Shale-shocked OPEC and the GHG benefits of cellulosic biofuels

D. Rajagopal, UCLA, IU Bloomington

M. Accordino UCLA

Objective

- How do the fuel market effects and GHG impacts of cellulosic biofuels change as OPEC's behaviour changes in response to the new regime of oil prices?

"Booming global production—led by soaring North American output—has contributed to a glut. Amid the oversupply, Mr. Naimi and other OPEC officials have said the cartel wasn't going to sacrifice market share to non-OPEC producers" - WSJ *Jan 23 2015*

According to a Saudi official - *"The kingdom wants to maintain market share regardless of the price. … And the new king will continue with this policy even if prices fall further."* - WSJ *Jan 23 2015*

Implications of a positive oil supply shock for biofuel

- Economic (monetary)
  - Costs of oil substitution increase
  - Demand for ethanol in E10 increases and in E85 decreases (Babcock 2015)
- Environment
  - Direct effect – positive if marginal oil is more polluting
  - Indirect effects
    - ILUC - unchanged
    - **IFUE - ?**

Indirect fuel use change effect (IFUE)

- A type of leakage caused by price effects
- Ethanol policy lowers world oil price, might either raise or lower home gasoline price, and raises world price of rest of oil products (Rajagopal et al. 2011, Rajagopal and Plevin 2013)
- Hochman et al. (2011) simulate ethanol mandates under competition and two different models of OPEC market power

Behavioral models of OPEC

Various types of behaviour posited and econometrically estimated (al-Qahtani et al. 2008)

- Market power
  - Cartel behaviour
  - Dominant firm behaviour
  - Target behaviour models: target capacity, price or revenue
- Other
  - Political explanations
  - Property rights models

Overall, market power models explain prices better but the empirical literature suggests no single model of market power explains all the different price regimes since 1970. "*Recognizing that OPEC does not fit neatly into a single behavioral model is not an intellectual retreat*" Kaufman et al. 2008

Two alternative market power models

In both we assume OPEC is a monolithic dominant producer facing a competitive fringe

1. maximizes domestic surplus (domestic consumer WTP + export revenues – total production cost)
2. As above but with a constraint that OPEC market share is above a threshold

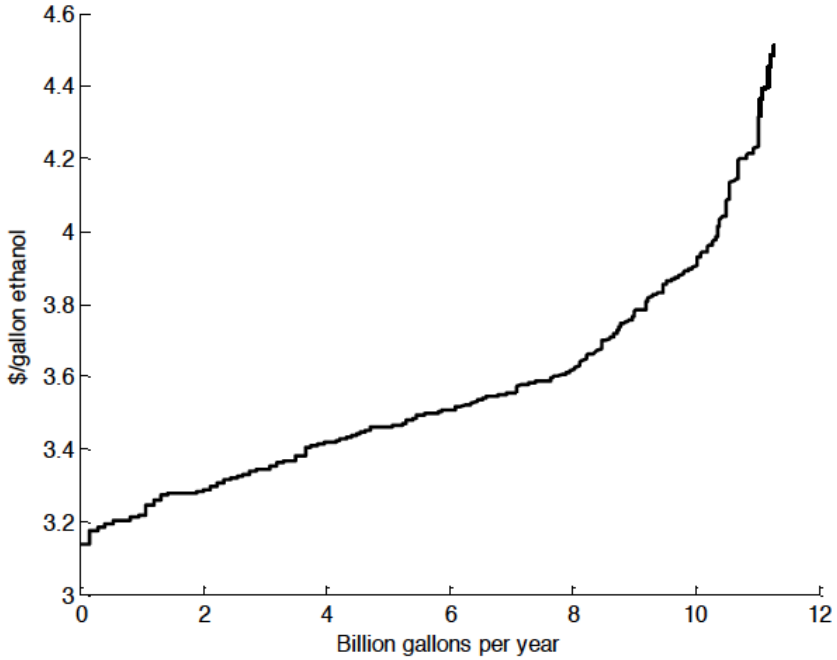
Model

- Static, partial equilibrium model
- Three regions, OPEC (dominant producer) and US and ROW (both as competitive fringe)
- Primary products (supply) - Oil, corn ethanol and cellulosic ethanol
- Finished products (demand) – gasoline-ethanol blend and a rest of oil product aggregate (each produced in fixed proportion)

