■ 論 文 ■

The Effect of Road Investment on Logistics Cost in Manufacturing Industry

-Investigation of the Investment Effects Using Stated Preference-

도로에 대한 투자가 제조업 물류비에 미치는 영향에 대한 연구

-SP 기법 활용-

Chung, Il Young

(건설교통부 국제항공과 과장, 교통경제학박사)

목 차

요 약

'90년대 들어 미국을 중심으로 Double Counting 문제와 Keynesian/Neo-classical economics theory 까지 연계되어 교통투자가 경제성장에 거의 영향을 주지 않는다는 이론과 영향을 많이 준다는 상충되는 연구결과가 계속 발표 되었다. 본 논문은 교통에 대한 투자가 경제성장에 미치는 영향을 계량적으로 분석한 것이다. 범위를 좁혀 도로에 대한 투자가 생산성 즉 제조업체의 물류비에 미치는 영향을 Stated Preference Technique를 이용하여 분석한 것이다. 도로이용 승객의 시간가치를 추정하는 일반적인 Cost/Benefit Analysis와는 달리 화물수송과 관련된 투자효과를 분석하였다. 먼저 도로에 대한 투자가 화물의 수송시간절약과 그에 따른 창고시설, 재고관리등에 미치는 영향을 continuous review system과 periodic review system으로 나누어 이론적으로 고찰하였다. 또한 본 논문에서는 Utility Model에 기초하여 시간가치(value of time)와 화물도착의 정확성 (value of reliability)을 도착지별(depot/consumer)과 상품별로 econometrics 기법을 활용 분석한 후 영국의 COBA와 비교 검토하였다. 종합적으로 도로에 대한 투자가 시간절약, 운행비용절감, 사고비용절감 등 직접적인 효과(direct benefit)외에 depot감소, 운행차량감소, 재고비용절약, 유휴자원의 활용 등(secondary benefits)을 통하여 경제성장에 긍정적인 영향을 끼치고 있는 것으로 나타났다.

I. Introduction

This paper investigates the road investment effects on freight transport, introducing the Stated Preference method. This study, using Stated Preference, was carried out in order to obtain more quantitative data on the effects of road investment on freight transport.

Road investment can directly contribute to a reduction in logistics costs which results from the benefits of time savings on driver and goods in transit. The logistics costs reduction leads to a decrease in total production costs and distribution costs.

The reduction in production costs is likely to raise the competitiveness of manufacturing firms. The improvement in competitiveness results in output growth. Indirectly, road investment causes the stockholding reduction through vehicle speed increase and reliability improvement. Stockholding reduction also raises the productivity of firms.

In particular, this paper focuses on the benefits of stockholding reduction and time savings of freight which are rarely studied in the literature. In the first part of this paper, the benefits of stockholding reduction and time savings in freight transport are theoretically examined. In the second part, overall benefits to freight transport are investigated through the Stated Preference experiment.

II. Measuring the Benefits of Road Investment

1. Overview

With regard to freight transport, the benefits resulting from road investment consist of the direct benefits such as time savings and operating cost change, and the indirect benefits like stockholding reduction. The direct benefits are measured according to the magnitude of time savings and operating cost change.

The indirect benefits of stockholding reduction can be measured mainly in terms of working capital. A transportation improvement has a direct effect on the distribution gap which is the duration of time in which capital invested is unproductive. The benefits of stockholding reduction can be examined with regard to inventory level and warehousing facilities.

2. Reductions in Stockholding

The benefits of stockholding reduction are first examined.[1] One of the key factors deciding the level of stockholding is transport delivery time since this is a major component of lead time. The decrease in delivery time leads to the reduction in lead time; as this is reduced, so is the amount of inventory that must be held to maintain a given service level. A decrease in unproductive capital will have taken place.

Average stockholding can be shown through the equations below. The benefits of stockholding reduction may be illustrated in different ways according to the ways of adjusting deliveries to cope with variability in demand.

