Economic Effects Analysis of Public Investment in Road Improvement Works in Hokkaido

- Simulation Analysis based on a Macro-econometric Model of Hokkaido -

•Hideaki Abe, Faculty of Commerce, Hokkai Gakuen University of Kitami
Toshio Kuroyanagi, Faculty of Economics, Sapporo University
Tatsuhide Ito, Docon Co., Ltd.
Hiroki Katagiri, Docon Co., Ltd.
Akihiro Izumi, Ministry of Land, Infrastructure and Transport, Hokkaido Bureau
Tadayuki Wada, Sapporo Development and Construction Department, Hokkaido Regional Development Bureau

1. Research Objective

The objective of this study is to clarify how application of road improvement projects over a given analytical period of time has affected Hokkaido's overall economic structure, consisting of the industrial economy, prefectural income, household consumption, and commodity prices, through a simulation analysis based on a macro-econometric model. Although the economic effects of road improvements have been measured fairly precisely through cost-benefit analyses, they have been mostly confined to specific regions. This study, however, attempts to understand the economic effects on Hokkaido as a whole, covering not only communities near particular road infrastructure but also marginal areas (which have been excluded from cost-benefit analyses) on an assumption that the economic effects of road improvement should be analyzed both macroscopically and microscopically. Although a "road improvement project" is a public project, the concept here is that its effects on capital formation, stock production, distribution, consumption, lifestyle, and living areas/environments should be examined as "social overhead capital (SOC)", instead of viewing it from the perspective of the Keynesian short-term effective demand principle. Precisely put, our goal is to build an effective simulator that can model as many the following effects as possible:

- Direct effects including the reduction of time-distance coefficients, reduction of transportation costs, and market expansion which all benefit from road network improvement.
- Indirect effects such as greater convenience and lifestyle improvement.
- Multiplier effects that induce effects on other public projects including living area improvement and promotion of regional areas

In other words, among these direct and indirect effects, all that can be evaluated in quantitative or monetary terms are to be included.

Taking data availability into consideration, this study covers a 21-year analysis period covering the years 1976 through 1996. As for the evaluation of economic effects brought about by road improvements, road infrastructure and other exogenous variables will be tested under certain

conditions by sensitivity analysis and some scenarios will be designed for evaluation of quantitative effects. Based on these results, a simulation will be run on a traffic model and other potential scenarios to measure the macro-economic effects brought about by road investments.

2. Current Industrial Structure in Hokkaido

Before establishing a quantitative model, we will briefly review the characteristics of the industrial structure within Hokkaido.

Table 1 shows production output share for tertiary industries. Production share for the service industry and the wholesale/retail industry in particular, are relatively higher in Hokkaido than the national level, while production output share for secondary industries is contrarily lower. Data for 1997 reveals that the manufacturing industry was the area of industry with the largest production output share at the national level (23.2%), followed by the service industry (17.8%), the finance, insurance and real estate industries (15.9%), the wholesale/retail industry (13.4%), and the construction industry (8.13%), while in Hokkaido, the service industry (19.0%) had the largest share, followed by the finance, insurance and real estate industries (14.3%), the wholesale/retail industry (13.8%), the government service sector (12.5%), the construction industry (12.3%), and the manufacturing industry (10.7%). Thus, when the industrial structures are compared between Hokkaido and the nation as a whole, we can see that Hokkaido is characterized by having a proportionally smaller manufacturing industry, and a proportionally larger service industry and official sector.

Meanwhile, the relative production share that primary industries take up of the whole Hokkaido economy is on the decline, but their share is comparatively higher than the national level, exceeding double the national production output share of each year. Accordingly, primary industry associated production, ranging from food production to forage/fertilizers, agricultural chemicals and machine production, is particularly extensive and contributes considerably to the economy of Hokkaido. The Department of Agriculture in the Hokkaido Prefectural Government has estimated that the share of total employment in Hokkaido taken up by the manufacturing industry is 9%, while its shipping/transportation expenses account for 17% of the total shipping/transportation expenses of all business establishments in Hokkaido. When compared with national levels, we see that the manufacturing industry in Hokkaido is characteristically represented mainly by the food production industry (36% production share for Hokkaido and 11% for the national level). The proportions of production output taken up by agriculture related food industries such as dairy products, beet refining and starch production are particularly high. If capital-input industrial sectors such as fertilizers, forages, agricultural implements, agricultural chemicals, rice/livestock facilities are all added, the proportion is estimated to reach 50% of the total production output, playing a major role in the local economy. For this reason, Hokkaido has attempted, under its development plans, to encourage firms (from other sectors) to set up operations in Hokkaido by developing of the eastern Tomakomai area and also through industrial promotion in agricultural areas. But despite the painstaking efforts of those promoting such

schemes, advanced machinery industries including the processing/assembly industry, the general machinery industry, and the chemical industry have not become as developed as they are in prefectures outside of Hokkaido. Thus, Hokkaido still remains at the first developmental stage, where non-primary industry imports exceed primary industry exports. Therefore, primary industry in Hokkaido is particular in that it not only supplies materials produced by primary industry but also supplies materials to primary industry itself.

