Sustainable Forest Management
Department of Forest Engineering, Resources & Management

EVALUATING THE COSTS AND CREDIT MARKET DYNAMICS OF OREGON'S CLEAN FUELS PROGRAM

Insights from the Oregon Clean Fuels Program for Sustainable Development

(Chukwuemeka Valentine Okolo, Andres Susaeta, Mindy Crandall, John Sessions)

Western Forest Economist Annual Meeting
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AGENDA

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Oregon State University

INTRODUCTION

- Climate change - Development of policies -reduce GHGs.
    - Oregon’s Clean Fuels Program (CFP) in 2016
- Statewide market-based incentive program
    - Low-carbon fuel adoption through credit generation and trading for surpassing CI benchmarks

State of Oregon Department of Environmental Quality

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INTRODUCTION

Goals of the Oregon Clean Fuels Program

- Reduce the CI of transport. Fuels by 10% (2015–2025).
- Encourage the use of:
  - *Biofuels: Ethanol, biodiesel, renewable diesel*
  - *Electricity: EV charging incentives*
  - *Renewable Natural Gas (RNG) & Hydrogen*
- Create a market for clean fuel credit trading.

INTRODUCTION

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HOW THE OREGON CLEAN FUELS PROGRAM WORKS

Set Carbon Intensity (CI) Targets
Oregon DEQ sets annual CI reduction targets

Fuel Suppliers Report CI Values
Fuel producers/importers report fuel carbon intensity.

Clean Fuel Providers Generate Credits
Low-carbon fuel suppliers earn credits below CI target.

Deficit Holders Buy Credits
High-CI fuel suppliers must buy credits to offset excess.

Credit Trading Market Balances Compliance
Market-based credit trading enables flexible compliance.

Oregon DEQ Monitors & Enforces Compliance
Ensures accurate reporting and enforces compliance.

Reduced Transportation Emissions
Program outcome: lower GHGs and cleaner air.

INVESTIGATING THE EFFICIENCY OF OREGON CFP IN CI REDUCTION

This study aims to explore the relationship between Cost of Oregon's CFP, credit markets and CI reduction as Manage by the Sate DEQ

Framework

Supplier and Demander Equations

$$D(P) = \alpha - \beta P + \lambda(Cost\ of\ Emissions\ Reductions)$$

$$S(P) = \Upsilon + \delta P$$

Market Clearing Reduced-Form Equation

$$\alpha - \beta P^* + \lambda(Cost\ of\ Emissions\ Reductions) = \Upsilon + \delta P^*$$

$$P^* = \frac{\alpha - \Upsilon + \lambda(Cost\ of\ Emissions\ Reductions)}{\beta + \delta}$$

$$CI = \theta - \phi P + k(Low - CI\ Fuel\ Production)$$

$$CI = \theta - \phi P + k(Low - CI\ Fuel\ Production) + \gamma Z + \epsilon$$

PRE-TEST & METHODOLOGY

Stationarity Test

- Augmented Dickey-Fuller (ADF) Test
- Phillips–Perron (PP) Test

Regression Techniques

- Ordinary Least Squares (OLS)
- ARCH model (non-constant error variance)
- Quantile model (different distribution points (quantiles))
- Fully Modified Ordinary Least Squares (FMOLS)

$$CI_{avg} = \gamma_1 + \gamma_2 S_t + \gamma_3 D_t + \epsilon_t$$ **Mean Equation**

$$Q_T(CI_{avg} \backslash X) = \gamma_1 + \gamma_2 S_t + \gamma_3 D_t + \epsilon_t$$

EMPIRICAL TECHNIQUE

$$CI_{avg} = \gamma_1 + \gamma_2 Ave\ CFP\ Cost_t + \gamma_3 Bioenergy\ + \gamma_4 Total\ Credits_t + \gamma_5 Low\ Carbon\ Transport_t\ +\ \epsilon_t$$

$$CI_{avg} = \gamma_1 + \gamma_2 Ave\ CFP\ Cost_t + \gamma_3 GBioenergy\ + \gamma_4 Total\ Credit\ Value_t + \gamma_5 Low\ Carbon\ Transport_t\ +\ \epsilon_t$$

$$CI_{avg} = \gamma_1 + \gamma_2 Ave\ CFP\ Cost_t + \gamma_3 Bioenergy\ + \gamma_4 Avg\ Price\ per\ Credit_t + \gamma_5 Low\ Carbon\ Transport_t\ +\ \epsilon_t$$

$$CI_{avg} = \gamma_1 + \gamma_2 Ave\ CFP\ Cost_t + \gamma_3 Bioenergy\ + \gamma_4 Credits\ Transferred_t + \gamma_5 Low\ Carbon\ Transport_t\ +\ \epsilon_t$$

DATA AND VARIABLES

Variables	Abbreviation	Definition	Units
Ethanol CI	CI	Measures the grams of CO2 equivalent per megajoule (gCO2e/MJ).	gCO2e/MJ
Bioenergy	BIO	State-level innovation index in bioenergy technologies.	Index score
Total Credits	TC	Total number of emission reduction credits generated or traded within CFP.	Number of credits
Total Credit Value	TCV	The total monetary value of credits traded within Oregon CFP.	USD
Credits Transferred	CT	Total credits transferred between parties in the market.	Number of credits
Avg Price Per Credit	APPC	The average market price for credits traded in the Oregon CFP.	USD
Low-Carbon Transport	LCT	Innovation index in low-carbon transport technologies.	Index score
Avg B5 CFP Cost	AB5C	Average compliance cost for B5 biodiesel under CFP.	USD
Avg E10 CFP Cost	AE10C	Average compliance cost for E10 ethanol under CFP.	USD

EMPIRICAL ANALYSIS

BASELINE ESTIMATION RESULTS

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Augmented Dickey-Fuller Test for Stationarity (Unit Roots)

Variable	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value	p-value
CIR 1(1)	-10.023	-3.518	-2.895	-2.582	0.0000
BIO 1(1)	-9.598	-3.518	-2.895	-2.582	0.0000
TC 1(1)	-13.872	-3.511	-2.891	-2.580	0.0000
TCV 1(1)	-13.435	-3.511	-2.891	-2.580	0.0000
APPC 1(1)	-9.714	-3.516	-2.893	-2.582	0.0000
CT1(1)	-12.052	-3.516	-2.893	-2.582	0.0000
LCT 1(1)	-9.615	-3.518	-2.895	-2.582	0.0000
AB5C 1(1)	-9.555	-3.535	-2.904	-2.587	0.0000
AE10C 1(1)	-9.559	-3.535	-2.904	-2.587	0.0000

