Modeling Non-CO2 Gas Emission Regulations: Korea's Automobile Oil Program

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The Economic Impact of Strengthening Fuel Quality Regulation

– Reducing Sulfur Content in Diesel Fuel

Motivation

- Improving Air Quality
  - Regulation: Aggregate Limit, Car Emission Standard, Fuel Quality
- Economic Impact of Strengthening Fuel Quality Regulation
  - Cost-effective regulation to achieve given air quality target
- Minimization of Economic Loss
  - Minimizing the inflation and GDP Loss due to Fuel Quality Regulation

Background

- Transportation Sector's Air Pollutant Emission: 55.8%
  - Cars & Trucks: 42.2% (1999)
- Diesel: 41.1% of Transportation Energy
  - 2001 Diesel(41.1%), Gasoline(27.1%)
- Diesel Cars: 30.7% of Total Cars
- Diesel Cars: 51.8% of Car Emission
  - Diesel Cars(51.8%), Gasoline Cars(48.2%)

Assumption I

- Aggregate Limit: 2007 Emission Level
  - 2007 EURO4 & ULEV Emission Level
- Sulfur Content Scenario for Target
  - 2007 all at once: 430 → 50ppm
  - 2007 all at once: 430 → 15ppm
  - Gradual Transition: 2007: 50ppm, 2010:15ppm

Assumption II

- Automobile Emission Standard
  - New Cars: EURO4 Standard from 2007
- Emission Trade
  - Optimal Market Price for Emission
- Others considered
  - Allow for Emission Reduction in Existing Cars through Fuel Quality Improvement
  - 15ppm diesel: emission less than in EURO4

Assumption III

- Additional Investment Cost for Reducing Sulfur Content
  - 2007 50ppm: 824.1Bwon
  - 2007 15ppm: 3,964.9 Bwon
  - Gradual Transition: 2007: 824.1Bwon, 2010: 3,140.8Bwon
- Investment Cost for EURO4 New Cars
  - Additional Cost for new cars: 910.0Bwon

Model I

- Computable General Equilibrium(CGE)
  - Setting up Emission Level
  - New Car (A) ⟷ Old Car+ E-Trade (B)

    ⇧ ⇧

    Transportation Service

    (A) < (B): Promoting new cars & high quality fuel

    ⇧ ⇧

    Supply new car & fuel ⇧ production cost

    ⇧ Price increase in cars & fuels

    ⇧ Price increase in other goods & services

    high inflation & low competitiveness

Model II

- Model Description
  - Period: 2007 ~ 2012
  - Pollutants: CO, HC, NOx, PM
  - Industries: Petroleum, Transportation Services, Automobile, Others

