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GTAP Data Update, Forecasting and Backcasting in GTAP, and CRC Work on CARB Results

Farzad Taheripour
Wallace E. Tyner

Purdue University

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Background

- Prior GTAP biofuels induced land use change analysis has been done using the 2004 or 2001 data bases
- Recently the standard GTAP data base for 2011 was released
- We have created a new GTAP-BIO data base using the new GTAP data base for 2011
  - That is, all the changes over the years that had been introduced into the 2004 data base have now been introduced into the 2011 data base.

Presentation Outline

- Comparison of 2011 and 2004 data bases
- Preliminary test simulations
- Discussion of what this all means for future biofuels work using the 2011 data base
- Backcasting and forecasting
- CRC project preliminary results

Population

- Global population grew 8% over the 7 year period, with half the growth coming from India and Sub-Saharan Africa.
- China, India, and Sub-Saharan Africa together accounted for half the world's population in both 2004 and 2011.

GDP

- GTAP data bases represent monetary values of economic activities (including GDP) in nominal terms for each year.
- Therefore, changes in the nominal values between 2004 and 2011 do not measure real values.
- Real GDP of China grew 108%, while Brazil grew 33% over this period, but nominal growth rates were about the same for both.

GDP as share of world GDP in 2004 and 2011 (%)

Country	2004	2011
US	28.5	21.7
EU	31.5	24.6
Japan	11.4	8.3
China	4.5	10.6

Per Capita GDP (US $)

Region	2004	2004	2011
Oth_Europe	51,241	1	1
USA	39,517	2	3
JAPAN	36,419	3	4
CAN	30,639	4	2
EU27	26,411	5	6
CHIHKG	1,398	15	14
R_SE_Asia	1,372	16	16
S_S_AFR	713	17	17
INDIA	583	18	18
R_S_Asia	498	19	19

Ranks of richest regions

Ranks of poorest regions

Ratio of richest to poorest region in 2011 was 85.

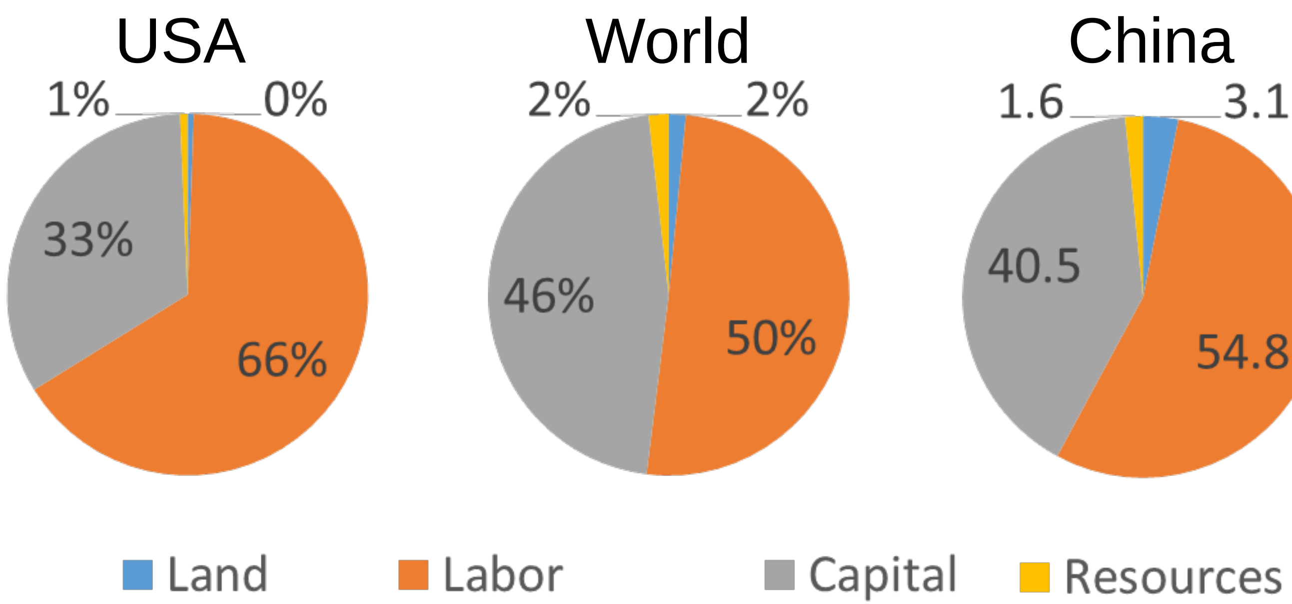
Expenditures (1)

- The share of consumption expenditures in global output was about 59% in 2011, slightly lower than 61% of 2004.
- The share of investment was about 24% in 2011, slightly higher than 21% of 2004.
- The share of government expenditure was about 17% in both 2004 and 2011.
- The share of exports (as an index for global trade) in global output was about 28% in 2011, slightly higher than 26% of 2004.

