A FRAMEWORK ON THE ESTIMATION OF THE ECONOMIC EFFECTS OF INTELLIGENT TRANSPORTATION SYSTEMS

Chih-Peng CHU
Assistant Professor
Department of Economics
National Dong Hwa University
Hualien, Taiwan, R.O.C
Email: chpchu@mail.ndhu.edu.tw
Fax: +886-3-8662535

Shou-Ren HU
Assistant Professor
Department of Transportation Management
Tamkang University
Taipei, Taiwan, R.O.C.
Email: shouren@mail.tku.edu.tw
Fax: +886-2-2622-1135

Abstract: The purpose of this research is to provide a framework to evaluate the economic effects for the development of ITS. The framework covers both direct and indirect industry impacts. The evaluation framework applies a semi-closed input-output (I/O) model that effectively estimates the economic impacts of the development of ITS. The economic impacts include output effect, income effect, and employment effect. To demonstrate the feasibility of employing the proposed framework, numerical tests are conducted based on the potential development and deployment of ITS in Taiwan. The test results show that the total outputs for ITS (development / deployment) in Taiwan will generate total value of \$3.81 ~ 94.96billion US dollars, increase household's income by \$0.61~ 19.8 billion US dollars, and create 16 thousands ~ 1 million jobs. The evaluation results have provided both the public and private sectors with useful information in allocating their limited resources for the development and deployment of ITS.

Key words: Intelligent transportation systems, Input-output model, Inter-industry relationship analysis

Acknowledgements: This work was supported by Taiwan's National Science Foundation grant NSC 89-2211-E-295-001/002.

1. INTRODUCTION

Traffic congestion and safety have caused serious problems in most metropolitan areas around the world. These problems are due to the unbalanced supply and demand of transportation services / systems, lack of travel information, and ignorance of transportation externality. In order to overcome the above problems, the applications of advanced technologies (such as information, communication, and remote control devices, etc.) to the operations of existing transportation systems have been widely adopted. This new transportation architecture is called: Intelligent Transportation Systems (ITS). It is recognized that ITS will not only have significant impacts on the transportation sector, but also have direct and indirect impacts on ITS related industry. However, most current research has been focusing on the investigation of technical issues and the direct impacts on the transportation sector itself. Moreover, the work concerning the economic impacts of ITS are usually evaluated from a qualitative point of view with the major concern on the direct impacts of ITS, which cannot reasonably capture the total impacts of ITS, especially for the industry sector.

The purpose of this research is to provide a framework to evaluate the economic impacts for the development of ITS (see Figure 1). Figure 1 demonstrates that under different ITS development scenarios, the impacts of ITS include transportation effects, social effects, and economic effects. This paper will be focusing on the evaluation of economic impacts of ITS. The economic impacts include output effect, income effect, and employment effect. In the proposed framework, a semi-closed input-output model has been developed. By incorporating the local survey results of the forecasts for the final demands of ITS related industry sectors in the short-term (3 years), mid-term (5 years), and long-term (10 years) stages, it is found that the total outputs for ITS (development / deployment) in Taiwan will generate total value of \$3.81 ~ 94.96 billion US dollars, increase household's income by \$0.61 ~ 19.8 billion US dollars, and create 16 thousands ~ 1 million jobs. The evaluation results have provided both the public and private sectors with useful information in allocating their limited resources for the development and deployment of ITS.

