Analyzing The Impact of Construction Industry Under Potential Carbon Regulation Policies

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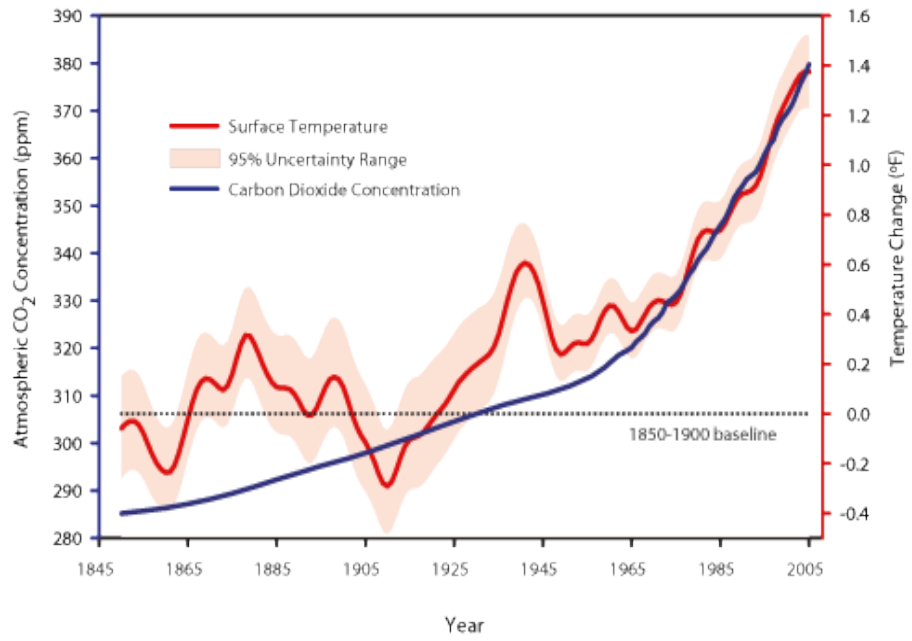
Outline

1. Research Background
2. Global Carbon Policies
3. Model Setup
4. Empirical Analysis
5. Conclusion

1. Climate Change Basic

Atmospheric CO_2 & Global Surface Temperature Trends

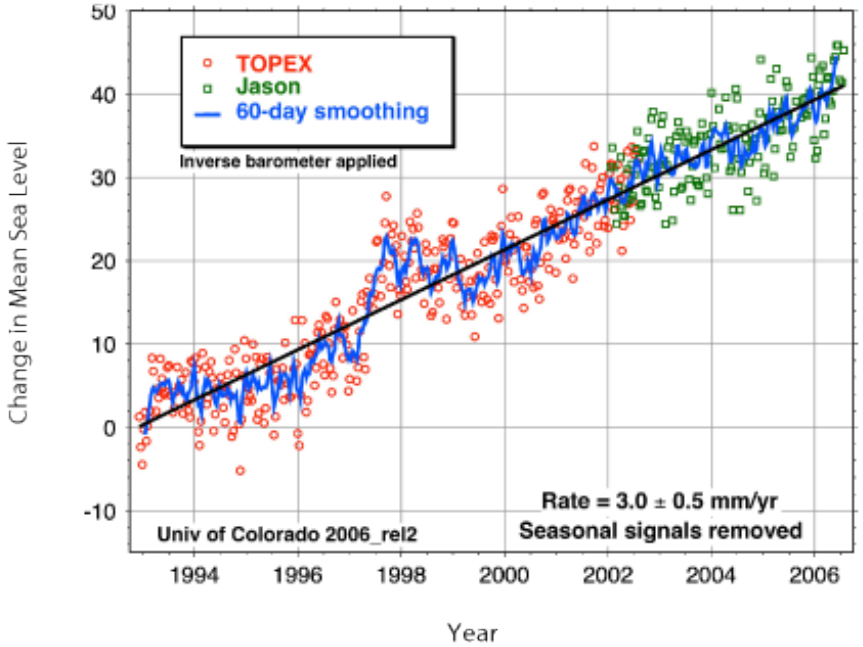
1800 - 2005



Source of CO_2 Concentration data: Keeling, C.D. and T.P. Whorf. 2005. Atmospheric CO_2 records from sites in the SIO air sampling network. In Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. DOE, Oak Ridge, Tenn., U.S.A.

Source of Temperature data: Brohan, P., J. J. Kennedy, I. Haris, S. F. B. Tett, and P. D. Jones. 2006. Uncertainty estimates in regional and global observed temperature changes: a new dataset from 1850. Journal of Geophysical Research 111: D12106, doi:10.1029/2003JA009974.

Mean Sea Level Rise



Graph Source: Cazenave, A., and R. S. Nerem (2004), Present-day sea level change: Observations and causes, Rev. Geophys., 42, RG3001, doi:10.1029/2003RG000139.

No Matter You Believe or Not,

Carbon Regulation is Underway.

Federal Level: EPA Formally Announces Phase-in of Clean Air Act Permitting for Greenhouse

State and Local Level: Carbon markets and tax have been established and are being developed

- RGGI, WCI, and MGGRA
- CO and MD carbon tax

Other Legislative Efforts

2. Global Carbon Policies

- **Carbon Tax**
- A tax levied on carbon dioxide emissions from fossil fuels
- A price instrument

- **Emission Standards (Command-and-Control)**
- The government regulates all activities' carbon emission up to a certain amount of number, and strictly implements for all units.
- A quantity instrument

- **Cap And Trade**
- Set an overall limits on fossil fuel emissions, requires firms to purchase permits to discharge carbon emission, and establishes a market in those permits. The transfer of permits is referred to as a trade.
- A quantity instrument

- **Others**

Should the AEC Industry Care?

