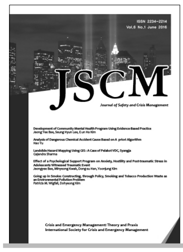

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Spatial Characteristics and Factors of Truck Accidents

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A B S T R A C T

Identifying the causes of truck accidents is very important for efficient traffic safety policies. Thus, previous studies have dealt with human factors, vehicle factors, and environmental factors (road, weather). However, according to a recent research, the spatial characteristics of truck accidents must be considered when analyzing the causes of traffic accidents. Therefore, this study has intended to analyze the spatial characteristics of truck accidents and to derive the spatial factors that would affect traffic accidents. To meet the objectives, this study employed Getis-Ord Gi* Hotspot analysis and Local Score statistics, and set three hypotheses as follows: First, truck accidents show local clustering distribution; Second, individual factories significantly affect truck accidents more than the planned factories; and, Third, the old factories significantly affect truck accidents more than the non-old factories. As a result of testing the hypotheses, this study has found that truck accidents tend to cluster locally, and factories negatively affect truck accidents. Especially, old individual location factories very negatively affect truck accidents.

Key words: factories, truck accidents, local score statistics, road network analysis, Hot-spot analysis

Introduction

Backgrounds and Research Objectives

Truck accidents have been on a steady rise in the last five years. In the event of truck accidents, the fatality rate is more than twice as high as that of a regular car accident, which has escalated into a social problem (Kim, 2017). Therefore, for efficient traffic safety management, measures should be taken to identify and reduce the clear cause of truck accidents.

Accordingly, the government regulates the approval of the truck business by enacting the Traffic Safety Act (December 28, 1997) to regulate traffic safety management of business vehicles at the national level. It has also pursued traffic safety management through stricter regulations, such as strengthening administrative measures for transportation operators, making digital operation records system attached, and cracking down on traffic safety of drivers (Lim, 2018).

Recent studies, however, showed that the system of regulating traffic through psychological pressure has little effect on reducing traffic accidents, and suggested that a shift in traffic safety measures is needed (Lim, 2009).

Currently, studies on the causes of truck accidents are mainly related to human factors, vehicle factors, and environmental (weather,

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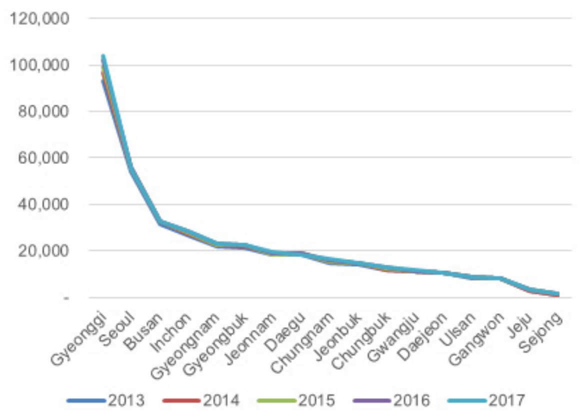
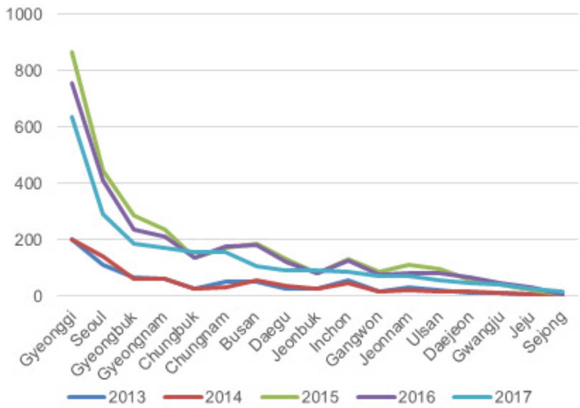
road conditions) (Lee, *et. al.,* 2012, Choi, *et. al.,* 2013, Kim, *et. al.,* 2001). However, it is difficult to come up with a plan for a recurrence prevention, which is a fundamental measure of the accident, since analysis of these causes leads to a uniform regulation focusing on administrative disposition of drivers, vehicles and transport operators. Therefore, this study is intended to analyze the impact of the indirect effects on truck accidents by noting the spatial factors.

Recent heavy traffic accidents in business trucks have been found to be out of proportion to the number of trucks owned for business purposes, with the exception of some areas (<Figure 1>, <Figure 2>). Since traffic accidents are usually correlated with the number of vehicles in operation, it is possible to estimate that the number of heavy traffic accidents that are not proportional to the number of vehicles in question has been affected by special spatial factors in the area (Lim, 2018).