1) Stockholding in the Continuous Review System

The reorder quantity (Q) is the same on each occasion it is placed, but the reorder cycle (T) between the placing of orders varies. It is generally assumed that the lead time for a given item is known and does not vary. The average stock-on-hand has to be estimated in order to investigate the impact of transport improvement on stockholdings. The average stock is the sum of buffer stock plus average active stock-on-hand over the

1) The benefits of stockholding reduction which are over and above the direct benefits of road investment are suggested in some literature (Turner 1987, Quarmby 1989, and Mackie and Tweddle 1993).

lead time. The average value of the active stock is Q/2, given a reorder quantity Q. The fixed reorder quantity (Q), using the concept of the economic order quantity (EOQ), can be formulated as follows:

The total annual cost of ordering and holding stock (C_t) is given by

$$C_t = \frac{DC}{Q} + \frac{QIC_i}{2}$$

where,

Q : reorder quantity
C : ordering cost
D : annual demand
I : holding cost (as a percentage of the value of an item)
C_i : actual value of an item

To find the minimum cost value, this expression is differentiated with respect to Q and put equal to zero. Thus, $Q = \sqrt{\frac{2CD}{IC_i}}$ is obtained.

For the buffer stock, the variance of the demand over lead time (L) is s^2L, and the standard deviation $sL^{1/2}$, when s is a standard deviation of demand. Thus the desired buffer stock will be $ksL^{1/2}$, when k is a level of service parameter which determines what the stock-out risk will be.

Average stock on hand (Sa) can be estimated as follows (Willis 1977):

$$Sa = \frac{Q}{2} + ks\sqrt{L}$$

2) Stockholding in the Periodic Review System

The reorder cycle time (T) is constant so that inventory is reviewed at the end of fixed regular intervals. An order is then placed to bring the stock up to a predetermined level. The average stock on hand (Sa) in periodic review system can be represented as follows (Willis 1977, Nash 1982):

$$Sa = \frac{mT}{2} + \sqrt{ks(L+T)}$$

where,

m : mean value of demand
T : reorder cycle, which is the time interval between consecutive planning of orders.

The average active stock-on-hand over the lead time (L) is $\frac{mT}{2}$. For the buffer stock, the expected amount demanded between the time at which the current order is placed and the time at which the following order is delivered is assumed $m(L+T)$. The standard deviation is $s\sqrt{(L+T)}$, and the desired buffer stock is $ks\sqrt{(L+T)}$.

The necessary buffer stock $ks\sqrt{(L+T)}$ in this policy is greater than the stock $ks\sqrt{L}$ under the continuous review system. A way of minimising buffer stocks is to reduce lead time (L) through a reduction in delivery time. Another way is to minimise the number of depots holding stocks. However, this process can involve switching to higher transport costs.

3) Benefits from Stockholding Reductions

Therefore, the reduction in average stockholding (ΔSa) can be formulated as below.

$$\Delta S_a = S_a - S'_a$$

where,

S_a : average stockholding before transportation investment
S'_a : average stockholding after transportation investment
ΔS_a : change in stockholding, which can be released for investment in other areas by reducing lead time and by improving delivery reliability

Total savings (TS) resulting from stockholding reduction can be represented as follows:

$$TS = \Delta S(I + \alpha + \beta)$$

Total savings consist of the financial cost saving

($\Delta S \times I$), the reduction in physical distribution costs and storage facilities ($\Delta S \times \alpha$), and the other cost reduction such as obsolescence and deterioration reduction, handling and insurance cost saving ($\Delta S \times \beta$).

3. Time Savings in Freight Transport

Now, we should consider the benefits on freight in transit because transportation improvements give rise not only to the reduction in stockholding but also to the benefits of freight journey time saving. The latter is concerned with the accurate measurement of the freight journey time savings that are not incorporated in the standard Cost Benefits appraisal.

Standard appraisal methods ignore the value of the load, implying that the value of the reduced freight journey time of a full, high-value load is equal to those for an empty vehicle. There can be substantial economic benefits associated with transport infrastructure which are not currently captured in the traditional cost and benefit analysis being used (Oscar Faber TPA and Cambridge Systematics 1993).

Although the literature on travel time values has been growing, relatively few studies have been done in the area of valuation of time saving of freight in transit. The benefits to the load in transit resulting from transportation improvement can be measured in three ways.

The first method is an application of microeconomic theory. Some economists suggest that the economic value of time saving on freight can be estimated as equal to the value of freight multiplied by the rate of interest for the time saved (Meyer, Peck, Stenason, and Zwick 1959).

