Proceedings of the Eastern Asia Society for Transportation Studies, Vol. 5, pp. 2123 - 2135, 2005

MACRO-ECONOMETRIC MODEL BASED SIMULATION ANALYSIS OF ROAD NETWORK EFFECT

Tatsuhide ITO
Engineering Deputy Manageer
Docon Co., Ltd.
1-5-4-1, Atsubetsu-chouo, Atsubetsu-ku, Sapporo,
004-8585 Japan
Fax:+81-11-801-1556
E-mail:ti840@docon.jp

Kiyoshi TAKAHASHI
Associate Professor
Dept. of Civil Engineering
Kitami Institute of Technology
165, Koen-cho, Kitami
090-8507 Japan
Fax:+81-157-26-9502
E-mail:kiyoshi@mail.kitami-it.ac.jp

Hiroki KATAGIRI
Docon Co., Ltd.
1-5-4-1, Atsubetsu-chouo, Atsubetsu-ku, Sapporo,
004-8585 Japan
Fax:+81-11-801-1556
E-mail:hk1240@docon.jp

Abstract : This study is an attempt to develop a new model to clarify the effectiveness of investments on distribution cost, on the basis of the simulator (macro econometric model) capable of analyzing the comprehensive effects brought about by investments in road network improvement projects.At first, the effect on production efficiency: Time savings achieved by improvements to the road network can be assumed to be associated with the expansion in the market, employment and productivity as well as with cost reduction. These items are then linked to price reduction and income increase, and eventually economic demand is expected to boost. Secondly the effect on living standards: Time savings achieved by improvements to the road network can be assumed to be associated with the rise in the housing land development rate and the proper pricing of residential land. These items are then linked to the expansion of housing investment and housing supply.

Key Words Macro-Econometric Model, Regional Economy, Road Network Effect

1. STUDY OBJECTIVES

Various social infrastructure projects have been undertaken aimed at equilibrating development of national land and rectifying regional economic gaps. Of these projects, considerable importance has been laid upon capital investments in road improvement projects. Yet, to what extent have they actually contributed to regional economies? Focusing on expressway improvement projects in Hokkaido, Japan, this study clarifies the effects of investments in expressway improvement projects on Hokkaido's entire economic structure including industrial outputs, prefectural income, household consumption and commodity prices through a simulation analysis based on a macro-econometric model. More specifically, our goal is to construct a model which takes multi-faceted effects into account and to evaluate them quantitatively. Those effects include both direct and indirect effects achieved through the use of improved expressways (e.g. shortened time-distance, reduction of transportation costs, market expansion, enhancement of comfortableness and convenience) and also influences on other public projects which possibly improve living area environments and promote regional vitalization. Taking data availability into consideration, this study covers a 22-year analysis period from the year 1975 thorough the end of 1996.

2. FLOW OF POTENTIAL EFFECTS RELATED TO THE FORMULATION OF THE ECONOMETRIC MODEL

The whole structure of the model consists of six blocs focusing on the interdependence among all the economic activities to fully depict Hokkaido's economic attributes (Figure 1). These blocs are:

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

Details of the inter-bloc relationship are omitted here due to space limitations. But, the model overall explicitly deals with industrial interdependence, particularly with the interdependent relationship (e.g. investment and production) between agriculture, non-agriculture and public economies. At the same time social benefits obtained through expressway improvement such as comfortableness and convenience, expansion of commercial areas and improved amenities are also indexed, implicitly though. Then the cause and effect relationships between road improvement works and the economic indexes resulting from those social benefits are modeled. In identifying mobility effects in terms of time-distance and economic-distance, economic-distance indexes including interregional travel costs and expressway tolls are introduced to our earlier econometric model. Therefore the new model is characterized by the formulation of spatial elements.

The flow of potential effects is described from two major viewpoints; 1) effects of expressway improvement reflected in production/market efficiency and 2) effects reflected in living standards through convenience and lifestyle improvement. These effects are evaluated from the perspectives of both "flow" and "stock" in a theoretical model.