According to a study conducted by the Korea Institute of Civil Engineering and Building Technology, the frequency of traffic accidents on roads near industrial complexes is more than twice as high as that of national roads (KICT, 2017). In addition, individual location factories that are naturally clustered around highways and national roads are cited as potential reasons for preventing proper road infrastructure supply (CRI, 2007). These low road rates and underdeveloped road infrastructure act as environmental factors for traffic accidents.



<Figure 1> Number of truck cars for business by region



<Figure 2> Number of serious truck accidents for business by region

In other words, it is estimated that both industrial complexes and individual location factories will affect as spatial factors of traffic accidents. However, since these factories are the destination of trucks, the volume of trucks is inevitably high. Therefore, it was deemed that the location of the factories would also act as a spatial factor of truck accidents.

Also, according to Lee(2017), there are differences in traffic accidents depending on the level of aging in industrial complexes. This is because the aging of industrial complexes reduces efficiency of road infrastructure. Therefore, it was deemed that the aging of the factories would affect of truck accidents.

Therefore, this study is aimed at analyzing the spatial characteristics of truck accidents and identifying the spatial factors that are predicted to have affected them. Through this research, we are trying to present the direction of traffic safety policy considering the spatial factors of truck accidents, which deviates from the regulation system through psychological pressure from the incumbent government.

Literature Review

In looking at the literature review on truck accidents, there were no studies that analyzed the spatial factors of truck accidents, while studies related to human factors, vehicle factors, and environmental (weather, road conditions) factors were conducted in various aspects. Therefore, this chapter focuses on the study of spatial characteristics of general traffic accidents and on the analysis method of spatial point patterns in terms of research methods.

Spatial Characteristics of General Traffic Accidents

Traffic accidents involve a combination of one or more of several factors, which should be looked at in a comprehensive way (Kang, *et. al.,* 2002).

In addition, Heo, *et. al.*(2014) argued that the statistical model reflecting spatial influence is more descriptive than the existing model of technical statistics and that the relative risk of traffic accidents should be estimated by reflecting the spatial correlation between regions.

In other words, traffic accidents result from a combination of spatial factors, which are indirect factors in addition to direct factors such as human factors, vehicle factors, and environmental (climate, road conditions). Therefore, spatial distribution characteristics must be considered when analyzing the causes of traffic accidents.

As a result, studies related to general traffic accidents are actively conducted with a focus on analyzing spatial distribution characteristics. These studies are mainly aimed at finding the cause of accidents according to the spatial clustering characteristics of traffic accidents, and spatial cluster analysis such as hotspot analysis, kernel density estimation, etc. (Anderson, 2009; Prasannakumar, *et. al.,* 2011; Xie, *et. al.,* 2008).

There is also a study that analyzes the spatial clustering distribution of traffic accidents and their impact on neighboring spatial objects. Lee(2004) conducted a spatial pattern analysis of traffic accidents using GIS and spatial data manning. Analysis shows that traffic accidents can be classified through characteristic cluster types, and that each cluster has different characteristics. Also, the location of traffic accidents was found to be related to nearby spatial objects. This indicates that the spatial objects around the location of the traffic accident have acted as a spatial factor in the traffic accident.

In addition, there is a literature review that analyzes the spatial factors of pedestrian traffic accidents. Based on the location of jaywalking, Cho, *et. al.*(2018) identified the geographical and structural characteristics of jaywalking frequent areas by analyzing hotspot for jaywalking accidents. This indicates that the spatial clustering distribution and the spatial factors that affected the spatial distribution are different depending on which caused the traffic accident. Therefore, it is deemed necessary to analyze the characteristics and factors of the spatial cluster distribution of truck accidents.

Spatial Point Pattern Analysis Method

truck accidents are geographical point events that occur in geographical space. Geographic point events indicate where they occurred, so they have coordinates, which allows analysis of spatial point patterns with distance information calculated from them. Spatial point pattern analysis is quantitatively typifying what distribution characteristics spatial data have in space. Therefore, the preceding study related to spatial point pattern analysis is to be reviewed and the spatial characteristics of truck accidents are analyzed.

