California's Bioenergy Potential

Lessons learned from recent European Union Policies

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Introduction

With growing ambition from the Californian legislature to be a leader in climate change mitigation, legislators have renewed their interest in alternative renewable energy production techniques. Low carbon fuel standards and credits (SB 32), organic waste diversion requirements (SB 1383), renewable portfolio standards (SB 350), and a bioenergy feed-in-tariff (SB 1122) will all drastically increase demand for bioenergy production in the near future. But, California's bioenergy sector is nascent and requires thoughtful funding standards, allocations and compliance requirements to ensure investment. The European Union – on the other hand – has already experienced several bioenergy technological innovations a decade ago and have tested several policy mechanisms to bolster their bioenergy sector – including but not limited to biofuel blending requirements, feed-in-tariffs, organic waste quality controls, sustainability criteria, and certification systems. In the following evidence summary, I review and evaluate two quasi experiments and one life cycle assessment - the prior based in the Netherlands and Spanish context and the former encompassing the entire continent of Europe. From these evaluations, I determine and discuss what causal inferences (if any) can be deduced and applied to the Californian context. Overall, my central question regards whether or not continued funding should be allocated to bioenergy production and if so, in what manner.

Bioenergy Policy Initiation and Reform

One critical tool for initiating and reforming bioenergy policy is stakeholder engagement and participation. Consideration for the efficacy of existing policy will be critical as California continues to strengthen their environmental programs. Given the variety of opinion and ambition in the policy arena, matching stakeholder impetuses can be difficult and enacted policy may be infeasible or unnecessary. In the case of the Netherlands, the Dutch legislature reduced a formerly ambitious biofuel content requirement of 5.75 % to 4 %. Cuppen questions whether such inaccuracies in standards may be due to stakeholder inflexibility and evaluates one methodology to streamline decision making.

Causal Questions

Cuppen (2012) examines the process of facilitating stakeholder engagement in the context of the Netherlands. She conducts a quasi-experimental evaluation of a dialogue funded by the Netherlands Organization for Scientific Research (NWO) – an independent national research organization with statutory authority for policy and rulemaking. The research ambitions of both NWO and Cuppen were parallel: (1) to elucidate the multi-faceted impetus for bioenergy policy to relevant stakeholders and (2) determine the efficacy of the dialogue structure by implementing the NWO's Constructive Conflict Methodology (CCM). In other words, *do relevant stakeholders learn about each perspective of bioenergy? Is CCM an effective program for collaboration?*

Study Design

Factor designation and selection

As part of CCM, Cuppen implemented Q methodology for designing and evaluating the deemed "Biomass Dialogue". The design is quasi-experimental in that participants were not randomly assigned. Instead, 75 stakeholders from academia, consultancies, nongovernmental organizations, and government were screened prior to the dialogue. Stakeholders were selected to participate based on the diversity of their perspectives regarding sustainable bioenergy production impetuses and methods. Six dominant perspectives were identified during the pretreatment screening, and these perspectives were then incorporated into the dialogue. Of the 75, 40 were invited to take part in the dialogue, equally divided by their respective six dominant perspective. For the analysis, these six dominant perspectives are considered factors, and will be referenced as such for the remainder of this section.

There is unequal division between treatment and control groups. Cuppen does not mention any incentives provided to bolster dialogue participation. The overall sample of 75 for treatment solicitation is small – this may be because these were in person interviews which are cost intensive. Lacking resources is a significant limitation to the study.

Treatment group selection

The focus of CCM was to create constructive conflict, stimulating learning and factor change. As such, the 40 participants created equally divided groups based on these predominating factors. Facilitated throughout four workshops, each group would articulate arguments, deliver arguments, and suggest revisions to arguments. After the dialogue, those who had attended at least two workshops were selected for posttreatment follow up phone interviews. Of the 12 participants eligible and invited, 11 would create the experimental group.

Results from these 11 participants would represent the treatment effect for the treatment group of 40. If Cuppen had provided more incentive for the participants to continue attending the workshop, they would have a more representative and causal treatment effect as it would reduce their standard error. In addition, 11 of 12 identified participants were successfully interviewed. Measures to compensate for this attrition is never addressed in the study.

Control group selection

The control group was determined from those not participating in the dialogue. Researchers implemented a form of covariate matching – linking factors from the 12 treated individuals to 12 untreated individuals. However, as the factors were different for the control group, researchers developed new factors based on this new subset for comparison, and determined correlations between these treatment and control perspectives. For the analysis, the control group is intended to be those who would have had been selected for the dialogue, yet resemble closely the treatment group. These selected 12 were then interviewed over the phone for any factor change.

