Analysis of Tradable Corporate Average Fuel Economy Credit Systems

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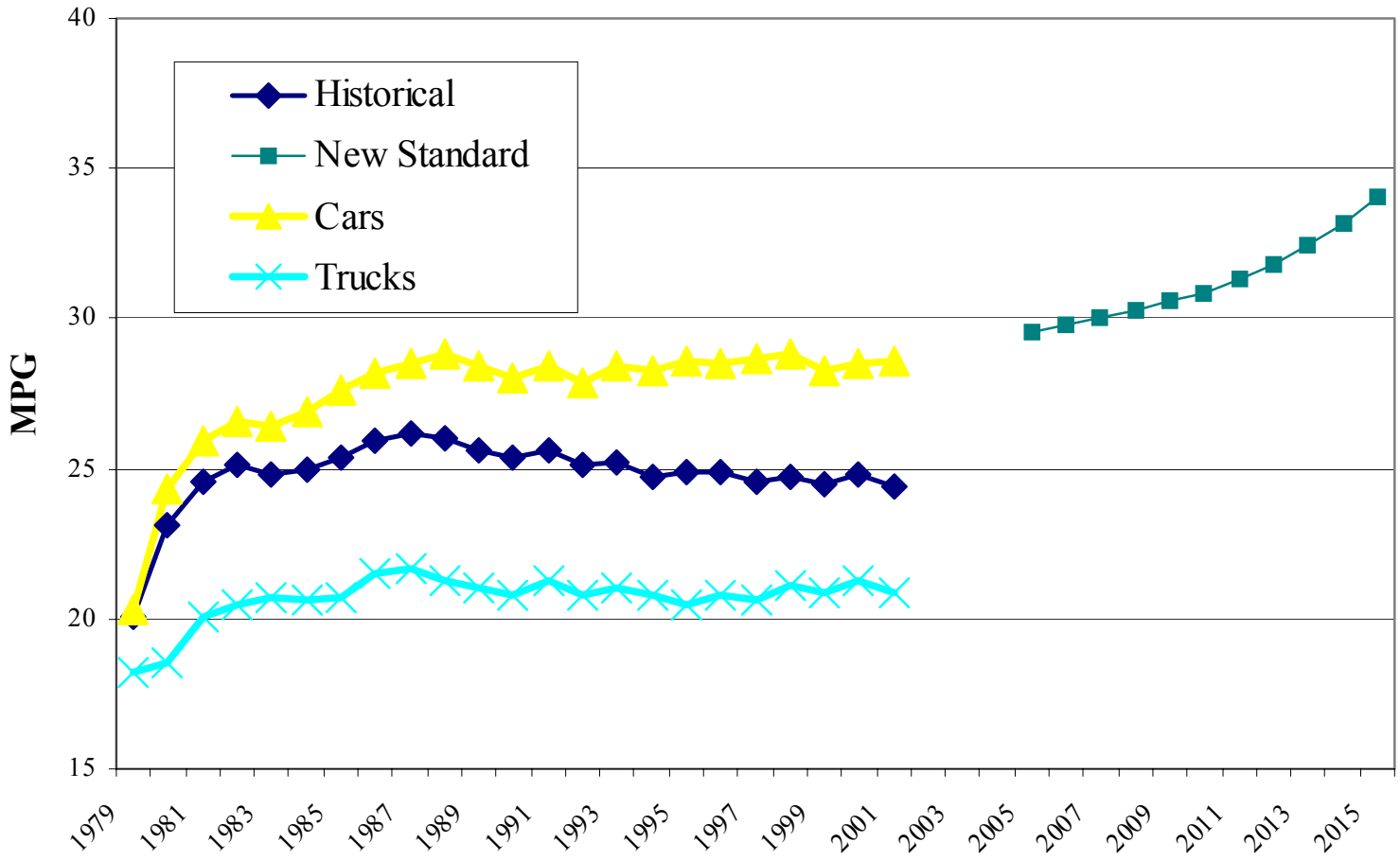
Motivation of Research

- US **oil dependence**
  - Passenger cars and light trucks alone account for 40% of U.S. petroleum use
- Curbing the growth of **GHG emissions**
  - 20% of U.S. CO_2 emissions
  - 57% of transportation CO_2 emissions

Standard Considered is Most Demanding for Trucks

Fleet Average Fuel Economy



US CAFE System

- The CAFE standard
  - Sales weighted harmonic average fuel economy per manufacturer
    - By vehicle-type
      - (passenger car or light truck)
    - By country of origin
      - (domestic for foreign)

Research Motivation Continued

- National Research Council study concluded
  - "…it is appropriate for the federal government to ensure fuel economy levels beyond those expected to result from market forces alone."
  - "Changing the current CAFE system to one featuring tradable fuel economy credits and a cap on the price of these credits appears to be particularly attractive.

Assumed Manufacturers' Response

- Manufacturers meet higher fuel economy standards via fuel economy technologies
- Fuel economy technology
  - Increase the retail price
  - Does not affect other attributes
    - Size
    - Safety
    - Performance

Flexibility Mechanisms

- Credit trading across vehicle manufacturers
  - Domestic
  - Import
  - Cars
  - Trucks
- Credit trading across time