The spatial point pattern analysis method associated with most traffic accidents has been performed using Euclidian distance from a two-dimensional plane. However, since traffic accidents occur along the road network, they make up space information on the network space rather than flat space information. Therefore, for spatial analysis of traffic accidents, analysis should be performed based on the network distance (Yamada, *et. al.,* 2004; Okebe, *et. al.,* 2006; Kang, *et. al.,* 2017; Cho, *et. al.,* 2018).

Therefore, we reviewed the overseas papers that analyzed traffic accidents based on road network. Yamada, *et. al.*(2004) compared the results of the K function of the plane and network using traffic accident data in the Buffalo area of New York. Okebe, *et. al.*(2006) performed a kernel analysis by aggregating traffic accident point data based on the road network.

In addition, recent papers in Korea also showed significant results by conducting spatial analysis of traffic accidents based on road networks. Kang, *et. al.*(2017) conducted a road network based spatial point pattern analysis to analyze the cluster of traffic accidents. The analysis results showed that network-based spatial analysis results were more accurate compared to the plane-based spatial analysis.

Cho, *et. al.*(2018) conducted a traffic accident hotspot analysis along the road network. Analysis results showed a more specific area of accident concentration than the results of hotspot conducted in plane space when hotspot were performed by purifying traffic accident data based on road links.

In addition, a spatial correlation analysis between the factories and truck accidents should be conducted to determine whether the factories acts as a spatial factor of truck accidents. Therefore, a literature review on the analysis of spatial correlation of geographical point events was reviewed.

Oh, *et. al.*(2018) analyzed the spatial correlation between road roadkill and traffic accidents. It also utilized local Score statistics to quantify the spatial correlation between the two phenomena, which are geographical point events.

Rogerson, *et. al.*(2009) analyzed spatial cluster patterns based on the frequency of rare diseases occurring on the U.S. county level. He calculated the probability of an event occurring within a certain spatial range and determined the cause of the occurrence in an event.

In order to analyze the spatial characteristics of truck accidents, a spatial analysis based on the road network will have to be carried out. In addition, the analysis is to be carried out using local Score statistics to quantify the spatial correlation between the plant and the truck accidents.

The Differentiation of Preceding studies

Literature review has led to implications in research, as shown in <Table 1>. First of all, the previous research has the limitations

<Table 1> Deduction of implications through consideration of literature review

Content	Author	Goal of study	Implication
Traffic Accident Analysis Based on Road Network	Kang *et. al.*, (2017)	In the spatial analysis of f car accidents, the network-based results were found to be more accurate compared with plane-based results.	Truck accidents also need to be analyzed based on road network.
Traffic Accident Hotspot Analysis	Cho *et. al.*, (2018)	A traffic accident hot-spot analysis based on a road network indicates a more concentrated section of traffic accidents than a plane-based analysis.	Identifying roads where truck accidents are concentrated by analyzing hot-spots based on road network.
Local Score Statistics	Oh *et. al.*, (2018)	The spatial correlation between the two phenomena of geographical fortunetelling was quantified using local Score statistics.	Spatial correlation between factories and truck accidents.

of finding causes on truck accidents. Previous research have identified the cause of truck accidents as human, vehicle and environmental factors. However, since this is a micro-level analysis, it is necessary to conduct a macro-level analysis of the spatial factors of truck accidents. In addition, studies on the causes of recent general traffic accidents are analyzed considering spatial factors. Also literature review on spatial analysis of traffic accidents was conducted using euclidian distance based plane spatial analysis. However, this is an analysis that does not fully reflect the spatial characteristics of traffic accidents, which occur in road networks. Therefore, recent research in Korea and overseas have been conducted based on road networks in analyzing spatial characteristic of traffic accidents. However, most of these studies are conducted in general traffic accidents and there are very few studies involved.

Thus, the differentiation of this study is based on the use of spatial point pattern analysis to identify the spatial characteristics of truck accidents and to derive the spatial factors that are thought to have contributed to the formation of it. In analyzing these spatial characteristics, we would also like to apply a road network-based spatial analysis method to infer the characteristics of a clearer spatial process.

Based on this theoretical background and literature review, the following research questions were derived. The first question is, "Do factories have a significant effect on truck accidents?" And if the plant is a spatial factor that significantly affects on truck accidents, the second question then is, “Does the location and age level of factories has a significant effect on truck accidents?” The first question relates to the spatial characteristics of truck accidents, while the second question is to ascertain whether there are any spatial factors that are assumed to affect it if the spatial characteristics of truck accidents.