Table 1. Changes in Production Output Share by Industry
(Hokkaido vs. National Average) Unit:%

Major industries	1985		1990		1993		1997	
	Hokkaido	National	Hokkaido	National	Hokkaido	National	Hokkaido	National
Agriculture, forestry and fishery	6.8	3.1	5.8	2.4	4.3	2.0	3.6	1.4
Manufacturing	10.9	28.4	11.6	26.8	11.1	24.5	10.7	23.2
Construction	12.0	7.6	12.5	9.6	14.0	10.3	12.3	8.1
Wholesale/retail	15.4	12.8	14.1	12.9	13.1	12.4	13.8	13.4
Finance, insurance and real estate	13.4	14.8	13.1	16.0	13.3	16.4	14.3	15.9
Transportation/ communication	7.3	6.3	7.1	6.3	7.1	6.1	8.6	7.1
Service	15.1	13.9	18.0	14.1	19.3	16.0	19.0	17.8
Government service sector	13.1	7.9	12.6	7.2	12.7	7.4	12.5	7.8
Others	6.0	5.2	5.2	4.7	5.1	4.9	5.1	5.3

3. Formulation of the Quantitative Model

As the flow diagram of the model in Figure 1 shows, the whole system model includes six blocks focusing on the interdependence among all the economic activities. They are;

- “Primary Industry Production Block” dealing with production in primary industries
- “Pricing Block” addressing food/consumer prices including those for agricultural produces
- “Secondary Industry Production Block” and “Tertiary Industry Production Block”, describing investments and production in secondary and tertiary industries (multi-sections)
- “Prefectural Income/Final Demand Block” for the distribution structure of income and demand by residents in Hokkaido
- “Public Finance Block” for government tax revenue and government final consumption expenditure.

In the “Primary Industry Production Block” the agriculture, forestry, and fishery sectors are each formulated and aggregated, and are then linked to the “Secondary” and “Tertiary Industry Production Blocks” passing through the manufacturing and processing stages. The “Primary Industry Production Block” and the “Pricing Block” are linked by endogenous variables such as primary industry production output and food prices including those of agricultural products. Then the “Pricing Block”, both “Secondary” and “Tertiary Industry Production” blocks and the “Prefectural Income/Final Demand Block” are linked by the net prefectural product and food/consumer prices. The “Public Finance Block” is linked with the “Prefectural Income Block” by endogenous tax variables such as business taxes, municipal taxes, and indirect taxes, and also

associated with policy variables such as the formation of public capital assets and government final consumption expenditure to form the “Final Demand”. In this manner, the model overall explicitly deals with industrial interdependence, particularly with the interdependent relationship between the agricultural and non-primary industry prefectural economies. At the same time, social benefits obtained through road improvement such as convenience and improved lifestyles, the expansion of commercial areas, and benefits in daily life were also indexed, then, the cause and effect relationships between road improvement works and the economic indexes resulting from those social benefits were modeled.

4. Flow of Potential Effects

The flow of potential effects is described from two major viewpoints; 1) effects of road network improvement reflected in production/market efficiency and 2) effects reflected in living standards through convenience and lifestyle improvement[1)].

1) For effects reflected in production efficiency, transportation time reduction resulting from road network improvement would promote market expansion, promote an increase in both employment and productivity, and induce cost reduction. These factors are expected to stimulate a price-lowering effect and an income-rise effect. Then, multiplier effects from income-rise and price lowering are expected to expand economic demand.

2) As for effects reflected in living standards, travel time reduction resulting from road network improvement would enhance the supply of housing land and maintain reasonable housing land prices, increasing housing investment and also increase the supply of housing. Meanwhile, controlled consumer prices would increase the consumption level.

When these effects are viewed from the perspectives of both “flow” and “stock” in a theoretical model, the following cause and effect relationships can be suggested.

- The investment or ‘benefit’ effect (flow effect) of road improvement, bringing about direct effects on productivity, added values and employment in secondary industries such as civil engineering and the construction industry, would affect Hokkaido’s entire economy - more precisely, Hokkaido’s gross prefectural product and distribution of income, and local tax revenues. These effects are flow effects directly caused through road infrastructure improvement.
- In addition, economic effects obtained through road use after the completion of road improvement projects[2)] are recognized as indirect stock effects, which would manifest in: the growth of production and employment in the transportation-service industry caused by the increase in shipping volumes after road length extensions and time-distance coefficient

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[1)] Reductions in traveling time, traveling costs and traffic accidents are generally listed as benefits achieved through public investment in road improvement works, of which the first two items (time and cost reduction) are focused on here for this model-building. Please refer to [7] and [8] in References for detailed information about economic benefit evaluation for social group risks (catastrophes) including the reduction of traffic accidents.

[2)] •t-n of road investments in this study represents a cumulative value from the past, for which •4-term with a large contribution rate was selected as a reference year. The contribution rate was obtained through a time difference correlation between an output and a cumulative amount of a given industry.

reductions; also the stimulation of production and employment in the wholesale/retail industry due to the widening of commercial areas; and an increase in consumer demand and a lowering of prices.

- Beside the production-based improvement effects described above, public investment in road improvement works are expected to bring about multiplier effects in providing convenient land and housing sites, enhancing demand from other regions (neighborhood effect), luring new firms and creating employment opportunities.
- These effects, in turn, would become potential incentives to attract other public projects. For instance, they would stimulate factors to initialize projects for the improvement of living areas/environments, to further develop communication infrastructure and to promote local vitalization, and eventually invigorate the service sector in tertiary industries.

5. Structural Equation Estimation and Test of Goodness of Fit

The model consists of 72 simultaneous system determination equations: 55 structural equations, 12 defining equations, and 5 price deflator/adjustment functions. Estimations for the structural equations are based on the ordinary least-square method (OLS). For the solution of the model, the Gauss-Sidel method was employed. Regarding the measurement results, because of limited paper space, selected major structural equations are listed in Appendix 1.

