THE PROSPECT OF A WINTER SNOW CHARGING SYSTEM

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Abstract: Sapporo, a major city in northern Japan, has an annual snowfall of over 5 metres and snow removal is a major civic concern. In this study, we analysed and compared various examples of road pricing projects around the world to ascertain their various characteristics. From these findings, we then imposed a hypothetical road pricing system in Sapporo, on the basis of providing revenue to help cover the city’s winter road maintenance costs. We designed two different winter-time road pricing systems; a bounded cordon toll and a mileage charge. To get an indication of the acceptability of road pricing for the citizens, a survey was conducted. Findings indicate that residents would be willing to pay a minimal amount in support of road pricing and the bounded cordon toll as the preferable design. Residents residing within and around the cordon were also found to be more sensitive to road pricing changes

Key Words: Road Pricing, Snow Removal, Transportation Policy

1. INTRODUCTION

Sapporo city was founded some 100 years ago to eventually become Japan’s 5th populous city, some 1.8 million inhabitants. Its recent founding means it is different from most Japanese cities, as its streets and layout were originally designed by American city planners. Sapporo is located on the island of Hokkaido and is well known for its heavy snowfall. Unlike the metropolises on the main island, Sapporo has no other sizable rival close to it, and is by far the most dominant city on Hokkaido.

In Sapporo, annual snowfall often exceeds 5 meters. Her citizens identify snow removal as their main civic concern, and their overall satisfaction with it is low despite the large financial resources the city spends on it (Some 2% of the city’s total annual budget). Budget constraints prevent the city from increasing expenditures on snow removal. Consequently, more efficient and effective removal is required if the city is to satisfy the demands of its citizens.

However, without financial relief, efficiency can only go so far. Both local tax revenue and central government funding are expected to shrink, despite growing demands for various social services and overall growth in the city’s fiscal obligations. In the three decades from 1965, the population more than doubled from 820,000 to 1,750,000. Vehicle ownership jumped from 830,000 vehicles in 1995 to 980,000 vehicles in 2003 and continues to grow. It is in the last statement where we believe a possible solution can be found.

It is our observation that executing a new road pricing project is politically unviable other than in certain extraordinary circumstances (London, Singapore). Sapporo, we believe, is an unusual case. Our objective is to test the hypothesis that a road pricing system can be one of the options implemented in Sapporo as a means of revenue for winter road maintenance.
To emphasise this point, the following (Figure 1) illustrates the proportion of the city’s road maintenance cost budget that goes towards servicing road users and associated activities. Snow removal for roads, prevention of road icing and road heating costs alone make up some 29%. Associated activities such as disposal of removed snow add to this and it can reasonably be imagined that up to half of the budget caters to road users. Yet, car users in winter make up only a small proportion of the taxpaying population of Sapporo.

The optimal way to induce drivers to take account of this disutility that they cause to others is to charge them fees for driving during snowbound periods that would vary with the degree of the cost it would take to clear the snow. The same principle can be applied to the congestion that is caused. Combining these, fees would be higher during rush hours than during other hours of the day, and they would be lower on weekends when traffic is generally lighter than on weekdays. Fees should also be greater when it is snowing heavily since there is greater more snow to remove. That said, to create a road pricing system that satisfies all these requirements and more is highly impractical. One may as well tax pedestrians for the amount of pavement they use! Therefore a system that goes some way towards balancing these inequities without being too cumbersome would be best for all concerned.

The disadvantages of road pricing are largely related to perceptions of fairness. By charging for something that was once "free" it may be seen as unfair. The burden falls more heavily on the poor drivers than the rich. However, this should be compared with the burden of other financing systems, such as the fuel tax. New tolls in a largely free system may be seen as punishing one area when others don't pay for roads. This could be countered by stating that prices create choices, which is only fair since people are not identical, sometimes people have higher values of time/travel (e.g. when late for a meeting), and sometimes lower. Thus making everyone pay the same tax isn't fair if everyone doesn’t benefit from the service provided.