Research Method

Hypothesis Setting of Research

The purpose of this study is to discover that the location of factories is a spatial factor affecting truck accidents. Therefore, based on research background and literature review, the research questions were asked: "Do factories have a significant effect on truck accidents?" and "Does the location and age level of a factories has a significant effect on truck accidents?"

A research hypothesis was established based on these research questions. First, in order to determine about the first question is whether the location of factories is a spatial factor of truck accidents, it should be analyzed whether the truck accidents are affected by special spatial characteristics. Therefore, it was decided that it was necessary to analyze whether truck accidents showed local clustering distribution. Thus, the first hypothesis was, "Truck accidents show local clustering distribution." If this first research hypothesis is adopted, it can be estimated that it has been affected by a special spatial factor of truck accidents.

In addition, the spatial correlation between the factories and the truck accidents by location characteristic and age needs to be analyzed in order to determine whether the effects on truck accidents depend on the location characteristics of the factories and the degree of age. However, according to literature review and research trends, it is estimated that individual location factories will have a significant impact on traffic accidents as reduce efficiency of road infrastructure because they cause reckless development. In addition, studies have shown that the level of aging in factories has a more significant effect on traffic accidents (Lee, *et. al.,* 2017). Thus, the second hypothesis was, "individual location factories has a more significant impact on truck accidents than the planned location factories." Also, the third hypothesis was, "The old factories has a more significant impact on truck accidents than the non-old factories."

Scope of Research

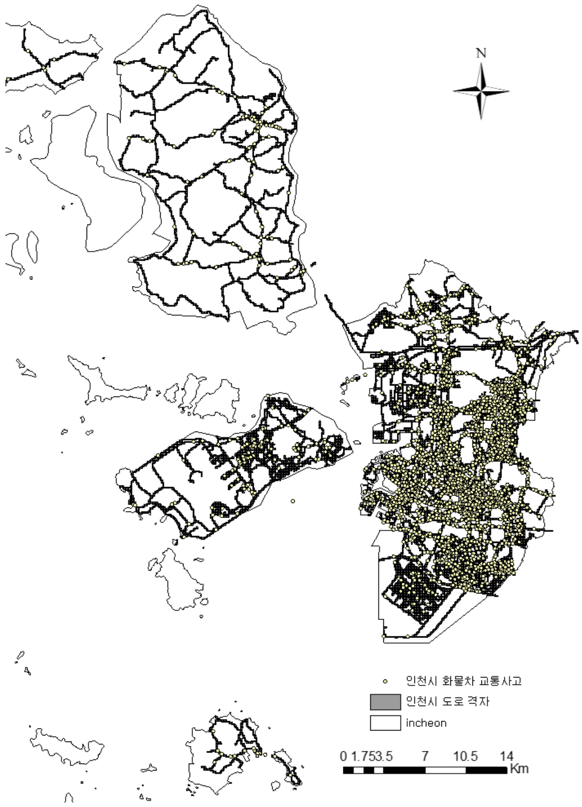
Prior to setting up a target area for the research, research trends related to truck operation were reviewed. The Incheon Government announced that it would introduce a system of the exclusive road for truck in its 'Incheon-style truck development master plan'. The system of the exclusive road for truck should designate and operate restricted areas to grant the passing priority on truck cars. It was estimated that this would have the effect of reducing traffic accidents on truck cars due to reckless traffic. Therefore, prior to the introduction of this system, it was deemed necessary to grant a passing priority considering the spatial characteristic of truck accidents. Therefore, the target area for the research was set up throughout the city of Incheon.

In this study, data provided by the Road Traffic Authority through the TAAS system at the point of truck accidents in Incheon from 2012 to 2016 were utilized. From 2012 to 2016, a total of 4,886 truck accidents occurred in Incheon. A total of 4,083 cases were used for the analysis, except for data that is more than 100 meters away from road links, for the accuracy of the analysis.