Correlations between initial Q factors (based on $N = 75$) and 'new' Q factors (based on $N = 98$).

Factors	Correlation
Factor $1_{\text{initial}} \times$ Factor 1_{new}	$.92^{*}$
Factor $2_{\text{initial}} \times$ Factor 2_{new}	$.97^{*}$
Factor $3_{\text{initial}} \times$ Factor 3_{new}	$.87^{*}$
Factor $4_{\text{initial}} \times$ Factor 4_{new}	$.94^{*}$
Factor $5_{\text{initial}} \times$ Factor 5_{new}	$.82^{*}$
Factor $6_{\text{initial}} \times$ Factor 6_{new}	$.74^{*}$

* $p < .01$.

Cuppen may be attempting to reduce bias from confounding variables found when estimating the treatment effect. However, rather than rely on randomization, she is creating a brand new control group to do achieve this. Her defense for executing the analysis with a synthetic control is because the new control's factors / perspectives are correlated with the former group. However, as the interviews from the original 75 influenced the dialogue structure, the control group had an equal influence over the treatment as well – thus the treatment and control groups are not necessarily mutually exclusive. I find this methodology unusual and unfamiliar, causing me to question the validity. Perhaps these correlations could be used as weights or instruments for the treatment effect – otherwise how do we know the treatment effect is valid? In addition, the control group and treatment group are unequal.

Results

Cuppen demonstrates that in the treatment group 8 out of 11 experienced factor change while in the control group 5 out of 12 experienced factor change. For the treatment group, six came to agree the following: (1) Knowledge development is key to bioenergy development and bio-refinement is an acceptable process, as not one single development or biomass resource can be applied to the entire problem. (2) If there should be development it should be small-scale and innovative, not central and monopolistic. And (3) the potential for biomass is overestimated, focus should be emphasized on using biomass in a more efficient manner. What stakeholders came to disagree on in the treatment group was to "hit the brakes," or halt bioenergy development all together as it could potentially be unsustainable globally. In the control group all five came to disagree with the following: (1) "hit the brakes," (2) biomass's primary role in the economy is to replace fossil fuels, (3) the potential for biomass is overestimated, and (4) we should act now on bioenergy development, despite having limited information.

Number of significant changes in factor loadings (Q2–Q1) on each of the six perspectives, for the dialogue and the control group. (+) indicates that the changes concern increases and (−) indicates that the changes concern decreases from Q1 to Q2.

	Dialogue group	Control group
P1 Keep all options open	4 (+)	–
P2 Hit the brakes	2 (−)	1 (−)
P3 Support small-scale innovative initiatives	1 (+)	–
P4 Security of supply with global, certified, 2nd generation biomass	–	1 (−)
P5 Efficiency the aim: biomass a means?	1 (+)	2 (−)
P6 Just do it, step by step	–	1 (−)
Total	8 (of which 6(+), 2(−))	5 (of which 5 (−) –)

To verify the results, Cuppen uses a multivariate analysis of variance (MANOVA). The MANOVA consisted of three variables – a between subjects variable of control and treatment levels, a within subjects variable with pre and post levels, and a factor variable with all six perspectives. Of the total 10 levels and four interactions between them – the only significance difference was between the treatment and control groups. That being, on average those treated come to agree and those not treated come to disagree.

Due to lack of significance overall, the specific results and perspectives are not a reputable and valid. The only significance gleaned from the experiment was that CCM can bring relevant stakeholders into agreement – which although may be important for Cuppen, gives us little insight into the bioenergy debate. What can be recommended from the above is an adoption of CCM to develop California policies.

Bioenergy Standards

As stakeholder engagement may have led to a policy change in the Netherlands, the outcome of such a change is reflected in Spain. The results of an increased requirement of biofuel content in Spain, may result in similar backlashes as those of the Dutch. de Alda and colleagues develop an econometric model for gasoline consumption.

Causal Questions

de Alda and colleagues strive to evaluate the impact of three policies executed in the nation of Spain on national gasoline consumption. The three policies - a reduction in highway speed limits, a reduction in public transit fares, and an increase in biofuel content - were all executed simultaneously in February of 2011 until July of 2011. Although the increase in biofuel content is of particular interest for this paper and evaluation methodologies will be considered as such, de Alda and colleagues evaluate each policy simultaneously through econometric modeling, specifying certain controls to determine individual policy impacts. Specifically, *how will an increase in biofuel content for fuels overall and for diesel in particular from 5.9 % and 3.9 % to 6.2% and 6.0%, respectively, impact gasoline consumption?*

Study Design

Data Acquisition

de Alda and colleagues conducted a difference in difference regression analysis by acquiring the following monthly panel data ranging from January 2008 to December 2011 for 48 of 50 Spanish provinces from a variety of national institutions: gasoline consumption, Spanish gasoline price, international oil price and US-Euro exchange rate (to instrument for external validity), consumption per vehicle stock (as short-run consumption), unemployment rate and number of workers in social security (to control for economic shocks), an Easter holiday dummy (to control for consumption spikes), public transit fares (for consumption elasticity evaluation), and biofuel content in gasoline.