Table GHG emissions in the construction industry

Sectors	Data	GHG Emission (MMTCO2e)	% of US Emissions	Data Source
Construction Site Fossil Fuel Combustion Purchased Electricity	2002	131① 100 31	1.7%	EPA
Upstream – Material Processing				
Cement Combustion related CO_2 Cement Production related CO_2	2001	76.9② 35.5 41.4	1.1%	EIA
Iron and steel	2002	20.2③	0.3%	EIA, USGS
Limestone	2006	19.6	0.3%	EIA
Construction – Life Cycle	2002	498④	7.2%	CMU-GDI
Buildings	2002	2236	32.2%	DOE

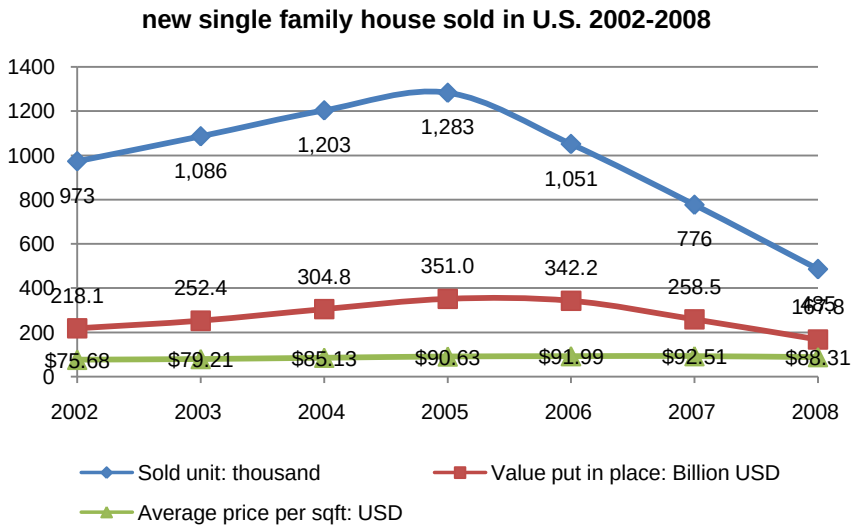
Sources: ①(U.S. EPA 2008); ②(Hanle 2004); ③(US Geological Survey 2002); ④(Hendrickson and Horvath 2000).

How will the AEC industry be affected?

- **industrial production and capacity** (output, unit price, etc)
- **Industrial Structure** (market share, emission reduction contribution)
- **Individual Firm's reaction** (technology v.s. production strategy)
- **Impact on consumers** (sharing of carbon price)

3. Model Setup

- Full Competition V.S. Monopoly
- Market Driven V.S. Cost Driven
- Construction Sectors
- Product Indifference



- Industrial Production (Unit Selection)
- Dynamic V.S. Stationary
- Data Source (Census, Economic Report Of The President, NAHB Survey, Chicago Climate Exchange, IPCC)

Duopoly Competition Model ---- Without Carbon Policy

Building Supplier

Construction Company 1

Construction Cost C1(q1)

Decision Variable q1

Maximize Total Profit
Π1=p1(q1+q2)-C1

Construction Company 2

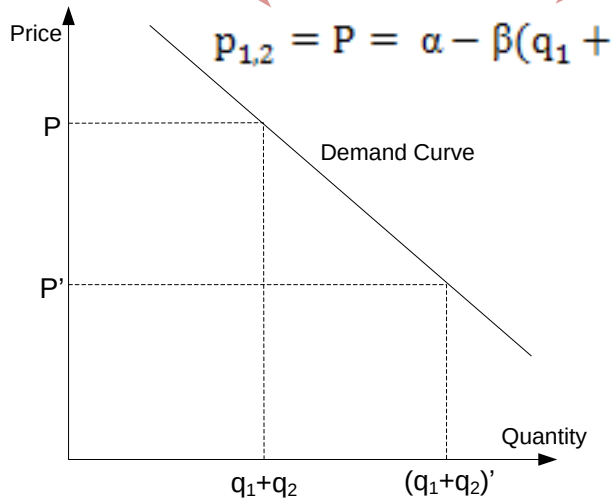
Construction Cost C2(q2)

Decision Variable q2

Maximize Total Profit
Π2=p2(q1+q2)-C2

Building Market Demand

$$p_{1,2} = P = \alpha - \beta(q_1 + q_1)$$



Improved Model

- **Consider Carbon Policy**
  - **Carbon Cost**
    - **Cp1**
    - **Cp2**
  - **Technology Investment**
    - **Ct1**
    - **Ct2**

Environmental and Social Externality

- **Carbon emission does not influence companies' cost and revenue structure.**
- **Impact the society and environment.**

Carbon Regulation Based Duopoly Model

Building Supplier

Construction Company 1

Construction Cost C1(q1)

Carbon Cost Cp1(e1)

Technology Cost Ct1(e1)

Decision Variable q1,e1

Maximize Total Profit

$\Pi 1=p1(q1+q2)-C1-Cp1-Ct1$

Construction Company 2

Construction Cost C2(q2)

Carbon Cost Cp2(e2)

Technology Cost Ct2(e2)

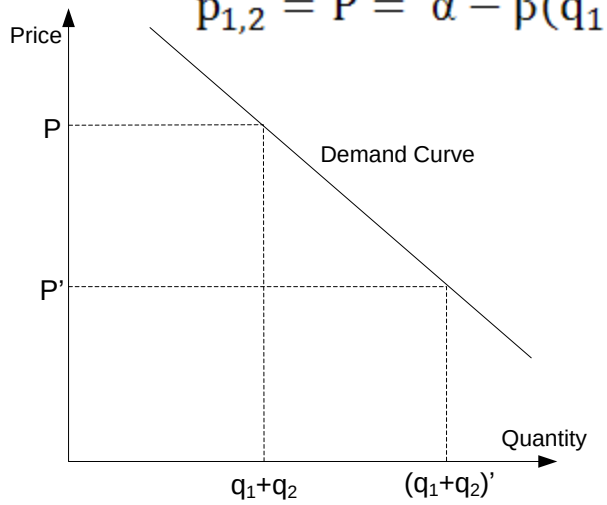
Decision Variable q2,e2

Maximize Total Profit

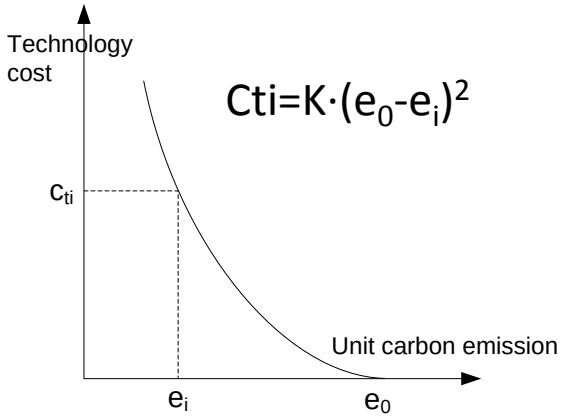
$\Pi 2=p2(q1+q2)-C2-Cp2-Ct2$

Building Market Demand

$$p_{1,2} = P = \alpha - \beta(q_1 + q_2)$$



✓ Technology Cost Cti



✓ Carbon Cost Cpi

Carbon Policy	Carbon Cost C_{pi}
Carbon Tax	Cpi=μ·(ei·qi), μ: the tax rate
Emission Standard	Cpi= M·(ei·qi-θ·e0·q0) M: positive infinite if ei·qi≥θ·e0·q0 Otherwise, 0 θ: emission standard
Cap and Trade	Cpi= C·(ei·qi-θ'·e0·q0) C: market carbon trading price Θ': emission cap