Supply of cellulosic ethanol

Switchgrass yield per hectare – 10 tonne/hec
Ethanol yield per ton of biomass – 75 gallons/tonne
Land available for switchgrass – 13 million hec. (12 mil. hec CRP + other)
Corn ethanol production fixed at 13.5 bil gal

Figure 4– Estimated ethanol supply curve from switchgrass



Rosburg, Miranowski, Jacobs 2013

Select model parameters

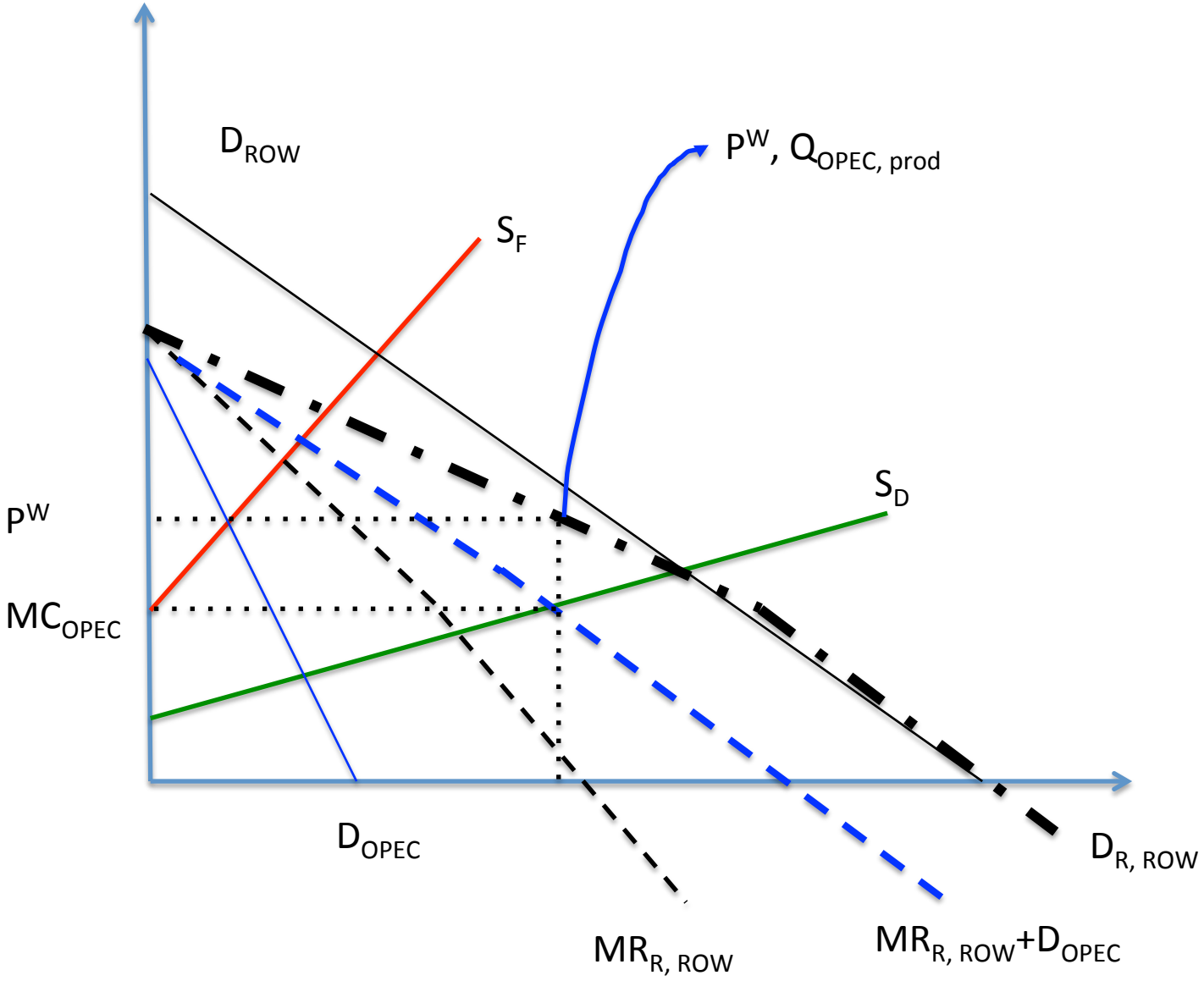
- Oil supply
  - Home 0.3
  - ROW 0.25
  - OPEC 1.0
- Fuel demand (gasoline and ROP)
  - Home -0.4
  - ROW -0.4
  - OPEC -0.4

