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Allocating human resources in organizations operating under crisis conditions: A fuzzy input-output optimization modeling framework


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Ensuring the resilience of industrial systems to perturbations is a vital strategy for climate change adaptation to maintain sustainable consumption and production. Business decision-making models are essential in providing rational support for choices made by managers and industry practitioners under crisis conditions that may result from climatic disruptions. To date, most of the techniques proposed in the literature focus on the disruptions of physical resources that propagate through supply chain linkages; nonetheless, a significant research gap remains on mitigating impacts caused by disruptions in workforce availability. In this work, a fuzzy input-output optimization model is developed for allocating scarce labor resources within a business enterprise or organization. This model uses the input-output framework to take into account organizational interdependencies that exist among workers or departmental units, to ensure minimal loss of vital services delivered to external clients. The model is demonstrated using two illustrative case studies. The first case study involves medical staff deployment in a hospital during a pandemic event; while the second case study involves allocation of personnel in a business process outsourcing firm during an adverse weather event. The examples illustrate how the proposed fuzzy input-output optimization model can provide decision support for practitioners in industry, in order to mitigate the impacts of human resource shortage on business continuity during a crisis.

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1. Introduction

Atmospheric CO₂ concentration has reached historic record levels, even as emission rates continue to grow due to global economic and demographic trends (Steffen et al., 2015). Links between greenhouse gas (GHG) emissions and climate change are already well-established, and now necessitate adaptation strategies to be integrated into sustainability measures (IPCC, 2014a). Meanwhile, sustainable consumption and production (SCP) is one of the holistic strategies being proposed to curb environmental impacts by considering both upstream (production) and downstream (consumption) ends of industrial systems (Tseng et al., 2013). Current trends in sustainability literature suggest the need to synchronize climate change mitigation and adaptation efforts through the development and use of business decision-making models. For example, Wedawatta and Ingrige (2012) studied how flood risks threaten business continuity, particularly in small and medium-sized enterprises (SMEs), while Constable and Chrysostomidis (2015) explored the implications of climate change adaptation framework on project management. It has thus been argued by Kurupp et al. (2014) that research efforts need to be intensified on various aspects of climate change adaptation in the private sector.

It is important for organizations to be prepared to deal with climatic impacts that threaten operational continuity; hence, researchers should provide support to practitioners through business decision-making models for various aspects of business operations. Climate change adaptation literature has heavily focused on disruptions in the supply of physical resources. For example, water resources are expected to be affected by climate change, with resulting implications for water supply planning (Papadaskalopoulos et al., 2015). Furthermore, research on water reuse and recycling has intensified (Alkaya and Demirer, 2015; Garcia and Pargament, 2015; Xu et al., 2015), with some effort...
that affect mobility; the spread of disease vectors that may trigger pandemic events; and droughts that may cause health problems due to unavailability of food and water, among others. Indeed, the IPCC (2014b) in its Climate Change Synthesis Report maintained with high confidence that: “The aspects of climate change with direct effects on stored terrestrial carbon include high temperatures, drought, and windstorms; indirect effects include the increased risk of fires, pest and disease outbreaks.”

This work seeks to address the research question of how to provide effective decision support for managers to deal with disruptive events that result in a transient reduction in workforce availability. Thus, a novel fuzzy input-output (I-O) optimization model is developed for allocating human resources to business enterprises or organizations operating under crisis conditions. Unlike previous I-O models for human resources (e.g., Correa and Craft, 1999), the formulation proposed here is meant to prescribe optimal damage control responses to adverse events; by comparison, the previously developed I-O framework in Correa and Craft (1999) was limited to descriptive modeling capabilities only. The limitations of previously developed approaches creates a research gap, which can be addressed by developing an optimization model that can recommend to decision makers in industry the best reallocation of human resources during a crisis. The approach used is based on prior work for I-O systems at the economy-wide (Tan et al., 2015) or industrial complex (Tan et al., 2016) scales. Yu et al. (2016) developed an overall index of satisfaction for economic output under climate change conditions; this model incorporates preference weights through a previously developed vulnerability index (Yu et al., 2014). The rest of this paper is organized as follows. The next section provides a brief literature review. The section that follows describes the model framework itself, with subsections for a formal problem statement, nomenclature, and mathematical formulation. Then, two representative case studies are explored to illustrate the model functionality; both examples deal with plausible real-life scenarios that may transpire as a result of climatic disruptions. The first case study deals with the allocation of medical personnel in a hospital during a pandemic event. The second case study then deals with the allocation of personnel in a business process outsourcing (BPO) firm during adverse weather conditions. Both of these sectors are typical examples of human resource-intensive activities that are highly reliant on workforce availability, and thus serve to demonstrate how the proposed model can provide recommendations for “damage control.” Finally, conclusions and prospects for future work are discussed.

2. Literature review

Rational allocation of human resources during a crisis requires an understanding of the interdependencies between workers or between departmental units in an organization. Input-output (I-O) analysis provides an elegant and effective framework for modeling such linkages (Correa and Craft, 1999). I-O approach has been used in the analysis of relationships in hospitals (Correa and Parker, 2005), libraries (Correa and Correa, 1996) and government offices (Correa and Guañardo, 2001, Correa, 2002) also proposed to extend the framework to general societal systems; however, with the exception of a recent paper on organizational influence by Hester and Adams (2013), there have been no developments on this class of applications of the I-O framework.

I-O models have traditionally been used for economic analysis (Leontief, 1936), and its mathematical foundations are outlined in the classic textbook by Miller and Blair (2009). Because of their inherent capability to reflect interdependencies that exist within complex systems, there is also extensive literature on the use of I-O models for the analysis of sustainable industrial systems, dating...
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