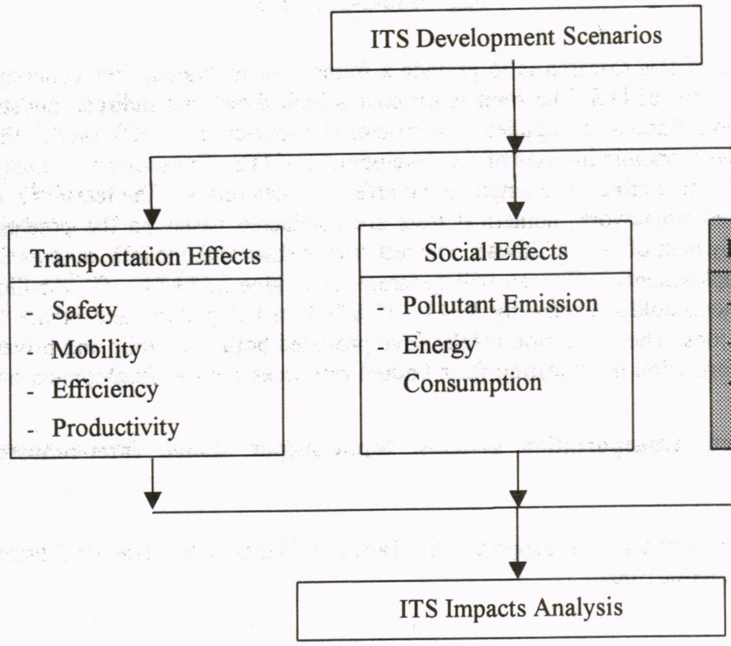

Figure1 Framework for ITS Impacts Analysis

2. BACKGROUND AND LITERATURE REVIEW

Since the Intermodal Surface Transportation Efficiency Act of 1991, the area of ITS has been developed from a conceptual stage into physical projects in the United States. However, the studies of ITS benefits in U.S. have been focusing on the transportation sector itself, including cost reduction in transportation infrastructures, savings on travel times / accidents, increase of customer satisfaction, and reduction of pollutant emission / fuel consumption [FHWA, 1997; Proper, 1999]. The evaluation of cost / benefit results from field operation tests or based on the forecasts for future application of ITS technologies is generally ad-hoc. Therefore, benefit-cost ratio plays an importation role in most benefit-evaluation reports. These benefits of the evaluation process are usually referred to the benefits on transportation related issues. Japan has similar situation on ITS benefit studies, since the goals of ITS in Japan are based on the scope of U.S. with a highlight on environment protection. The goals for the development of ITS in Europe have broader range in which they cover not only the transportation system and environment but also take the industry impacts into account. The reports concerning ITS benefits assessment in Europe, however, do not provide quantitative analyses on the economics impacts. Indeed, the investment (most from the public sectors) in ITS infrastructure would certainly leverage on the existing telecommunications, because it takes a tremendous amount of capital to build ITS communication services [Chen et al., 1999]. A market report by Business Communications Company Inc. forecasted that total U.S. expenditures of ITS for consumer, commercial and public applications will grow to $14 billion US dollars by 2002[Microwave Journal, 1998]. Kujawa estimated that the global market value for wireless intelligent vehicle system would be increased to more than $5 billion US dollars by 2005 [Kujawa, 1999]. These reports show the notable economic impacts of the development of ITS. In fact, it is understandable that not only the telecommunication sector, other ITS related industry sectors will also have significant impacts directly and indirectly. This research aims to provide a general framework that incorporates the economic benefits (impacts) assessment into the "traditional transportation" benefits evaluation process.

3. METHODOLOGY

This research has provided an input-output based model to estimate the economic impacts of the development of ITS. It has been proved [Chu et al., 2000] that a semi-closed I/O model outperforms the open-form I/O models. Therefore, the framework being developed and tested is a semi-closed I/O model.

3.1 Basic Formulation

An I/O model can be expressed in general as follows:

$$\begin{cases} x_{11} + x_{12} + \ldots\ldots + x_{1j} + \ldots + x_{1n} + Y_1 = X_1 \\ x_{21} + \ldots\ldots\ldots\ldots + x_{2j} + \ldots + x_{2n} + Y_2 = X_2 \\ . \\ x_{n1} + x_{n2} + \ldots\ldots + x_{nj} + \ldots\ldots + x_{nn} + Y_n = X_n \end{cases} \tag{1}$$

$$\Rightarrow \sum_{j=1}^{n} x_{ij} + Y_i = X_i \quad (i=1,2,3,\ \ldots,\ n) \tag{2}$$

where X_i is the output of the i^{th} industry sector, x_{ij} represents the amount of input of the j^{th} industry sector used to produce output of the industry sector i, X_i, and Y_i means the final demands of the i^{th} industry sector, which includes household's consumption, private investment, government expense, and net export. Equation (2) is the total output of the i^{th} sector, X_i, is equal to total intermediate demands, Σx_{ij}, plus final demands of this industry sector, Y_i.

The technical (improvement) relationship between input and output is called input coefficient or technical coefficient, a_{ij}, i.e.,

$$a_{ij} = {}^{x_{ij}}\!\big/_{X_j} \tag{3}$$

Based on the assumption of I/O model theorem, a_{ij} is assumed to be fixed. Therefore equation (1) can be further simplified by the following equation with appropriate vector-matrix dimensions:

$$[I - A]X = Y \tag{4}$$

where A is the input coefficient matrix, and $[I-A]$ is called the Leontief Matrix. If $[I-A]$ is non-singular, then X can be solved by the following equation:

$$X = [I - A]^{-1} Y \tag{5}$$

where $[I-A]^{-1}$ is called the degree of inter-industry relationship, and it is the Leontief inverse matrix. Equation (5) indicates the input-output relationship of Leontief's theorem.