Another estimation can be made by applying the revealed preference method. The revealed preference methodology, which is usually used for the research on time savings on passenger transport, can be applied to freight transport. Blauwens and Voorde (1988) considered the competition between road haulage and inland navigation to identify the value of time saving on freight. It was assumed that decision taker based his modal choice on the time factor and the cost factor.

Therefore, the modal choice was a function of the difference in time between the alternative modes, as well as of the difference in costs. An econometric function was applied to estimate the value of time saving. The theoretical conclusion is that the value of time savings for a commodity is proportional with the value of the goods. The result of empirical estimation of transport among Belgian districts shows that the value of one hour gained is 0.0000848 times the value of the goods. It is argued that the value of time savings in commodity transportation is considerably higher than the interest on goods.

The third method for measurement of the benefits is the Stated Preference technique. Hypothetical choice possibilities are suggested to a sample of respondents, asking them to indicate their own likely behaviour. The essential point of this method consists in fixing for every member of the sample to what extent the option chosen is preferred to an alternative one. The method is often the only usable method when there are no data available concerning the real modal choice.

Fowkes, Nash, and Tweddle (1991) showed the value of transit time for freight in a study of inter-modal freight technologies; investigating how far customers of different types were willing to pay to reduce transit time or increase reliability. The results of the Stated Preference exercise are shown in Table 1. Industries such as tubes, paper, brewery, and automotive electronics require a rate reduction greater than 25% to accept a transit time half a day longer, and a relatively large rebate to accept a deterioration in reliability. At the other extreme, some commodities require very small rebates to accept a longer, or less reliable, transport service. This applies to fertilisers, oil products, and cement; and is particularly true of flows to depots, rather than direct to customers. It also seems to apply to smaller companies such as those surveyed in the chocolate industry. Finished consumer goods, such as consumer durables and chocolate from large manufacturers, produce moderate valuations for longer transit times though a higher valuation for reliability.

〈Table 1〉 Valuations of Attributes as a Percentage of the Freight Rate

	Half day longer/ shorter transit	Reliability, 1% more/ less delivered on time
Cement and Lime	11%	2%
Tubes	25%	6%
Oil products	10%	1%
Fertilisers to customers	7%	1%
to depots	5%	1%
Consumer durable	14%	3%
Paper	32%	3%
Chocolate Large firms	13%	5%
Small firms	7%	0.4%
Beer	29%	5%
Automotive electric	26%	3%

Source : Fowkes, Nash and Tweddle (1991)

Ⅲ. Stated Preference Experiment

1. Survey Plan

This survey aims to investigate the benefits identified in the previous sections, using the Stated Preference method (SP). The binary semantic rating scale SP experiment is conducted to show the preferences for a hypothetical freight distribution between two hypothetical motorway routes.

In particular, the impacts of transportation improvement with regard to value of time savings and delivery reliability of freight distribution are examined through the Stated Preference method.

2. Sampling and survey schedule

The survey was first carried out to investigate the share of logistics cost in manufacturing cost, and then the value of time saving through the S.P. technique. A pilot survey was carried out using mail and telephone methods. The survey was carried out using a sample of 180 firms in Korea. The sample was selected randomly from the manufacturing firm list. The usable response rate for the first survey which was undertaken during the period of four month from January 1996 was 41.7% (75firms). After contact with firms, 60 firms were selected for the S.P survey. The Stated Preference experiment was carried out during two months from April to May 1996.

3. Questionnaire Design

1) Overview

For the research, an orthogonal design assuming zero correlation between variables was used because the orthogonal design had no problem in estimating the relative value of travel time and reliability in terms of motorway toll. Although the coefficients of utility functions between firms would be different, the coefficients in this research were assumed to be identical between firms because segmented experiments required a larger number of observations and hence a higher cost.

Although the full factorial design shows main and interaction effects, the fractional factorial design was used for the direct main effects only, because the monetary value of time and reliability in terms of toll is the target in the research.

Boundary values are important for accurate estimation of the relative values of variables. Starting values of the variables were decided taking into account the existing levels for the current Motorway toll and traffic condition. Thereafter, the levels were increased by unequal increments between alternatives.

2) Hypothetical Context

A hypothetical context was assumed as follows:

Two hypothetical motorways, which result in different journey time and delivery reliability, are introduced in the specific distribution network. Different levels of motorway tolls are charged for the use of each motorway.