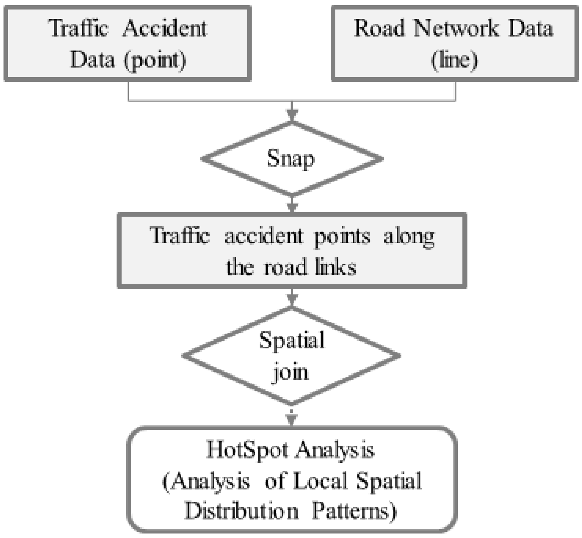
For the road network data, data provided by the Korea Transport Institute through Korea Transport Data Base at network of roads of 2012 was utilized. Because the study did not take into account variables resulting from changes in road networks, it utilized only single-year road network data. Node and link data in road network data include information on ID, road grade, top speed, length, etc.

The data from the planned location factories used the location drawings of industrial complexes provided by the Korea Research Institute for Human Settlements through the National Spatial Data Infrastructure Portal. In addition, data from individual location factories were processed and utilized through Geo-cording for street name address-based statistical data provided by the Korea Industrial Complex Corporation.

In this study, the analysis of the spatial clustering characteristic at the point of truck accidents and the spatial correlation between factories and truck accidents were applied empirically to all sections of the road in Incheon. For convenience of calculation, the data processing of the grid was carried out on the Incheon road overlaid with the square grid measuring 100 meters, and the total number of lattice was applied to the total area of the road in Incheon. <Figure 3> is the same as that mapping the points of truck accidents in Incheon from 2012 to 2016 on a road grid in Incheon.



<Figure 3> The city of Incheon truck accidents



<Figure 4> Data processing

Research Method (1) Getis-Ord Gi* Hotspot analysis

In this study, analysis were conducted in the same process as <Figure 4> through the ArcGIS 10.3 program in order to identify local spatial clusters in the event of truck accidents on a road network.

This is a process of analyzing hot-spots of the number of truck accidents per meter, combining road links with the number of truck accidents (Cho, *et. al.,* 2018).

To this end, the road link data were first allocated the data of truck accidents using the Snap feature. Through spatial join, the number of truck accidents per meter on the road link was calculated and entered as the property value. Hot-spot analysis by Getis-Ord Gi* statistics was conducted using the number of truck accidents per meter on the road links. The Getis-Ord Gi* statistical formula used is as shown in Expression (3).

$$G_i^* = \frac{\sum_{j=1}^{n} w_{ij}x_j - \overline{X}\sum_{j=1}^{n} w_{ij}}{S\frac{\sqrt{n\sum_{j=1}^{n} w^{2_{ij}} - \left(\sum_{j=1}^{n} w_{ij}\right)^2}}{n-1}}$$

$$\overline{X} = \frac{\sum_{j=1}^{n} x_j}{n}, S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\overline{X})^2}$$

xj = Property value for j

wi,j = Space Weight Between I and J

n Total number of features

<Formula 1> Getis-Ord Gi*

Research Method (2) Local Score statistics

Local Score statistics were used in this study. The Score statistic uses information about the expected frequency and observed frequency of events to indicate spatial clustering trends in unit areas where the observed frequency of events is higher than that of expected (KRIHS, 2015). Local Score statistics explore specific sections that have contributed to the overall population trend increasing. And for each of those sections, it can be explored to what extent the observed frequency of events is outside of the expected frequency.

Therefore, this study used the Score statistics to explore the spatial cluster section of truck accidents according to the location characteristics and age of the factories. First, the factories in Incheon were divided into old-planned location factories, non-old-planned-factories, old-individual location factories and non-old individual location factories. And the spatial cluster tendency of truck accidents according to the factories points by four characteristics was analyzed.

The geographical point ideas of factories and truck traffic accidents all have Poisson distribution because the spatial distribution is random. Thus, the probability variable of Poisson distribution was converted to an approximate into the standard normal distribution probability variable to interpret the analysis results more easily and clearly. In other words, probability variable X following Poisson distribution was converted to an approximate standard normal distribution probability variable (Rogerson, 2005; Rogerson, *et. al.*, 2009), as shown in Formula 2 below.

$$z_i(d) = \frac{o_i(d) - e_i(d)}{\sqrt{e_i(d)}}$$

<Formula 2> Approximate standard distribution probability variables

In Formula 2, $o_i(d)$ and $e_i(d)$ indicate the number of observed truck accidents (observation frequency) and the number of statistically expected occurrences (expected frequency) in the geographical area within the radius of the factories.