Outcomes of interest

Outside of the formerly described intentions, the following assumptions are made: (1) To evaluate public transit fare impact - car use is directly proportional to gasoline consumption; (2) Due to lacking data on vehicle flow, the post dummy variable will account for the impact of reduced speed limits - although the resulting effect will be from the macro level; (3) We can attribute a similar rise in biofuel content for gasoline in that same time period to the increase biofuel content standard for all fuel types and diesel.

Difference in Difference Regression

To evaluate the impact of gasoline consumption, gasoline demand curves are calculated through regression analysis.

$$ln(Q_{pt}) = X'_{pt}\beta + \delta \cdot D_{3-6/11} + \rho \cdot Bio_t + \gamma \cdot D_{A,B} + \psi_p + \epsilon_{pt}$$

Where,
pt = province and/or month
X = the explanatory variables
D3-6/11 = the time period in which the policy was active
Bio = the fuel content in gasoline
DA,B = a specific time dummy for two provinces who shifted their fares at an alternate time

As the dummy variable D3-6/11 is assumed to provide an underestimated account of the impact of the speed limit policy, it may as well impact the results of the specified variables for the other two policies, or include within the estimate other policies unaccounted for by the researchers. In addition, the time frame chosen for the dummy variable is not representative of all three policies. For example, as shown earlier in the paper, biofuel minimum content continues to rise well beyond June of 2011. The dummy may not fully isolate the results, or confound the results of the other two policies.

Results

de Alda and colleagues present results for three regression analyses. The one shown below is their final regression, ruling out the variable Da/b after repeated insignificance during an additional robustness analysis and replacing it with transit fares. Their models are as follows: (9) using the Spanish gasoline prices, (10) the same but including the errors in 9, (11) instrumenting the gasoline prices based on the international price of oil, (12) the same but including the errors in 11.

Gasoline consumption equation including transit fares (all provinces)

Estimation technique:	FE (9)	GLS (10)	IV (11)	IV-GLS (12)
Ln(Price)	-0.200***	-0.185***	-0.227***	-0.212***
	(0.0202)	(0.0113)	(0.0158)	(0.0109)
Ln(Transit fare)	0.116	0.0791***	0.106***	0.0673***
	(0.0703)	(0.0191)	(0.0271)	(0.0183)
Ln(Total vehicle stock)	1.076***	1.054***	0.997***	0.933***
	(0.309)	(0.115)	(0.138)	(0.107)
Ln(Motorcycle stock)	-0.379***	-0.440***	-0.397***	-0.462***
	(0.0932)	(0.0308)	(0.0409)	(0.0283)
Ln(Total employment (dependent))	0.732***	0.612***	0.766***	0.659***
	(0.103)	(0.0368)	(0.0449)	(0.0340)
Dummy 3/11 to 6/11	-0.0306***	-0.0177***	-0.0281***	-0.0192***
	(0.0052)	(0.0031)	(0.0044)	(0.0030)
Biofuel content (%)	0.00582*	0.00289**	0.00718***	0.00533***
	(0.0030)	(0.0013)	(0.0017)	(0.0013)
Constant	-8.296*	-6.319***	-7.693***	-5.177***
	(4.586)	(1.323)	(1.692)	(1.223)
Province fixed effects	yes	yes	yes	yes
Month-Province effects	yes	yes	yes	yes
Easter-Province effects	yes	yes	yes	yes
Panel specific AR(1) errors	no	yes	no	yes
Panel heteroskedastic errors	no	yes	no	yes
Wooldridge AR(1) test (P-value)	0.0047	—	0.0003	—
Observations	2,208	2,208	2,208	2,208
R-squared	0.927	—	0.998	—
Number of Provinces	46	46	46	46

Note: Standard errors in parenthesis, significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Both their model and independent variables are highly significant and account for most of the variation (R2 = 0.927 - 0.998). Most important is that the treatment effect variable (Dummy 3/11 to 6/11) is highly significant throughout. Based on their results, a 1% increase in biofuel content results in a 0.4 % to 0.9% increase in gasoline consumption. Similar results have been observed in laboratory settings, largely due to the lower energy content of ethanol.