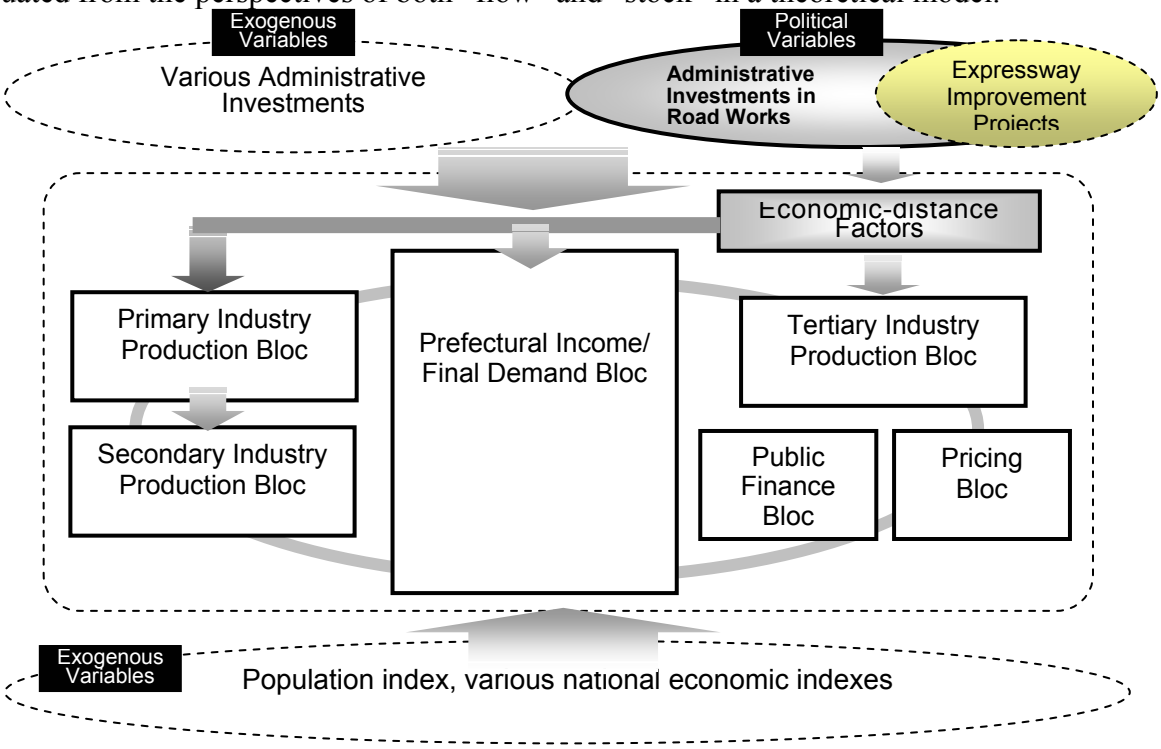

Figure 1 Conceptual flow of Hokkaido macro-econometric model

3. METHOD TO MEASURE ECONOMIC-DISTANCE INDEXES

The economic-distance considered in this study is an index which does not simply deal with the time reduction effect but also incorporates travel costs. As Equation (1) defines, the economic-distance can be formulated with variables necessary to move a car between municipalities *i* and *j*, including fuel cost, expressway tolls and time cost.

More specifically, a shortest-time route is first sought for between the municipalities *i* and *j*, and its road distance (*Lij*), distance of expressway section traveled (*Hij*) and time distance (*Tij*) are obtained, which are then multiplied by such factors as fuel cost, fuel efficiency, expressway toll and time value. This suggests that the introduction of an expressway reduces the time-cost due to shortened travel time in comparison with a case where no expressway is introduced even though an expressway toll is added.

Economic-distance $Rij = G/M \times Lij + T' \times Tij + Hij \times Cij$ ……(1)

Rij: Economic-distance (yen)
G: Fuel cost (yen/*l*)
M: Fuel efficiency (km/*l*)
Lij: Road distance (km)
T': Time value (yen/minute)
Tij: Time distance (minute)
Hij: Distance of expressway section traveled (km)
Cij: Expressway toll（yen）
＝Section/mileage rate＋Terminal charge

The economic-distance index can be expressed by Equation (2), where the economic-distance matrix between the municipalities *i* and *j* (*Rij*) derived from Equation (1) is weighted by population from the census data of the most proximate year.

Economic-distance index $D = \Sigma(NiNjRij/NiNj)$ ……(2)

D: Economic-distance index
Rij: General cost (travel cost (yen))
Ni,Nj: Population (persons)

To arrange 7-point cross-section indexes for the years 1975, 1980, 1985, 1990, 1995, 1999 and 2002 time-serially while formulating the economic-distance index, data for missing years are estimated in the proportionally complemented manner, by tracing trends of economic-distance indexes between the points. For the long-term future analysis up until 2020, population will be projected through the cohort method. In addition, future network systems are assumed under three schemes: 1) a fully completed 9,342km nationwide expressway system; 2) a 9,342km nationwide expressway system with some sections remaining uncompleted; and 3) a fully completed 14,000km nationwide expressway system.

4. 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 Gausss-Sidel method is employed. Because of limited paper space, the measurement results are omitted. So please see References [1] and [15] for more details. The structural model, having been tested for goodness of fit with nonconformity coefficients by the ordinary Theil-U method, was generally regarded to be within an acceptable range.

5. SIMULATION ANALYSIS OF NETWORK EFFECTS

(1)Hypotheses of three scenarios

Hypotheses under the following three scenarios are suggested and simulated to evaluate

network effects after the completion of expressways.

Table 1 Three scenarios

Classification		Content
Short-term prediction analysis	Scenario 1	A target year is set at 2002. Economic losses are estimated for the case where no additional investments had been made in expressway projects from 1985. (post-analysis)
Long-term future prediction analysis	Scenario 2	A target year is set at 2020. Economic losses are estimated for the case where specific sections would have remained uncompleted in the 9,342km nationwide expressway system. [Uncompleted sections] Hokkaido Jukan Expressway System: Kunnui-Nanae and Wassamu-Nayoro Hokkaido Odan Expressway System: Yoichi-OtaruJCT, Yubari-Tokachishimizu, Ikeda-Kitamiminami, Memanbetsu-Abashiri and HonbetsuJCT-Kushiro
	Scenario 3	A target year is set at 2020. Benefits of the fully completed 14,000km nationwide expressway system are estimated and compared with the 9,342km system.

(2) Formulation of exogenous variables and political variables

The following table indicates both exogenous and political variables used in Scenarios 1 to 3 and the way data for missing years is calculated.

