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Modeling the effects of labor on housing reconstruction: A system perspective

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ABSTRACT

The quick recovery and rebuilding of the housing stock after disaster (natural or man-made) is critical for an affected region, from the socio-economic perspective. The recovery efforts demand a considerable amount of time and resources. An efficient emergency management response system needs to be designed, with the intention of allowing a smooth post disaster reconstruction operation. This paper seeks to analyze the impacts of a disaster on labor for housing recovery and rebuilding of a devastated region. A System Dynamics (SD) model is proposed to mimic and explore the issue of labor force (namely, construction workers) management. The model describes the behavior of labor in the housing restoration process. It provides insights on the interactions between the labor force and the housing inventory management.

1. Introduction

The occurrence of disasters in a region may produce a negative impact on the housing stock. This paper examines the housing recovery by focusing on the management of labor force needed for the achievement of this operation. The emphasis of this study will be on variations of labor resourcing and their impact on the reconstruction process. The technique of modeling is used in this sense, to study the implication of this relationship. The simulation model suggested in this paper presents the housing recovery process, from the labor force standpoint. It addresses the issues of size of the labor force and the policy design to enhance the stability of the system. The model ties the labor supply to the housing inventory to better appreciate the response of the whole system, given an unanticipated jump in demand caused by the disaster. The use of System Dynamics (SD) modeling is appropriate in those circumstances as this paradigm shows how housing construction and hiring policies can interact and create favorable conditions for recovery. This application follows the suggestion of Sterman [43] through the use of a stock management structure. Sterman [43] offered a generic model of a stock management system which forms the basic structure in an environment for a decision-making experiment. The model consists of two parts, the physical stock and flow structure of the system, and the decision rules used to control the system. This generic stock management structure is applicable to many different scenarios, including raw material ordering, production control, emergency management, or at a macroeconomic level, the control of the stock of money.

The paper is structured as follows: Section 2 develops a brief literature review of research addressing the issue of labor force supply in the aftermath of a disaster. Section 3 describes the research approach employed to overcome the issues encountered. Section 4 presents the model used. The results obtained after experiments are explained in Section 5. Finally, Sections 6 and 7 offer contribution of the study and conclusions with options for eventual future work.

2. Literature review

The occurrence of a disaster imposes the need to recover and try to restore a sense of normality. Disaster mitigation in this case can be defined as taking measures in post-disaster stage aiming at reducing the adverse effects. The housing recovery process

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planning should address the sufficiency of resources in order to be effective and flow smoothly. The size of the labor force (i.e., number of workers) and its availability as an emergency resource are of a key importance in this process. A few significant studies in the following seven areas are reviewed and summarized which serve as a basis for our analysis.

2.1. Disaster preparedness and risk reduction

Hadiguna et al. [25] present the processes required to build an effective and reliable web-aided decision support system to assess the feasibility of public facilities during an evacuation of the affected population after a disaster has occurred. The results from this study confirm that this system can provide critical and timely insights into complex evacuation scenarios. Kala [27] explores and reviews the factors responsible for increased intensity and scale of disaster due to flash floods in the Uttarakhand state of India. He presents various options for disaster risk reductions in the sensitive ecosystem such as the Himalaya. Cavallo and Ireland [8] promotes the need for disaster preparedness strategies to deal with complex interdependent risks where such risks may be novel or unforeseen and which may connect in a cascading manner. The resulting causal network needs to be addressed with a networked approach to enrich existing linear approaches by recognizing the need for an interconnected holistic approach to deal appropriately with interconnected risk factors. Authors used System of Systems (SoS) and complex systems thinking to inform a sense-making framework to distinguish between approaches to known/knowable and unknown risks. In preparation and mitigation of consequences of future earthquakes Yulita and Yau [49], explore the extent to which the use of assembled housing would be effective. This technique requires the assessment of material, labor and also workmanship necessary for the recovery process and the estimation of the number of houses to build per designated area.

