



# COST STRUCTURE OF HIGHWAY BUILDING AND MAINTENANCE

*- HOW SHOULD WE LEVY TAXES  
ON FREIGHT VEHICLES? -*

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# Today's contents

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- Question

*Does freight vehicles pay appropriate tax in their activities in city logistics?*

- Key concept

- Cost structure & Cost responsibility

- Approach

- Cost allocation study & Econometrics

- Object of analysis

- Tax payment & Highway investment cost

- Thesis

*How should we levy taxes on freight vehicles?*



# Today's contents

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Introduction



Perspective of this study



Review of studies concerning cost structure in highway investment



Estimation of cost structure based on the 'econometrics approach'



Conclusion



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# Decision-makings of Govt. and Logistics Service Providers: LSPs

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Sophistication and Diversification of consumer needs

Advanced logistics system

Policies by govt. and actions by LSPs in city logistics (e.g. Investment in public freight terminals, deregulation, Programming and modelling of scheduling, routing with ITS, so on)

Efficiency and environmental improvement

Aiming target (e.g. Kyoto Protocol)



# Decision-makings of Govt. and Logistics Service Providers: LSPs

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Necessary basis: all players perceive appropriate cost

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Clarification of cost responsibility by vehicle  
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terminals, deregulation, Programming and  
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*How should we levy taxes  
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# Highway cost as full cost

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- Social costs
  - Congestion cost
  - Environmental pollution costs
  - Highway investment cost, etc



# Highway cost as full cost

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- Social costs
  - Congestion cost
  - Environmental pollution costs
  - *Highway investment cost* ← Provision by govt.



# Highway cost as full cost

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- Social costs
  - Congestion cost
  - Environmental pollution costs
  - *Highway investment cost*
- Characteristics of highway
  - Essential production factor of city logistics
  - Social infrastructure for all generations



# Highway cost as full cost

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- Social costs
  - Congestion cost
  - Environmental pollution costs
  - Highway investment cost
- Characteristics of highway
  - Essential production factor of city logistics
  - *Social infrastructure for all generations*
- Necessary discussion
  - Appropriate highway stock for future generation
  - Appropriate tax payment level for highway investment of current generation



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- Policies by governments and actions by LSPs should be based on full cost