In equation (4), if the final demands, Y, are all exogenous sectors, then it is an open I/O model, otherwise if any one sector in Y is endogenous, then it is called semi-closed I/O model. A typical semi-closed I/O model assumes the household sector to be endogenous. In a semi-closed I/O model, the input coefficient matrix A^* adds one more row of household's earning coefficients, and one more column of household's consumption coefficients to the matrix of A in equation (4). Since a semi-closed form of I/O model could take the inter-relationships of household's sector into account, it is a much desirable model for analyzing industry impacts of transportation policy [Chu et al., 2000]. The I/O model referred below is a semi-closed form model.

3.2 Multiplier Analysis

In the content of the I/O analysis, the impacts due to the change of the final demands generally include output effect, income effect, and employment effect. These effects are evaluated through multiplier analysis.

3.2.1 Output Multiplier

The output multiplier of a semi-closed I/O model is defined as follows:

$$\Delta X / \Delta Y = [I - A]^{-1} \tag{6}$$

where ΔY is the change of the final demands, and ΔX is the effect of the final demand change on total output.

3.2.2 Income Multiplier

The income multiplier of a semi-closed I/O model is defined as follows:

$$\Delta W / \Delta Y = A_{hi} [I - A]^{-1} \tag{7}$$

where A_{hi} is the diagonal matrix of the household's sector, and ΔW is the total income impacts due to the change of the final demands.

3.2.3 Employment Multiplier

The employment multiplier of a semi-closed I/O model is defined as follows:

$$\Delta L / \Delta Y = L\,[I - A]^{-1} \tag{8}$$

where L is the employment coefficient matrix, and ΔL is the total employment impacts as a result of the change of the final demands.

4. DEFINITION OF ITS INDUSTRY

It has been identified 7 prioritized ITS development areas to be promoted in Taiwan. They are ATMS, ATIS, APTS, CVO, EMS, EPS, and AVCSS. Based on the prioritized development areas, and mapping these areas into corresponding industry sectors, we have defined the ITS related industry as shown in Table 1. Specifically, the ITS related industry can be briefly categorized into two main domains: 1) the area of introduced technology, including industry sectors of communications, electronics, information, consultant services, and construction; 2) the area of basic transportation infrastructure / services, including (surfaced) transportation and transportation service sectors. ITS industry has traditionally been focusing on advanced technology related sectors. In fact, partial ITS benefits are attributed to added value of existing transportation infrastructure / services. Therefore, in defining ITS industry, we need to take both introduced technologies and basic transportation infrastructure / services into considerations.

5. DATA DESCRIPTION AND ESTIMATION PROCESS

The main objective of this research is to investigate the economic effects of the development of ITS. To demonstrate the feasibility of employing the proposed framework, we have obtained the "Table for Inter-industry Relationships in Taiwan of 1996 (160 sectors)". To focus on ITS related industry in the evaluation process, the 160-sector inter-industry relationship table is further modified into a 48-sector table by composing and decomposing the relevant elements of the corresponding rows / columns in the 160-sector table (matrix). The economic effects are further analyzed in the light of the modified table.

5.1 Estimation of Output Effect

To analyze the output effect, we need to forecast the final demands for ITS related industry at different development stages (to be detailed in section 5.4). By multiplying the increment of the final demands of ITS by the corresponding I/O table, one can obtain the output effect as a result of developing ITS.

5.2 Estimation of Income Coefficient and Multiplier

Income coefficient, or the direct income effect, is the transfer of the change of final demands into that of household's earning. In the proposed semi-closed I/O model, the income multiplier is as follows.

Income Multiplier = (direct + indirect + induced income effects) / direct income effect

5.3 Estimation of Employment Coefficient and Multiplier

Employment coefficient of the i^{th} industry, L_i, is the ratio of labor input and output. Since the

48-sector I/O table does not include the employment sector, therefore we have obtained the employment coefficients and multipliers based on a simplified 38-sector I/O table.