Table 2 Exogenous variables and political variables in each scenario

Exogenous/Political variables	Scenario setting	Time period	Value			Remarks
			1999	2003	2020	
Net production of other/civil service sectors	1.0109487	1990-	2,374,185	2,479,882	2,984,187	5 year average growth rate (before 1998)
GDP	1.0161058	1990-	526,707	561,467	736,693	5 year average growth rate (before 1998)
Gross domestic expenditure	1.0161058	1990-	512,935	547,111	717,856	5 year average growth rate (before 1998)
Administrative investment in fishery ports	CONSTANT	1990-	88,909	88,909	88,909	Constant from 1999
Administrative investment in living infrastructures	CONSTANT	1990-	292,407	292,407	292,407	Constant from 1999
Administrative investment in production infrastructures	CONSTANT	1990-	1,038,564	1,038,564	1,038,564	Constant from 1999
Administrative investment in forest roads	CONSTANT	1990-	73,956	73,956	73,956	Constant from 1999
Livestock product price index	CONSTANT	1990-	100.1	100.1	100.1	Constant from 1999
Rice price index	CONSTANT	1990-	98.3	98.3	98.3	Constant from 1999
Public fixed capital formation	CONSTANT	1990-	2,937,362	2,937,362	2,937,362	Constant from 1999
Employment in other/civil service sectors	1.0102982	1990-	407,229	424,265	504,987	5 year average growth rate (before 1998)
Population density	CONSTANT	1990-	68.3	68.3	68.3	Constant from 1999
Hokkaido's local allocation tax + Others	1.0268704	1990-	8,606,098	9,569,050	15,018,778	5 year average growth rate (before 1998)
Rate of sustainers	CONSTANT	1990-	1.96	1.96	1.96	Constant from 1999
Imputed interest	1.0368942	1990-	443,550	512,720	949,218	5 year average growth rate (before 1998)
Bank rate	CONSTANT	1990-	0.50	0.50	0.50	Constant from 1999
Area of private forests	CONSTANT	1990-	2,378	2,378	2,378	Constant from 1999
Number of ships registered	CONSTANT	1990-	31,469	31,469	31,469	Constant from 1999
Investment in agricultural infrastructures	CONSTANT	1990-	280,175	280,175	280,175	Constant from 1999
Demand factor outside of Hokkaido	CONSTANT	1990-	0.500	0.500	0.500	Constant from 1999
Administrative investment in road improvement works (flow)	Rate for Case1-6	2003-	661,434	724,220	1,095,053	Rate depending on Scenario Case
Investment in road improvement works Σ4t	Rate for Case1-6	2003-	2,689,502	2,944,801	4,452,671	Rate depending on Scenario Case
Rate of change for Case-1	Rate for Case 4	2003-	1.000	1.044	2.310	Fully completed 9,342km nationwide expressway system
Rate of change for Case-2	Rate for Case 5	2003-	1.000	1.028	1.682	Improved 9,342km nationwide expressway system (including specific uncompleted sections)
Rate of change for Case-3	Rate for Case 6	2003-	1.000	1.093	6.306	Fully completed 14,000km nationwide expressway system

(3) Estimation of economic-distance indexes

The simulation results of the economic-distance indexes used in the short-term prediction (Scenario 1) are shown in the following diagram. "Improvement level: ΣniNjRij/ΣniNj" in the legend stands for the real value of the economic-distance index while "Improvement level: Final-test" is a final test value obtained through the econometric model or a simulation

reference value. "Constant from 1985: Final-test" describes the yearly change of the economic-distance index used in analyzing Scenario 1 which will be explained later.

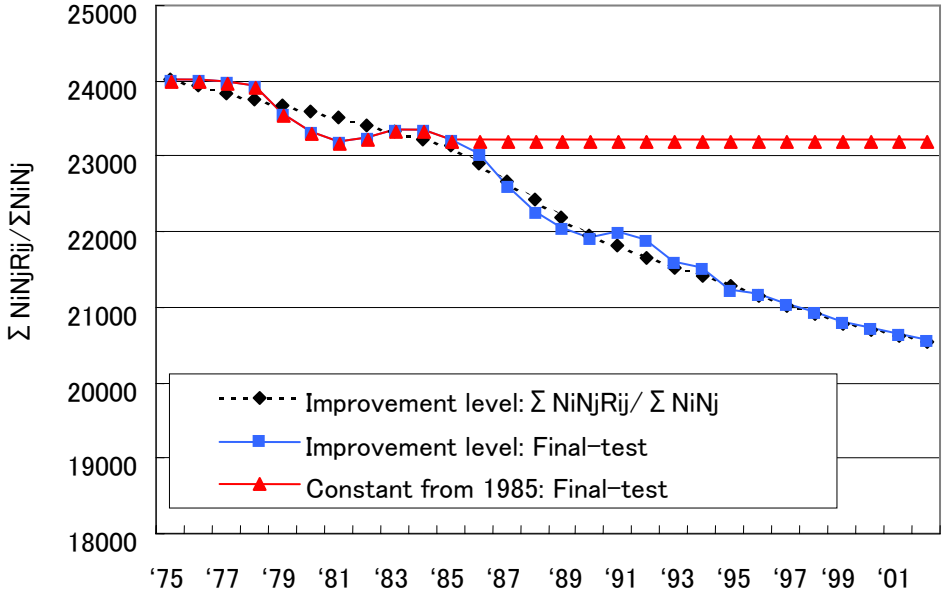

Figure 2 Yearly change of the economic-distance indexes used in analyzing Scenario 1

