

Determinants Analysis of Fire Risk in Korea

– Focused on the Risk Assessment –

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Abstract

Forty-six percents of fires in Korea during 2011 were due to carelessness. A little more attention could reduce property damage and protect loss of human lives. The multiple regression analysis shows that more fires occurred among the construction companies ($p < 0.1$) while fewer fires were observed among the business companies ($p < 0.05$) and in urbanized areas ($p < 0.05$). The regions which are more vulnerable to fire were occupied with many construction companies and the more urbanized regions with many business companies were found safer in terms of fire hazard. This finding indicates that more urbanized regions and business companies tend to have larger fire protecting capacities including sufficient fire-fighting equipments. On the other hand, construction companies may contain facilities and equipments which are vulnerable to fire. Further efforts should be given to improve fire protecting capacities and reduce vulnerabilities of fire.

Key words: fire risk assessment, fire risk analysis, fire risk evaluation

1. Introduction

There are many fires around us and we have lost lots of lives and property every years. Four people have been killed and scores injured in an apartment building fire in Uijeongbu on January 10, 2015. Of the four people who died, three were women – two in their twenties, the other in her sixties and a man in his forties. At least ten of the 100 people who were injured are said to be in critical condition suffering from severe smoke inhalation

(Arirang News, 2015.01.10.). The Seohae Grand Bridge, a major artery connecting southwestern cities with Seoul, was shut down after three cables were damaged by a fire sparked by lightning on December 5, 2015. One of the cables snapped. It links Pyeongtaek, Gyeonggi, and Dangjin, South Chungcheong, where major heavy industries have factories and ports, to the capital region. It would take almost 20 days to replace the three cables, one snapped and two damaged by fire. A 54-year-old firefighter was hit by the snapped cable

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and died. Two other firefighters were injured(Korea Joongang Daily, 2015. 12. 07).

We have to reduce casualties and property damage and find determinants associated with fire. One of the ways to search the methods of determinants analysis of fire risk is a fire risk assessment.

Risk Assessment is to improve coherence and consistency among the risk assessments undertaken in the national level, regional and individual level in the prevention, preparedness and planning stages. Comparability of risk assessment methods would add value to the individual efforts of member state and region and would allow risk assessments to be pooled(shared risk assessments) facing shared risks. Risk Assessment could provide risk information for disaster authorities, and also other policy-makers, public interest groups, civil society organizations and other public or private stakeholder involved or interested in the management and reduction of disaster risk(European Commission, 2010: 7).

The result of risk assessment is to be utilized in decision making for the disaster management and many activities and projects are to be implemented by risk assessment. Lots of Members of agencies are not involved in the risk assessment process and they have no opportunity to understand the problem and the effectiveness of the risk assessment. Risk assessment consists of risk identification, risk analysis and risk evaluation. In this paper, I would like to know a fire risk assessment. That is different other disaster risk assessment according to disaster which is fire. In the disaster risk assessment, there are many disasters which are natural disaster and man-made disaster compared with fire disaster. In this

paper, I would like to know how to prepare the fire, how to reduce damages due to fire and what are valuables.

A fire risk assessment is a tool to identify potential fire vulnerability and to be taken to remove or reduce these risks to as low level as practically possible and then decide what physical fire precautions and management arrangements are necessary to ensure people's safety and reduce damages.

The aims of the fire risk assessment are to identify vulnerabilities, capacities according to analysis. So, the fire risk assessment are to reduce the risk of those hazards causing harm and to determine what policies are necessary to ensure the safety of people in the building should fire occur.

In this paper, the main method of this research is literature research, I have searched government data, government publications, policy report, domestic and foreign various research materials and analyze them and I would like to search variables of vulnerability and capacity related with fire risk.

II. Definition

1. Fire Risk Assessment

Fire Risk Assessment have two types, one is a five-step method and the other is analysis method. A five-step method is the purpose for a Fire Safety Inspectors and analysis method is the purpose for a Fire Safety Inspectors and decision (policy) maker. The five-step method have five steps on fire risk assessment(www.london-fire.gov.uk). First step, we identify hazards and how

people could be harmed, eg, by being overcome or trapped by fire or smoke, burned, unable to escape due to locked fire exit doors, etc. Second step, we have to effort to search who could be harmed? and consider the risk to people, particularly an vulnerable groups such as young persons, the elderly or visitors unfamiliar with the premises. Third step, we have to effort to know what existing fire safety measures are provided? and decide whether your existing fire safety measures for the premises are adequate or are additional measures necessary? Forth step, we have to record the significant findings of your fire risk assessment. Prepare an action plan, priorities actions and allocate deadlines and responsibilities for implementation. Fifth step, we have to make arrangements for regular review of the fire risk assessment.