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PHILLIPS-PERRON TEST FOR STATIONARITY (UNIT ROOTS)

Phillips–Perron Test for Stationarity (Unit Roots)

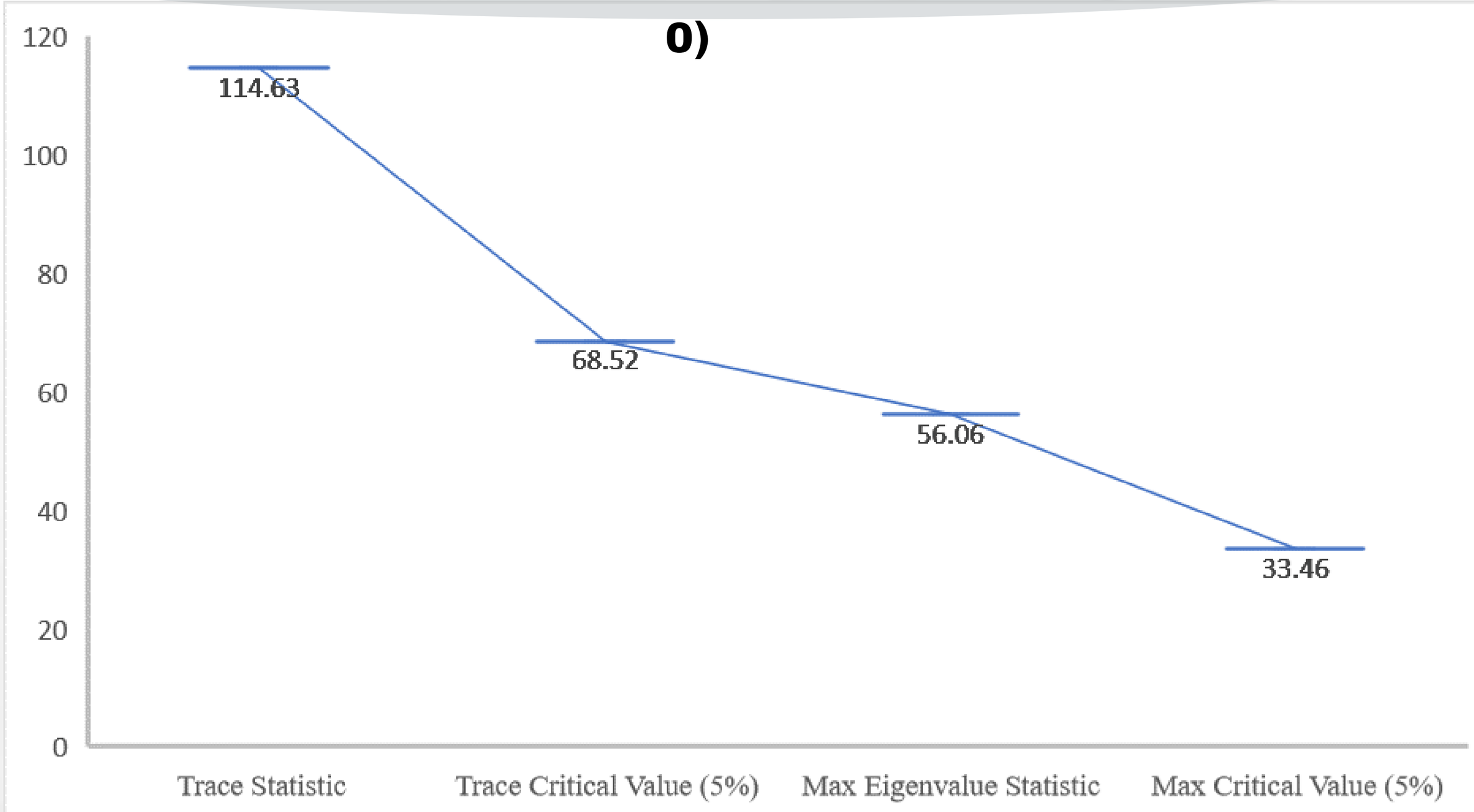
Variable	Test Statistic		1% Critical Value		5% Critical Value		10% Critical Value		p-value
	Z(rho)	Z(t)	Z(rho)	Z(t)	Z(rho)	Z(t)	Z(rho)	Z(t)	
CIR 1(1)	-93.476	-10.054	-19.692	-3.518	-13.652	-2.895	-10.964	-2.582	0.0000
BIO 1(1)	-94.013	-9.597	-19.692	-3.518	-13.652	-2.895	-10.964	-2.582	0.0000
TC 1(1)	-103.827	-18.045	-19.782	-3.511	-13.692	-2.891	-10.994	-2.580	0.0000
TCV 1(1)	-101.212	-16.985	-19.782	-3.511	-13.692	-2.891	-10.994	-2.580	0.0000
APPC 1(1)	-72.248	-10.268	-19.728	-3.516	-13.668	-2.893	-10.976	-2.582	0.0000
CT1(1)	-89.158	-14.589	-19.728	-3.516	-13.668	-2.893	-10.976	-2.582	0.0000
LCT 1(1)	-94.049	-9.615	-19.692	-3.518	-13.652	-2.895	-10.964	-2.582	0.0000
AB5C 1(1)	-82.327	-9.611	-19.476	-3.535	-13.556	-2.904	-10.892	-2.587	0.0000
AE10C 1(1)	-82.323	-9.616	-19.476	-3.535	-13.556	-2.904	-10.892	-2.587	0.0000