(4) Analysis of effects of improved expressway network systems

1) Result of short-term prediction analysis (Scenario 1)

In this scenario, a simulation is carried out on the assumption that no additional investments had been made in expressway projects from 1985 and the situation had remained unchanged thereafter. The evaluation results of major economic variables are shown in Table 3 (see Table 3-1 for more details). The figures indicate economic losses in the case where some sections in the Asahikawa area and the southern Hokkaido area had remained unimproved from 1985 up to 2002. The findings are summarized as follows.

Table 3 Economic losses in the case where no additional investments had been made in expressway projects from 1985

Major index	Economic effect	Contribution rate
Net prefectural product	△2,545.1 billion yen	△14.19%
Gross prefectural expenditure	△1,305.2 billion yen	△6.15%
Total prefectural capital formation	△92.7 billion yen	△1.37%
Total population employed	△78,000 persons	△2.52%
Hokkaido's total tax revenue	△325.8 billion yen	△2.61%

① Direct damages (flow effects) inflicted by this situation would have included substantial reductions in various areas such as employment in the construction industry, capital investments by private firms, Hokkaido's total fixed capital formation and construction and civil engineering outputs. These reductions would have induced other negative effects on items such as outputs, added values and employment in secondary industries, which would have further affected Hokkaido's whole economy by lowering the gross prefectural product and prefectural income. As a consequence, local taxes would have decreased by 325.8 billion yen.

② Regarding stock effects from incomplete expressways, because of the great reduction in investments in transportation and communication facilities, the output of related industries would have declined by 707.2 billion yen. The lack of expressway advancement, hindering any shortening of time-distance, would have prevented the expansion of commercial area, decreased the number of wholesalers and retailers, discouraged private investments in commerce, and reduced commerce outputs. Such negative effects on the

output and employment in the service industry (a reduction of 78,000 workers from the total number of employed) would apparently have caused tertiary industry output to plummet which eventually would have caused a 2,545.1 billion reduction of prefecture net product.

③ The agricultural sector would also have been adversely affected. The impaired distribution efficiency of agricultural products would have discouraged agricultural investments, decreasing agricultural output and labor productivity while increasing agricultural costs, which would have heightened agricultural prices. Such rises in agricultural prices and consumer food prices would have been associated with a reduction of expenditure on food and drink.

④ Negative effects of deterred expressway advancement on living area environments would have been seen in a lower residential site development rate and a reduced level of investments in residential additions and betterments, which then link to a reduction of private investments in housing construction and housing supply.

Table 3-1 Economic losses in the case where no additional investments had been made in expressway network systems from 1985

Major endogenous variable	Theil-U	Effect in the final year	Contribution rate of effect	Total economic effect	Cumulative contribution rate
Net prefectural product	0.0500	-2,545,067	-14.194%	-24,656,488	-152.566%
Primary industry net product	0.0393	-404	-0.055%	-4,035	-0.589%
Secondary industry net product	0.1269	-166,983	-3.525%	-1,582,684	-37.346%
Tertiary industry net product	0.0198	-1,991,610	-15.777%	-19,329,540	-166.200%
Transportation/communication net product	0.0528	-707,216	-41.673%	-6,752,247	-471.507%
Construction net product	0.0264	-97,513	-3.753%	-924,857	-39.650%
Mining net product	0.1672	-743	-2.240%	-6,623	-15.893%
Manufacturing net product	0.1639	-369	-0.022%	-3,297	-0.189%
Agriculture net product	0.0627	-404	-0.085%	-4,035	-0.873%
Commerce net product	0.0437	-881,773	-26.721%	-8,669,669	-301.714%
Expenditure on food and drink	0.0168	-126,588	-4.268%	-1,081,754	-37.854%
Private final consumption expenditure	0.0281	-1,370,634	-10.140%	-11,211,221	-90.794%
Government final consumption expenditure	0.0196	-82,820	-2.887%	-801,290	-31.179%
Gross prefectural expenditure	0.0359	-1,305,150	-6.151%	-12,009,393	-63.091%
Prefectural income	0.0550	-2,030,121	-12.565%	-19,667,719	-133.206%
Corporate income	0.0935	-481,454	-14.983%	-4,664,305	-168.004%
Private investment in agriculture	0.1431	-5,135	-2.922%	-51,039	-29.626%
Private investment in mining	0.1437	-466	-2.557%	-4,155	-18.870%
Private investment in commerce	0.0741	-164,547	-38.747%	-1,736,592	-466.877%
Private investment in manufacturing	0.1726	-67	-0.020%	-569	-0.171%
Private investment in transportation/communication	0.1541	-325,708	-63.697%	-2,953,005	-785.706%
Capital investment by private enterprise	0.0395	-63,977	-2.288%	-579,514	-23.535%
Private investment in housing	0.0515	-30,236	-2.906%	-290,586	-28.500%
Total consumer price	0.0279	2	2.527%	26	26.424%
Consumer food price index	0.0252	0	0.131%	1	1.014%
Agricultural price index	0.0197	0	0.409%	4	4.019%
Total prefectural capital formation	0.0176	-92,695	-1.368%	-856,082	-13.882%
Population in secondary industries	0.0166	-9,723	-1.283%	-73,758	-10.249%
Population in tertiary industries	0.0167	-72,298	-3.552%	-479,401	-24.746%
Population in transportation/ communication industry	0.0445	-12,986	-6.280%	-76,248	-38.584%
Population in construction industry	0.0144	-9,686	-2.230%	-73,535	-18.640%
Total population employed	0.0175	-77,740	-2.517%	-524,208	-17.747%
Resident population in Hokkaido	0.0177	-152,370	-2.517%	-1,031,678	-17.747%
Hokkaido's total tax revenue	0.0204	-325,757	-2.610%	-3,098,944	-28.479%
Export from Hokkaido	0.0529	-547,721	-8.944%	-5,306,298	-95.704%
Import to Hokkaido	0.0577	-1,068,489	-11.356%	-8,739,802	-103.488%
Carrying capacity	0.0557	-91,428	-14.839%	-755,958	-139.294%
Time-distance reduction rate in urban area	0.0061	2,639	12.821%	28,585	134.634%