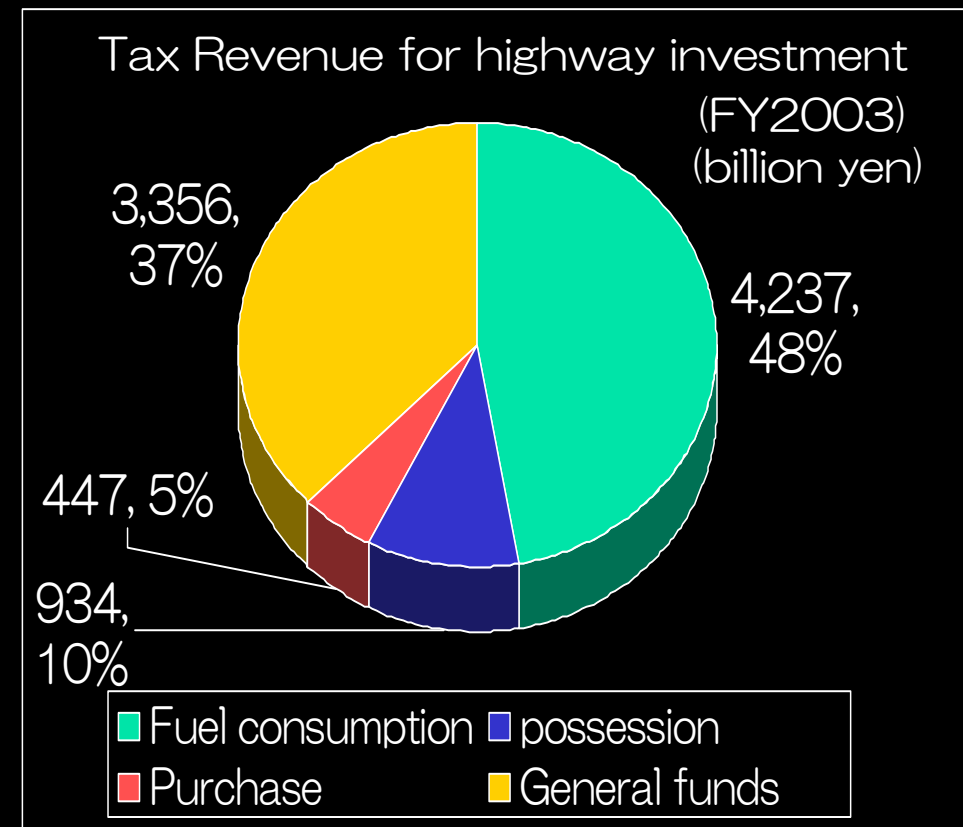
# Highway cost as full cost

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- Full highway cost cannot be recovered with MCP
  - ↓ but
- Highway is social infrastructure for all generations
  - ↓ so
- Policies by governments and actions by LSPs should be based on full cost
  - ↓ If so
- *How should we allocate full cost among vehicle*



# Current tax system

- Acceptable solution: Modifying tax rates of current system
- Current structure of tax revenue for highway investment in Japan
  - automobile-related taxes
    - Purchase: 5%
    - Possession: 10%
    - fuel consumption: 48%
  - Non automobile-related taxes: 37%



\* US\$ = about 115 JPN Yen



# Cost responsibility

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- 'Direct use' & 'privilege to use' of highway
- Simple evaluation standard
  - Cost responsibility closely related to direct use
  - Marginal cost: 'Fuel consumption'
  - Cost responsibility for the privilege to use
  - Except marginal cost: 'Purchase,' 'Possession' & non automobile-related taxes