JOHANSEN TESTS FOR COINTEGRATION

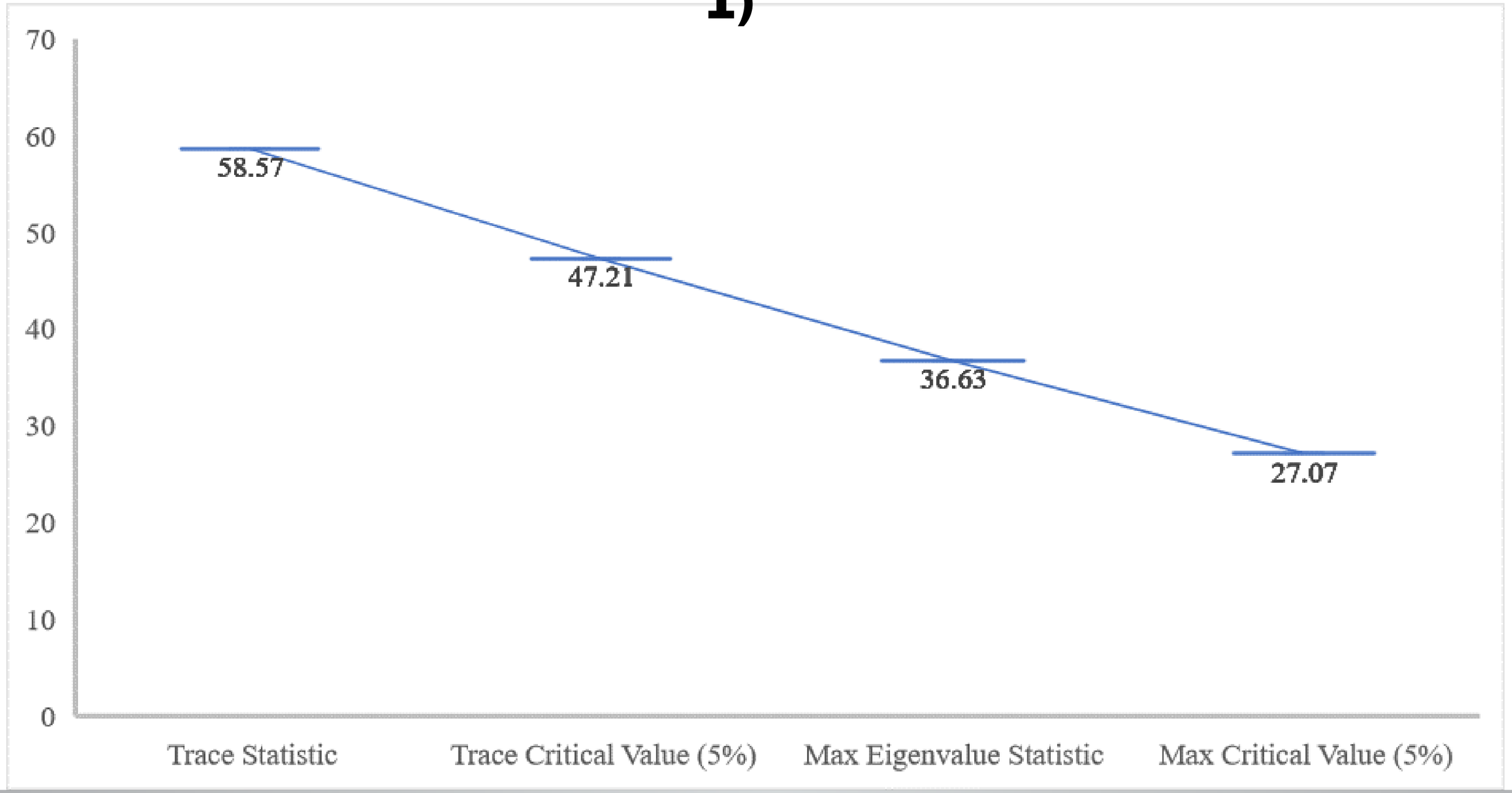
Johansen tests for cointegration

Rank	Number of Parameters	Log-Likelihood (LL)	Eigenvalue	Trace Statistic	Critical Value (5%)	Max Eigenvalue Statistic	Max Critical Value (5%)	Conclusion
0	130	385.17	-	114.63	68.52	56.06	33.46	Evidence of cointegration
1	139	413.2	0.51262	58.57	47.21	36.63	27.07	Evidence of cointegration

JOHANSEN TESTS FOR COINTEGRATION (RANK 0)



JOHANSEN TESTS FOR COINTEGRATION (RANK 1)