When the structural equations were evaluated as a whole, some measurement results were not necessarily favorable in terms of the magnitude of coefficients of determination, t-values of parameters and D.W statistics, but the parametric coding conditions were theoretically appropriate in all structural equations. The theoretical model, having been checked in a test of goodness of fit with nonconformity coefficients by the ordinary Theil-U method, was generally regarded to be within an acceptable range (Table 2).

6. Simulation-based Measurements of Economic Effects of Public Investment in Road Improvement

At this stage, the multiplier analysis was conducted based on the quantitative models, which had been built earlier. Among all exogenous variables, the road improvement project cost is extracted as a strategic policy variable, which is then simulated to see what economic effects are put on the model constituent endogenous variables in the case of a 10% reduction. To obtain the economic effects, each estimated endogenous variable, when policy variables in road improvement work investment was reduced by 10%, was subtracted from the final test value. The contribution rate (%) for the final test period of 1996 and the cumulative value of contribution rates (%) for the test period are listed in Table 2.

- As a direct effect of the level of road improvement work investment, its 10% reduction in 1996 would have decreased the production output of the construction industry by 0.766%[3)]. A

[3)] With a 10% reduction of investment in road improvement works, the construction net product would have declined by 18,112 million yen in 1996 (Final test value of Construction: 2,366,031 million yen – Simulation value

cumulative effect between 1976 and 1996 shows a 13.799% decrease, adversely affecting employment rates in the construction industry (a -0.548% change for the final year and -7.194% for the overall cumulative effect), capital investment by private enterprises (-0.449% and -8.826, respectively), and total fixed capital formation in Hokkaido including non-public sectors (-0.244% and -4.815%). These negative effects including a reduction in secondary industry output (-0.582% and -14.168%), a drop in added values and a reduction in employment rates (-0.296% and -3.709%), would have had great percussions on the Hokkaido economy by adversely affecting Hokkaido's gross prefectural product and overall income, and hence a reduction in the amount of local tax revenues (-0.494% and -9.549%). The reduction in the net prefectural product (- 424 billion yen) would be equal to a 70% reduction in primary industry production output, which is Hokkaido's base industry, or equivalent to the processing costs of the food manufacturing industry.

- Regarding the stock effects after the completion of road improvement projects, it was revealed that investment in the transportation/communication industry would have declined by 13.533% in 1996 and its cumulative effect between 1976 and 1996 would have been a reduction of 569.834%. This would have brought about a production output reduction in the industry of 7.788% and 160.859% respectively, or 109.3 billion yen in monetary terms. In addition, the reduction in the level of road improvement works would have had a negative effect on time-distance coefficient reduction, keeping time-distance coefficients unchanged (5.120% and 65.194%). This would have prevented the expansion of commercial areas, reducing the number of wholesale/retail stores, private investment in commerce (-7.867% and -160.673%), and commercial production output (-5.206% and -114.452%). With these negative effects on production and employment in the transportation-service industry and in the wholesale/retail industry due to reduced commercial areas, it was proved that tertiary industry output would have reduced (-2.826% and -51.025%) which would have adversely affected Hokkaido's net prefectural product (-2.456% and -50.408%) at large. These negative effects would have led to a reduction in prefectural income (-2.165% and -42.573%) and private final consumption expenditure (-2.044% and -32.995%). In the monetary terms, it amounts to a 250.6 billion yen reduction, or about 88,000-yen reduction in consumption per worker.

Table 2 Economic Effects of Public Investment in Road Improvement Works in Hokkaido
(in the case of a 10% reduction)

Endogenous variable		Administrative investments in road improvement projects			
	(Theil-U)	Effect in the final year	Contribution rate	Total economic effect	Cumurative contribution rate
Net prefectural product	0.0511	-424,014	-2.4564%	-6,500,943	-50.4079%
Primary industry net product	0.0393	-64	-0.0106%	-765	-0.1140%
Secondary industry net product	0.1286	-30,760	-0.5821%	-458,603	-14.1679%
Tertiary industry net product	0.0332	-328,868	-2.8260%	-5,055,424	-51.0254%
Transportation/communication net product	0.0901	-109,350	-7.7876%	-1,675,270	-160.8591%

with 10% reduction: 2,347,920 million yen = 18,112 million yen, which was expressed with a contribution rate at -0.766%).

