensation mechanisms were implemented, the toll collection times were shifted, and even the contract's duration was extended.

4 CONCLUSIONS

Various studies on PPP renegotiations have been conducted, resulting in a fairly extensive literature. However, the literature does not provide an understanding of the effects and implications of the Covid-19 pandemic on PPP road projects. For this reason, the purpose of this research is to provide a comprehension of the impacts of the pandemic and the respective mitigation measures on this type of project, as well as establish a framework for a multilateral analysis of renegotiations. In general, the findings indicate that the main effects of the pandemic on PPP projects are economic and time-related. Furthermore, when a force majeure event occurs, the results show that there is a mutual interest in responding and seeking more favorable conditions. Simultaneously, it was discovered that even though the projects are part of the same PPP program, it is not possible to develop a general recognition of the consequences of an event of the magnitude of Covid-19. Therefore, the findings revealed that the renegotiation processes could differ depending on the

initiator or the project phase in which the renegotiation occurs. Thus, it was possible to conclude that the effects of Covid-19 differed depending on the project phase and that the motivations of each process differed depending on the initiator.

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