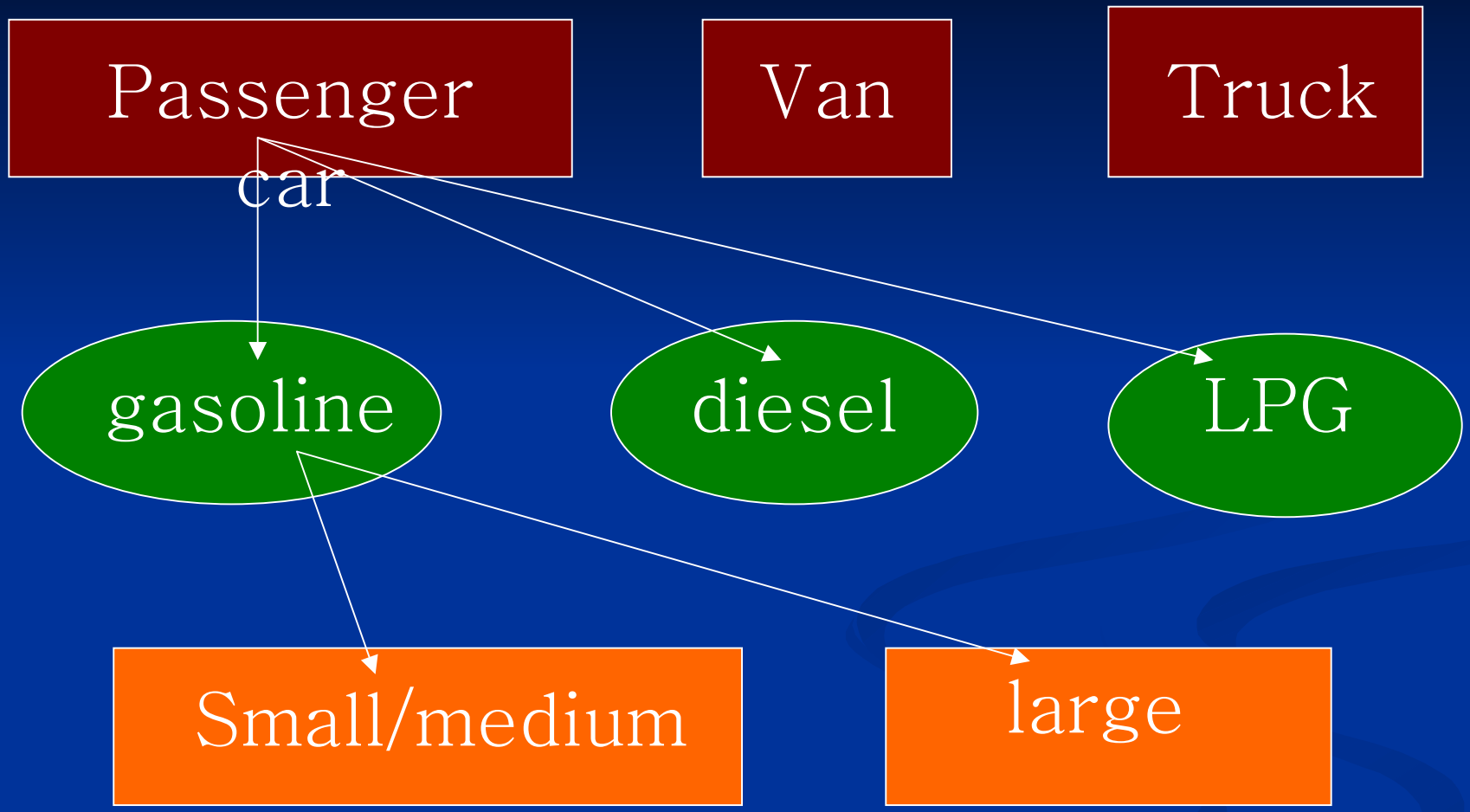
    Petroleum: Gasoline, Diesel, LPG, others

    Automobile: passenger car, van, truck

    gasoline, diesel, LPG

    small/medium, large
  - Production: Labor, Capital, Energy, Intermediary goods

→ Profit Maximization


Passenger car
Van
Truck
gasoline
diesel
LPG
Small/medium
large

Model III

- Consumption Sector

$$\text{Max } U(C_t) = \sum \beta^t C_t^{1-\theta}/(1-\theta)$$

Subject to

$$\sum P_{ao}AO + \sum P_y Y + \sum P_k I = \sum WL + \sum P_k K + \sum Tr$$

$$C_t = [\alpha AO_t^{\rho} + (1-\alpha)Y_t^{\rho}]^{1/\rho}$$

$$AO = [a_1 PRI^{\rho a} + a_2 PUB^{\rho a} + a_3 FRE^{\rho a}]1/^{\rho a}$$

$$PRI = [b_1 GSLS^{\rho b} + b_2 DSLS^{\rho b} + b_3 LPGS^{\rho b}]^{1/\rho b}$$

$$DSLS = [c_1 BIG^{\rho c} + c_2 SMALL^{\rho c}]^{1/\rho c}$$

$$BIG = [d_1 CON^{\rho d} + d_2 NEW^{\rho d}]^{1/\rho d}$$

$$CON = [e_1 CFS^{\rho e} + e_2 LFS^{\rho e}]^{1/\rho e}$$

Model IV

- Production Sector
  - Final Goods

    $Y=[\gamma_1 KLE^{\rho y}+\gamma_2 XA^{\rho y}]^{1/\rho y}$

    $KLE= K^{\eta}L^{\xi}E^{1-\eta-\xi}$
  - New Car and New low sulfur diesel

    $Y_{new}=[\gamma_n KLE^{\rho n}+\gamma_n XA^{\rho n}]^{1/\rho n} + K_{new}$
  - Oil Products