![Figure 1 Snow removal budget allocation costs](image-url)
2. CASE STUDY ANALYSIS

A few cities throughout the world have successfully employed cordon tolls, including Oslo, Trondheim, Bergen, Singapore, Durham, and London. Meanwhile, similar projects are (or were) being evaluated in New York, Hong Kong, Jakarta, Dublin, Genoa, Rome, Stockholm, Bristol, Edinburgh, and Leicester. From an implementation perspective, then, cordon congestion tolls are clearly feasible, though to date no consensus has emerged as to the best technical approach. Singapore, for example, has relied on on-board units with electronic transponders and overhead gantries at entry points, while London has pursued a strategy based on stringently enforced self-reporting (e.g., via the Internet). However, technical implementation is not the focus of this paper.

Before creating a Sapporo Road Pricing System from scratch, we felt that it was necessary to select and analyze various other road pricing projects that were in existence (or at an advanced stage). There were not many to choose from, but an initial roster of over a dozen projects, namely; London, Bristol, Durham, Edinburgh, Bergen, Oslo, Stockholm, (Scandinavia) Austin, Texas, California, Randstaat and Singapore were studied. Of these, London, Edinburgh, Oslo and Singapore merited further study since they had some outstanding points that we felt were relevant to the study. From these 4 case studies we were able to gain an understanding of on-the-ground issues that face practical road pricing projects. Full analyses of the 4 projects are available from the main author.

From the case studies analyzed, we have come up with a set of criteria that we deemed as vital facilitators to the success (or failure) of the individual project.

2.1 London

• Identification of a Project ‘Hero’

The implementation of London’s Road Pricing scheme is undoubtedly due to the actions of one man – Ken Livingstone, the mayor of London. Introducing a road pricing system to combat London’s traffic became the cornerstone of his manifesto in the mayoral elections and despite national government objections (his own political party severed links) he pushed through the project to the end with ruthless efficiency and zeal. Perhaps it would be too much to expect a ‘Ken Livingstone’ for Sapporo, but it is clear that the leadership of a zealous, charismatic individual would enhance the chances of introducing a road pricing system in these shores.

• Use the Media

Residents in London did not lack for information on the road pricing project – and the advantages it would purportedly bring. The implementation of the scheme became a national issue thanks to its outspoken leader and it became a major issue in the newspapers, who were quick to take sides. What this entailed was that coverage of the scheme was highly satisfactory; reaching out and energizing those who would benefit yet may be too apathetic to vote for the scheme i.e. pedestrians and bus commuters. Media outlets in Japan, much more staid than those in Britain, if brought over to the side of road pricing, could massively boost the chances of a successful system. The more advanced state of communication technology in Sapporo also should be used to the utmost.
2.2 Singapore

- **Use Proven Technology**
  Singapore’s Road Pricing system is renowned for its longevity – in operation in one form or another for the past four decades. We believe part of its success is its simplicity and reliability, especially in the form of easy payment – initially in the form of manual tolls, and more recently in the form of cashless credit units. This is considerably less of a hassle than the payment methods of London’s system. It may be argued Singapore’s authoritarian city-state government (Singapore registered cars must have a compulsory transponder) makes dissent less likely, but a similar scheme has been applied with success in a far larger and more libertarian Norway. Yet it is certain that Singapore’s compactness and government makes fine-tuning the system easier.

- **Logical pricing methods**
  Singapore has managed to price roads in such a way as to truly provide choice to the driver. He is given the freedom to drive the road at any time, as long as he is willing to pay the price. As a means of reducing congestion and spreading over traffic density this has proved remarkably effective. As a means of pricing roads in differential winter conditions, it is possible that similar means can be adopted. However we believe that differential pricing methods for snow removal may run into numerous practical problems.

2.3 Norway

- **Identify a proposal highlight that can capture public imagination**
  This does not mean promoting the road pricing system and filling up newspaper and television advertising slots. This does mean however, politically promoting a project indirectly via promoting a concrete benefit of the scheme. In Norway, residents of road pricing scheme areas were made aware of the more easily understood advantages they could gain by – in Oslo’s example – of a new tunnel through the city. They knew what they would be paying for. For promoting a winter maintenance road pricing scheme, we believe that for it to have any chance of success, the aspect of better roads and sidewalks as well as improved transport services must be brought to the attention of the public.