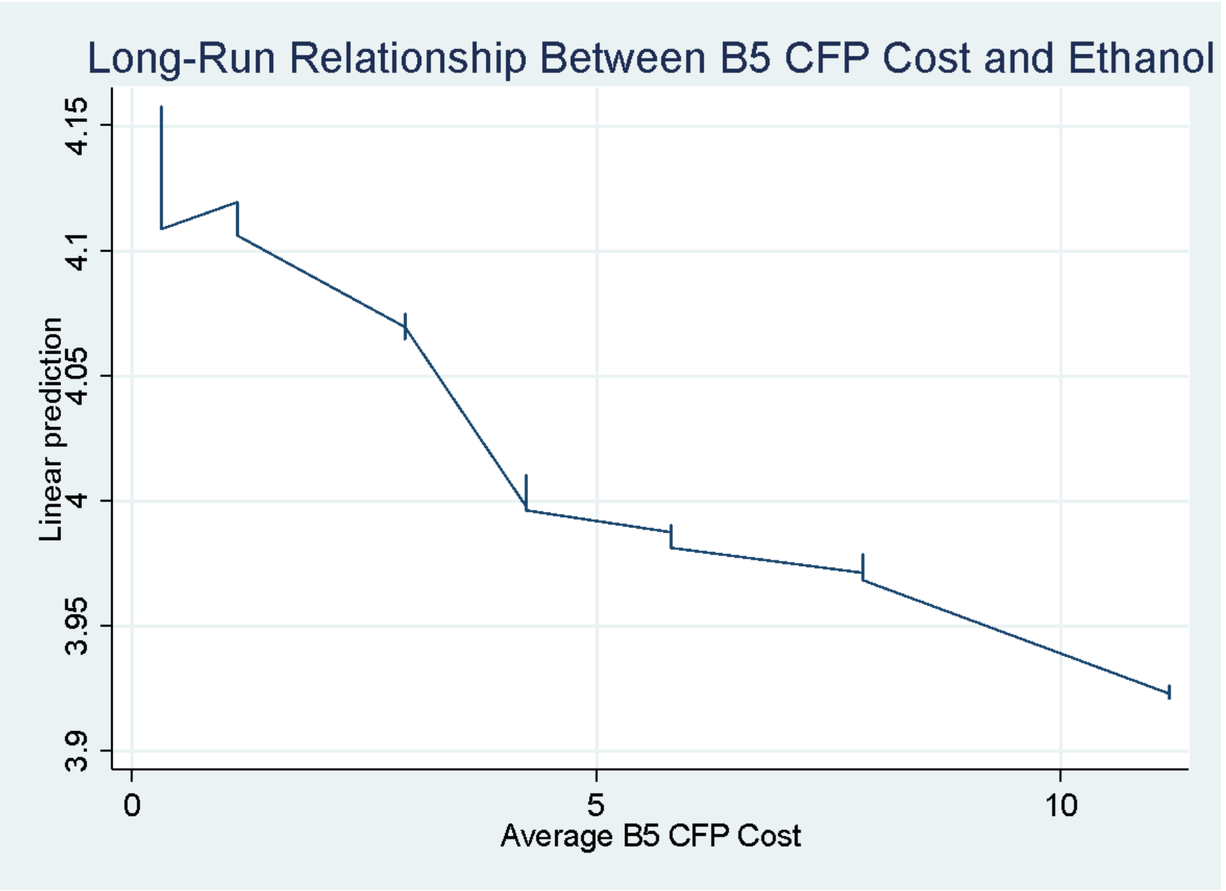


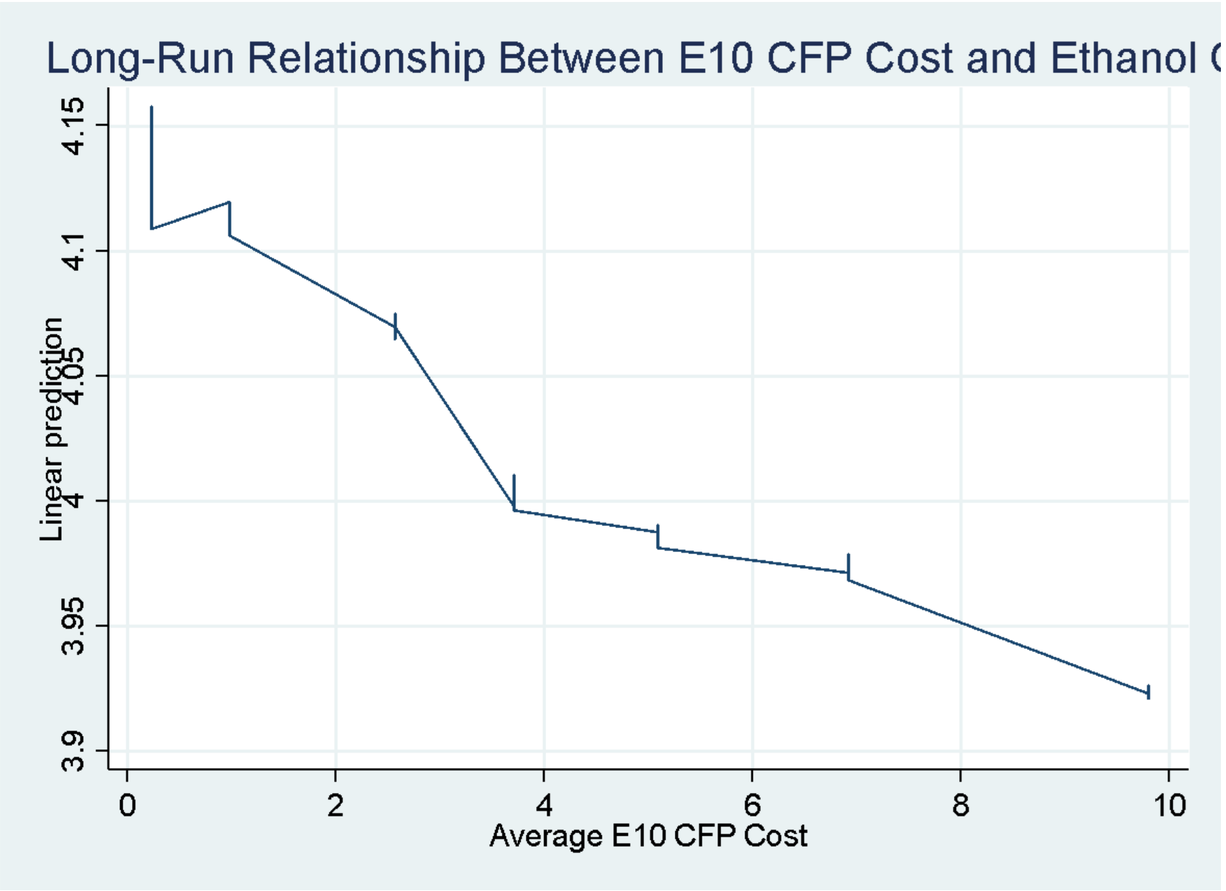
COINTEGRATION REGRESSION (FMOLS)

Cointegration regression (FMOLS)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lagged CI	0.780***	0.780***	0.774***	0.774***	0.779***	0.776***	0.778***	0.778***
	(0.0356)	(0.0357)	(0.0340)	(0.0340)	(0.0373)	(0.0373)	(0.0326)	(0.0326)
BIO	-0.136***	-0.136***	-0.140***	-0.140***	-0.139***	-0.140***	-0.126***	-0.127***
	(0.0403)	(0.0403)	(0.0383)	(0.0383)	(0.0421)	(0.0419)	(0.0361)	(0.0361)
LCT	-0.0101***	-0.0102***	-0.0104***	-0.0104***	-0.0101***	-0.0101***	-0.00917***	-0.00921***
	(0.00274)	(0.00274)	(0.00259)	(0.00258)	(0.00287)	(0.00286)	(0.00248)	(0.00248)
AB5C	-0.00269***		-0.00281***		-0.00269***		-0.00298***	
	(0.000545)		(0.000514)		(0.000572)		(0.000496)	
AE10C		-0.00306***		-0.00321***		-0.00311***		-0.00340***
		(0.000620)		(0.000585)		(0.000649)		(0.000565)
TC	-0.00162***	-0.00162***						
	(0.000429)	(0.000429)						
TCV			-0.00103***	-0.00102***				
			(0.000261)	(0.000261)				
CT					-0.00180***	-0.00180***		
					(0.000516)	(0.000514)		
APPC							-0.00270**	-0.00268**
							(0.000952)	(0.000952)
Constant	1.319***	1.322***	1.355***	1.356***	1.334***	1.348***	1.292***	1.295***
	(0.226)	(0.226)	(0.216)	(0.216)	(0.236)	(0.236)	(0.203)	(0.204)
Adjusted R2	0.95324	0.95362	0.95266	0.95266	0.95873	0.95914	0.95447	0.95448
Long run S.E.	0.00649	0.00649	0.00612	0.00612	0.00679	0.00677	0.00585	0.00585
Bandwidth	17.0138	16.7796	18.0184	17.9477	13.9830	13.4786	17.7105	17.4884
Observations	83	83	83	83	82	82	82	82