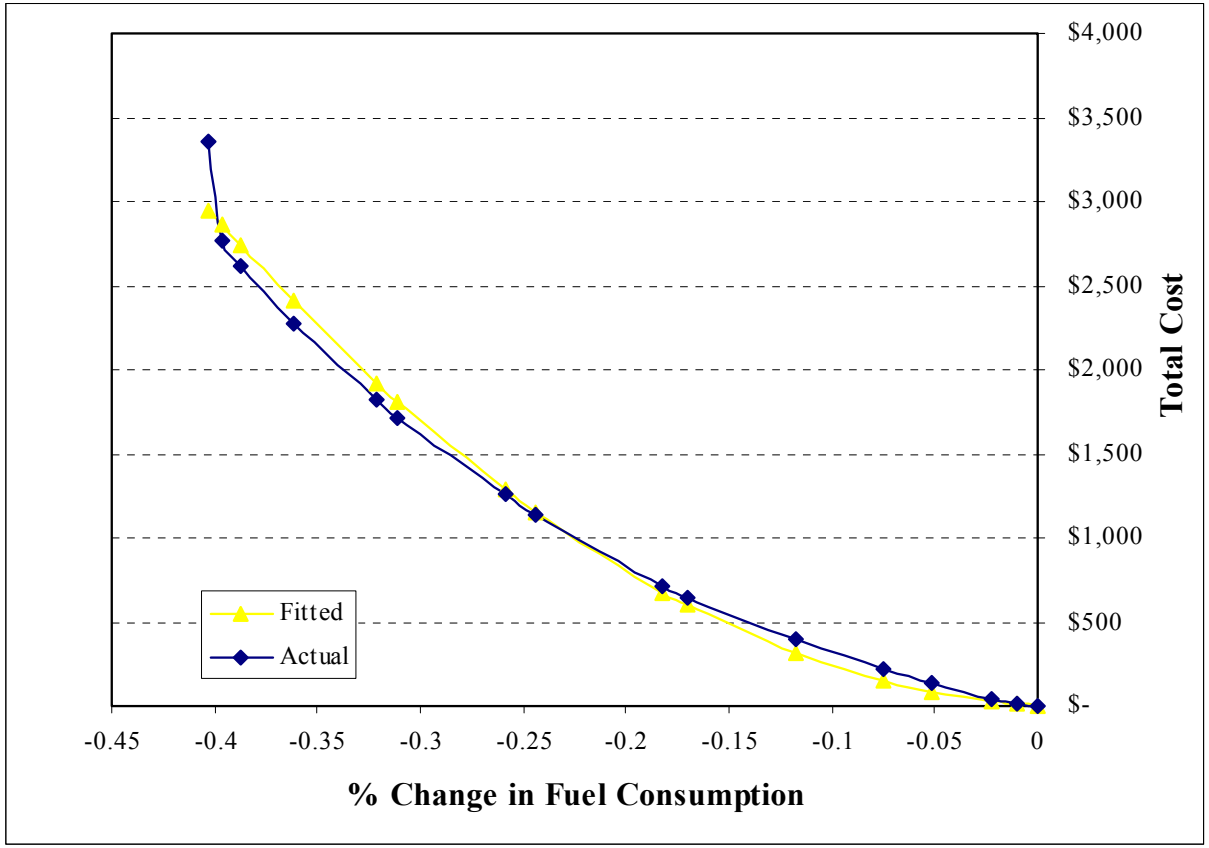
Cost Assumptions

- Data do not include diesel or hybrid technologies
  - Conservative assumption
  - NAS technologies are nearly invisible to the consumer
  - US diesel use still very low (and may stay low)
- All manufacturers have available the same suite of technologies

Cost Curve Construction

- Rank data according to cost-effectiveness
- Make sure technologies come in valid order:
  - insure that a prerequisite technology isn't ranked after the later implemental one
  - Example: VVT and VVT + Lift
- Calculate cumulative fuel efficiency gain and price
- Perform regression analysis to yield cost curve
- Manufacturer specific costs based on sales-weighted vehicle categories and observed fuel economy

Midsize Cars Cost Curve, Average



Objective Function

- Represents the private (not social) fuel saving benefits less technology costs

$$Net\ \ Value_{mov}(X_{mov}) =$$

$$\sum_{l=1}^{L}\left[\frac{1}{(1+r)^{l}}P_f\frac{M_l}{k}\left(\frac{1}{E_o}-\frac{1}{E_o(1+X_{mov})}\right)\right]\{Benefit\}$$

$$-\ \left(bX+cX^2\right)\ \{Cost\}$$

Alternative View

- Current fuel tax is like an externality tax
  - Carbon and oil dependency externalities less than existing fuel tax
- Tightening CAFE could reduce welfare by increasing congestion and injury externalities