Model Solvability

Company 1:

$$\max \Pi_1 = [\alpha - \beta(q_1 + q_2)] * q_1 - (\gamma_1 * q_1) + \mu * (e_1 * q_1) + F(e_1))$$

s.t. $q_1 \geq 0, e_1 \geq 0$

Company 2:

$$\max \Pi_2 = [\alpha - \beta(q_1 + q_2)] * q_2 - (\gamma_2 * q_2 + \mu * (e_2 \cdot q_2) - F(e_2))$$

s.t. $q_2 \geq 0, e_2 \geq 0$

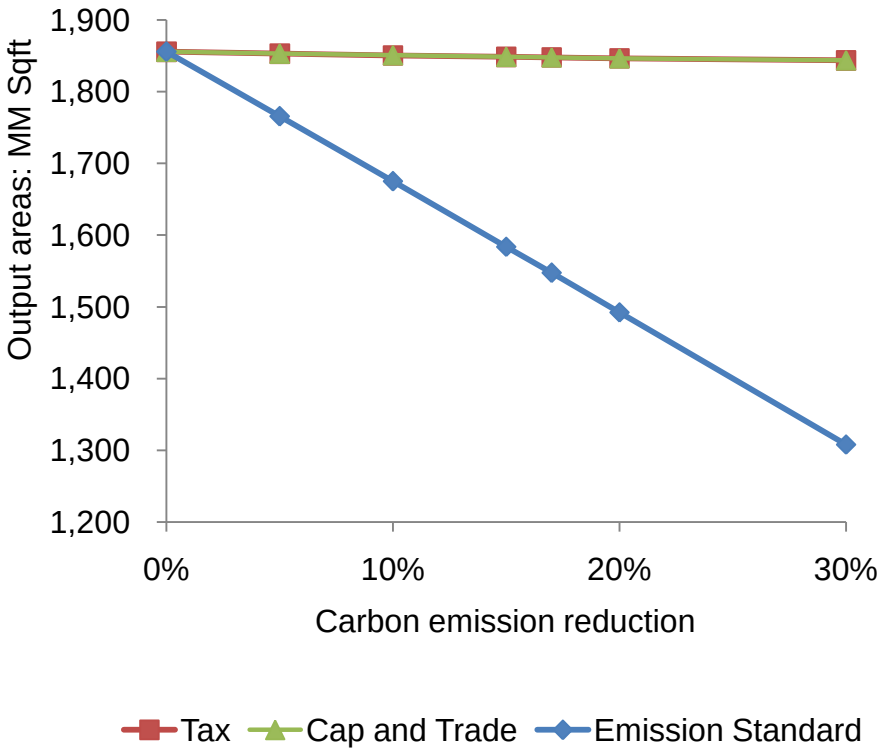
After proving its optimality sufficient by KKT conditions, we solve the problem using Non-linear Complementary Problem(NCP):

$$0 \leq \begin{pmatrix} q_1 \\ e_1 \\ q_2 \\ e_2 \end{pmatrix} \perp G \begin{pmatrix} q_1 \\ e_1 \\ q_2 \\ e_2 \end{pmatrix} = \begin{pmatrix} 2\beta q_1 + \beta q_2 - \alpha + \gamma_1 + \mu * e_1 \\ \alpha_p * q_1 + F'(e_1) \\ 2\beta q_2 + \beta q_1 - \alpha + \gamma_2 + \mu * e_2 \\ \alpha_p * q_2 + F'(e_2) \end{pmatrix} \geq 0$$