COINTEGRATION REGRESSION (FMOLS)





OLS - THE IMPACT OF AVERAGE COST OF THE CFP (B5 COST) ON CI REDUCTION

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lagged CI		0.776***		0.772***		0.777***		0.777***
		(0.0754)		(0.0764)		(0.0758)		(0.0772)
BIO	-0.707***	-0.119	-0.715***	-0.126	-0.702***	-0.116	-0.686***	-0.113
	(0.0967)	(0.0853)	(0.0957)	(0.0862)	(0.0976)	(0.0857)	(0.0972)	(0.0859)
LCT	-0.0212**	-0.00959	-0.0217**	-0.00990	-0.0211**	-0.00957	-0.0181**	-0.00872
	(0.00871)	(0.00582)	(0.00862)	(0.00583)	(0.00878)	(0.00586)	(0.00882)	(0.00591)
AB5C	-0.0125***	-0.00293**	-0.0125***	-0.00302**	-0.0125***	-0.00294**	-0.0130***	-0.00318***
	(0.00105)	(0.00116)	(0.00103)	(0.00116)	(0.00107)	(0.00117)	(0.000997)	(0.00118)
TC	-0.00408***	-0.00154*						
	(0.00116)	(0.000797)						
TCV			-0.00282***	-0.00100*				
			(0.000747)	(0.000527)				
CT					-0.00442***	-0.00166*		
					(0.00128)	(0.000883)		
APPC							-0.00897***	-0.00272
							(0.00276)	(0.00193)
Constant	5.930***	1.293***	5.952***	1.327***	5.921***	1.283***	5.851***	1.264**
	(0.240)	(0.477)	(0.237)	(0.484)	(0.242)	(0.479)	(0.241)	(0.483)
F-Statistics	240.42	469.06	245.51	468.29	235.55	460.85	231.44	443.19
Probability Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared	0.9241	0.9678	0.9255	0.9678	0.9235	0.9677	0.9223	0.9664
Root MSE	.02105	.01379	.02085	.01381	.02121	.01389	.02108	.01394
VIF	1.83	5.55	1.81	5.62	1.85	5.52	1.71	5.48
Durbin-Watson Statistic		1.8128(6,84)		1.8183(6,84)		1.8026(6,83)		1.8425(6,83)
Breusch–Godfrey LM test		1.244(0.2647)		1.190(0.2753)		1.351(0.2451)		0.766(0.3816)
Breusch–Pagan Test	0.9534	0.0017	0.9138	0.0020	0.9990	0.0018	0.8633	0.0031
White's Test	0.0040	0.0080	0.0027	0.0090	0.0046	0.0073	0.0000	0.0184
Number of Observations	84	84	84	84	83	83	83	83

OLS - THE IMPACT OF AVERAGE COST OF THE CFP (E10 COST) ON CI REDUCTION

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lagged CI		0.776***		0.777***		0.777***		0.776***
		(0.0756)		(0.0765)		(0.0760)		(0.0774)
BIO	-0.707***	-0.120	-0.714***	-0.126	-0.701***	-0.116	-0.686***	-0.113
	(0.0966)	(0.0854)	(0.0956)	(0.0862)	(0.0975)	(0.0857)	(0.0971)	(0.0859)
LCT	-0.0213**	-0.00961	-0.0218**	-0.00992	-0.0212**	-0.00960	-0.0182**	-0.00875
	(0.00870)	(0.00582)	(0.00861)	(0.00583)	(0.00877)	(0.00586)	(0.00881)	(0.00591)
AE10C	-0.0142***	-0.00334**	-0.0142***	-0.00344**	-0.0142***	-0.00334**	-0.0148***	-0.00362***
	(0.00119)	(0.00132)	(0.00117)	(0.00132)	(0.00121)	(0.00133)	(0.00113)	(0.00134)
TC	-0.00404***	-0.00153*						
	(0.00116)	(0.000797)						
TCV			-0.00279***	-0.000995*				
			(0.000747)	(0.000527)				
CT					-0.00438***	-0.00165*		
					(0.00128)	(0.000883)		
APPC							-0.00887***	-0.00270
							(0.00275)	(0.00192)
Constant	5.928***	1.295***	5.951***	1.329***	5.919***	1.286***	5.850***	1.267**
	(0.239)	(0.478)	(0.237)	(0.484)	(0.241)	(0.480)	(0.241)	(0.484)
F-Statistics	241.12	469.06	246.15	468.29	236.27	460.88	232.07	443.21
Probability Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared	0.9243	0.9678	0.9257	0.9678	0.9238	0.9677	0.9225	0.9664
Root MSE	.02102	.01379	.02082	.01381	.02118	.01389	.02105	.01394
VIF	1.84	5.56	1.81	5.64	1.86	5.54	1.71	5.50
Durbin-Watson statistic		1.8125(6,84)		1.8180(6,84)		1.8024(6,83)		1.8422(6,83)
Breusch–Godfrey LM test		1.251(0.2633)		1.197(0.2740)		1.357(0.2441)		0.772(0.3796)
Breusch–Pagan test	0.9387	0.0017	0.8997	0.0020	0.9834	0.0018	0.8509	0.0031
White's test	0.0038	0.0081	0.0026	0.0091	0.0045	0.0074	0.0000	0.0185
Number of Observations	84	84	84	84	83	83	83	83