Due to the high significance of the model, I am confident to make causal inferences. For bioenergy policy, increasing biofuel content would not be the most environmentally advantageous technique, as although biofuel production would be bolstered stimulating the bioenergy market, additional fossil fuel based gasoline would be consumed - further limiting precious resources and contributing to additional lifecycle carbon emissions. Given the stated environmental ambitions in California, ethanol content in gasoline is much higher than that of Spain - a total of 10 %. California should consider reducing such a standard and use the ethanol elsewhere.

Bioenergy Emissions

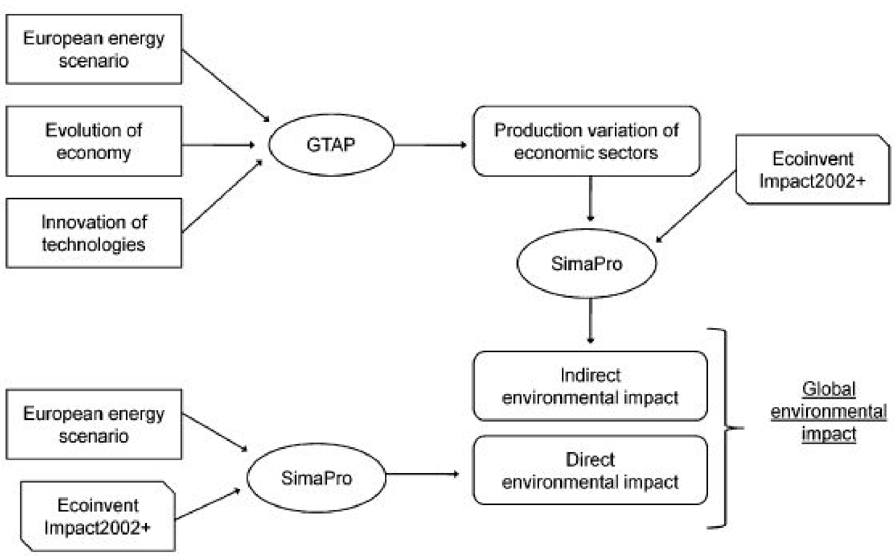
As the impact of Spain's biofuel policy may be detrimental to the environment in terms of greenhouse gases, one can also determine other ways in which bioenergy policies can impact emissions on a more macro level. Dandres and colleagues attempt to understand the impact of bioenergy policy for the entire continent of Europe relative to lifecycle emissions produced.

Causal Questions

Dandres and colleagues use lifecycle analysis (LCA) to predict the future impacts of bioenergy policy on Europe. Both attributional and consequential LCA approaches focus on minor system disruptions and assume and unchanging world - especially in terms of economy. Dandres and colleagues propose a new Macro LCA (M-LCA) - which considers technological and economic innovations for macro level system disturbances. Their causal question is whether or not the environment would improve if bioenergy standards continued to be developed or were held constant in Europe.

Study Design

To answer this question, Dandres and colleagues project European resource consumption and their associated emissions using a general equilibrium economic model and the ecoinvent lifecycle impact database.