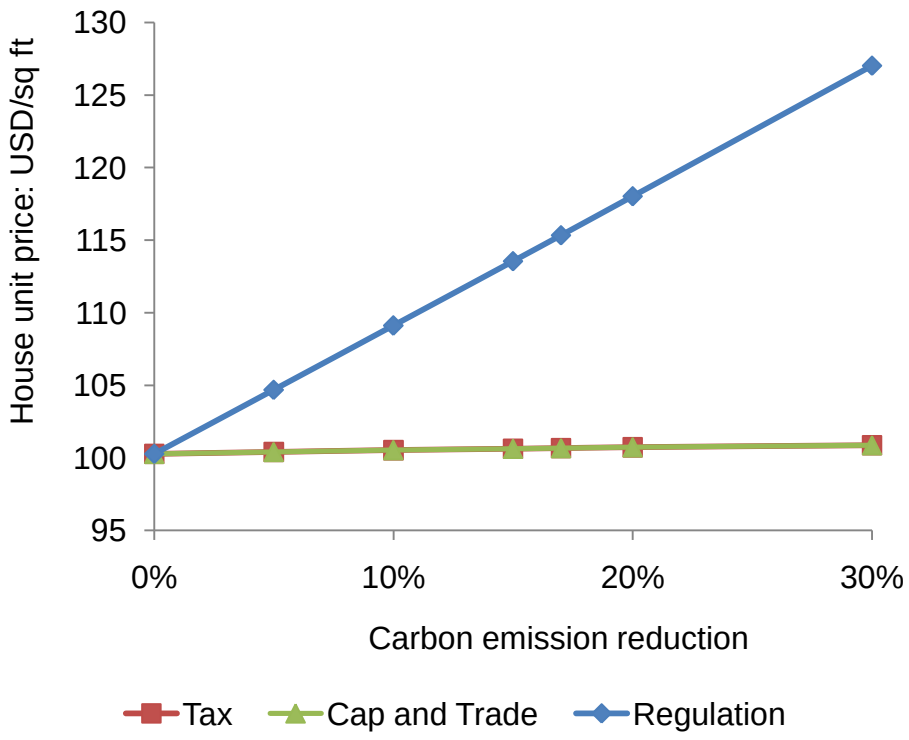
4. Empirical Analysis

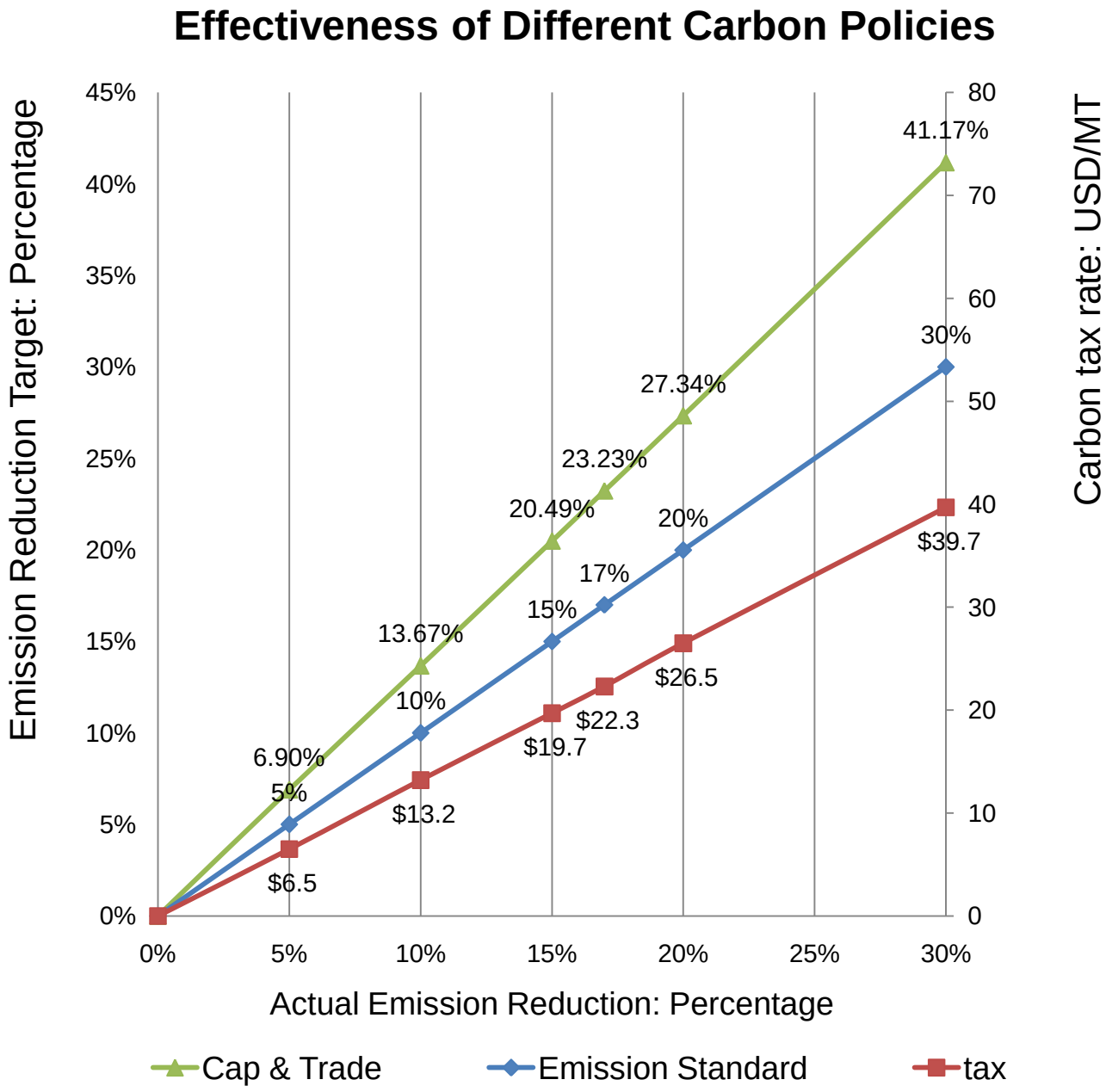
Different Policies Impact On The Industrial Production