- The specific distribution networks are assumed to be about 170 kms linking the capital city Seoul and the sixth largest city Taejeon.
- Driving conditions on other roads in the region are assumed to be unchanged.
- There is no difference in the vehicle operating costs between two hypothetical motorways.

3) Levels of Attributes

A situation was assumed to have six attributes each with two levels in two hypothetical motorways. Toll levels were decided taking into account the current toll level of the existing Motorways in Korea. Reliability was measured as the percentage of delivery arrivals on time. The definition of on-time arrival was arrival within 10 minutes of the scheduled delivery time. Table 2 shows the levels and attributes used for the survey.

4) Boundary Value of Time and Reliability

The fractional factorial design was made of 16 options. Two sets, each consisting of 8 options, were used for the experiment. Boundary values of time covered from 60Won/min to 450Won/min. The boundary values of reliability implied from 150Won/percentage point to 1,750Won/percentage point. Boundary values of time and reliability were spread with wide ranges.

4. Measuring Trade-off Ratios

Through a boundary value map, the appropriateness of the Stated Preference design was examined (Swanson and Pearmain 1995). The value of time was plotted as a straight line on a graph with VOT (value of time) and VOR (value of reliability) as the axes. Each pairwise choice corresponded to one line, or ray.

Each respondent could therefore be positioned at a point on our graph corresponding to their values. Trade-off ratios were proved to be widely spread. The design of Stated Preference was shown to be appropriate for the experiment. After measuring trade-off ratios, a simulation test was required for examining the appropriateness of the Stated Preference design through a more formal and statistical method (Fowkes 1992).

〈Table 2〉 Levels of Attributes

	Motorway A			Motorway B		
	Toll A	Time A	Reliability A	Toll B	Time B	Reliability B
Level 0	8,000 Won	170 mins	80%	10,500 Won	150 mins	82%
Level 1	9,000 Won	160 mins	85%	12,500 Won	145 mins	90%

5. Simulation Test

First, the orthogonality of design was tested using a correlation matrix. The test showed zero correlation between variables. Normality test showed that the values of time and reliability were normally distributed. The adequacy of the design was checked using computer packages. Responses were simulated and an attempt made to recover the assumed parameter values. For the simulation test,

① a set of artificial utility values was given;
② responses to the stated preference design using a FORTRAN package were created;
③ the simulated responses were modelled to produce estimates of the artificial utility values through the ALOGIT package; and
④ the model estimates (implied utilities) were compared against the original value of the artificial utilities.

The test result proved that the design recovered wide range of assumed values. Rho-values were relatively high.

6. Presentation

The information was provided to respondents by way of option cards. The preference-based approach required the respondent to appraise option cards, each comprising two alternatives made up of differing levels of the variables being examined.

7. Utility Function

Random utility theory implies that individuals will express their preferences in terms of probabilities of responding in a certain way. The utility function for this research was assumed as follows:

$$U = b_0 + b_1 TO + b_2 T + b_3 R + e$$

where, U : utility function (random utility)
TO : motorway toll level
T : journey time of freight
R : reliability level of freight arrival
b_0 : constant
b_i : coefficients of attributes
e : error term

8. Estimation Model

A binary logit model used for the study was specified as follows:

$$\log[P/(1-P)] = a_0 + a_1(TO_A - TO_B) + a_2(T_A - T_B) + a_3(R_A - R_B) + e$$

where,
P : probability of choosing alternative A over alternative B
TO_A-TO_B : differences in tolls between alternative A and alternative B
T_A-T_B : differences in travel time between alternative A and alternative B
R_A-R_B : differences in reliability between alternative A and alternative B
e : random error

The logit model depends on the assumption that the errors are independent and identical across the alternatives. The error term is also assumed to be small relative to the model coefficients. To analyse the data, a probability is assigned to each of the five levels of response as follows (Fowkes and Nash 1991, Bates and Roberts 1983): Using these probabilities, the equation is estimated using multiple regression method

Response	Definitely prefer A
Probably prefer A	0.9
Like A and B	0.7
Probably prefer B	0.5
Definitely prefer B	0.3
Probability of choosing A	0.1

Ⅳ. Estimated Results

1. Analysis of the Responses of Whole Firms

The estimated result implies that the respondents are found to be highly sensitive to changes in delivery reliability. This result is not unexpected given the additional production costs and consumer disutilities which delays may cause. The model performs satisfactorily in terms of goodness of fit and significance of the parameter estimates. R square (36.72%) is satisfactory. The F-test statistics and t-test statistics of three explanatory coefficients are highly significant. The coefficient of reliability is relatively high and more significant compared to the coefficient of travel time. The value of time are inferred to be 158.3 Won per minute. This value includes the value of time saving on driver as well as the value of time on freight.