Expenditures (2)

- Among the five richest regions, the US has the highest consumption share (about 70%) and the lowest investment share (about 19%) in GDP in both years.
- Among the five poorest regions, China has the lowest consumption share (43% in 2004 and 37% in 2011) and the highest investment share (39% in 2004 and 45% in 2011).
- The regional distribution of GDP between consumption, investment, and government expenditures in 2004 and 2011 are not very different except for China and India, where consumption dropped in favor of investment.
- The export share dropped for China, Malaysia, and Rest of South-east Asia.

Factor Income Shares in 2011



- Factor income shares vary across region
- The shares for 2004 generally are quite similar.
- Labor share increased and capital fell in China, India, and Sub-Saharan Africa

Distribution of Final Output

- Agriculture has a small share, particularly in rich countries. Agriculture share is larger in poorer countries.
- Share of food and feed has increased in most regions.
- Share of biofuels has increased.

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US Ag Export Shares

Commodity	2004		2011		Export
	Domestic	Exported	Domestic	Exported	change
Paddy Rice	66.3	33.7	65.0	35.0	1.3
Wheat	25.4	74.6	33.3	66.7	-8.0
Sorghum	72.7	27.3	80.8	19.2	-8.2
Oth_CrGr	68.1	31.9	78.7	21.3	-10.6
Oilseeds	55.7	44.3	54.3	45.7	1.4
Sugar_Crop	100.0	0.0	100.0	0.0	0.0
OthAgri	83.4	16.6	73.9	26.1	9.5
Livestock	97.2	2.8	96.5	3.5	0.7
Forest	91.1	8.9	89.8	10.2	1.3
Food and feed	95.1	4.9	91.8	8.2	3.3
Biofuels	100.0	0.0	94.8	5.2	5.2
Traditional energy	97.2	2.8	90.5	9.5	6.7
Fuel Blend	-	-	100.0	0.0	-
Others	94.8	5.2	93.8	6.2	0.9
Total	94.7	5.3	93.5	6.5	1.3

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US Cost Structure for Major Categories

Industry groups	2004			2011			Difference 2011-2004		
	Primary inputs (%)	Non-energy intermediate inputs (%)	Energy inputs (%)	Primary inputs (%)	Non-energy intermediate inputs (%)	Energy inputs (%)	Primary inputs	Non-energy intermediate inputs	Energy inputs
Crop	56.0	40.5	3.6	51.9	42.9	5.2	-4.1	2.4	1.7
Livestock	25.8	72.5	1.7	20.6	76.3	3.1	-5.1	3.7	1.4
Forestry	50.1	49.0	0.9	50.2	48.5	1.3	0.1	-0.4	0.3
Food and feed	32.7	65.6	1.7	29.4	69.1	1.5	-3.3	3.5	-0.1
Grain ethanol	52.2	38.3	9.5	14.0	80.5	5.5	-38.2	42.3	-4.0
Biodiesel	27.6	70.1	2.3	7.7	90.5	1.8	-19.9	20.4	-0.5
Blender	-	-	-	0.0	0.0	100.0	-	-	-
Traditional energy	34.1	19.9	46.0	29.2	17.2	53.6	-4.9	-2.8	7.6
Others	49.9	47.9	2.2	49.2	48.2	2.6	-0.7	0.3	0.4
Total	48.8	47.4	3.8	46.7	46.7	6.6	-2.0	-0.8	2.8

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Global Accessible Land Cover (mil ha)