Construction industry total production



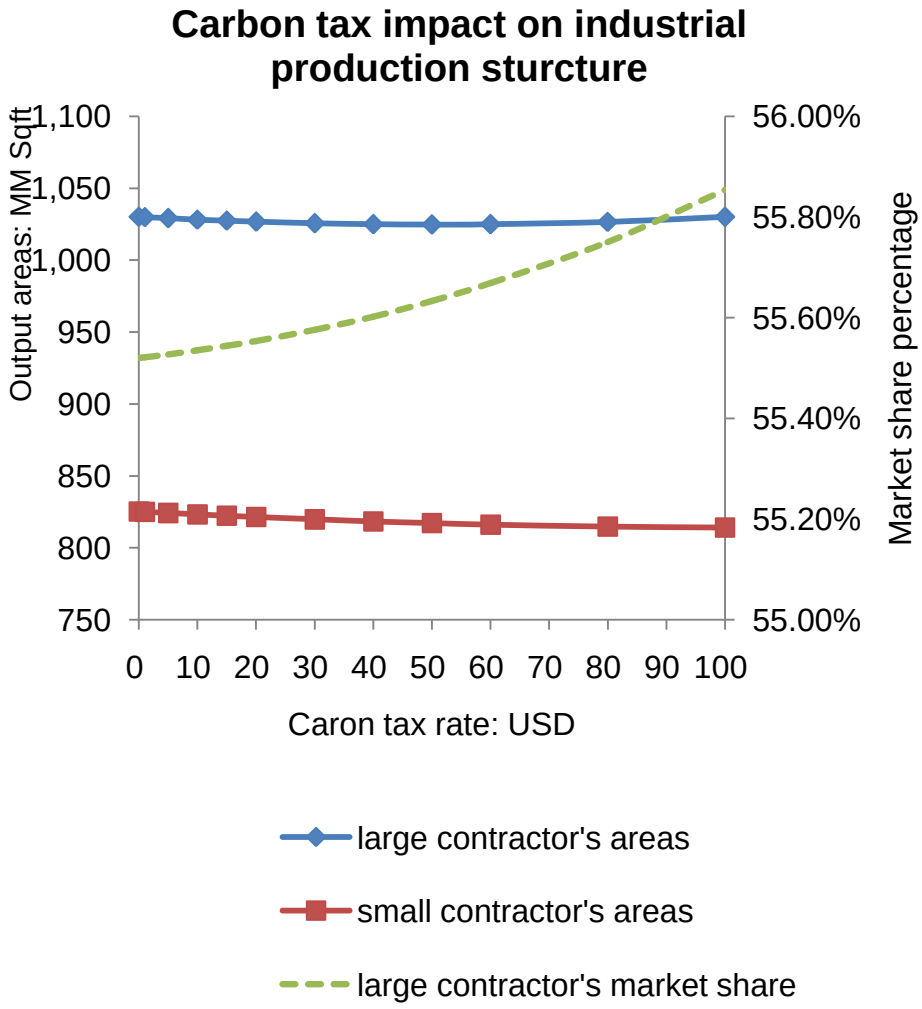
House market price

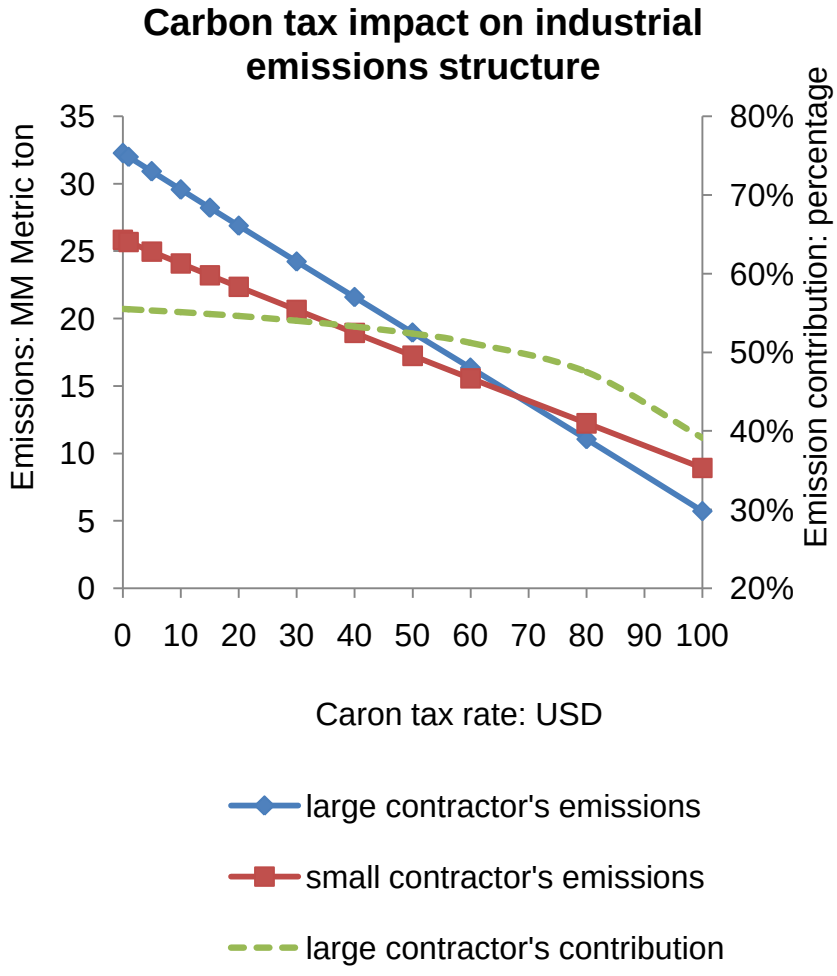



Effectiveness of Different Carbon Policies
Emission Reduction Target: Percentage
Carbon tax rate: USD/MT
Actual Emission Reduction: Percentage
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
80
70
60
50
40
30
20
10
0
0%
5%
10%
15%
20%
25%
30%
41.17%
27.34%
23.23%
20.49%
13.67%
6.90%
30%
20%
17%
15%
10%
5%
$39.7
$26.5
$22.3
$19.7
$13.2
$6.5
Cap & Trade
Emission Standard
tax