Risk assessment is a methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend(ISDR, 2009: 26).

Risk assessment is a multi-disciplinary process, rather than an activity, that allows for the identification, quantification and understanding of the nature and extent, and impacts of the risks a community or society is facing, which are associated with unanticipated extreme events and the vulnerability of the exposed community or society. Risk assessment is an integral part of decision/policy making processes and its implementation should involve and require close collaboration among all the sectors of society(Jianping, 2010).

Analysis method of fire risk assessment in this paper consists of risk identification, risk analysis and risk evaluation.

2. Vulnerability

The word “vulnerability” is used in the English hazards and disaster management literature in a very large number of ways. This is not necessarily a matter of ambiguity or semantic drift, but disciplinary focus. Essentially these different uses have invisible, implied adjectives preceding them, as following: structural, implied adjectives preceding them, as following: structural, engineering vulnerability, lifeline infrastructural vulnerability, communications system economic vulnerability, commercial vulnerability(including insurance exposure), social vulnerability(Ben Wisner, 2001: 1).

By ‘vulnerability’ we mean the characteristics of a person or group in terms of a person or group in terms of their capacity to anticipate, cope with, resist, and recover from the impact of a fire hazard. It involves a combination of factors that determine the degree to which someone’s life and livelihood is put at risk by a discrete and identifiable event in nature or in society(Blaikie, *et. al.*, 1994: 9).

3. Capacity

Capacities are the assets, resources and skills available within a community, society or organization that can be used to reduce the risks or effects of a disaster. Capacity may include physical, institutional, social or economic means as well as skilled personal or collective attributes such as leadership and management(ISDR, 2009: 5–6). Capacities enable households and communities to cope with, withstand,

prepare for, prevent, mitigate, or quickly recover from a disaster. People's capacity can also be categorized in the same categories as was done with vulnerabilities in the previous section(ADPC, 2006: 10).

4. Fire Risk

Risk is the probability of something happening in the future, which has a negative consequence. It is a prediction of suffering harm or loss or of meeting danger. It has an additional implication of a fire to occur and cause damage or loss to a vulnerable community or group. Fire Risk is presented as follows(www.adpc.net):

$$\text{Fire Risk} = \frac{\text{Fire} \times \text{Vulnerability}}{\text{Capacity}}$$

III. Fire Risk Assessment

1. Fire Impact Analysis

1) Numbers of Fire

The table show the numbers of fire from 2007 to 2011. Total numbers are 356,885 and the most occurred year of fire is in 2008, 49,631 numbers. This means 137 numbers occurred a day. There are

47,882 numbers in 200, 47,318 numbers in 2009, 41,863 numbers in 2010 and 43,875 numbers in 2011.

2) Fire Factors

Table 2 show fire factors in 2011. Accident fires are 36,883 numbers, natural fire are 386 numbers, arsons are 2,250 numbers and unknown fires are 4,356 numbers. There are 263 deaths and 1,599 injuries in 2011. The results of fire have brought 2,565 hundred million won.

3) Caused Fire

Caused fire has four factors, one is accident fire, another is natural factors, the others are arson and unknown factors. Accident fire factors are electrical accident fire, mechanical and chemical accident fire, gas leak, traffic accident and carelessness accident fire.

4) Numbers of Fire by Carelessness

Table 4 shows that how many fires have occurred by carelessness. Carelessness fire are tobacco, cooking, playing with fire, welding, cutting, grinding, embers, incineration, washing

Table 1. Numbers of fire from 2007 to 2011

(unite : year/number)

total	2007	2008	2009	2010	2011
356,885	47,882	49,631	47,318	41,863	43,875

Table 2. Fire factors

total	number				casualty(number)			property damage (one hundred million won)		
	accident fire	natural fire	arson	unknown	total	death	injury	total	real estate	estate
43,875	36,883	386	2,250	4,356	1,862	263	1,599	2,565	1,132	1,433

Table 3. Fire causes

(unite : number)

total	accident fire						natural factors	arson			
	electrical	mechanical	chemical	gas leak	traffic accident	carelessness		others	arson	suspected arson	unknown
43,875	10,664	4,071	299	217	532	20,238	862	386	488	1,762	4,356

boil, combustibles left, fuel handling, etc.

5) Numbers according to every two hours

Table 5 shows numbers of according to every two hours.

Fires have occurred 5,579 numbers from 13:00 to 15:00 most of all other two hours, 5,394 numbers fires have occurred on the second times.