Region	2004				2011				Difference 2011-2004			
	Forest	Cropland	Pasture	Total	Forest	Cropland	Pasture	Total	Forest	Cropland	Pasture	Total
USA	229	176	229	633	232	165	229	627	3.7	-10.5	0.4	-6.4
EU27	153	125	60	338	155	123	60	338	2.3	-2.3	0.0	0.1
BRAZIL	156	61	176	392	154	63	174	390	-2.5	2.0	-1.9	-2.4
CAN	100	40	20	160	101	36	20	156	0.1	-3.7	-0.5	-4.0
JAPAN	18	4	0	22	18	4	0	22	0.0	-0.1	0.0	-0.1
CHIHKG	144	141	277	562	152	144	277	573	8.4	3.5	0.0	11.9
INDIA	18	171	11	200	18	172	10	200	0.2	0.2	-0.4	0.0
C_C_Amer	49	57	84	190	49	57	84	190	0.0	0.5	-0.5	0.1
S_o_Amer	109	59	254	422	107	64	256	428	-1.7	5.5	2.0	5.8
E_Asia	17	5	76	99	17	5	77	99	-0.3	-0.3	0.4	-0.3
Mala_Indo	40	72	2	114	40	75	2	117	-0.4	3.1	0.0	2.7
R_SE_Asia	96	53	5	154	94	59	5	157	-2.3	5.4	0.2	3.3
R_S_Asia	8	47	37	92	8	48	37	92	-0.2	0.7	0.0	0.5
Russia	267	125	79	470	267	124	79	470	0.2	-0.7	-0.1	-0.5
Oth_CEE_CIS	51	112	280	443	54	110	280	444	2.3	-1.4	-0.6	0.3
Oth_Europe	28	1	1	30	30	1	1	32	1.1	0.0	0.0	1.1
MEAS_NAfr	1	54	152	207	2	54	129	185	0.3	0.2	-22.4	-21.9
S_S_AFR	187	211	729	1127	184	227	732	1142	-3.5	15.7	2.5	14.7
Oceania	5	34	272	311	5	34	251	290	0.0	-0.3	-20.8	-21.2
World	1678	1544	2746	5968	1686	1562	2704	5952	7.8	17.5	-41.7	-16.4

Changes in other types of land are not included

Harvested Areas by Region & Crop (mil ha)

Region	2004						2011						Difference 2011-2004					
	Paddy Rice	Wheat	Coarse grains	Oil seeds	Other crops	Total	Paddy Rice	Wheat	Coarse grains	Oil seeds	Other crops	Total	Paddy Rice	Wheat	Coarse grains	Oil seeds	Other crops	Total
USA	1.3	20.2	35.2	31.8	39.4	128.0	1.1	18.5	37.2	31.5	37.7	125.9	-0.3	-1.7	2.0	-0.4	-1.7	-2.1
EU27	0.4	26.6	33.8	13.9	41.0	115.7	0.5	26.1	30.0	16.7	39.6	112.9	0.1	-0.5	-3.9	2.9	-1.4	-2.9
BRAZIL	3.7	2.8	13.9	22.3	20.1	62.8	2.8	2.1	14.3	24.8	24.1	68.1	-1.0	-0.7	0.4	2.5	4.0	5.3
CAN	0.0	9.4	6.8	6.9	10.4	33.5	0.0	8.5	4.9	9.4	5.6	28.5	0.0	-0.8	-1.9	2.5	-4.8	-5.1
JAPAN	1.7	0.2	0.1	0.1	2.0	4.2	1.6	0.2	0.1	0.1	1.7	3.7	-0.1	0.0	0.0	0.0	-0.4	-0.5
CHIHKG	28.6	21.6	29.4	24.2	57.0	160.8	30.1	24.3	36.7	22.0	61.5	174.6	1.4	2.6	7.3	-2.2	4.5	13.7
INDIA	41.9	26.6	29.3	27.5	61.5	186.8	44.0	29.1	27.5	28.9	79.3	208.7	2.1	2.5	-1.8	1.4	17.8	21.9
C_C_Amer	0.7	0.5	12.3	1.1	12.0	26.7	0.8	0.7	11.0	1.0	11.9	25.4	0.1	0.1	-1.3	0.0	-0.1	-1.3
S_o_Amer	2.1	7.4	7.6	20.3	19.2	56.6	2.4	6.3	10.6	26.9	16.9	63.0	0.2	-1.1	3.0	6.5	-2.3	6.4
E_Asia	1.6	0.2	0.7	0.4	1.9	4.9	1.4	0.4	0.7	0.4	1.8	4.7	-0.2	0.1	0.0	0.0	-0.1	-0.1
Mala_Indo	12.6	0.0	3.4	11.0	9.0	36.0	13.9	0.0	3.9	14.8	13.5	46.0	1.3	0.0	0.5	3.8	4.5	10.0
R_SE_Asia	31.0	0.1	5.5	7.9	15.7	60.2	35.5	0.1	6.2	8.8	20.5	71.1	4.5	0.0	0.7	0.9	4.8	10.9
R_S_Asia	15.3	11.4	3.6	2.2	11.2	43.7	17.4	12.3	3.7	2.1	12.0	47.5	2.1	0.9	0.1	-0.1	0.8	3.8
Russia	0.1	22.9	17.4	5.7	35.1	81.2	0.2	24.8	15.6	9.7	31.1	81.4	0.1	1.9	-1.9	4.0	-3.9	0.2
Oth_CEE_CIS	0.3	32.2	21.2	7.1	34.1	95.0	0.3	33.7	19.6	11.5	31.9	97.0	0.0	1.4	-1.6	4.4	-2.3	2.0
Oth_Europe	0.0	0.2	0.3	0.0	0.6	1.2	0.0	0.2	0.3	0.0	0.7	1.1	0.0	0.0	0.0	0.0	0.0	0.0
MEAS_NAfr	1.3	18.1	10.7	4.2	15.7	49.9	1.2	16.7	10.4	4.8	15.8	49.0	-0.1	-1.4	-0.2	0.6	0.2	-0.9
S_S_AFR	7.7	2.9	72.3	21.6	71.4	175.8	10.2	2.8	85.1	27.3	83.0	208.3	2.6	-0.1	12.8	5.7	11.6	32.5
Oceania	0.1	13.4	6.9	1.8	20.0	42.2	0.1	13.6	5.6	2.6	20.3	42.1	0.0	0.1	-1.3	0.7	0.3	-0.1
World	150.5	216.8	310.4	210.2	477.3	1365.2	163.3	220.3	323.3	243.4	508.7	1458.9	12.8	3.4	12.9	33.2	31.4	93.8