2.2. High disasters vulnerabilities of countries and rebuilding challenges associated with emergency supply, labor force and collaboration among decision makers

Makhanu [32] examine the high vulnerability of developing countries to disasters and the difficulties in rebuilding. Several practices and methods are reviewed in his study, putting the focus on resource mobilization and the integration of the community, namely human support, in development programs for the reconstruction projects. Olshansky [36] underline the high complexity underlying the reconstruction planning after the passage of hurricane Katrina, in the regions of Louisiana and Mississippi. In the same line of thought with Makhanu [32], the author suggests projects involving the participation of both the local authorities for planning and funding and the local population for reconstruction activities. Mumtaz et al. [33] point out the challenge faced by the Pakistan government and its population in efforts to undertake massive scale reconstruction after the passage of Kashmir Earthquake. The researchers assess the importance of the reconstruction policy in place, allowing the large scale training and hiring of labor force, which lead the recovery process with more smoothness and efficiency. Lawther [29] looks into the importance of the involvement of the affected community in the success of the post disaster reconstruction process. The study suggests the implementation of programs involving the training and inclusion of inhabitants in the reconstruction through a project procurement model. Yongling [48] analyzes the demand structure of emergency resources. He proposes building the demand structure at different levels and categories (human and material), which will allow an effective management of resources and a better handling of the disaster. Li [30] explores the issue of emergency resource supplies through the analysis of demands, as well. The author recommends the nearest neighbor method and the combination of case based reasoning and fuzzy reasoning for demand forecasting, with the objective of meeting the population needs. Chang et al. [13,14] highlight the likelihood of resources shortage (human and material) during post-disaster housing reconstruction and the consequences of this shortage. The authors propose a comparative analysis of China, Australia and Indonesia and examine the interventions used in those countries. The study supports the idea that effective resource management is the result of the appropriateness of the response and collaboration between decision makers.

2.3. Post disaster rapid capital turnover and human capital loss

A number of researchers including Albala-Bertrand [1], Stewart and Fitzgerald [45], Okuyama [34] and Benson and Clay [5] have suggested that destruction following a disaster can foster a more rapid turnover of capital. Hallegatte and Dumas [26] have examined whether disasters have positive consequences; and their findings indicate the more rapid embodiment of new technologies would yield speedy turnover of capital. It has been observed that disasters can lead to significant migrations. If skilled workers in the labor force, who have the financial means to move and settle down in other regions, leave the affected region in the disaster aftermath and do not return during and after reconstruction, then the human capital loss can largely exceed all impacts on productive capital. After Katrina, for instance, many workers in the health care sector left New Orleans and did not return, impairing the economic recovery of the city [20].

2.4. Impact of availability and provision of resources in a post disaster reconstruction environment

Chang et al. [13,14] address the issue of availability and provision of resources in a post disaster reconstruction environment. The authors suggest the Triangulation methodology with the objective of raising the importance of emergency supply and underlining the need for labor force. In chapter 4 of the book entitled *Post-Disaster Reconstruction of the Built Environment: Rebuilding for Resilience,* Chang et al. [11,12] highlight the problems encountered by the Chinese government following the Wanchuan earthquake. They conduct a longitudinal study, analyzing the impact of the human resourcing policies, decisions and programs on the effectiveness of the housing reconstruction [11]. They go on to examine the factors impacting the availability of resources for post-disaster recovery in China. Through a survey, the authors identify factors like quantity of required resources, lead time procurement, resourcing management and policies as influential in the recovery process [12]. They propose a multi sector approach in order to improve the emergency management planning operations.

2.5. Impact of availability of resources on recovery process

Chang et al. [10] emphasize the impacts of an earthquake on the availability of the resources. The authors identify a shortage of resources, namely labor force, causing a limited capacity for recovery and propose solutions to overcome this issue. Chang-Richards et al. [15] investigate the challenges of reconstruction resourcing, namely the lack of builders and construction workers, faced during the housing rebuild phase in Australia in 2009. The authors propose a longitudinal study to identify the causes of these issues. This approach looks into the impact of policies on availability of resources and resourcing fluctuation on the recovery process.

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