5.4 Demands for ITS Related Industry

To forecast the final demands for ITS related industry at various development stages, we have conducted a questionnaire survey by employing the Delphi method. A group of respondents with various expertises were asked to forecast the final demands for ITS related industry at different development stages under three scenarios: optimistic, fair, and conservative. The forecast of the final demands comes to a conclusive result in terms of less variance after a few runs of the survey. Table 2 shows the survey results.

6. NUMERICAL TEST RESULTS

The ITS related I/O tables and the forecasted final demands for ITS related industry are inputted to the proposed framework to estimate the economic effects of ITS. These effects are forecasted at the short, mid, and long-term development stages under three scenarios.

6.1 Output Effects

We have evaluated the output effects for the development of ITS under three scenarios at the short, mid, and long-term development stages. Take fair scenario for example, in the short-term (3 years) it is estimated that the \$0.7547 billion US dollars of final demands for ITS will generate \$3.8071 billion US dollars of total value, in which contribute to ITS related industry \$1.0227 billion US dollars.

In the mid-term (5 years), the 3.0617 billion US dollars of final demands for ITS will generate total value of \$15.1924 billion US dollars for the whole economic system, in which contribute to ITS related industry \$4.1368 billion US dollars.

Finally, as shows in Table 3, in the long-term (10 years), the \$19.0013 billion US dollars of final demands for ITS will generate total value of \$94.9581 billion US dollars for the whole economic system, in which contribute to ITS related industry \$25.6422 billion US dollars.

To sum the overall output effects of ITS development, the output value of ITS related industry accounts for 25~27% of total output of the economic system. Moreover, the output effects in terms of monetary value of ITS related industry is 1.3 times of the final demands for ITS, in which information hardware, fine manufacturing, communication service, and information service industry sectors have significant output effects.

6.2 Income Effects

Table 4 shows the income coefficients and multipliers of the investigated industry sectors. It is seen from the column of income coefficients that most industry sectors of the ITS basic transportation service area have greater income coefficients than the average level of the entire industry. It means that the development of the ITS related industry sectors of the basic transportation service area (e.g., surfaced transportation, transportation service, travel service, etc.) are beneficial to the increase of household's income.

In table 4, it is also shown that most of the income multipliers of the ITS related industry sectors of the introduced technology area are greater than the average level of the entire industry, whereas the income multipliers of the ITS related industry sectors of the basic transportation service area are relatively less. These results indicate that the development of ITS related industry sectors of the introduced technology area is helpful for the enhancement of total income. In conclusion, the development of ITS has positive effects on the increase of total income.

In quantifying the income effects, the proposed semi-closed I/O model was employed to evaluate the potential effects. Table 5 shows the income effects of the development of ITS under three scenarios at the long-term development stage. As shown in Table 5, the development of ITS will increase total income up to $10.5161, 14.9132, and 19.7990 billion US dollars at the conservative, fair, and optimistic development scenarios, respectively. It is also shown that ITS related industry of communication service, information service, consultant service, and surfaced transportation have significant income effects. These four industry sectors account for 26% of total income effects.

6.3 Employment Effects

In analyzing the employment effects of the development of ITS, we first obtain the employment coefficients and multipliers of the investigated industry sectors as shown in Table 6. It is shown in Table 6 that for those labor-intensive ITS related industry sectors, the employment coefficients are greater than the average level of the entire economic system. These industry sectors have generally larger employment multipliers, which means the development of these ITS related industry has a positive effect on the creation of new working opportunities.

It is further estimated that, under the fair scenario, the development of ITS will create 28 thousands, 121 thousands, and 781 thousands jobs at the short, mid, and long-term stages, respectively. The quantitative estimation results for the long-term development stage are shown in Table 7. It is also shown that the industry sectors of information service, surfaced transportation, communication service, and fine manufacturing industry have significant employment effects. These four industry sectors account for 19% of total employment effects. It is meant that the development of these ITS related industry sectors will require significant labor forces.

7. CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

This research has proposed an I/O based model that estimates the economic effects of the development of ITS. The main contribution of this research is that the proposed framework provides a systematic mechanism to estimate the economic impacts for the development of ITS. Specifically, the total output effect, income effect, and employment effect are forecasted under three scenarios of estimation at various development stages. To test the validity and feasibility of the proposed model, local ITS development data were employed. The proposed framework has been shown to be capable of building a desirable bridge between the transportation and industry viewpoints for the estimation of ITS potential impacts.

