A STUDY ON PROGRAM EVALUATION OF ROAD MAINTENANCE
BY LOGIC MODEL
- IN THE CASE OF THE NON-STUDDED-TIRE POLICY-

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Abstract: Starting in the early 1960’s, studded tires had been popular with motorists in the
cold and snowy region Hokkaido, Japan. However, after about 20 years dust pollution caused
by these studded tires became a serious environmental problem. Then, throughout various
public “Non-Studded-Tire” movements, the Studded Tire Regulation law of 1990 was enacted
to prohibit the use of them in order to eliminate dust pollution. The regulation has positively
eliminated dust pollution; on the other hand, however it has brought about the negative effects
with the regulation’s unexpected result of making winter roadways extremely slippery. Those
include increased winter accidents, worsened winter traffic pattern, and increased deicing
chemical usage, and these remain unsolved. The following study evaluates the studded tire
regulation enacted in 1990 by employing the logic model approach with the intention of
contributing how to evaluate road maintenance programs.

Keywords: Program Evaluation, Road Maintenance, Logic Model, Outcome Indicator,
Non-studded Tire Policy

1. INTRODUCTION

Implementing the “Special Measure Law for Ensuring Road Transportation in the Cold
Region,” well known as “Snow-Cold Law” and “Five-Year Plan for Ensuring Road
Transportation in Special Cold and Snowy Region,” Japan has dramatically expanded its
snow-removal operations. At the same time, maintaining sustainable mobility on the road
networks in the cold, snowy region throughout the year is an important mission for road
administrations. On the other hand, environmental pollution caused by studded tire dust
became a serious social issue since the late 70’s. This led to the implementation of the “Law
for the Prevention of Studded Tire Dust (Studded-Tire Regulation),” which prohibits the
studded tire use in its entirely, in 1990.

In Hokkaido, the mountainous town Kutchan, located nearby Metropolitan Sapporo, has the
highest average annual snowfall of 1,243 cm (40.8 ft) while Sapporo has 496 cm (16.3 ft). In
the United States, the regions with heavy snowfall reaching up 500 cm (16.4 ft) are only
located on the certain highlands like the Rockies (PIARC, 2002). Thus, Hokkaido’s winter
condition can be characterized as significantly severe in the world. Nevertheless, it is an
unusual case in which the regions with heavy snowfall and freezing climate like Hokkaido
have adopted such regulations; otherwise, this is the leading policy with studded tire
regulation.
However, while the law enforcement has solved the studded-tire dust problems, it leads to the negative effects such as increased winter accidents and worsened winter traffic pattern due to extremely slippery roadways that were unexpected before the regulation implemented. Reflecting on unexpected events, road administrations see effective winter maintenances as essential to reduce the negative effects in addition to improving traditional ways of snow-removal operations. So, the regulation has the intended effect on the studded-tire dust problems, but it has provided some negative effects as mentioned before. Therefore, it is necessary to have policy evaluation theoretically.

This study has developed a logical model that illustrates the policy evaluation results by identifying logical linkages between causes and effects involving in the policy events such as inputs, activities, outputs, and outcomes (Ryu and Sasaki, 2000). Then, by using the model developed here and discussing the overall value of policy-making with monitoring outcome indicators (Furukawa and Kitaoji, 2004), the study attempts to evaluate “Non-Studded-Tire Policy.”

2. ISSUE ON STUDDED-TIRE DUST

Studded tire generated dust resulted in not only adverse human health impacts but also deteriorated living environment during winter months. Traveling on roadways, high volumes of vehicles with studded tires certainly contributed to high urban dust levels that posed human health risks including sore throat, cough, and bronchial asthma. An experiment on animals also showed the presence of any foreign substance in the lungs and lymph system and idiopathic pulmonary fibrosis. Besides, deteriorated living environment such as stains on body and clothes, unpleasant feelings and stains on washings and furniture had been reported as a result of studded tire generated dust.

As studded-tire-related problem become a serious social issue, medical and attorney groups as well as community activists moved on to prevent studded tire generated dust. Then, throughout various administrative procedures, the ordinances to control the use of studded tires were adopted at the prefecture and local levels, as well as enacting the regulation at the national level.