Crop Yield Differences

Region	Percent Change 2011-2004					
	Paddy Rice	Wheat	Coarse grains	Oil seeds	Other crops	Total
USA	1.1	1.4	-4.0	-0.2	1.1	-0.7
EU27	-3.7	-5.9	-2.3	-2.5	6.6	2.6
BRAZIL	37.7	28.3	26.2	33.1	38.5	47.2
CAN	0.0	12.0	18.0	19.7	-30.3	-27.5
JAPAN	3.9	-12.8	-17.5	30.8	-5.6	-9.3
CHIHKG	6.0	13.8	14.1	8.7	16.4	14.8
INDIA	20.7	10.2	39.3	26.2	14.1	25.3
C_C_Amer	15.0	22.1	-1.4	41.7	9.5	12.1
S_o_Amer	3.5	18.7	14.7	17.7	3.5	-7.1
E_Asia	7.5	23.5	-5.7	0.7	-2.3	-3.2
Mala_Indo	10.0	0.0	36.7	7.7	-24.1	3.6
R_SE_Asia	6.1	38.4	24.1	13.9	-1.6	7.3
R_S_Asia	17.7	18.7	39.4	9.4	5.2	11.4
Russia	35.2	14.3	27.5	33.6	11.0	4.7
Oth_CEE_CIS	36.9	21.6	29.4	39.9	15.0	12.0
Oth_Europe	0.0	-5.2	-18.5	1.5	6.7	7.3
MEAS_NAfr	3.3	2.9	10.3	7.0	16.3	15.5
S_S_AFR	20.4	26.3	7.8	-4.7	6.6	5.6
Oceania	14.7	24.0	22.0	6.0	-8.3	-3.1
World	9.7	8.8	7.8	13.8	7.2	7.8

Preliminary Simulations

- ***B2011***: A reduction in US corn ethanol from its 2011 level to 2004 level, a net reduction by 10.519 BGs, using the new model and its data base,
- ***F2004***: An increase in US corn ethanol by 10.519 BGs using the older version of the model and its data base.