Construction net product	0.0274	-18,112	-0.7655%	-270,217	-13.7985%
Mining net product	0.0738	0	0.0000%	0	0.0000%
Fishery net product	0.0678	0	0.0000%	0	0.0000%
Manufacturing net product	0.1639	-57	-0.0025%	-647	-0.0427%
Agriculture net product	0.0627	-64	-0.0148%	-765	-0.1722%
Forestry net product	0.1158	0	0.0000%	0	0.0000%
Commercial net product	0.0763	-153,035	-5.2055%	-2,358,159	-114.4516%
Processing charge In manufacturing	0.0300	-4	-0.0010%	-52	-0.0124%
Expenditure on food and drink	0.0186	-23,920	-0.8390%	-357,919	-13.5303%
Consumption expenditure on other than food and drink	0.0446	-226,682	-2.4087%	-3,008,328	-39.9133%
Private final consumption Expenditure	0.0359	-250,609	-2.0438%	-3,366,246	-32.9947%
Government final consumption expenditure	0.0209	-13,808	-0.5262%	-211,490	-9.8488%
Gross prefectural expenditure	0.0389	-223,640	-1.1407%	-3,298,382	-21.8773%
Prefectural income	0.0619	-338,227	-2.1649%	-5,185,601	-42.5732%
Corporate income	0.1002	-80,212	-2.5260%	-1,229,793	-55.9941%
Private investment in agriculture	0.1427	-816	-0.4892%	-9,635	-5.1799%
Private investment in mining	0.1004	0	0.0000%	0	0.0000%
Private investment in commerce	0.1194	-30,265	-7.8669%	-439,245	-160.6733%
Private investment in fishery	0.1516	0	0.0000%	0	0.0000%
Private investment In manufacturing	0.1726	-10	-0.0028%	-113	-0.0395%
Private investment in forestry	0.0956	0	0.0000%	0	0.0000%
Private investment In transportation/communication	0.2246	-55,344	-13.5332%	-783,046	-569.8341%
Capital investment by private Enterprise	0.0401	-10,942	-0.4486%	-159,269	-8.8259%
Private investment in housing	0.0517	-4,703	-0.4211%	-83,378	-8.8885%
Total consumer price	0.0289	0	0.4149%	8	8.4144%
Consumer food price index	0.0252	0	0.0332%	0	0.4648%
Agricultural price index	0.0196	0	0.0719%	1	1.3251%
Total prefectural capital Formation	0.0179	-15,390	-0.2440%	-238,737	-4.8149%
Population in secondary Industries	0.0164	-2,099	-0.2964%	-25,373	-3.7085%
Population in tertiary industries	0.0186	-16,484	-0.8692%	-180,778	-10.1433%
Population in the transportation/ communication industry	0.0432	-3,282	-1.7215%	-32,400	-17.2191%
Population in the construction Industry	0.0152	-2,099	-0.5482%	-25,366	-7.1937%
Population in the mining Industry	0.0324	0	0.0000%	0	0.0000%
Total population employed	0.0179	-17,617	-0.6178%	-195,412	-7.0083%
Population in the commerce Industry	0.0112	-1,828	-0.3305%	-23,640	-4.3792%
Population in the manufacturing Industry	0.0274	-1	-0.0002%	-7	-0.0021%
Resident population in Hokkaido	0.0178	-34,529	-0.6178%	-396,914	-7.0083%
Indirect taxes (a)	0.0543	-20,071	-1.4366%	-296,032	-30.2631%
Direct taxes (b)	0.1218	-34,756	-2.2218%	-532,882	-44.0487%
Tax revenue of the prefectural government (a+b+c)	0.0215	-54,827	-0.4936%	-828,914	-9.5486%
Export from Hokkaido	0.0567	-91,249	-1.5733%	-1,399,061	-31.6254%
Import to Hokkaido	0.0632	-195,359	-2.3307%	-2,624,186	-39.3772%
Carrying capacity	0.0609	-15,802	-2.9722%	-216,556	-47.2429%
Residential site development Rate	0.0251	0	-2.0604%	-1	-43.2684%
Actual wage index (all industries : national)	0.0105	0	0.0785%	1	0.9878%
Time-distance reduction rate In the urban area	0.0330	12	5.1199%	177	65.1937%
Cultivated area (1,000ha)	0.0071	0	-0.0002%	0	-0.0016%
Population in the agriculture Industry	0.1081	5	0.0032%	59	0.0270%

- As for the effects on the agricultural industry, the distribution efficiency of agriculture products would have been impaired by reduced investment in road network development, discouraging

agricultural investment (-0.489% and -5.180%). Under these circumstances, agricultural output would have declined (-0.015% and -0.172%), lowering labor productivity but in turn raising agricultural prices (0.072% and 1.325%) due to cost increases. These increases in agricultural prices and consumer food prices (0.033% and 0.465%) would have led to a decrease in expenditure on foodstuffs (-0.893% and -13.530%). Furthermore, it was found that the rise in the consumer prices (0.415% and 8.414%) caused by the decrease in prefectural output would have also discouraged spending in areas other than foodstuffs (-2.409% and -39.913%).

- Regarding improvement of living areas/environments, road network improvement is able to provide more land suitable for housing sites. However, as the simulation results indicate, the reduction of investment in road network projects would have reduced the residential site development rate (-2.060% and -43.268%) and investment in housing construction/renovation, which then would have led to the reduction of private investment in housing (-0.421% and -8.889%) and a reduction in the supply of private housing.

7. Provisional Estimation of Economic Effects of Public Investment in Road Improvement Works

For this section, the economic effect (benefit listed in monetary units of one million yen) of each economic index, which would have been brought about through a 10% cost input in road improvement work investment, has been provisionally estimated from the investment efficiency perspective (B/C).

To obtain the economic effects, theoretical values of major endogenous variables (in the case that 10% of capital investments had been added to road improvement projects), were subtracted from the final test results, which were defined as a benefit and then divided by the input of road improvement work investment (cost) to calculate the ratio (B/C index). In this way the economic effect of each benefit brought about by investment in road construction work was calculated as the economic efficiency (Table 3).