3. “NON-STUDDED-TIRE” POLICY EVALUATION

Policy evaluation is to determine whether the public policy is balanced or not with constructing and empirically implementing a model which includes the necessary structural detail required by the specific policy scenario. Especially, judging the quality and worth of a policy-based program is called “Program Evaluation” (Miyakawa, 2002). It is a systematic social research work which identifies public value such as goal, objectives, implementation process, outputs, outcomes and efficiency on policy (Ryu and Sasaki, 2000).

As for “Non-Studded-Tire Policy,” the main purpose of policy evaluation is to evaluate the policy’s goal and objective, and rationality and suitability for inputted activities such as committee, mediation, legislating, self-control movement, and technological development. Additionally, with defining positive and negative effects, as well as costs and benefits, it is to make clear whether or not the goal is achieved and what are further issues.
4. LOGIC MODEL

Policy evaluation can be classified into four stages; “Theory Evaluation,” “Process Evaluation,” “Impact Evaluation,” and “Performance Evaluation,” and then “Logical Model” is developed as results of “Theory Evaluation.” Logic Model describes logical linkages among inputs into a policy, activities for a policy, outputs of a policy, and what the intended outcomes of a policy (Ryu and Sasaki, 2000).

5. LOGIC MODEL BEFORE THE STUDDED-TIRE REGULATION

Before the studded tire regulation was implemented, theory evaluation was not designed and performed. Therefore, the logic model was developed, as shown in Figure 1, with supposing that it would be performed at the time.

![Figure 1. Before-Regulation Logic Model for “Non-Studded-Tire Policy”](image)

5.1 Goal & Objectives

The goal of “Non-Studded-Tire Policy” is to preserve living environment and protect human health with preventing the generation of studded tire dust. Its objective is the specific and definite statement that identifies the specific item to be measured and quantify the degree of the policy’s attainment. As for “Non-Studded Tire Policy,” the objective is to regulate the use of studded tires, and this can be measured with the value of the proportion of vehicles with studded tires.

5.2 Inputs & Activities

Inputs into and activities for “Non-Studded-Tire Policy” are a variety of activities and discussions to implement the studded tire regulation. Those include all relevant committees, researches, self-control and educational movements, pollution mediation, ordinance establishment, and technological development for non-studded winter tires.
5.3 Outputs

The studded tire regulation’s outputs are results of regulating its as the policy’s specific objective. This can be identified by measuring the proportion of vehicles using studded tires.

5.4 Outcomes

As the studded tire regulation’s main goal is to prevent the generation of studded tire dust, its outcomes can be recognized by measuring dustfall and suspended particulate matter (SPM).

6. AFTER THE REGULATION (RECOGNIZED EXTERNAL FACTOR)

In winter 1992, which applied the penal regulation and fine for studded tire use violation, the proportion of vehicles with studded tires in the areas restricted for using them was approximately 2-3 percent. This means implementing the regulation brought about sharply decreasing its usage. At the same time, however, non-studded winter tires made roadway surface extremely slippery. This unexpected event can be thought of as an external factor (Ryu and Sasaki, 2000).

7. MONITORING

7.1 Outputs: Studded-Tire Use

The objective of “Non-Studded-Tire” Policy is to regulate the use of studded tires, and its achievement can be recognized by measuring the proportion of vehicles using them. As shown in Figure 2, it had begun to decrease around 1988 before the regulation was enacted in 1990. This was due to adopting ordinances and self-control for using them. With enforcing the regulation in winter 1992, the proportion of vehicles using studded tires in the designated areas to restrict their uses (restricted area) was approximately 2-3 percent. It shows therefore that the policy achieves its success as output.

Figure 2. Proportion of Vehicles Using Studded Tires
7.2 Outcomes: Dustfall & SPM

Assessing the regulation’s effectiveness by analyzing trends of dustfall, which is a criterion for designating the restricted area, it is recognized that the dustfall amount declines while the proportion of studded tire use decreases (see Figure 3). Indeed, the 1994 dustfall amount was under 20 t/km²/month, which is the standard for the restricted area (Environment Agency of Japan, 1990).