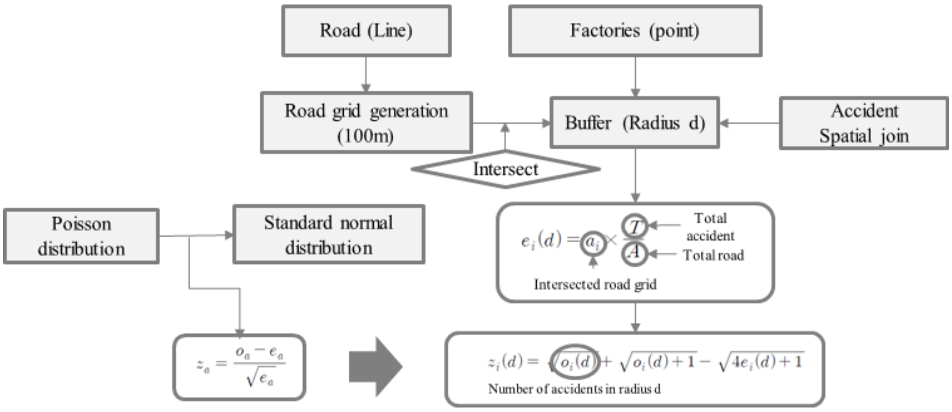
In this study, the spatial correlation between the factories and the points where the truck accidents occurred was analyzed by applying the method of converting the Poisson distribution to the z-value. In other words, $z_i(d)$ is the conversion of the probability variable of a Poisson distribution into the probability variable (z-value) of the standard normal distribution. Therefore, $z_i(d)$ can apply a general basis for interpretation with respect to the statistical significance of z-values. The general analysis criteria for z-values indicate that a z-value is statistically significant if the z-value is above the absolute value of 1.96 corresponding to the 5% significance level, and that a value of 2.57 or higher that corresponds to the 1% significance level is considered statistically significant.

$o_i(d)$ represents the observed frequency of events and $e_i(d)$ represents the expected frequency. The expected frequency can be calculated as shown in Formula 3 since it assumes the same probability of truck accidents at any location within the target area. Formula 3 to a_i is the sum of the area of the geographical area with a radius d around the factories i. That is, the sum of the areas of the road grids inside the circle with a radius of d passing through the factories i. T and A indicate the total number of truck accidents and the total area of the roadway in the target area (Oh, *et. al.,* 2018).

$$e_i(d) = a_i \times \frac{T}{A}$$

<Formula 3> Expected Frequency

However, Freeman, *et. al.*(1950) proposed alternative ways to convert Poisson probability variables into z-values in the following Formula 4, replacing Formula 2 for distributed stabilization, if the data follow the Poisson distribution but the frequency of occurrence is not generally high, such as rare diseases. Truck accidents also have an average of 977 from 2012 to 2016, with the frequency of occourrence is not high. Thus, in this study, the spatial clustering of truck accidents by factories point was analyzed by alternating Formula 4 for the spatial statistics index indicating the spatial correlation between the factories point and truck accidents.



<Figure 5> Data processing

$$z_i(d) = \sqrt{o_i(d)} + \sqrt{o_i(d)+1} - \sqrt{4e_i(d)+1}$$

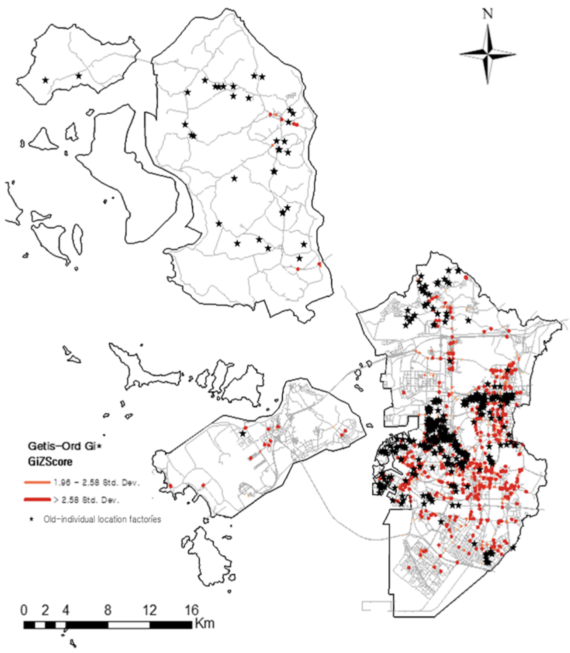
<Formula 4> Convert Poisson Probability Variables to Z-Values