Our response

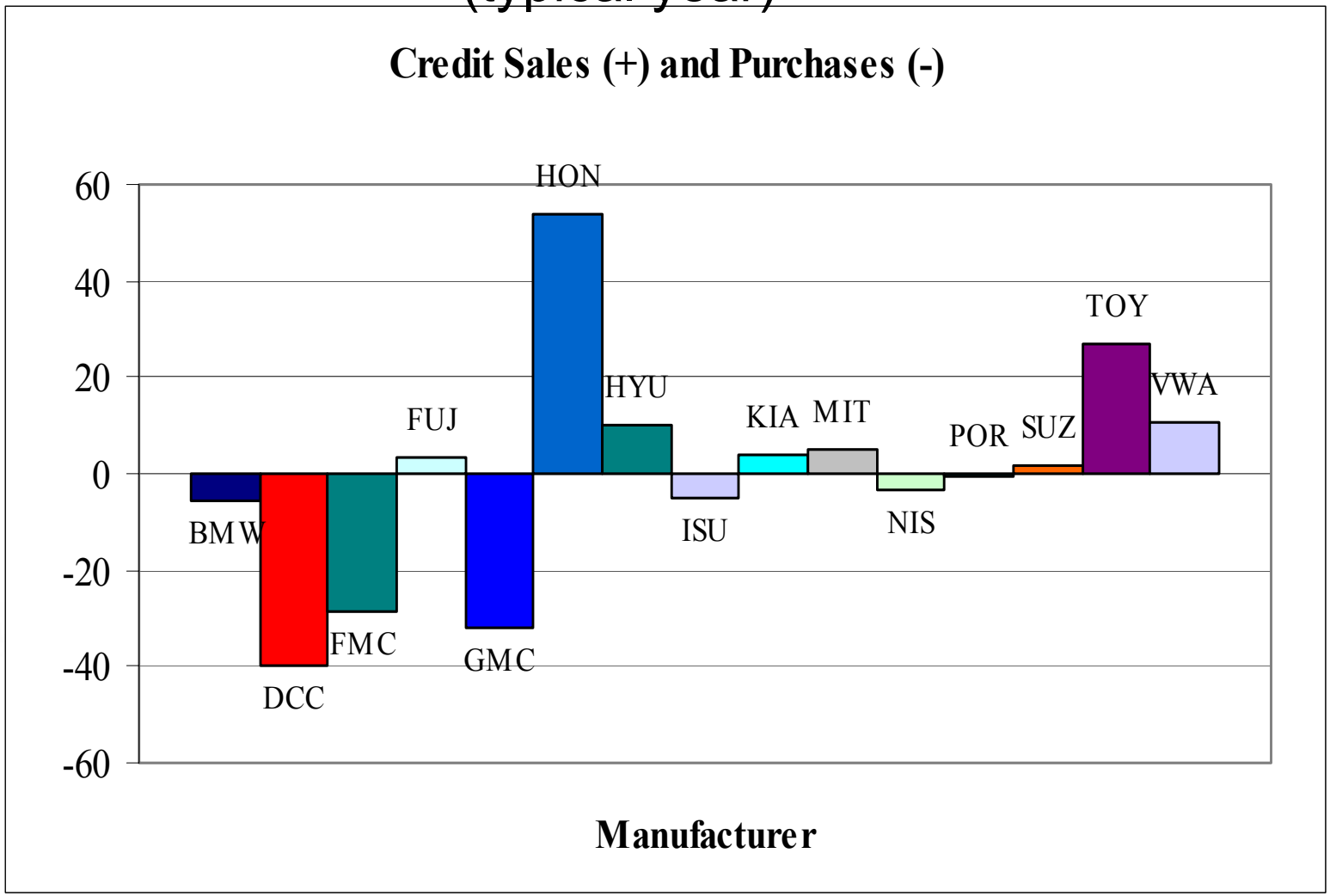
- Fuel tax is a highway user fee
- Multiple market failures require multiple policy tools
- Lower fuel economy is a poor way to reduce congestion
- Consumers under value fuel economy and not respond efficiently to fuel taxes

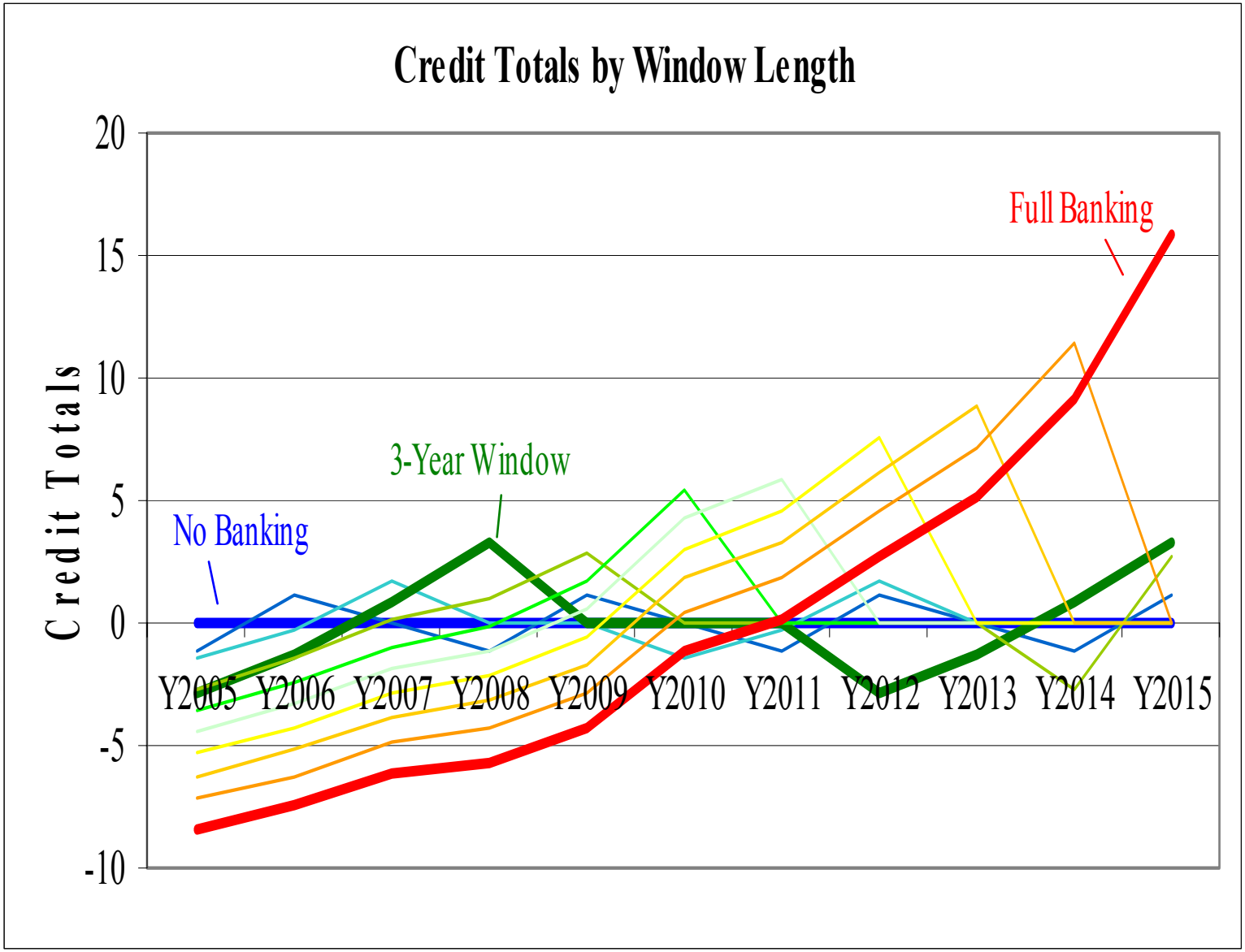
Results

- Savings from Trading Flexibility
- Savings from Time Flexibility
- Permit Prices over Time
- Fuel Consumption Paths over Time
- Price Effects from Market Power
- Trade Volume Effects, Market Power