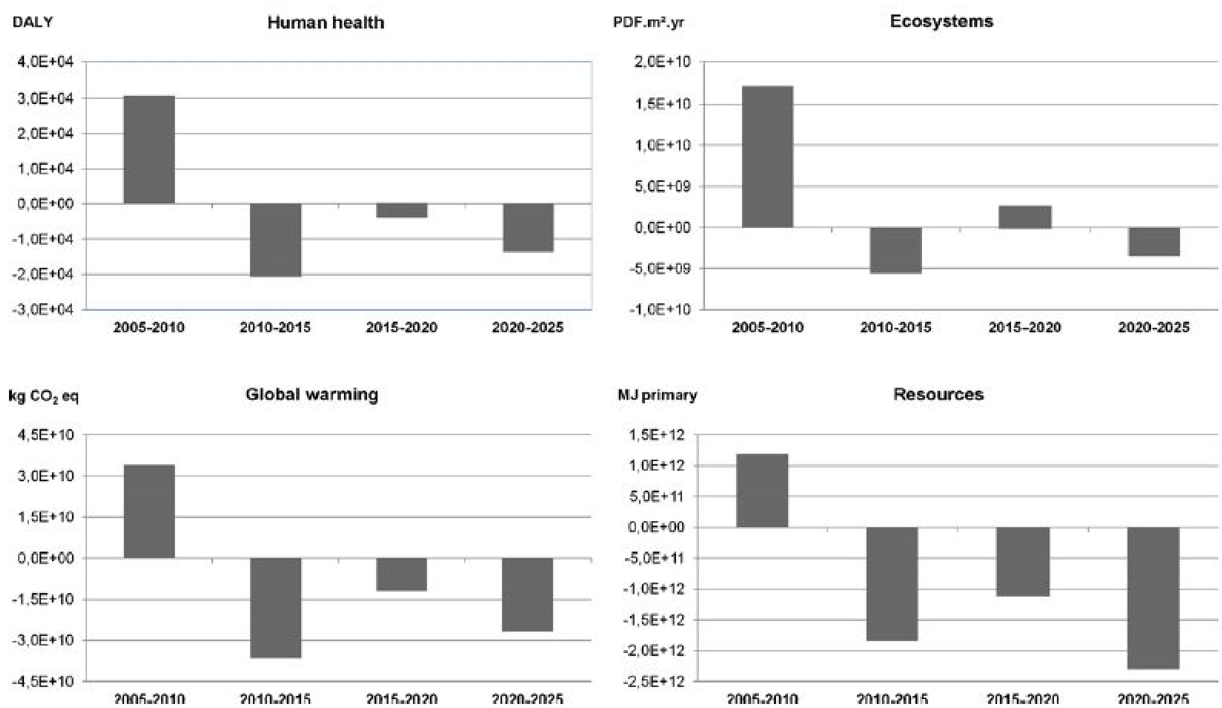


Two European energy scenarios are outlined which impact both the general equilibrium and the emission factors for the analysis. In both scenarios 2005 data is projected to 2025. In the first baseline case, the EU improves upon their renewable energy policy in a normal fashion and in the second, heavy improvements are placed on bioenergy. Both scenarios are inputted to generate descriptive calculations of emission impacts. The specifics of the model and the model itself are sourced in the article.

To validate the model and assess robustness, it is common for LCA to use additional sensitivity and monte carlo analyses. For the economic model a sensitivity of 50 % was used for the elasticity of competition between domestic and foreign products - which is considered the most sensitive variable in the general equilibrium economic model. For Monte Carlo, a distribution is defined for each emission factor based on previous results from literature and 1000 iterations of the model are run, using the central limit theorem to estimate each emissions' true mean.

Results

Dandres and colleagues aggregate results into four categories: human health, ecosystems, global warming, and energy resources - presenting them as global and regional scaled time series.



Globally scaled results are shown above comparing the two scenarios. Positive values represent improved baseline performance and negative values represent improved bioenergy performance. The model results demonstrate that the bioenergy scenario has less significant impacts on human health, global warming, and energy resources and more significant impacts on ecosystems than the baseline scenario.

To validate their results, the researchers test the null hypothesis that the bioenergy scenario would be more impacting than the baseline scenario (generally opposite to the findings). The results from sensitivity and monte carlo demonstrate no probability of this case being true for global warming and energy resource categories, whereas there remains a ~20% probability of this being the case for human health and ecosystem categories.

The approach used by these researchers introduces a large amount of risk. Whereas before causal inferences are drawn from single quasi experiment results, now the results from a multitude of experiments are aggregated into a model, of which additional results and computed. Each experiment in itself hold individual methodologies, and their respective computational errors. Great effort is required to decipher the methodological errors within each result and include them into the model output. Despite verification that the results are robust for two scenarios for these researcher's analysis, this robustness is limited to the model outputs, not the individual inputs.

Conclusion

Despite increased interest in the Californian legislature to bolster their bioenergy sector, special consideration must be taken to account for stakeholder consensus, environmental impetus, and macro level impacts. As evidenced by Cuppen and de Alda and colleagues, ambitions regarding climate change mitigation may run counter to the expected outcomes of biofuel standards. Instead - Cuppen purports - facilitated conflict between bioenergy stakeholders may ameliorate misdirected ambition - although exactly which of bioenergy perspectives have a greater impact remains uncertain. Such a conflict mediated workshop led by representatives of the California Air Resources Board, California Public Utilities Commission., and California Department on Resources Recycling and Recovery would prove advantageous for future policy enactment. de Alda and colleagues rather significantly demonstrate an increase in gasoline consumption in response to increase in biofuel standards in Spain, causing concern in the short term from a greenhouse gas mitigation perspective; California's existing 10 percent biofuel content standard may be causing more harm than good. However, Dandres and colleagues represent with some certainty that on the macro scale a range of bioenergy policies could indeed abate greenhouse gases and additionally have improved human health outcomes in the long term. As such, California would be better off developing an organized and collaborative programme dedicated to sustainable bioenergy production rather than scattered and decentralized policies. Considering the risk and limitations of the above studies, there indeed still lies potential for California to reshape their bioenergy landscape and generate environmentally beneficial outcomes.

References

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