Different Policies Impact On Industrial Structure

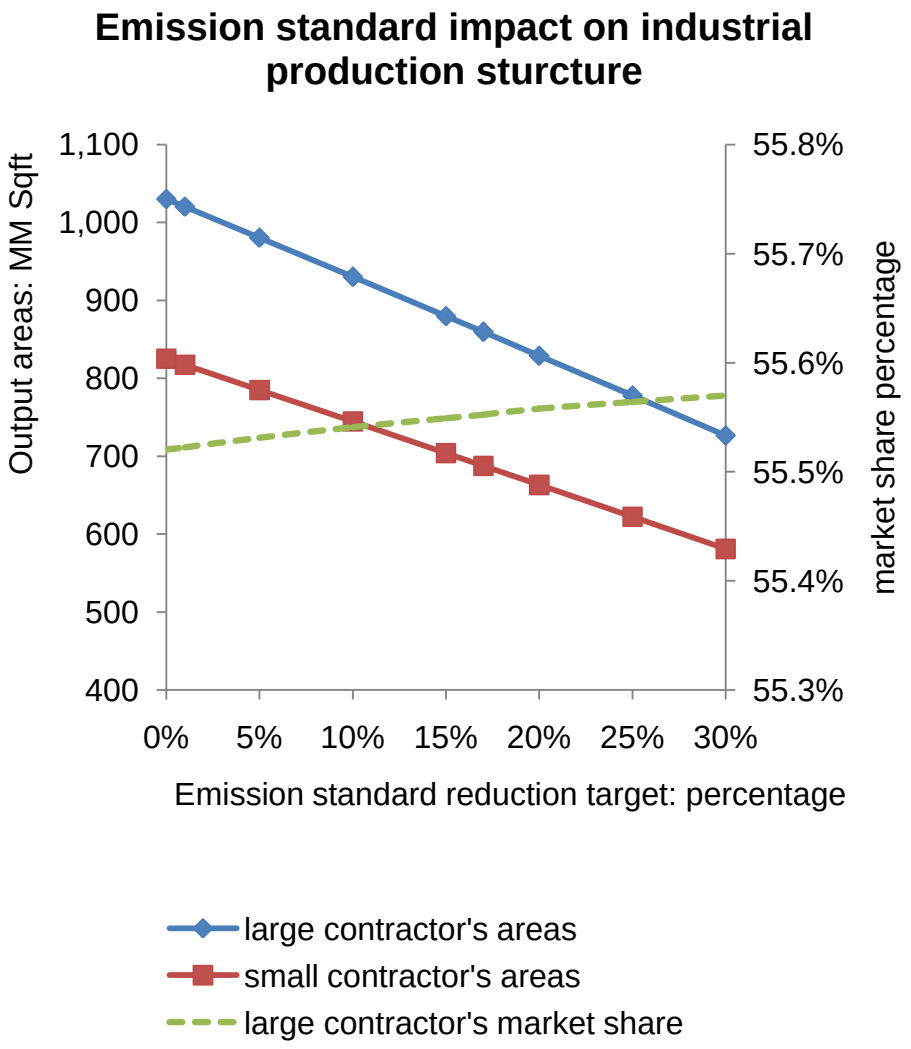
Carbon Tax

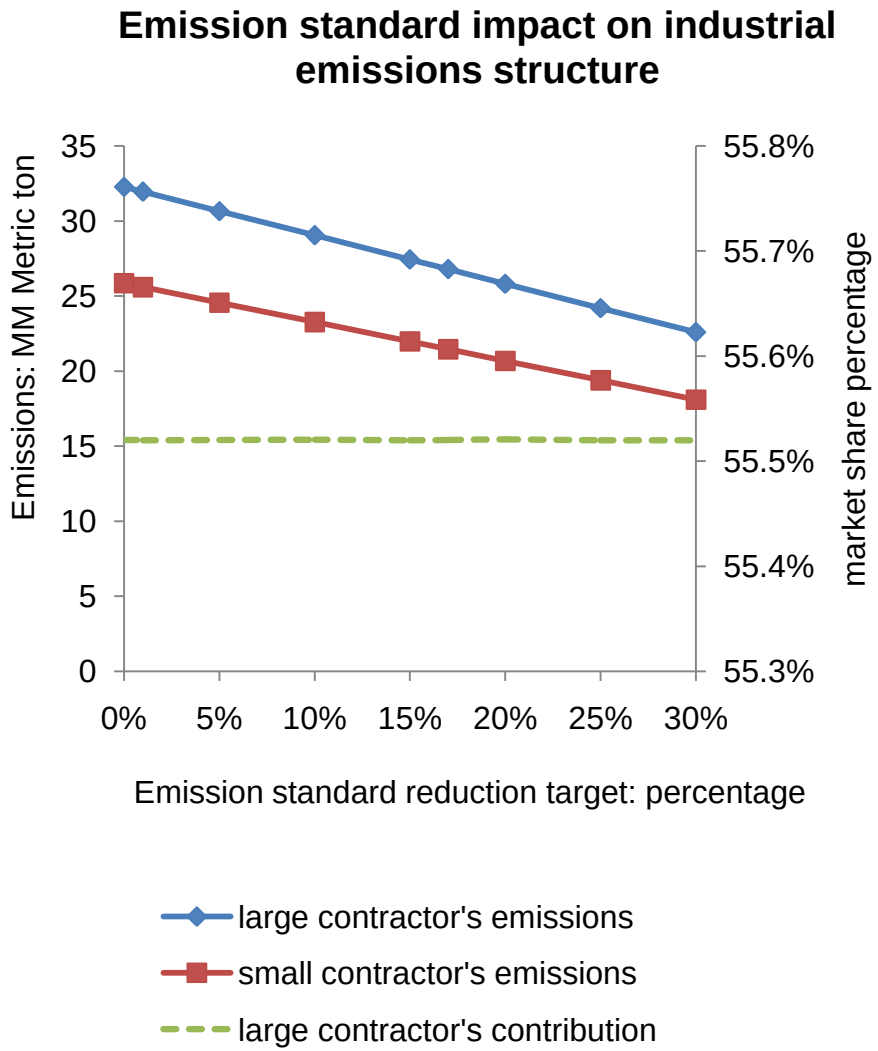




Different Policies Impact On Industrial Structure