    $E=[\gamma_{e1} GSL^{\rho e}+\gamma_{e2} DSL^{\rho e}+\gamma_{e3} LPG^{\rho e}$

    $+\gamma_{e4} OIL^{\rho e}+\gamma_{e5} CRUD^{\rho e}]^{1/\rho e}$
  - Capital Stock

    $K_{t+1} = (1-\delta)K_t + I_t$

Result I

- Emission Trading Permit Price (won/ton)

		2007	2010	2012
50PPM	CO	808,550	555,650	489,360
	HC	1,177,190	859,150	871,770
	NO x	1,266,170	1,073,470	1,040,770
	PM	1,942,620	1,445,140	1,383,840
15PPM	CO	684,290	417,560	366,860
	HC	814,910	567,740	564,700
	NO x	965,680	779,610	751,130
	PM	1,428,390	1,051,820	1,000,130
50PPM + 15PPM	CO	807,270	416,570	365,730
	HC	1,156,330	552,720	545,190
	NO x	1,250,810	768,250	736,840
	PM	1,889,690	1,009,040	947,000

Result II

- Emission Reduction Cost & GDP Loss

	50ppm	15ppm		50ppm+ 15ppm	
	To BAU	To BAU	To 50ppm	To BAU	To 50(07-09) &15(10-)
Reduction Cost	283.9 Bwon	1,540.7 Bwon	-543.2 Bwon	1,781.3 Bwon	-302.7 Bwon
GDP Loss	4,037.3 Bwon	7,146.4 Bwon	3,109.1 Bwon	5,768.4 Bwon	-142.8 Bwon
Net Loss			2,565.9 Bwon		-445.4 Bwon

Result III

- 50ppm vs 15ppm
  - 15ppm improves fuel quality -543.2Bwon
  - GDP loss due to cost increase 3,109.1Bwon
  - net loss difference ⇒ 2,565.9Bwon
- 50&15ppm vs 15ppm
  - Gradual Transition: reduction cost down -302.7 Bwon
  - GDP loss down -142.8Bwon
  - Net loss difference ⇒ -445.4Bwon

Result IV

- TAX RECYCLING
  - Double Dividend: laying a tax on pollutants and using the revenues to stimulate the economy, We can seek environmental protection & economic growth simultaneously
  - Using tax revenues to support the petroleum industry, the model can trace out changes in GDP loss over scenarios