In the numerical analysis, it is found that the development / deployment of ITS in Taiwan will generate total value of $3.81~ 94.96 billion US dollars, increase household's income by $0.61 ~ 19.8 billion US dollars, and create 16 thousands ~ 1 million jobs. The evaluation results have provided both the public and private sectors with useful information in allocating their limited resources for the development and deployment of ITS.

The research has the following limitations, and it is recommended that the issues listed below are worthy of future research.

1) Definition of ITS Industry

ITS involves the applications of advanced technologies to the transportation sector. One can hardly define exactly the ITS industry. Future research seeks to realistically define ITS industry in the sense that the investigation of how much percentage of a certain industry sector contributing to the development of ITS is a critical point to be clarified.

2) Forecast of the Final Demands for ITS

This research has employed the Delphi method to forecast the possible demands for ITS at various development stages. However, these forecasted demands may vary based on the responses of different group of respondents. It may also vary as the time horizon moves forward. Therefore, we need to periodically update these forecasted demands once further data are available.

3) Estimation of Complete ITS Benefits

This research has provided the preliminary evaluation results concerning the economic effects of ITS. To capture the overall benefits of ITS, it needs to incorporate the impacts of the transportation sector. The assessment of these impacts includes: traffic safety, transportation mobility and efficiency, and environmental concerns (i.e., air pollution and energy consumption). By incorporating the impact assessment of the transportation sector, it is able to provide a complete picture of potential benefits in the development / deployment of ITS.

REFERENCES

Chen, K. and Miles, J.C., (editors), **ITS Handbook 2000: Recommendations from the World Road Association**, PIARC, 1999.

Chu, C.P., Hu, S.R., and Sung, D.P., "The Analysis of Inter-industry Relationship Effects for the Development of Intelligent Transportation Systems" (in Mandarin), Proceedings of the 2nd ITS Taiwan's International Conference and Exhibition, Taipei, Taiwan, April 28 ~ May 1st, 2000.

FHWA, **ITS Benefit: Continuing Successes and Operational Test Results**, U.S. Department of Transportation, Federal Highway Administration, Washington D.C., October 1997.

Kujawa, M., “Navigating the Market for ITS”, Telecommunications, February 1999, pp. 51-54.

Proper, A.T., **ITS Benefits: 1999 Update**, U.S. Department of Transportation, Federal Highway Administration, Washington D.C., May 1999.

The Commercial Market, Microwave Journal, January 1998, pp. 47.

Table 1 ITS Industry and the Relationships with ITS Development Areas

ITS Area	Industry Classification	Content	Development Area						
			ATMS	APTS	AVCSS	EMS	ATIS	EPS	CVO
Introduced Technology Area	Communication	Wire	★	★	★	★	★	★	★
		Wireless	★	★	★	★	★	★	★
		GPS	★	★	★	★	★		★
	Engineering Consultant	System Integration	★	★	★	★	★	★	★
		Consultant	★	★	★	★	★	★	★
	Fine Manufacturing	Traffic Signal	★						
		Vehicle Detector	★	★	★			★	★
		Vehicle Control	★	★	★		★		★
		ETC	★	★				★	★
	Auto Manufacturing	Auto Manufacturing	★	★	★	★	★	★	★
	Information Hardware	Computer Hardware	★	★	★	★	★	★	★
		On-board Computer	★	★	★	★	★	★	★
	Information Software	Computer Software	★	★	★	★	★	★	★
		Traffic Management	★	★	★	★	★	★	★
		Fleet Management							★
		Traveler Information Guidance		★			★		
		Public Transportation		★					
	Construction Engineering	Public Work	★	★				★	
		Outdoor Transmission Line Engineering	★	★			★	★	
		Telecommunication Engineering	★	★			★	★	
Basic Transportation Infrastructure / Service Area	Surfaced Transportation	Passenger Transport	★	★	★	★	★	★	★
		Freight Transport	★		★	★	★	★	★
		Surfaced Transportation Supported	★			★	★	★	
	Related Service	Transportation Service					★		★
		Travel Service		★			★		
		Warehousing					★		★
		Telecommunication Service	★	★	★	★	★	★	★
		Communication Service	★	★	★	★	★	★	★
		Financial Service						★	
		Auto Service		★	★	★	★		★
		Emergency and Medical Service	★	★	★	★	★	★	★