Table 3 Results of B/C Analysis on Public Investment in Road Improvement works

Unit: million yen, index

Major economic index	Benefit	B/C Index	.Benefit	.(B/C) Index
Net prefectural product	424,014	7.1964	6,500,943	7.0358
Primary industry net product	64	0.0011	765	0.0008
Secondary industry net product	30,760	0.5221	458,603	0.4963
Tertiary industry net product	328,868	5.5816	5,055,424	5.4713
Transportation/communication net product	109,350	1.8559	1,675,270	1.8131
Construction net product	18,112	0.3074	270,217	0.2924
Manufacturing net product	57	0.0010	647	0.0007
Agriculture net product	64	0.0011	765	0.0008
Commercial net product	153,035	2.5973	2,358,159	2.5522
Processing charge in manufacturing	4	0.0001	52	0.0001
Expenditure on food and drink	23,920	0.4060	357,919	0.3874
Consumption expenditure on other than food and drink	226,682	3.8473	3,008,328	3.2558
Private final consumption expenditure	250,609	4.2534	3,366,246	3.6432

Government final consumption expenditure	13,808	0.2344	211,490	0.2289
Gross prefectural expenditure	223,640	3.7956	3,298,382	3.5697
Prefectural income	338,227	5.7404	5,185,601	5.6122
Corporate income	80,212	1.3614	1,229,793	1.3310
Private investment in agriculture	816	0.0138	9,635	0.0104
Private investment in commerce	30,265	0.5137	439,245	0.4754
Private investment in manufacturing	10	0.0002	113	0.0001
Private investment in transportation/communication	55,344	0.9393	783,046	0.8475
Capital investment by private enterprise	10,942	0.1857	159,269	0.1724
Private investment in housing	4,703	0.0798	83,378	0.0902
Total prefectural capital formation	15,390	0.2612	238,737	0.2584
Indirect taxes	20,071	0.3407	296,032	0.3204
Direct taxes	34,756	0.5899	532,882	0.5767
Tax revenue of the prefectural government	54,827	0.9305	828,914	0.8971
Export from Hokkaido	91,249	1.5487	1,399,061	1.5142
Import to Hokkaido	195,359	3.3156	2,624,186	2.8401

Note:

1} B/C Index: The investment efficiency (B/C) of the economic effects (benefits) of the various resulting economic indexes from road improvement works is calculated for each 10% of administrative investment, according to 1996 levels. The listed items are limited to the money-termed economic variables.

2} •(B/C)Index: The investment efficiency (B/C) of total economic effects (•benefit) brought about by each economic index for each 10% of administrative investment in road projects is calculated for the entire period.
10% administrative investments in road projects (1996) : 58,920 (million yen)
Cumulative 10% administrative investments in road projects (1976-1996) : 923,984 (million yen)

The results of the estimation revealed that public investment in road improvement projects would have brought about a 1.86 time greater capital investment efficiency in transportation/communication production output and a 2.6 time greater investment efficiency in commercial production output due to the expansion of commercial areas. As a consequence, the investment efficiencies in tertiary industry production output and the gross prefectural product would have expanded as high as 5.59 times and 7.2 times respectively. From the distribution perspective as well, prefectural income and private final consumption expenditure would have enjoyed a 5.7 time and a 4.3 time increase in capital investment efficiency, respectively.

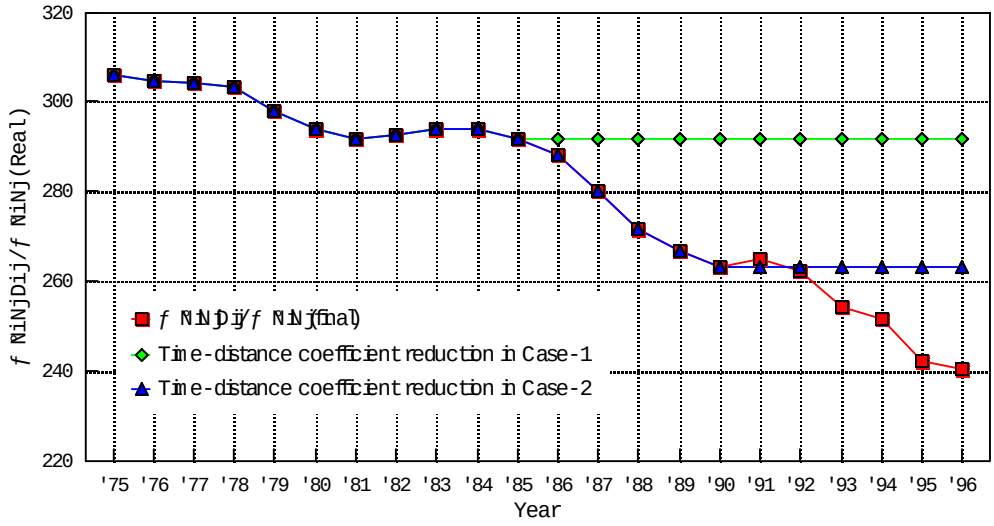
One special point was that while the investment efficiency for exports from Hokkaido was estimated to expand 1.55 times, that for imports to Hokkaido was to expand 3.32 times – twice as much as the increase in the investment efficiency rate for exports. When the B/C analysis results on cumulative road works investment are examined, similar trends in economic efficiencies are observed.

From the above outcomes, it was clarified that public investment in road improvement works would bring about pronounced increases in economic efficiencies in tertiary industries, in particular the transportation-service and wholesale/retail sectors, and that the prefectural production output on the whole would expand 7 times. Furthermore, although an effect by public investment in road works on the level of exports of raw materials from Hokkaido was noticed, it was clearly exceeded by the effect on imports from outside of Hokkaido.