6) Numbers of Seasonal Fire

Table 6 shows how many times have occurred each season. There are 13,357 numbers in winter, 13,050 numbers in spring, 8,491 numbers in summer and 8,977 numbers in fall. The most season of occurred fire is in winter.

2. Correlation Analysis

1) Analysis Framework

We try to find the independent variables that can affect the rate of property damage that is dependent variable. We can find independent variables according to the previous studies and empirical verification as shown in Figure 1 that is analysis framework in this paper. There are three independent variables which are construction rate, urbanization rate and business company

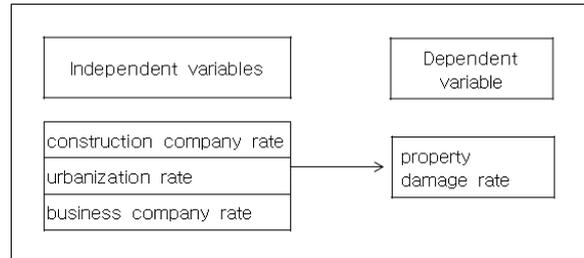


Figure 1. Analysis framework

rate. There is one dependent variable which is property damage rate.

2) Variable Definition

To reach the purpose of this paper, I have researched three variables which are construction company rate, urbanization rate and business company rate according to other paper and pre-test data in 2011. The vulnerability variable is construction company rate and the capacity variables are urbanization rate and business company rate.

- construction company rate : construction companies by dividing the local population.
- urbanization rate : proportion of people living in urban areas.
- business company rate : business companies by dividing the local population.
- property damage rate : property damages per

Table 4. Numbers of fire by carelessness (unite : number)

total	tobacco	cooking	playing with fire	welding, cutting, grinding	embers, flame	incineration
20,238	6,592	2,504	1,182	1,255	2,569	2,609
washing boil	combustibles left	forest burning	fuel handling	playing firecracker	others	
137	878	789	84	34	1,605	

Table 5. Numbers of according to every two hours (unite : hour/number)

total	23~1	1~3	3~5	5~7	7~9	9~11	11~13	13~15	15~17	17~19	19~21	21~23
43,875	2,938	2,629	2,279	2,138	2,470	3,618	4,656	5,579	5,394	4,561	4,169	3,444

Table 6. Numbers of seasonal fire (unite : number)

total	winter	spring	summer	fall
43,875	13,357	13,050	8,491	8,977

Table 7. Results of correlation analysis

correlation	property damage rate	construction company rate	urbanization rate	business company rate
property damage rate	1	.547*	-.825**	.536*
construction company rate		1	-.680**	.912**
urbanization rate			1	-.798**
business company rate				1

*; $p < 0.05$, **; $p < 0.01$

Table 8. Empirical analysis

Source	SS	DF	MS	F	P
Regression	9.746E9	3	3.249E9	15.744	.000
Residual error	2.476E9	12	2.063E8		
Total	1.222E10	15			

$R^2 = 0.747$

Table 9. Multiple regression analysis

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	297615.234	50621.023		5.879	.000
construction company rate	12397.247	5876.012	.683	2.110	.057
urbanization rate	-2843.764	527.798	-1.184	-5.388	.000
business company rate	-7735.944	2951.453	-1.032	-2.621	.022

10 thousand people.

3) Results of Correlation Analysis

Table 7 shows that three variables are significant at the 0.05.

I want to investigate disaster risk factors that may be affected by hazard, which are vulnerable factors and ability factors in our country according to empirical verification. The vulnerable factors are the percentage of woods and fields area, the primary and secondary industrial structure ratio, the detached house ratio, the percentage of non-urban area and the infrastructure area ratio. The ability factors are the percentage of forest area, the urban forest area per capita, the social welfare budget rates, the medical institution per capita, the rate of paved road, the urbanization ratio, the economic activity participation rates.

3. Empirical Analysis

The Multiple Regression Analysis describes the effect of three explanatory variables on property damage rate. The F-values is significant at the 0.01 level and The adjusted R2 value is 0.747 level.¹⁾ This provides evidence of existence of linear relationship between the property damage rate and three explanatory variables.

Table 9 is the result of multiple regression analysis. Three variables are significant at the 10 percent. The construction company rate is vulnerability variable and urbanization rate and business company rate are capacity variables. That means vulnerable region on fire is located in lots of construction companies and safe region on fire are located in lots of urbanization area and business company area.