Table 2 Forecasts for the Final Demands of ITS Related Industry

Unit：billion US dollars

	Industry Sector	Short-term			Mid-term			Long-term		
		Optimistic	Fair	Conservative	Optimistic	Fair	Conservative	Optimistic	Fair	Conservative
Introduced Technology Area	Cable / Wireline	0.0059	0.0039	0.0020	0.0222	0.0174	0.0126	0.1466	0.1199	0.0932
	Information Hardware	0.0775	0.0520	0.0265	0.2933	0.2298	0.1663	1.9399	1.5868	1.2337
	Communication Media	0.0136	0.0091	0.0046	0.0515	0.0404	0.0292	0.3406	0.2786	0.2166
	Fine Manufacturing	0.0913	0.0612	0.0312	0.3457	0.2708	0.1960	2.2860	1.8699	1.4539
	Public Work	0.0476	0.0319	0.0163	0.1803	0.1413	0.1022	1.1923	0.9753	0.7583
	Construction Engineering	0.0196	0.0131	0.0067	0.0741	0.0581	0.0420	0.4902	0.4010	0.3118
	Consultant Service	0.0548	0.0368	0.0187	0.2076	0.1626	0.1177	1.3726	1.1228	0.8730
	Information Service	0.1331	0.0893	0.0455	0.5040	0.3949	0.2857	3.3331	2.7264	2.1197
	Auto Manufacturing	0.0145	0.0099	0.0056	0.0483	0.0297	0.0123	0.2042	0.1160	0.0348
Basic Transportation Infrastructure / Service Area	Other Surfaced Transportation	0.0256	0.0213	0.0171	0.1119	0.0826	0.0550	0.5112	0.3661	0.2319
	Transportation Service	0.0265	0.0206	0.0150	0.1216	0.0834	0.0497	0.7263	0.4620	0.2415
	Travel Service	0.0020	0.0011	0.0003	0.0085	0.0046	0.0011	0.0382	0.0219	0.0074
	Warehousing	0.0159	0.0110	0.0069	0.0666	0.0464	0.0292	0.3882	0.2608	0.1556
	Communication Service	0.2087	0.1423	0.0869	0.9668	0.5796	0.2784	5.7250	3.5109	1.7941
	Auto Service	0.0181	0.0123	0.0070	0.0594	0.0406	0.0235	0.3067	0.2134	0.1298
	Total	0.7547	0.5159	0.2903	3.0617	2.1821	1.4008	19.0013	14.0320	9.6554

Table 3 Output Effects of ITS Related Industry for the Investigated 48 Industry Sectors*
(Long-term)

Unit：billion US dollars

Sector No.	Industry Sector	Forecasted Final Demands			Total Output		
		Optimistic	Fair	Conservative	Optimistic	Fair	Conservative
11	Cable / Wireline	0.1466	0.1199	0.0932	0.5676	0.4388	0.3202
12	Information Hardware	1.9399	1.5868	1.2337	2.3205	1.8891	1.4611
17	Communication Media	0.3406	0.2786	0.2166	0.5026	0.3878	0.2828
22	Auto Manufacturing	0.2042	0.1160	0.0348	1.5105	1.0782	0.6864
24	Fine Manufacturing	2.2860	1.8699	1.4539	2.7693	2.2504	1.7371
28	Public Work	1.1923	0.9753	0.7583	1.2145	0.9921	0.7702
29	Construction Engineering	0.4902	0.4010	0.3118	0.9633	0.7320	0.5236
32	Other Surfaced Transportation	0.5112	0.3661	0.2319	1.4735	1.0985	0.7548
34	Transportation Service	0.7263	0.4620	0.2415	0.9795	0.6517	0.3739
35	Travel Service	0.0382	0.0219	0.0074	0.1200	0.0838	0.0514
36	Warehousing	0.3882	0.2608	0.1556	0.4846	0.3334	0.2067
38	Communication Service	5.7250	3.5109	1.7941	6.9012	4.3295	2.3140
40	Consultant Service	1.3726	1.1228	0.8730	1.6921	1.3706	1.0543
41	Information Service	3.3331	2.7264	2.1197	3.5332	2.8774	2.2262
46	Auto Service	0.3067	0.2134	0.1298	0.6099	0.4424	0.2913
	Non ITS Related Industry				69.3159	52.7385	37.6500
	Total	19.0013	14.0320	9.6554	94.9581	71.6943	50.7039

Note: * The proposed semi-closed I/O model includes the household sector as the 48th industry sector.