8. Provisional Estimation of Network Effects brought by Express-Highway Improvement

In this section, the network effects brought by express-highway improvement will be estimated from the perspective of time-distance coefficient reduction. More specifically, to clarify the economic efficiency brought onto Hokkaido's entire economy with the advancement of the express-highway network, a simulation analysis will be carried out based on two scenarios. (Figure 2 and Table 4)

Figure 2 Senarios of Network Effects



Note) Regarding indexes for time-distance coefficients, the interregional time-distance coefficient (OD table) was weighted by population. The prefectural time-distance coefficient can be defined as follows, if the interregional time-distance rate is d_{ij} and the population in the region is N_i.

$$D \equiv \frac{\sum_{i \neq j} N_i N_j d_{ij}}{\sum_{i \neq j} N_i N_j} \quad \cdots\cdots(1)$$

As for the value of D, which is obtained through weighting the interregional time-distance coefficient with the population, the projected size of population is required for each region to estimate the future trend. However, since this study deals with post-analysis, the latest population rates were used.

Case-1: When time-distance coefficients for the actually used road sections and their time periods are examined, those for the years since 1985 are significantly reduced. This time period, corresponding to the time when a project to develop an express-highway between Sapporo and Asahikawa was completed, was used as a case where the network between the Sapporo metropolitan region and the Asahikawa area was consolidated. In Case-1, therefore, the simulation will be conducted with the time-distance coefficients since 1985 kept constant, and the economic effects will be derived from the resulting differences.

Case-2: The reduction in the time-distance coefficients has been further accelerated since 1990.

During this period, on top of a facilitated access to express-highways from the Sapporo urban district, urban bypasses were further developed, promoting the Sapporo metropolitan network as an access hub for the Otaru, Chitose/Tomakomai and Asahikawa areas. In Case-2, therefore, the simulation will be conducted with the time-distance coefficients after 1990 kept constant, and the economic effects will be derived from the resulting differences.

1) Provisional estimation for Case-1

In Case-1 where the assumption was that the express-highway to Asahikawa had not been improved since 1985 and hence there were unchanged time-distance coefficients, direct influences from the absence of road work investment would have appeared in the form of decreases in construction industry production output (a -2.982% effect for the final period and a -20.56% cumulative effect), its employment rates (-1.499% and -7.328%) and capital investment by private enterprises (-1.773% and -10.743%), and would further lead to a significant decline in the total prefectural fixed capital formation (-1.021% and -6.368%) including that from non-public sectors. When these negative effects are converted into monetary terms, we see that losses of the net construction product and the total prefectural fixed capital formation would have been 70.5 billion yen and 64.4 billion yen respectively. These negative effects, reducing secondary industry production output (-2.266% and -19.464%), lowering added values, and reducing employment rates (-0.81% and -3.858%), would have had great percussions on the Hokkaido economy by adversely affecting Hokkaido's gross prefectural product and its income distribution, and hence causing a reduction local tax revenues (-2.015% and -13.499%).

As for the stock effects, transportation/communication related investments would have declined (-55.725% and -422.861%). As a consequence, the industrial production output would have diminished by 33.611% and 238.885%. This loss is equivalent to 471.9 billion yen, corresponding to nearly 80% of the primary industry net product, which is Hokkaido's base industry. Because the absence of road improvement would have kept the time-distance coefficients unchanged, commercial area expansion would have been prevented, reducing wholesale/retail investments (-32.225% and -223.325%) and hence a decline in commercial production output (-21.639% and -143.724%). Due to these negative effects, tertiary industry output would have declined (-11.935% and -77.207%), leading to a significant decrease in the net prefectural product as a whole (-10.304% and -72.843%)[4]. It was shown that these negative effects would have led to a reduction in prefectural income (-9.082% and -62.913%) and private final consumption expenditure (-6.577% and -36.728%).

As for the effects on the agricultural industry, the distribution efficiency of agricultural products would have been impaired by the absence of road improvement, which would keep the time distance coefficients unchanged, discouraging agricultural investment (-1.897% and -9.487%). Under these circumstances, agricultural output would have declined (-0.058% and -0.292%),

[4] When these negative effects are converted into monetary terms, the tertiary industry net product and the net prefectural product would have lost 1,388.9 billion yen and 1,778.7 billion yen respectively. The amount combined parallels the total corporate income in Hokkaido.

lowering labor productivity but in turn raising agricultural prices (0.288% and 1.762%) due to cost increases. These increases in agricultural prices and consumer food prices (0.073% and 0.347%) would have led to a decrease in expenditure on foodstuffs (-2.737% and -15.193%). Furthermore, it was found that the rise in consumer prices (1.779% and 12.365%) triggered by the decrease in prefectural production output might also have discouraged spending in other market areas as well (-7.74% and -43.688%).

As for the effects on living areas/environments, the lack of reduction in time-distance coefficients due to the absence of public investment in road network improvement projects would have reduced both the residential site development rate (-9.926% and -59.956%) and also investment in housing construction/renovation, which would have caused the supply of private housing to shrink (-1.99% and -12.82%).

2) Provisional estimation for Case-2

In Case-2 where the assumption was that the Sapporo metropolitan road network had not been improved since 1990 and hence there was no change in time-distance coefficients, direct influences would have appeared in the form of reductions in construction industry production output (-1.167% and -3.215%), its employment rates (-0.287% and -0.482%) and capital investment by private enterprises (-0.63% and -1.202%), and would have further led to a decrease in the total prefectural fixed capital formation (-0.371% and -0.731%). These negative effects which would have reduced secondary industry production output (-0.886% and -2.639%), lowered added values and reduced employment rates (-0.155% and -0.26%), would have had great percussions on the Hokkaido economy by adversely affecting Hokkaido's gross prefectural product and income distribution and hence reduction in local tax revenues (-0.777% and -2.01%). Although these negative effects are not as great as those in Case-1, their detrimental effects still proved to be influential.