ARCH - THE IMPACT OF THE AVERAGE COST OF THE CFP ON CI

REDUCTION

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CI								
BIO	-0.846***	-0.846***	-0.845***	-0.839***	-0.834***	-0.825***	-0.821***	-0.821***
	(0.0399)	(0.0382)	(0.0364)	(0.0352)	(0.0394)	(0.0376)	(0.0348)	(0.0344)
LCT	-0.0274***	-0.0272***	-0.0265***	-0.0263***	-0.0268***	-0.0262***	-0.0246***	-0.0247***
	(0.00451)	(0.00416)	(0.00392)	(0.00376)	(0.00446)	(0.00404)	(0.00347)	(0.00342)
AB5C	-0.0135***		-0.0138***		-0.0134***		-0.0137***	
	(0.000422)		(0.000366)		(0.000408)		(0.000419)	
AE10C		-0.0155***		-0.0157***		-0.0153***		-0.0155***
		(0.000453)		(0.000410)		(0.000445)		(0.000480)
TC	-0.00143**	-0.00128**						
	(0.000557)	(0.000577)						
TCV			-0.000753***	-0.000737***				
			(0.000218)	(0.000219)				
CT					-0.00162***	-0.00219***		
					(0.000524)	(0.000360)		
APPC							-0.00687***	-0.00674***
							(0.000955)	(0.000952)
Constant	6.277***	6.273***	6.259***	6.248***	6.247***	6.227***	6.211***	6.211***
	(0.123)	(0.116)	(0.111)	(0.106)	(0.119)	(0.106)	(0.102)	(0.101)
ARCH								
L.arch	1.520***	1.582***	1.636***	1.638***	1.474***	1.438***	1.507***	1.505***
	(0.343)	(0.340)	(0.330)	(0.327)	(0.335)	(0.378)	(0.339)	(0.337)
Constant	0.0000138	0.0000105	0.00000734	0.00000709	0.0000167	0.0000228	0.00000537	0.00000537
	(0.00000871)	(0.00000893)	(0.00000664)	(0.00000625)	(0.00000871)	(0.0000149)	(0.00000281)	(0.00000275)
Wald chi2(4)	13111.54	19329.25	19558.74	17691.99	10964.01	11703.63	7246.43	7122.79
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Log-likelihood	230.1127	230.2223	230.9511	231.0593	226.7829	226.7689	231.2652	231.1364
Observations	84	84	84	84	83	83	83	83

.25 QUANTILE - THE IMPACT OF AVERAGE COST OF THE CFP ON CI

.25 Quantile regression	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
BIO	-0.457***	-0.455***	-0.4[illegible]***	-0.451***	-0.453***	-0.451***	-0.647***	-0.646***
	(0.151)	(0.150)	(0.132)	(0.132)	(0.149)	(0.149)	(0.118)	(0.117)
LCT	-0.0101	-0.0102	-0.0125	-0.0125	-0.00949	-0.00962	-0.0479***	-0.0480***
	(0.0136)	(0.0135)	(0.0119)	(0.0119)	(0.0134)	(0.0134)	(0.0107)	(0.0107)
AB5C	-0.0152***		-0.0151***		-0.0152***		-0.0129***	
	(0.00163)		(0.00143)		(0.00163)		(0.00120)	
AE10C		-0.0173***		-0.0172***		-0.0173***		-0.0147***
		(0.00185)		(0.00162)		(0.00185)		(0.00137)
TC	-0.00346*	-0.00342*						
	(0.00180)	(0.00180)						
TCV			-0.00250**	-0.00247**				
			(0.00103)	(0.00103)				
CT					-0.00346*	-0.00341*		
					(0.00196)	(0.00196)		
APPC							-0.0105***	-0.0104***
							(0.00333)	(0.00333)
Constant	5.252***	5.248***	5.283***	5.277***	5.238***	5.234***	6.050***	6.048***
	(0.373)	(0.372)	(0.328)	(0.328)	(0.369)	(0.368)	(0.291)	(0.291)
Raw sum of deviations	1.794951	1.794951	1.794951	1.794951	1.793222	1.793222	1.751402	1.751402
Min sum of deviations	.537982	.5378936	.5239388	.5240265	.5354404	.5352256	.5105647	.5107544
Pseudo R2	0.7003	0.7003	0.7081	0.7081	0.7014	0.7015	0.7085	0.7084
Number of Observations	84	84	84	84	83	83	83	83

.50 QUANTILE - THE IMPACT OF AVERAGE COST OF THE CFP ON CI

.50 Quantile regression	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
BIO	-0.768***	-0.770***	-0.7[illegible]	-0.7[illegible]	-0.761***	-0.763***	-0.704***	-0.707***
	(0.0882)	(0.0867)	(0.104)	(0.102)	(0.0923)	(0.0932)	(0.112)	(0.111)
LCT	-0.00833	-0.00838	-0.00966	-0.00966	-0.00704	-0.00709	-0.00291	-0.00304
	(0.00794)	(0.00781)	(0.00941)	(0.00922)	(0.00831)	(0.00838)	(0.0101)	(0.0101)
AB5C	-0.0126***		-0.0130***		-0.0133***		-0.0139***	
	(0.000956)		(0.00113)		(0.00101)		(0.00114)	
AE10C		-0.0143***		-0.0147***		-0.0150***		-0.0157***
		(0.00107)		(0.00126)		(0.00116)		(0.00129)
TC	-0.00349***	-0.00345***						
	(0.00105)	(0.00104)						
TCV			-0.00152*	-0.00151*				
			(0.000816)	(0.000801)				
CT					-0.00204*	-0.00200*		
					(0.00122)	(0.00123)		
APPC							-0.00469	-0.00459
							(0.00316)	(0.00315)
Constant	5.934***	5.939***	5.952***	5.951***	5.892***	5.896***	5.725***	5.733***
	(0.218)	(0.215)	(0.259)	(0.254)	(0.228)	(0.231)	(0.277)	(0.275)
Raw sum of deviations	2.635532	2.635532	2.635532	2.635532	2.620674	2.620674	2.56403	2.56403
Min sum of deviations	.6136059	.6129506	.6056751	.6053263	.6167313	.6163539	.6045176	.6043123
Pseudo R2	0.7672	0.7674	0.7702	0.7703	0.7647	0.7648	0.7642	0.7643
Number of Observations	84	84	84	84	83	83	83	83

.75 QUANTILE - THE IMPACT OF AVERAGE COST OF THE CFP ON CI

.75 Quantile regression	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
BIO	-0.836***	-0.838***	-0.849***	-0.850***	-0.839***	-0.840***	-0.822***	-0.822***
	(0.115)	(0.115)	(0.119)	(0.118)	(0.116)	(0.116)	(0.145)	(0.142)
LCT	-0.00147	-0.00153	-0.00322	-0.00332	-0.00243	-0.00246	-0.00291	-0.00306
	(0.0104)	(0.0104)	(0.0107)	(0.0106)	(0.0104)	(0.0104)	(0.0132)	(0.0129)
AB5C	-0.0128***		-0.0127***		-0.0125***		-0.0133***	
	(0.00125)		(0.00128)		(0.00127)		(0.00149)	
AE10C		-0.0144***		-0.0145***		-0.0143***		-0.0152***
		(0.00142)		(0.00145)		(0.00144)		(0.00165)
TC	-0.00235*	-0.00233*						
	(0.00138)	(0.00138)						
TCV			-0.00160	-0.00157				
			(0.000928)	(0.000924)				
CT					-0.00401**	-0.00393**		
					(0.00153)	(0.00153)		
APPC							-0.00207	-0.00196
							(0.00412)	(0.00403)
Constant	6.015***	6.018***	6.061***	6.063***	6.048***	6.049***	5.987***	5.987***
	(0.285)	(0.285)	(0.295)	(0.293)	(0.287)	(0.287)	(0.360)	(0.352)
Raw sum of deviations	2.09603	2.09603	2.09603	2.09603	2.064991	2.064991	2.05525	2.05525
Min sum of deviations	.4522363	.4510645	.4509423	.4498267	.4539622	.4525811	.4505775	.4494983
Pseudo R2	0.7842	0.7848	0.7849	0.7854	0.7802	0.7808	0.7808	0.7813
Number of Observations	84	84	84	84	83	83	83	83