The value of delivery reliability is estimated to be 548.9 Won per percentage point. The t-test shows that the values of time and delivery reliability are significant at the 1% significance level.[2)]

2. Analysis by Delivery Destination

1) Delivery to Consumers

Estimated results imply that the value of time is 158.1 Won per minute, which is very similar to the value of time for total deliveries of the whole sample firms. The value of delivery reliability is estimated to be 640.7 Won per percentage point, which is higher than the value for whole firms. The high value is inferred to be produced by firms effort to keep their credibility with customers.

As shown in the estimated equation, F-test and t-test statistics of toll and reliability are highly significant. However, the coefficient of travel time does not pass the significance test at the 1% level, but is significant at the 5% significance level. R square of 42.25% is very powerful. The importance of reliability is supported by Walkers argument (1990). He explains that in the UK receivers of goods are placing restrictions on the timing of deliveries at an accelerating rate. Reliability of arrival is an important part of customer service (Walker 1990).

2) Delivery to Depots

The value of time is 183.9 Won per minute, which is greater than the value in the delivery to consumers. The value of delivery reliability is estimated to be 471.4 Won per percentage point, which is smaller than the estimates in the delivery to consumers. The t-test shows that the value of time is significant at the 5% and that of delivery reliability at the 1% level. Overall F-test statistic and R square are highly significant. However, the value of R square (26.38%) is smaller than the value in the case of delivery to consumers. The reason is inferred to be varieties of depots and different distances from plants to depots.

3. Examination by the Industry

1) Chemical Industry

The value of time is 312.3 Won per minute and value of delivery reliability is 635.9 Won per percentage point. The value of time for the chemical industry is much greater than the value for industry as a whole. The value of reliability is a little bigger than that in the industry as a whole. It is supposed that the high values are related to the characteristics of chemical goods. The value of time and delivery reliability is signicant at the 5% level.

The hazardous nature of chemical products places restrictions on how they can be moved and stored. Some chemicals are highly specialised products which means that they are often moved over long distances from factories to customers.

2) Electronic Industry

The value of time is measured to be 102.4 Won per minute, which is smaller than the value for

---

2) The significance t-tests are carried out using following formula (Gujarati 1995, Maddala 1992, and MVA Consultancy, Institute for Transport Studies University Leeds, and Transport Studies Unit University of Oxford 1987).
Suppose a multiple regression as follows:

$Y = b_0 + b_1X_1 + b_2X_2 + \varepsilon$ where, ε is the random noise distributed Nor $(0, \sigma^2)$

$$t_{stat} = \frac{1}{\sqrt{\frac{var(b_1)}{b_1^2} + \frac{var(b_2)}{b_2^2} - \frac{2cov(b_1, b_2)}{b_1 b_2}}} \quad \text{where, } cov(b_1, b_2) = \frac{-r_{12}\sigma^2}{(1-r_{12}^2)\sqrt{\sum x_1^2}\sqrt{\sum x_2^2}}$$

when r_{12} is the correlation between X_1 and X_2, σ^2 is the variance of the random noise series, and χ denotes deviations from the mean.

whole industries. The value of delivery reliability is 622.4 Won per percentage point, which is a little greater than the value for the whole industries. The t-test shows that the value of time is not significant at the 5% level and the value of delivery reliability significant at the 1% level. The coefficient of delivery reliability is highly significant. Overall F-test statistic is highly significant and R square (58.26%) is very high. The very successful goodness of fit results from the homogeneity of electronic industry.

3) Food and Drink Industry

The value of time for the food and drink industry is estimated to be 165.7 Won per minute, which is a little higher than that for the industry overall. The value of delivery reliability is 778.7 Won per percentage point, which is greater than the value for all industry. A reason for the high value is thought to be that the food and drink industry has the characteristics of perishability, high turnover, and high reliability. However, the t-statistics imply that the value of time and delivery reliability are not significant at the 5% level.