Base year data for select model variables

Base year is 2015

	Units	Base
Cellulosic biofuel as % of Available Marginal Land	%	0
Conventional Biofuel	Billions of Barrels/Year	0.32
Cellulosic Biofuel	Billions of Barrels/Year	0.00
Price of Cellulosic Biofuel	U.S. $/Barrel	$133.22
U.S. Domestic Oil Production	Billions of Barrels/Year	5.10
U.S. Oil Imports	Billions of Barrels/Year	1.64
U.S. Share of Oil Imported	%	24.3
ROW Oil Production	Billions of Barrels/Year	15.49
ROW Oil Imports	Billions of Barrels/Year	8.12
World Oil Price	U.S. $/Barrel	$57.56
OPEC Oil Production	Billions of Barrels/Year	13.32
OPEC Oil Consumption	Billions of Barrels/Year	3.56
OPEC Oil Price	U.S. $/Barrel	See Note
OPEC Oil Exports	Billions of Barrels/Year	9.76
OPEC Market Share	%	32.2
Shadow Price of Market Share Constraint	U.S. $/Barrel	$9.01

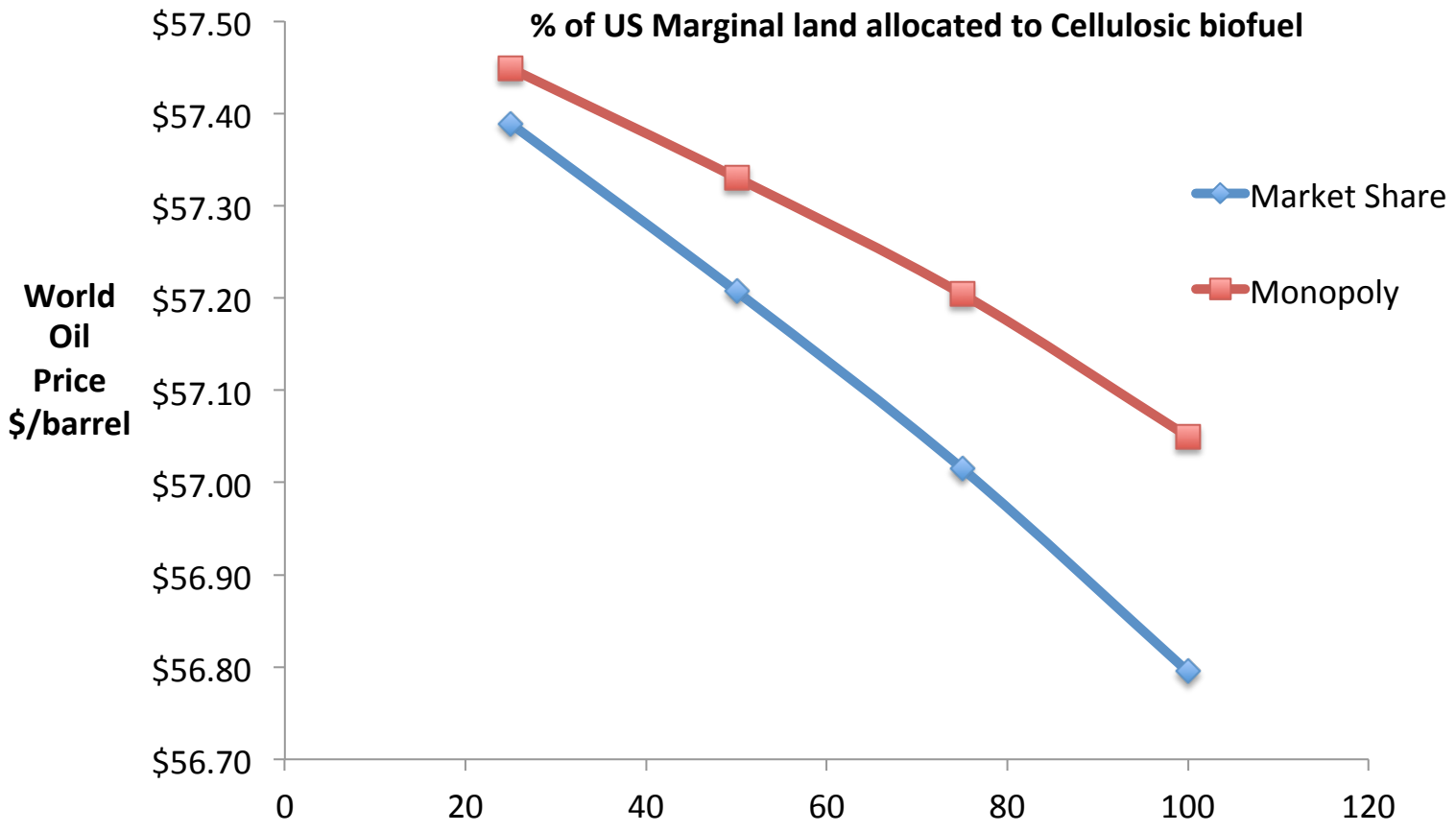
Basic approach

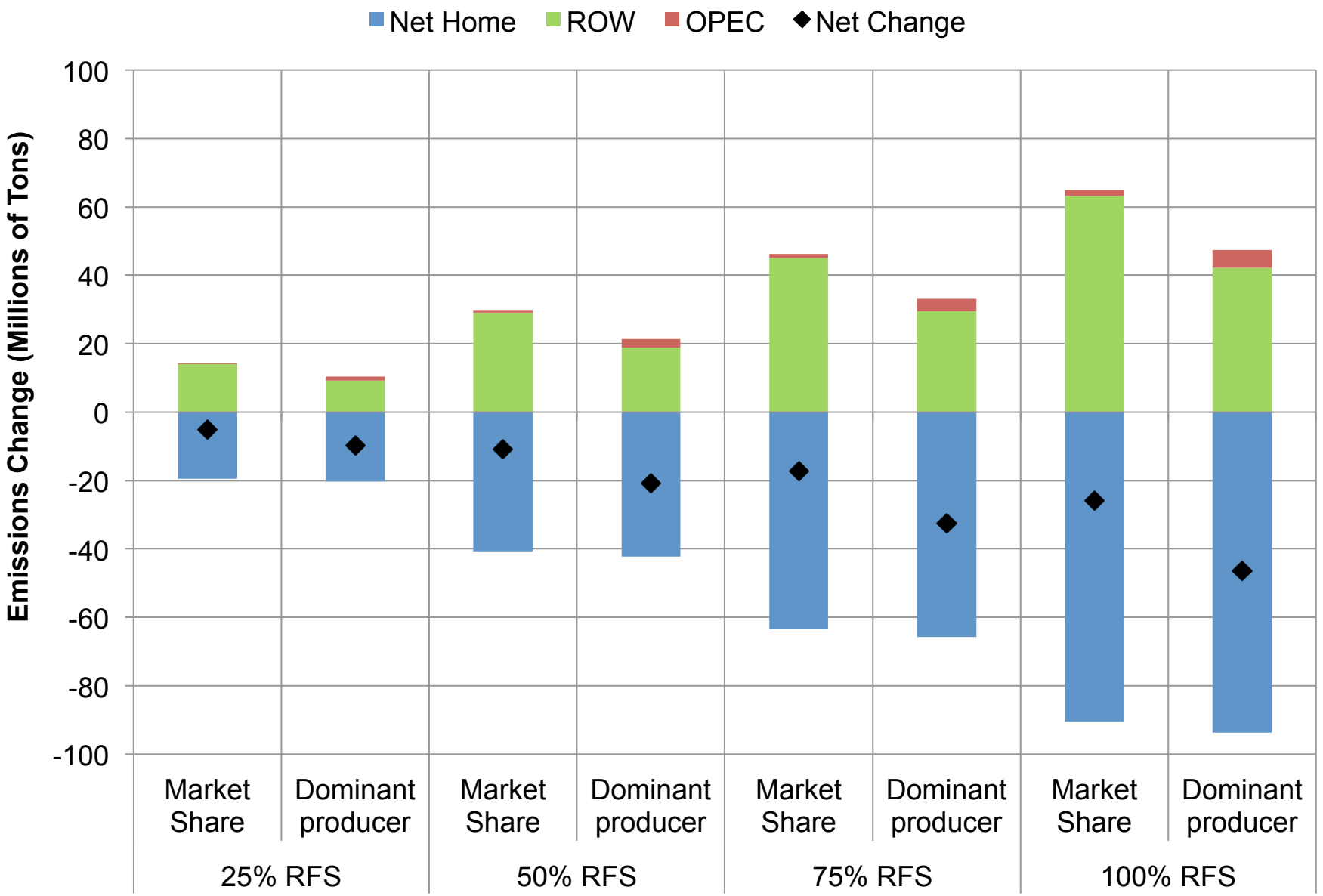


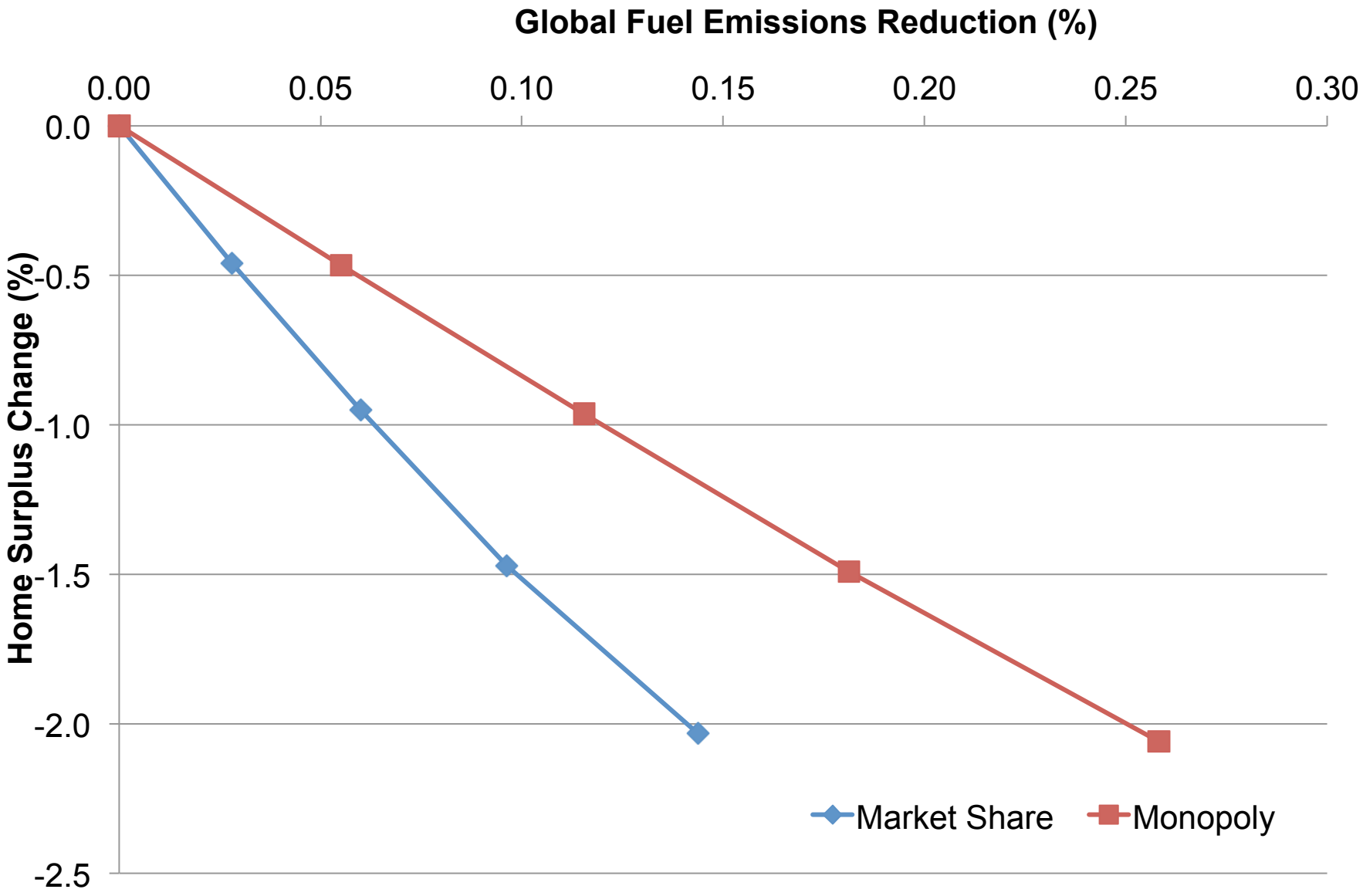
Simulation scenarios