Permit Trades Under Competition

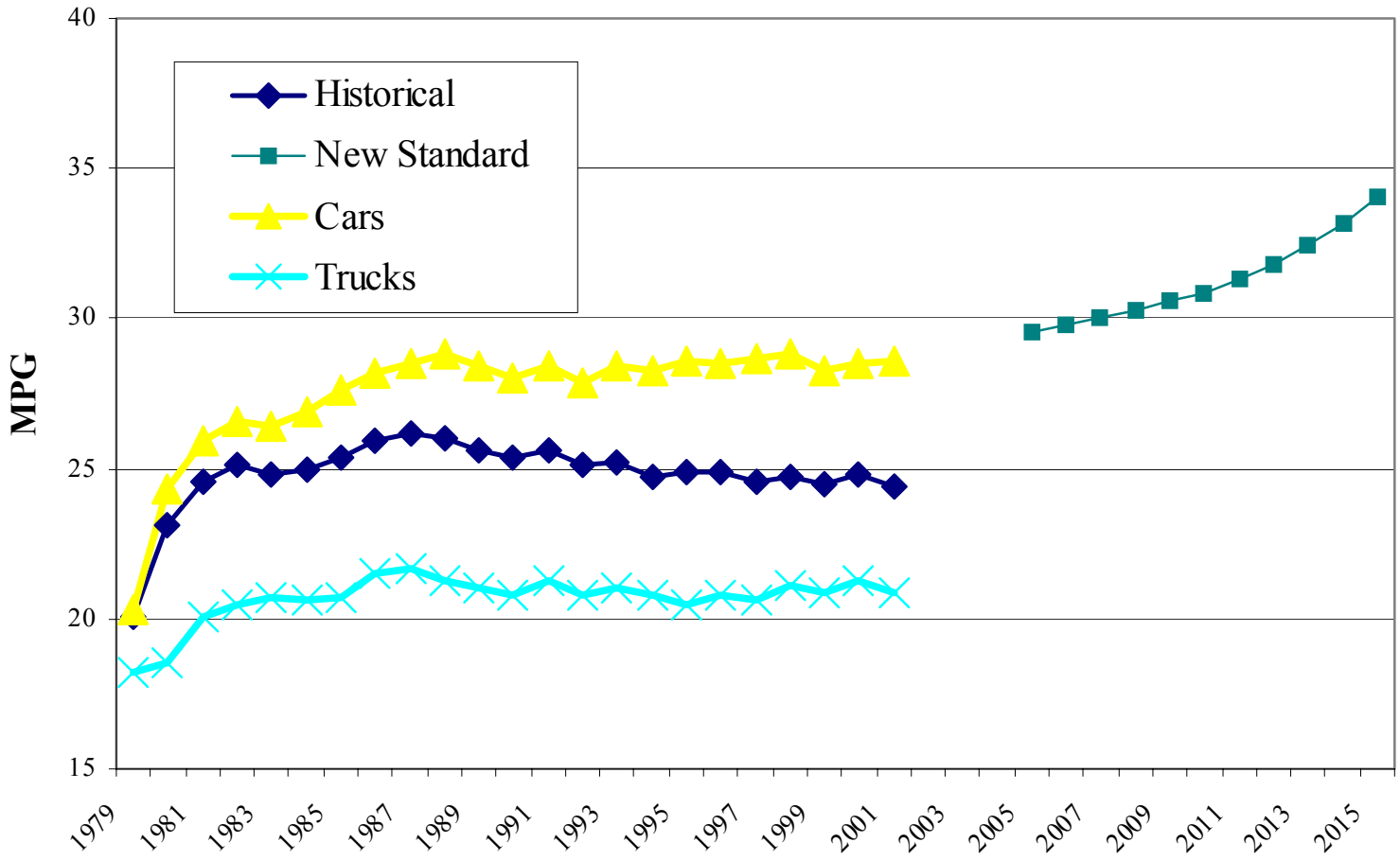
(typical year)




Credit Totals by Window Length
Credit Totals
20
15
10
5
0
-5
-10
Y2005
Y2006
Y2007
Y2008
Y2009
Y2010
Y2011
Y2012
Y2013
Y2014
Y2015
Full Banking
3-Year Window
No Banking