Therefore, this process was carried out through the ArcGIS 10.3 program. The data processing is as shown in <Figure 5>. For convenience of calculation, the road in Incheon was overlaid with a 100-meter square grid, and the total number of grid was applied to the entire area of the road in Incheon. It is also necessary to set a radius d, which is a parameter representing the geographical range of spatial correlations, around factories i. Also, the number of truck accidents (observation frequency) in the geographical range of radius d was calculated.

Discussion

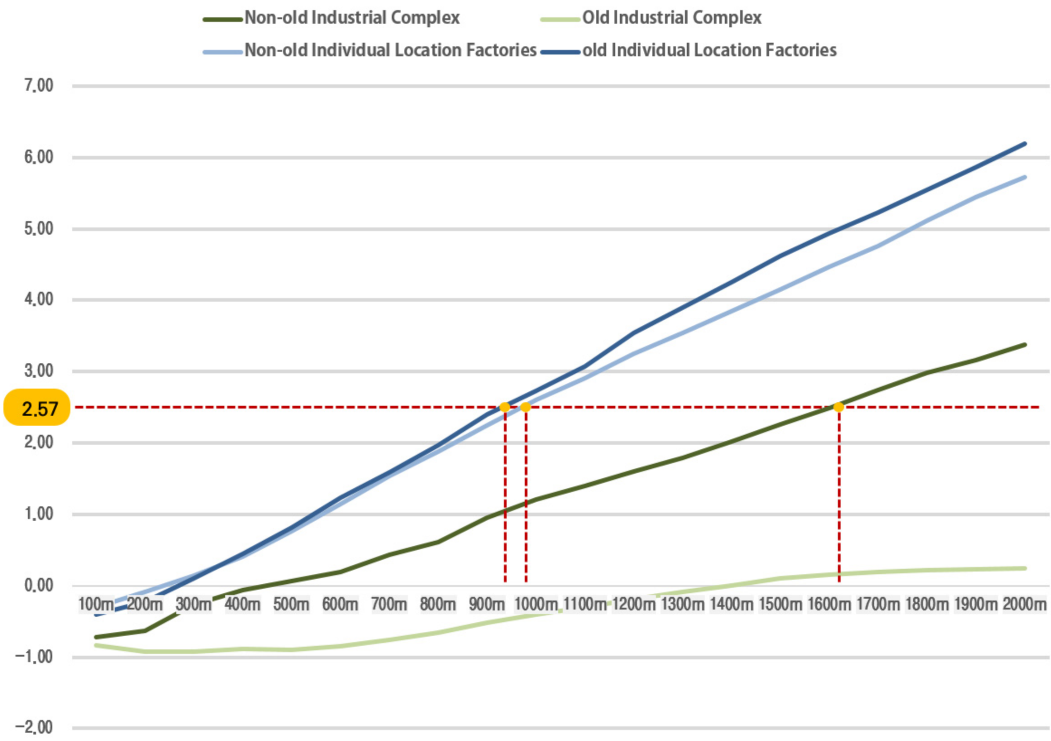
The analysis of hot-spots by Getis-Ord Gi* statistics revealed a section where truck accidents were concentrated, such as <Figure 6>. This confirmed the first hypothesis that "Truck accidents show local clustering distribution." Analysis shows that many sections with z-value equal to a 1% significance level or higher have been found, which can be interpreted as showing local clustering characteristic in the event of truck accidents. Therefore, the first research hypothesis was adopted. This can be interpreted as a result affected special spatial characteristics of the truck accidents. In addition, a comparison of these spatial clustering trends with the location of old-individual location factories shows that the two features are spatially quite similar. Therefore, it can be estimated that the factories may have had a negative effect on the spatial cluster trend of truck accidents.

In addition, the spatial clustering characteristic of freignt accidents according to the location of factories by location characteristics and age was analyzed using local Score statistics. From this we explored the effect of the factories on which the pattern was assumed to have been formed from the cluster pattern found from the first hypothesis verification. This led to an exploratory understanding of the spatial factors that are believed to have affected the cluster pattern found from the first hypothesis.