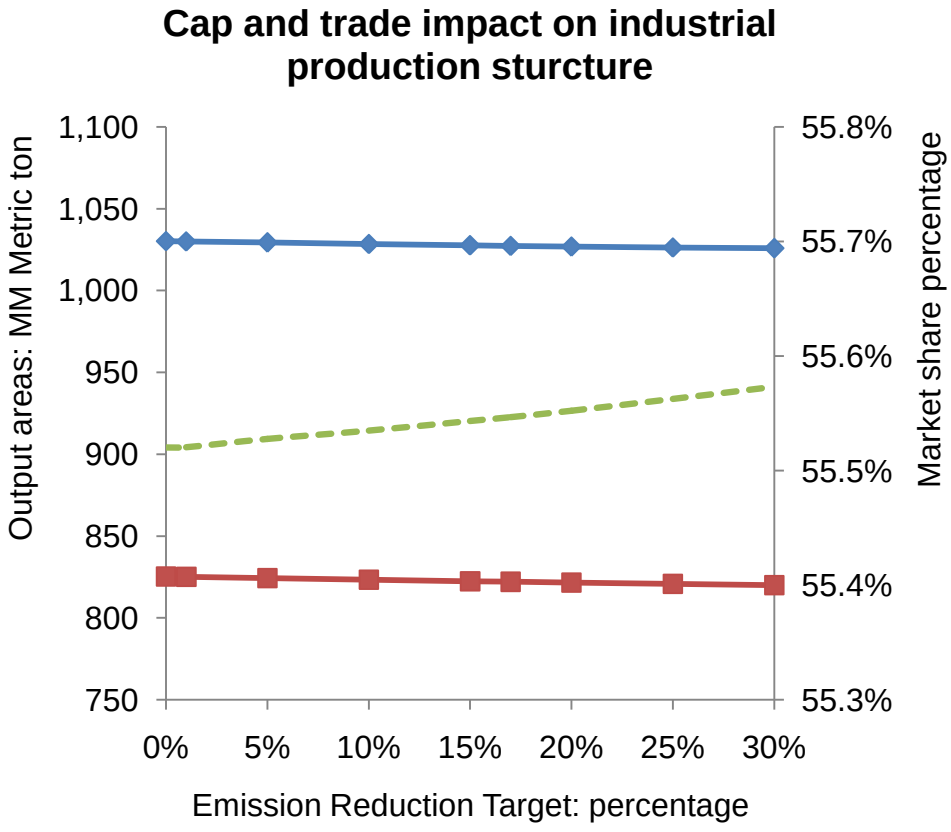
Emission Standard

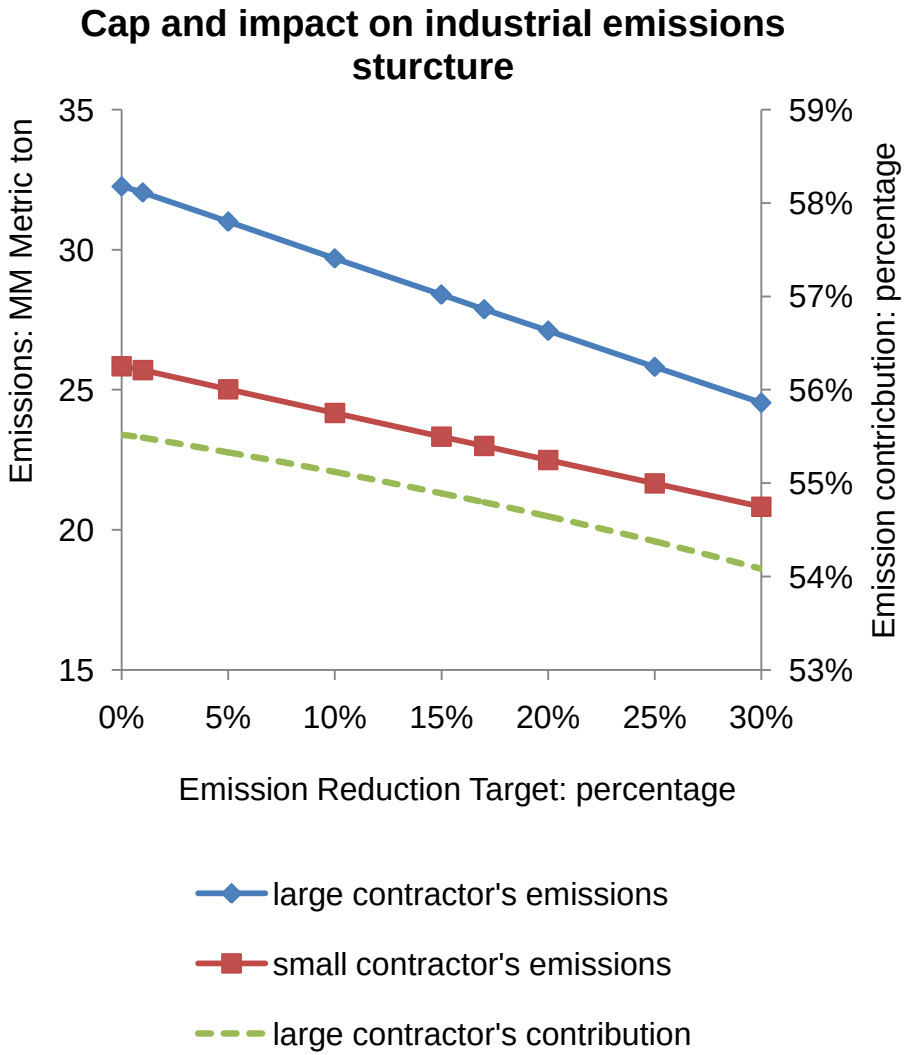




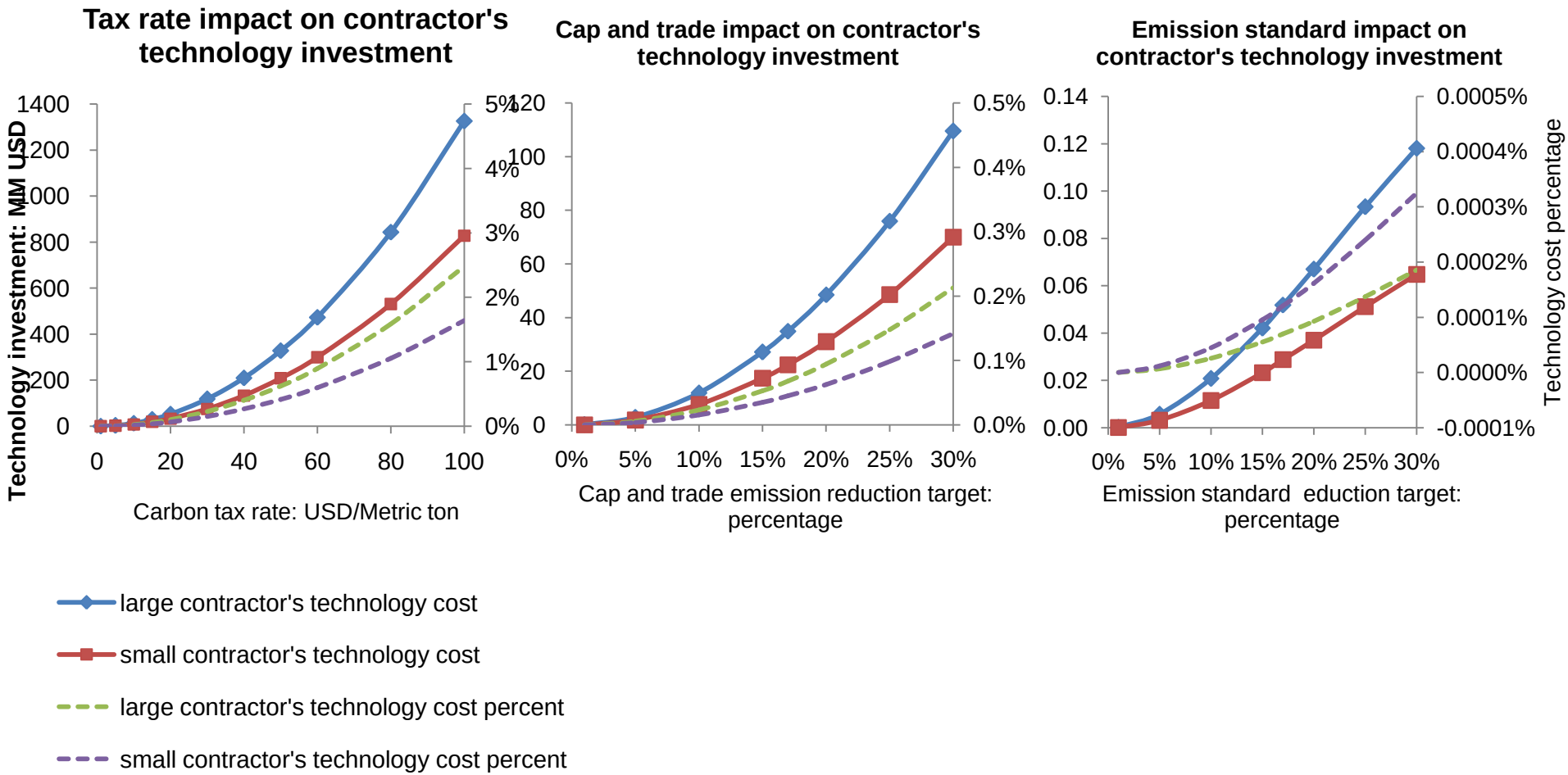
Different Policies Impact On Industrial Structure