In addition to dustfall, suspended particulate matter (SPM) also positively declines with the decreased studded tire usage although SPM slightly increased in 2000 (See Figure 4): this increased SPM seems to be due to yellow sand dust, known as Asian Dust, which transported from China with harmfully affecting the Asian region at that time. Therefore, it is clear that decreasing studded tire usage leads to air quality improvement.

![Figure 3. Studded Tire Use & Dustfall](image)

Figure 3. Studded Tire Use & Dustfall
(Monthly Peak Value from Nov. to Mar. at the Observation Point in Sapporo)

![Figure 4. SPM on Air](image)

Figure 4. SPM on Air
(Mean Value for Peak Months from Nov. to Mar. at the Observation Point in Sapporo)
7.3 Major Negative Outcomes

7.3.1 Winter Traffic Accident

The number of winter-typed traffic accidents mainly caused by slippery and rutting roadways, and poor visibility has increased with the decreased studded tire use. Indeed, as shown in Figure 5, it has almost doubled from 1989 to 1993.

And, it has been expected that accident risk with rutting roadways would be reduced due to the eliminating of rutting caused by studded tires wear. However, the number of winter accidents does not decreased as fluid rutting has come to be left and non-studded winter tires do not perform well on ice-covered roadway in comparison with studded tires.

![Figure 5. Winter Accidents in the City of Sapporo](Source: Takashima. (2003))

7.3.2 Winter Traffic Pattern

Employing the results of the travel speed study conducted in 1986 and 1997, it explores winter traffic pattern with comparing the average travel speeds in the Sapporo metropolitan area before and after the regulation was adopted. The average speed before the regulation was 39.0 km/h and after the regulation was 32.8 km/h, which results in 16% decrease after the regulation was adopted. In addition to travel speed, as shown in Table 1, it is recognized that maximum traffic capacity, which is determined by the k-v value calculated with the regression analysis of these travel studies, has been also decreased after the regulation was adopted (Asano, Motoki et al, 2001-a).
7.3.3 Increasing of Deicing Agent Usage

The use of deicing agents in Hokkaido has been rapidly increased since 1994 in which extremely slippery roadways could be recognized (see Figure 6). The deicers’ environmental impact was first introduced in Itakura’s 1968 report showing the U.S. case of the salt level in the ground along roadways reaching the critical stage, which would damage the growth of plants.

![Figure 6. Amount of Deicer Use on National Highways in Hokkaido](source)

In the recent case of Northern Europe, Sweden had the research on reducing winter salt damage, called “MINSALT Project,” from 1985 to 1991. The research reports that even if the use of sodium chloride, started in 1960’s, is good enough as anti-slipping agent, concrete damage, steeled structure corrosion, vegetation damage, and stains are critical problems, especially in urban areas. The report then shows some technical suggestions to reduce its use (Swedish Road and Traffic Research Institute, 1991).

Another example of Northern Europe is Finland with a serious environmental problem of deicer negatively affecting groundwater. Although a number of studies have concluded that there are no easy solutions, current studies are extending to reduce deicer not only spreading over roadways but also sweeping into the ground such as the installing of devices for shielding groundwater (PIARC, 2002).
8. LOGIC MODEL AFTER THE REGULATION

In a case where public policy mission and goal statement are specified in logic model, it is to be desired specifying to minimize negative effects being caused by the adopted program (Hatry, 1999). Therefore, it needs to revise the logic model shown in Figure 1 (see Figure 7).

![Figure 7. Revised Logic Model for “Non-Studded Tire Policy”](image)

First point for the revised logic model is to add the statement of “keeping its balance with minimizing negative effects” as the policy’s significant goal to the original goal statement. Second is to need additional inputs and activities for the policy because of unexpected external factor, extremely slippery roadway, after the regulation implemented. Those include an improving of winter maintenance by road administrators such as winter maintenance committees, the improving of non-studded winter tires and vehicle performance, and the environmental impact studies for deicers. Third, it is necessary to have overall evaluation with considering negative effects for the policy’s outcomes (see Figure 7).