Note: a simulation on the assumption that no additional road investments had been made from 1985（effects of the final year 2002）

2) Result of long-term future prediction analysis (Scenarios 2 and 3)

The simulation results of the economic-distance indexes for Scenarios 2 and 3 are shown in the following diagram. "CASE-1" in the legend presents the yearly change of economic-distance index up to 2020 for the 9,342km nationwide expressway network improvement plan while "CASE-2" shows the situation where some specific sections remain incomplete in the 9,342km total expressway network system. "CESA-3" depicts the yearly change of economic-distance index up to 2020 assuming the completion of the 14,000km national expressway network system improvement plan.

a. Scenario 2: specific sections in the 9,342km expressway network system remain incomplete.

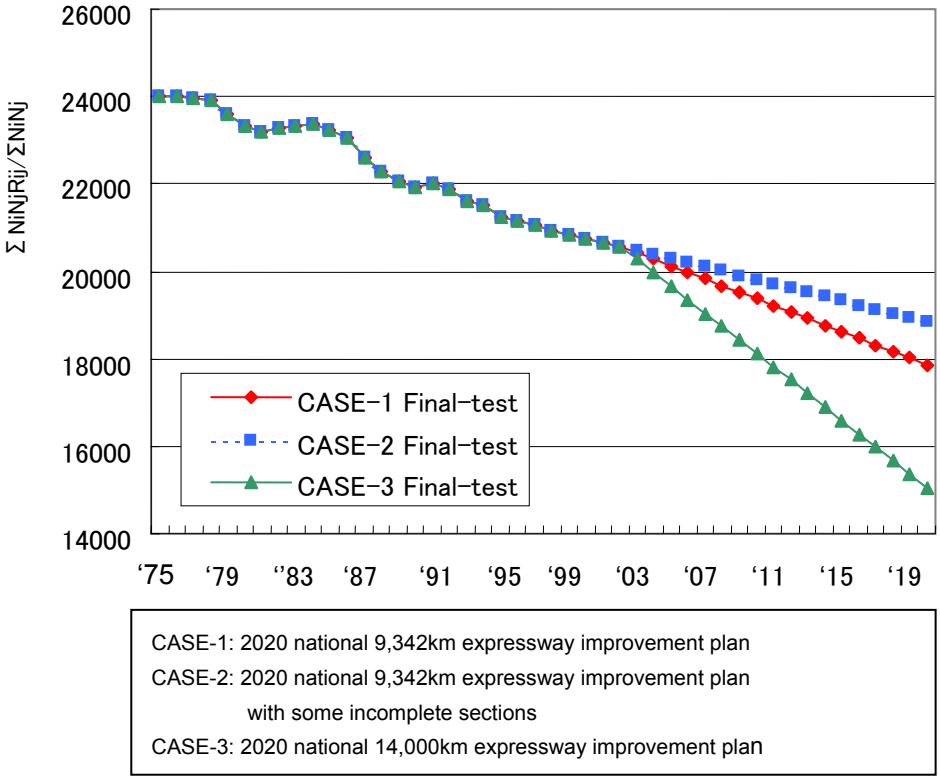

Figure 3 Yearly change of economic-distance indexes used in the analysis of Scenarios 2 and 3

The results of simulation analysis for Scenario 2 are shown in Table 4 (see Table 4-1 for more details). This illustrates the economic losses on the assumption that seven road sections including passages between Kunnui and Nanae in the Hokkaido Jukan Expressway and between Yubari and Tokachi-shimizu in the Hokkaido Odan Expressway remain incomplete in the 9,342km nationwide two-lane expressway network system although central and nodal cities in Hokkaido are all networked. The findings are summarized as follows.