LUC Results

Region	Experiment B2011				Experiment F2004			
	New cropland in 1000 hectare	Regional shares in %	Forest share in %	Pasture share in %	New cropland in 1000 hectare	Regional shares in %	Forest share in %	Pasture share in %
USA	-212.9	15.0	20.6	79.4	138.0	14.4	41.3	58.7
EU27	-93.5	6.6	56.5	43.5	31.2	3.2	45.5	54.6
BRAZIL	-293.6	20.7	-3.2	103.2	104.4	10.9	23.6	76.4
CAN	-58.6	4.1	74.0	26.0	32.3	3.4	62.1	37.9
JAPAN	-5.1	0.4	98.7	1.3	4.9	0.5	97.3	2.8
CHIHKG	-79.1	5.6	-20.0	120.0	73.3	7.6	1.0	99.0
INDIA	-63.7	4.5	54.8	45.2	10.2	1.1	64.7	35.5
C_C_Amer	-8.7	0.6	26.5	73.5	5.0	0.5	-71.7	171.8
S_o_Amer	-74.0	5.2	-39.1	139.1	49.7	5.2	-64.8	164.8
E_Asia	-7.1	0.5	25.4	74.8	1.5	0.2	-124.4	225.5
Mala_Indo	-6.8	0.5	72.3	27.5	1.9	0.2	-38.1	137.4
R_SE_Asia	-26.2	1.8	88.9	11.2	13.1	1.4	83.6	16.4
R_S_Asia	-25.2	1.8	21.8	78.1	21.9	2.3	12.9	87.1
Russia	-21.3	1.5	-17.4	117.2	10.5	1.1	-110.4	209.7
Oth_CEE_CIS	-36.1	2.5	30.2	69.8	26.6	2.8	26.1	73.9
Oth_Europe	-0.8	0.1	71.3	28.2	0.4	0.0	54.3	45.2
MEAS_NAfr	-31.8	2.2	-0.2	100.2	21.2	2.2	-0.4	100.5
S_S_AFR	-351.4	24.8	27.0	73.1	397.4	41.4	37.6	62.4
Oceania	-23.5	1.7	4.5	95.4	16.3	1.7	2.9	96.7
World	-1,419.5	100.0	18.8	81.2	959.7	100.0	25.9	74.1
Region	Cropland pasture transferred				Cropland pasture transferred			
USA	-749.7				1,538.7			
Brazil	-270.6				283.8			
Canada	-130.6				0.0			
World	-1,150.8				1,822.5			

Land Use Change Emissions

- Backcasting from 2011 results in a reduction of emissions of 14.5 g CO_2 e/MJ.
- Forecasting from 2004 results in an increase of emissions of 13.1 g CO_2 e/MJ.
- Difference is mainly due to endowment and data changes between 2004 and 2011.

Implications for Future Work

- Do we need to change the 2011 yields?
- Do we need to do a capital shock when simulating off the 2011 base?
- How about DDGS export?
- Getting cropland pasture data for other regions may be important.
- Taking into account double cropping is also important.
- We have just begun to reflect on all the possible implications of this research.

Sensitivity Analysis on CARB Results

- **YDEL** – the yield price elasticity
- **ETA** – the productivity of land converted to cropland relative to cropland productivity
- **PAEL** - the elasticity that drives the increase in yield on cropland pasture as the rent for cropland pasture increases.
- **Armington elasticity** - a measure of the degree of substitution between home and imported goods and also differentiation by exporting country.

Cases Run by CARB

- CARB ran 30 cases and used the average of the 30 as the corn ethanol ILUC emission, which was 19.8 g CO_2 e/MJ.
  - **YDEL** – 5 cases: 0.05, 0.10, 0.175, 0.25, 0.35 with an average value of 0.185 compared with the GTAP default of 0.25
  - **PAEL** – 2 cases: BR 0.1, US 0.2; BR 0.2, US 0.4
  - **ETA** – 3 cases: baseline, 120%, 80%

YDEL Sensitivity

- One of the first tests we did was to determine if the average of the five sensitivity cases gives the same answer as the average YDEL value.
- In other words, holding all other values constant, is the land use change (and resulting emissions) calculated from the average of the five YDEL cases the same as the land use change from using YDEL of 0.185.
- The result is that it is not because of non-linearity in the response to the YDEL value. The average has higher land use change and higher emissions.