4) Metal Industry

The value of time is estimated to be 140.2 Won per minute, which is a little smaller than the value for total industries. The value of delivery reliability is 352.4 Won per percentage point, which is much smaller than the value for the whole sample firms. The low values are expected because the metal industry is a low value and heavy industry. The value of time is significant at the 5% level and the value of delivery reliability is significant at the 1% level.

4. Summary

The estimated results of the Stated Preference experiment are summarised in Table 3. On the whole, the estimations are significant, and R squares are satisfactory in terms of the goodness of fit. As expected, the values of time and delivery reliability are different between models. The highest value of time is identified in the chemical industry (312.3 Won/min).

The value of delivery reliability to consumers (640.7 Won/percentage point) is higher than the value for the whole sample industry and that for the delivery to depots. The value of delivery reliability for the food and drink industry is the highest (778.7 Won/percentage point). All values of delivery reliability except for the industry of food and drink are significant at the 5% or 1% significance level, whereas the values of time except for the industry of electronics, and food and drink are significant. This result implies that delivery reliability is very important in the distribution of goods.

〈Table 3〉 Summary of Estimated Results

	Value of time (Won per minute)	Value of delivery reliability (Won per percentage point)	R^2 (%)
Whole industry	158.3** (2.95)	548.9** (4.36)	36.72
By destination			
To consumers	158.1* (1.97)	640.7** (2.92)	42.25
To depots	183.9* (1.99)	471.4** (2.69)	26.38
By industries			
Chemical	312.3* (1.73)	635.9* (1.91)	44.00
Electronics	102.4 (1.47)	622.4** (3.13)	58.26
Food and drink	165.7 (0.81)	778.7 (1.28)	30.20
Metal	140.2* (1.87)	352.4** (3.96)	24.37

Note : The figures in parentheses are t-values.
The * on the values indicates that it is significant at the 5% significance level and the ** at the 1% level.

The estimated results support that the improvement in delivery reliability is growing in importance with the tendency for manufacturers, retailers, etc. to hold minimum stocks on site. A survey of the service preferences of appliance dealers showed that the reliability of delivery times was the most important variable to these dealers (Gattorna 1983).

V. Implications of the Survey Results

On the whole, the value of time for a total firms is identified to be 158.3 Won/minute. The value of delivery reliability is found to be 548.9 Won/percentage point. The values are believed to be produced by the benefits of time savings to both vehicle driver and freight, stockholding reduction, and other economic effects. In this study, operating cost has been assumed to be unchanged. The implications of the values of time and delivery reliability are compared to other studies as follows:

a) Compared to the value of time for the freight transport in COBA 9, the value of time in Korea (9,500 Won/h, 759.8 p/h) is a little less than the value in COBA 9 manual[3] (950 p/h at 1996 price). Taking into account that the value of time on goods vehicle in COBA 9 is estimated with regard to the time saving of driver only, the value of time on vehicle driver in Korea may be estimated using the average wages of drivers. The value of time is estimated to be about 4,800 Won per hour, using the average wages of 934 thousand Won per month (National Statistical Office 1995). Therefore, the value of time on freight, excluding the benefits of time saving on driver, is likely to be 4,700 Won per hour. It should be noted that the value of time saving on freight is additional to the ordinary time saving on driver.

b) The value of one hour saved for goods in transit (4,700 Won) was about 0.00156 times the value of goods (3,005 thousand Won) shown in the first survey, which is much greater than that identified (0.0000848) in Blauwens and Voordes study (1988). Compared to the value of interest savings per hour (34.2 Won), the estimated value of time saved was over 137 times higher than the interest on goods in transit. This high value is supposed to result from the shortage of working capital and the difference in between real and nominal interest rate in a developing country.

c) Even though the values of delivery reliability have been proved to be high in the experiment, the values are not incorporated in the standard Cost Benefit appraisal. The value of delivery reliability is not included in the COBA manual. In Korea, the values of time and delivery reliability for freight transport are not considered in the road investment appraisal.

In all, the high value of time and reliability is inferred to include other economic benefits as well as reduction in transport costs. The experimental results imply that road investments produce some significant benefits relating to freight transport.