Table 4 Negative effects brought about by seven incomplete expressway sections in the 9,342km nationwide expressway network system

Major index	Economic effect	Contribution rate
Net prefectural product	□1,924.0 billion yen	□7.91%
Gross prefectural expenditure	□946.3 billion yen	□3.43%
Total prefectural capital formation	□61.8 billion yen	□0.79%
Total population employed	□54,000 persons	□1.46%
Hokkaido's total tax revenue	□242.6 billion yen	□1.26%

① Direct damages brought about by the seven incomplete expressway sections would include substantial reductions in areas such as employment in the construction industry, capital investments by private firms and Hokkaido's total fixed capital formation, causing a decrease in construction industry output of 110.3 billion yen. These negative effects would adversely affect outputs, added values and employment in secondary industries, which would hurt Hokkaido's entire economy by reducing gross prefectural product and prefectural income and consequently reduce local taxes by 242.6 billion yen.

② Regarding stock effects of the incomplete expressway sections, because of the great reduction of investments in transportation and communication facilities, the output of related industries would decline by 725.3 billion yen. The deterrence of expressway improvement would prevent the expansion of commercial area, decrease the number of wholesalers and retailers, discourage private investments in commerce, and reduce commerce outputs. Such negative effects on output and employment in the service industry would reduce tertiary industry output and consequently decrease the prefectural net product by 1,924 billion yen.

③ As for the agricultural sector, the impaired distribution efficiency of agriculture products would discourage agricultural investments, decreasing labor productivity and agricultural output. On the contrary, the rise in agricultural costs would heighten agricultural prices. Such rises in agricultural prices and consumer food prices would be associated with a reduction of expenditure on food and drink.

④ Negative effects of an unimproved expressway system on living area environments are also apparent. A lowering of the residential site development rate would occur, discouraging private investments in housing and shrinking housing supply.

b. Scenario 3: effects of the fully improved 14,000km future expressway network system in comparison with the 9,342km system

The results of the simulation analysis based on Scenario 3 are shown in Table 5 (see Table 5-1 for more details). This illustrates the effects of expressway improvement on the assumption that cities in Hokkaido are all linked through national development arterial expressways, national highways and regional expressways in the fully improved 14,000km nationwide four-lane network system instead of the 9,342km two-lane system. The findings are summarized as follows.

Direct effects brought about by the completed 14,000km expressway network system in comparison with the 9,342km system include an increase in employment and output in the construction sector, additional capital investments by private firms and the growth of Hokkaido's total fixed capital formation. These positive effects would expand outputs, added values and employment in secondary industries, which would accordingly boost Hokkaido's entire economy by inflating the gross prefectural product, prefectural income and local taxes.

Table 4-1 Economic losses in the case where specific road sections in the 9,342km nationwide expressway network system remain uncompleted

Major endogenous variable	Effect in the final year	Cumulative effect	Contribution rate of effect in the final year (%)	Contribution rate of cumulative effect (%)
Net prefectural product	-1,923,984	-15,103,323	-7.913%	-68.072%
Primary industry net product	-136	-1,236	-0.018%	-0.168%
Secondary industry net product	-187,820	-1,379,893	-3.222%	-25.089%
Tertiary industry net product	-1,444,172	-11,431,118	-8.525%	-73.827%
Transportation/communication net product	-725,260	-5,544,948	-21.958%	-205.867%
Construction net product	-110,305	-810,388	-3.428%	-26.777%
Mining net product	-508	-3,626	-1.123%	-8.740%
Manufacturing net product	-119	-989	-0.007%	-0.057%
Agriculture net product	-136	-1,236	-0.028%	-0.258%
Commerce net product	-426,961	-3,575,276	-9.265%	-85.560%
Expenditure on food and drink	-72,889	-529,509	-2.218%	-16.567%
Private final consumption expenditure	-930,156	-6,531,969	-5.351%	-40.194%
Government final consumption expenditure	-62,541	-490,570	-1.540%	-13.313%
Gross prefectural expenditure	-946,343	-7,201,554	-3.428%	-28.118%
Prefectural income	-1,534,702	-12,047,454	-7.223%	-61.589%
Corporate income	-363,963	-2,857,118	-6.465%	-59.833%
Private investment in agriculture	-1,725	-15,654	-0.965%	-8.816%
Private investment in mining	-319	-2,275	-1.235%	-9.707%
Private investment in commerce	-64,061	-588,694	-10.547%	-107.737%
Private investment in manufacturing	-21	-170	-0.006%	-0.050%
Private investment in transportation/communication	-370,797	-2,666,791	-28.070%	-265.141%
Capital investment by private enterprise	-45,986	-345,415	-1.192%	-9.780%
Private investment in housing	-16,869	-139,384	-1.553%	-13.003%
Total consumer price	1	11	1.341%	11.324%
Consumer food price index	0	0	0.056%	0.375%
Agricultural price index	0	2	0.205%	1.661%
Total prefectural capital formation	-61,842	-476,988	-0.786%	-6.329%
Population in secondary industries	-8,873	-56,409	-1.035%	-6.758%
Population in tertiary industries	-48,350	-279,757	-1.867%	-11.376%
Population in transportation/communication industry	-10,920	-58,436	-3.950%	-22.475%
Population in construction industry	-8,829	-56,165	-1.655%	-11.003%
Total population employed	-54,248	-318,660	-1.463%	-8.944%
Resident population in Hokkaido	-106,327	-624,574	-1.463%	-8.943%
Hokkaido's total tax revenue	-242,644	-1,884,364	-1.259%	-11.083%
Export from Hokkaido	-414,059	-3,250,371	-5.082%	-43.414%
Import to Hokkaido	-725,111	-5,092,051	-5.772%	-43.763%
Carrying capacity	-93,689	-638,278	-10.680%	-80.599%
Time-distance reduction rate in urban area	986	9,370	5.523%	50.128%