1) R2 shows how well terms(data points) fit a curve or line. Adjusted R2 also indicates how well terms fit a curve or line, but adjusts for the number of terms in a model. If you add more and more useless variables to a model, adjusted r-squared will decrease. If you add more useful variables, adjusted r-squared will increase. Adjusted R2 will always be less than or equal to R2.

IV. Fire Risk Evaluation

1. Fire Impact

There are 43,875 numbers occurred fire in 2011 and the results of fire have brought 2,565 hundred million won property damages. There are 263 death and 1,599 injury persons in 2011. The 46 percentage of fire is carelessness. If we have a little more attention, we can reduce property damage and protect loosing of our life.

2. Correlation and Empirical Analysis

The construction company rate is significant at the 0.1 and the urbanization rate and the business company rate are significant at the 0.05 according to the correlation analysis. The construction company rate is vulnerability variable and urbanization rate and business company rate are capacity variables. That means vulnerable region on fire is located in lots of construction companies and safe region on fire are located in lots of urbanization area and business company area.

V. Conclusion

We have known determinants analysis of fire risk in Korea focus on the risk assessment. Fires have occurred 356,885 times total and about average 89,221 times annually until 2011–2007 in Korea. A total of 43,875 fires have occurred during 2011 and casualties have occurred 1,862 times(4.2%) including wounded. Fires caused by carelessness have accounted for 20,238 times (46%). Fires caused by tobacco have occurred 2,609 times, by cooking waste incineration have occurred 2,609 times, by embers and flame have

occurred 2,569 times, by cooking of food have occurred 2,504 times and by playing with fire have occurred 1,182 times among the carelessness fires. Fires have occurred 43,875 times total and 13,357 times have occurred in winter, 13,050 times have occurred in spring, 8,977 times have occurred in autumn and 8,491 times have occurred in summer

This paper have been used the risk assessment tools. A Fire Risk Assessment is a tool to identify potential fire vulnerability and to be taken to remove or reduce these risks to as low level as practically possible and then decide what physical fire precautions and management arrangements are necessary to ensure people's safety and reduce damages. The 46 percentage of fire is carelessness in 2011 especially. If we have a little more attention, we can reduce property damage and protect loosing of our lives.

As the result of multiple regression analysis, three variables which are construction company rate, urbanization rate and business company rate are significant at the 0.1 and the construction company rate is vulnerability variable and urbanization rate and business company rate are capacity variables.

The vulnerable region on fire is located in lots of construction companies and safe region on fire are located in lots of urbanization and business company area according to the empirical analysis. These means region of urbanization and business companies have capacities protecting fire due to have lots of fire-fighting equipments. On the other hand, construction companies have some vulnerable facilities and equipments which are vulnerable to fire. We have to effort to improve capacities and reduce vulnerabilities of fire for

our properties and lives.

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Received: Nov. 21, 2015 / Revised: Dec. 30, 2015 / Accepted: Jan. 5, 2016

우리나라의 화재 리스크 영향요인 분석

- 리스크 평가를 중심으로 -

국문초록 본 논문에서는 우리나라 화재 리스크 영향요인 분석을 위해 리스크 평가(risk assessment) 방법을 사용했다. 리스크 평가 단계는 화재 발생 현황 분석, 관련 요인들과의 상관관계분석, 회귀분석 그리고 리스크 사정(risk evaluation) 단계로 진행된다. 2011년의 경우 총 43,875건 중 부상자를 포함한 인명피해는 1,862건으로 4.2%를 차지했고, 부주의에 의한 화재는 총 20,238건으로 46%를 차지했다. 2011년도 자료를 사전 검증을 통해 인구 1만명당 재산피해, 건설업체수 비율, 도시화율, 사업체수 비율의 회귀분석 결과 1% 유의수준에서 통계적으로 유의미하게 나타났다. 본 논문의 분석 결과, 건설업체수 비율은 취약요인으로 나타났으며, 도시화율과 사업체수 비율은 능력요인으로 나타났다. 다시 말해 건설업체수 비율이 높은 지역은 화재로 인한 재산피해가 많은 지역으로 나타났고, 도시화율과 사업체 수 비율이 높은 지역은 화재로부터 안전한 지역으로 나타났다. 화재로 인한 피해를 줄이기 위해서는 건설업체수가 많은 지역에 대해서는 화재를 줄이기 위한 다양한 방법들을 강구해야 하겠으며, 도시화와 사업체들이 많은 지역에 대해서는 화재 발생 억제 요인들을 발굴하여 적극 활성화해야 하겠다.

주제어 : 화재 리스크 평가, 화재 리스크 분석, 화재 리스크 사정

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