Standard Considered is Most Demanding for Trucks

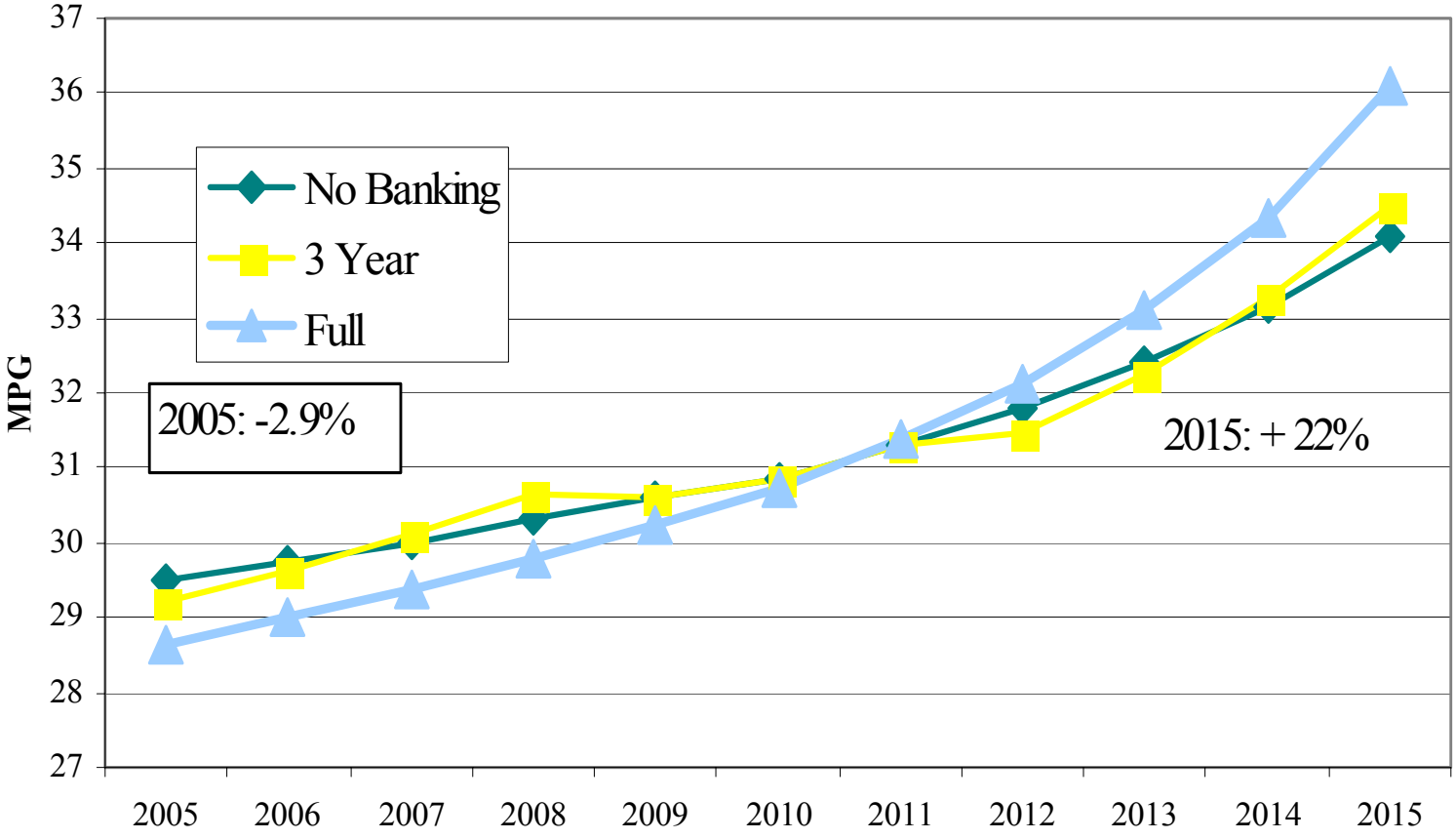
Fleet Average Fuel Economy



Savings: Trade & Time Flexibility

Window Length	Time Flexibility	Trade Flexibility
0	0.0%	12.5%
3	0.3%	12.4%
Full	3.9%	11.5%

Fuel Economy Paths with Different Banking Windows



Discussion

- Value of trade flexibility substantial
- Value of time flexibility appears low
  - Mix of vehicles is constrained, limits value
  - Uncertainty not taken into account
  - Different MPG path, adj costs
- Time and Trade Flexibility are (Limited) Substitutes

Non-Competitive Permit Trading

- Cournot – Nash with a Competitive Fringe
- Cournot oligopolies
  - GM
  - Ford
  - DCC
  - Honda
  - Toyota
- Assumes each Cournot player acts simultaneously by anticipating other's reactions