<Figure 6> Road network based truck accident hotspot

The analysis showed that the locations of the factories, excluding the old-planned location factories, have a significant impact on truck accidents within 2 kilometers, as shown in <Figure 7>. For old individual location factories, a total of 1,012 points are larger than the z-value of 2.57 corresponding to the 1% significance level from a radius of 1 km or more, corresponding to the ratio



<Figure 7> The effect of factory location characteristics and aging level on truck accidents

of about 56% of the total old individual location factories. For non-old individual location factories, a total of 260 points are larger than the z-value of 2.57 corresponding to the 1% significance level from a radius of 1 km or more, corresponding to the ratio of about 52% of the total non-old individual location factories. For non-old planned location factories, a total of 709 points are larger than the z-value of 2.57 corresponding to the 1% significance level from a radius of 1.7 km or more, corresponding to the ratio of about 37% of the total non-old individual planned location factories. As a result, it is difficult to assume that truck accidents occurred within the radius of the factories sites by accident. In other words, the fairly large z-value derived from the factories points is a testament to the possible involvement of some kind of spatial factors that can only be suspected of having affected the truck accidents.

Thus, the second hypothesis that "individual location factories significantly affect truck accidents more than the planned location factories." and the third hypothesis that "the old factories significantly affect truck accidents more than the non-old factories." was verified.

First, in the second hypothesis, it was found that both the individual and planned location factories had a significant effect on truck accidents. However, although individual location factories have more than half of the total, 52 % of the points where the z-value corresponds to the 1% criterion of the significance level within the geographical range of 1 km radius, the planned location factories have one-third of the total, 37% of the points where the z-value corresponds to the 1% criterion of the significance level. This means that individual location factories have had a more significant effect on the spatial clusters of truck accidents than on the planned location factories. Therefore, research hypothesis was adopted that individual location factories would have a more significant effect on truck accidents than planned location factories.

In addition, in the third hypothesis, the individual location factories did not show much difference in truck accidents depending on the degree of aging. However, it has been found that non-old industrial complexes have a significant effect on truck accidents rather than old industrial complexes. This is estimated to be related to the productivity of the industrial park and the amount of truck traffic since the planned location factories is planned in the form of an industrial park. Therefore, additional research is needed to take into account the traffic volume of trucks in old and non-old industrial complexes.

Conclusion

The differentiation of this study is based on the use of spatial point pattern analysis to identify the spatial characteristics of truck accidents and to derive the spatial factors that are thought to have contributed to the formation of it. In analyzing these spatial characteristics, we would also like to apply a road network-based spatial analysis method to infer the characteristics of a clearer spatial process.

Therefore, the study confirmed that truck accidents are affected by spatial characteristics and that the factories is the spatial factor of the phenomenon. This suggested that spatial factors should also be considered in the cause analysis of truck accidents that were limited to existing human factors, vehicle factors and environmental factors.

Thus, this study suggests that a reasonable traffic safety policy is needed, taking into account the spatial characteristic of truck traffic, away from the conventional uniform traffic safety regulation policy. Therefore, for efficient traffic safety management, spatial factors should be analyzed by region, road, and section of the truck accidents, and this discussion should be carried out in the previously described introduction of system of the exclusive road for truck in Incheon. In other words, in making policy decisions, the government should prepare a plan to eliminate the fundamental cause of accidents and prevent recurrence, such as designating the passing priority on truck cars in consideration of the spatial factors in truck accidents.

In addition, it was also possible to confirm that the reckless individual location factories had a very significant effect on truck accidents. Therefore, it suggests that the planned location-oriented industrial environment should be taken into account and that reckless development of individual location factories should be avoided.

There is a limit to this study that has been analyzed without identifying all the topographical and physical conditions at the point where the truck accidents occurred. Therefore, it is necessary to analyze all factors affecting the purpose of the truck, such as supply areas, logistics facilities and consumption areas of distribution, in addition to the factories, in order to derive clear spatial factors for truck accidents.

In addition, this study quantitatively estimated the spatial correlation between the two phenomena through spatial statistics, using location information such as the location of factories and the truck accidents. In this process, however, it is difficult to infer directly the characteristics of a specific spatial process, such as how some kind of extraneous environmental factor, which is believed to have contributed to the formation of this spatial correlation. Therefore, it appears that a study of the analysis methods for these spatial processes will be needed.

Also, since the study was based on an analysis of Incheon city alone, the scope of the study should be expanded nationwide to identify the specific nature of truck traffic by region.

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