As for the stock effects, due to the reduction in transportation/communication related investment (-23.689% and -49.306%), industrial production output would have diminished by 14.314% and 40.863%. This loss is equivalent to 200.9 billion yen, corresponding to nearly half of the agricultural net product, which is Hokkaido's base industry. Because the absence of road improvement would have kept the time-distance coefficients unchanged, the expansion of commercial areas would have been prevented, reducing wholesale/retail investments (-13.455% and -36.647%), and hence causing a decline in commercial production output (-8.254% and -20.162%). Due to these negative effects, tertiary industry production output would have also been reduced (-4.778% and -12.347%), leading to a significant decrease in the net prefectural product as a whole (-4.118% and -11.004%)[5)]. It was revealed that these negative effects would have led to a reduction in prefectural income (-3.629% and -9.636%) and private final consumption expenditure (-1.684% and -3.577%). Although these negative effects are not as

[5)] In monetary terms, the tertiary industry net product and the net prefectural product would have lost 556 billion yen and 710.7 billion yen respectively. The amount combined equals a value half the size of the total government final consumption expenditure.

great as those in Case-1, they were all shown to bring about significant detrimental effects.

As for effects on agricultural prices and consumer prices, the distribution efficiency of agricultural products would have been impaired by the absence of road improvement which would have kept the time distance coefficients unchanged, raising agricultural prices (0.099% and 0.193%), although only slightly. These increases in agricultural prices and consumer food prices (0.01% and 0.017%) might have led, even slightly, to a decrease in expenditure on foodstuffs (-0.69% and -1.464%). Furthermore, it was found that the rise in the consumer prices (0.679% and 1.81%) triggered by the decrease in the prefectural production output could have discouraged spending in other market areas as well (-1.984% and -4.229%).

As for the effects on living areas/environments, the absence of investment in road network improvement projects, causing time-distance coefficients to remain unchanged, would have reduced the residential site development rate (-3.749% and -7.478%) and investment for housing construction/renovation, which would have reduced the supply of private housing (-0.757% and -1.678%).

As has been shown above, both cases have revealed that the effects of express-highway networks on Hokkaido's entire economy should be significant. Among all, effects on investment and production output in the transportation/communication industry as well as on the commercial production output in the wholesale/retail industry were shown to be significant.

Table 4 Two Cases (Scenarios) of Network Effects materialized by Road Improvement

Endogenous variable	Case-1		Case-2	
	Contribution rate of 1996 effects	Contribution rate of cumulative effects	Contribution rate of 1996 effects	Contribution rate of cumulative effects
Net prefectural product	-10.3044%	-72.8428%	-4.1178%	-11.0042%
Primary industry net product	-0.0413%	-0.2011%	-0.0179%	-0.0345%
Secondary industry net product	-2.2664%	-19.4644%	-0.8860%	-2.6387%
Tertiary industry net product	-11.9347%	-77.2071%	-4.7782%	-12.3469%
Transportation/communication net product	-33.6105%	-238.8845%	-14.3138%	-40.8634%
Construction net product	-2.9817%	-20.5590%	-1.1667%	-3.2154%
Mining net product	0.0000%	0.0000%	0.0000%	0.0000%
Fishery net product	0.0000%	0.0000%	0.0000%	0.0000%
Manufacturing net product	-0.0083%	-0.0526%	-0.0021%	-0.0035%
Agriculture net product	-0.0576%	-0.2915%	-0.0250%	-0.0480%
Forestry net product	0.0000%	0.0000%	0.0000%	0.0000%
Commercial net product	-21.6390%	-143.7239%	-8.2540%	-20.1615%
Processing charge in manufacturing	-0.0037%	-0.0197%	-0.0014%	-0.0026%
Expenditure on food and drink	-2.7370%	-15.1925%	-0.6904%	-1.4642%
Consumption expenditure on other than food and drink	-7.7404%	-43.6876%	-1.9854%	-4.2289%
Private final consumption expenditure	-6.5771%	-36.7284%	-1.6843%	-3.5766%
Government final consumption Expenditure	-2.2030%	-14.6714%	-0.8781%	-2.2932%
Gross prefectural expenditure	-4.4329%	-28.9611%	-1.5905%	-3.9396%
Prefectural income	-9.0815%	-62.9126%	-3.6291%	-9.6362%
Corporate income	-10.5963%	-81.4661%	-4.2345%	-11.7318%
Private investment in agriculture	-1.8968%	-9.4867%	-0.8114%	-1.6070%
Private investment in mining	0.0000%	0.0000%	0.0000%	0.0000%
Private investment in commerce	-32.2253%	-223.3245%	-13.4453%	-36.6470%
Private investment in fishery	0.0000%	0.0000%	0.0000%	0.0000%
Private investment in manufacturing	-0.0086%	-0.0477%	-0.0016%	-0.0023%
Private investment in forestry	0.0000%	0.0000%	0.0000%	0.0000%
Private investment	-55.7251%	-422.8613%	-23.6897%	-49.3056%