- In the next sections, we clarify cost responsibility for direct use by vehicle type through estimation of cost structure in highway investment



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# Review of previous studies of cost structure <sup>24</sup>

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- A lot of studies are in the field of transportation industries and public utility industries
- In contrast, few studies of cost structure based on the econometrics approach in highway investment
- Moreover Cost allocation study (CAS) approach is adopted than the econometrics approach in highway investment



# Applying the CAS approach for<sup>25</sup> Japanese highway investment

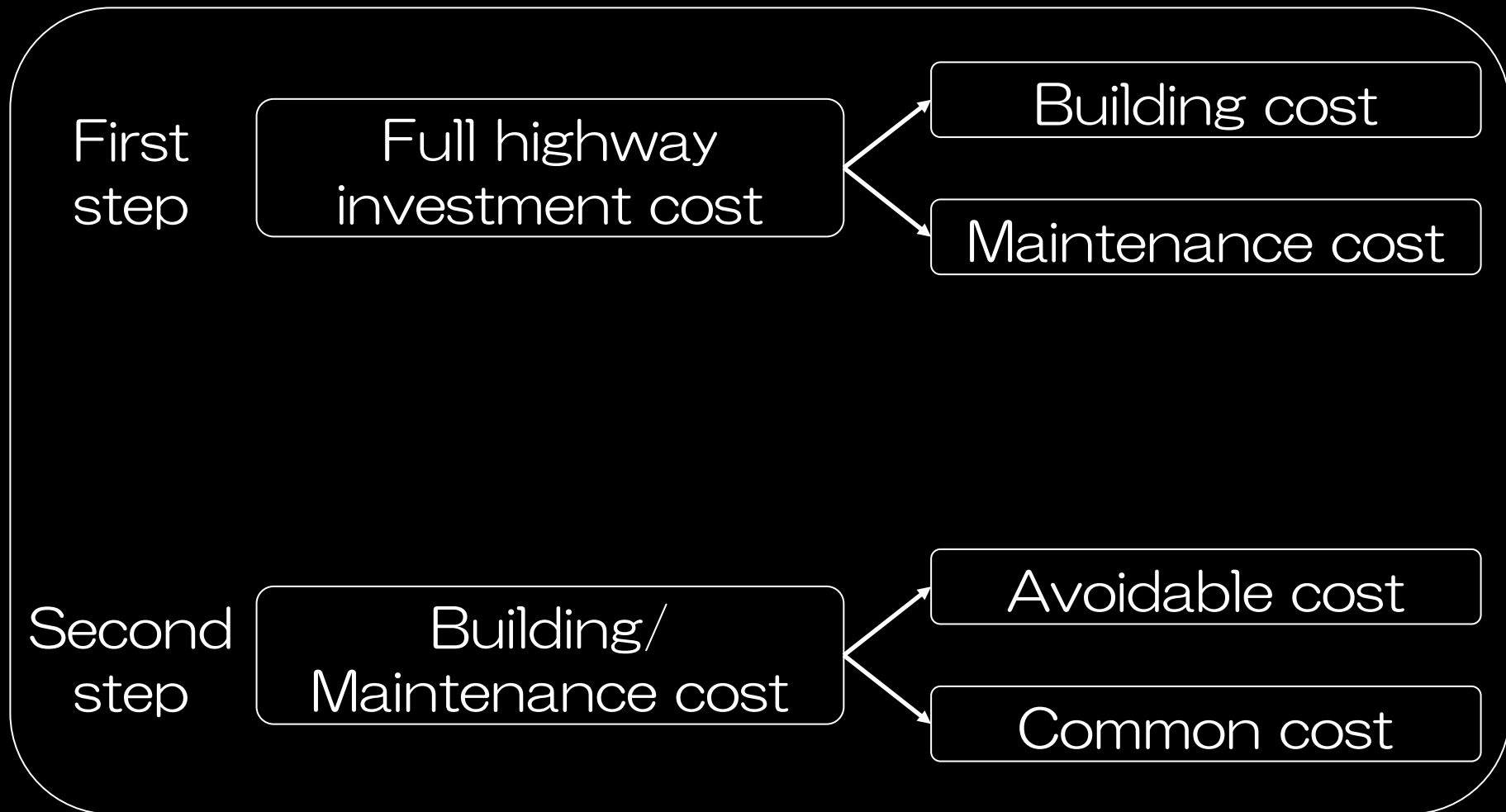
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- CAS approach
  - Merit
    - There are a lot of stock of studies
    - It is able to estimate stable results
  - Demerit
    - A large volume of data are required
    - Complicated programs are required
- Applying of the simple CAS approach
  - For Japanese highway investment
  - Using the estimation results from previous studies as the allocation bases



