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## 博士学位論文調査報告書

論文題目

Economic Analysis of Resilience to Natural Hazards in Industrial Sectors  
(自然災害による産業部門の回復力に関する経済分析)

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( 続紙 1 )

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|---|---|----|----------|
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| 論文題目  | Economic Analysis of Resilience to Natural Hazards in Industrial Sectors<br>(自然災害による産業部門の回復力に関する経済分析) |    |          |
| (論文内容の要旨)   |   |    |          |
| <p>The thesis “Economic Analysis of Resilience to Natural Hazards in Industrial Sectors” proposes a methodology to estimate quantitatively industrial sectors’ resilience to disasters from the resistance and recovery aspects and evaluate the economic impacts caused by disasters. Specifically, the thesis aims at answering the following research questions:1) Resistance: how many percentages of production capacity rate remained in industrial sectors in the condition of lifeline disruptions immediately after disasters?; 2) Recovery: how is the post-disaster recovery process in industrial sectors in consideration of the uncertainty and influencing factors?; 3) Economic impact estimation: how much production capacity losses have caused in industrial sectors due to disasters?</p> <p>To address these research questions, the thesis consists of six chapters. Chapter 1 introduces the background of the thesis and highlights the importance of building resilience in reducing economic losses caused by disasters. The objectives, significance, and framework of the thesis are also summarized in this chapter. Chapter 2 reviews the literature in the economic resilience field, focusing on the studies in industrial sectors. This chapter defines and introduces the economic analysis from the resistance and recovery aspects, and introduces the economic losses estimation framework by integrating these two aspects. After pointing out the gaps in resilience analysis, the main focus and research questions are proposed. Chapter 3 measures the resistance to disasters in industrial sectors, which describes the ability of industrial sectors to absorb the shocks due to disasters. Lifeline resilience factor is introduced to measure the remaining production capacity of firms immediately after the disaster, which describes the importance of each lifeline in supporting firms’ productivity. A quantitative lifeline resilience factor estimation model is proposed and applied to a real post-disaster case study for the first time. A comparison is made between the manufacturing and non-manufacturing sectors since recovery varies depending on the resilience and vulnerability of different sectors. Estimation results show consistency with the previous hypothetical disaster survey data results and experts' opinion-based results. Chapter 4 describes the post-disaster recovery ability by proposing a methodology to estimate the recovery curves, which is conditional on the initial production capacity rate and lifeline supply status. The proposed model is validated through a post-disaster recovery case study commenced after the 2016 Kumamoto earthquakes. In this research, the production capacity recovery is modeled via a multi-state semi-Markov model for the first time. The relevant determinants are considered in the recovery function through the adaptation of a regression model for the sojourn time. The influencing factors, including initial production capacity damage rates and lifeline supply status (i.e., electrical power supply, water supply, and gas supply), are considered in the recovery function in comparison to various industrial sectors. Chapter 5 estimates the production capacity loss rate due to disasters by adopting the new resilience estimating methodology in Chapter 3 and the recovery function in Chapter 4. In this case, the overall economic impact due to the disaster can be assessed, and the applicability of the proposed methodology can be identified. Also, the validation is done by comparing the estimated results to the observed index of industrial production and the existing research. Chapter 6 summarizes the main findings of the research and provides strategies for improving resilience in industrial</p> |   |    |          |

sectors in case of future hazards. Also, the limitations of this research are discussed, and the subsequent steps in future work. Overall, this thesis has significant importance in estimating economic resilience in industrial sectors to natural hazards.

The contributions of the thesis include 1) Empirically estimating the lifeline resilience to disasters; 2) Modeling the stochastic recovery process for the first time; 3) Quantitatively estimate the economic impacts due to disasters; 4) Building resilience through providing empirical evidence. Besides, the findings of the thesis stress the lifeline disruptions could cause huge indirect economic losses after disasters. The importance of lifeline disruptions varies in different industrial sectors because of the characteristics and recourses requirement differences. Also, the findings highlight that building resilience is essential to the global goals of reducing economic losses due to natural disasters.

(続紙 2)

(論文審査の結果の要旨)

自然災害に見舞われた際に産業が有するレジリエンスの定量化のために、必要となる抵抗力と回復力の計量化の枠組みの精緻化に大いに貢献している。抵抗力の計量化に関しては、従来、専門家インタビューを用いて設定されていたライフライン途絶抵抗係数を、2011年3月に発生した東日本大震災後の企業アンケート調査結果を用いて、実証データに基づいたライフラインの途絶抵抗係数の推計に世界で初めて成功している。企業の生産能力の回復過程に関しても、離散的に生じる生産能力の回復タイミングとその際の回復量をセミマルコフ過程として記述することを提案し、2016年熊本地震でのアンケートを用いてその有効性を示している。特に、生産能力の回復のタイミングとライフラインの回復タイミングが関連を有することに着目し、同モデルのパラメータをライフラインの回復状態に依存させて推計することで、極めて高い現象再現性が確認されることを示した点は特筆に値する。このようにして改良されたモデルを、熊本地震時の産業全体の回復状況と対応させて分析し、提案した方法が十分な現象再現性を有することも併せて示している。

このように、本研究は自然災害に見舞われた際に産業が有するレジリエンスの定量化の枠組みの精緻化に極めて重要な貢献を果たしており、博士(情報学)の学位論文として価値あるものと認める。また、令和3年2月16日、論文内容とそれに関連した事項について試問を行った結果、「合格」と認めた。

なお、本論文は、京都大学学位規程第14条第2項に該当するものと判断し、公表に際しては、(令和5年3月31日までの間)当該論文の全文に代えてその内容を要約したものとすることを認める。

要旨公開可能日： 年 月 日以降