in transportation/communication				
Capital investment by private enterprise	-1.7732%	-10.7431%	-0.6301%	-1.2023%
Private investment in housing	-1.9898%	-12.8192%	-0.7573%	-1.6783%
Total consumer price	1.7785%	12.3648%	0.6793%	1.8100%
Consumer food price index	0.0727%	0.3465%	0.0104%	0.0171%
Agricultural price index	0.2881%	1.7623%	0.0996%	0.1927%
Total prefectural capital formation	-1.0214%	-6.3675%	-0.3717%	-0.7309%
Population in secondary industries	-0.8101%	-3.8576%	-0.1550%	-0.2595%
Population in tertiary industries	-1.7388%	-7.3924%	-0.2024%	-0.2985%
Population in the transportation/ Communication industry	-2.6901%	-10.0565%	-0.1778%	-0.2170%
Population in the construction industry	-1.4984%	-7.3276%	-0.2868%	-0.4824%
Population in the mining industry	0.0000%	0.0000%	0.0000%	0.0000%
Total population employed	-1.2867%	-5.4727%	-0.1640%	-0.2484%
Population in the commerce industry	-0.9208%	-4.2566%	-0.1538%	-0.2416%
Population in the manufacturing industry	-0.0005%	-0.0017%	0.0000%	0.0000%
Resident population in Hokkaido	-1.2867%	-5.4727%	-0.1640%	-0.2484%
Indirect taxes (a)	-5.5830%	-37.8407%	-2.0031%	-5.0074%
Direct taxes (b)	-9.3205%	-64.8205%	-3.7247%	-9.9022%
Tax revenue of the prefectural government (a+b+c)	-2.0149%	-13.4994%	-0.7765%	-2.0080%
Export from Hokkaido	-6.6000%	-45.3151%	-2.6375%	-6.9932%
Import to Hokkaido	-7.5005%	-42.5488%	-1.9208%	-4.0987%
Carrying capacity	-10.5385%	-60.4792%	-3.1343%	-5.9057%
Residential site development rate	-9.9255%	-59.9559%	-3.7489%	-7.4783%
Actual wage index (all industries : national)	0.1701%	0.8639%	0.0296%	0.0607%
Time-distance reduction rate in the urban area	21.4522%	127.2025%	9.5895%	26.3686%
Cultivated area (1,000ha)	-0.0004%	-0.0015%	0.0000%	0.0000%
Population in the agriculture industry	0.0113%	0.0451%	0.0031%	0.0046%

9. Further issues to be addressed

The objectives of this study were to develop an effective simulator to analyze what effects are brought about by public investment in road improvement works on Hokkaido's entire economic structure including its industrial economy, prefectural income, household consumption, and commodity prices, and to identify the actual economic effects brought about by investment in road improvement projects. Our efforts were particularly devoted to the construction of a model that takes into consideration as many of the following effects as possible:

- Direct effects from the use of improved roads, including reductions in time-distance coefficients, reductions in transportation/shipping costs, and market expansion
- Indirect effects such as enhanced convenience and lifestyle improvement
- Multiple effects which have active effects on other public projects and living areas/environments.

We consider the model has performed quite satisfactorily. However, in the specification and estimation processes, there are still several problems which need to be addressed.

- If the flow of roadwork investment effects is considered from an inter-industrial business aspect, the industrial sectors need to be classified more precisely. In this model we attempted to classify as many industrial sectors as possible into eight different categories. However, as seen in the formulation for the forestry and fishery industries, there were some sectors to which only an autoregressive model was applied, depending on the availability of economic statistic data. For the mining industry as well, its influence on other industrial sectors could not be fully illustrated. These, admittedly, are minor setbacks. Even if the inter-industrial business relationship for intermediate goods is supplemented with data estimated on the basis of input

coefficients in the inter-industry-relations table, changes in the industrial structure cannot be traced if a measurement time period is long. Therefore, data availability is a problem to be addressed in the future.

- How time-reduction effects due to road network improvement should be indexed and linked to macro-variables is another important issue. It is somewhat like an integration of micro-indexes such as reduced inter-regional time and distance into a macro-econometric model. In our study, the formulation of time-distance reduction indexes was also kept in mind (e.g. introduction of potential indexes for logistic accessibility, time reduction costs, and time values[6]). In this model, the time-distance reduction index is expressed by •NiNjDij/•niNj, where d_{ij} is an inter-regional time-distance coefficient and N_i is a local population. We consider the formulation has performed quite satisfactorily. For future research, a more advanced formulation needs to be developed which can better illustrate the effects, dealing with inner areas, outer areas and overall wide areas.
- Since public investment in road improvement projects potentially has a direct effect on other areas of government expenditure, a model needs to be developed which deals with not only the effects brought about by a single road improvement project but also the multiplier effects (inducing or interactive effects) on other public projects.
- To address non-econometric values or qualitative data about lifestyle improvement and convenience and to objectively evaluate their effects, and also to address qualitative changes in certain environments that are generally regarded as effects outside of the transportation market[7], the formulation of indexes for environmental factors will be required and their interdependence with economic activities needs to be identified for future studies.

Briefly listed above are some problems that could not be resolved in this model. Nonetheless, its stable analytical performance covering as long as a 21-year time period has validated the feasibility of simulators of this type. Therefore, we will further develop the model and conduct further simulation analyses under several possible scenarios.

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6) As for logistic accessibility indexes for items being sent to places within/outside of Hokkaido, those of a potential type were considered, for which, each variable was multiplied by the inhabitable land area of a given place and divided by the minimum value of general transportation costs. Please refer to [13] in References for more details.

7) Changes in living area/environmental standards and the reduction of traffic congestion resulting from the selection of alternative routes or transportation modes are regarded as external effects in some cases. However, they are user benefits in a broad sense so they need to be treated as effects within the market.

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Figure 1. Flow Diagram of Model