- **Trust**
  Securing public trust is not easy and once lost is hard to regain. In Norway, politicians at all levels work with ordinary citizens to alleviate their concerns. Allocation of funding is transparent and promised improvements are visibly on show. It is important not to fall into the trap of bureaucracy and squabbling over revenues that only adds to the perception of the public of the self-serving politician. It is unfortunate that the image of politicians in Japan has been tarnished recently in this manner (highway financing scandal) but hopeful this can be redressed in the future.

2.4 Edinburgh

Thought the need for a road pricing system in Edinburgh was technically feasible, we contend that the system failed the criteria that had made road pricing possible in the other cities. Edinburgh tried to follow London’s lead without having some of the advantages that London had, and by exacerbating a major point of discontent in London’s scheme. Edinburgh did not have a ‘Ken Livingstone’ – it had a council leadership that was distracted with political challenges by the opposing party and it promoted a pricing scheme that was more complicated
and troublesome (to drivers). The political commitment wasn’t there – this was apparent in
the referendum where citizens were given an outwardly more palatable alternative to road
pricing – a ‘package’ aimed at improving public transport without road pricing. Of course,
how this ‘packaged’ would then otherwise be financed was a mystery. This however, was
apparently less of a mystery to a complicated 2 ring system that would have different charging
times and thus the electorate voted accordingly.

We believe that the criteria we had obtained from analyzing the experiences of the four cities
will prove useful as benchmarks for the implementation of a feasible road pricing system not
just in Sapporo, but in other cities. What is striking is that most of the criteria are based on
public policy, and failure in complying leads to rejection in the ballot box. In practical terms,
it is possible that public sentiment of a road pricing project can be attributed to each of these
criteria and from there, the likelihood of acceptance.

<table>
<thead>
<tr>
<th></th>
<th>London</th>
<th>Singapore</th>
<th>Oslo - Akershus</th>
<th>Edinburgh</th>
<th>Sapporo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pop</td>
<td>7,500,000</td>
<td>4,400,000</td>
<td>1,090,000</td>
<td>450,000</td>
<td>1,880,000</td>
</tr>
<tr>
<td>Citizen Power</td>
<td>Mayoral</td>
<td>Limited</td>
<td>Full</td>
<td>Full</td>
<td>Full</td>
</tr>
<tr>
<td>Climate</td>
<td>Temperate</td>
<td>Tropical</td>
<td>Temperate</td>
<td>Temperate</td>
<td>Sub-frigid</td>
</tr>
<tr>
<td>Snowfall</td>
<td>25mm</td>
<td>None</td>
<td>180mm</td>
<td>50mm</td>
<td>465mm</td>
</tr>
<tr>
<td>Road Pricing</td>
<td>Congestion</td>
<td>Congestion</td>
<td>Revenue</td>
<td>Congestion</td>
<td></td>
</tr>
<tr>
<td>Overview</td>
<td>Success</td>
<td>Success</td>
<td>Renewal</td>
<td>Failure</td>
<td></td>
</tr>
</tbody>
</table>

We had mentioned the criteria as useful for the implementation of a feasible road pricing
system – but not a winter road maintenance pricing system. This was because there was
insufficient information as to the effects of harsh winter conditions on road pricing. Norway,
although cold and wintry, does not have as much snow as Sapporo so we were unable to
return a definite conclusion on this aspect of the study. The above Table 1 briefly compares
the case study cities to Sapporo.

This ends the first half of the study and in the second half; we will demonstrate the public
reaction of the introduction of a hypothetical winter road maintenance pricing system.