KEY DRIVERS OF CI REDUCTION

- - Bioenergy adoption significantly contributes to CI reduction.
- - Low-carbon transport options play a critical role.
- - Average B5 CFP cost and E10 CFP are strong indicators of CI improvement.

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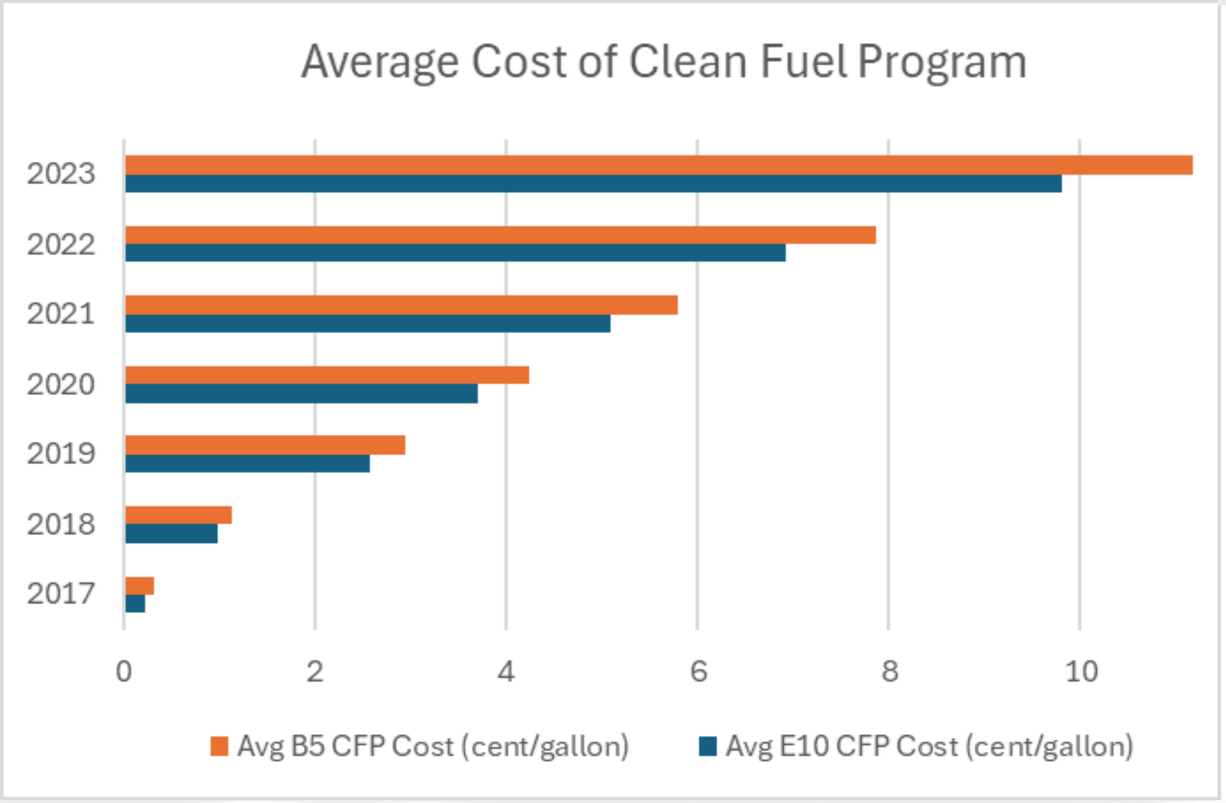
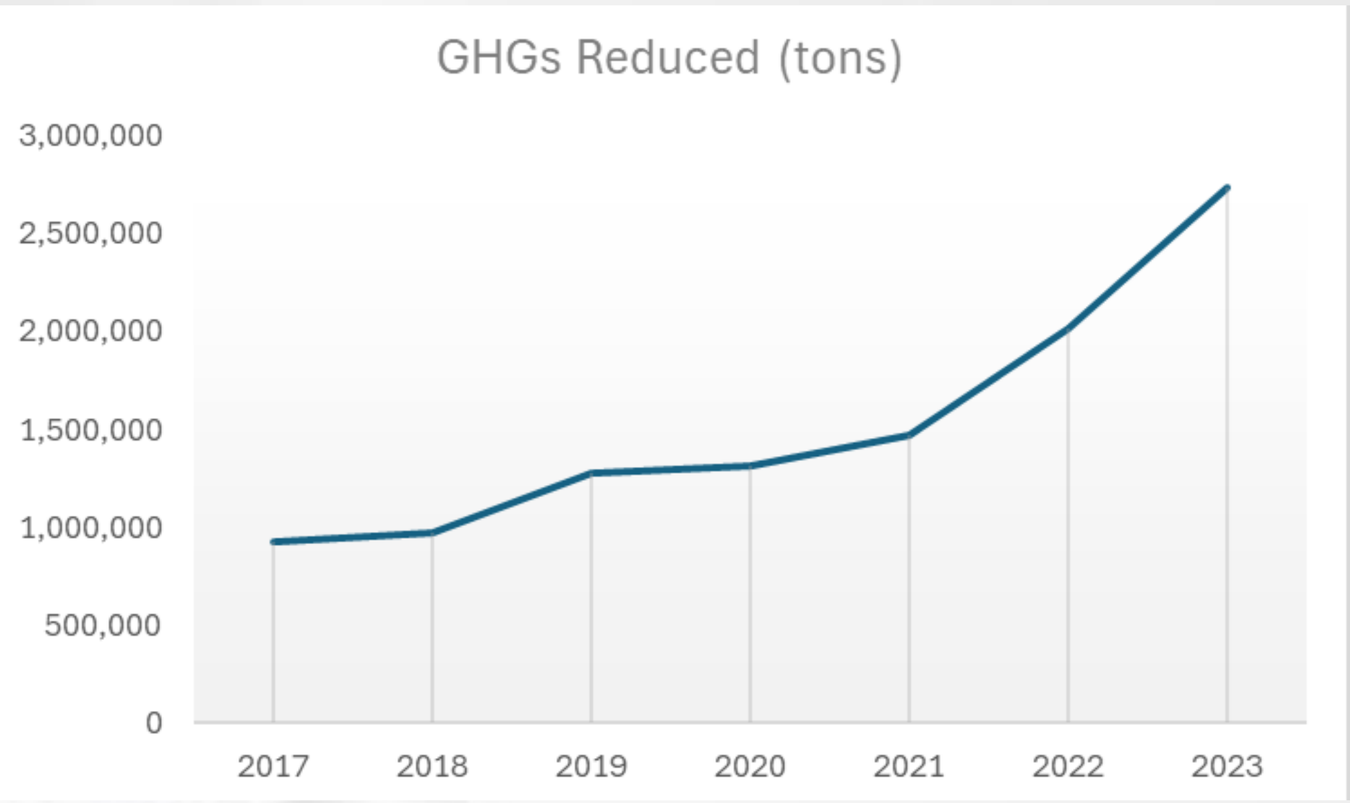