Note: Scenario 2: the case where specific road sections in the 9,342km nationwide expressway network system remain uncompleted

Table 5 Effects of the improved 14,000km nationwide expressway network system in comparison with the 9,342km system

Major index	Economic effect	Contribution rate
Net prefectural product	9,592.7 billion yen	39.45%
Gross prefectural expenditure	4,565.8 billion yen	16.54%
Total prefectural capital formation	278.9 billion yen	3.54%
Total population employed	235,000 persons	6.35%
Hokkaido's total tax revenue	1.196.1 billion yen	6.21%

Table 5-1 Effects of the improved 14,000km nationwide expressway network system in comparison with the 9,342km system

Major endogenous variable	Effect in the final year	Cumulative effect	Contribution rate of effect in the final year (%)	Contribution rate of cumulative effect (%)
Net prefectural product	9,592,676	62,564,068	39.454%	279.160%
Primary industry net product	345	3,295	0.047%	0.447%
Secondary industry net product	1,107,084	6,587,038	18.989%	118.830%
Tertiary industry net product	7,030,101	46,483,173	41.496%	297.369%
Transportation/communication net product	4,090,799	25,453,492	123.851%	920.400%
Construction net product	651,248	3,873,615	20.242%	126.942%
Mining net product	2,318	14,210	5.127%	33.977%
Manufacturing net product	308	2,660	0.018%	0.154%
Agriculture net product	345	3,295	0.072%	0.688%
Commerce net product	1,518,110	11,632,730	32.944%	277.067%
Expenditure on food and drink	305,193	1,967,109	9.288%	61.421%
Private final consumption expenditure	4,228,872	25,666,246	24.326%	156.970%
Government final consumption expenditure	311,566	2,031,193	7.670%	54.519%
Gross prefectural expenditure	4,565,835	29,266,830	16.538%	113.379%
Prefectural income	7,651,782	49,905,424	36.011%	252.823%
Corporate income	1,814,661	11,835,339	32.232%	243.336%
Private investment in agriculture	4,381	41,736	2.451%	23.509%
Private investment in mining	1,454	8,915	5.639%	37.702%
Private investment in commerce	189,999	1,708,663	31.280%	312.362%
Private investment in manufacturing	56	458	0.016%	0.135%
Private investment in transportation/communication	2,208,146	12,840,785	167.159%	1228.886%
Capital investment by private enterprise	218,947	1,388,318	5.675%	38.951%
Private investment in housing	64,519	481,624	5.938%	44.895%
Total consumer price	-5	-38	-5.209%	-39.647%
Consumer food price index	-0	-1	-0.202%	-1.254%
Agricultural price index	-1	-6	-0.791%	-5.773%
Total prefectural capital formation	278,899	1,839,815	3.545%	24.317%
Population in secondary industries	43,872	239,426	5.117%	28.606%
Population in tertiary industries	204,405	1,053,881	7.892%	42.675%
Population in transportation/communication industry	49,798	237,675	18.014%	90.940%
Population in construction industry	43,702	238,556	8.190%	46.518%
Total population employed	235,386	1,226,058	6.348%	34.296%
Resident population in Hokkaido	461,356	2,403,073	6.348%	34.296%
Hokkaido's total tax revenue	1,196,098	7,755,095	6.205%	44.989%
Export from Hokkaido	2,064,430	13,464,351	25.338%	178.163%
Import to Hokkaido	3,296,653	20,008,338	26.240%	170.758%
Carrying capacity	520,401	2,931,870	59.324%	365.638%
Time-distance reduction rate in urban area	-2,798	-26,582	-15.669%	-142.205%

Note: Scenario 3: the case that the 14,000km nationwide expressway network system is fully completed

Regarding stock effects, investments and outputs in the transportation and communication sector would greatly increase. The shortened time-distance materialized by the improved network system would expand the commercial area, encourage investments in the wholesale and retail sector and consequently escalate commercial output. These positive effects would increase tertiary industry output, which would most likely be linked to a rise in prefectural net product, prefectural income and private final consumption expenditure. On the whole, the effect of an improved expressway network system on Hokkaido's entire economy, particularly on investments and outputs in the transportation and communication sector as well as commercial outputs by wholesalers and retailers, appears to be substantial.

6. CONCLUSION

On the basis of the simulation analysis by the macro-econometric model, this study attempted to clarify how capital investments in road improvement projects, which have been

taking a major role among all social infrastructure improvement projects implemented for equilibrating development of national land and rectifying regional economic gaps, have contributed to regional economies in Hokkaido. Specifically, its goal was to construct a model which takes multi-faceted effects into account and to identify them quantitatively. Those effects include both direct and indirect effects achieved through the use of improved expressways (e.g. shortening of time-distance, reduction of transportation costs, market expansion, enhancement of comfortableness and convenience) and also influences on other public projects which may improve living area environments and promote regional vitalization. In identifying mobility effects in terms of time-distance and economic-distance, economic-distance indexes including interregional travel costs and expressway tolls were newly introduced to the existing econometric model. Therefore this new model is characterized by the integration of spatial elements.