3. WINTER ROAD PRICING SYSTEM DESIGN

As a consequence of conclusions derived from the first part of the study and our initial
objectives, the second half of the study records our efforts in documenting and analyzing real
public reaction to hypothetical road pricing measures in Sapporo city. Mainly based on
analysis and conclusions of the case studies, two different schemes were proposed for
presentation to the public in a survey.
3.1 Cordon Toll Scheme (Scenario A)

The Underground system in London runs on a zonal payment system, as displayed in Figure 3.2. When superimposed with the current congestion charging area and its western extension (Figure 2) it can be imagined that was designed in part to correspond with the area designated as Zone 1 within London Underground. This forms the inspiration of the idea of a pricing synergy between the underground mass transit (the major form of modal change for car users) and surface road transportation systems. The innermost pricing zone, ‘Zone 1’ in London’s case, would provide the basis of the ‘city core’ of the city, subjected to modifications imposed by practical geographical and road traffic considerations. This would also simplify pricing and other logistical considerations for the mass transit authorities on whom the burden and responsibility for accommodating drivers who convert to using mass-transit.

Following this line of reasoning, a similar application can be made for a hypothetical winter road charging system for Sapporo, referring to Odori Station as the point of origin, from where zones can be demarcated as per the current subway charges. Odori was chosen as it is the station closest to the financial, administrative, commercial and geographical heart of the city, with major department stores and prefectural buildings within walking distance of the station. It is also the only station where all three Sapporo subway lines intersect. These zones illustrated on a public subway map of Sapporo (Figure 3) which also shows the local streetcar system as well as suburban railway lines.
Thus, a zonal map akin to that of London can be constructed, with each area within a ‘zone’ a possible cordon. This was superimposed onto a map of the city of Sapporo, providing a basis for the proposed winter road pricing cordon toll area. In this manner, the outermost zone would correspond with the outer cordon (Figure 4a) and the inner zone to the inner city cordon (Figure 4b). Adjustments were then made with respect to geographic realities (Toyohira River) and the current shape of the road network. In this respect, Sapporo’s lack of an inner city ring road system could pose traffic flow problems which will be commented on further in the following chapter. However, contracting the cordon to the closest main through roads resulted in a workable inner city cordon area that is illustrated in the map below in Figure 4c.

From the case study reviews, snow has not been a major factor in any road pricing system thus far. However, in an attempt to compensate for this, an area (following examples from case studies) rather than facility pricing (as is prevalent in America) is considered. After all, snow does not fall selectively! However, as to the characteristics of the scheme, many of the points have been evaluated and picked from the studies, following the design criteria that had been developed from analysis.
Main points of Hypothetical Cordon Toll Scheme (Scenario A)

- **Downtown cordon operating from 7am to 6.30pm Monday to Friday**
  This timing would cover the peak commute times without overly affecting the important evening commercial activities centered on Susukino. Weekends are also not charged so as not to alienate shoppers. The whole-day set time would also reduce likelihood of loitering during changeover periods.
- **A fixed ¥300 (proposed) inbound only charge per day, no matter how many cordon crossings are made each day**
  Simple to understand and implement, and is standard procedure in most of the road pricing systems studied. However, runs the risk of drivers that have already paid to ‘over-drive’ in order to make the most of their one-off payment.
- **Special exemption for selected groups**
  As in most current systems, special vehicles such as doctors’ cars will be exempted. However, the range of exemptions should not range too widely or revenue would be needlessly lost. Taxis and rented cars are unlikely to be exempted.
- **Enforcement by cameras discreetly placed at the cordon**
  Depending on the state of the art at the time of implementation, this may include GPS identification in addition to digital imaging technology. A transponder system would be too cumbersome to implement considering the significant population of ‘out-of-city’ cars coming into the city.
- **A penalty charge notice will be issued to those liable for payment but who have not done so within the designated time**
  This is in order to induce prompt payment, but with greater latitude than the British systems. Prevalence of 24 hour convenience stores and vending machines throughout the country should mean fewer problems with payment opportunities.
- **Revenue collected will then be distributed to each ward’s snow clearing executive as seen fit**
  For example, a scheme-payer coming from the direction of Kita-ku can expect his/her payments to be used towards more road heating locations from that direction. This can alleviate fears of possible revenue mismanagement as the drivers are paying for their stretch of road used.