Table 4 Income Coefficients and Multipliers of ITS Related Industry among 48 Sectors

Sector No.	Industry Sector	Income Coefficient	Rank	Income Multiplier	Rank
11	Cable / Wireline	0.1489	33	7.3946	12
12	Information Hardware	0.1163	41	8.8226	5
17	Communication Media	0.1394	36	7.3629	13
22	Auto Manufacturing	0.0991	47	9.2509	3
24	Fine Manufacturing	0.2017	25	5.6343	21
28	Public Work	0.2400	20	5.2314	25
29	Construction Engineering	0.3072	16	4.0114	29
32	Other Surfaced Transportation	0.4445	10	2.8362	37
34	Transportation Service	0.4657	8	2.8046	39
35	Travel Service	0.4712	7	2.7539	40
36	Warehousing	0.3314	13	2.9840	36
38	Communication Service	0.2906	18	2.6016	42
40	Consultant Service	0.5058	5	2.5662	43
41	Information Service	0.4775	6	2.4652	45
46	Auto Service	0.3408	12	3.3538	33

Table 5 Income Effects of ITS Related Industry for the Investigated 48 Industry Sectors**
(Long-term)

Unit：billion US dollars

Sector No	Industry Sector	Total Income Effects		
		Optimistic	Fair	Conservative
11	Cable / Wireline	0.0845	0.0653	0.0477
12	Information Hardware	0.2699	0.2197	0.1699
17	Communication Media	0.0701	0.0541	0.0394
22	Auto Manufacturing	0.1497	0.1069	0.0680
24	Fine Manufacturing	0.5586	0.4540	0.3504
28	Public Work	0.2914	0.2381	0.1848
29	Construction Engineering	0.2959	0.2249	0.1609
32	Other Surfaced Transportation	0.6550	0.4883	0.3355
34	Transportation Service	0.4561	0.3035	0.1741
35	Travel Service	0.0565	0.0395	0.0242
36	Warehousing	0.1606	0.1105	0.0685
38	Communication Service	2.0055	1.2582	0.6725
40	Consultant Service	0.8558	0.6933	0.5333
41	Information Service	1.6873	1.3741	1.0631
46	Auto Service	0.2078	0.1508	0.0993
	Non ITS Related Industry	11.9941	9.1323	6.5245
	Total	19.7990	14.9132	10.5161

Note: ** to avoid double counting the income effect of the household sector, the household sector is excluded from the 48-sector I/O table.

Table 6 Employment Coefficients and Multipliers of ITS Related Industry among 38 Industry Sectors***

Sector No.	Industry Sector	Employment Coefficient	Rank	Employment Multiplier	Rank
12	Communication Media	0.2542	33	1.5033	32
14	Auto Manufacturing	0.2419	35	1.3289	34
16	Fine Manufacturing	0.5721	16	3.4940	15
20	Public Work	0.5884	14	3.6806	12
21	Construction Engineering	0.5884	13	3.5212	14
24	Other Surfaced Transportation	0.9757	4	5.4112	5
26	Transportation Service	0.5913	11	3.2501	17
27	Warehousing	0.4928	20	2.2573	26
29	Communication Service	0.2160	36	0.7686	37
31	Consultant Service	0.7273	8	3.8840	9
32	Information Service	0.5904	12	2.9045	20
37	Auto Service	1.0024	3	5.4655	4

Note: *** due to data availability, only partial ITS related industry sectors are analyzed.

Table 7 Employment Effects of ITS Related Industry for the Investigated 38 Industry Sectors (Long-term)

Unit: jobs

Sector No.	Industry Sector	Total Employment Effects		
		Optimistic	Fair	Conservative
12	Communication Media	3,833	2,958	2,157
14	Auto Manufacturing	10,960	7,824	4,980
16	Fine Manufacturing	47,529	38,623	29,813
20	Public Work	21,437	17,513	13,596
21	Construction Engineering	17,003	12,921	9,243
24	Other Surfaced Transportation	43,129	32,154	22,094
26	Transportation Service	19,502	13,046	7,543
27	Warehousing	7,164	4,929	3,055
29	Communication Service	44,726	28,059	14,997
31	Consultant Service	36,919	29,905	23,003
32	Information Service	62,576	50,962	39,429
37	Auto Service	18,342	13,304	8,759
	Non ITS Related Industry	694,531	529,726	379,291
	Total	1,027,651	781,923	557,960