Analyzing Indirect Economic Impacts of Wildfire Damages on Regional Economy

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Key words: Cost management; Implementation of plans; Land management; Risk management

SUMMARY

Abstract: Disasters such as floods, landslides, typhoons, earthquakes and wildfires have negative impacts on ecological biodiversity, personal health, commodity flows and regional incomes. For example, wildfires in California, 2008 have burned more than 17,582 ha, destroying at least 400 houses and 500 mobile homes. While they were aggravated by a combination of low humidity, high winds, and high temperatures, white ash and smoke have spread as far away as 25 miles away from the fires. This tragic loss is regarded as the worst case ever in California, exceeding the loss of 484 residences in the 1961 Bel Air fire. The wildfire is expected to become one of the critical disasters to have negative effects on household consumptions and housing services, the production of activities and logistics, as well as travel and tourism in Korea considering that two thirds of total national lands are covered with mountain and forest areas. Moreover, the fire frequency will further increase due to the climate change as drier conditions would result in the increase of frequency of extreme events and fire activities across the U.S. by 2050 using NASA satellite data and climate (Giglio et al., 2012).

The economic damages of the disaster can be classified into direct and indirect ones. The former includes physical losses such as business interruption and unemployment, while the latter does the consequence of interactions between transactions across sectors (Cochrane, 2004; Rose, 2004; Ding et al. 2011). The direct damages can be easily captured compared with the indirect ones due to the innate complexities and uncertainties: it implies that the economic values of damages from the disaster have been underestimated because of the negligence in indirect impacts on the economy. Therefore, it is worthwhile to develop an analytic framework for the impact analysis because the model can provide policy makers with how much financial resource should be allocated in terms of precaution and rehabilitation activities. In addition, growing climate change can deteriorate disaster damages in regional basis events even linked to the national task. The representative concentration pathways (RCPs), RCP2.6, RCP4.5, RCP6, and RCP8.5, are named after a possible range of

radiative forcing values in the year 2100 relative to pre-industrial values (+2.6, +4.5, +6.0, and +8.5 W/, respectively). A scenario of comparatively high greenhouse gas emissions (RCP8.5) combines assumptions about high population and relatively slow income growth with modest rates of technological change and energy intensity improvements, leading in the long term to high energy demand and GHG emissions in absence of climate change policies (Riahi et al, 2011). To consider extreme weather conditions to degrees of wildfire losses, a high emission scenario (RCP8.5) in this paper is applied to estimate indirect economic effects caused by the wildfire in Korea. So what amount of indirect economic losses are contributing to wildfire without or with climate change? To analyze the impact, the methodological development is needed to add the issues in the disaster management field.

This paper develops an Integrated Disaster-Economic System of Korea to estimate the economic impacts of wildfire damage on regional economies. The system is composed of four modules (ICGE model for Eastern Mountain Area and ROK at province level, and the Bayesian wildfire model, the transportation demand model, and the tourist expenditure model at city and county level), but in terms of the model's hierarchical structure, the ICGE model is linked to three other modules. The Integrated Disaster-Economic System (IDES) is composed of four modules; (1) the ICGE model for economic analysis of macro-regions, (2) the transportation demand model for calibration of travel times, (3) tourist expenditure model for estimating visitors' spending, and (4) the disaster model of wildfires to estimate the damaged areas. The simulations are conducted with econometric models and related variables are presented in the IRCGE model. For example, we are interested in the annual GRP losses of the Eastern Mountain Area from the wildfire.

Figure 1 Structure of Integrated Disaster-Economic System

The ICGE model as the backbone of the entire system, the IDES, is developed to assess the economic impacts of wildfire on the regional economic growth, using the travel times from the transportation demand model, visitors' spending from the tourist expenditure model, and the wildfire damage areas from the disaster model. In principle, this model accounts for maximization of producer's profit and consumer's utility in the real side economy, following market-clearing prices under equilibrium. There are two macro-regions, Eastern Mountain Area (EMA) and the Rest of Korea (ROK) in Korea, and one representing the rest of the world (ROW) in the model. Production activity is divided into 13 sectors such as five forest sectors (forest products, wood & wood products, pulp & paper products, other manufacturing and processing of timber), five tourism sectors (retail & wholesale, transportation, restaurants & accommodation, cultural services, and sports & entertainment services), primary, manufacturing, and service sector. Each industrial sector is assumed to produce a single commodity, which is disaggregated into an intraregional supply, a regional export, and a foreign export by production destination, while there are three types of commodities such as an intraregional supply (demand), a regional import, and a foreign import in the regional market in terms of the product origin. Each commodity and factor input price is determined through an equilibrium process between supply and demand in each market.

Figure 2 Structure of Interregional Computable General Equilibrium Model

The IDES is applied

to the simulation of the wildfire in Goseong County in the EMA of Korea. In the simulations, three external shocks are injected into the ICGE model: (1) The wildfire damaged area in Goseong derived from the Bayesian wildfire model, (2) changes in travel times among cities and counties due to the wildfire from the transportation demand model, and (3) decreases in visitor's expenditures derived from the tourist expenditure model.

The IDES is applied to estimate economic effects of the wildfire on regional incomes. As a case, we assume that the wildfire takes place in Goseong county in Eastern Mountain Area (Gangwon province), where more than half of the large wildfires occur in Korea. Eastern Mountain Area is well known for tourist destination, holding for the 2018 PyeongChang Winter Olympics. The area has high risk of wildfires because more than 80% of the total area is covered with mountain area. The wildfire seasons are growing longer and more intense, as a result of climate change according to PBS News Transcript on Aug 06, 2018. (https://www.pbs.org/newshour/show/climate-change-is-making-wildfires-more-extreme-heres-how). It helps ordinary wildfires to quickly become large scale wildfires owing to high winds, high temperatures and fuel accumulation in the mountainous area. In addition, the EMA has been faced with the difficulty to put out wildfires because of low accessibility of high-sloped mountains above 1,000m. Among alternatives (RCPs) for the wildfire damage simulation, the RCP8.5 (a proxy or result as the climate change as a high emission scenario of GHG) is selected to capture economic impact of wildfires in EMA affected by climate change. There are two experiments with one baseline as followings. In the simulations, three external shocks are injected into the ICGE model: (1) The wildfire damaged area in Goseong derived from the Bayesian wildfire model, (2) changes in travel times among cities and counties due to the wildfire from the transportation demand model, and (3) decreases in visitor's expenditures derived from the tourist expenditure model.

Figure 3 Damaged Areas of Wildfires

This paper provides the evidence when establishing the wildfire control policy of central or local government in Korea, especially distributing government budget resources for the policy utilizing investment of ICT facilities such as UAV, Beacon, and IoT sensors to minimize the losses from wildfires. One of the major contributions in this paper is to integrate regional economic model with the place-based disaster model and the demands of tourism and transportation (trip) and to build up quantitative linkages between macro and micro spatial models in a bottom-up system for an impact analysis of disasters. This approach could be applied to economic issues of integrated pest management for agricultural products and disaster planning for the commodity flows.

As further research issues, the spatial diffusion pattern of wildfires should be examined at city and county level since the weather conditions usually depend on not only natural resources but also built-environment and structures. More efforts need to be focused on the dynamic analysis for interactions and spillover effects among environment and economic agents. Finally, it would be possible to develop an allocation method of government budgets on the forest preservation if we take into account economic values of forest assets or damage to the natural resources with estimation of costs of suppression and recovery as well as the direct and indirect economic effects derived from this paper.