# Applying the CAS approach for<sup>26</sup> Japanese highway investment

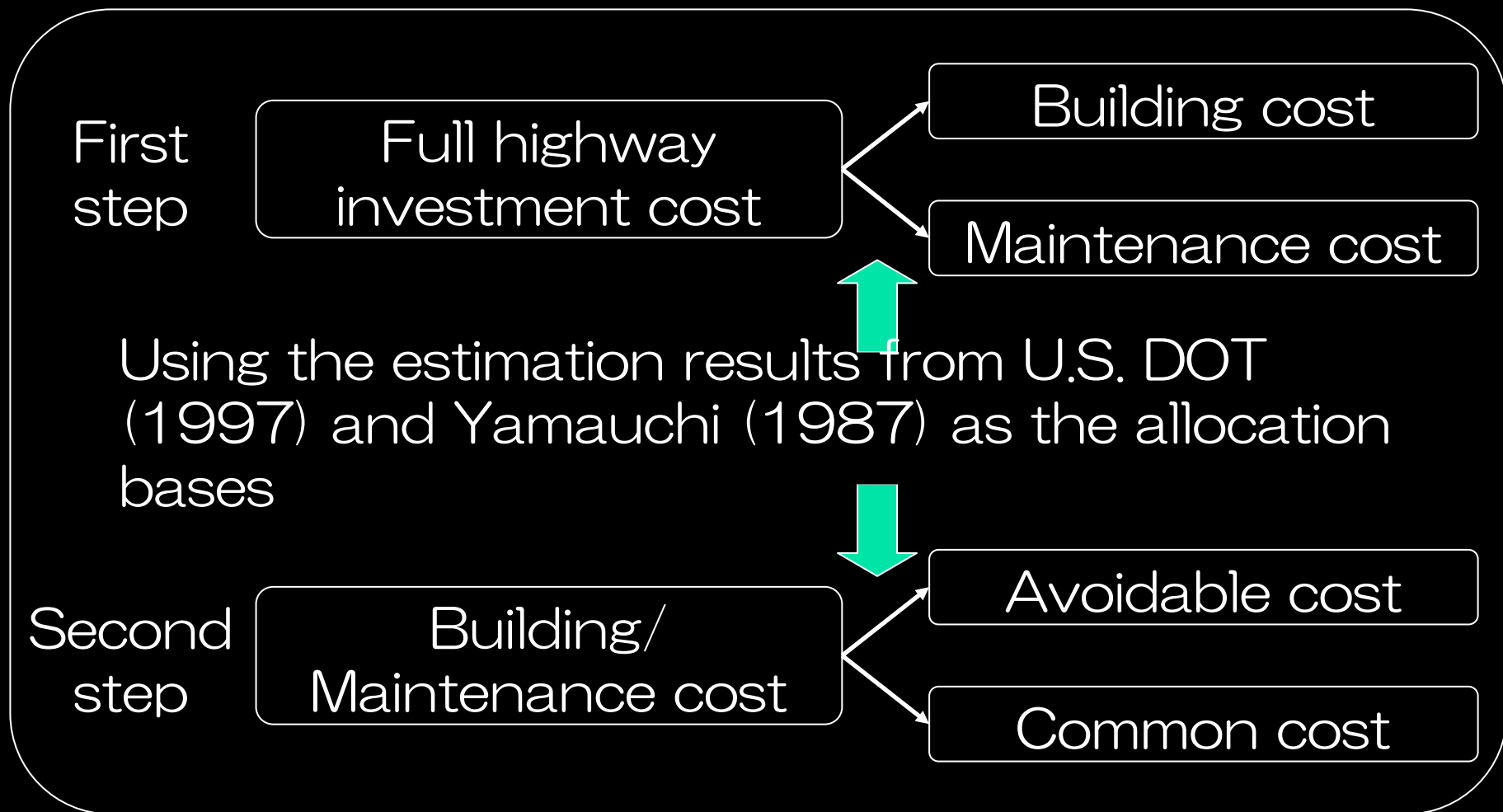
- Procedure of CAS approach





# Applying the CAS approach for<sup>27</sup> Japanese highway investment

## ■ Procedure of CAS approach





# Applying the CAS approach for<sup>28</sup> Japanese highway investment

## ■ Procedure of CAS approach



- U.S. DOT (1997) : federal highway in the United states
- Yamauchi (1987): expressway in Japan





# Applying of CAS approach for Japanese highway investment <sup>29</sup>

## ■ Allocation bases of CAS approach

Table 4 The allocation bases of avoidable cost among vehicle types

U.S. DOT (1997)	Cars	Single trucks	Combination trucks
Building cost (US dollar/vehicle-mile)	0.050 (1.00)	0.050 (1.00)	0.200 (4.00)
Maintenance cost (US dollar/vehicle-mile)	0.063 (1.00)	0.075 (1.19)	0.758 (12.03)
Yamauchi (1987)	Cars	Small trucks	Ordinary trucks
Building cost (Yen/vehicle-kilometer)	0.330 (1.00)	2.211 (6.70)	2.411 (7.31)
Maintenance cost (Yen/vehicle-kilometer)	3.103 (1.00)	5.581 (1.80)	8.411 (2.71)



# Applying of CAS approach for Japanese highway investment <sup>30</sup>

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# Applying of CAS approach for Japanese highway investment <sup>31</sup>

## ■ Estimation results

Table 5 Avoidable cost by vehicle type  
(yen/vehicle-kilometer: national mean value)

Allocation Bases	Avoidable cost	Cars	Small trucks	Ordinary trucks
U.S. DOT (1997)	Building cost	4.982	5.214	18.729
	Maintenance cost	0.695	0.849	8.255
	Total	5.677	6.063	26.985
Yamauchi (1987)	Building cost	6.125	6.374	10.572
	Maintenance cost	0.957	1.076	6.442
	Total	7.082	7.450	17.014
Current fuel tax payment level		6.456	6.356	8.105

Note: In addition to the avoidable costs, there is a common cost of 6,705,054 million yen. Current fuel tax payment level is estimated by Misui (2004).



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Yamauchi (1987)	Building cost	6.285	6.274	10.572
	Maintenance cost	0.57	1.076	6.442
	Total	7.082	7.400	17.014
Current fuel tax payment level		6.456	6.356	8.105

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# Econometrics approach

- *Summary of econometrics approach for highway investment cost*
  - The econometrics approach is based on the economic theory (cost function)
  - Cost function: cost is explained by output variables, factor price variables, network variables, and so on.
  - Few previous studies concerning the cost structure of highway investment (Levinson, Gillen, Kanafani and Mathieu (1996) etc)
  - This study is a basic study for the cost structure of highway investment and cost responsibility of LSPs (freight vehicle) in Japan



# Econometrics approach

- *Summary of econometrics approach of this study*
  - Purpose: estimating the cost structure of highway investment and clarifying the cost responsibility by vehicle type
  - Data: 47 local governments in Japan in 1999 fiscal year
  - Cost function: log linear cost function
  - Explained variable: investment cost
  - Explaining variables: vehicle kilometer by vehicle type (output), factor price, and network
  - Sign conditions: all coefficients are positive