### 3.2 Winter Mileage Scheme (Scenario B)

A less technical solution is a mileage pricing scheme that charges the driver for the distance driven during the winter. Here, vehicle owners pay a one-off fee per year based on the distance traveled from December to April. Vehicle odometers are checked by the end of November and reviewed in April at gas stations and land transport offices and owners pay variable rates per unit km depending on their package (Figure 5). Packages may depend on various factors depending on the type of driving lifestyle that may be most preferred by the authorities. It could also depend on the type of vehicle usage so as not to overly penalize frequent long distance drivers. The scheme would cover Sapporo city and ideally extend throughout Hokkaido in order for city residents not be penalized compared with out-of-city drivers.
Main points of Hypothetical Winter Mileage Pricing Scheme (Scenario B)

- **Vehicle owners pay a one-off fee per year based on the distance traveled from December to April**
  This will cut down on unnecessary or ‘trivial’ driving and makes people think twice about using their car for just any purpose. However, this may be detrimental to the economies of some communities that are not well served by public transport. It will adversely affect roadside stations (michi no eki) that cater to long distance drivers as well.

- **Vehicle odometers are checked by the end of November and reviewed in April at gas stations and land transport offices.**
  Drivers can register their vehicles they buy petrol for their vehicles. Some mechanism will to be in place to compensate drivers who register earlier than the start of the charging period.

- **Variable rates per unit km depending on package**
  More administrative work, but necessary to avoid blatant inequities suffered by those who may have no choice but to travel long distances regularly.

- **Enforcement by using stickers on vehicles those are visible to traffic enforcement officers**
  Best way to deter drivers from skipping out on the mileage charge. The stickers will also determine to the enforcer the type of package.

- **Scheme covers the whole of Sapporo city and can be extended throughout Hokkaido**
  This will be necessary so that city citizens are not unfairly penalised compared to drivers from other towns. Since registration in on an individual ward basis, revenue can be granted to the wards depending on registration.

### 3.3 Comparative Assessment

The scenarios, by design, differ in many aspects despite the fact that they are both winter road pricing systems. A comparative assessment table (Table 2) outlines these differences. The technology gap is reflected in the relative implementation costs of the two scenarios, as well as the estimated revenue collected. It should be noted that these assessments are presumptions that needed to be confirmed. Thus it is only estimated (on the basis of case study data) what the impact of the respective systems on the public are. Mileage systems have not been widely implemented so estimations for this will need further confirmation. From these presumptions, the actual data will be compared with the results of the survey.
Table 2 Comparative Assessment Table

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>A – cordon</th>
<th>B - mileage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementation cost</td>
<td>HIGH</td>
<td>LOW</td>
</tr>
<tr>
<td>Revenue collected</td>
<td>HIGH</td>
<td>MED?</td>
</tr>
<tr>
<td>Simplicity</td>
<td>COMPLEX</td>
<td>SIMPLE</td>
</tr>
<tr>
<td>Public Acceptability</td>
<td>Low?</td>
<td>Medium?</td>
</tr>
<tr>
<td>Impact on Commuters</td>
<td>High?</td>
<td>Medium?</td>
</tr>
<tr>
<td>Impact on Commerce</td>
<td>High?</td>
<td>Medium?</td>
</tr>
<tr>
<td>Equity</td>
<td>High?</td>
<td>Low?</td>
</tr>
<tr>
<td>CBA rating</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>

Lacking data for a quantitative CBA, a qualitative one was conducted (Table 3). This allowed us to define more preconceptions for the initial pilot study. The value in this was more towards identifying the main players in the road pricing project as well as deciding what effect road pricing would have on these groups. Stakeholder analysis revealed that the distinct groups involved for consideration are the vehicle users, public transport users, pedestrians and the city authorities. Members of these groups may interchange, but they would tend to identify with one over the other. The city government would be a major player as it would fall upon this group to implement and manage the road pricing system. Car users would be affected in obvious ways. Pedestrians and Public Transport users may seem to be as uninvolved, but their support is essential in ensuring a road pricing system can be legislated. They also stand to gain from improved snow clearing.