Emission Comparison

YDEL		g/MJ
0.050	Case1	27.15
0.100	Case2	22.60
0.175	Case3	17.88
0.250	Case4	14.64
0.350	Case5	11.64
0.185	Case AV	17.38
	Average of cases 1 to 5	18.78

Emissions for the five case average are 8.1% higher than for the average YDEL value.

ETA Sensitivity

- What CARB did in its sensitivity analysis was use three sets of values: baseline, 120% of baseline, and 80% of baseline.
- In other words, for the two sensitivity cases, they multiplied the matrix of ETA values by 1.2 and 0.8. However, when the ETA matrix was multiplied by 1.2, CARB truncated the upper value at 1. That is, they assumed that the highest value ETA could have is 1, meaning that productivity of new land was equal to existing cropland.
- Since this assumption means that the base ETA values were not actually increased by 120%, the 80% and 120% cases are not actually symmetric in terms of emission values as one might expect.

ETA Sensitivity (2)

- The bottom line is that the CARB approach to the simulations results in an increase in land use GHG emissions of about 9% compared with the case with symmetric emission results.

Cases	ILUC	ILUC
CARB baseline	14.1	14.1
CARB 120%	13.4	13.4
CARB 80%	17.3	
CARB 80% with 95% ETA		14.8
Average	15.35	14.10
Difference	1.25	0

PAEL Sensitivity

- For the PAEL analysis we take a similar approach. We run five new cases which represent the simulated value for PAEL half way between the values for both the US and Brazil. That is, we simulate with values of 0.15 for Brazil and 0.3 for the US. We do this for each of the five YDEL values all for the TEM baseline.
- The results of this analysis show that the responses are completely linear. For example for cases with YDEL = 0.25 and ETA baseline, the average emissions are 14.65, and the emissions using the average PAEL values are 14.64. Thus, the sensitivity analysis is totally symmetric.

Armington Sensitivity

- Many international trade models, especially computable general equilibrium models, use what is called an Armington structure named after the economist who developed the original idea.
- It is based on the notion that substitution among products produced in different countries is not perfectly elastic and that there is some degree of differentiation by country of origin.
- Thus, an Armington elasticity is a measure of the degree of substitution between home and imported goods and also differentiation by exporting country. The other modeling alternative is termed a homogeneous goods model, with perfect substitution among imnported and domestic goods.

Armington Sensitivity (2)

- Like most CGE models, GTAP uses an Armington structure. However, it could be argued that given the medium to longer time frames being modeled in the biofuels work, the Armington structure may be overly restrictive.
- One way to test the sensitivity of the Armington structure is to increase the values of the Armington elasticities to more closely approximate a homogeneous goods model structure. For this exercise, we have run four cases to compare with the CARB base cases:
  - A1 – Armington elasticities are increased 50% for crops only
  - A2 – Armington elasticities are increased 50% for all goods
  - A3 – Armington elasticities are increased to 15 for crops only
  - A4 – Armington elasticities are increased to 15 for all goods

Armington Sensitivity (3)

- We did many simulations, and in all cases the emissions increase to some extent with higher Armington elasticities.
- There is less LUC in the US and more in the rest of the world with higher Armington elasticities.

Armington Sensitivity (4)

- Increasing crops only by 50% results in smaller increase than all sectors.
- Increasing crops to 15 has the largest increase because coarse grains and sorghum have low values in the base data

Case	g/MJ	% Change
Average of CARB cases 4 and 6, YDEL = 0.1375	19.33	
Increase in Armington by 50%: only crops	20.64	6.8%
Increase in Armington by 50%: all sectors	20.97	8.5%
Uniform large Armington (15): only crops	23.51	21.6%
Uniform large Armington (15): all sectors	22.26	15.2%

Armington Sensitivity (5)

- Economic theory (since Armington’s paper in 1969) favors the Armington view of the world.
- Thus, the 50% increase likely is the more appropriate sensitivity analysis, and it shows little difference in terms of total emissions.

CARB Sensitivity Conclusions

- The sensitivity for YDEL (yield price elasticity) and ETA (productivity of new land relative to existing cropland) shows that that CARB approach results in an overestimation of emissions.
- Armington sensitivity suggests there could be a small increase in emissions if a homogenous goods assumptions were introduced.

Thanks!
Questions and Comments