Average Cost of Clean Fuel Program
2023
2022
2021
2020
2019
2018
2017
0
2
4
6
8
10
Avg B5 CFP Cost (cent/gallon)
Avg E10 CFP Cost (cent/gallon)


GHGs Reduced (tons)
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
2017
2018
2019
2020
2021
2022
2023

MARKET-BASED MECHANISMS

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- - Credit transferred and total credit value reflect market activity.
- - Average credit prices influence stakeholder behavior.
- - Financial incentives are aligned with environmental goals.

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MARKET-BASED MECHANISMS

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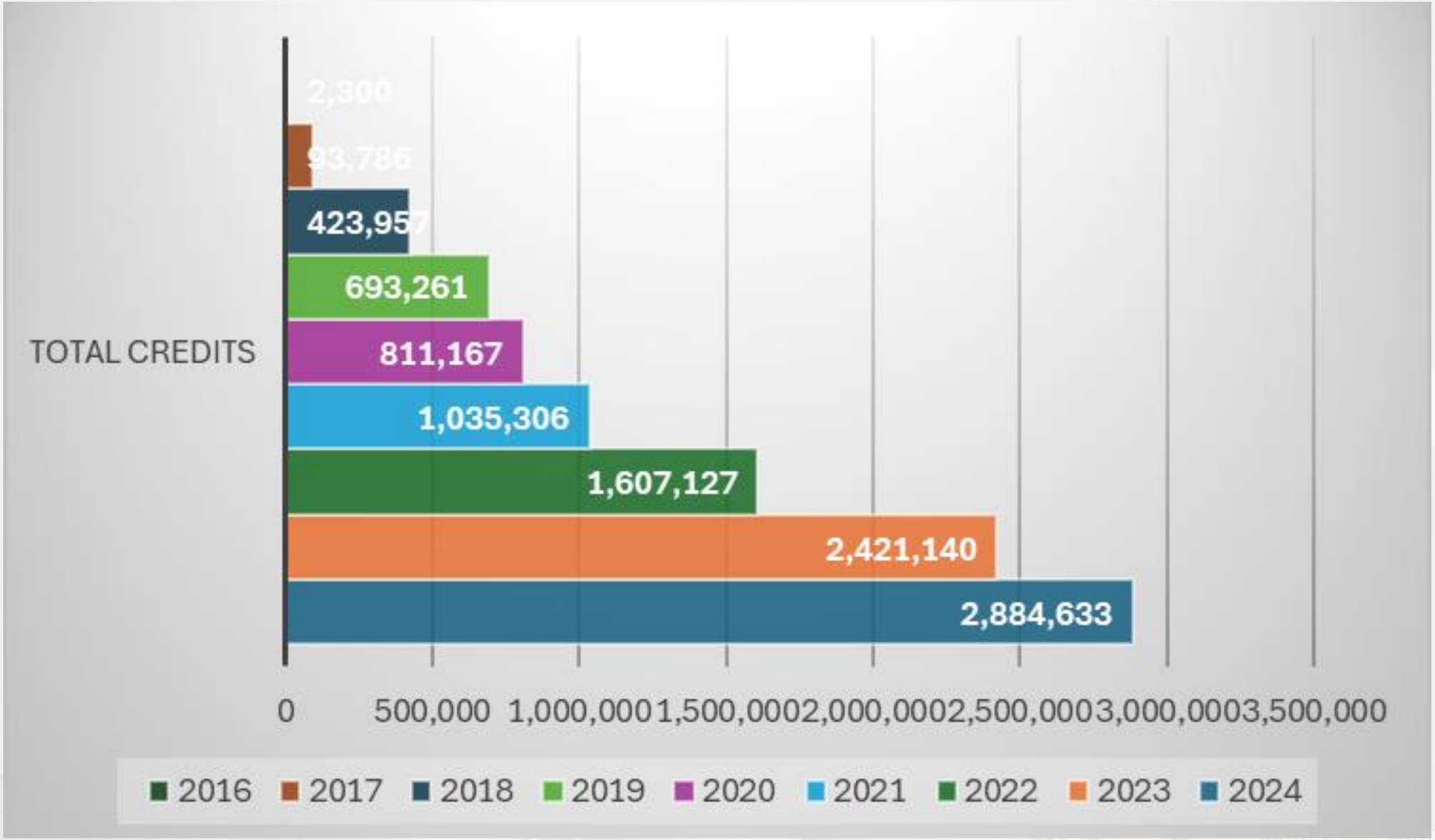

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POLICY IMPLICATIONS

- Expand CFP credit opportunities for advanced biofuels with low lifecycle emissions.

- Support research and development to improve feedstock conversion efficiency and reduce production costs.

- Create targeted incentives or subsidies for biorefineries using regionally abundant feedstocks (e.g., woody

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POLICY IMPLICATIONS

- Integrate fuel switching (biofuels) with vehicle electrification & public transit expansion.

- Promote infrastructure development (e.g., renewable diesel pumps, EV chargers).

POLICY IMPLICATIONS

- Use average CFP credit prices as indicators of clean fuel market effectiveness.

- Ensure price transparency and stability in credit markets to attract investment.

THANK YOU!

For more questions, contact

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