Table 3 – Estimated CBA relative comparisons

<table>
<thead>
<tr>
<th></th>
<th>Pedestrians</th>
<th>Car Commuters</th>
<th>Public Transport Users</th>
<th>City</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Inc. Traffic</td>
<td>Financial</td>
<td>Inc. Usage</td>
<td>Manage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less Traffic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Improved LOS</td>
<td>Improved LOS</td>
<td>Improved LOS</td>
<td>Revenue</td>
</tr>
<tr>
<td></td>
<td>Financial</td>
<td>Less Traffic</td>
<td>Financial</td>
<td></td>
</tr>
<tr>
<td>Overview</td>
<td>Winners</td>
<td>Losers?</td>
<td>Winners</td>
<td>Neutral</td>
</tr>
</tbody>
</table>

In a winter road pricing system, we believe that for pedestrians and public transport users, a possible cost would be increased pedestrian/user traffic as commuters change modes. More funding for road pricing and road heating would mean improved pavement and walking conditions, especially at public transport termini and transit points. Car commuters would bear the direct financial costs but could benefit from improved traffic conditions and improved roads. Interestingly though, it has been suggested that decreased traffic levels may result in higher speeds and thereby more accidents. Overall however, car commuters are likely to see themselves as losers in this scheme. The city government would bear the expenses and risks of implementing and managing the system with the benefit of increased money to spend on winter road pricing.

4. SURVEY RESULTS AND METHODOLOGY

Billions of yen are spent annually in order to make Sapporo’s roads in winter safe for travel. The objective of the survey was to determine the willingness of Sapporo’s residents to help pay for this service with the introduction of a seasonal road pricing system. In creating the
survey, it was decided that the data we would like to obtain would be usable in future WTP and AHP analyses. In order to prepare for a proper survey a pilot study along with a focus group discussion was conducted in November 2005, testing out variables and gaining feedback. From here, the variables for the survey proper could then be redefined and an idea of the requirements of the surveyed residents can be ascertained. It was suggested that a concrete benefit such as a ‘residential driveway snow clearance’ be offered. With data from the pre-survey the more details of the system could then be clarified.

1508 printed copies of the survey via means of mailbox posting (1350 copies) and direct handouts (158 copies) beginning from 24/12 until 27/12 were distributed with a deadline date of 5/1 though responses were received right up to February. The survey was made in conditions of intermittent heavy snowfall.

Five main locations throughout Sapporo were chosen as mapped in Figure 6. They are of varying directions to the city centre. In particular, car owning households were targeted.

The survey was difficult to answer resulting in a low response rate. On the other hand, the quality of the responses was generally quite good. That the majority of the survey targeted household mailboxes did not help. This did mean a relatively large and satisfactory response from car users though. Generally, user feedback was extremely polarized. Respondents seem to generally love or hate the idea and there was also much curiosity about certain aspects of the road pricing system that were not explained fully, due to time and space constraints. There were certainly many comments about the system, positive and negative, with plenty of constructive criticism.

Table 4 below shows the basic demographic breakdown of the respondents at a glance. The majority of respondents were male, reflecting the fact that most questionnaires were sent to households with families, where the head of the household was usually male.

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>140</td>
</tr>
<tr>
<td>Female</td>
<td>65</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
</tr>
<tr>
<td>under 29yrs</td>
<td>74</td>
</tr>
<tr>
<td>30 to 59 yrs</td>
<td>81</td>
</tr>
<tr>
<td>over 60s</td>
<td>50</td>
</tr>
</tbody>
</table>

The statistical analysis software SPSS was used to analyse the data. Scalar variables from the survey were converted to categorical variables in order obtain the statistical bar charts that appear in the following pages.
Figure 7 to the right shows the monthly income breakdown of the respondents. From this it is clear that we managed to capture a uniform range of household incomes. This allowed us to get a better ‘snapshot’ of the target stakeholders i.e. the citizens of Sapporo.

Figure 8 Mode with respect to Location

The graph right (Figure 9) differentiates between those who use their car as their main mode of commute during winter and those who don’t. Analysis of mode with car ownership reveals that a significant minority of car owners do not use their car(s) as their main mode of transport to the city centre. The graphs suggest that roughly half of car owners do not use their car as their main mode of transport during winter.