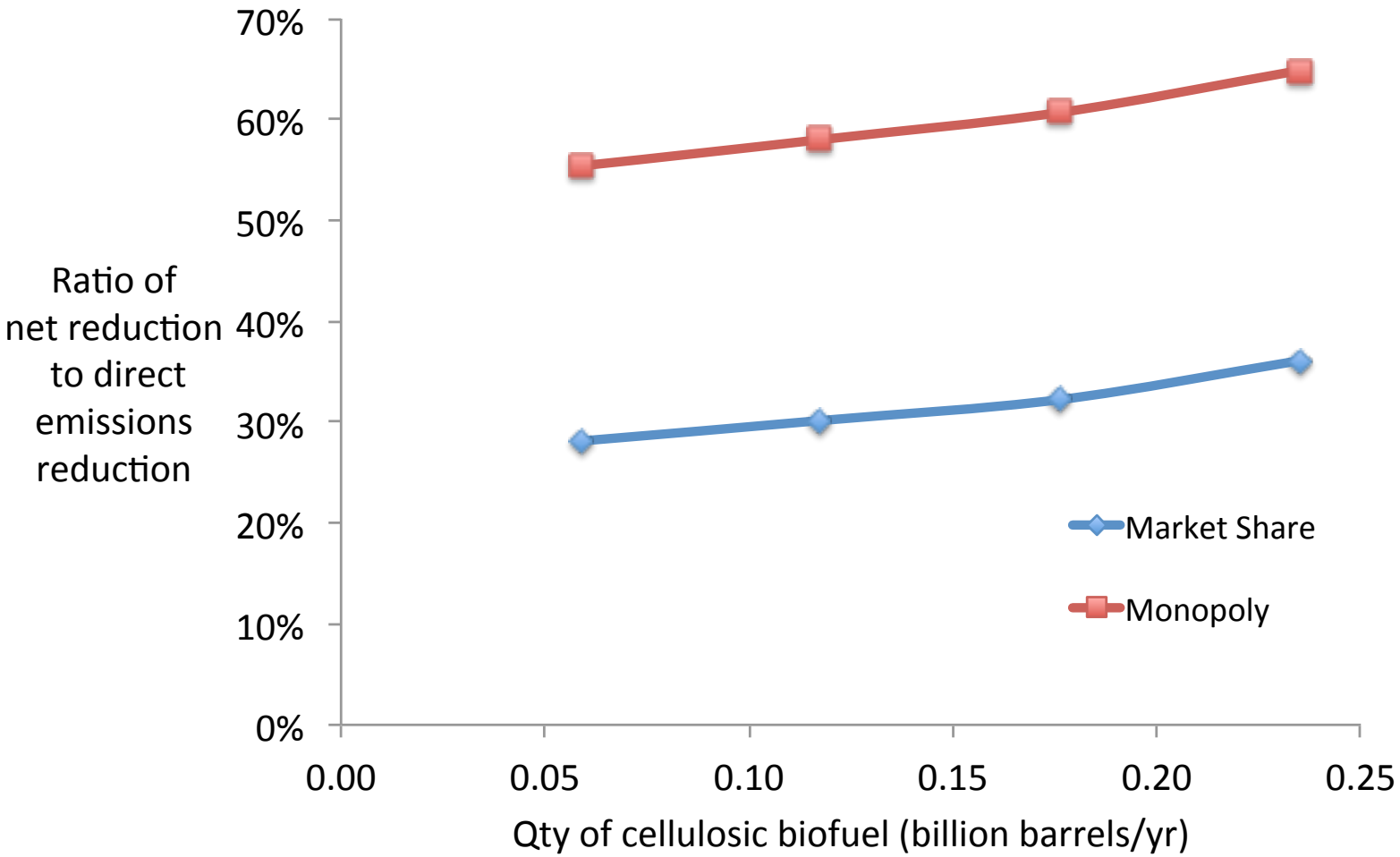
- For each of the two types of OPEC behavior we simulate four scenarios each of which involves a fixed portion of marginal land devoted to cellulosic ethanol
  - 25%, 50%, 75% and 100%

Results


% of US Marginal land allocated to Cellulosic biofuel
World Oil Price $/barrel
$57.50
$57.40
$57.30
$57.20
$57.10
$57.00
$56.90
$56.80
$56.70
0
20
40
60
80
100
120
Market Share
Monopoly


Net Home
ROW
OPEC
Net Change
Emissions Change (Millions of Tons)
100
80
60
40
20
0
-20
-40
-60
-80
-100
Market Share
Dominant producer
Market Share
Dominant producer
Market Share
Dominant producer
Market Share
Dominant producer
25% RFS
50% RFS
75% RFS
100% RFS