Result V

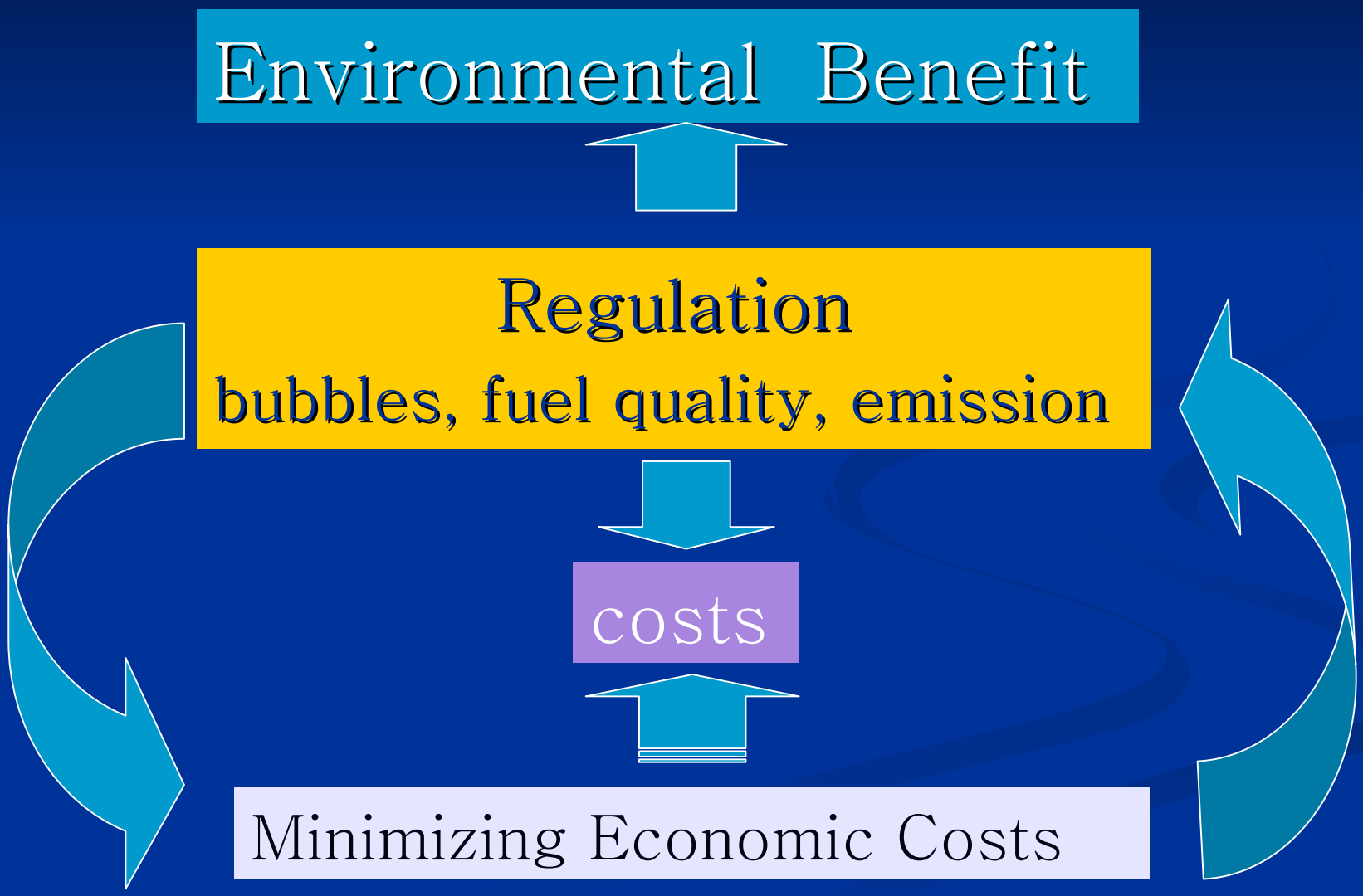
- TAX RECYCLING Effect

	50ppm	15ppm	50&15ppm
GDP loss	4,037.3Bwon (GDP 0.58%)	7,146.4Bwon (GDP 1.03%)	5,768.7Bwon (GDP 0.82%)
Tax Recycling GDP loss	1,648.0Bwon (GDP 0.24%)	5,952.9Bwon (GDP 0.86%)	4,052.0Bwon (GDP 0.56%)
Difference	2,389.3Bwon (-0.35%p)	1,193.5Bwon (-0.17%p)	1,716.3Bwon (-0.25%p)

Result VI

- TAX RECYCLING Effect
  - Tax Recycling system reduces GDP loss by 0.35%p in 50ppm, 0.17%p in 15ppm & 0.25%p in 50/15ppm compared to effect without tax recycling system
  - It is important to prepare an alternative to minimize negative economic impact, together with environmental benefits.

Policy Implication I



Policy Implication II

- Environmental Benefit & Regulation Cost
  - Given environmental target, 50ppm is better than 15ppm to minimize negative impact (net GDP loss)
  - Gradual transition or step-by-step approach to improve fuel quality is more cost-effective than rapid change.

Policy Implication III

- Time for introduction of 50ppm
  - Things to be considered
    - Automobile Technology
    - Experiences in other countries
    - Additional costs in petroleum industry
    - Additional CO2 emission in processing
    - Transportation, distribution, storage costs
  - Interim target: 2007
    - Consider experiences in Japan and EU

Policy Implication IV

- Active Response of government to Regulation Impact
  - Fuel quality regulation leads to economic costs
  - Government fiscal policy to reduce the impact
- TAX RECYCLING
  - Using tax revenue to reduce the economic costs
  - Compensation for GDP loss
  - Direct subsidy to petroleum industry?