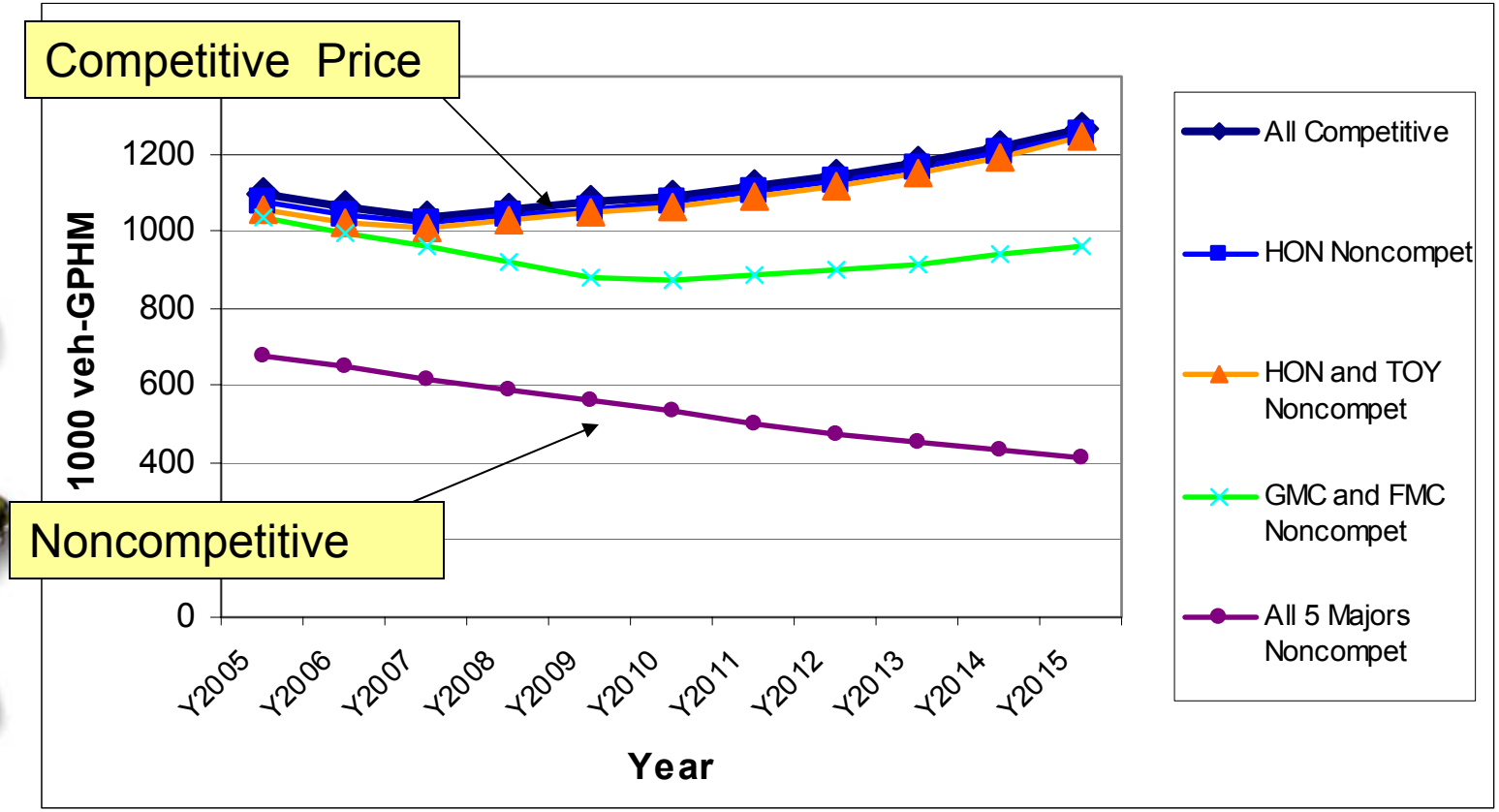
Non-Competitive Optimality Condition

- Marginal cost of a permit balances marginal revenue to firm *j*

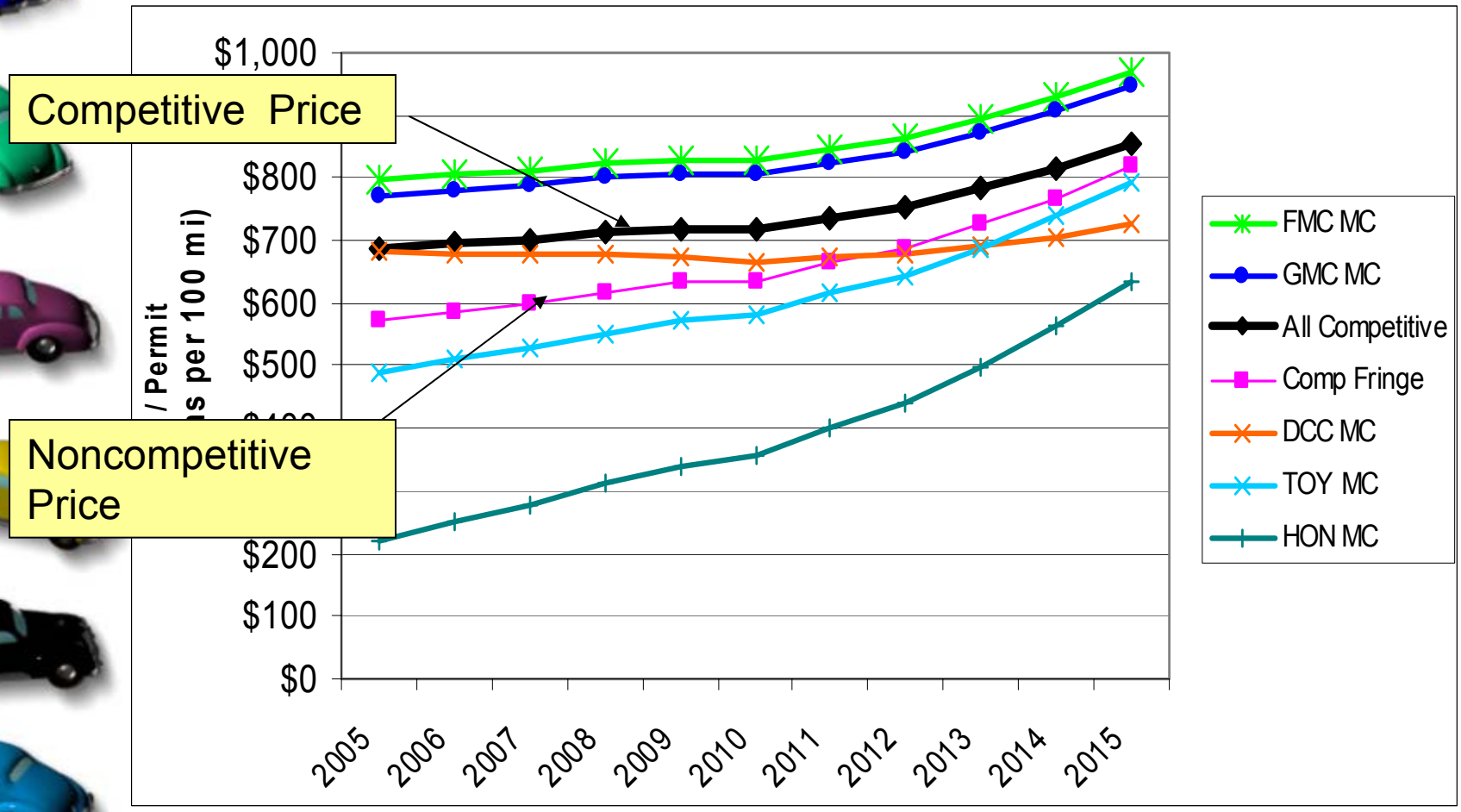
$$\frac{\partial C_{jv}(Z_{jv})}{\partial Z_{jv}} = P + \frac{\partial P}{\partial Z_{jv}} Z_j$$

  – for every vehicle *v* made by firm *j*
- Determine each player's reaction function (solve system FOCs)

Total Volume of Credit Trade: Competitive Regime v. Various Non-competitive Regimes