VI. Conclusion

The survey results show that manufacturing firms are very aware of time saving and delivery reliability. The value of time saving implies the value of time on freight besides the ordinary time saving of vehicle driver. Analysing the results of the Stated Preference experiment, it is inferred that transportation investment produces indirect benefits as well as direct benefits, contributing to

3) COBA(Cost Benefit Analysis) manual has been developed by the Department of Transportation (the UK). The program is used as a method of cost benefit analysis for the appraisal of trunk road investment in the UK.

reduction in logistics costs.

With regard to the S.P. technique, a possible serious problem is that the response to S.P. survey may not be the same as that in real life. However, this does not matter when estimating relative valuations, since these are obtained as the ratio of estimated coefficients. However, Adaptive Stated Preference technique and Revealed Preference method would be helpful to find out an exact answer.

In conclusion, the value of 158.3 Won per minute for time saving and 548.9 Won per percentage point for delivery reliability is high in the context of the Korean economy. The high values of time and delivery reliability are inferred to result from the reduction in generalized transport costs, stockholding reduction benefit, and load benefits discussed in the previous sections. Therefore, it is concluded that road investment, which leads to reduction in logistics costs and other production costs, can lead to some economic benefits beyond direct benefits of time savings and operating cost reduction.

Further research is recommended to examine the exact value of time saving, operating cost reduction, and accident cost reduction, using the S.P. technique, for effective transportation investment. Multinomial logit, Hierachical, and Nested logit model may be very useful for the forecast of total traffic volume and traffic share by transportation mode.

References

1. Aschauer, D.A. (1990). Highway capacity and economic growth, *Economic Perspectives*, Federal Reserve Bank of Chicago, September/October1990, pp.14~24.
2. Berechman, J. (1994). Urban and regional economic impacts of transportation investment: A critical assessment and proposed methodology, *Transportation Research* A, Volume 28A, Number4, pp.351~362.
3. Blauwens,G. and E. Van de Voorde (1988). The valuation of time savings in commodity transport, *International Journal of Transport Economics*, Volume 15, Number 1, pp.77~87.
4. Dodgson,J.S. (1973). External Effects and Secondary Benefits in Road Investment Appraisal, *Journal of Transport Economics and Policy*, Volume7, Number2, pp.169~189.
5. Fowkes, A.S. (1992). *How Reliable Is Stated Preference ?*, ITS Working Paper 377, Institute for Transport Studies, University of Leeds.
6. Fowkes, A.S., Nash, C.A. and Tweddle, G., (1991). Investigating the market for inter-modal freight technologies, *Transportation Research* A., Volume 25A, Number 4, pp.161~172.
7. Gattorna, J. (1983). Handbook of Physical *Distribution Management*, Gower, Aldershot.
8. Mackie, P.J. and Tweddle, G. (1993). *Measuring the Benefits Gained by Industry from Road Network Improvements*, ITS Working Paper 391, Institute for Transport Studies, University of Leeds.
9. Meyer, J.R., Peck, M.J., Stenason, J., and Zwick, C. (1959), *The Economics of Competition in the Transportation Industries*, Harvard University Press, Cambridge, Mass.
10. Munnell, A.H. (1992). Infrastructure investment and economic growth, *Journal of Economic Perspectives*, Volume6, Number4, pp.189~198.
11. MVA Consultancy, Institute for Transport Studies University of Leeds, and Transport Studies Unit University of Oxford (1987). *The Value of Travel Time Savings*, Policy Journals, A report of research undertaken for the Department of Transport, London.
12. Nash, C.A. (1982). *Economics of Public Transport*, Longman, London.
13. Oscar Faber TPA and Cambridge Systematics (1993). *The Assessment of the Economic Development Impact of Road Infrastructure*, Report to the Scottish Office.

14. Quarmby, D.A. (1989). Developments in the retail market and their effect on freight distribution, *Journal of Transport Economics and Policy*, Volume 23, Number 1, pp.75~87.
15. Turner, R. (1987). Freight operators requirements for infra-structure plans, *Proceedings 15th PTRC Summer Annual Meeting*, Freight, Volume P294, September 1987, pp.1~10.
16. Walker, M. (1990). The transport cost of customer service, in Cooper, J. (ed.), *Logistics and Distribution Planning*, Kogan Page, London.
17. Willis, R. (1977). *An Analytical Approach to Physical Distribution Management*, Kogan Page, London.