Cap and Trade

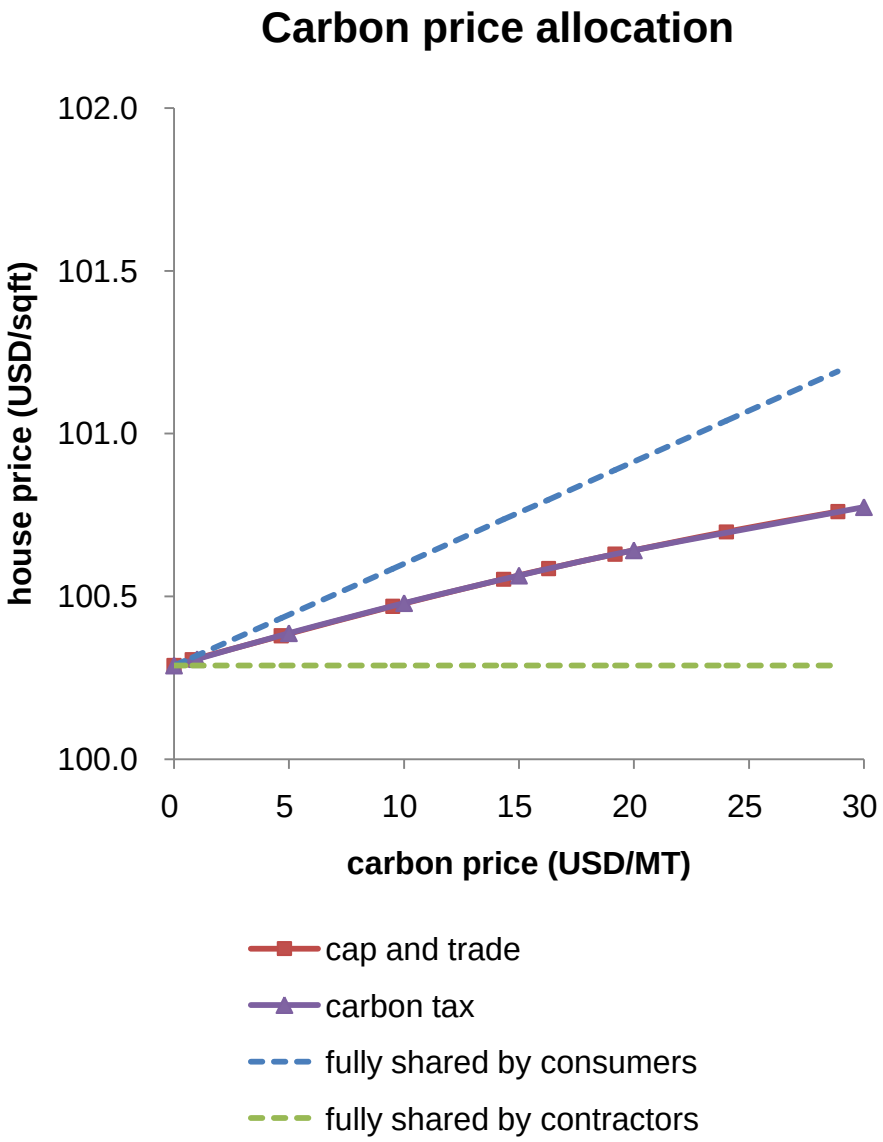


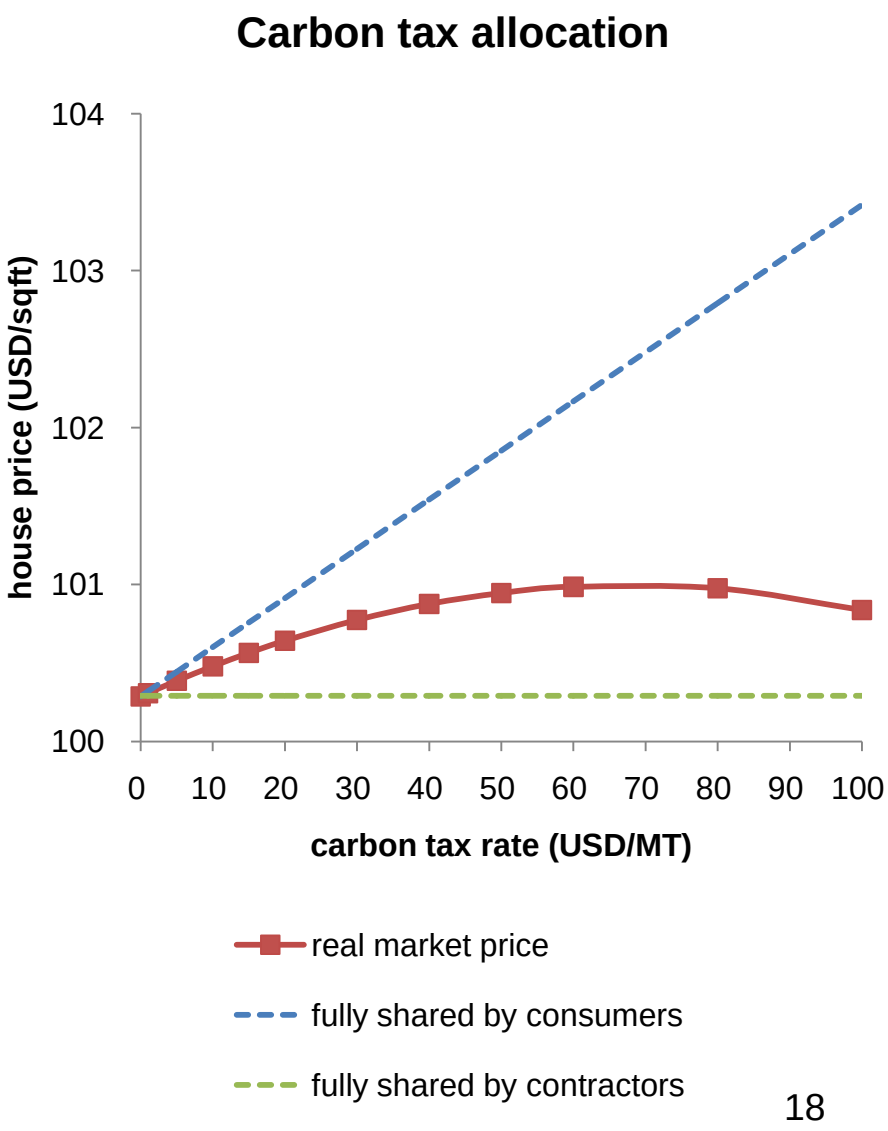


Individual Firm's Reaction



Impact On Consumers





5. CONCLUSION

- INDUSTRY IMPACT: emission standard
- STRUCTURE IMPACT: limited
- INDIVIDUAL REACTION: dependent
- IMPACT ON CONSUMER: significant and sharing

Questions?

Thank you

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