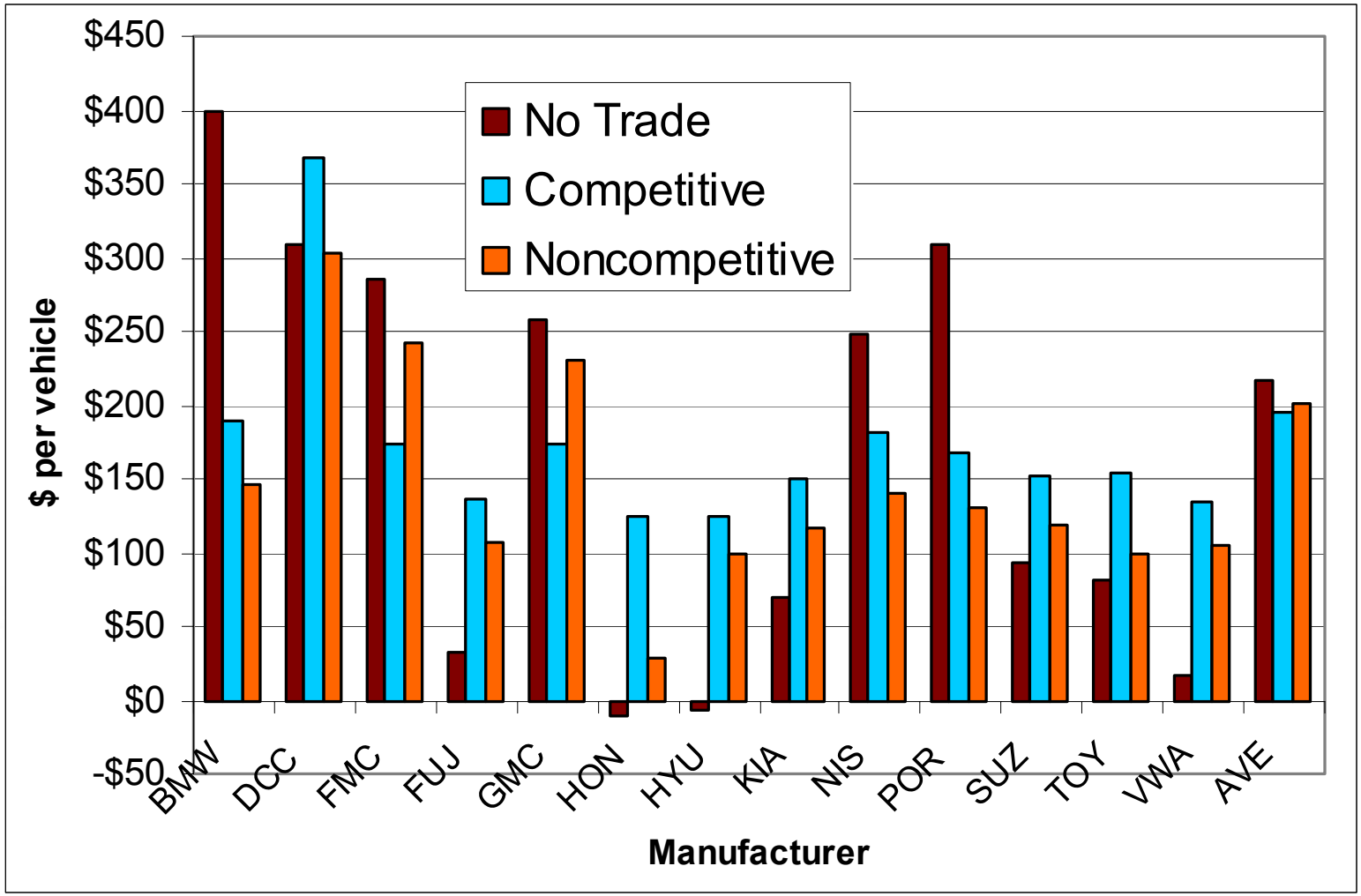


Permit Prices & Marginal Costs Competitive v. Noncompetitive



Technology Costs of Achieving CAFE

Omits Costs/Revenues from Permit Trade



Total Costs of Achieving CAFE

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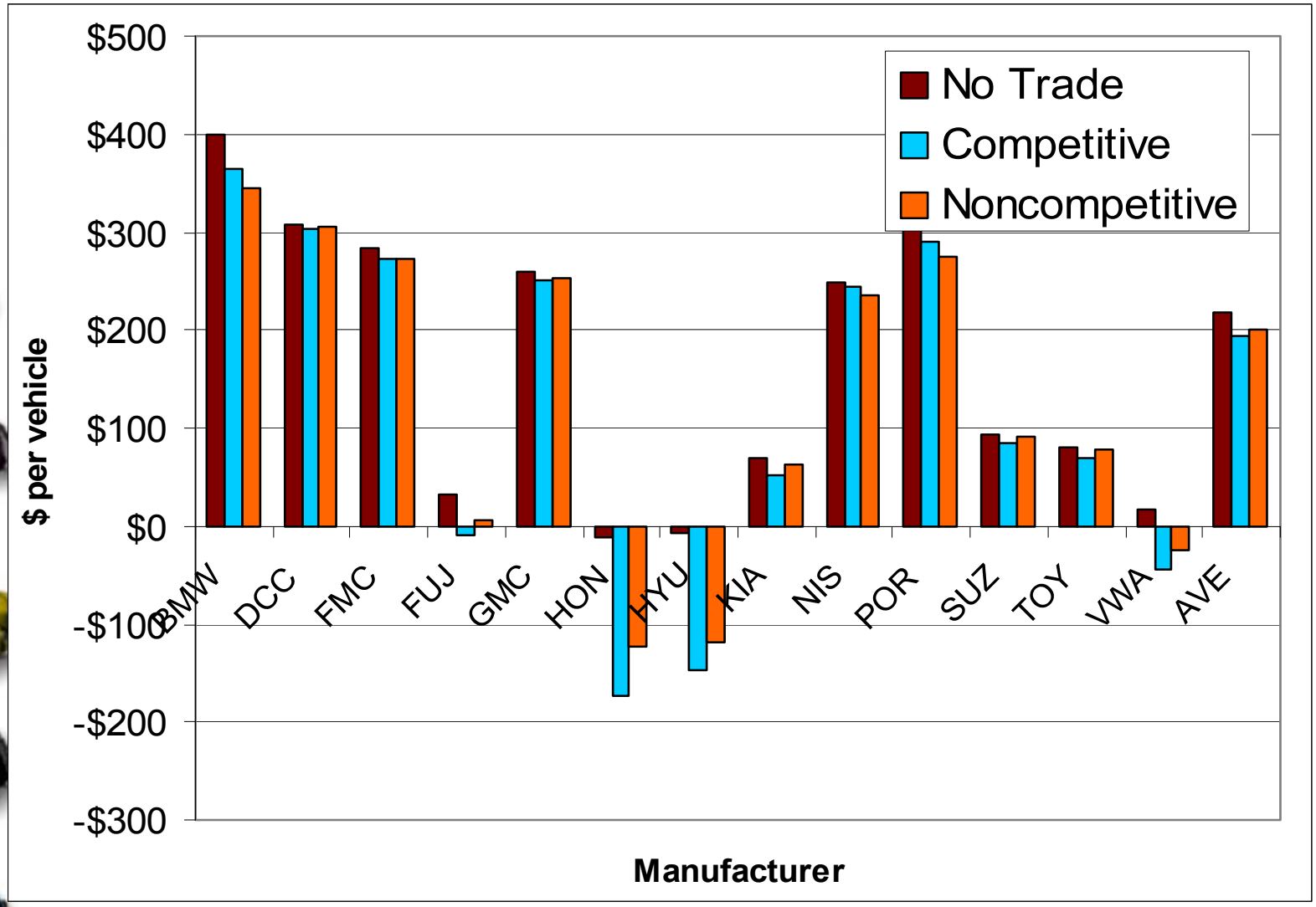
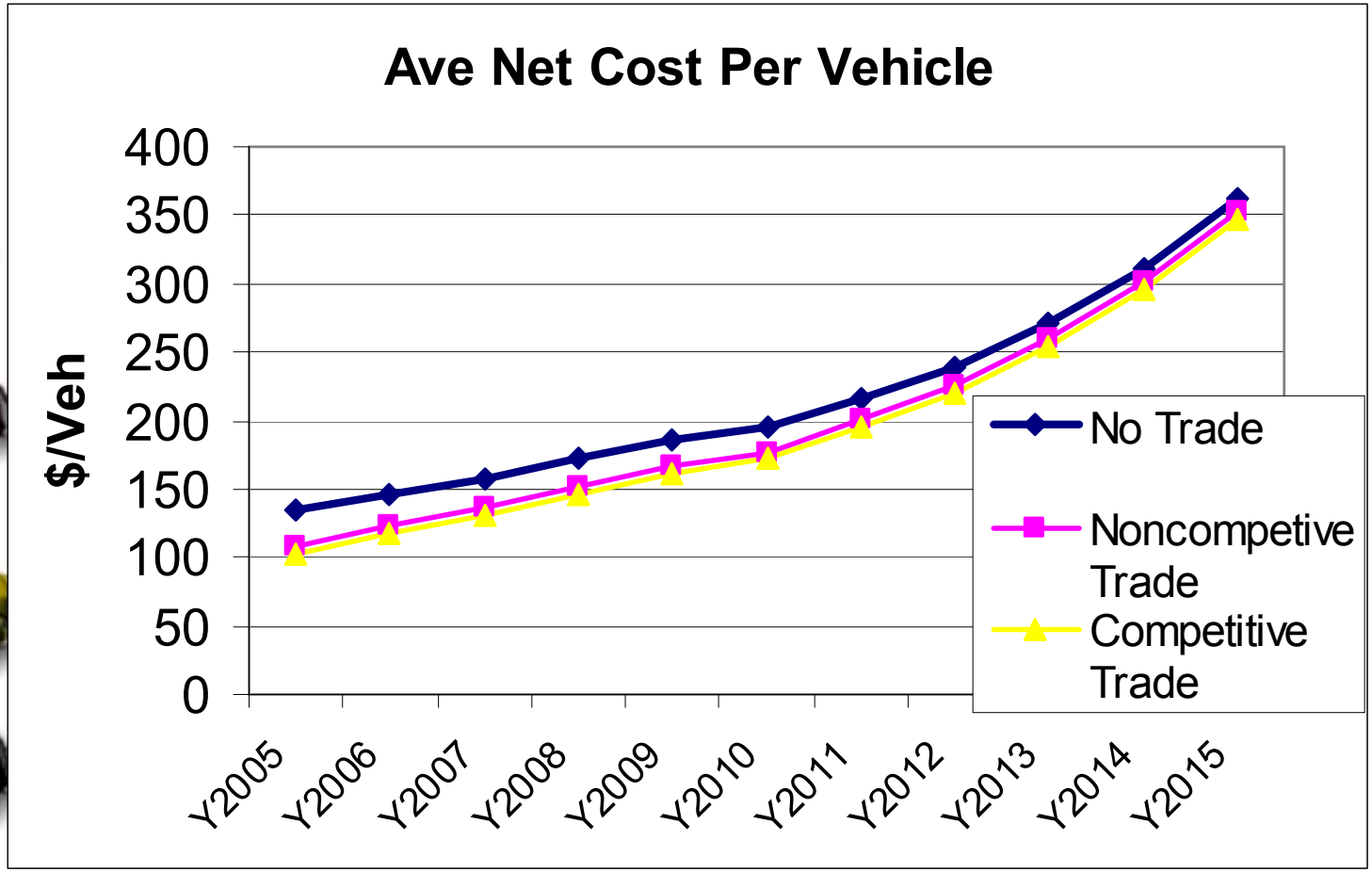


Average Costs of Achieving CAFE



Discussion

- Imperfect competition lowers credit trading volume by more than half
- Imperfect competition lowers average savings from trading only slightly
  - Larger effects on individual manufacturers
- Possibly significant political implication of income redistribution needs consideration

Additional Work

- Finalize data and scenarios
- Capital turnover/adj cost considerations
- Uncertainty in future demand for credits and vehicles
- Other forms of CAFE standards

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