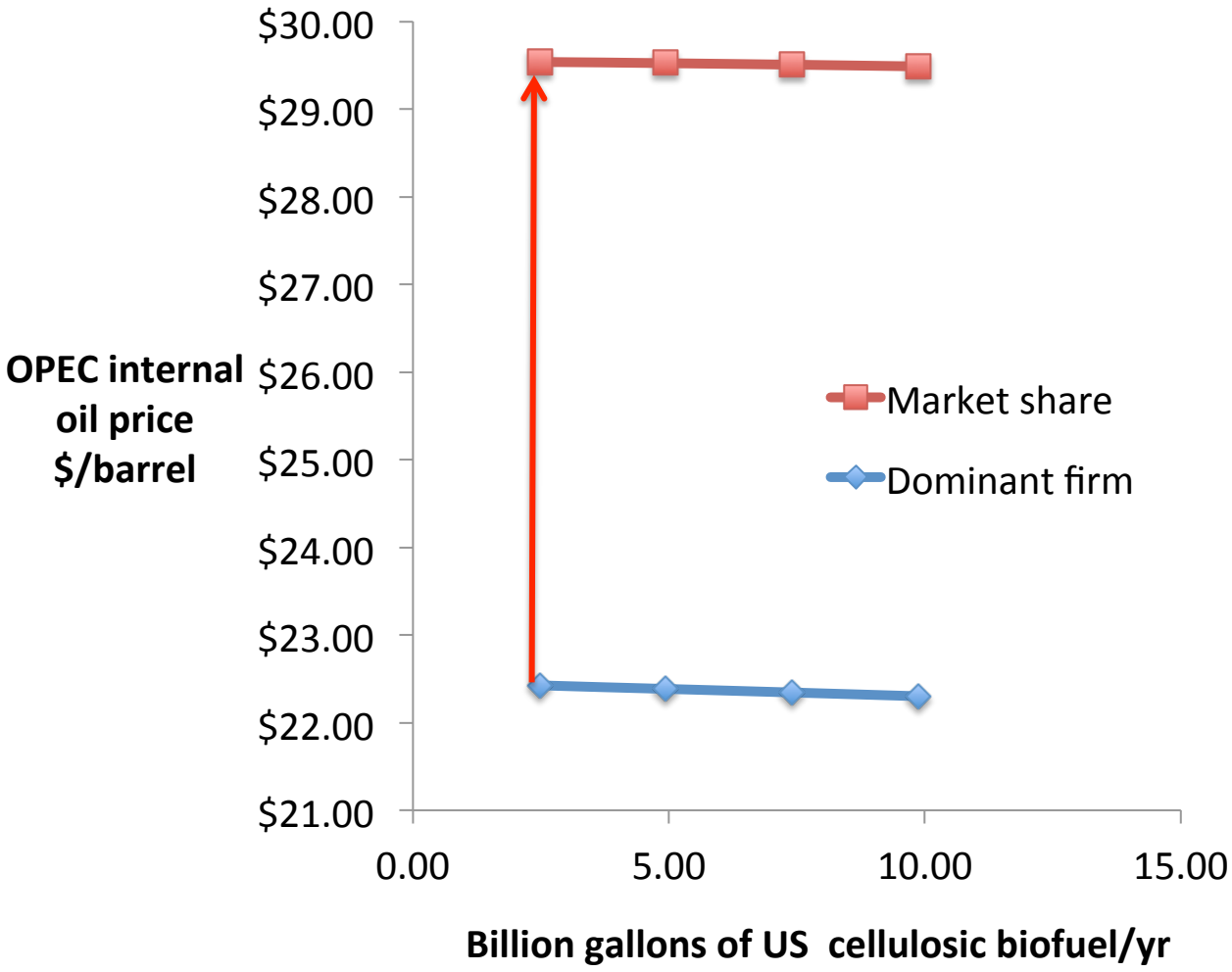

Global Fuel Emissions Reduction (%)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Home Surplus Change (%)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
Market Share
Monopoly


70%
60%
50%
40%
30%
20%
10%
0%
Ratio of net reduction to direct emissions reduction
0.00
0.05
0.10
0.15
0.20
0.25
Qty of cellulosic biofuel (billion barrels/yr)
Market Share
Monopoly

Summary

- GHG benefits of 2nd gen., while less prone to ILUC, is vulnerable to IFUE
- IFUE in turn depends on type of market power exercised by OPEC
- Preliminary calculations suggest this effect could substantially erode the direct benefits of oil substitution
- Price effects accompany any incomplete policy and there are multiple such policies
- Suggests the need for policies that seek to manage global fossil fuel supply, just like managing global land use to limit LUC

Extra


$30.00
$29.00
$28.00
$27.00
$26.00
$25.00
$24.00
$23.00
$22.00
$21.00
OPEC internal oil price $/barrel
Market share
Dominant firm
0.00
5.00
10.00
15.00
Billion gallons of US cellulosic biofuel/yr