Figure 9 Travel Mode with respect to Vehicle Ownership

The frequency of commuters against their WTP (Figure 10a and 10b) reveals interesting tendencies. The graphs show those who only occasionally come to the city centre are even less likely to travel should there be a road pricing scheme. This would have ramifications towards commercial activities within the city-centre as these particular groups likely have alternate forms of transport or destinations.
The graphs to the right compare the two scenarios in terms of a respondent’s willingness to pay against their view of traffic conditions in winter. The comparisons were made to see if there was any outright relationship between willingness to pay and the drivers’ view of winter traffic. The graphs suggest that winter traffic conditions play some role in the drivers’ willingness to pay, yet more than half of those who would not pay had admitted that they viewed winter traffic as a ‘major problem’. This may reflect a level of distrust in payment revenue allocation, as was reflected in comments by these drivers.

Table 5 is a selection of respondent groups and their relevant mean WTP. Although only indicative (due to data not being representative and evidence of respondent bias), from here certain groups may pay more than others. This may mean that these groups value winter road maintenance highly i.e. residents of East Naebor or, aren’t affected i.e. pedestrians.
Unfortunately, ANOVA 2 tailed t-tests assuming unequal variances proved negative in attempting to confirm the above hypotheses. The reason for this is the large variation in WTP responses as well as the relatively small sample size. Purely estimating from this sample data (130 drivers averaging ¥2000 per driver per week) the revenue would amount to some 0.8 – 1.5 billion yen a year.

5. Conclusions and Further Studies

This study barely is only a precursor to introducing a road pricing system in Japan. However it can be surmised that the majority of residents would pay at least a minimal amount of money (lowest band of values) towards the operation of a winter road pricing system, and that, in the survey conducted, a cordon toll scheme would be more popular than a mileage scheme. In terms of public opinion, a minority of vocal opponents to any road pricing scheme would be expected and this was borne out by comments in writing and over the phone by a few respondents. The biggest obstacle to a positive public referendum decision is the apathy of non-car users. Other major obstacles would include the resistance of businesses located within the cordons that see the tolls as a threat to their profitability. Also, unless inner cordon residents are given substantial discounts, they too would be disenfranchised. What must be made clear are the benefits that would be derived from the system and transparency in how revenues are allocated. More in-depth studies can and will be conducted on virtually all aspects of the research, as expanded upon below:

- Reducing survey scope and increasing sample size

A major difficulty encountered in conducting the second part of the research was the poor number of responses which made accurate modeling impossible. To counter this, another survey should be undertaken with an increased sample size with a simpler questionnaire format. AHP results have proved unreliable and this line of questioning may have to be deleted or replaced.
• **Zonal Pricing and Applications in other towns and cities**

There is no reason why road pricing in Japan should be limited to Sapporo, though a winter based system would perhaps only be feasible in other snowbound cities, in the rest of Hokkaido or cities in Honshu like Niigata. There are certainly other cities which are more densely populated than Sapporo and it would be interesting to see how these would take to road pricing measures. However, in order to apply a zonal pricing system, it is necessary for these cities to have a good public transportation system.

• **Expansion into All-year system**

In line with other cities, the road pricing schemes can be converted to all-year round systems. The main purpose would then be to gain revenue and reduce congestion.

• **Development of a ‘Design Criteria’ to assess a town or city’s suitability for Zonal Road Pricing**

This would be an expansion of the first part of the research study. By looking at successful cities and their road pricing systems, common values can be ascertained and turned into quantifiable criteria. These criteria would take into account geographic, demographic and systemic variables.

• **Comparative Analysis**

To achieve more definite results, locations and respondent types can be pared. Promising groups have been outlined in this study, based on location and commute frequency. With more data, in-depth clustering analysis can be conducted to determine reasons for discrepancies. When key variables have been reliably determined, specific commuter reaction to the system can be modeled.

• **Traffic Flow Analysis of Cordon Toll Scheme**

The impact on traffic flows in the advent of the introduction of Cordon Scheme needs to be investigated. In order to attempt this, modal change data from respondents need to be further analyzed and added to. From here, the diversion of traffic to areas outside the cordons, or to alternate destinations can be determined (Figure 12) Ideally, this will allow the creation of a simulation that models traffic patterns after the introduction of a road pricing system.

![Conceptual Traffic Flow changes](image-url)
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