# Econometrics approach

## ■ *Summary of variables*

Table 2 Unit of credit, simple mean value, and source

	Variable	Simple mean value
STC	Short-term total cost (building and maintenance cost, millions yen)	113,778
Vk <sub>a</sub>	Vehicle-kilometer of cars (millions km)	6,675
Vk <sub>st</sub>	Vehicle-kilometer of small trucks (millions km)	1,748
Vk <sub>ot</sub>	Vehicle-kilometer of ordinary trucks (millions km)	1,184
N	Network (thousands km)	3.871
P <sub>k</sub>	Capital cost (expenditure for bonds/outstanding local government bonds, %)	0.100
P <sub>l</sub>	Labor cost (thousands yen/person)	7,395
P <sub>m</sub>	Material cost (other cost/highway area, thousands yen/km <sup>2</sup> )	3,009,187

Note: Samples comprise data from 47 local governments. Factor prices are standardized on average.



# Econometrics approach

- *Estimation results: Short-term total cost*

$$\begin{aligned} \ln(STC) = & 7.203 + 0.292 \cdot \ln(Vk_a) + 0.140 \cdot \ln(Vk_{st}) + 0.006 \cdot \ln(Vk_{ot}) & \bar{R}^2 = 0.968 \\ & (13.178) \quad (2.117) & (1.092) \quad (0.076) \\ & + 0.599 \cdot \ln(N) + 0.141 \cdot \ln(P_k) + 0.327 \cdot \ln(P_l) + 0.951 \cdot \ln(P_m) \\ & (8.598) \quad (1.023) & (0.745) \quad (15.157) \end{aligned}$$

➡ Transforming to Marginal cost and Average cost



# Econometrics approach

- *Short marginal cost by vehicle type*

$$SMC_a = 1,344.04 \cdot 0.292 \cdot Vk_a^{-0.708} \cdot Vk_{st}^{0.140} \cdot Vk_{ot}^{0.006} \cdot N^{0.599} \cdot P_k^{0.141} \cdot P_l^{0.327} \cdot P_m^{0.951}$$

$$SMC_{st} = 1,344.04 \cdot 0.140 \cdot Vk_a^{0.292} \cdot Vk_{st}^{-0.860} \cdot Vk_{ot}^{0.006} \cdot N^{0.599} \cdot P_k^{0.141} \cdot P_l^{0.327} \cdot P_m^{0.951}$$

$$SMC_{ot} = 1,344.04 \cdot 0.006 \cdot Vk_a^{0.292} \cdot Vk_{st}^{0.140} \cdot Vk_{ot}^{-0.994} \cdot N^{0.599} \cdot P_k^{0.141} \cdot P_l^{0.327} \cdot P_m^{0.951}$$

- *Short average cost by vehicle type*

$$SAC_a = 1,344.04 \cdot (Vk_a^{0.292} - 1^{0.292}) \cdot Vk_{st}^{0.140} \cdot Vk_{ot}^{0.006} \cdot N^{0.599} \cdot P_k^{0.141} \cdot P_l^{0.327} \cdot P_m^{0.951} / Vk_a$$

$$SAC_{st} = 1,344.04 \cdot Vk_a^{0.292} \cdot (Vk_{st}^{0.140} - 1^{0.140}) \cdot Vk_{ot}^{0.006} \cdot N^{0.599} \cdot P_k^{0.141} \cdot P_l^{0.327} \cdot P_m^{0.951} / Vk_{st}$$

$$SAC_{ot} = 1,344.04 \cdot Vk_a^{0.292} \cdot Vk_{st}^{0.140} \cdot (Vk_{ot}^{0.006} - 1^{0.006}) \cdot N^{0.599} \cdot P_k^{0.141} \cdot P_l^{0.327} \cdot P_m^{0.951} / Vk_{ot}$$



# Econometrics approach

- *Estimation results*

Table 3 Marginal cost and average cost by vehicle type  
(yen/vehicle-kilometer: national mean value)

	Cars	Small trucks	Ordinary trucks
Marginal cost	5.191	8.937	0.679*
Average cost	16.326	40.997	4.464*
Current fuel tax payment level	6.456	6.356	8.105

Note: Long-term cost of ordinary trucks and short-term cost of cars have low t-values. Current fuel tax payment level was estimated by Misui (2004).



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# Conclusion

## ■ *Policy implication*

- CAS approach
  - Required changes of tax level:  
Small truck: 17% up, Ordinary truck: 110% up
- Econometrics approach
  - there are economies of scale in the whole country

## ■ *Future issue*

- Sophistication of econometrics analysis
- Focusing the object of analysis from the whole country to city area
- Consideration of highway investment in long-term



*Thank you for your attention*

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