As an analysis result, it should be pointed out that the improvement of the transportation system connecting isolated Hokkaido to Japan's main land areas is one of the most highly prioritized issues. As this study has revealed, investments in improving expressway systems which play a major role among all infrastructure projects bring about positive economic effects on tertiary industries, particularly on transportation, service, wholesale and retail sectors, and substantially increase the net prefectural product. Their multiplier effects induce the growth of prefectural income and private final consumption expenditure. An advanced expressway network enhances investments and outputs of transportation and communications sectors as well as commercial outputs of wholesale and retail sectors. Thus, the necessity of improving road network systems in Hokkaido is strongly stressed. Especially, beside producers' efforts to promote the production of value-added foods and ingredients, cooperation with non-agricultural industries including processing, distributing and commercial sectors is important. It is also essential for the road network system to have easy access to both seaports and airports.

All improved roads do not necessarily cut down on costs. Therefore, it is particularly important to reexamine and modify the road network system holistically to enhance the efficiency of transportation routes and methods (e.g. securing return shipments and promoting the integration of an interregional shipping system over a wider area). On the policy side, an effort should be made to advance the system by reinforcing cooperation among agglomerated areas and installing storage centers in both production and consumption sites. Furthermore, in relation to distribution policy, Hokkaido's agriculture plays an important role in industrial activities as a supplier (input) of source materials to relevant industries, which in turn have effects on other industries. With due consideration of such an interdependent relationship between agriculture and related industries, local agriculture needs to be promoted along with agriculture related industries including agribusiness, which will eventually develop not only agriculture itself but the entire local economy.

REFERENCES

Abe,H., Kuroyanagi,T., Ito,T., Katagiri,H., et al., (2002), "Economic Effects Analysis of Public Investment in Road Improvement Works in Hokkaido: Simulation Analysis based on a Macro-econometric Model of Hokkaido", 42nd European Congress of the Regional Science Association Aug. 27-31, 2002, Dortmund, **Germany/ Journal of DPRI, Vol.4**,The Development Policy Research Institute.

Abe,H., (1988), "A Study of the Economic Effects of Agricultural Policy on Agriculture and Non-Agricultural Sectors in Japan: Through the Application of Macro-econometric Model", **Kitami-Daigaku Ronshu,** Vol.20.

Abe,H., Ito,A. and Kraybill,D.S., (1999), "Towards the Construction of a Hokkaido Agricultural Computable General Equilibrium Model", **Journal of DPRI, Vol.1**,pp19-33, The Development Policy Research Institute, Hokkai-Gakuen Unversity of Kitami.

Abe,H., Ito,A., McGregor,P.G., McNicoll,I.H., (2000), "Towards Sustainable Development Strategies for the Northern Regions of Japan", **Journal of DPRI, Vol.2**,pp5-31, The Development Policy Research Institute, Hokkai-Gakuen Univ. Kitami.

Abe,H., (2001), "Issues Concerning Provision of Social Overhead Capital for Sustainable Economic Development-Provision of Social Overhead Capital Assisted by Private Sector Vitality", **Journal of DPRI**, **Vol.3**, pp.41-60,The Development Policy Research Institute, Hokkai-Gakuen University of Kitami,.

Abe,H., (2001), "Current Situations of Hokkaido's Economic Structure and Innovation for Economic Independence", Hirose,M., Yu.B. and Abe,H. (eds.), **Approach to Local Development Strategies**, Senbundo, pp.157-178.

Kuroyanagi,T., (1997), "Local Strategies for Development and Independence", Chuokeizai-sha. (in Japanese).

Kobayashi,K., (1991), "Risks of Social/Public System-Methods for their Economic Evaluation", **Civil Engineering Planning Study/Proceedings**,No.14(2). (in Japanese).

Study Group of Road Investment Evaluation, (1997), **Socioeconomic Evaluation of Road Investment,** Nakamura (ed.), Toyo Keizai Inc. (in Japanese).

Tsujimura,K. and Kuroda,M., (1992), **General Equilibrium Analysis of the Japanese Economy,** Chikuma-shobo (in Japanese).

Metrology Committee, Economic Council (ed.), (1984), **Multi-sectoral Quantitative Model for Middle/Long Term Economic Analysis**, Printing Bureau, Ministry of Finance (in Japanese).

Economic Research Institute, Economic Planning Agency, (1998), "Structure of Macro-econometric Model for Short-term Japanese Economy and Effects of Macro-economic Policy", **Economic Analysis, Economic Planning Agency, Vol.157** (in Japanese).

Ihara,T. and Yamamura,Y., (1998), "Benefits brought about by the Improved Seto Ohashi Bridge", **Express-highway and Automobile, No.41, Vol.3**, pp.46-5 (in Japanese).

Jang,T., Aoyama,Y., Matsunaka,R., and Kuribayashi,D., (2000), "A Study on the

Accessibility Index for Evaluating the Railway Service Level", **Proceedings of Infrastructure Planning, Vol.17.**

Kuroyanagi,T., and Abe.H., (2001), "Development of an Econometric Model to Evaluate Effects of Public Investment in Road Improvement Projects", **Report on Road Improvement Effects by a Macro-econometric Model,** Sapporo Development and Construction Department, Hokkaido Development Bureau.