9. OUTCOME INDICATORS

Even thought the “Non-Studded-Tire” policy evaluation, like other policy evaluations, has faced with limited resources and data, based on the other works and expected results, it is possible to identify the following outcome indicators in the logic model after the implementation of the studded-tire regulation.

![Figure 8. Positive & Negative Outcomes from the Studded-Tire Regulation](image)
10. DISCUSSION OF OVERALL EVALUATION

10.1 Adaptability of The Process

Prohibiting the use of studded tires, the Studded Tire Regulation Law of 1990 has achieved its intended goal which preserve living environment and protect human health with controlling dust pollution caused by these studded tires. Enacting the regulation went through the stage with various inputs into and activities for the enactment, such as all relevant researches, committees, self-control and educational movements, technological development for non-studded winter tires and pollution mediation, and it had argued the pros and cons of the enactment. The government finally decided to regulate the use of studded tires; however, it might not totally consider the preliminary evaluation for negative effects as a part of policy-making processes. This could be clear from bringing about the unexpected external factor of extremely slippery roadways, its related problems, many ongoing discussions, various works practiced by the agencies concerned, technological development, and researches.

10.2 B-C Analysis and Community Survey

Policies encouraging protection of the environment such as “Non-Studded-Tire Policy” are strongly supported by the public preference recognizing environmental protection as the society’s worth; therefore, considering the policy’s advantage, it must specify the functions of public welfare (Furukawa and Kitaoji, 2004). So, for “Non-Studded-Tire Policy,” it is significant to take account of difficult measurable, quantitative aspect of the environment, like the risk levels of human health and the quality of urban landscape which are especially relevant in the policy analysis concerning the environment, in addition to easy measurable indicators such as dustfall and SPM.

Table 3. Example of Measuring the Studded Tire Regulation’s Impacts

<table>
<thead>
<tr>
<th>TRAVELERS</th>
<th>ENVIRONMENT</th>
<th>LOCAL</th>
<th>NATIONAL</th>
<th>TRAVELERS</th>
<th>PEDESTRIANS</th>
<th>RESIDENTS</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased Travel Times</td>
<td>-11,133</td>
<td>-11,133</td>
<td></td>
<td></td>
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<tr>
<td>Increased Travel Costs (fuel costs)</td>
<td>-43</td>
<td>-43</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Increased Travel Costs (tire costs)</td>
<td>-5,850</td>
<td>-5,850</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Increased Traffic Accidents</td>
<td>-687*</td>
<td>-687</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved Driving Comfortability</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Deteriorated Driving Safety &amp; Comfortability</td>
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<td>0</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Increased NOx Emissions</td>
<td>-48*</td>
<td>-48</td>
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<tr>
<td>Reduced Noise</td>
<td>-446*</td>
<td>-446</td>
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<tr>
<td>Reduced Dust (improved Urban Landscape)</td>
<td>1,461</td>
<td>1,461</td>
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<td>Improved Ecosystem</td>
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<td>0</td>
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<td>Increased CO2 Emissions</td>
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<td>0</td>
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<td>Decreased Opportunities for Life &amp; Interaction</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
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<tr>
<td>Deteriorated Public Services</td>
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<td></td>
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<tr>
<td>Stabilized Population</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>National Taxes (benzine tax)</td>
<td>37</td>
<td>-37</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Writer Maintenance Costs</td>
<td>125</td>
<td>22</td>
<td></td>
<td></td>
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<tr>
<td>Snow-Removal Costs</td>
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<td>-647</td>
<td></td>
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<td>TOTAL</td>
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<td>1,850</td>
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</tbody>
</table>

Source: Asano et al. (2001-a)
As the policy’s overall evaluation, Asano at al. (2001-a) has studied on the totaled impacts (benefits-incidence) of both positive and negative outcomes (see Table 2). However, the study could not be captured accurately with the overall evaluation because the study has not adequately considered all the effected indicators and the applied measurement for each indicator is incomplete. The community survey which evaluates the policy from residential viewpoints is also important resource for the policy’s overall evaluation, and Asano et al. (2001-b) conducted an opinion poll on the policy.

Figure 9. Community Survey about the Studded Tire Regulation (Overall Evaluation)
Source: Asano et al. (2001-b)

Evaluating these indicators, almost half of the residents see the studded-tire regulation positively as shown in Figure 9 while the totaled impacts shown in Table 2 explains considerable negative value. So, the evaluation for environmental improvement with employing the incidence-benefit approach describes the studded tire regulation with an underestimated value in comparison with the community survey. Otherwise, it shows great difficulty in doing the overall evaluation.

10.3 Discussion from Social Science Viewpoint

Fujii (2004) defines “Social Dilemma” which can be expressed with employing “Game Theory,” and the definition is as follows:

“Social Dilemma” is a social situation which requires choosing to perform a “cooperative action” or “uncooperative action.” Cooperative action is essential to contribute increasing long-term public benefits while decreasing short-term individual benefits. On the other hand, uncooperative action is essential to contribute increasing short-term individual benefits while decreasing long-term public benefits.

Applying this definition to the case of studded tires, the cooperative action is to stop using studded tires while the uncooperative one is to continue using these tires. Therefore, the Studded Tire Regulation Law of 1990 can be viewed as, choosing the cooperative action, performing it in the form of the legal regulation.

However, even if the regulation was enacted, every year the problems on winter roadways have argued over and over. This means that a dilemma can not be generally resolved without difficulty and a social dilemma is not exception, as Fujii has stated. Therefore, it is not surprising that the social dilemma is existed even after taking the selected action of the legal regulation.
Because the social dilemma is unlikely to resolve easily, the way to deal effectively with the dilemma is inevitably to attach greater importance to day-to-day management. This needs considering regularly the social management policy that encourages changing individual actions from the uncooperative action to the cooperative one and guiding individual attitudes toward changing individual actions. To be concrete, this is the communication-oriented policy that encourages changing individual actions and attitudes on their own initiative. For the studded tire regulation, it needs to develop the communication policy that makes the public administrations thoroughly responsible for explaining the regulation’s positive and negative effects to the public (accountability) while continuously monitoring each outcome indicator. However, if these public actions do not lead to the complete public acceptance, it further needs considering an alternative policy to reduce the seriousness of the social dilemma with relieving conflicts between individual and public benefits. This might appropriately ease restrictions on the use of studded tires; however, because the authorities in charge show the course to make the regulation more strictly, it might be very difficult to encourage appropriate deregulation.

11. CONCLUSION

The Studded Tire Regulation Law of 1990 shows a solution to reduce dust pollution with prohibiting the use of studded tires. However, the regulation itself only shows the solution, and it does not respond to the necessity of management to deal with conflicts that would arise after the regulation was enacted. Instead of the regulation, the related practitioners deal with these realized conflicts.

At the deliberation of the Diet on the Studded Tire Regulation law of 1990, it shows following supplementary resolutions.

- Consider necessary costs of winter maintenance, including snowplowing and removing, carried out by the road administrations without imposing them excessive heavy financial burden

- Consider what the dust pollution measures should be, with taking the circumstances; such as the situation in the designated areas regulating the use of studded tires after the regulation was enacted, the amount of dust pollution, and the developing conditions of alternative winter tires, into consideration and depending on the situation. Then, take necessary actions to realize “Non-Studded-Tire Society” based on the results of consideration

- Pay special attention to secondary pollution caused by taking measures to eliminate dust pollution

These resolutions require program management considering the ideal method of carrying out anti-dust pollution measures with taking dust pollution, traffic safety, technological development, winter maintenance and secondary pollution equally into consideration. Realized “Desirable Non-Studded-Tire Society” resolved social dilemma conflicts with encouraging the public acceptance based on justice and trustworthiness while valuing these supplementary resolutions, it is necessary to continue monitoring the outcome indicators identified here and to fulfill accountability on communication policy as the authorities in charge playing a key role. However, if the complete public acceptance is not fulfilled as a
result of these public actions, it needs appropriate deregulation in order to reduce social
dilemma conflicts.

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